

RADIO FREQUENCY PASTEURIZATION
THE *wave* OF THE FUTURE

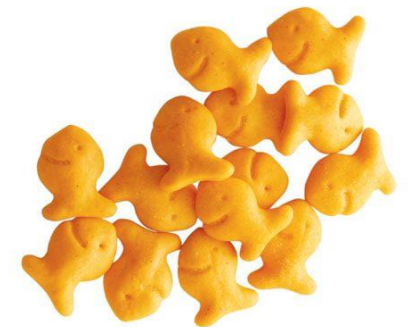
Radio Frequency has been proven as a kill step in pasteurization and disinfestation of dry (Grain and grain products) and RTE (Ready To Eat) products.



Radio Frequency Heating has also been proven in post-baking dryers, where this technology has increased the traditional conveyORIZED oven efficiency and throughput capacity by as much as 50%.



RF improves shelf-life, eliminates checking and over-colouring, and also minimizes water activity both in human, animal feed and pet foods.



With major food recalls in USA beginning in 2009, as well as the recent implementation of FSMA (Food Safety Modernisation Act), a “**New Wave**” of interest in pasteurization and disinfestation applications of this mature technology has developed.

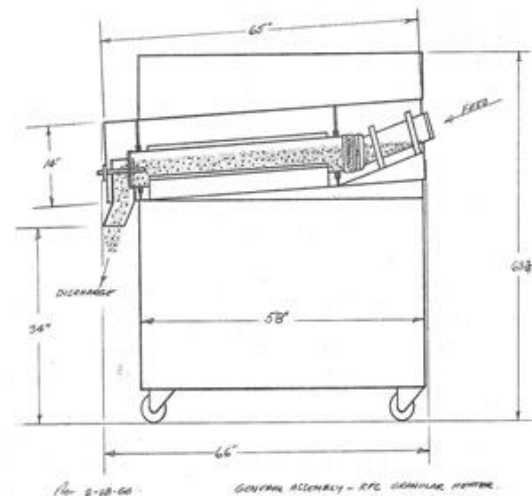
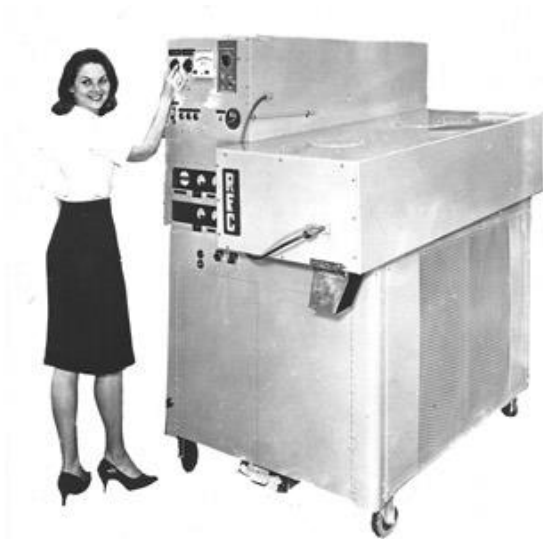
Both human, animal feed and pet food manufacturers are evaluating the safety of their supply chain and manufacturing / storage processes, and in many instances **RF is a great fit**.

RF technology kills pathogens, APC's, and insects very definitely.

Exciting work

- ❑ Our system substantially reduces Aerobic Plate Counts (APC) including moulds and yeasts, however, some moulds are very thermally stable.
- ❑ Research is in process to verify which moulds and yeasts are killed.
- ❑ The toxins produced (Mycotoxins) will not be removed, however.

Radio Frequency Heating, Drying and Pasteurisation has been commercially utilized in the food industry since the 1960's.

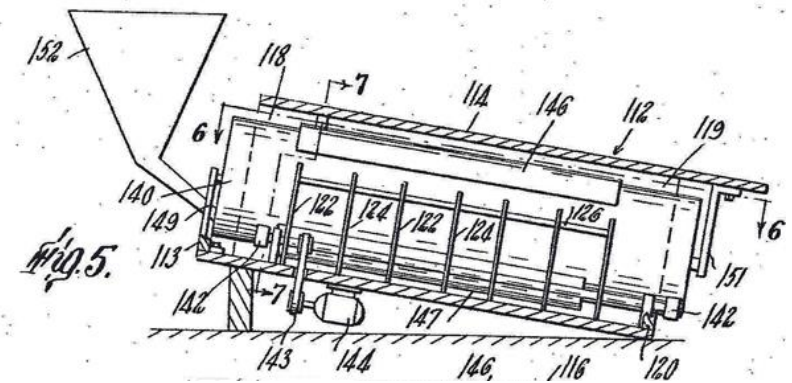


July 4, 1967

J. G. D. MANWARING
RADIO FREQUENCY APPARATUS

Filed July 28, 1966

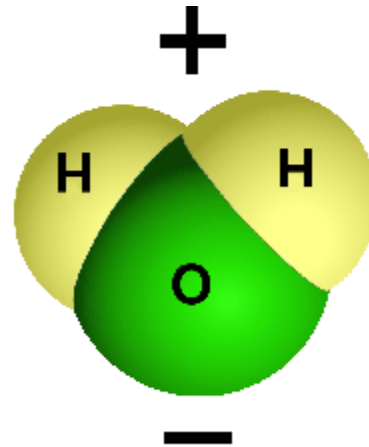
4 Sheets-Sheet 3



This 30 kW Macrowave™ Pasteurization System for granular food products was designed and patented by Radio Frequency Co.'s founder, Mr. Joshua G.D. Manwaring in 1966. His design featured a rotary product feeding tube to prevent agglomeration, and a closed loop temperature control system, both considered cutting-edge technology at that time.

