Department of Biosystems and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

BE 487 - Spring 2025
Biosystems Design Projects

Preventing Foreign Material Contamination in Corned Beef Through Detection

(Under CDA)

Quinn Armstrong, CJ Buchta, Avery Partlow, and Kelley Titus
Client: Amber Mostiller Faculty Advisor: Dr. Ilce Medina-Meza

Background

E.W. Grobbel is a corned beef processing facility based in Detroit, Michigan. In the food industry, it is a widespread practice to stay above regulations and combat problems before they become an issue. This ideology caused E.W. Grobbel (also known as Grobbel) to explore their foreign material contamination procedures. Foreign material is any non-food body not typically part of the food [1]. Foreign Material Contamination (FMC) is a large concern due to adverse health effects like choking, cuts, sores, and illnesses [2]. Examples of foreign material that have been found in Grobbel's facility are pieces of nitrile and chain mail gloves, pieces of blue plastic from the conveyor belts seen in Figure 1, metal shards from slicing blades, and scrub pad remnants as seen in Figure 2.


Figure 1. Food-grade conveyor belt


Figure 2 Scrub pads used for cleaning

Most instances of foreign material contamination occur due to unintentional introduction into food, and effective control and detection measures must be established to minimize this occurrence [3]. Designing a Foreign Material Control and Prevention Program (FMCPP) is an effective way of identifying and preventing foreign material contamination. One specific sector of Grobbel's company is the direct-to-deli area, where corned beef slabs, seen in Figure 3, are sold in kegs filled with brine.


Figure 3. Corned beef slabs


Figure 4. Keg packaging area

The direct-to-deli packing area can be seen in Figure 4. This area does not currently have detection methods in place, so the team chose to focus on this product for the project.

Objectives

- Identify five top risks of foreign material contamination within the food processing areas
- The design must reduce potential customer waste volume by 50%
- The design must remove/detect plastic and metal contaminants greater than industry size constraints of 1.25 mm

Constraints

- Cost near $200,000
- Complete by April 2025
- Less than 8ft wide
- Fit USDA-approved boundary of the facility
- Meet all FDA regulations of food safety

Design Alternatives

To determine where in the process detection methods should be implemented, a Hazard Analysis Critical Control Point (HACCP) flowchart was created, seen in Figure 5.

