Technology Considerations for Safe Food Processing

Bühler Aeroglide

3-A SSI 2018, Exceeding Customer Expectations Through Hygienic Design

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Innovations for a **better world**.

Introduction.

Douglas Beloskur is Product Manager, Digital Services for Buhler Aeroglide. He holds a Master of Science in Engineering and BSME, from Kettering University in Flint, Michigan, USA. Since joining Buhler Aeroglide in 2007, he has evaluated and commissioned various types of convection drying equipment and conducted drying theory courses all over the world. He has spent nearly three years working in Bühler’s head offices in Uzwil, Switzerland as Process Engineering Manager. Doug has also been published in various trade magazines on the topic of industrial automation and thermal processing.

Email douglas.beloskur@buhlergroup.com
Phone +1 919 851 2000

Co-Author
Kaitlyn Casulli – Red Wolf Consulting
Email kaitlyn.casulli@redwolfconsulting-llc.com
Phone +1 252 365 0794

Agenda.

Take-away considerations.

- Understanding interaction of product, pathogen and process variables is a prerequisite for food safety technology enablement.

  What foundational information is necessary to harness the power of the latest technology advances?

- Sensor and data collection technology continues to become more robust and less costly, implementation of new technology can improve food safety.

  How can additional sensors and process data improve food safety and reduce operational costs for your dry roasting process?

Dry roasting and pathogen inactivation background.

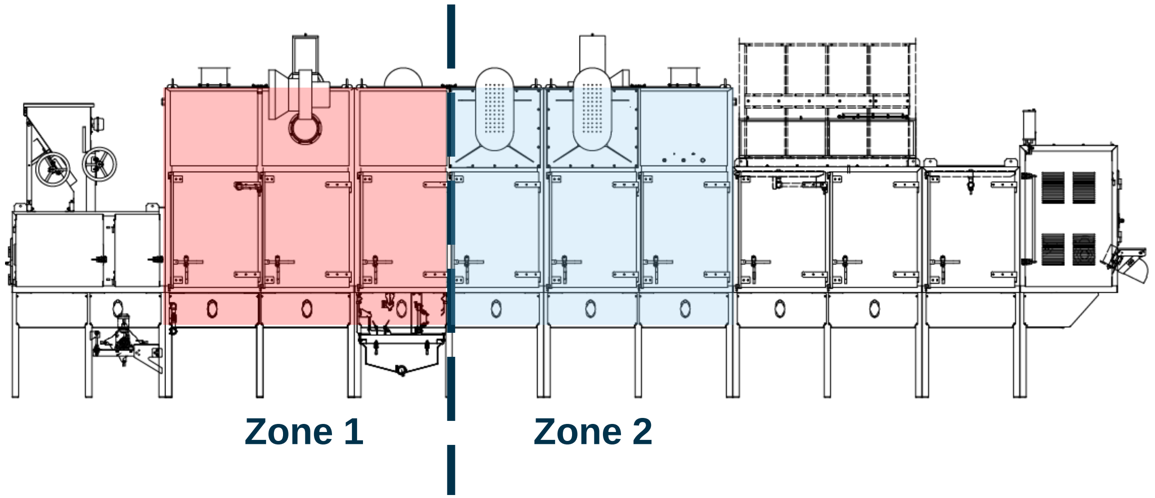
Background.
Dry roasting inactivation

- Uses convective heat transfer as a preservation technology that reduces the probability of spoilage and pathogenic growth

- Brings about positive chemical and physical changes
  - Develops final color and flavor profile synchronously with pathogen reduction
  - Dewaters product for increased shelf stability

- Reduces number of processing steps

- Reduces cost of finished product



Zone – Referencing a specific dryer area with individually controlled airflow, volume, temperature, exhaust volume, and humidity

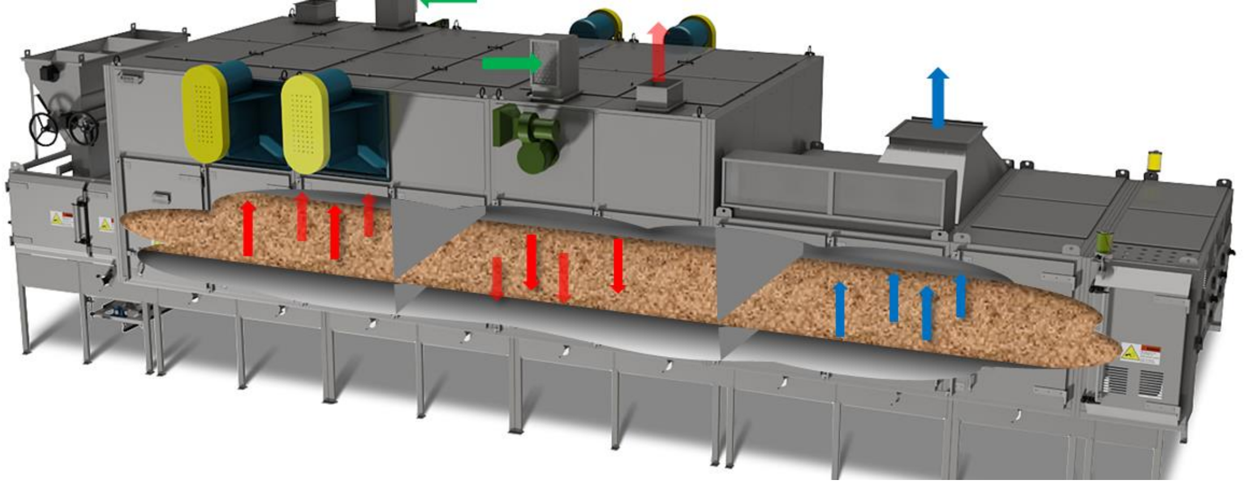
Background.
Why validate a dry roasting process for pathogen reduction?