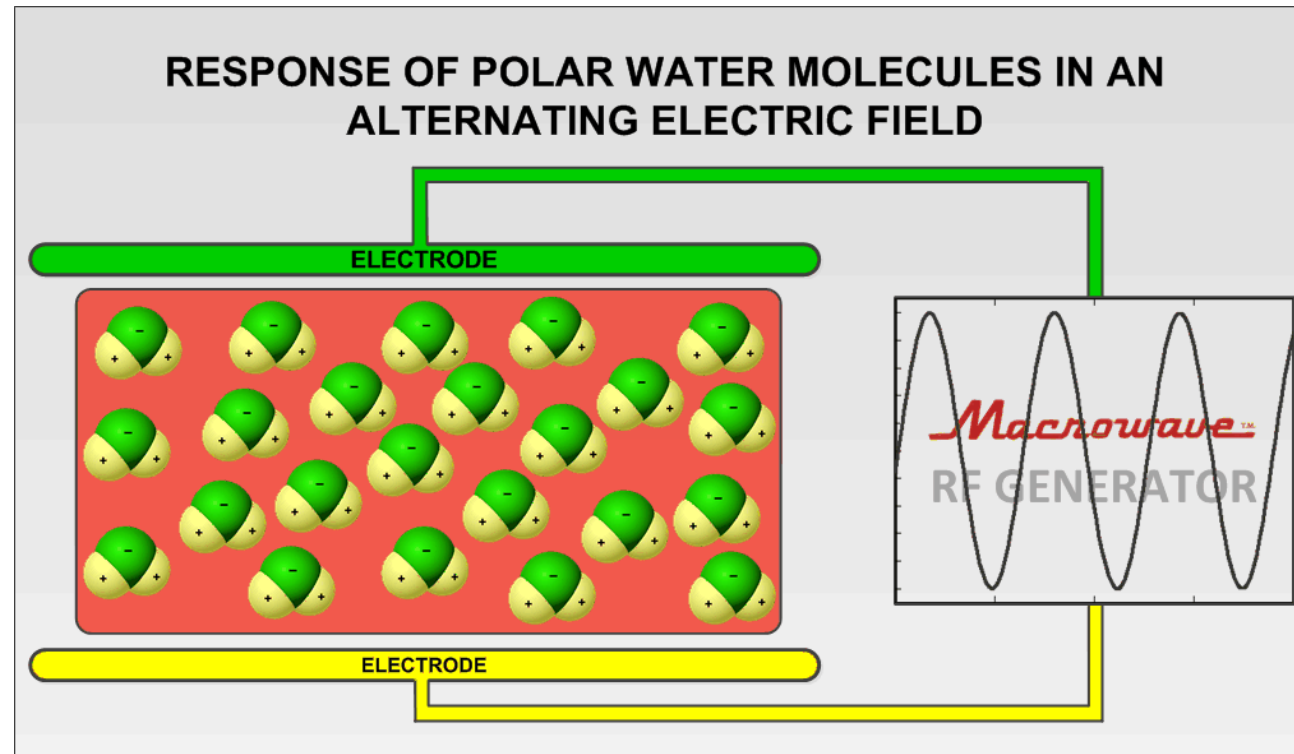
How Radio Frequency Heating Works

The unique structure of the magnetically polar water molecule, H₂O is the basis for the thermal response of water when subjected to an alternating RF energy field.



- In a Radio Frequency Heating System, the RF generator creates an alternating electric field between two electrodes, above and below the conveyor.

How Radio Frequency Heating Works



This causes the polar water molecules within the product to rapidly reorient, creating friction, and in turn heat the product rapidly and **uniformly** throughout.

Is Radio Frequency Heating Safe?



RF heating is a thermal process caused by a non-ionizing electromagnetic form of energy, just like an FM radio transmitter

The USDA does not view the RF thermal process as an added ingredient. Therefore an organic product treated with RF can carry the certified organic label



Thermal
Process

The FDA does not view the RF thermal process as invalidating the application of “natural” on the label, unlike irradiation, which is considered an additive, and therefore requires approval and special labeling.

