

CSA GRADE 5 THESIS

Environmental Testing

What are the requirements?

Andrew Lawlor, Sutton Services International Ltd.

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Introduction

This document is a thesis on the requirement to carry out Environmental testing on a construction project and the problems that are frequently encountered whilst attempting this.

This thesis will discuss the current ways that Environmental testing or monitoring can be carried out, the problems that are regularly faced both in agreeing the procedures that are required as well as the problems that can be encountered whilst actually carrying out the tests.

I will then attempt to address these issues and propose a way forward in order to produce a standard procedure for environmental testing on all projects.

The Current Situation

In order for a construction project to be awarded practical completion, it is usually a requirement of the contract that the Environmental Testing of the building is carried out. Environmental testing is a term commonly used but there are other examples of terminology which are frequently used to describe these tests such as Environmental monitoring, Seasonal testing, or Seasonal commissioning. The different terminologies can mislead people into what is actually occurring during this process and that is part of the issue at hand. Testing, Commissioning and Monitoring are all very different activities from each other and it easy to see why confusion can be encountered on nearly all projects regarding what is exactly required during this process. Commissioning of a system obviously relates to the balancing and setting up of flow rates on the system, as well as the BMS commissioning which will involve the fine tuning of control loops and configuration of system and room set points. Testing, in my opinion refers to the various requirements of different systems each been tried and proven, in particular the systems being tested running automatically and performing as per its initial design to demonstrate that all aspects of the system has been commissioned correctly. Therefore there is a distinct difference between testing and commissioning. Monitoring obviously explains itself.

There is no official standard for carrying out this process. Usually there is a British Standard, or a CIBSE or BSRIA guideline which clarifies and standardises a process when testing needs to take place on a specific system but for the overall building environment there is no such document. Again this leads to people having different expectations of what should be carried out during this process and when there are numerous agendas present on a construction project then it can become a big, divisive issue.

BREEAM have made it part of their requirements that in order to receive all credits available in the commissioning section of the review it is necessary to carry out “Seasonal Commissioning”. The tasks that are required to be carried out for this are extensive and are not clearly explained, with little detail given towards how the listed tests and tasks should be carried out. The requirements for seasonal commissioning are listed below:

Credit criteria
Two credits available as follows:
Credits
1 Where evidence provided demonstrates that an appropriate project team member has been appointed to monitor commissioning on behalf of the client to ensure commissioning will be carried out in line with current best practice.
2 Where, in addition to the above, evidence provided demonstrates that seasonal commissioning will be carried out during the first year of occupation, post construction (or post fit out).
Second credit
1. The first credit has been achieved. DETAILS NOT SHOWN
2. The above appointment(s) include the following seasonal commissioning responsibilities over a minimum 12 month period, once the building becomes occupied:
Complex Systems – Specialist commissioning manager
a. Testing of all building services under full load conditions, i.e. heating equipment in mid-winter, cooling/ventilation equipment in mid-summer, and under part load conditions (spring/autumn)
b. Where applicable, testing should also be carried out during periods of extreme (high or low) occupancy
c. Interviews with building occupants (where they are affected by the complex services) to identify problems or concerns regarding the effectiveness of the systems
d. Re-commissioning of systems (following any work needed to serve revised loads), and incorporating any revisions in operating procedures into the O&M manuals.
Where specialist building services systems such as fume cupboards, microbiological safety cabinets and a cold storage system are present then the assessor must ensure that these systems are included in the specialist commissioning agent’s responsibilities.

Simple Systems (naturally ventilated) – External Consultant/Facilities Manager
Review thermal comfort, ventilation, and lighting, at three, six and nine month intervals after initial occupation, either by measurement or occupant feedback.

As you can see, rather than clarify what is required from this process the only thing that the BREEAM publication does is lead to further questions which require answering. What are the “concerns regarding the effectiveness of the system”? If this means that occupants can have an input into their environment in order for it to be changed, and possibly re-commissioned, then why was this not carried out when the building was initially designed? What happens in an open plan office where there are numerous opinions on what the environment should be? This publication only to confuse the situation regarding what is required during this process rather than clarify it.

The other documents that should clarify the requirements for the environmental testing process on a construction project are the contract specification and the owner requirement documents (what specifications are usually based on). The problem is that these can be very vague and generic for testing overall and almost always are regarding the building environmental conditions. Designers use generic specifications rather than a project specific specification as this is usually a cheaper and easier service to provide. They should take more responsibility for the test that they request – they should stipulate what is required and how it should be proven.

