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tempris® Easify Your Lyo Process

TEMPRIS –
Closed Loop Control for Pharmaceutical Freeze Drying

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RAYA 2025 Finalist Event

Tempris Introduction

62% of Shortages linked to Manufacturing Quality

A Critical Challenge in Lyophilization

When quality fails,
patients wait!

What FDA Says about Lyophilization

Current State of Lyophilization*

- Despite being an ancient practice dating back to the 13th century
- Process design was more of an art than a science – "Quality by accident??"
- Batch process, process failure can lead to batch reject
- Average process time of 3 – 7 days
- Cost intensive
- Limited or no product monitoring at manufacturing scale
- Limited adoption of mathematical models, feed back control at scale or advanced manufacturing practices

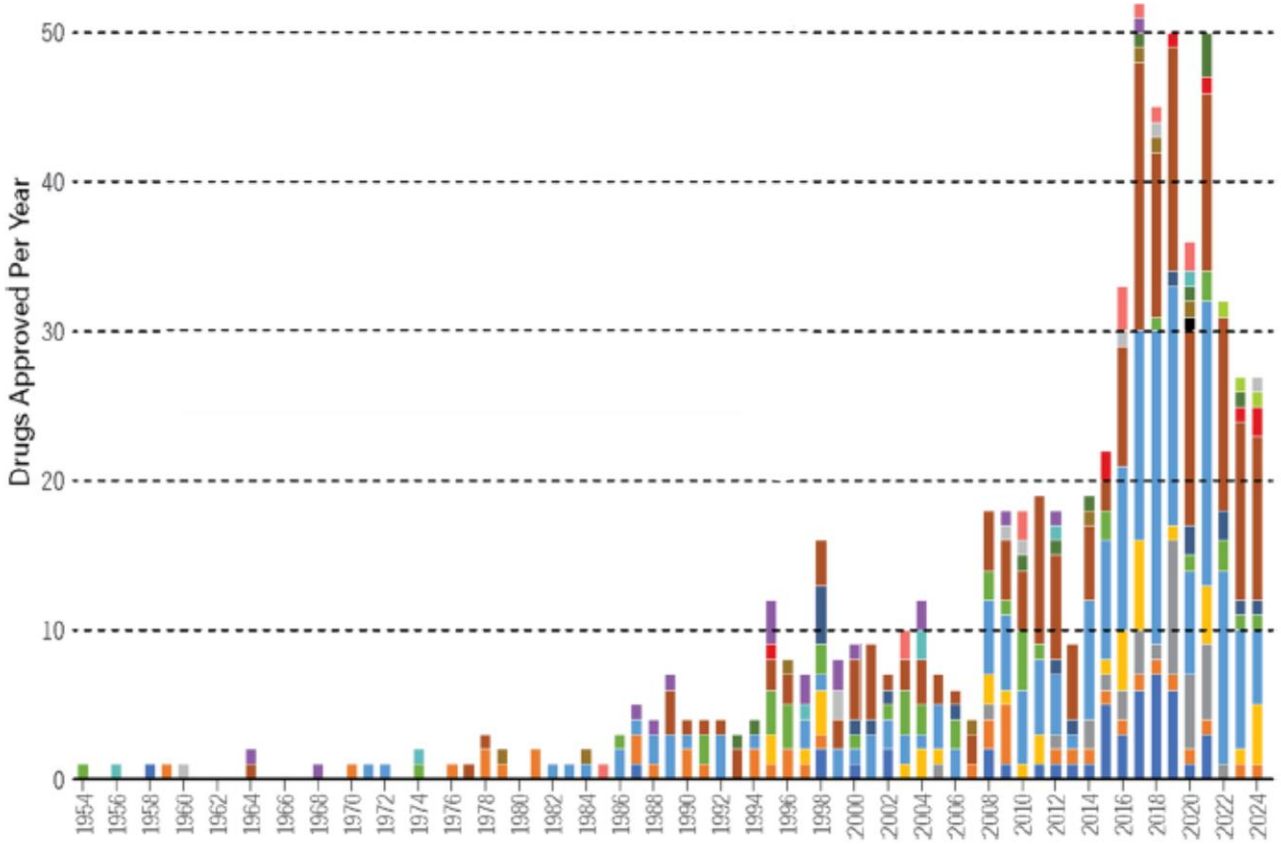
Conclusion *

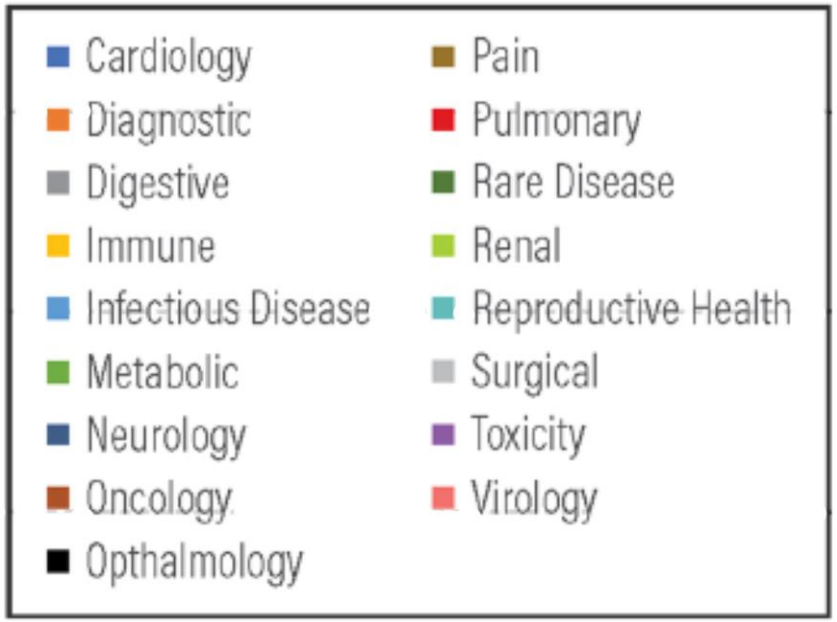