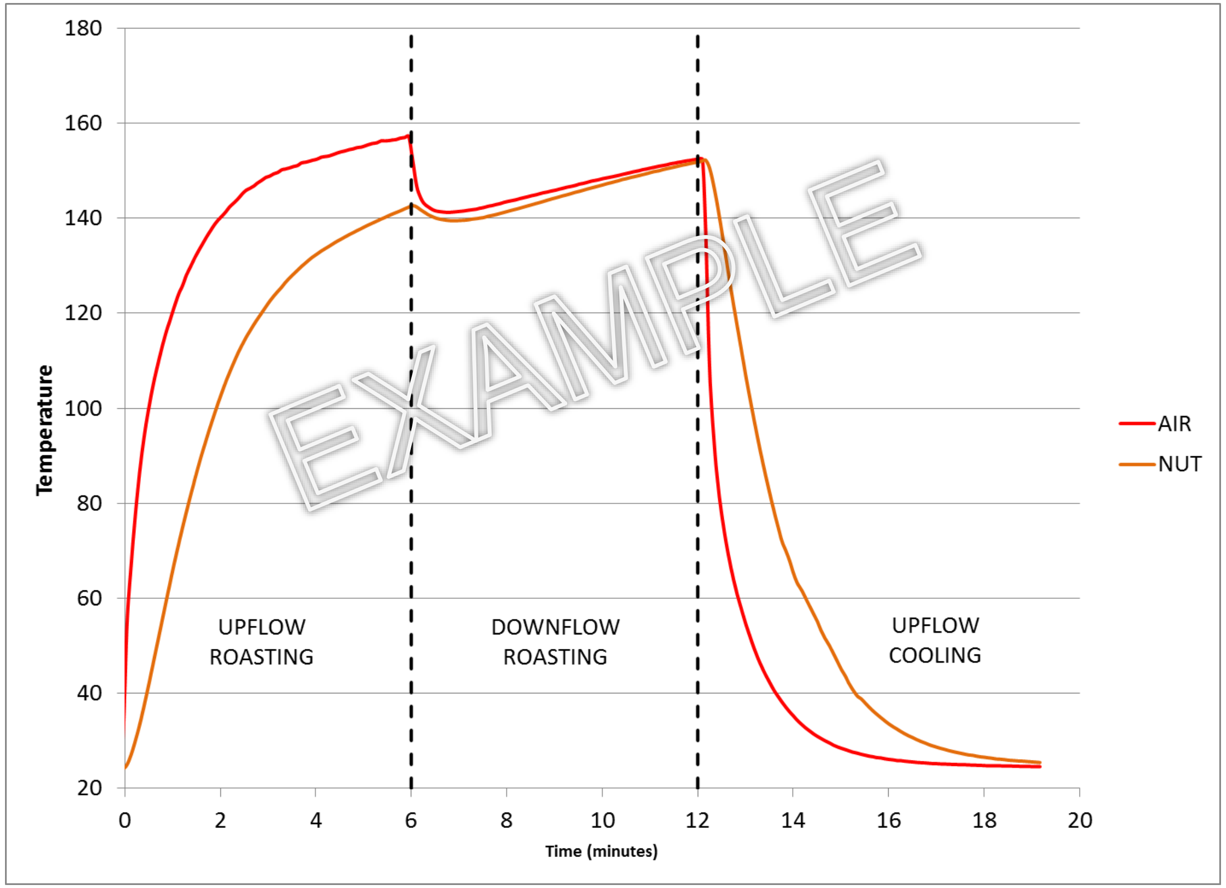
- Dry foods were previously considered low risk because they do not support pathogenic growth

- Pathogenic contamination in dry foods is now broadly recognized (Beuchat et al., 2014)

- Pathogens like *Salmonella* have the ability to survive for long periods of time (>1 year) in dry environments
  - *Salmonella* can cause illness with as few as 1 cell
  - *Salmonella* is often recognized as the target pathogen for validations because it's often the most difficult to inactivate.

- Validation of dry roasting operation reduces a need for further processing





Key factors of validation science.

