Longitudinal Temperature Telemetry Enables Early Risk Stratification of IVF Cryogenic Storage Dewars

Michael Rusnack, BSE/ME — PharmaWatch

Why This Matters in IVF

Cryogenic storage failures are uncommon but potentially catastrophic, as specimen viability depends on uninterrupted maintenance of liquid nitrogen conditions. Current monitoring strategies rely primarily on threshold-based alarms, which are designed to detect failure after significant thermal deviation has already occurred.

Objective

To determine whether routinely collected longitudinal liquid nitrogen temperature and level telemetry contain early, physically interpretable signatures of progressive cryogenic dewar degradation that precede conventional alarm conditions.

Limitation of Conventional Monitoring

Cryogenic storage failures are uncommon but potentially catastrophic, as specimen viability depends on uninterrupted maintenance of liquid nitrogen conditions. Current monitoring strategies rely primarily on threshold-based alarms, which are designed to detect failure after significant thermal deviation has already occurred.

MEASUREMENT PLATFORM
Continuous temperature and liquid nitrogen level telemetry were acquired using an in-situ cryogenic monitoring probe (LevelSense™), providing 5-minute resolution data for longitudinal stability, evaporation behavior, and drift analysis across IVF storage dewars.

Methods & Analytical Framework

Multi-site IVF cryostorage telemetry comprising continuous liquid nitrogen temperature and level monitoring at 5-minute resolution.

Key Metrics:
- DHI — composite stability index
- NER — evaporation energy metric
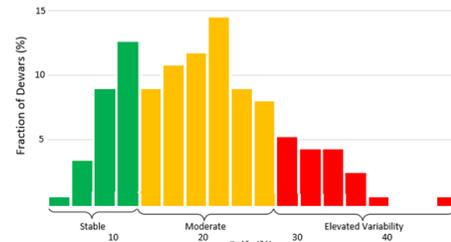- Drift — longitudinal deviation indicator

Figure 1 – NER distribution
The normal evaporation rate varies across dewars, indicating differences in steady-state thermal performance.
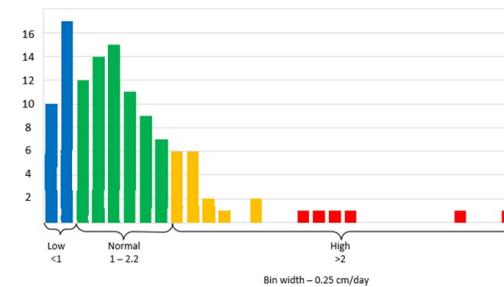

Figure 2 – Drift distribution
Longitudinal thermal drift identifies progressive loss of stability before conventional alarm thresholds are reached.
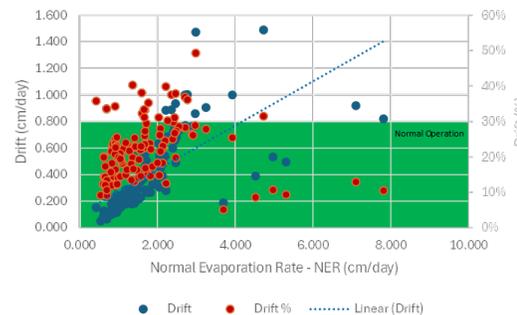

Figure 3 – NER vs Drift scatter
Combined NER and drift metrics separate stable and degrading dewars, enabling early non-invasive risk stratification.

Key Results

✓ Deward exhibit non-binary degradation behavior
✓ Detectable thermal drift precedes alarm thresholds
✓ Temperature and level-derived metrics enable early, non-invasive risk stratification

Clinical Impact

- No workflow change required
- Uses existing monitoring infrastructure.
- Enables preventive maintenance before specimen risk.
- Supports quality systems and accreditation readiness

Risk Category	DHI Range	Dewars (n)
Stable	High	34
Monitor	Intermediate	5
High Risk	Low	16

DHI integrates thermal excursion, recovery behavior, and drift to classify dewar stability risk.

Routine LN$_2$ telemetry reveals early, physically interpretable signatures of progressive cryogenic dewar degradation that conventional alarm-based monitoring cannot detect.