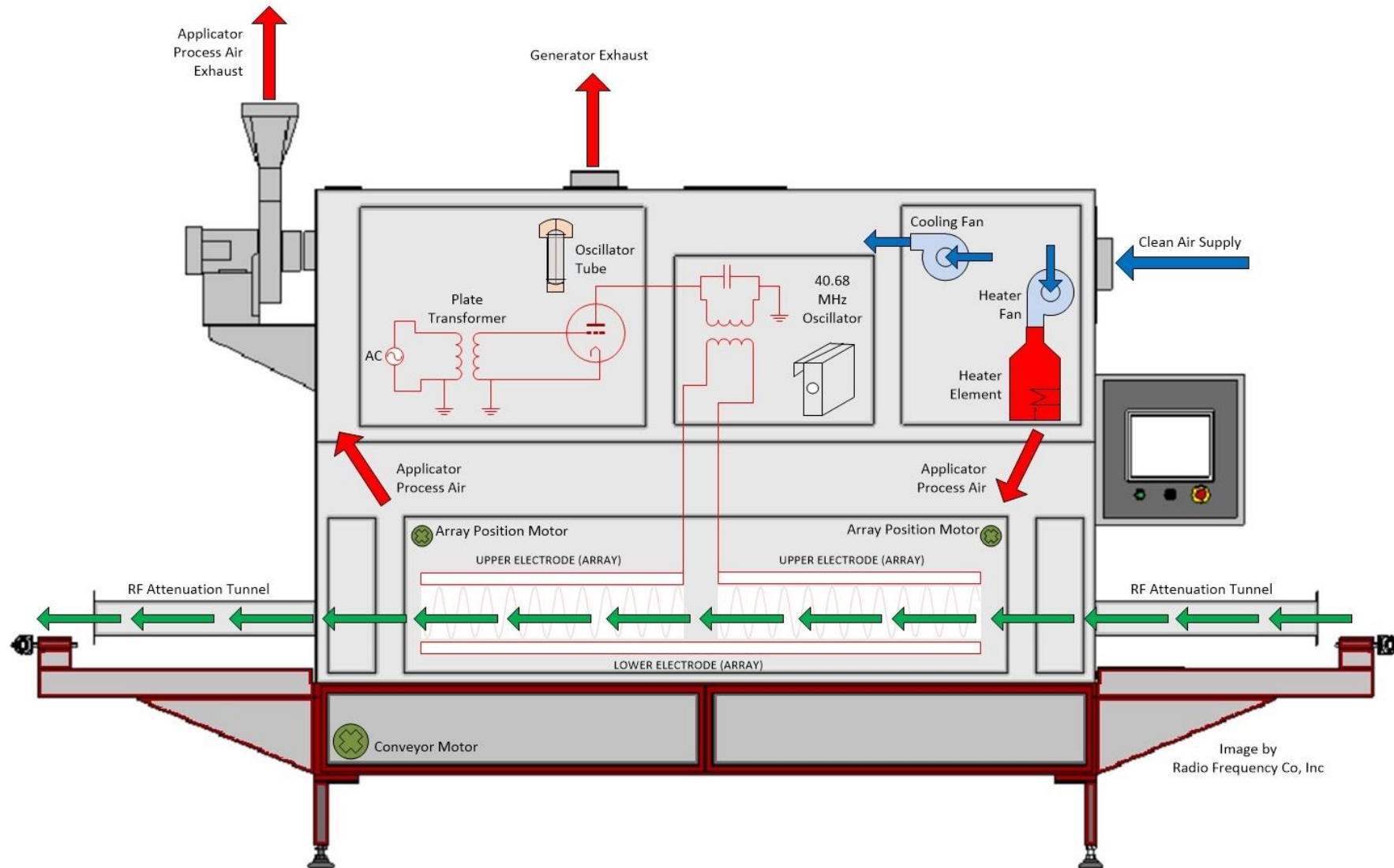


Non-Additive
Clean Label

Typical RF Heating System



Typical RF Heating System



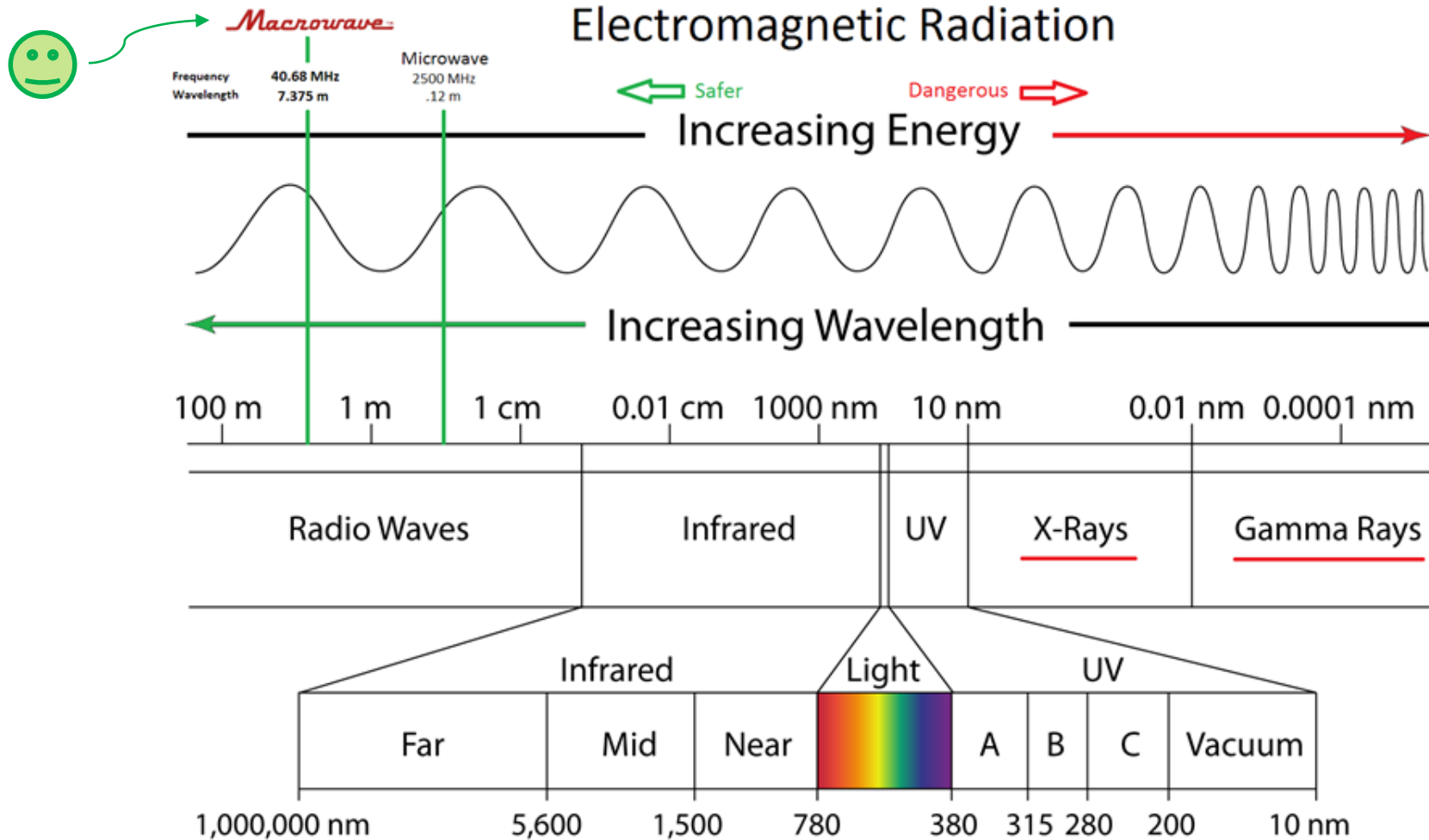
Frequencies Allowed

Permissible Operating Frequencies
for Dielectric Heating

Microwave - 915 MHz and 2.45 GHz

RF - 13.56, 27.12 and 40.68 MHz

Why 40 MHz RF?

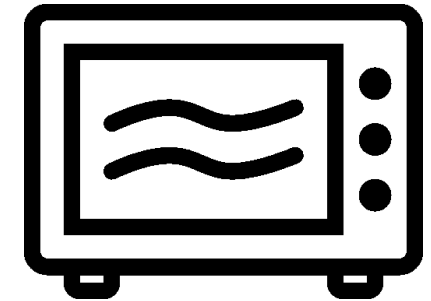


Why 40 MHz RF?



← 40 MHz

Microwave →



- ✓ YES!
- ✓ YES!
- ✓ YES!
- ✓ YES!
- ✓ YES!

Greater Depth Penetration
Instant Volumetric Heating
Superior Power Control
Lower Operating Costs
More Processing Versatility

- ✗ NO!
- ✗ NO!
- ✗ NO!
- ✗ NO!
- ✗ NO!

RF Heating for Disinfestation

In the 1980s Radio Frequency Disinfestation Systems were introduced to the manufacturers of cigars and cigarettes for the control of tobacco beetles. Since that time, tobacco beetles and other agricultural insects, such as granary weevils, confused flour beetles etc, have been consistently eradicated by RF heating systems in all life stages, adult, pupae, larvae and eggs. Test data indicates that total mortality is achieved with RF heating at temperatures as low as 58°C

Stem Temperature/Granary Weevil Mortality Results - Continuous Mode Testing				
Target Temp °C	Run	Avg Actual Temp °C	Mortality	Overall Temp Range
70	1	68.7	100% A,P,L,E	75
	2	82.2	100% A,P,L,E	
	3	74.4	100% A,P,L,E	
	4	73.3	100% A,P,L,E	
65	5	59.4	100% A,P,L,E	64.4
	6	66.1	100% A,P,L,E	
	7	66.7	100% A,P,L,E	
	8	66.1	100% A,P,L,E	
60	9	60	100% A,P,L,E	57.8
	10	61.1	100% A,P,L,E	
	11	60.6	100% A,P,L,E	
	12	48.9	100% A,P,L,E	

A=Adult, P=Pupae, L=Larvae, E=Eggs

A continuous flow treatment system for the pasteurization of grain.
In the photos below, bulk product is vacuumed from river barges into a silo. The Macrowave™ System, located at the bottom of the silo, is then fed by an auger into a product feed hopper for treatment.
After processing, the material is fed to a separate clean silo.
Proximity sensors in the feed hopper signal the auger when to add more product.