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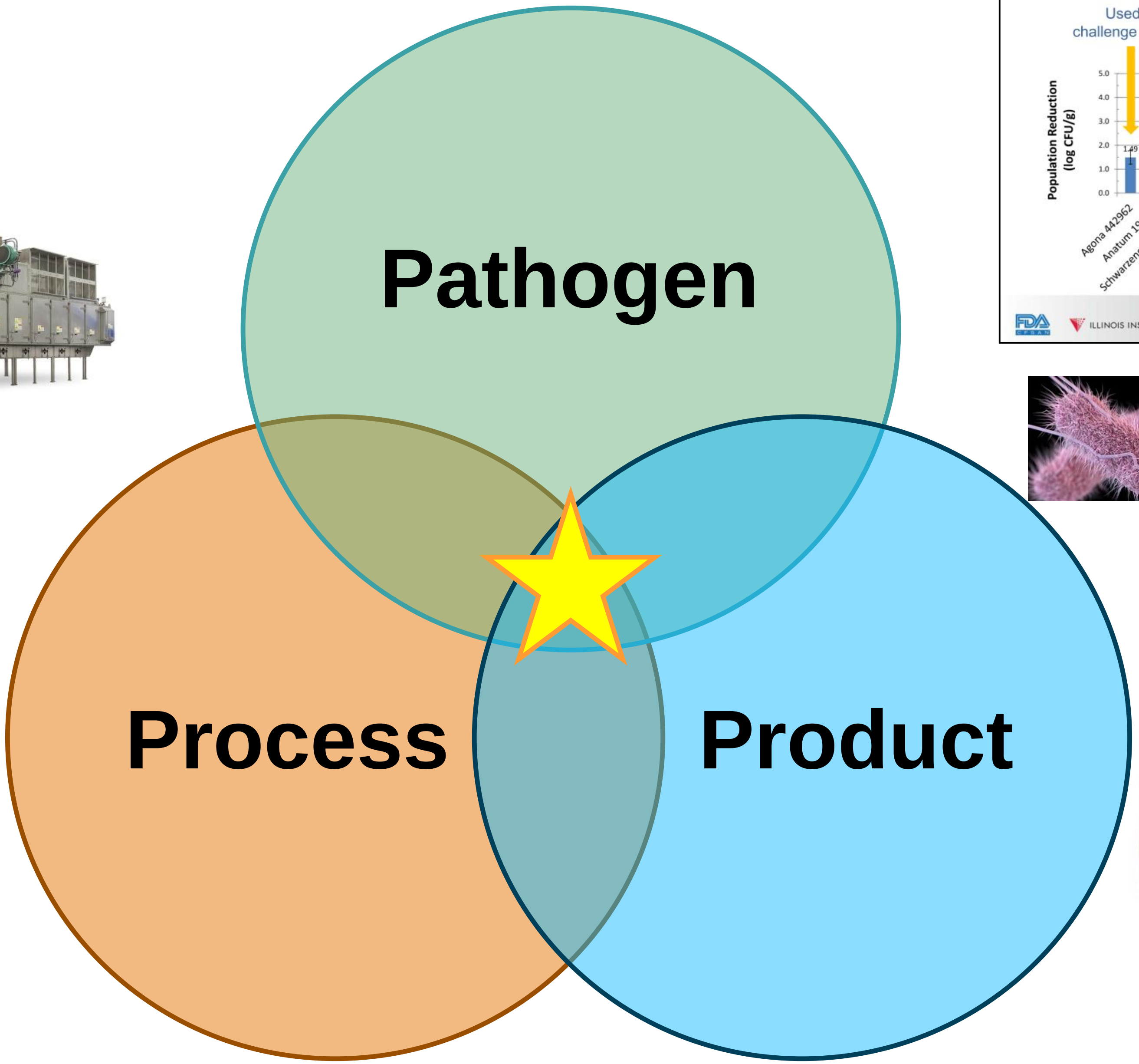

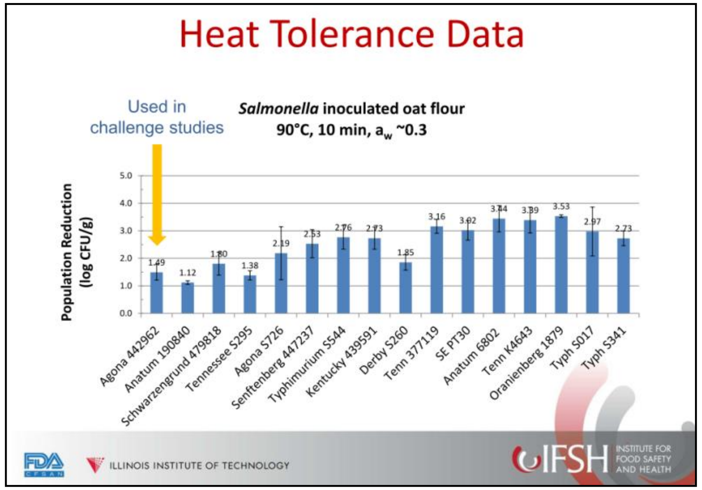

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Background.

Market drivers for new validation services

Shared

- Impact to brand due to market recall.

Producers

- Validation process is expensive and time consuming.
- Validation “minimums” can limit ability to develop desirable product characteristics.
- Wasted product is added cost.
- Re-processing adds cost.
- Industry benchmark of paper records are costly to manage.
- Limiting human interaction with food production.

Machinery OEMs

- Paper recording equipment expensive to supply, difficult to service.
- Instrumentation and automation solutions becoming more effective and lower cost.
- Validation services and products are an added revenue stream.

Regulatory / Associations

- FSMA mandates preventive controls for hazards in foods
- Risk management decisions can be made with greater confidence
- Regulatory groups (e.g., GMA) have developed guidelines for low moisture foods with limited published data

