MAPLE R&D Ltd

BUILDING MOISTURE INDEX (BMI)

ENVIRONMENTAL DIAGNOSTIC REPORT

PCA Property Care ASSOCIATION

Building Professional:	eeee
Company Name:	eee
Property Address:	16 Spencer Hill, SW19 4NY
Date of Inspection:	2024-08-23 14:34:57.826067+00:00

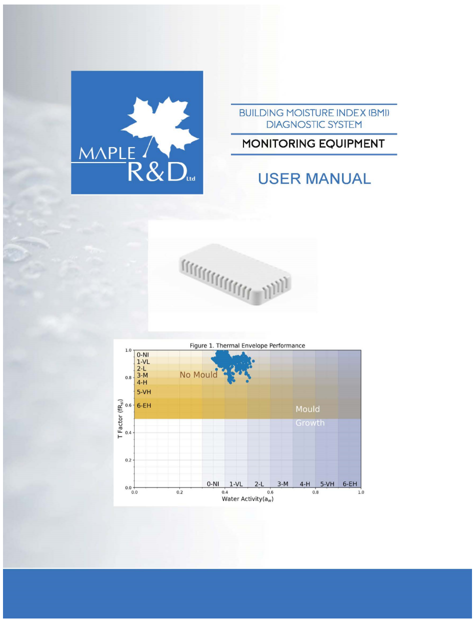
CONTENTS

1. INTRODUCTION

Maple R&D Ltd is a research and development PCA subsidiary company offering innovative diagnostic systems to analyse moisture-related problems in buildings.

The Building Moisture Index (BMI) diagnostic system has been developed by The Property Care association (PCA) and University College London (UCL). It is based on years of research collaboration, is internationally peer-reviewed and has been tested and validated by monitoring numerous private and social properties (including Local authorities, Housing Associations).

The BMI system produces diagnostic reports on indoor air and surface moisture in buildings by processing environmental data. A protocol to install data loggers (environmental sensors) in properties and a novel method integrated in a computer program enables the system to generate autonomous diagnostic reports.



This technical report consists of several sections which include a description of the BMI method, photos and plans together with details and comments about the property (provided by the surveyor). A summary of results on the moisture diagnostic assessment includes the BMI scores indicating the severity of moisture imbalance and the causal factors leading to condensation and mould. This is complemented with tables and graphs showing the representation of all data and averaged values gathered by the loggers.

A user manual is provided for the installation of the data loggers in the property. These sensors gather environmental data every 30 minutes (ambient air-atmospheric relative humidity (RH) and temperature (T), plus surface T) in the identified problem room and area of the property, during a minimum period of two weeks. Raw data collected by the sensors is then processed by establishing links through other computed environmental parameters that relate to the root causal factors leading to surface condensation and mould growth.

The BMI system identifies the severity of the problem based on the objective quantification of atmospheric and surface moisture levels. It analyses the data (critical thresholds and weighted values) to establish the severity and likelihood of moisture imbalance leading to condensation and mould. Provided that the BMI protocol to install the data loggers in the monitored property has been accurately followed, the BMI method provides a quick, accurate and impartial assessment to identify and quantify the root cause of the problem.

Please, note that this report is not a building survey; it complements property inspections. This report is based solely on the data processed from the environmental sensors placed in the dwelling and on the understanding they have not been moved or manipulated.

2. ENVIRONMENTAL MONITORING AND ASSESSMENT PROCEDURE

Indoor water vapour from day-to-day activities can give rise to condensation on wall or ceiling areas in buildings. A high level of moisture production is a trigger factor which may lead to surface condensation and mould growth resulting in a moisture imbalance environment.

The environmental sensors (data loggers) gather data which can be used to assess moisture imbalance leading to condensation and mould in dwellings. A minimum set of three data loggers has been installed in the property. A surface T sensor has been located on the area showing the main damp/mould issue or potential problem spot. An ambient T-RH sensor has been installed in the same room while an external sensor has been placed outdoors (inside an open-air protective case) to register the weather conditions during the monitoring period.

