Performance Assessment of TECNIC Single-Use Bioreactor Family

Introduction

Single-use bioreactors have become increasingly prevalent within the biopharmaceutical industry, particularly for mammalian cell cultivation, due to significant advantages such as reduced lead times, minimized risk of cross-contamination, and operational flexibility. Efficient oxygen transfer, represented by the volumetric mass transfer coefficient (kLa), and optimized power input per volume are crucial parameters for process performance and scalability. This report evaluates these key parameters across a range of bioreactor scales, comparing a single-use 0.5L system with larger stirred-tank reactors (STR30, STR50, STR300, and STR1000).

Ratio	eLAB 0.5L	ePilot 30 L	ePilot 50 L	eProd 300 L	eProd 1000 L
Vessel height / vessel diameter	2,5	2,9	3	2,3	3,1
Liquid height / vessel diameter	2,1	2,1	2,5	1,8	2,5
Impeller diameter / vessel diameter (CC)	0,5	0,4	0,5	0,5	0,5
Impeller diameter / vessel diameter (MC)	0,5	0,4	0,5	0,4	0,4

Table 1. Ratios of TECNIC's range of Single Use STR equipment.

Volumetric Mass Transfer Coefficient (kLa)

The volumetric mass transfer coefficient (kLa) was measured at varying tip speeds, using a constant aeration rate of 0.10 vvm (air) in PBS at 37 °C to assess oxygen transfer efficiency. Results demonstrated consistent scalability across bioreactor sizes:

At lower tip speeds (0.3 m/s), kLa values were comparable across all scales (0.3-0.6 h^{-1}).

At increased tip speeds (1.8 m/s), the STR300 exhibited the highest kLa (25.3 h^{-1}), while the STR50 and SU 0.5L reactors showed the lowest values (18.0-19.0 h^{-1}).

This indicates suitable oxygen transfer rates (>7 h^{-1}) were achieved across all bioreactor scales, enabling efficient cell cultivation.

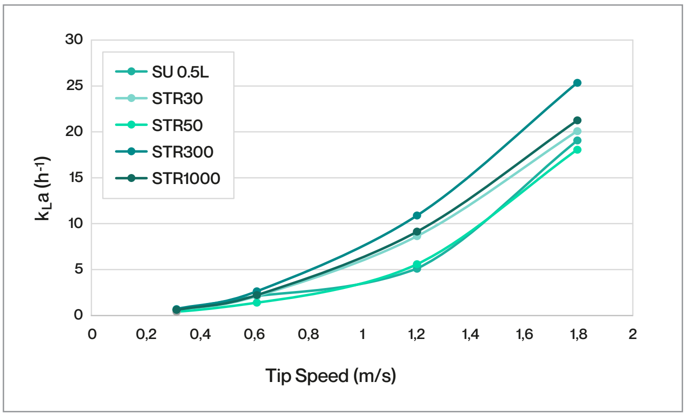


Figure 1. Volumetric mass transfer coefficient.

Power Input per Volume (P/V)

Power input per volume, vital for mixing and gas dispersion, was analyzed across varying tip speeds:

At lower agitation speeds (0.3 m/s), the SU 0.5L reactor required significantly higher power input (1514 W/m^3) compared to larger reactors (1-3 W/m^3).

At higher speeds (1.8 m/s), power input dramatically increased for the SU 0.5L system (326,925 W/m^3), whereas larger scales (STR1000, STR300, STR50, and STR30) showed lower and comparable power inputs (261-552 W/m^3).

This trend indicates a scalable power input strategy, ensuring sufficient agitation for effective cell culture at larger scales without excessive energy consumption.

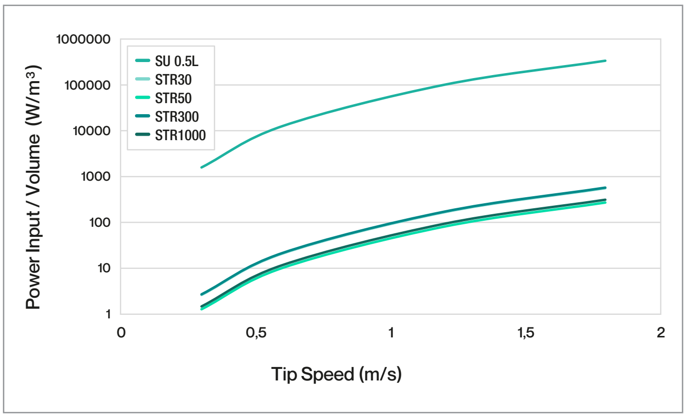


Figure 2. Power input per volume.