- There is an urgent need for the adoption of advanced manufacturing practices, such as real time product monitoring and computational models for lyophilization of pharmaceuticals
- Verification and validation activities for lyophilization computational models should be commensurate with the context of use and model risk
- Not "one size fit all"
- Current regulatory standards/guidelines offer a useful framework for lyophilization model verification and validation
- ICH points to consider, ASME V&V 40 and FDA/CDRH guidance for assessing the credibility of computational modeling and simulation

* FDA U.S. FOOD & DRUG ADMINISTRATION / Maxwell Korang-Yeboah, Ph.D.

Current Reality

Nearly 100% of Parenteral drugs are made without controlling "product temperature," which is a significant issue

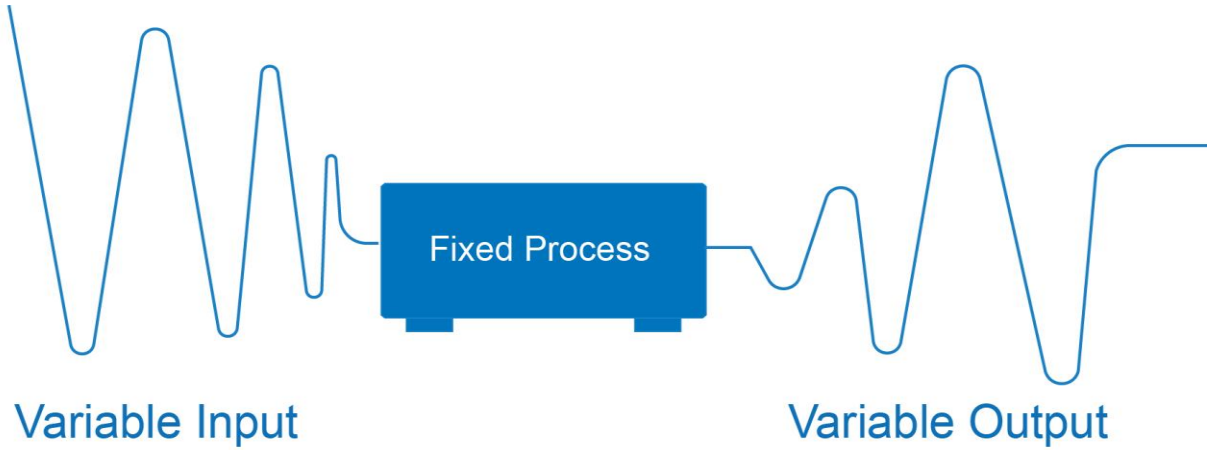




*Source of data: Lyo-HUB Lyo Drug Database | Annual approvals by the FDA of lyophilized drugs and biologics.