Moisture imbalance may occur from high moisture levels and the following causal factors:

- Poor Building Thermal Envelope Performance as a whole and/or related to the presence of thermal bridges (cold spots with low surface T, e.g. concrete lintels, etc.). This involves environmental parameters such as low T factors (poor thermal behaviour) and high water activity values (high surface RH).

- Inadequate Heat-Moisture Regime caused by insufficient or irregular heating, heat loss and/or infiltrations, such as cold air entry through gaps and around thermal bridges. This relates to low indoor air T and high indoor air RH levels.

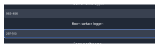
- Insufficient Ventilation related to high indoor vapour pressure excess (VPE), from internal and external vapour pressure differentials, and high surface RH.

Analysis of the data gathered by the sensors helps to identify which (if any) factors, or combination of factors, are the most likely cause/s of any condensation or mould issues. The extent of the Impact of each individual causal factor leading to moisture imbalance, condensation and mould has been expressed by a numerical moisture impact indicator (BMI score). The higher the impact the larger the score and the severity of the moisture problem:

-0- No Impact (NI);
-1- Very Low (VL);
-2- Low (L);
-3- Moderate (M);
-4- High (H);
-5- Very High (VH);
-6- Extremely High (EH)

The individual impact of each causal factor leading to moisture imbalance is shown in Section 4 Results of Environmental Assessment, in the BMI graphs and in Table 1. This Table also shows the combined impact of the various causal factors involved in the assessment (Total BMI). Table 2 and Table 3 show the average, maximum and minimum values obtained for each environmental parameter considered in the BMI assessment during the recording period.

Finally, advice on different rectification strategies (based on the results) is provided in Section 5 Recommendations. Definitions and benchmarks for each parameter and causal factor involved in the BMI assessment are explained in Section 6 Symbols and Definitions.



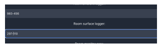
3. PROPERTY AND SURVEYOR: MOISTURE OBSERVATIONS

Building professional: eeee
Company Name: eee
Date of inspection: 2024-08-23 14:34:57.826067+00:00
Property Address: 16 Spencer Hill, SW19 4NY

Occupied or empty (void)?: Yes
During all the monitoring period?: 12 days, 23:59:59.999999
If occupied, how many occupants?: 3

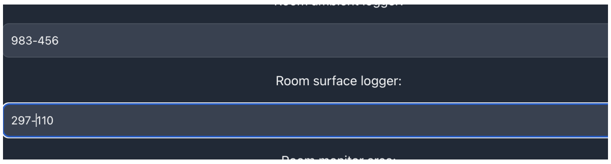
Monitored Problem room: test
Monitored Problem area: wall
Is there visible mould?: False

Comments and additional relevant observations:
dcdc



Building Moisture Index (BMI)
Environmental Diagnostic Report

Outdoor Image



4. RESULTS OF ENVIRONMENTAL MONITORING ASSESSMENT

4.1. TEST

Two weeks are considered to be the minimum period of monitoring needed in order formulate an accurate and reliable Building Moisture Index. A report will be created if data sets have been gathered for shorter periods of time, however the user should be aware that accuracy may be compromised when monitoring periods are less than 14 days.

Table 1.1 Building Moisture Index (BMI): imbalance scores

CAUSAL FACTORS	No Impact	Very Low	Low	Moderate	High	Very High	Extreme H	BMI
Envelope				M				3.0
Ventilation		VL						0.5
Heating			L					1.5
Total BMI Imbalance			L					1.7

The analysis of the environmental data gathered from the sensors during 12 days 23 hours (start from 2023-06-06 00:00:00 until 2023-06-18 23:30:00) period, every 30 mins, shows that the total Building Moisture Index (BMI) in test displays a Low score (1.7 out of 6.0 BMI-T) of a moisture imbalance environment.