RF Heating for Pasteurization

In March of 2006, a Pasteurization System capable of providing a 5 log reduction for a particularly dangerous form of salmonella, *Enteritidis PT30* was developed.

Trial III Log Reduction Results									
Sample (Nuts)	1A	1B	1C	2A	2B	2C	3A	3B	3C
Pasteurisation Temp. (°C)	87.8			105.6			129.4		
Log Reduction - TSA	6.11	6.11	6.11	>6	>6	>6	>6	6.11	>6
Log Reduction - XLD	>6	>6	>6	>6	>6	>6	>6	>6	>6

Systems for pasteurizing bagged foodstuffs have also been provided for products such as pea starch, rendered animal products, fishmeal, various bean protein products, flax meal, nuts, spices, grains, wheat & maize meal, other agricultural products, and prepared food items.

Thermal Pasteurization/Disinfestation

Key Success Factors for any Thermal Pasteurization Process

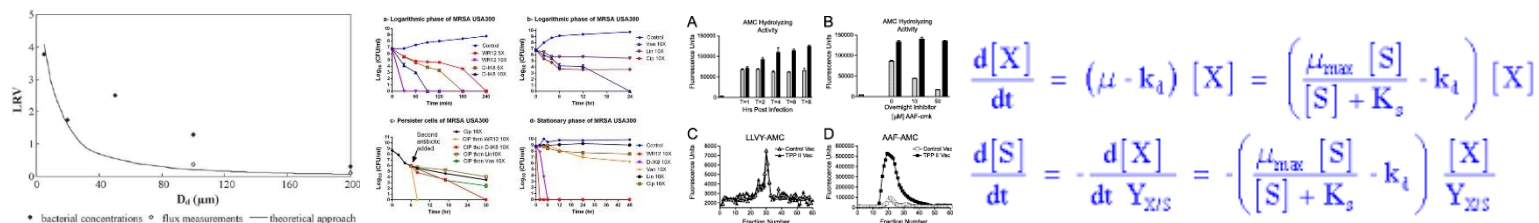
Combination of Temperature & Time

The higher the temperature, the shorter the time required to kill

Thermal Pasteurization/Disinfestation

Key Success Factors for any Thermal Pasteurization Process

Microbial Kinetics



D value. The time required at a certain temperature to kill 90% of specific bacterial populations or reduce the bacterial load by one log under specified conditions.

Z value. The change in the temperature, in degrees Fahrenheit (F) or Celsius (C), required to reduce the specific bacterial load by a factor of 10 or by one log.

Thermal Death Time (TDT). The shortest time needed to kill all bacteria or microorganisms in a product at a specific temperature and under defined conditions.

RF Pasteurization/Disinfestation

Key Success Factors for Dry Ingredients

Combination of Temperature & Time

The higher the temperature, the shorter the time required to kill

Achieving Hold Times

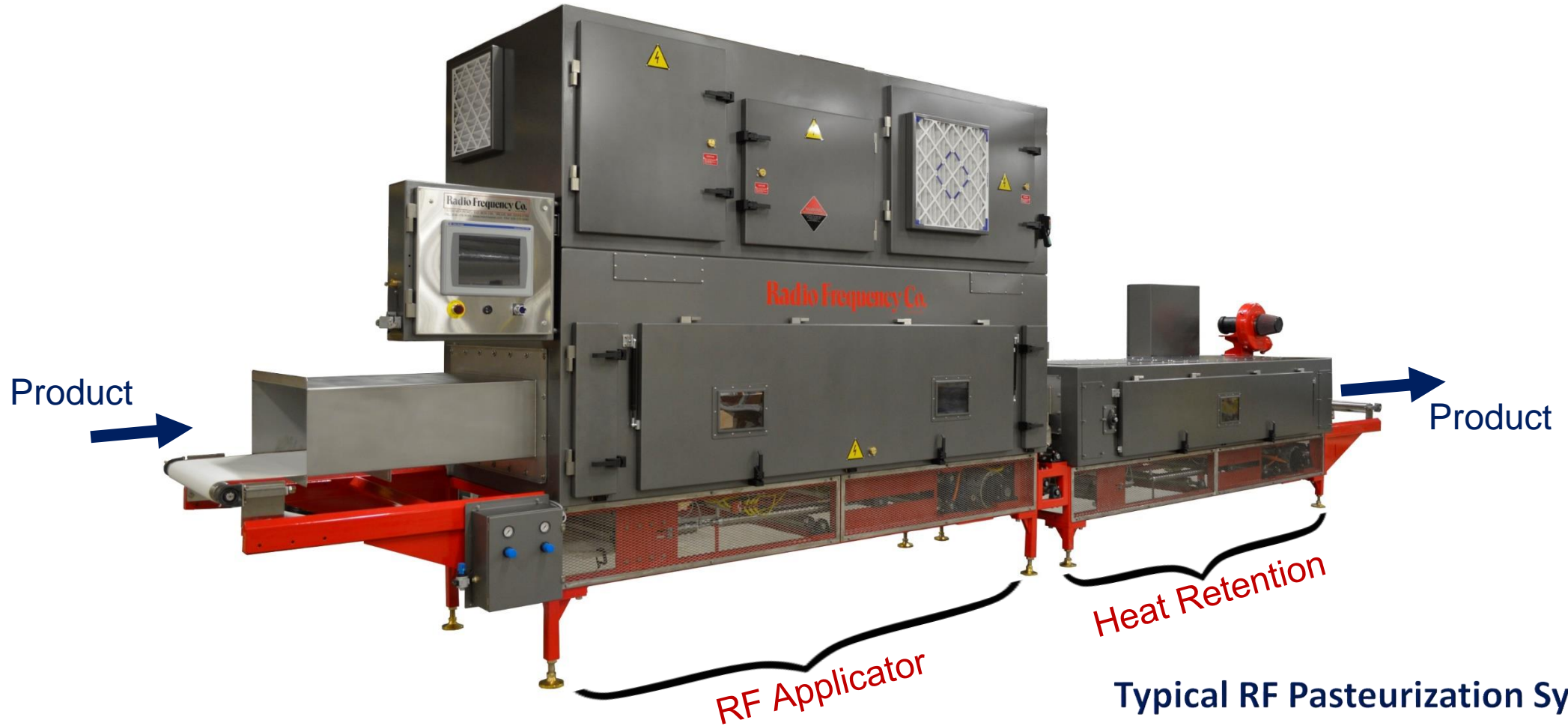
The applicator transition time needs to be sufficient

