SU780XLE TEMPERATURE TESTING

STIRLING'S COOLING POWER

Tissue cultures, samples, enzymes, hormones, DNA and other biospecimen building blocks for vaccine and advanced therapy development require ultra-low temperature (ULT) storage for preservation.

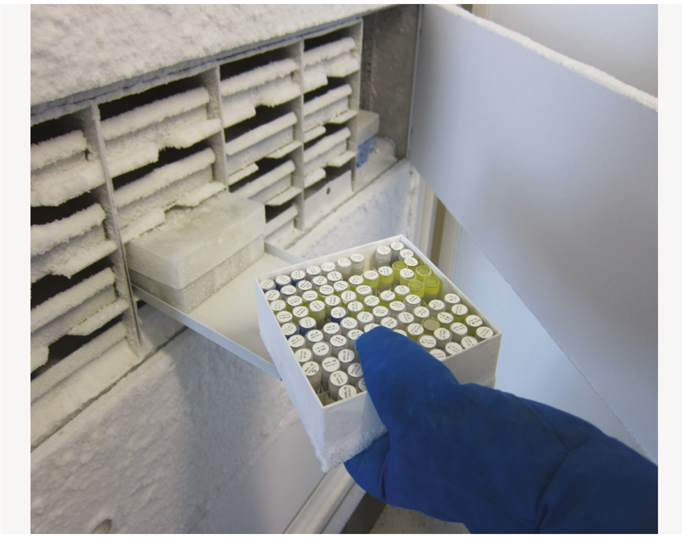
They are thermally fragile and composed of precious organisms and complex, non-living molecules used to treat or manage a vast array of diseases, immunodeficiencies and comorbidities, often making them mission-critical assets. Unfortunately, if these biologics are not stored in a reliable ULT freezer device when necessary, their protection and efficacy cannot be guaranteed.

Freezer flexibility and versatility are not always discussed in the drug research and development conversation, but remain important to maximize assets and streamline storage processes.

The tricky part to the biologic materials and treatments mentioned previously above is that no two are alike. Therefore, many of them require different storage conditions, depending on the research ambient environment and the level of cold required to slow or completely pause biological processing.

Designing a ULT freezer to span the ultracold storage range (-20°C to -80°C), while limiting heat output during operation is not an easy feat with a compressor-based engine system. Stirling Ultracold freezers employ an inherently efficient free-piston Stirling engine to achieve these standards, also having the ability to operate on different international power inputs while electronically modulating power controls to protect against brownout or freezer failure.

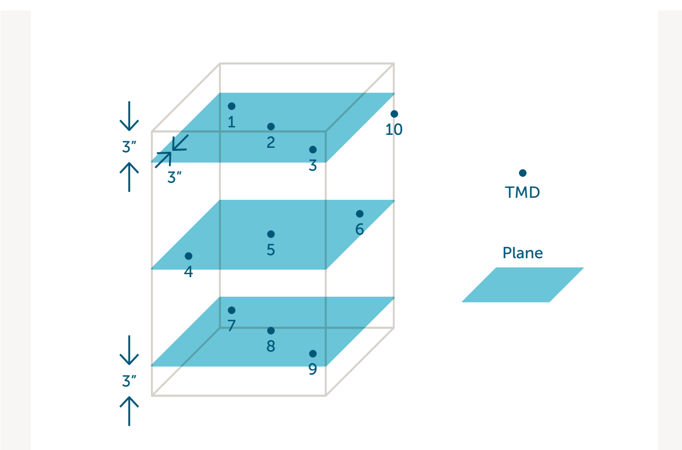
This white paper summarizes reliability and uniformity testing conducted on the Stirling Ultracold SU780XLE upright ULT freezer at a variety of temperature setpoints. When selecting a ULT freezer for today's range of biogenic materials, Stirling models should be considered for their operational flexibility and versatility to cover changing ultracold storage needs.