Current Problem

Models are used today to Guarantee Drug Quality



The challenge:

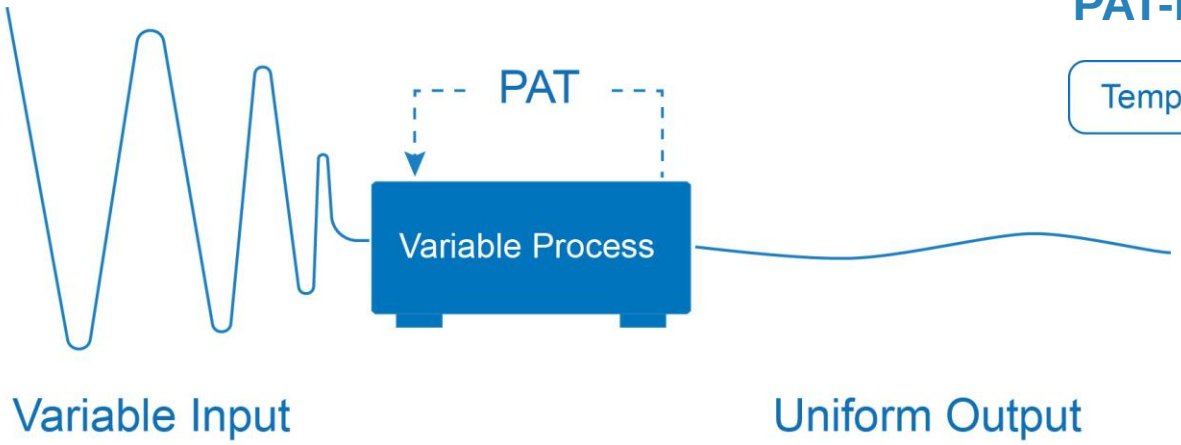
Process Control via Computational Models has limitations