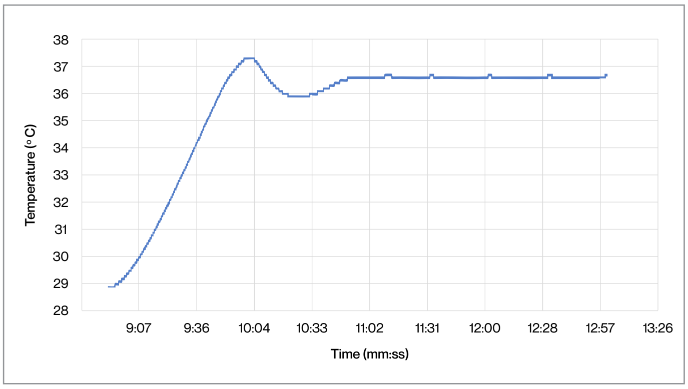
Conclusion

The results demonstrate the successful scalability of critical bioreactor parameters, including volumetric mass transfer and power input per volume, across different single-use stirred-tank bioreactor scales. The observed consistency in geometric ratios and process parameters confirms the suitability of these bioreactor systems for reliable scale-up and process development in mammalian cell cultures.

Performance Validation: FAT and Stress Testing (July 2024)

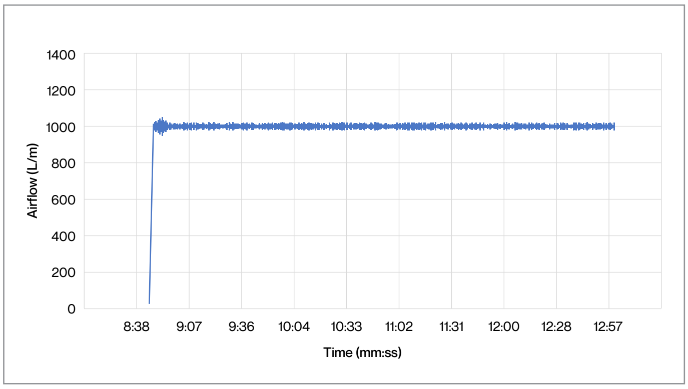
This section presents the experimental validation of TECNIC's single-use STR bioreactors, based on a series of Factory Acceptance Tests (FAT) and stress tests performed in July 2024. The tests evaluate the system's performance across different operational parameters, including temperature control, airflow regulation, and mechanical robustness, at various working volumes and under demanding process conditions.

Figure 1. Temperature Control (1000L)



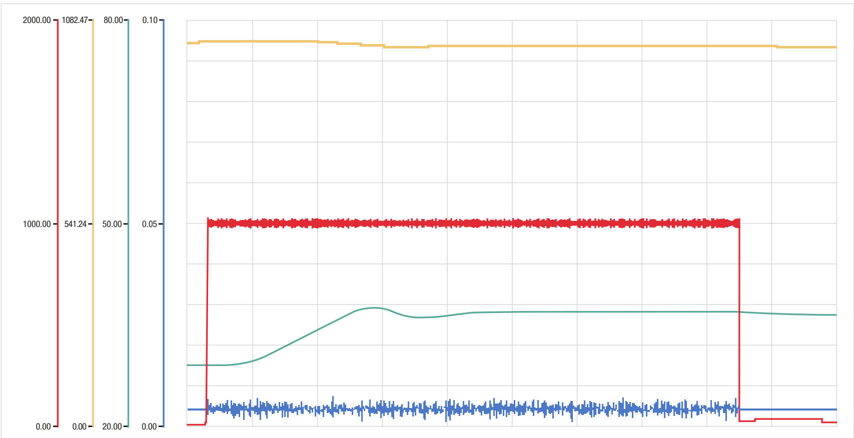
Test: Temperature set to 37°C from 29°C.
Result: Minor overshoot (to 37.5°C), stabilization at 36.7°C within ±1°C (better than industry standard ±2°C) for microbial and ±0.5°C for cellular.
Conclusion: Highly precise temperature management, essential for sensitive processes.

Figure 2. Airflow Profile (1000L)



Test: Airflow set to 1000 LPM.
Result: Stable at setpoint.
Conclusion: System quickly adapts to external disturbances, ensuring process reliability.