Shared

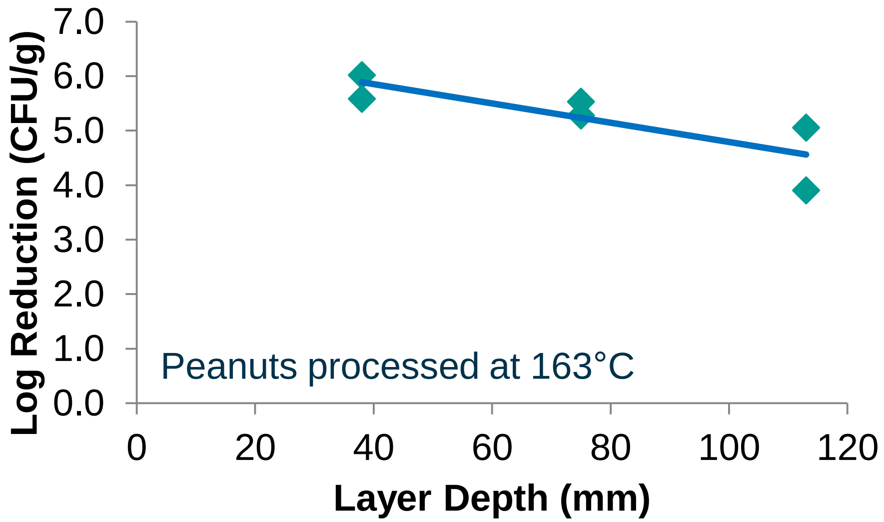
- Impact to people, sickness prevention.
- Future impact to people, lack of food / nutrition availability.

Study: Layer depth inactivation impacts.

Background, Objective and justification.

All nuts are not the same.

- Previously published study indicated that layer depth had **no statistical effect on inactivation in peanuts** (Poirier et al. 2014).
- Regulatory guidelines indicate that layer depth affects inactivation in almonds (ABC, 2014), but there is **no published study** to confirm this.
- Temperature distributions within a layer (“slab”) are driven by its **thickness** (i.e., thinner layers heat up faster than thicker layers).



Why did industry fund a study?

- Peanuts are not almonds, results for peanut studies cannot be assumed for almonds.
- To provide guidance on effects of bed depth on almonds.
- Layer thickness has direct correlation to capacity of conveyor-based dry roasters.
- To provide contribution to support industry in producing safer foods.
- To expand knowledge of machinery OEM into microbiology and effects of thermal processing on pathogen reductions.

The objective of this study is to quantify impact of **layer depth** on *E. faecium* inactivation on almonds for different **retention times** and **process temperatures**

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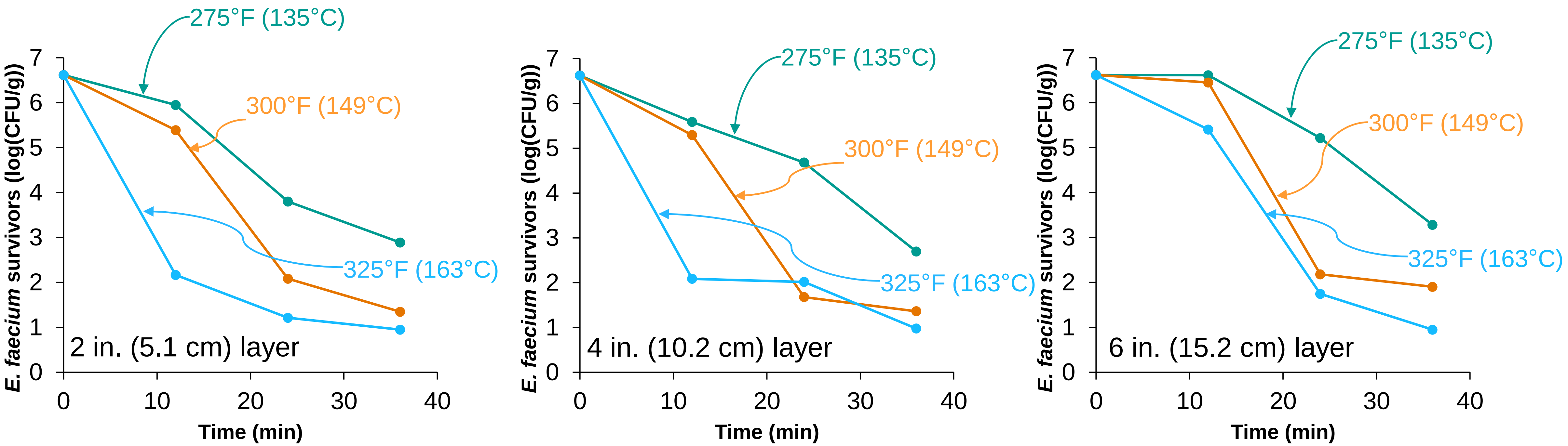
Microbiological results.

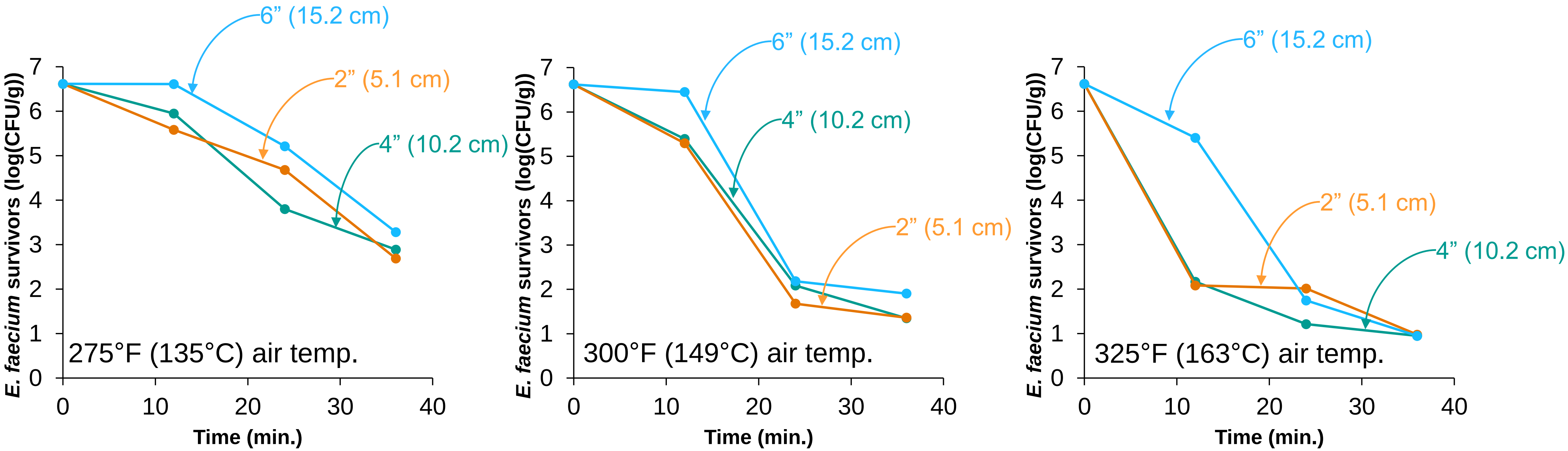
Comparing temperatures at constant layer depths