Impact of causal factors leading to risk of surface condensation and mould growth (Table 1.1):

* Poor Envelope Performance: Moderate impact
* Inadequate Heat-Moisture Regime: Low impact
    Low Indoor Air Temperature: Very Low impact (i.e. warm air)
    High Indoor Air Relative Humidity: Low impact (i.e. dry air)
* Insufficient / Inefficient Ventilation: Very Low impact

Table 2.1 and Table 3.1 show average values of raw and calculated environmental parameters. The thermal envelope performance graph (Figure 1.1) shows that most data fall into an area where the temperature factor (T Factor) values (0.48 average), can be considered problematic. However this, together with most water activity (aw, surface RH) values obtained during the recorded period (0.59 average), do not present a high risk for condensation and mould growth.

The likelihood of surface condensation occurring is also related to surface temperature (Surface T) and dew point (Dew P) temperature differentials (Surface T- Dew P (°C)). During the monitoring period, average Surface T is 8.4°C above Dew P temperature to give rise to condensation (Figure 4.1 and Table 2.1). The lower this difference the higher the risk of surface condensation occurring, which happens when Surface T reaches and goes below Dew P temperature.

The ventilation, i.e. removal of the moisture produced in this dwelling, does not seem to be a problem, with most vapour pressure excess (VPE) and water activity (aw) data (Figure 2.1) showing Very Low score (0.05 kPa and 0.59 average, respectively), in a warm (23.5°C average) and dry (46.4% average RH) environment (Figure 3.1).