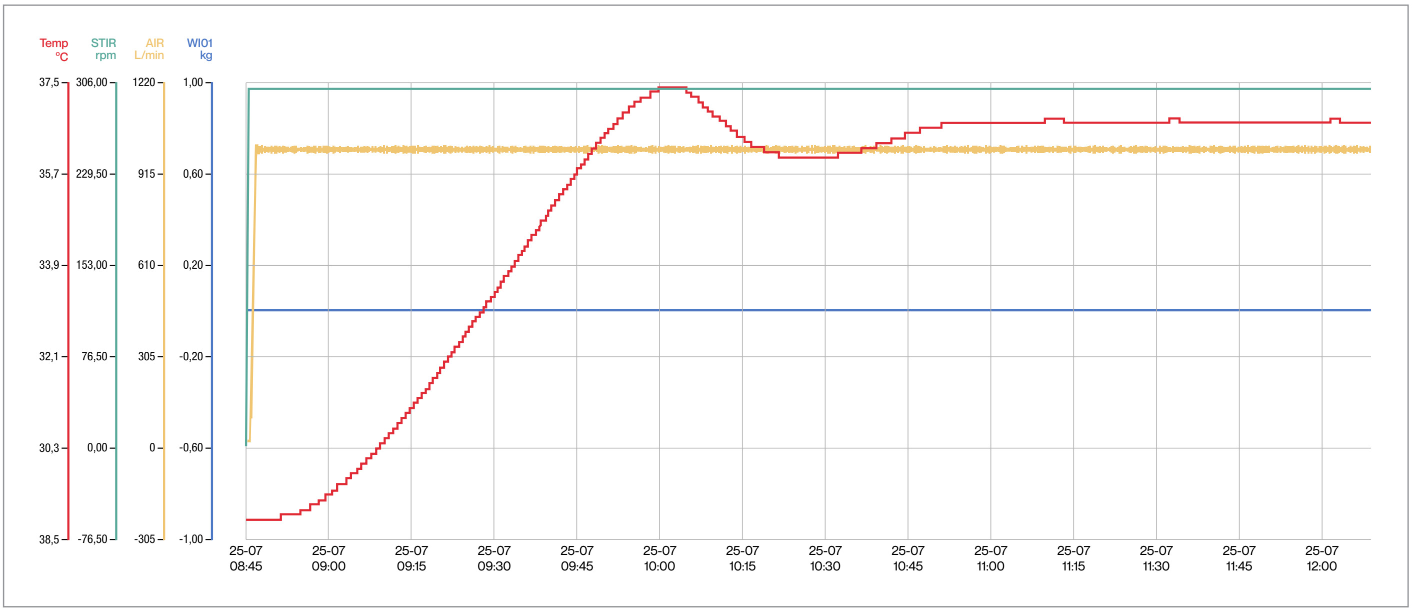
Figure 3. HMI Screenshot During the Test (STR 1000L)



	Label	Current	Cursor	Eng...	Min Value	Max Value	Average	Min Scale	Max Scale
	AIR	0.54	1007.74	l/min	0.00	1159.76	812.32	0.00	2000.00
	WI0001	985.20	1010.10	Kg	1005.90	1027.80	1012.77	0.00	1082.47
	TT0001	24-80	36.70	ºC	28.90	37.40	35.31	20.00	80.00
	PT0001	0.00	0.00	bar	0.00	0.00	0.00	0.00	0.10

Test: Real-time monitoring of temperature, agitation, and airflow via the HMI during FAT and stress tests.
Result: The HMI displayed stable and accurate process trends, allowing immediate detection of any deviations.
Conclusion: The HMI enables effective process supervision and rapid response, supporting reliable and precise bioreactor operation.