No improvement in long-term medication shortage

Graphic source: ISPE 2002

The Solution

Aseptic Product Temperature Control at Manufacturing Scale



PAT-based Approach

Tempris LyoCLC → Scale-up-and PPQ → Health Authority Approval

Reliable Product Quality

Graphic source: ISPE 2002

Robotics – the Key to Sterile, Real-Time Process Control

Precision Measurement

Energy Stored in Quartz Crystal

No Heat Input in Product

Retrofittable in Freeze Dryers

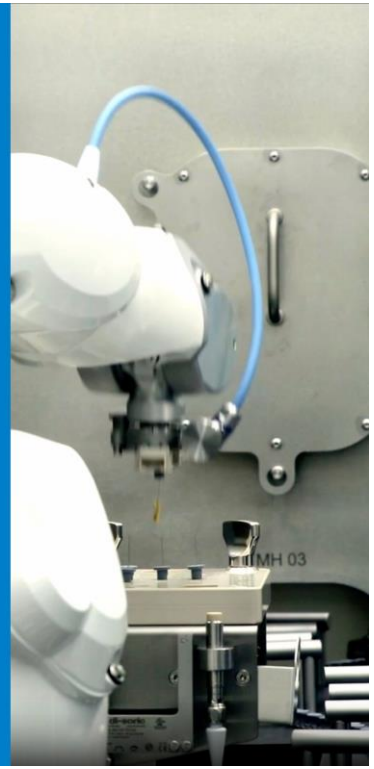
Globally Compliant

Automated Sensor Loading by Robot

Highest Aseptic Safety Level

Accurate Process Repetition

Successful Batch Comparison



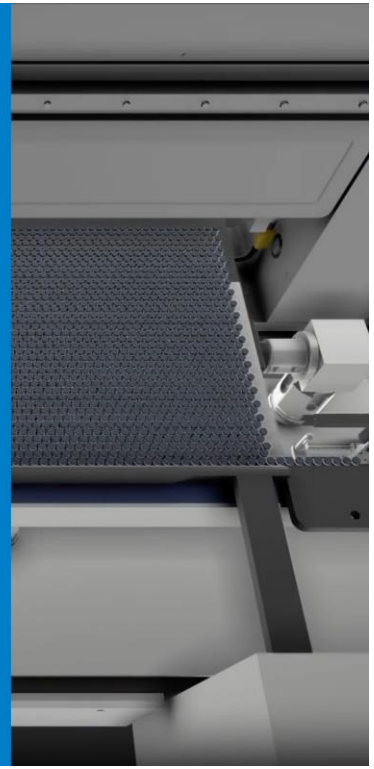
Tempris PAT Tool

Monitors Temperature in Real Time

Dynamic Optimization of Cycle Times

Digitalizes Batch Documentation

Maintains Design Space



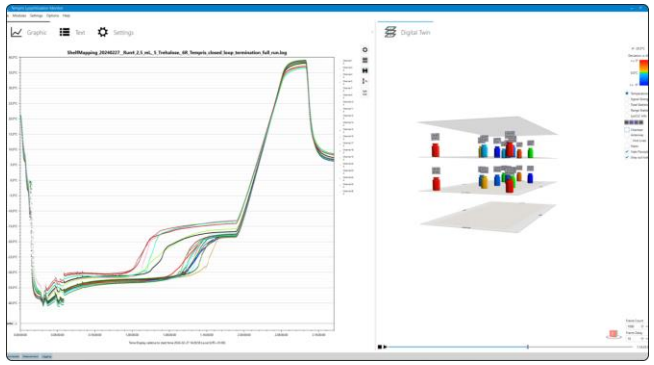
Precise measurement + Automated aseptic sensor loading + Dynamic process control with LyoCLC®

Technical Highlights

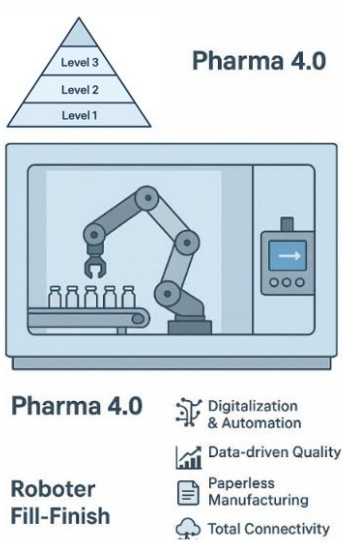
Real-time product temperature – from liquid fill to dried product

Robotics enables aseptic sensor loading – Annex 1 compliant

Digital twins for all freeze-dryer scales – visualizing sensor positions & variability



Tempris LyoCLC® transforms real-time sensor data into AI/ML-driven control – enabling Pharma 4.0 with predictive, closed-loop optimization.



ROI Consideration

Opportunities using Tempris + LyoCLC Solution

Significantly increase Production Efficiency:

By replacing model-based safety margins of up to 30% with real-time data

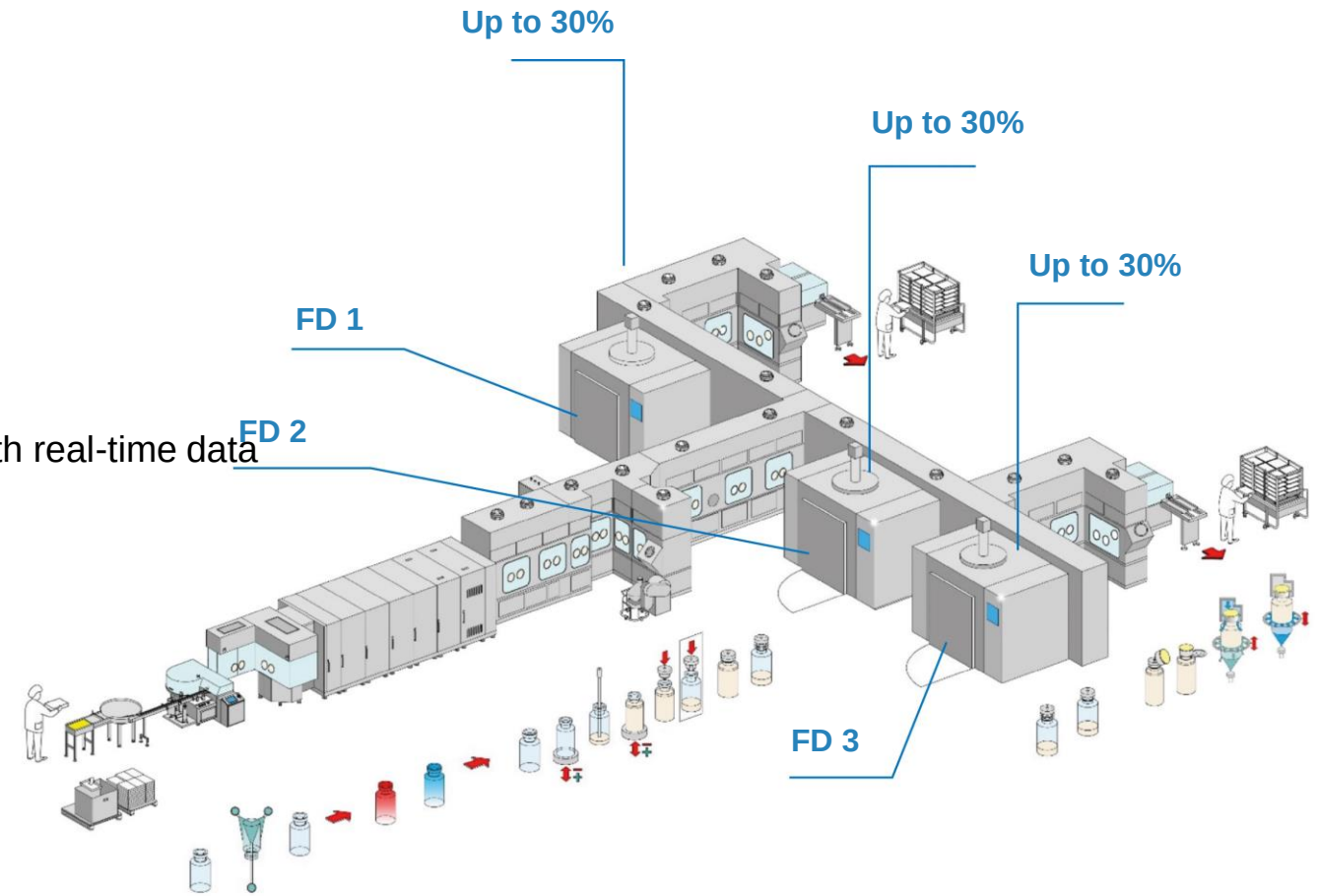
By reducing the production ramp-up times up to 40-50%

Repeatable product quality

Significant energy Savings

ROI < 1.3 Years

ROI < few Months – In case of quality issues



Source: Complexity of Wireless Produkt Temperature Measurment under Isolator Conditions, PDA Europe, W.Lau, Roche Diagnostics, F. Bosshammer, NNE GmbH, 19-20. Sept. 2017

Strategic Benefits

1.
Assured Product Quality

2.
Faster Time-to-Market

3.
Robust Scale-up & Control

4.
Cost Benefits & Sustainability

5.
Strategic Advantage

Benefit at a Glance

- **Economic Impact:**
  - Replace model-based safety margins (up to 30%) with real-time data
  - 40–50% faster ramp-up, ROI < 1.3 years
- **Quality & Compliance**:
  - Real-time product temperature control
  –> FDA & Annex 1 aligned
- **Innovation & Strategy**:
  - Robotics + LyoCLC® → enabler for Pharma 4.0 &
  - Real-Time Release Testing
- **Patient Benefit:**
  - Reliable global drug supply – faster, safer, more sustainable.

References

tempris® Easify Your Lyo Process

References (URLs)

1. FDA Drug Shortages – Root Causes and Potential Solutions (2019/2020): https://www.fda.gov/drugs/drug-shortages/report-drug-shortages-root-causes-and-potential-solutions
2. FDA Drug Shortages Task Force – Full Report PDF: https://www.fda.gov/media/132058/download
3. GAO-16-595 (2016) – Sterile Injectables & Shortages: https://www.gao.gov/assets/gao-16-595.pdf
4. GAO-25-107110 (2025) – HHS should implement a mechanism…: https://www.gao.gov/assets/gao-25-107110.pdf
5. ASHP Guidelines (2018) – Managing Drug Product Shortages: https://www.ashp.org/-/media/assets/policy-guidelines/docs/guidelines/managing-drug-product-shortages.ashx
6. NASEM/NIH 2022 – Medical Product Supply Chain Disruptions: https://www.ncbi.nlm.nih.gov/books/NBK583734/
7. Alexeenko et al., 2025 – Critical Needs & Opportunities (LyoHUB): https://pmc.ncbi.nlm.nih.gov/articles/PMC12222488/
8. FDA OPQ White Paper (2022) – Quality Management Maturity: https://www.fda.gov/media/157432/download