- ➢ Higher temperatures corresponded to faster inactivation

Microbiological results.

Comparing layer depths at constant temperatures



➢ Layer depth did not show an influence on inactivation

Summary and conclusions.

- Layer depth influenced **product temperature and moisture**, but **NOT microbial inactivation**.
- Both time and temperature had **practical and/or statistical** implications for microbial inactivation.

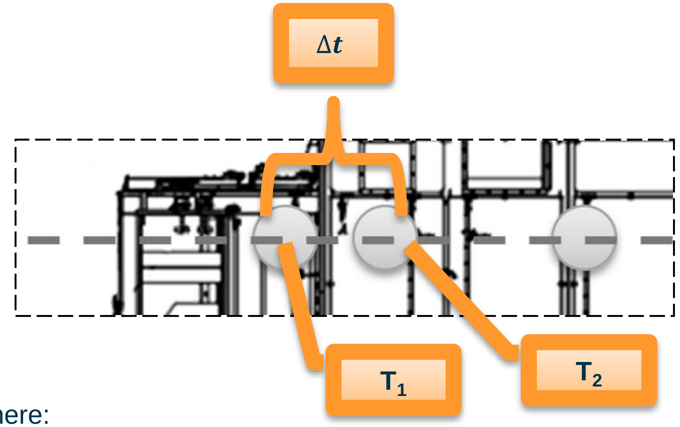
Detailed studies to understand **process variable impacts** are a foundation for IIoT enabled technologies.

Technology considerations
for
Safe Food Processing.

Continuous inactivation technology.