Figure 4. Process Report (1000L)

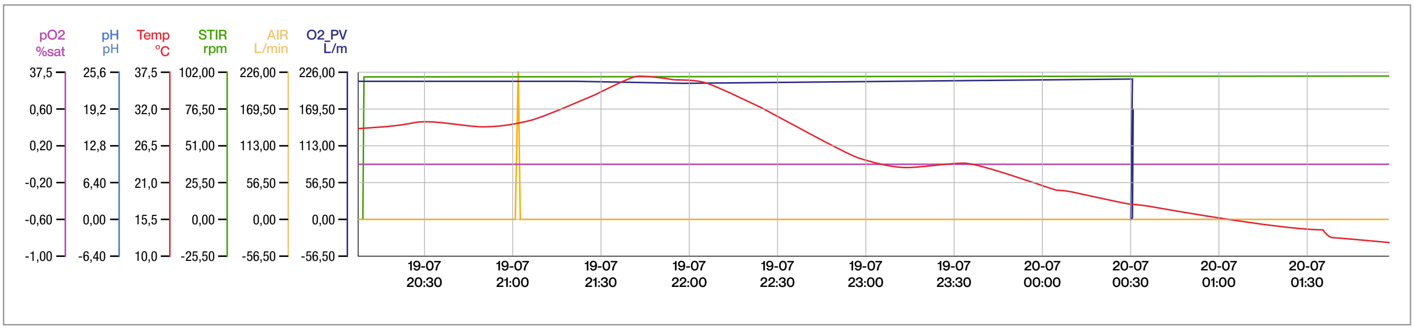


Test: The airflow was set to 1000 liters per minute, with initial fluctuations caused by external compressor limitations.

Result: Normal conditions observed.

Conclusion: TECNIC's ensures stable control of conditions.

Figure 5. Process Report (1000L)



Test: Temperature control during the FAT test: control loop from 28°C to 37°C setpoint, then cooled to 10°C.

Result: The equipment successfully managed both heating and cooling phases.

Conclusion: TECNIC demonstrates advanced thermal management, ensuring seamless transitions between heating and cooling phases.

Temperature Variation During FAT Testing

Test: FAT temperature control tests at STR 30L, STR 50L, STR 300L, and STR 1000L scales.
These figures illustrate the temperature variation during Factory Acceptance Tests (FAT) at dierent volumes.
Each test shows the bioreactor's ability to control temperature precisely:

- **Figure 6** (STR 30L FAT Test): The equipment maintained optimal temperature control throughout the heating and cooling cycles, even at smaller volumes.
- **Figure 7** (STR 50L FAT Test): The bioreactor continued to demonstrate stability in maintaining temperature control, confirming scalability across increasing volumes.
- **Figure 8** (STR 300L FAT Test): The equipment managed smooth temperature transitions, essential for medium-scale processes.
- **Figure 9** (STR 1000L FAT Test): The temperature control at the 1000L scale remained precise, showcasing the system's ability to scale eciently without sacrificing performance.