METHODS

Throughout this test, the SU780XLE freezer remained empty with two shelves installed. This is considered a worst-case scenario because all frozen materials stored within a freezer add additional thermal mass to the system. Ten naked thermocouples will be used for this test. Nine are placed throughout the freezer cabinet to measure cabinet temperature uniformity and one is placed as a control device within the freezer's RTD (Resistance Temperature Detector). Ambient temperature will also be monitored and recorded throughout the test duration to ensure it remains controlled around 21°C, or room temperature. FIGURE 1 demonstrates the thermocouple locations discussed.

FIGURE 1. THERMOCOUPLE LOCATIONS IN SU780XLE



All probe design and setup requirements are pulled directly from ENERGY STAR® Program Requirements for Laboratory Grade Refrigerators and Freezers, Version 1.1, Section 5 Test Setup. This test will be run for five different setpoint temperatures: -20°C, -40°C, -50°C, -70°C and -80°C. The freezer is programmed to the desired setpoint then allowed to adjust to that temperature and achieve a steady state condition for 8 hours.

The door opening procedure is executed against Section 6.2C, Version 1.1 of the ENERGY STAR Program Requirements for Laboratory Grade Refrigerators and Freezers.

SECTION 6.2C

1) Open outer door.

2) Open 1 inner door for 15 seconds.

3) Close inner door, then close outer door.

4) Repeat 6 times, 1 time every hour.

After the last door opening, the freezer achieved steady state and maintained that temperature for at least four hours before changing the temperature setpoint and moving on to the next phase of testing.

TEST RESULTS

Overall test results are detailed in FIGURE 2 below and summarized in TABLE 1. Individual temperature test profiles are shown in FIGURES 3 – 7.

FIGURE 2. SU780XLE TEMPERATURE MAPPING -20°C, -40°C, -70°C & -80°C

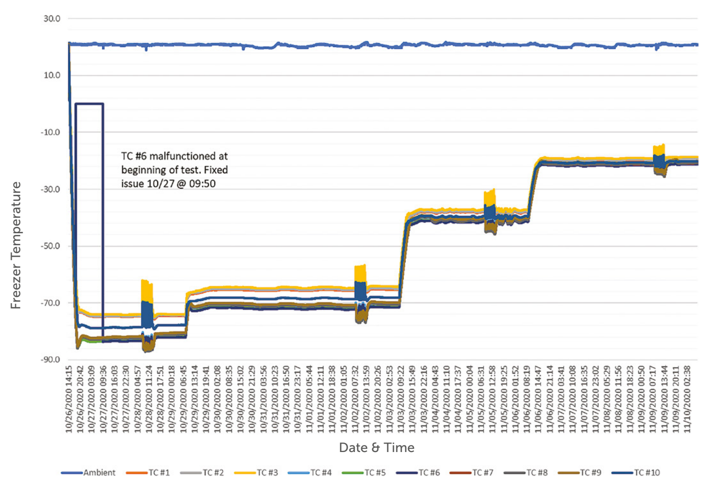
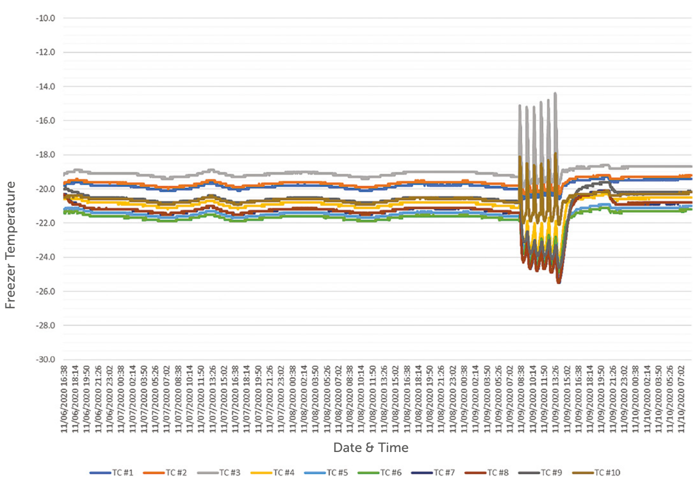