RF Pasteurization



Bagged RF Pasteurization System

RF Pasteurization



Typical RF Pasteurization System
with Heat Retention Zone

RF Pasteurization/Disinfestation

Key Benefits for Dry Ingredients

Volumetric Heating

No Temperature Differential from Surface to Center
No Prolonged Soak Time

Short Heating Cycle

Maintains protein and other organoleptic and nutritional qualities

Rapid Temperature Rise

Reduced ability for Insects or Microbes to Acclimate and Defend.
Kills them.

RF Pasteurization

20 tons
/hr



Large 400 kW Pasteurization System Example

RF Pasteurization



Small 80 kW Pasteurization System Example

RF Pasteurization

2
tons/hr



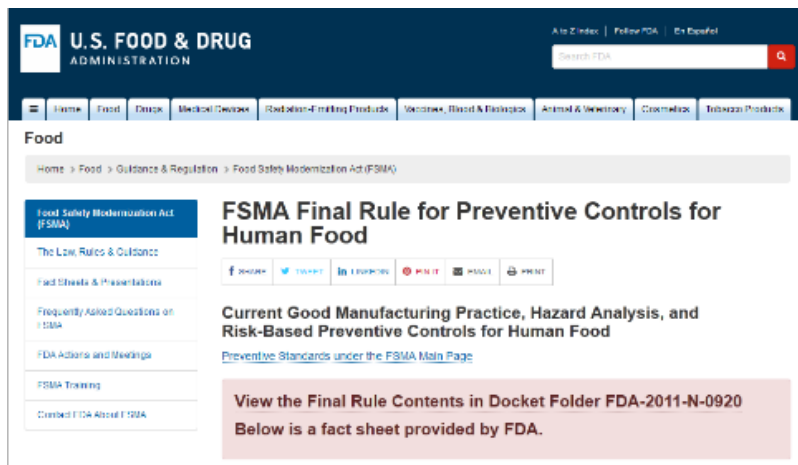
Compact 40 kW Pasteurization System Example

RF Pasteurization and Food Safety Acts



FDA FOOD SAFETY
MODERNIZATION ACT

Food Safety (FSMA) and Preventive Controls



The screenshot shows the FDA website's navigation bar with the U.S. Food & Drug Administration logo and a search bar. Below the navigation bar, the 'Food' section is highlighted. The main content area features the title 'FSMA Final Rule for Preventive Controls for Human Food' with social media sharing icons. A sidebar on the left contains links for 'The Law, Rules & Guidance', 'Fact Sheets & Presentations', 'Frequently Asked Questions on FSMA', 'FDA Actions and Meetings', 'FSMA Training', and 'Combined FDA Alerts FSMA'. A pink callout box at the bottom of the main content area reads: 'View the Final Rule Contents in Docket Folder FDA-2011-N-0920 Below is a fact sheet provided by FDA.'