Fore example, a typical owner’s requirement document could have the following conditions in:

External conditions:	
Summer:	
Air conditioning:	28°C dry bulb, 19°C wet bulb
Mechanical cooling:	28°C dry bulb, 19°C wet bulb
Evaporative applications:	28°C dry bulb, 21°C wet bulb
Winter:	-4°C dry bulb, 100% saturated
Internal conditions:	
Winter:	
Areas heated by under floor heating:	19°C (dry resultant) minimum
Areas heated by radiators:	20°C (dry resultant) minimum
Areas heated by convectors:	21°C (dry resultant) minimum
Summer:	
Generally:	26°C (dry resultant) maximum not to be exceeded for more than 2.5% of the working period June-September to be measured against the CIBSE/Met Office Test Reference Year set of weather data (CIBSE 2002 weather set)
Court, Tribunal & Hearing Rooms:	24°C (dry resultant) maximum
The Design Team are to use thermal modelling to demonstrate that the required ‘dry resultant’ temperature parameters can be achieved. However, controls and measurements on site are to use equivalent dry bulb temperatures.	
Room air velocity (in occupied zone): 0.17-0.4 m/s	

As you can see, they merely list the base design for the building external temperatures during which the given internal temperatures have to be achieved. It does not stipulate any test that needs to be carried out to prove the conditions apart from within the document they will reference that the conditions stipulated within BREEAM must be achieved in order to achieve as high a rating as possible, the details of which I have already stated are less than conclusive.

Similarly a typical project specification could include the following clauses within it relating to the building environmental conditions:

Y51.4010 SYSTEM PERFORMANCE TESTING:
Demonstrate the performance of installations including single, standby, multi-duty plants and systems, and of plants specified for future use.
Y51.4020A ENVIRONMENTAL TESTS, ARTIFICIAL LOADS:
Carry out environmental testing to prove the performance of the systems.
Apply artificial loads or provide test arrangements to simulate the full range of operating conditions and duties.
Y51.4020B ENVIRONMENTAL TESTS, AMBIENT AIR QUALITY
Carry out environmental testing to prove the performance of the systems.
Carry out ambient air quality tests in accordance with BS EN 13528-1 and BS EN 13528-2.
Y51.4020C ENVIRONMENTAL TESTS:
· Carry out environmental testing to prove the performance of the systems
· Apply artificial loads or provide test arrangements to simulate the full range of operating conditions and duties.
· Carry out ambient air quality tests in accordance with BS EN 13528-1 and BS EN 13528-2.
Y51.4030 RECORDERS:
Provide and maintain on free loan portable seven day space temperature and relative humidity recorders, as indicated, together with adequate charts.

These merely state that tests need to be carried out but they do not clarify what tests, or how or what methods need to be utilised in order to carry out the tests. It does state that artificial loads need to be applied to simulate full range of operating conditions and duties but this statement is so vague that the impact to both the Contractor and the Client could be massive. Does this mean that every room in the building has to be tested, as well every system, every coil, and every outlet being simulated with artificial loads as part of the test? That would be ridiculous and the owner of the building would not be able to use their building whilst this lengthy process was carried out. If this is required, why could these simulations have not been carried out earlier on test beds in the factories?

In my opinion, following the success completion of the Building Services commissioning, with all defects also being rectified, and following the Building Management System being fully functional as per the design intention then the purpose of the Environmental monitoring process is simply to do what it says – to monitor the internal environment within the newly finished building whilst it functions under normal operating conditions.

It is usually accepted that this process can only commence once all commissioning activities have been carried out, this often results in it being carried out post practical completion and is usually carried out in 2 phases to cover both extreme points in the annual weather - the hottest and coldest spells of the year. This of course leads to a series of endless arguments. How can you plan ahead to carry out the tests when you are dependant on the weather for those tests to prove successful? Yes, you can estimate that the hottest month of the year should be at the height of summer and the coldest month of the year will be in the middle of winter but how often does this prove to be exactly the case? Furthermore when you factor in that for the tests to prove that the design of the

system is correct, based on the owners requirement documents, and that the install and commissioning of the systems has been completed correctly then you will have to conduct the test whilst the ambient conditions reflect the stipulated baseline design figures. How often can we guarantee that we will reach 28 deg C for a whole week in the Summer and -5 deg C for a whole week in Winter, and not only that but on the exact weeks that tests are scheduled to be carried out? There is definitely a need to produce a way of confirming that the building environment can remain within its tolerances during the extreme external design conditions without waiting for the correct conditions to materialise because trying to predict the weather can be a lottery. It can lead to abortive visits to site and unnecessary costs to Project Contractors, who have to hire instrumentation and provide staff to carry out the activities, as well as unnecessary disruption to the occupiers of the building who may have to relocate staff and equipment in order to accommodate the tests.