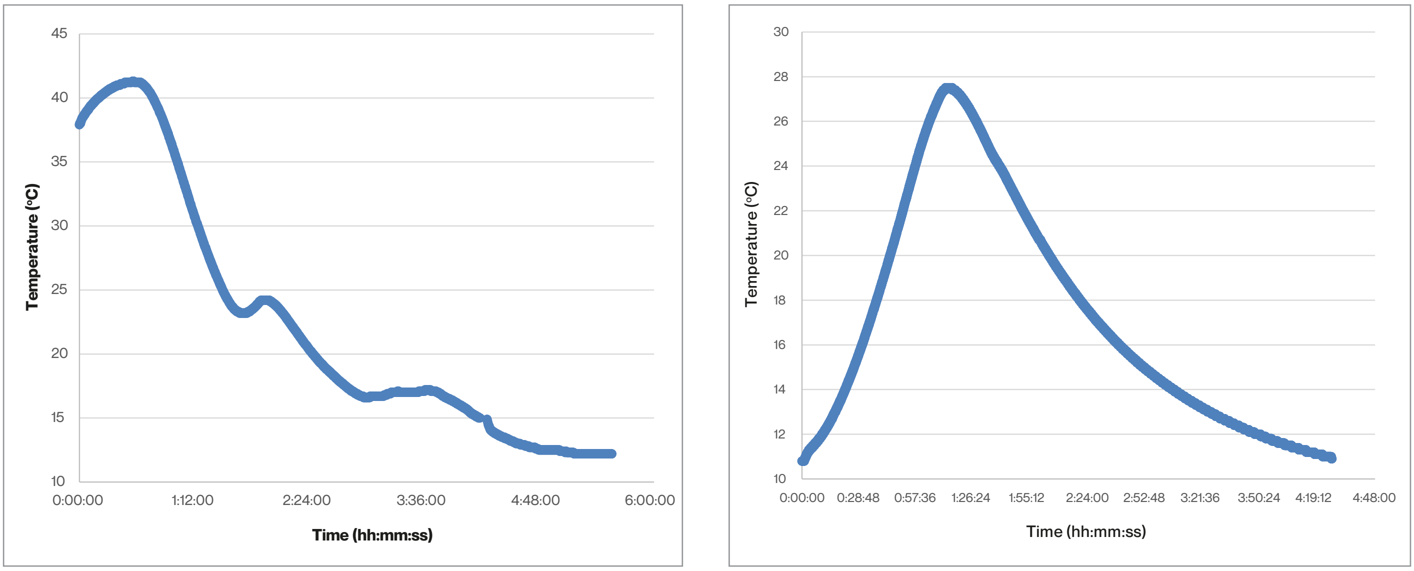


Figure 6. ePilot (30L) recordings of the temperature variation during FAT testing of the equipment.

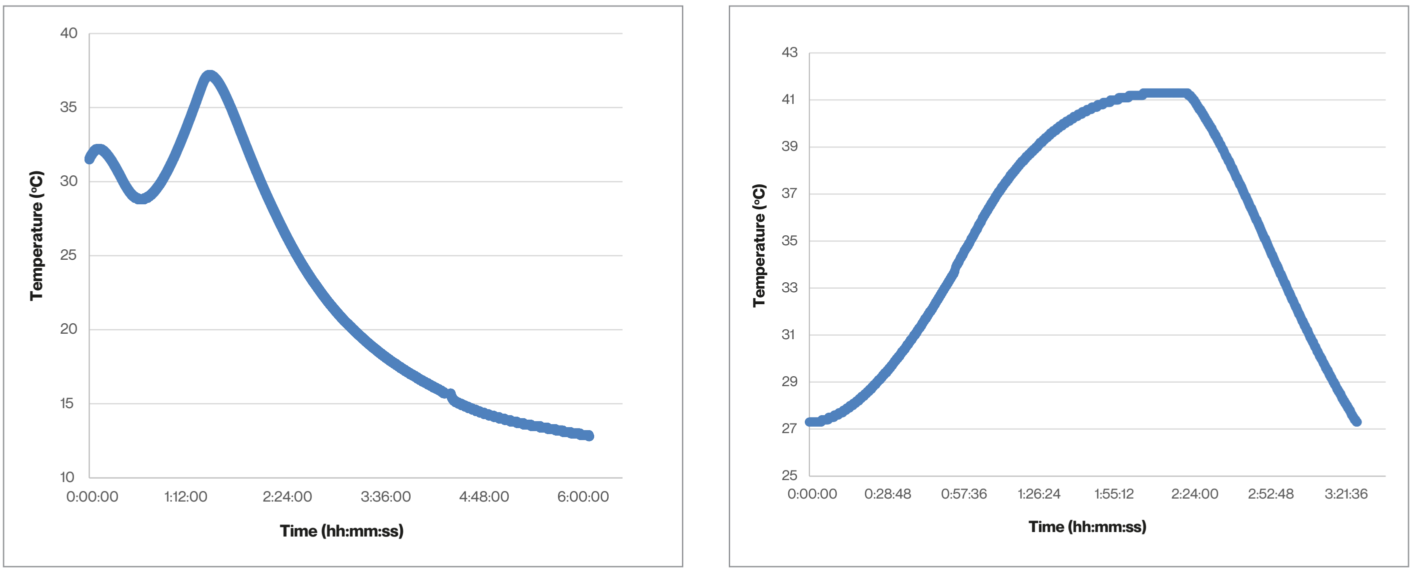
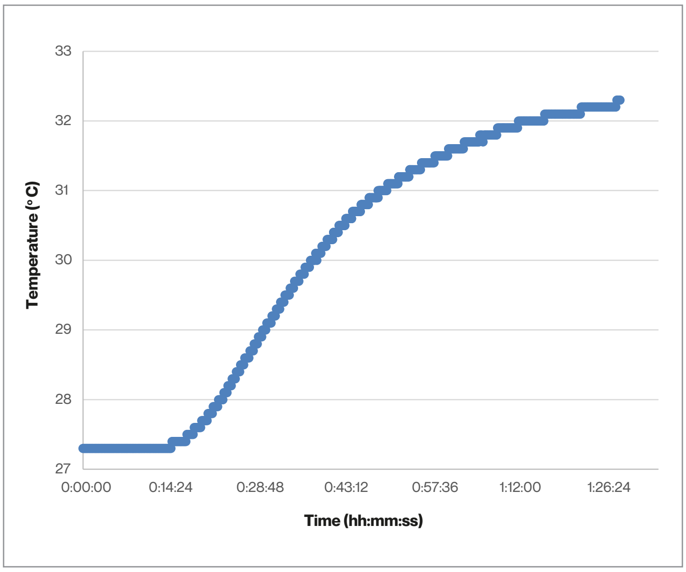


Figure 7. ePilot (50L) recordings of the temperature variation during FAT testing of the equipment.