Provided by

BMI causal factors graphs

Figure 1.1 Thermal Envelope Performance

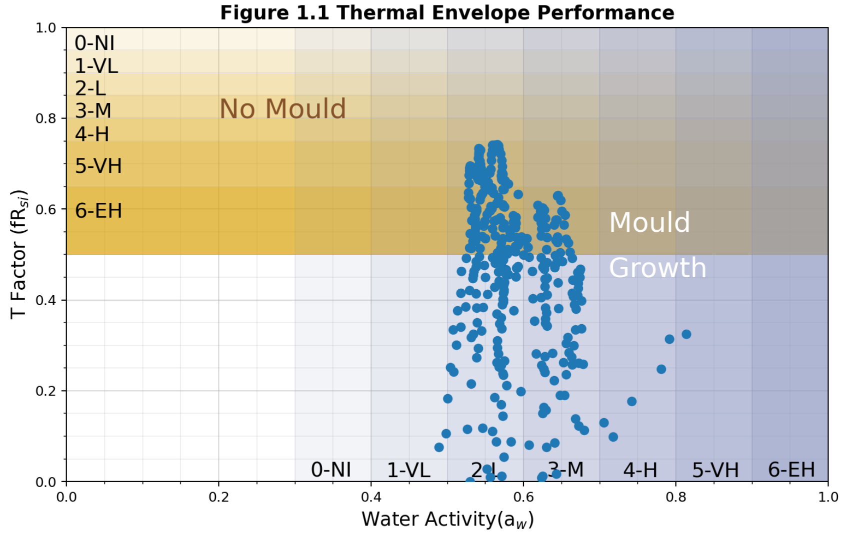


Figure 2.1 Ventilation

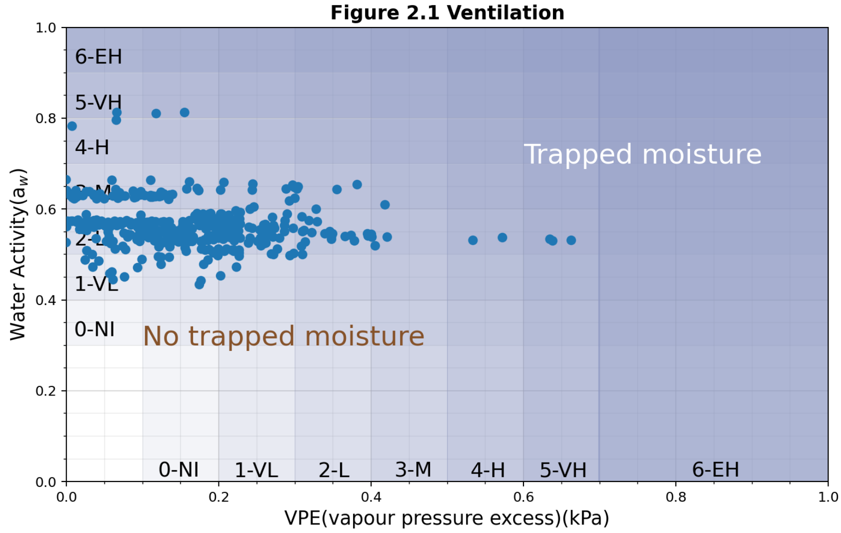
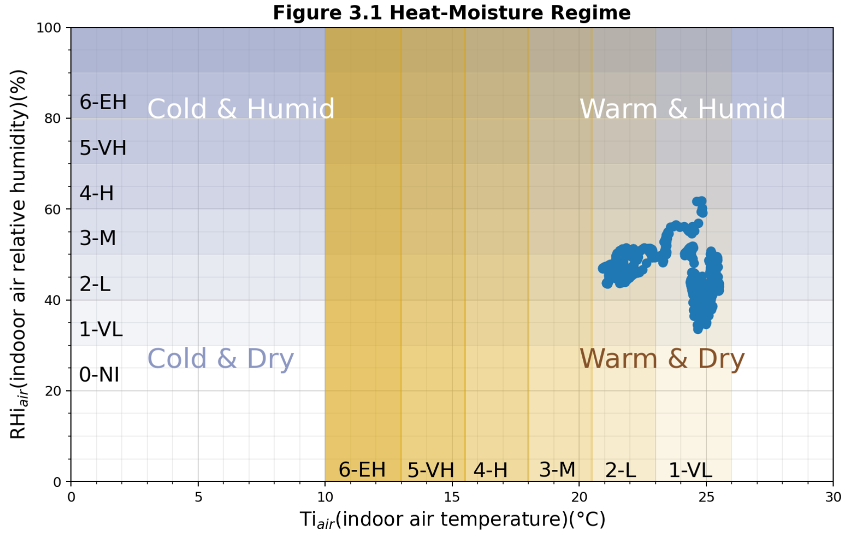


Figure 3.1 Heat-Moisture Regime



Raw and calculated parameters graphs

Figure 4.1 Temperature & Humidity

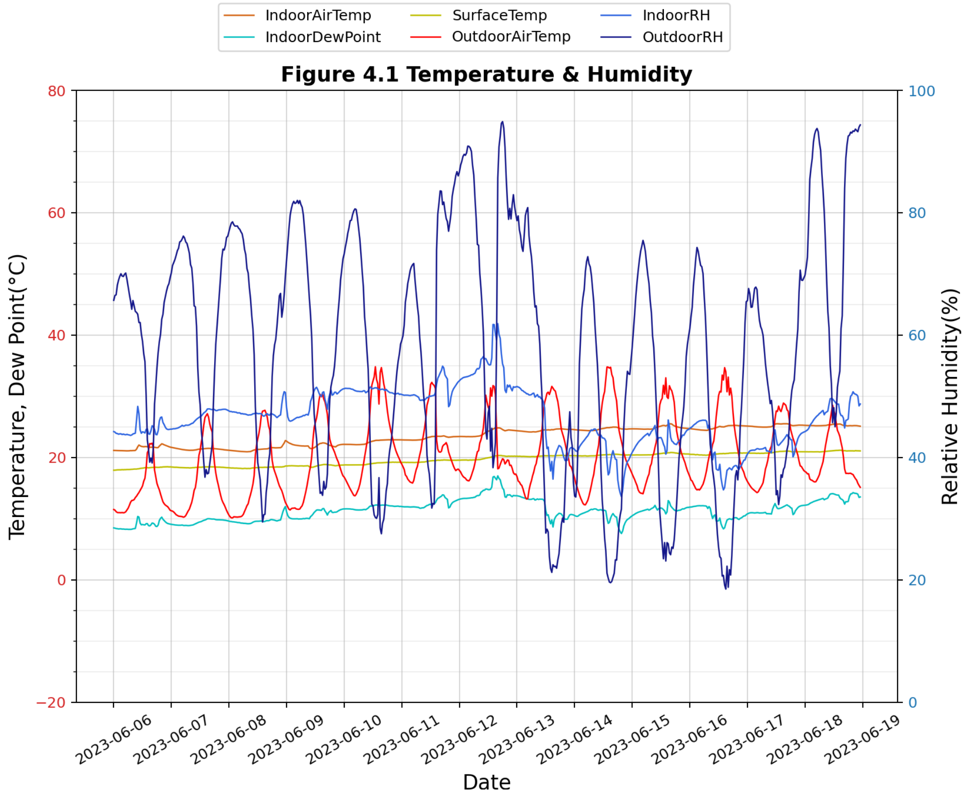


Table 2.1 Average environmental parameters gathered by the sensors. See Section 6 Symbols and definitions.

