



Superior 4 in 1 insulation

A SOUND SOLUTION FOR BUILT-UP FLAT ROOFING



ROCKWOOL

FUTUREPROOF INSULATION

RAIN NOISE TESTING ON LIGHTWEIGHT ROOFING

**The combined acoustic benefits of
Rockwool 4 in 1 insulation & Rockfon ceilings**

By Tim Spencer



FIGURE 01 A Rockwool roofing system being installed



Introduction

To be (as we believe) the first organisation in the UK to complete testing in accordance with the published version of ISO Standard BSEN ISO 140-18:2006 Measurement of rain noise on building elements [1] was quite an achievement for Rockwool Ltd.

BS EN ISO 140-8 describes a laboratory method for the measurement of sound generated by rainfall on building elements, using artificial raindrops produced by a water tank. Ideally, test specimens should be exposed to real rain for such measurements. But real rain is neither steady nor continuous with respect to time. Furthermore, raindrops can vary in diameter owing to several factors, including the geographical location, which introduces variability in measured values.

Artificial raindrop generation systems (other than the water tank used in this part of ISO 140) do exist, hydraulic spray nozzles being one example. However, nozzles corresponding to the specifications given in this part of the standard are not, so far, commercially available. Indeed, their flow rate is too high when the drop diameter is correct, and the drop diameter is too small when the flow rate is correct. Only the water tank method appears in the standard.

An alternative to real rain or artificial raindrops is the dry mechanical excitation of the test specimen. Researchers have

used different methods, such as excitation by an impact hammer or other mechanical impacting simulators with the aim of simulating the noise of real rain. These methods invariably suffer from the drawback that the noise source generates sound levels and sound spectra that taken together, do not compare well with corresponding values generated by the real rain on various types of test specimens. Further research work is encouraged to develop mechanical methods of rain noise generation that can match both the sound levels and spectra of real rain.

With increasing focus on noise issues and the need for proven, sustainable, good whole life value-for-money and safe building solutions, Rockwool Ltd and sister company Rockwool Rockfon Ceilings got on with the task of roof rain noise testing.

The testing, carried out at the end of 2007 at the Building Research Establishment, is believed to have been the first to be completed in the UK, and probably internationally, in accordance with the recently published International ISO 'rain noise' standard.

The tests demonstrated that Rockwool insulated roofs with the addition of a straightforward Rockfon low-weight stone wool suspended ceiling can ensure that rain noise resistance, reverberation time and speech intelligibility criteria, together with all the other necessary performance requirements in terms of fire safety, thermal performance, light reflection and sustainability are fully satisfied for all sectors. The testing further confirmed the superior performance, enhanced practicality and peace of mind when using Rockwool insulated roofs compared with foam insulated varieties.

Test Programme

The comprehensive test programme was completed at the BRE acoustics laboratory within the extensive Building Research Establishment at Garston, Watford in November and December 2007. BRE Acoustics specifically configured one of their existing laboratories to allow for the construction of roofs and ceiling elements together with the 'rain' water tank and all of its necessary supports allowing for easy tank movement so that measurements could be made in different roof positions. The rig also included water run-off and collection systems, water collection and recycling being particularly important to minimise the amount of water being used. Because the tests took place indoors, the 'rain' water was fed from and collected in a separate supply and recycling tank on the ground floor.

Testing indoors proved to be a great benefit compared with the outdoor option, because ironically the use of a test rig built outside would be weather dependent. In other words, tests would only be possible when the weather conditions allowed, and the ambient sound level was sufficiently low. Tests would certainly be impossible when...it was really raining! Everyone is well aware how much rainfall there can be in the UK, and the past 12 months have been exceptionally wet. Programme predictability, and completion of the tests as quickly and as efficiently as possible were key factors in laboratory design and choice. In a nutshell, the testing was completed indoors in accordance with the published International Standard (as opposed to the previous drafts) in a closely controlled laboratory environment with very low background noise levels and very high flanking limits, all as required by the new ISO standard.

The results obtained on the straightforward, economical, fire-safe and easily built roof and ceiling constructions were impressive, with the samples performing well, and demonstrating their ability to achieve results well within 'best practice' target values and the guidelines for resistance to rain noise.

Designers can be confident in the use of this data and the constructions used, compared with any other previously obtained data and any subsequent predictions in accordance with previous draft or ad hoc standards and laboratory set-ups. When looking for data and making comparisons for designs to resist the negative effects of rain noise, it is prudent to ensure that the test results are current and obtained in accordance with the published standard. The solution put forward should be straightforward and easy to construct. A BRE report from January 2008 contains all the test data and results. Further details are available from Rockwool Rockfon.



FIGURE 02 Rockwool Hardrock being laid on vapour control layer

For more information on fire safety legislation and Rockwool's range of dual density roofing boards visit www.rockwool.co.uk or call 0871 222 1780

Why do the tests?