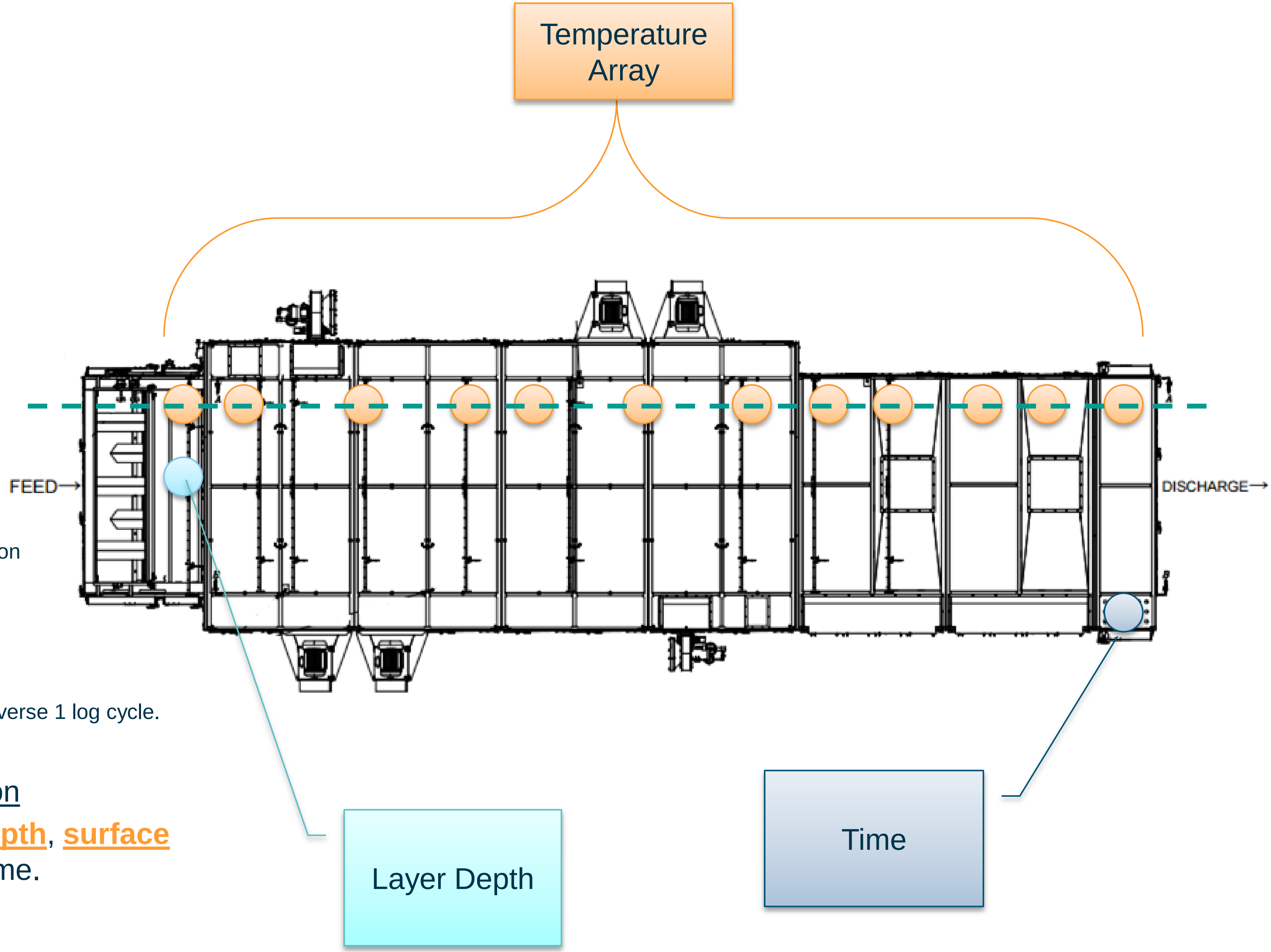
Cumulative Inactivation

Formula: Log reduction = $\sum \left[\left(10^{\frac{T-T_{ref}}{z}}\right)\Delta t\right]/D_{ref}$



Where:

D_{ref}	is the number of minutes required for a 1-log (90%) reduction of the target organism. Under constant conditions.
t	Is time, in minutes.
T	is the measured temperature in the heat penetration study.
T_{ref}	is the reference temperature of the TDT study.
z	is the number of degrees (°C or °F) of the TDT curve to traverse 1 log cycle.