Conditions	Indoor Air T(°C)	Indoor RH(%)	Surface T(°C)	Outdoor Air T(°C)	Outdoor RH(%)	Dew P(°C)	Surface T-Dew(°C)
Average	23.5	46.4	19.6	20.0	58.4	11.2	8.4
Max	25.5	61.9	21.2	34.8	94.9	17.0	12.9
Min	20.9	33.6	17.9	10.1	18.5	7.6	3.3

Figure 5.1. Thermal and moisture related parameters

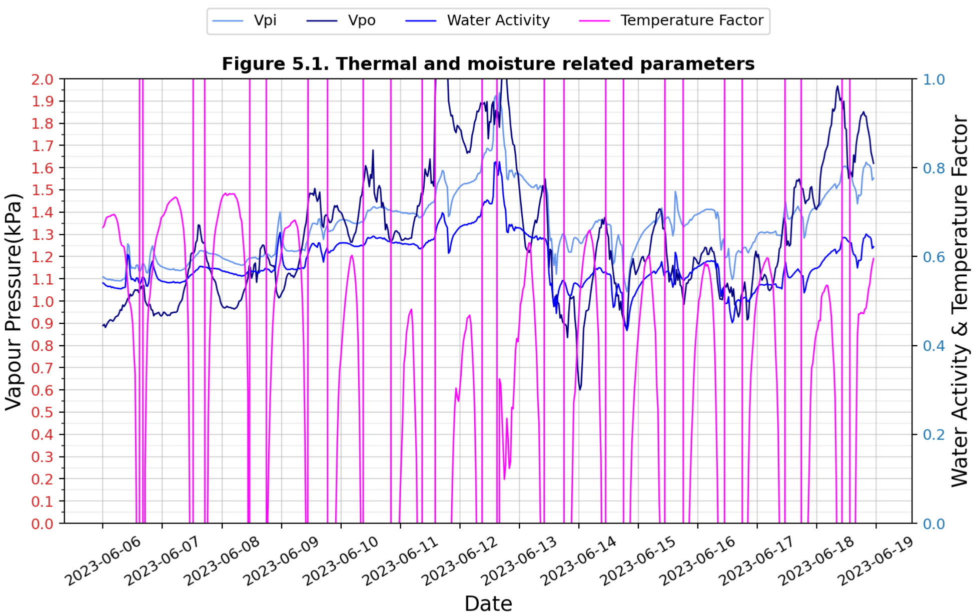


Table 3.1 Average calculated parameters from raw data

Conditions	Water Activity	T Factor	Vpi(kPa)	Vpo(kPa)	VPE(kPa)
Average	0.59	0.48	1.3	1.3	0.0
Max	0.81	0.74	1.9	2.2	0.7
Min	0.43	0.01	1.0	0.6	-0.6

Provided by

5. RECOMMENDATIONS AND LIMITATIONS

The results presented here have been obtained under the recorded external weather and indoor environmental conditions. The causal factors of moisture imbalance (poor envelope performance, inadequate heating, insufficient ventilation) are dynamic and interrelated. Any significant changes in the living conditions (e.g. increasing moisture production, reducing heating, not opening windows or using extraction fans, increasing occupancy, changing building usage, etc.) can upset the balance increasing the BMI score to higher levels. This could increase surface condensation or mould risk on thermal bridges.

The following recommendations are drawn from the environmental assessment undertaken after monitoring the building. Please refer to Section 4 Results, and Section 6 Symbols and Definitions and review all figures and comments on the data obtained.

