

## Simulated Freezer Failure (Thermo Scientific -86°C ULT, Model 8607)

G. Bullett, President BioRepository Resources, LLC

Based on available literature detailing the loss of frozen research material, researchers have not provided details about the rate of temperature loss in the affected ULT units. Often, these failures occur on weekends when staff are not present in the lab to hear the freezer alarms. In addition, monitoring systems required to safeguard this valuable material have either not been implemented or have not functioned properly to alert staff, remotely. The following information relates specifically to an unloaded ULT Thermo Scientific freezer unit, that was purposely shut off to simulate 'failure'. The unit was monitored electronically through the entire process (*Summary Graph is presented on the following page*). Typically, a unit full of frozen material (ie; plasma, blood, urine, etc.) may maintain temperature for a slightly extended time period but would still fall out of spec in a similar fashion to the data presented here. Note: An additional experiment utilizing a loaded freezer will be conducted in the near term and data will be compared to what is presented here.

A single unit was shut off on 10/19/18 at 14:43 with a temperature reading of -77.4°C. In just over 1 hour, the unit temperature was reading -68.1°C. By 16:42 (\*2 hours post shut down), the temperature reading was -61.3°C. The Grid below details the temperatures at the different timepoints in the first several hours of this event.

	TIME	TEMP °C
10/19/18	14:43	-77.4°C
	15:15	-72.1°C
	15:45	-68.1°C
	16:13	-64.7°C
	16:42*	-61.3°C
	17:14	-58.0°C
	17:43	-54.7°C
	18:13	-51.6°C
	18:42	-48.9°C
	19:19	-45.5°C



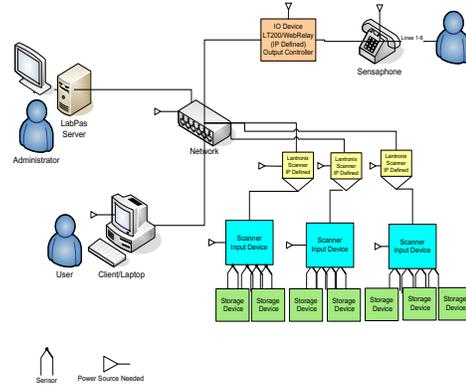
Within the first 4 hours of the freezer shut down, temperatures initially fell at a rate of approximately 9°C/hr but this rate seemed to decrease slightly with each consecutive hour.

	TIME	TEMP °C
	20:17	-40.3°C
	21:16	-35.9°C
	22:16	-31.3°C
	23:14	-27.2°C
10/20/18	00:13	-23.3°C
	01:14	-19.8°C
	02:13	-16.8°C
	03:13	-13.9°C
	04:18	-11.3°C
	05:20	-9.4°C



At a time when the temperatures were at approximately half of the original nominal starting point, temperatures decreased at an hourly rate of less than 4°C/hr. It would take another 10.5 hours before the freezer temperature would exceed 0.0°C. In all, it took about 25 hours for the Unit to go from -77°C to 0.0°C. It is anticipated that a loaded freezer may slow the progression of the rising temperature(s) within the unit but may not significantly extend the life of the stored samples. Exactly how different a 'loaded' freezer unit would perform as compared to the results from this 'unloaded' unit will be demonstrated in a future simulation.

	TIME	TEMP °C
10/20/18	6:18	-7.9°C
	7:18	-6.6°C
	8:22	-5.5°C
	9:23	-4.5°C
	10:21	-3.4°C
	11:20	-2.9°C
	12:18	-2.3°C
	13:19	-1.7°C
	14:17	-1.2°C
	15:17	-0.5°C
	15:46	0.0°C



Based on this information it's clear why an event on a weekend (mechanical failure) can prove to be disastrous. A -86°C ULT freezer unit only requires 1 day to go above freezing following mechanical failure, therefore, a Remote Data Monitoring system, with a UPS backup, is critical.

Just above is a schematic for a typical Environmental Monitoring system set-up and below is the Graph showing the progression of the rising temperature(s) as demonstrated with this simulation.