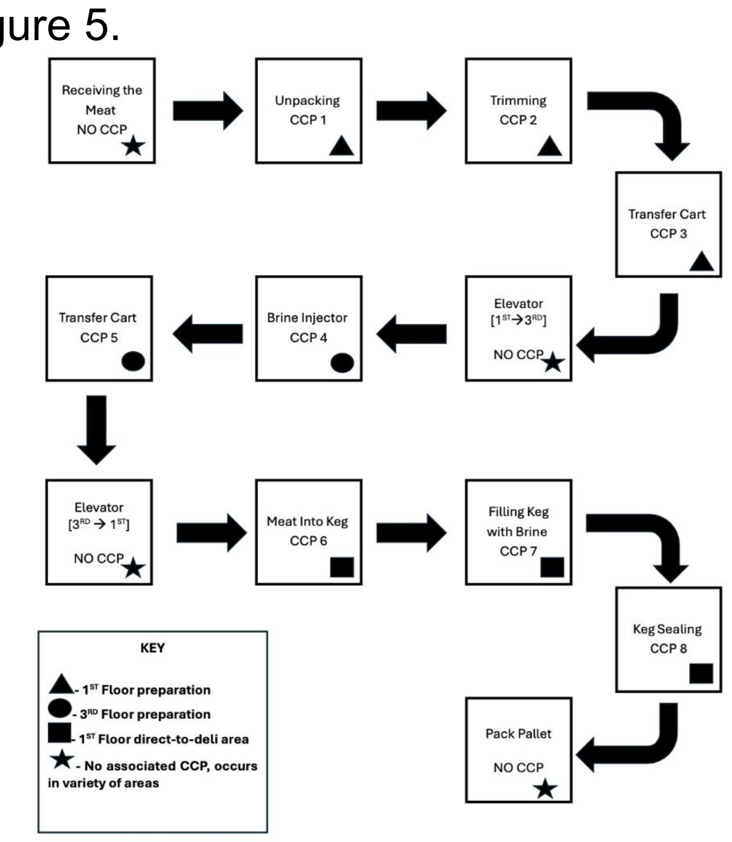

Figure 5. HACCP Flowchart for Direct-to-deli process

This outlines the entire process from raw product to finished product, while labeling each step where there is potential for a food safety hazard and where control measures should be put into place as a Critical Control Point (CCP). A decision matrix was created to determine the CCP with the highest risk, in addition to CCP 8, the final sealed product. Once the CCPs were chosen, the next step was to choose the most suitable detection method. The following are the most common detection methods in the industry:

- X-ray
- Metal detection
- Imaging/AI
- Ultrasound
- Visual inspection

X-ray and metal detection are most practical for this project and the product. X-ray can detect the non-metal contaminants such as nitrile gloves and conveyor belt pieces, while also detecting metals. For this reason, X-ray detection was chosen for the final sealed product, after the keg has been filled with meat and brine. The second CCP that was chosen to focus on was CCP 6, when the meat is being placed in the keg. The most practical detection method for this CCP that is not redundant to CCP 8 is visual inspection. This involves the operator inspecting the meat before placing it into the keg for foreign material contamination.

Selected Design

The selected design is the XR-8040B X-ray inspection system from TDI Packsys, as seen in Figure 6.


Figure 6. Selected X-ray machine from TDI Packsys

This X-ray detects metals within the 1.25 mm standard and detects other materials between 2-5 mm. This system has an inspection width of 31.49 in and an inspection height of 15.74 in. The X-ray is 4.5 ft wide, 3.8 ft long, and 7 ft tall. X-ray emissions are lower than 1 micro-Sievert per hour, which falls below FDA standards. The FDA states that X-ray emissions must not exceed exposure of 0.5 milliroentgens per hour, which is equivalent to approximately 4.385 micro-Sieverts per hour. [4] The X-ray material consists of heavy gauge 304 stainless steel.

This X-ray has an automated rejection system. When a contaminated keg is rejected, Grobbel's quality assurance team will inspect the keg and dispose of the product through a rendering process.

Floor Layout

To implement the selected X-ray design, the floor plan layout needed to be re-organized. The re-organized and original floor plans can be seen in Figure 7.

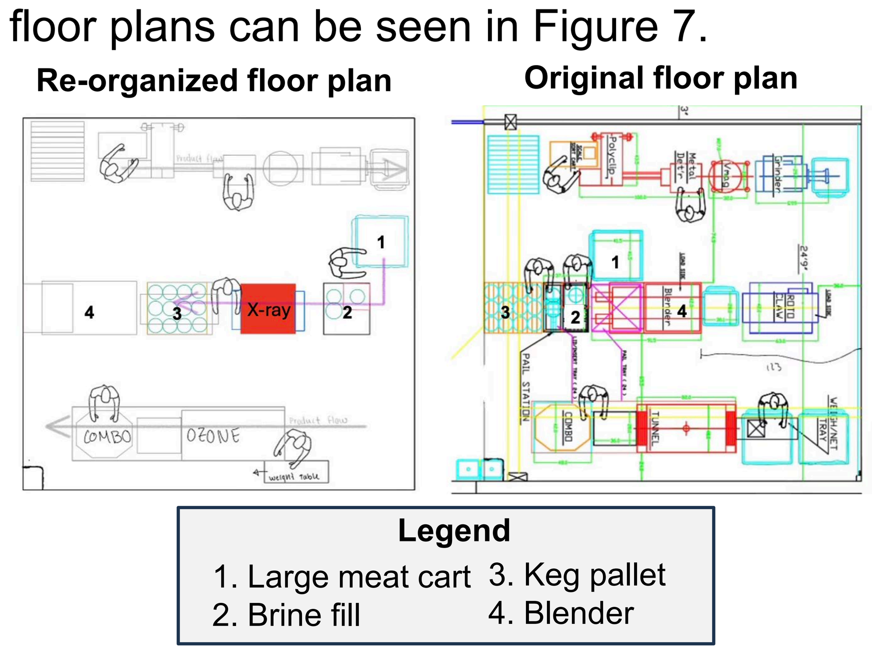

Figure 7. Re-organized floor plan

All gray items in the left image represent objects not-in-use during keg-line operation, and the colored items represent the keg-line. The re-organized layout depicts product flow with arrows, which is not included in the original layout. The only sector of the layout that was reorganized is the center section of the line. The blender was moved from the middle of the line to the left most side. The X-ray was implemented in the center of the keg-line.