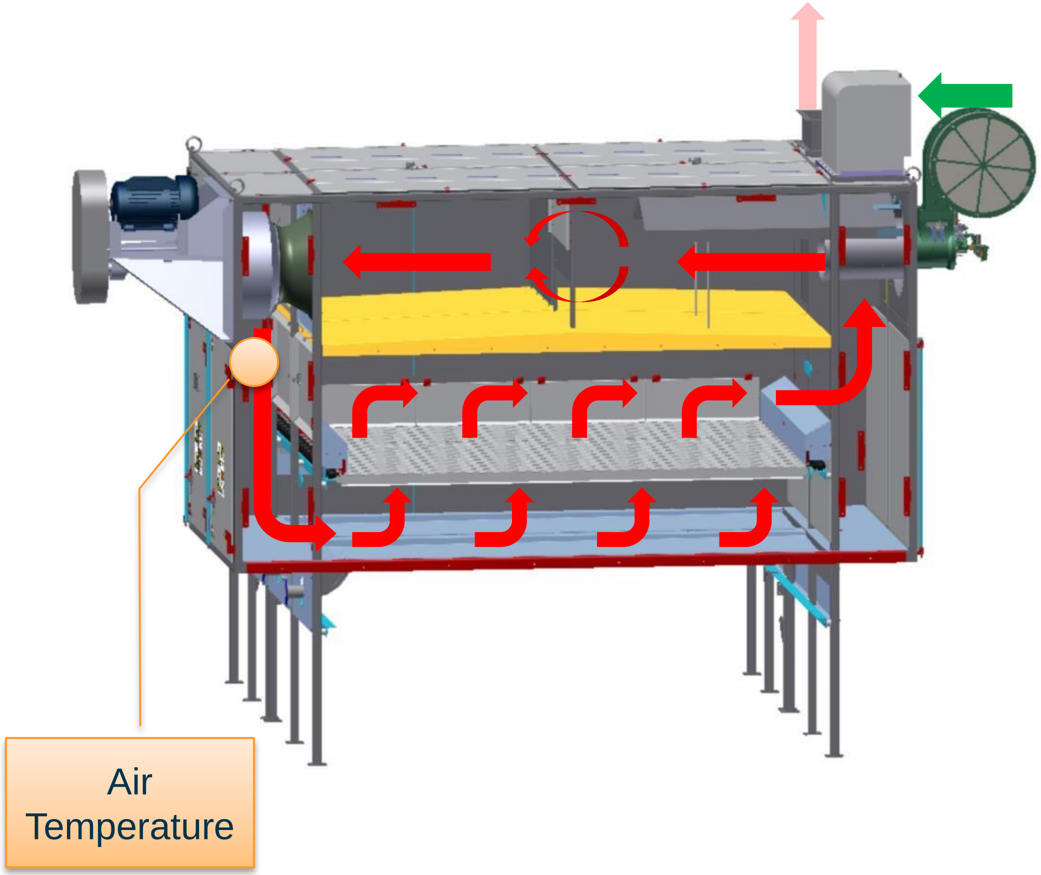


Traceability Improvements with Cumulative Inactivation

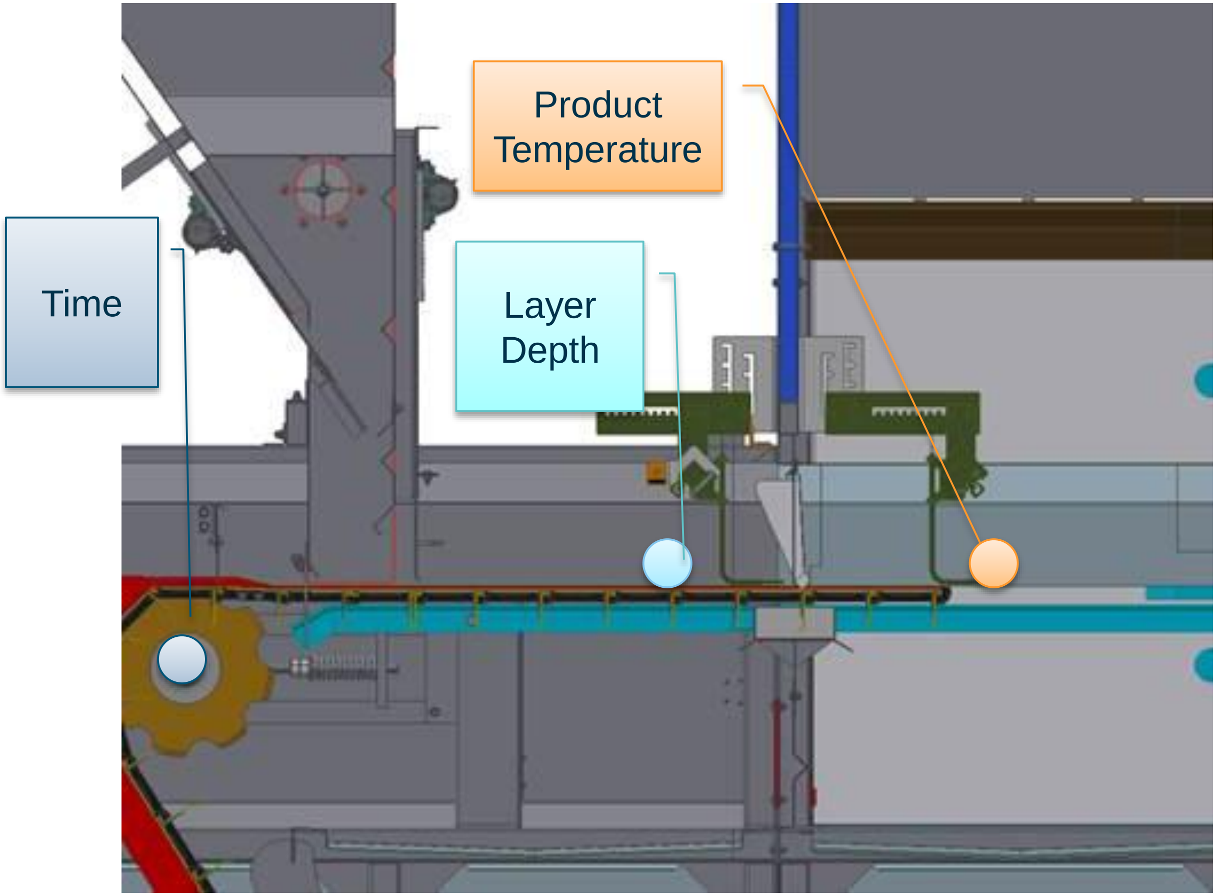
Ability to monitor, report and alert on product layer depth, surface temperature and roasting time parameters in real time.

Process measurements.
Sensor placement

Air temperature measurements



Depth, Time and In-product temperature measurements



Sensor technology.

Temperature

Measurement Method
RTD or Thermocouple

Pros
Durability against heated environment

Cons
Thermocouple – wiring type / extension leads

Where
In convective airstream and in product layer

Why
To measure heat availability in airstream – air measurements, or to measure heat transfer to product – product surface measurements

Time

Measurement Method
Magnetic proximity sensing – or VFD reading

Pros
Simple setup

Cons
Heat limitations (proximity sensing)

Where
Using mechanical relationships and variable frequency drive –or– at rotational shaft

Why
To measure time in heating / cooling sections

Depth / Distance

Measurement Method
Laser, time of flight

Pros
Simple setup, non-contact

Cons
Heat limitations, accuracy on varied mediums and distance from target

Where
Near inlet of roaster

Why
To maximize capacity, monitor depth per existing HARPC

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Data collection and records management methods.
Concept

Field Sensors Layer

Place where sensors are located and connected into machinery “neural” network. These connections are analog or digital direct wire, or communicated over industrial protocol to the IoT panel layer.

