❄ *Cognition Energy*

CellPod One: An example of flexibility

1. Introduction

The CellPod One is a game changer when it comes to flexibility in the lab. Unlike thermal chambers, which can only hold one temperature at a time, each CellPod Quad will contain four CellPods, each of which have independent temperature controls. This can save vast quantities of time when completing cell characterisation tests, and prevents unnecessary calendar ageing of cells whilst carrying out cycle life tests.

Below is a worked example of how the CellPod One can save time. This is based on test plans Cognition Energy has experienced as part of our testing service.

2. Test plan

Nine 21700 cylindrical cells, with a 4.5A capacity, are to be tested on three different variations of a cycle life test:

Plan number	Charge	Discharge	Rest between half-cycles
1	1C CCCV	2C CC	30 minutes
2	0.5C CCCV	0.5C CC	30 minutes
3	0.2C CCCV	0.5C CC	30 minutes

The test temperature is 40°C, but all plans require a reference parameter test (RPT) to be run every 50 test cycles. This is run at a temperature of 25°C and takes one day.

3. Testing schedule

Based on experience, we estimate the test durations for each block of 50 cycles to be:

Plan number	One cycle	50 cycle block
1	~3 hours (assuming 30 minutes for the CV step)	~150 hours
2	~5 hours (assuming 20 minutes for the CV step)	~267 hours
3	~8 hours minutes (assuming 10 minutes for the CV step)	~408 hours

4.   Testing via thermal chambers

There are two options for running this test within a thermal chamber. These options are described below:

4.1.   Test Option 1: Use one thermal chamber for all test plans

The most economical option for running this test plan with thermal chambers would be to use a single thermal chamber. Nine cylindrical 21700 cells will easily fit within one chamber, which is the most cost and space effective manner for testing in a thermal chamber.

However, with this option the chamber temperature cannot be changed for the RPT until all cells have completed their respective blocks of 50 cycles. Because of this, quicker tests will have to wait for the slower tests. Taking into account of the estimates above, plans one and two will have the following wait times between the ends of their test cycles and the RPT:
- Plan two will have to wait 141 hours
- Plan one will have to wait 258 hours

Note that the waiting period is carried out at the test temperature, and that it forms a significant part of these cells' overall test durations.

The extent of the wait times experienced by the shorter tests means that calendar ageing may be a significant factor in plans one and two. In the more extreme case, cells on plan one spend about six days undergoing the cycling test and then spend almost 11 days waiting at an elevated temperature. During these 11 days, the cells will be undergoing calendar ageing, which will no doubt influence the results of the cycling tests.

The differences in test duration between tests in the same chamber also sets up a conflict in optimising channel and chamber utilisation. During the wait period of the faster tests, the test channels themselves are not in use. Furthermore, if chambers are set up with a fixed number of test channels inside, there will be a number of unused test channels in each chamber. The fewer cells in a given chamber, the more test channels are blocked from use. In this way, differences in the durations of tests in a single chamber might have a significant impact on the overall efficiency of the test facility.

4.2.   Test Option 2: Use a thermal chamber per test plan

To prevent any questions of calendar ageing, and to be most efficient with the length of each test plan, each test plan could be placed within its own thermal chamber. This would require three thermal chambers, which is a large space requirement (approx. $25m^2$, based on three Binder MK115). Further to this, the utilisation of the chambers would be extremely low (three out of 24 spaces used in this example), as would the channel utilisation, if each chamber has a fixed number of cycler channels wired in.

This testing method causes concerns in the efficiency and space requirements of the facility.

5.   Testing via CellPod One

Alternatively the testing could be carried out on three CellPod One systems, the system is a table top design and with its peripherals can easily fit on a small rack, saving facility space in comparison to a thermal chamber.

The CellPod Quad contains four CellPods, each of which are independent of each other. This means that no cell has to wait for another to finish, thus no effective calendar ageing of the cells. Further to this, due to no cells waiting at rest, those CellPods which contain the faster test plans can either run additional cycles within the planned total duration of the test programme, or they could be used to run other tests on new cells without affecting the progress of the original set of tests.

6.   Gantt chart

Figure 1 shows the estimated schedule for the first 38 days of the three test plans. It can be seen that:
- Testing via thermal chamber: All cells have undergone 100 test cycles
  - Plan 1 cells have spent 12 days under test and 22 days waiting at the test temperature. These test channels are at ~35% utilisation.
  - Plan 2 cells have spent 22 days under test and 12 days waiting at the test temperature. These test channels are at ~65% utilisation.
  - Plan 3 cells have spent 38 days under test and are at ~100% utilisation.
- Testing via CellPod One:
  - Plan 1 cells have undergone >250 test cycles.
  - Plan 2 cells have undergone 150 test cycles.
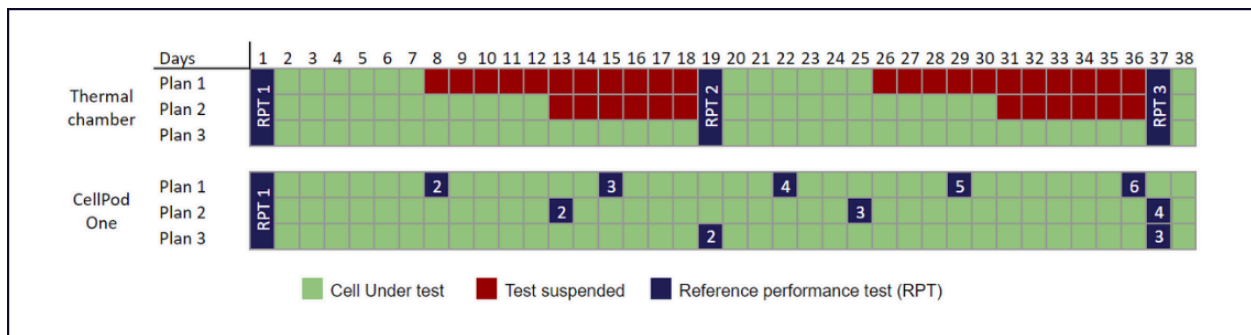 - Plan 3 cells have undergone 100 test cycles.

Figure 1: *Gantt of the estimated schedules for the test plans*

7.   Conclusion

When testing with thermal chambers, as in this example, there are a number of factors to consider:
- Utilisation of testing space: If each thermal chamber is not full then the efficiency of the facility is compromised.
- Calendar ageing: if multiple test plans are being run within a thermal chamber, those with faster test durations will encounter unnecessary rest at elevated temperatures, the impact of which may need to be deconvoluted from the main dataset.
- Thermal chambers are large pieces of equipment and take up significant space in a facility.

Conversely, the use of the CellPod One system in the example shows how each test is run at 100% utilisation and no concerns with calendar ageing is present. The system is compact and can be placed in the space of a single thermal chamber.