TABLE 1. TEST SUMMARY

SET POINT (°C)	-20	-40	-50	-70	-80
Min Steady State Temp. (°C)	-19	-37	-48	-65	-74
Max Steady State Temp. (°C)	-22	-42	-51	-72	-83
Steady State Temp. Delta (°C)	3	5	3	7	9
Temp. after Door Opening (°C)	-15	-31	-38	-57	-63
Delta to Set Point (°C)	5	9	11	13	17
Door Recovery (min.)*	14	18	21	26	35

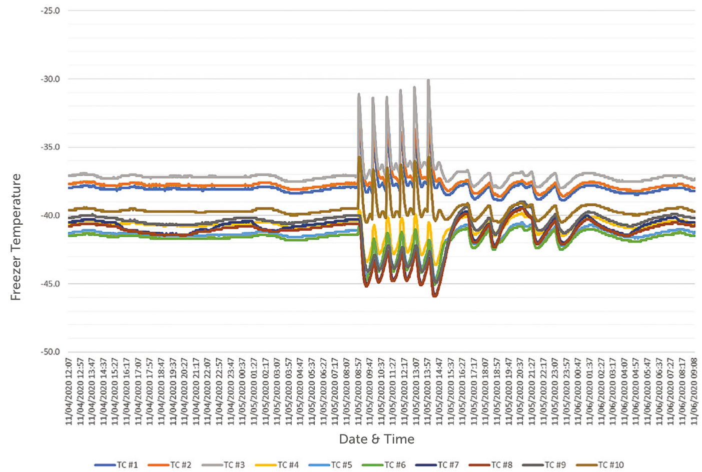
*Following the test protocol specified by ENERGY STAR®, door recovery time was measured back to temperature setpoint; not just within acceptable setpoint range.

FIGURE 3. -20°C STEADY STATE AND 6 DOOR OPENINGS



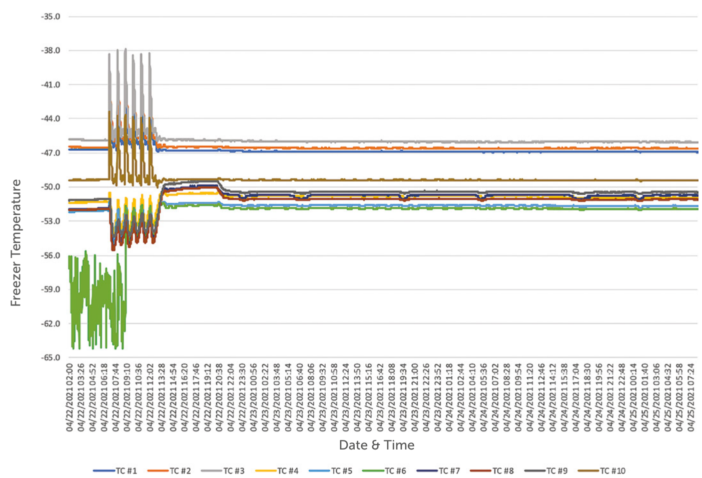
Once the freezer achieved steady state operation, the freezer maintained temperature between -22°C and -19°C. During door openings, the thermocouples in the upper chamber warmed to -15°C before returning to -20°C.

FIGURE 4. -40°C STEADY STATE AND 6 DOOR OPENINGS



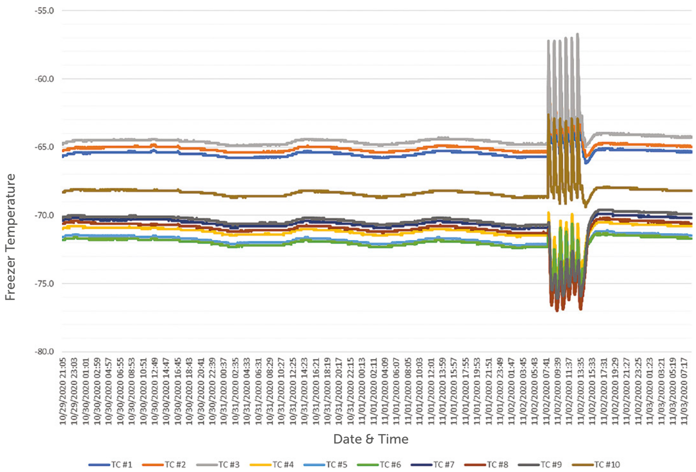
Once the freezer achieved steady state operation, the freezer maintained temperature between -42°C and -37°C. During door openings, the thermocouples in the upper chamber warmed to -31°C before returning to -40°C.