Another issue is that as part of the tests the maximum design heat load within the rooms would have to be simulated. This is required in order to prove that with the external condition at the maximum design temperature, and with the internal room at its maximum occupancy, the HVAC plant could overcome these factors and achieve the correct environmental condition within the room. This can be done by either filling the room with the correct amount of people, computers and other electrical equipment which were taken into account during the design or by simulating the maximum design heat load by using temporary heaters. This would then rule that the room is out of action during the course of the test and would be a nuisance to the user of the building.

It is common practice that not only is the temperature within the rooms to be monitored as part of the Environmental testing process but also the Lux level, the humidity and the noise level within each room. Again this stems from the lack of guidance for the environmental testing period. In my opinion the Lux level within rooms should be tested by the electrical subcontractor as part of their commissioning process (They already are required to test Emergency Lighting Lux levels and these tests for normal lighting lux levels should also be required on every project as sometimes in my experience these test are neglected) – how else can they state the lighting system is functioning correctly? The humidity and noise are environment issues, and doing these test during the contract could prove tricky so I can understand why these could be included but I could also see a reasoning for the Lux level tests to be grouped within this process as well because they would affect the end users environment. The problem being that there is no standard or procedure for what is required from this period.

Also the problems I have touched upon above are only referring to trouble proving and setting up the correct tests for temperature; imagine the issues with lighting and sound tests! The windows would have to be blanked out in every room so the only light source is from the installed lighting system. No noise would be permitted within rooms so that the building fabric could be monitored for its capability of keeping noise out. The complications and implications of all of these would surely mean that the end user would not be able to utilise their own building until all tests were completed.

The way forward

The first thing that needs to be addressed is the lack of guidance for this process. It could be that it's something that the CSA themselves could address by publishing a technical paper advising Commissioning Managers on the standardised procedures, or it could be that either BSRIA, CIBSE or even BREEAM publish a guideline which clarifies every requirement of the testing and how it is to be conducted.

The most important issue though is that the procedures themselves are clarified. My thoughts are that the requirements of BREEAM are too arduous and need to be amended and simplified. Any input into design conditions from the building users should be taken into account during the design of the building itself, not once the building is up and running. This would prove too disruptive. What should be carried out at the occupied stage is that the control loops on the Building Management System are correctly tuned and optimised to give best performance, energy consumption within the building. This would involve the controls engineers being involved in the contract post practical completion for maybe a year but this cost would be more than recuperated by reducing energy costs.

If occupants are hot or cold within their designated rooms then the set point for that room could be marginally adjusted on the building management system but any thought about re-commissioning or having to change plant Flowrates or capacities should be avoided. What happens if this person leaves the company and is replaced by somebody who wants the opposite of their requests? Would the process have to stop or be amended again? If people are asked if they want to change something then they usually will!

I believe that some of these tests could be incorporated into factory tests at an early stage in the construction project. Heating and cooling coils could be more stringently tested on a factory test bed to demonstrate that they can overcome maximum and minimum design conditions and still deliver the desired end environmental conditions. This could be hard to implement, as project conditions would have to be simulated fully (such as correct ductwork size and configuration, same grille fitted, same space to discharge into etc). The designer should be responsible for stipulating what tests are required and therefore should state within their specification:

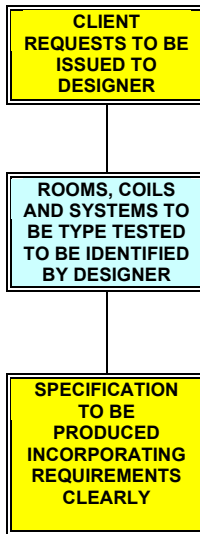
- What tests are to be carried out during off site factory tests,
- What is to be tested on site during environmental tests, and
- How exactly they are to be tested, methods to be used including what coils, rooms, systems are to be utilised during the test.
- What scenarios are to be simulated and how this will be achieved

For Example, if the coils are type tested in the factory then it could be that a further 5 are required to be tested within the AHU's once final commissioning has taken place and the building is handed over to show that they are achieving the conditions stipulated within the contract mechanical specification.