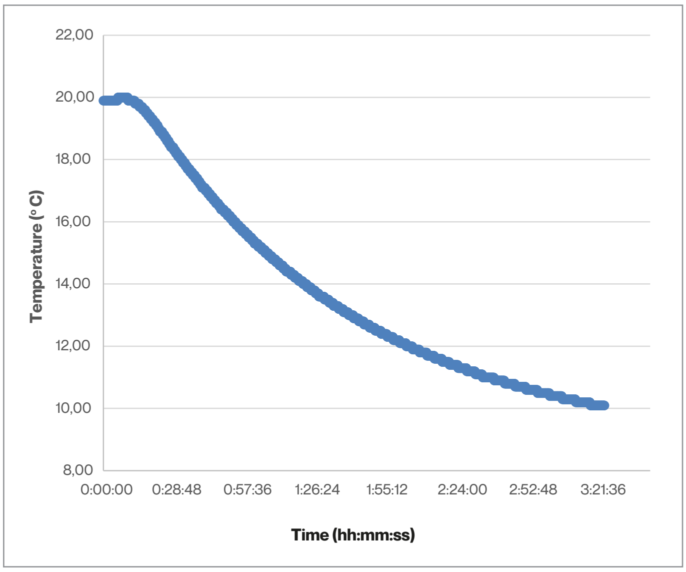


Figure 8. eProd (300L) recordings of the temperature variation during FAT testing of the equipment.

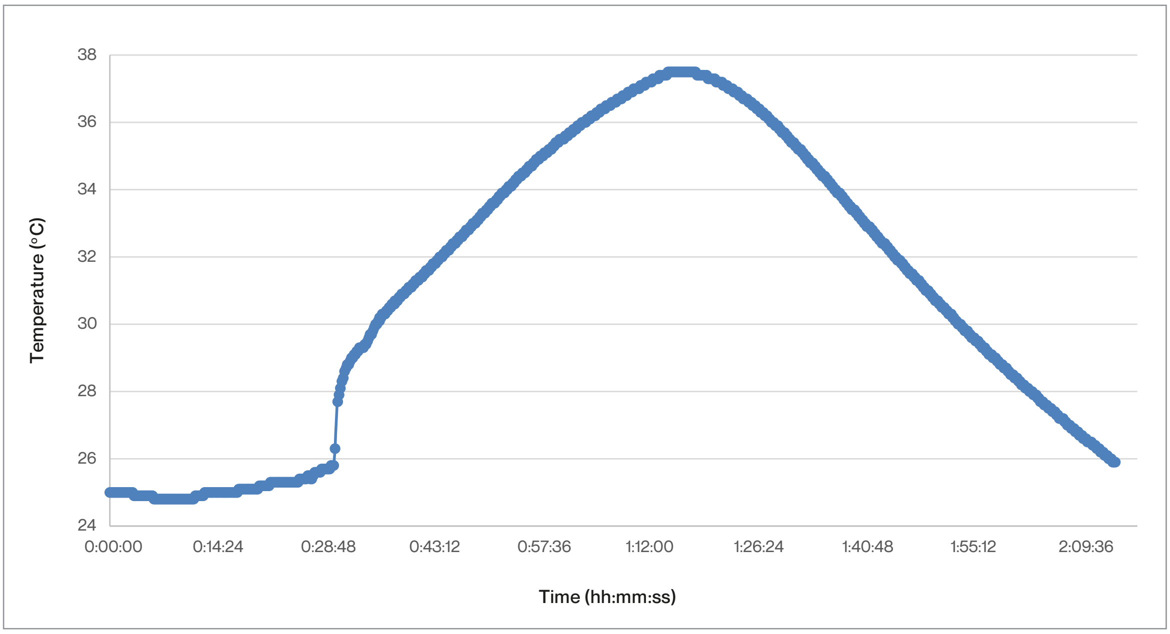


Figure 9. eProd (1000L) recordings of the temperature variation during FAT testing of the equipment.