Appropriate background sound pressure levels and the need for appropriate levels of resistance to noise generated by rain are 'must haves' in modern buildings. In any built environment, an appropriate background sound level should not be exceeded no matter what the weather conditions. In design work the sound pressure level due to rainfall in the room beneath the roof element should be of considerable interest.

In some buildings the background noise levels created by rain on the roof are unacceptable - the rain is simply too loud. The noise can be disruptive to learning and concentration in the education and commercial sectors, and is not conducive to health, wellbeing and efficient healing in the healthcare sector. The problem is becoming more recognised in various best-practice codes and guidelines.

To date, some installations have used complex and costly multi-layer ceilings to provide appropriate room acoustics (speech intelligibility and reverberation times) and to combat the high level of rain noise generated by lightweight foam insulated roofs. Our goal was to prove that by using a Rockwool insulated roof and a single layer Rockfon ceiling there would be no need for complex multi-layer ceilings with overlays or other devices.

The focus was on exploiting the damping and acoustical performance of Rockwool Hardrock insulation as well as reducing reverberation times and enhancing speech intelligibility. The sound absorption and sound insulation characteristics of Rockfon ceilings were known to be excellent. Of course, the programme was also intended to add peace of mind for acousticians, particularly as they are nowadays being pressed by architects and main contractors for solutions that reduce risk to their indemnities by providing good, up-to-the-minute data and reliable, safe value-for-money solutions for all.

Benchmarks for acceptable performance

Building Bulletin 93 [2] sets out the performance standards for the acoustics of new school buildings, and one of these performance standards is the indoor ambient noise level in unoccupied spaces. This noise level excludes contributions from rain noise, but the guidance states that it is essential that rain noise is considered in the design of lightweight roofs as it can significantly increase the indoor ambient noise level. When BB93 was published in 2004 the international standard for measuring rain noise was still being developed. The intention is that in the future, consideration will be given to including a performance standard for rain noise in BB93. Until this time, it is appropriate for design teams to provide evidence to Building Control that the roof has been designed to minimise rain noise.

In the meantime some specific benchmarking is available in the form of BREEAM for schools. The values stated in BREEAM for schools are likely to become the norm in future editions of BB93. BREEAM provides credits for roof designs that can demonstrate in the event of heavy rain that the ambient sound pressure level will not exceed normal allowable ambient sound levels by more than 20dB. Reference needs to be made to Table 1.1 of BB93 to determine the maximum levels allowable in the many different room types in educational buildings. Predictions for rain noise can then be accurately made based on test data and formulas in accordance with BS EN ISO 140-18:2006. Resistance to rain noise and its importance will also be covered in HTM 08-01 Healthcare premises - acoustics (soon to be published as a replacement for HTM 2045).

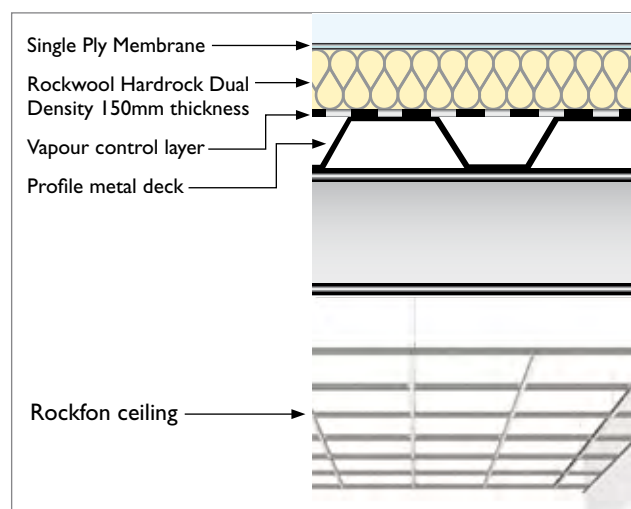


FIGURE 03 Sample configuration for rain noise test

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Results

TABLE 01

Room Type	Area(m)	Height(m)	Ceiling	Upper Limit (DB)	Internal (DB)
Primary classroom	56	2.4	none	55	59
Primary classroom	56	2.4	Rockfon 20mm Scholar	55	51
Secondary classroom	63	2.7	none	55	60
Secondary classroom	63	2.7	Rockfon 20mm Scholar	55	51
Lecture room large	180	3	none	50	61
Lecture room large	180	3	Rockfon 50mm Sonar 44 dB'sandwich'	50	45
as above	180	3	Rockfon 20mm Scholar	50	52
'Inclusive' classroom for use by hearing impaired	56	2.4	none	50	58
as above	56	2.4	Rockfon 50mm Sonar 44 dB'sandwich'	50	42
as above	56	2.4	Rockfon 50mm Sonar 44 dB'sandwich'	50	49

Sample performances in schools

Note: Lower values of internal sound pressure level indicate a better performance. All ceilings consisted of Rockfon tiles in 600mmx600mm modules and a RockLink 24 exposed grid.