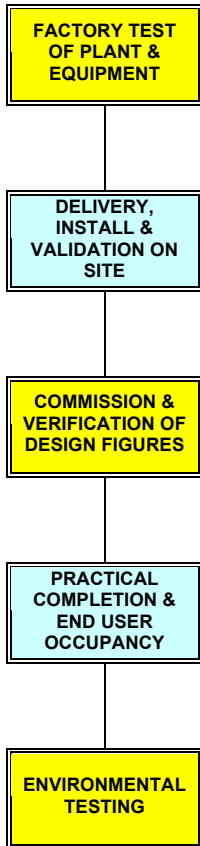
A method for simulating external conditions could be included within the specification and then this could be allowed for and built into the system during installation process. For example, utilising the BMS and manipulating the position of control valves will allow cooling / heating to be applied as required to simulate conditions. A benefit of this for example is that you could then simulate a high external temperature by controlling on coil temperature and then would not be tied to a specific date for carrying out summer environmental tests.

I think that the following flow charts show the processes that should be followed for both the issue of the requirements and methodology behind carrying out the environmental tests and also the processes that need to be followed on a construction project.

Design Production



Works to be conducted



As I have already stated, temperatures are only one of the internal conditions that may be required to be tested during an Environmental monitoring process. Humidity is another condition that is often measured but it is not always required. Noise levels and Lighting levels within rooms should definitely be recorded for compliance with design levels but when should this test be carried out and by whom? Different projects that I have worked on have treated these tests differently; sometimes the results are collated during the environmental monitoring by the commissioning Manager, sometimes they are collated by engineers during their commissioning processes. A standard procedure and guideline would assist with this – it would assist designers when producing their specifications as then they could easily stipulate the testing requirements and conditions.

This in turn would clearly identify the requirements during both the commissioning period and post practical completion period on site. The description could also state who would be responsible for each element of the works which would allow for correct tendering and quoting of works during the procurement stage of a contract, which should result in less debating over responsibilities and extra cost.

Conclusion

It is my conclusion that the production of an industry standard guideline for carrying out environmental tests would benefit all parties involved in this process. Firstly a standard terminology for this process would benefit all associated bodies and parties involved throughout the industry. Simply the purpose of this procedure is to either monitor the building environment during naturally occurring extreme design conditions or to simulate these design conditions and watch how the internal environment and plant reacts. On this basis, the process should be labelled as Environmental testing period and this terminology should be standardised and adapted throughout the industry.

The inclusion within the guideline of what environmental conditions are required to be tested, the methodology behind each test, the equipment and rooms to be tested and also the person responsible for carrying out the test, would greatly assist and should prevent disputes from occurring regarding Environmental procedures during contracts.

I have attached a sample extract from a specification which I feel, if issued on each project, would clear up any ambiguity there is towards these tests.

<u>Sample Specification for Environmental Testing Period</u>
Conditions to be tested during this process are as follows:
<ul style="list-style-type: none"> • Temperature (Deg C)
<ul style="list-style-type: none"> • Humidity (%)
<ul style="list-style-type: none"> • Noise (Nr)
<ul style="list-style-type: none"> • Lighting (Lux)
Tests are to be carried out by Appointed Commissioning Manager.
Temperature and humidity tests
AHU 1 to be tested at factory for correct air off temperatures with extreme design air on to coil temperatures simulated.
Internal Temperatures and humidity are to be measured in the following rooms when the external design condition is simulated:
<ul style="list-style-type: none"> • Room1 – Design temperature of 21 C
<ul style="list-style-type: none"> • Room2 – Design temperature of 22 C

<ul style="list-style-type: none"> Room3 – Design temperature of 21 C
<ul style="list-style-type: none"> Etc....
<p>The extreme design external temperatures are to be simulated by utilising heat exchangers and connections to both heating and cooling systems. Provision is to be made on system AHU 1 inlet ductwork which serves Rooms 1, 2, 3, etc.. for connection of temporary heat exchanger as and when needed for these tests.</p>
<p>Internal temperature and humidity readings are to be recorded in the above stated rooms whilst the external design conditions are simulated. Extreme design conditions are -4 deg C and 28 deg C.</p>
<p>Noise</p>
<p>Noise Levels are to be recorded in each room within the building during an unoccupied period following successful installation and commission of all system and with the building handed over. This is to ensure that readings are taken with the building in its final state and with all systems operating correctly.</p>
<p>This activity is to be carried out by Commissioning Manager and can be carried out any time following Practical Completion.</p>
<p>Lighting</p>
<p>Lux Levels are to be recorded in each room within the building during a night time period following successful installation and commission of the system. This is so natural light does not influence readings obtained.</p>
<p>This activity is to be carried out by Commissioning Manager and can be carried out any time following completion of above tests.</p>
<p>All of these tests are to be witnessed by Client or any of their relevant representatives.</p>