FIGURE 5. -50°C STEADY STATE AND 6 DOOR OPENINGS



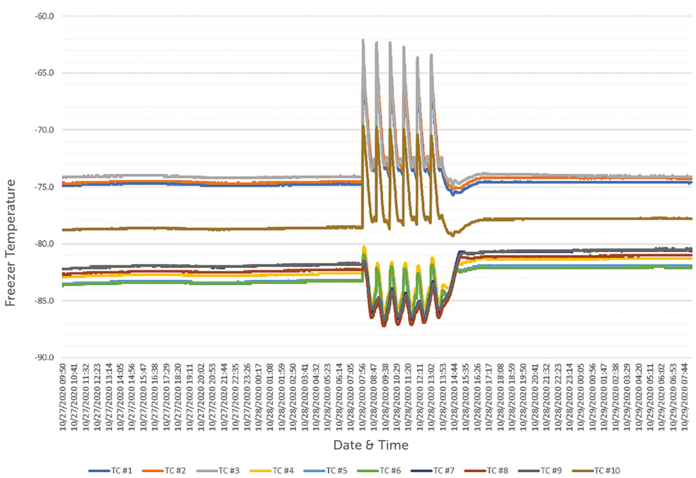
Initial pull down of the SU780XLE to -50°C took 3.5 hours. The freezer's control RTD was not adjusted after optimization -80°C, meaning it did not use the temperature offset feature inside the user interface Service Menu to remain consistent with other temperature testing on the same unit. This caused the freezer's average temperature to be slightly less than -50°C and the uniformity to be +/-3°C at 49°C. FIGURE 5 highlights the door openings and recovery. Recovery occurred in 21 minutes on each of the door openings when measuring the control probe (T10). During the door opening, the upper chamber briefly recorded -38°C before quickly recovering back to -50°C.

FIGURE 6. -70°C STEADY STATE AND 6 DOOR OPENINGS



Once the freezer achieved steady state operation, the freezer maintained temperature between -72°C and -65°C. During door openings, the thermocouples in the upper chamber warmed to -57°C, before returning to -70°C.

FIGURE 7. -80°C STEADY STATE AND 6 DOOR OPENINGS



Once the freezer achieved steady state operation, the freezer maintained temperature between -83°C and -74°C. During door openings, the thermocouples in the upper chamber warmed to -63°C, before returning to -80°C.

CONCLUSION

As observed in the test results, Stirling Ultracold freezers show improved uniformity and door recovery times at warmer setpoints. Commercially available, compressor-based freezers do not have this setpoint flexibility without hindering performance. After door opening events, at the warmer temperature setpoints, the upper cabinet warms by 3 degrees, or less, and the cabinet recovers from a door opening event within 20 minutes, or less. At steady state, a +/-1°C temperature tolerance is maintained, regardless of temperature setpoint or location within the cabinet.

The Stirling engine modulates cooling power much like cruise control in a car – it simply adjusts amplitude when over or under desired temperature. Compressor-based engines use an “on-off” mechanism to regulate temperature control which in turn can be very hard on motor windings and requires spikes of power to restart.

As mentioned, the ability to modulate the Stirling engine’s cooling power allows Stirling Ultracold freezers to be the only commercial models capable of achieving these results. As the ULT landscape and drug requirements continue to evolve, Stirling models will be the most economic selection because they are flexible and can be trusted to meet the widest range of ultracold temperature setpoints without sacrificing key performance parameters such as temperature uniformity, recovery and energy consumption.

To learn more about Stirling Ultracold’s SU780XLE ultra-low temperature freezer, visit:

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