Covered facilities must establish and implement a food safety system that includes an analysis of hazards and risk-based preventive controls. The rule sets requirements for a written food safety plan that includes:

Hazard Analysis

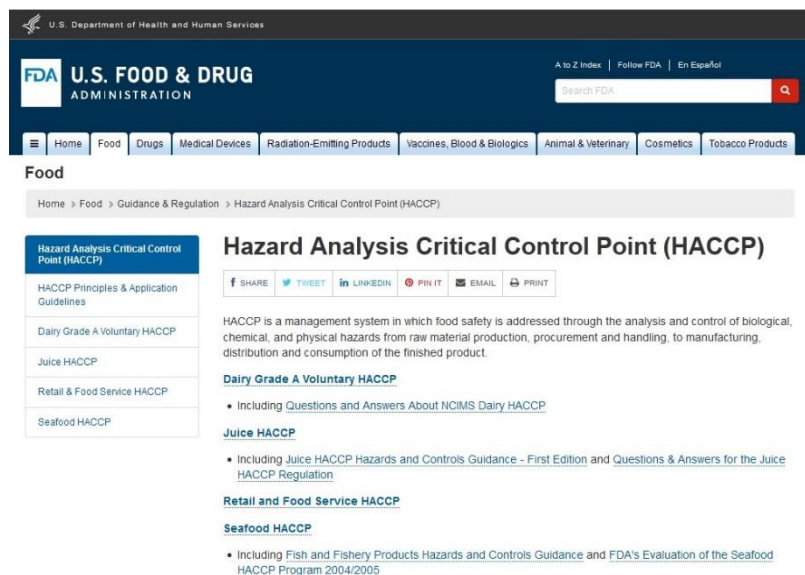
Preventive Controls

Oversight and Management of Preventive Controls

What is HACCP?

Hazard Analysis Critical Control Point or HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

The HACCP system is used to comply with Food Safety Hazard Analysis requirements.



The screenshot shows the FDA website page for Hazard Analysis Critical Control Point (HACCP). The page header includes the FDA logo and navigation links for Home, Food, Drugs, Medical Devices, Radiation-Emitting Products, Vaccines, Blood & Biologics, Animal & Veterinary, Cosmetics, and Tobacco Products. The main content area is titled "Hazard Analysis Critical Control Point (HACCP)" and includes a description of the system, a list of related resources, and social media sharing options.

Hazard Analysis Critical Control Point (HACCP)

HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

Dairy Grade A Voluntary HACCP

- Including [Questions and Answers About NCIMS Dairy HACCP](#)

Juice HACCP

- Including [Juice HACCP Hazards and Controls Guidance - First Edition](#) and [Questions & Answers for the Juice HACCP Regulation](#)

Retail and Food Service HACCP

Seafood HACCP

- Including [Fish and Fishery Products Hazards and Controls Guidance](#) and [FDA's Evaluation of the Seafood HACCP Program 2004/2005](#)

Is RF a Food Safety (FSMA) Preventive Control (Kill Step)?

In a word?



The RF Pasteurization System can be implemented as a Preventative Control, and as a thermal process, provides a Kill Step, which can be validated for compliance documentation.

What is Kill Step Validation?



Kill-step validation is a preemptive scientific evaluation that provides documentary evidence that a particular process (e.g. fumigation, chemical treatment, cooking, frying, extrusion, etc.) is capable of consistently delivering a product that meets predetermined specifications.

A successful validation study requires diverse expertise, detailed design, an experienced micro/biologist, a statistician, and a keen eye for sources of process variability. (RF experience)

What is Kill Step Validation?

A RF Pasteurization System Validation usually consists of a laboratory growing a surrogate for the targeted infestation, fungus or pathogen, and the microbiologist inserting packets of the insect/surrogate within the product itself, which is then treated by RF in a production environment. The packets are then retrieved from the product and returned to the laboratory for analysis against a control sample.



The analysis is presented to the client, which demonstrates that if the product is processed within a given set of parameters, the log reduction is expected to be within acceptable levels.

Is RF Pasteurization Food Safety (FSMA) Compliant?



The RF Pasteurization System, as a Critical Control Point, must be designed with Food Safety oversight and management in mind.

Monitoring, Corrective Actions and Corrections, and Verification are components of an oversight and management system

In most cases, each product (not kill target) will have its own treatment protocol. Accordingly, the treatment process parameters are recipe selectable from the Human/Machine Interface provided on the machine.

Is RF Pasteurization Food Safety (FSMA) Compliant?

Monitoring:

All set-points and process variables that affect product temperatures and exposure time are monitored by the system.

Is RF Pasteurization Food Safety Food Safety (FSMA) Compliant?

For example in a bulk processing system with a heat retention zone the product temperature is monitored at two critical locations.

- 1 After the RF heating to ensure the product achieved the target temperature
- 2 At the end of the heat retention zone to ensure the product remained at the target temperature for the entire retention time



Is RF Pasteurization Food Safety (FSMA) Compliant?

Corrective Action:

In the event of a process variable going out of specification, or a critical fault occurring, the event is recorded and the product stream is stopped or diverted to prevent it from entering the commercial area.