IoT Panel Layer

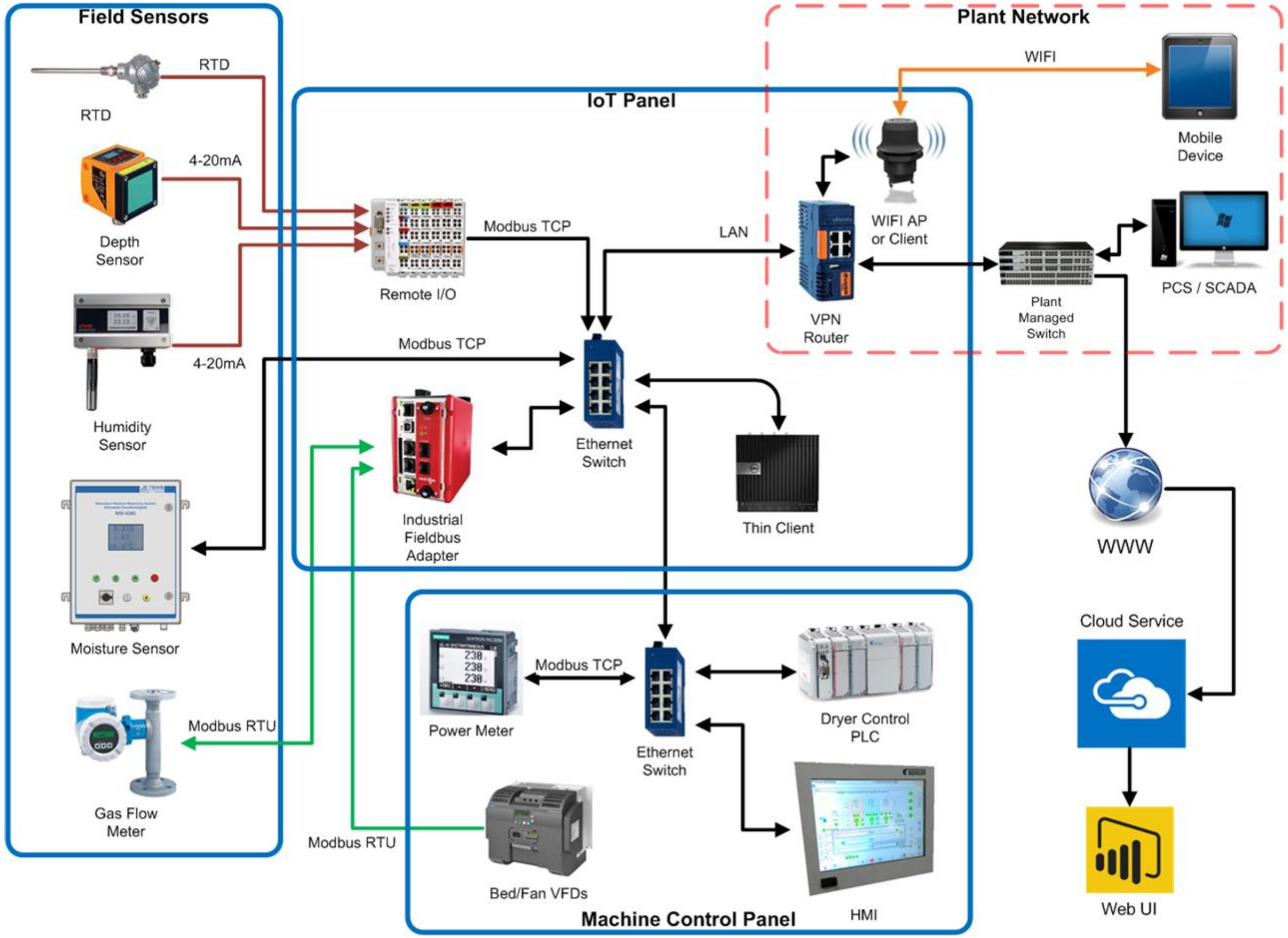
Place where sensor data is aggregated and formatted for transmission to cloud based storage. Affords opportunity for local processing for “near-real-time” events.

Machine Layer

Place where machine critical operations are done (e.g. safety management). This also includes sensing equipment which can be transmitted over industrial protocol to the IoT panel layer.

Cloud and Web Visualization Layer

Offsite, non-self hosted infrastructure, low costs for single machine related volumes. Receives all data from IoT panel layer and is final storage location for information. Affords location for event management, data visualization and big data analytics. Also allows aggregation with other databases which may enrich the quality of machinery related data.



HARPC changes applied.
Hazard Biological - Salmonella

Before, truncated

Critical Limit

Time/Temperature conditions to achieve at 4-log kill for Salmonella spp. are listed below:

Minimum Temperature	Minimum Time
280°F (138°C)	23 minutes

Monitoring Activity / Frequency / Responsibility

Temperature: Temperature of the product at the coldest spot or demonstration of sufficient time at temperature shall be recorded on a continuous chart recorder.

Time: flow rate shall be recorded continuously or belt speed setting is recorded once per shift and after speed changes by a designated, trained employee.

Corrective Action Activity / Responsibility

…product shall be identified and put on Quarantine Hold by designated trained employee. Notify the designated responsible personnel to determine disposition. Hold/ Release documentation is required.

Records / Location

…Records - located in Quality Assurance Office.

After, truncated

Critical Limit

Log reduction >4 log. Continuous inactivation of log reduction for Salmonella spp. is described by the following formula:

$$\text{Log reduction} = \sum\left[\left(10^{\frac{T-T_{ref}}{z}}\right)\Delta t\right]/D_{ref}$$

Monitoring Activity / Frequency / Responsibility

Temperature and roasting time: shall be recorded on <3s interval: Temperature measurements shall be recorded at the coldest lane. All data will be collected within Microsoft Azure cloud SQL database. A local, redundant data buffer of 30 days minimum will exist to mitigate cloud connectivity concerns.

Corrective Action Activity / Responsibility

…product shall be identified and put on Quarantine Hold by pre-defined control limits and automatically diverted to Quarantine Hold location. Notifications are automatically triggered to the pre-designated personnel to determine disposition. All anomalies are logged by event in Microsoft Azure cloud SQL database. Hold/ Release authorization is event logged in Microsoft Azure cloud SQL database by only authorized personnel.

Records / Location

Records - located Microsoft Azure cloud SQL database. Uncontrolled copies can be printed via web-based interface.

Wrap-Up.

Take-away objectives.

What foundational information is necessary to harness the power of the latest technology advances?

No two products, processes or pathogens are alike. Foundational research exists on many pathogens, processes and products. If not available many private and public resources exists to develop new know-how. With this information at hand, technology advances can be harnessed to produce safe food.

How can additional sensors and process data improve food safety and reduce operational costs?

With the addition of sensor and control technology available today processors can monitor in real time calculated pathogen kill. This enables faster corrective actions if deviations occur. This improves a producer’s ability to make safe food and improve sustainability.

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Q&A.

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