Secondary Designs

The team also suggests two secondary designs: keg-rinsing with brine and clear plastic vinyl curtains. Keg-rinsing with brine is suggested as an additional sanitation practice before keg-filling. A brine rinse will remove loose pieces of plastic inside the kegs. The plastic kegs are susceptible to holding chipped pieces of plastic, as no process is currently in place to wash the kegs before use. The kegs can be rinsed with a contraption like the Mark II Keg and Carboy Washer, as seen in Figure 8.


Figure 8. Mark II Keg and Carboy Washer

The keg is placed upside down onto this washer where brine will be sprayed for about five seconds. The brine used to rinse the keg will be disposed of and will not be used for keg filling. If Grobbel were to implement a keg washing system similar to the Mark II Keg and Carboy Washer, the team suggests implementing a filter system to prevent recirculation of contamination. The team recommends a catchment system leading to a separate effluent, keeping the brine that rinses the bucket out of the bottom catchment. Another recommendation is adding a brine inlet to the bottom catchment, constantly adding fresh brine to the catchment system.

Clear plastic vinyl curtains are suggested to be implemented in the direct-to-deli room. These curtains can be seen in Figure 9.


Figure 9. Clear plastic vinyl curtains

No practices are currently in place to separate the keg-filling area from other nearby processes. Vinyl curtains will function as a barrier to potential contaminants coming from the open space. Three curtain straights can be installed along the walkway of the direct-to-deli room. The curtain dimensions are as follows: 24 in. wide by 180 in. tall, 150 in. wide by 180 in. tall, 178.8 in. wide by 180 in. tall. The curtains are channel style curtains with ceiling mount hardware.

Economics

The team's initial project budget was $200,000. The total upfront cost include the X-ray, X-ray commissioning, the Mark II Keg and Carboy Washer, and clear vinyl curtains as outlined in Table 1 (some under CDA).

Table 1. Economics

Total upfront cost		[redacted]
X-ray (5-year lifetime)		[redacted]
Commissioning		[redacted]
Mark II Keg and Carboy Washer		$97
Vinyl curtains		$1,802
Annual maintenance		[redacted]
Total present value cost (PVC)		$260,195

The X-ray has an estimated 5-year lifetime. The Total Present Value Cost (PVC) was calculated to be $260,195. To cover the total cost of machine implementation, it is recommended to increase the cost per unit of the kegs which are sold to the consumer (delis). The cost increase per unit was calculated by dividing the PVC by the product of the machine lifetime and units sold per year, as seen below in Equation 1.

$$(1) \quad Cost\ increase\ per\ unit = \frac{PVC}{(Lifetime) * (A)}$$

PVC = Total Present Value Cost ($)
Lifetime = Machine Lifetime (years)
A = Annual units sold (kegs)

Select References

[1] Khairi, M. T. M., Ibrahim, S., Yunus, M. A. M., & Faramarzi, M. (2018). Noninvasive techniques for detection of foreign bodies in food: A review. Journal of Food Process Engineering, 41(6). https://doi.org/10.1111/jfpe.12808

[2] Smith, G. C. (2022, December 8). Extraneous & foreign material in food: Safety & consumer displeasure. FSNS. https://fsns.com/extraneous-foreign-material-in-food-safety-consumer-displeasure/

[3] Dumas, D. R. (2018). Foreign material identification and removal in the food safety industry. North Dakota State University. https://core.ac.uk/download/pdf/211309671.pdf

[4] Food and Drug Administration. (2020, September 28). *Cabinet x-ray systems (closed x-ray systems).* https://www.fda.gov/radiation-emitting-products/security-systems/cabinet-x-ray-systems-closed-x-ray-systems#:~:text=The%20FDA's%20radiation%20safety%20performance,the%20public%20from%20radiation%20emissions.