The roof construction without a suspended ceiling performed well, achieving 59dB $L_{Aeq,30min}$ (based on probable use in a typical classroom with a T_{mf} of around 0.6 seconds). This was certainly an impressive result, but as expected it was found to fall short of the target values when calculations were made for other types of spaces. By adding a straightforward and widely used Rockfon Scholar sound absorbing ceiling, installed using a RockLink 24 exposed T-grid to create a 600mm square module, an improved performance was achieved, meaning that in a typical classroom with dimensions 8m x 7m x 2.4m the sound pressure level from rain noise would be 51dB $L_{Aeq,30min}$ and therefore well within the target value of $35 + 20 = 55$ dB. Table 1 shows some examples of the performance achievable based on the data obtained from the test roof with and without Rockfon Scholar 20mm and Rockfon Sonar 44dB 50mm lightweight suspended ceiling tiles. The Rockwool insulated roof provides a high level

of rain noise resistance and the addition of a Rockfon ceiling provides a significant improvement owing to its pure stone wool construction (it is made from resin bonded mineral wool). The weighted sound absorption coefficient of both the fronts and the backs of the tiles exceeds 0.9, giving them a Class A (the highest) rating. This high performance is a feature of resin bonded mineral wool ceilings, which are superior to the traditional wet felted mineral fibre ceilings. The use of the Rockfon ceiling and the Rockwool Hardrock insulated roof is enough to meet the rain noise target: there is also a performance and cost-savings benefit because the Rockfon ceiling makes a significant contribution to achieving the reverberation time and speech intelligibility requirements of many areas, specifically those covered in BB93. The tests proved there to be no need for additional intermediate dense ceilings or overlays, thereby maintaining simplicity and reducing the installation time and cost.

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Test Programme

TABLE 02

Rainfall Type	Rainfall Rate mm/h	Typical Drop Diameter mm	Fall Velocity ms
moderate	up to 4	0.5 to 1	1 to 2
intense	up to 15	1 to 2	2 to 4
heavy	up to 40	2 to 5	5 to 7
cloudburst	greater than 100	>3	>6

Classification of rain type according to IEC 60721-2-2

A tank positioned above the test roof is filled with water and constantly recharged. The flow rate is calibrated and monitored to ensure a correct rainfall. Sound pressure level measurements are taken below each roof or roof/ceiling construction in the frequency range 100Hz to 5kHz. The rain noise standard describes various types of artificial rainfall that can be used, as shown in Table 2. Real rain can be classified in terms of rainfall rate, typical drop diameters and fall velocities. The artificial rainfall parameters that affect the noise generated by roof elements are controlled in the laboratory. At present, the intention is that 'heavy' rainfall shall be mandatory for the comparison of products and solutions.



FIGURE 07 Screenshot of the BRE/Rockwool rain noise prediction programme

Using the laboratory data to calculate the sound pressure level in rooms based on the results of the test programme the BRE has produced an easy-to-use calculator to predict roof rain noise in a wide variety of spaces. This is based around the spaces and reverberation time limits set by Building Bulletin 93, but it can also be set to user-defined requirements.

The calculator can be made available to acousticians on loan: contact Rockwool Rockfon for details. An example calculation is shown in the panel (see Figure 07). Rockwool and Rockfon would like to thank Dr Robin Hall and the team at BRE Acoustics for their assistance and involvement in the completion of the tests on which this article is based.

Sustainability

Finally, a word on sustainability, understandably a subject of increasing popularity and one that is quite rightly entering into and becoming part of an ever-increasing holistic approach by acousticians. The diabase rock from which Rockwool insulation and Rockfon ceilings are manufactured possesses a rare quality among the many types of raw materials used to manufacture insulation. The natural process by which diabase is formed is taking place continuously all over the world. Volcanic activity and plate tectonics mean that mother nature creates new reserves of diabase rock every year - around 38,000 times more than is extracted by Rockwool. This unique process of natural renewal completes the rock cycle and delivers sustainability. Not only does Rockwool enhance the environment for all, but it can continue to do so for thousands of years to come. Rockwool and Rockfon ceiling tile offcuts have for many years been recycled at the large and long-established Rockwool UK manufacturing facility just west of Cardiff. Tim Spencer is with Rockwool UK Ltd, Bridgend.

References

- [1] International Standards Organisation BSEN ISO 140 Acoustics – Measurement of sound insulation in buildings and of building elements – Part 18: Laboratory measurement of sound generated by rainfall on building elements.
- [2] Department for Education and Skills. Acoustic design of schools. DfES Building Bulletin 93. London, The Stationery Office, 2004.

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