The table below shows the moisture imbalance, risk of surface condensation and mould growth, causes and recommendations on remediation actions for each monitored room.

Monitored room	Moisture Imbalance	Mould Risk	Cause and Recommendation
TEST	No imbalance	low	Not applicable. Nevertheless, at some point the risk could increase because: C1

Possible causes and recommendations for rectification measures	
C1	The temperature factor results indicate that the building envelope performance in the measured area is poor. An investigation of the thermal performance of the walls in this area and surroundings is strongly recommended.

To maintain a moisture balanced environment, it is essential to ensure that the performance of the thermal envelope, the provision of ventilation and the heating regimes within the dwelling are always adequate.

It must be fully appreciated that the areas examined may not fully reflect other areas in the property that were not measured. To confirm the 'whole-house' performance of the thermal envelope, ventilation and heating systems, further inspections would be required.

Please note, this environmental assessment should be used together with a building condition survey. The diagnostic analysis informs and quantifies if condensation is present and may lead to mould growth. Typically, these problems are commonest during winter months (heating season) when cooler outdoor temperatures lead to cold wall surfaces and natural ventilation is less frequent.

Useful tips to reduce condensation and mould risk may involve simple lifestyle changes like modification of the occupants' activities. Some examples for this could be cooking with pan lids on, opening windows and closing bathroom doors, for drying laundry, or during and after showers, until surfaces get dry, using warm heating sources, allowing space for the air to circulate in and around furniture, etc. Information, education, and long-term collaboration may also prove beneficial.

6. SYMBOLS AND DEFINITIONS

The following symbols correspond to the environmental parameters used in this report:

a_w	Water activity [-]	*fRsi*	T Factor (Temperature factor) [-]
BMI	Building Moisture Index [-]	*Indoor T*	Internal (room air) temperature [°C]
Dew P	Dew point temperature [°C]	*Outdoor T*	External air temperature [°C]
RH	Relative humidity [%]	*VPE*	Vapour pressure excess [kPa]
Indoor RH	Internal (room air) relative humidity [%]	*Vpi*	Indoor partial water vapour pressure [kPa]
Outdoor RH	External air relative humidity [%]	*Vpo*	Outdoor partial water vapour pressure [kPa]
T	Temperature [°C]	*Vpsat*	Saturation vapour pressure [kPa]
Surface T	Internal surface temperature [°C]		

6.1. Raw data gathered by the sensors (data loggers):

Air temperature (*T*): ambient measure of how hot or cold the air is (degrees Celsius)

Air relative humidity (*RH*): water vapour proportion in air relative to 100% saturation at the same *T*

Indoor T and **Indoor RH**	18-24 °C and 45-60 %: Comfort zone

Surface Temperature: surface measure of how hot or cold the surface is (degrees Celsius)

Dew point: temperature at which air vapour needs to be cooled to reach 100% RH (condensation)

Surface T – Dew P (differential)	Surface T **>** Dew P: No condensation (larger the difference, lower the risk) Surface T **≤** Dew P: Condensation occurs

6.2. Calculated parameters assessed by BMI:

Water activity (a_w): relative humidity (RH) at the surface in steady state conditions (surface humidity)

$a_w = V_{pi} / V_{psat}$ = RH (surface) / 100 %	**< 0.6**: Mould growth unlikely **> 0.7**: Risk of mould growth **0.8-0.9**: High risk of mould growth

Temperature factor (*fRsi*): total thermal envelope resistance regarding Indoor & Outdoor *T*

T Factor= (Surface T – Outdoor T) / (Indoor T – Outdoor T)	**1.0**: Well insulated structure (*e.g.* passive house) **< 0.75**: Risk of surface condensation **≤ 0.5**: High risk (*e.g.* severe thermal bridges)

Vapour Pressure Excess (*VPE*): differential vapour pressure (*Vp*) regarding Indoor & Outdoor *Vp*

VPE = Indoor Vp – Outdoor Vp (differential)	**> 0.6 kPa**: Wet air environment from accumulation of moisture production **0.5 kPa**: Moderate wet air environment **< 0.4 kPa**: No trapped air moisture