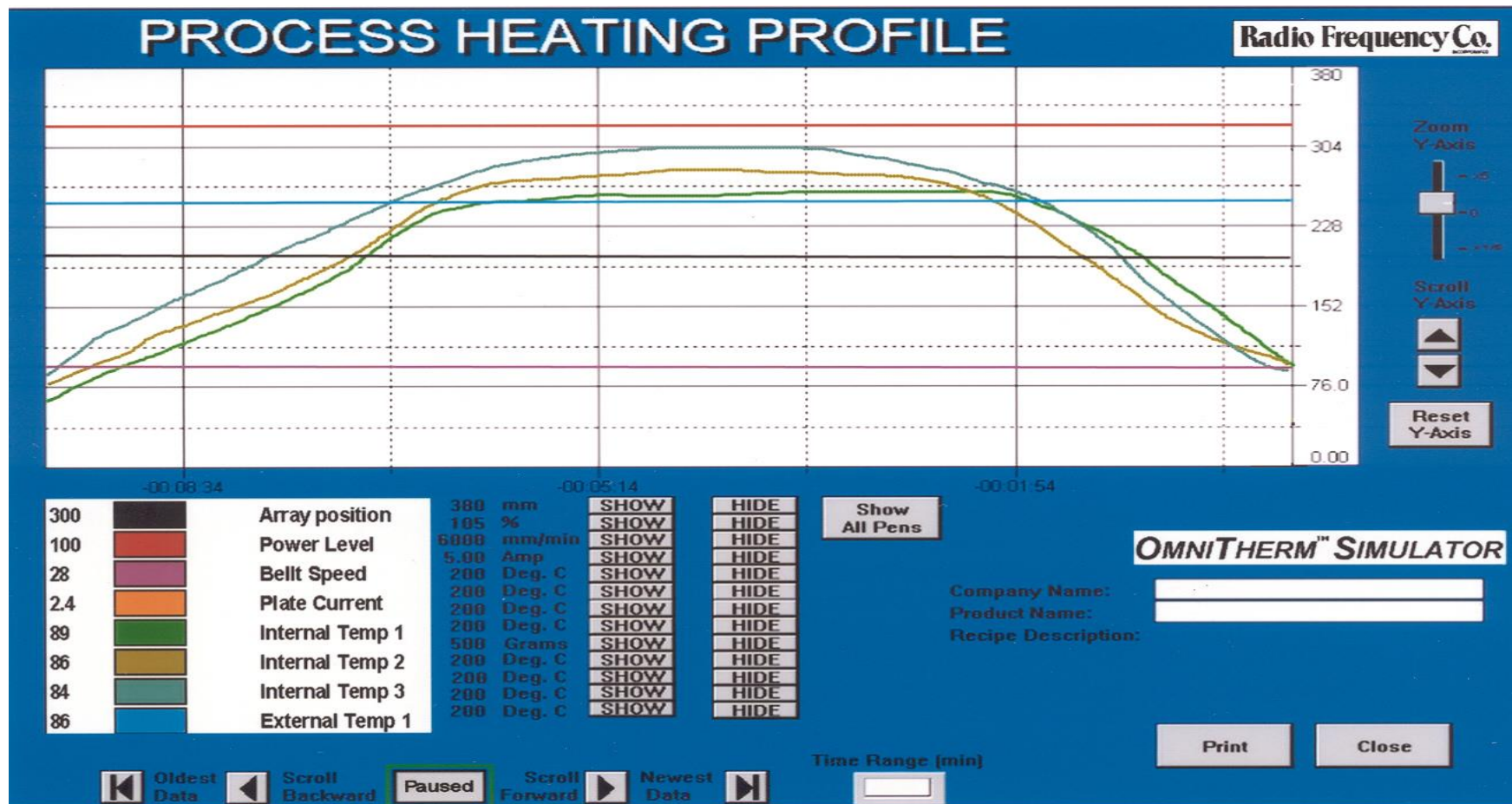
Is RF Pasteurization Food Safety (FSMA) Compliant?

Verification:

All of these critical process setpoints and variables must also be archived with reference to the product code and lot numbers being processed to establish an audit trail. This data can be reviewed in the future to demonstrate the validated time/temperature profile, and other established criteria, was adhered to during processing and therefore the product was successfully pasteurized/disinfested.

Is RF Pasteurization Food Safety (FSMA) Compliant?

Screen Shot of Real Time Data Trending and Archiving



Does this contribute to Brand Protection?

In 2016 (USA) a major manufacturer was forced to recall 22,000 tons of retail flour. Downstream commercial customers were impacted as well because they used potentially tainted flour as an ingredient.

The cost of notification, product retrieval, potential liability, preventative measures at numerous process points, and repairing public relations is a huge expense, easily mounting into the millions of Rands.

Does this contribute to Brand Protection?

While RF Pasteurization Systems are primarily targeted at grain, grain products, RTE and other high risk applications,

RF Pasteurization contributes not only to Brand Protection,
but to **Business Protection!**

Conclusion

RF is a proven thermal technology for pasteurization, disinfection and drying used in various industries for 70 years

With uniform controllable heating profiles and proven performance, RF Pasteurization has also become fully commercialised

Conclusion

RF Pasteurization is a USDA Organic Thermal Process

FDA Clean Label

FSMA compatible as a Critical Control Point Kill Step

Able to be validated to comply with FSMA or any other Food Safety regulation

RF Pasteurization truly is the *wave* of the Future

© MMXVII AE Solutions (pty) ltd