Foreign Material Detection and Control

FSIS Meeting

Omaha, NE

Sept. 24, 2002

FDC Act

- 402(a)(3)
  - "…consists in whole or in part of any filthy, putrid, or decomposed substance or is otherwise unfit for food…"
- 402(a)(4)
  - "…prepared packed or held under insanitary conditions whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health…"

GMP 110.40(a) Equipment and Utencils

- "...design construction, and use of equipment and utencils shall preclude the adulteration of food with lubricants, fuel, *metal fragments*, contaminated water, or any *other contaminants*..."

GMP 110.80(b)(8) Manufacturing Operations

- "…Effective measures shall be taken to protect against the inclusion of *metal or other extraneous materials* in food. Compliance with this requirement may be accomplished by using sieves, traps, magnets, electronic metal detectors, or other suitable effective means…"

Controls Necessary

- Required to control ‘adulteration’
- Specifically included in ‘HACCP’- physical hazards
  - Prerequisite Programs
  - CCP (?)
- Allow judgement of system integrity
- Prevent customer complaints

Control Program

- Incoming ingredients/raw materials
- Equipment protection
- After equipment which may fail or cause foreign materials
- End of system (e.g. packing, load out points)

Ingredients/Raw Materials

- Preventive approach
- Supplier performance measure
- GMP 110.80(a)(4), other regulations
- Down time and associated costs

Equipment Protection

- Protect expensive, sensitive equipment
- Examples: cutters, grinders, extruders, pumps, etc.
- After equipment which may generate-
  - cutter blades
  - mechanical wear points
- Maintenance/cleaning activity
- Break system into measurable parts

End of Systems

- Verification of overall program effectiveness
- ‘Proof’ of compliance- regulatory implications
- Protection against customer issues

Detection/Control Devices

- Magnets
- Screens/Scalping/Sifting
- Metal Detectors
- X-Ray Devices

Magnets

- Used to remove fine metals, not horseshoes
- May require several passes to retain ‘paramagnetic’ materials
- To protect equipment, particularly in explosive atmospheres

Magnet Function

- Attraction proportionate to size
- Strength varies by inverse square of distance from surface
- Field cannot be insulated
- Can be demagnetized by abuse: extremes of heat, proximity of opposing fields, disassembly, etc.

Magnet Types

- Plates
  - for chutes or spouts, can be suspended
  - barrier or taper steps catch small contaminants
- Humps
  - two or more plates in series
  - for use on free-flow materials
  - can catch hard to collect pieces
  - can be used in gravity or pneumatic spouting with proper housing

Magnet Types

- Bar
  - designed for fine contaminants in shallow product streams
  - product must be free-flowing
- Grate
  - for fine and small contaminants
  - materials washed to underside of bar stream
  - must be free flowing (no choke feed)
  - metal must be in contact with bars

Magnet Types

- Liquid traps
  - group of round bars vertically installed in pipe fitting
  - contaminants washed to downstream side of bars
  - viscosity of material in stream affects results- may need series of traps
  - available in sanitary versions
  - plate liquid trap also available with fitted baffle to direct stream down onto magnet surface

Magnet Selection

- Must consider types of expected contaminants
- Must be sized to capacity of site
- Flow characteristics must be considered
- Fabrication and construction are important
- Prior planning required to select strength, assure access

Magnet Checks

- Access to magnet is Critical!
  - Up to the magnet
  - Into the magnet
  - At floor or platform level if at all possible
- Best: ability to check during operational conditions

Magnet Checks

- Heavily contaminated magnets lose separation ability-
  - pulling and holding power decreased
- Expect complete cleaning and removal of any metallic materials
  - supplier performance implications
  - timing for decision making
- Understand product flow, accumulations

Magnet Program

- Determine frequency of checks
- Describe documentation of checks and findings
- Collect and evaluate ANY findings
- Documentation of evaluations and follow-up actions

Scalping/Sifting

- Sieves and screens to detect/remove materials of differing size
- May be used to detect oversized or undersized materials
- Capability dependent on differences in particle size
- Effective on dry and liquid systems

Screening/Scalping

- Requires prior planning
- Must be matched to system
  - purpose intended
  - location in the system
  - screen size and type
    - nylon
    - wire
    - plate

Screening/Scalping

- Throughputs must be taken into account
  - open area of screen
  - available footprint
- Particle sizes define separation capabilities
  - bulk density is key

Screen/Scalp Types

- Flow-through screens
  - pump liquids through screen traps
  - round hole, slots, wire sieve
- Vibratory
  - screen placed in product conveying bed
  - depth of bed and particle size affect tailings quality

Screen/Scalp Types

- Sweco
  - circular vibration for reduced footprint
  - vigorous screen movement can increase separation rates
  - may damage products
- Box sifter
  - gentle motion over screen surface
  - usually for fine particles
  - allows greater cloth surface

Screen/Scalp Types

- Turbo sifters
  - high speed rotary device within round horizontal screen assembly
  - rotary paddles throw material against the screen surface
  - may actually break-up foreign objects
- Many not considered effective as product protection devices!

Scalper Tailings

- Must maintain integrity of screen capture/tailings observations
  - covers in place
  - containers dedicated and identified
- Must be able to collect tailings
- Some screens/sifters may not ‘empty’
- Screens must be checked periodically for integrity

Scalper Tailings

- Determine frequency of tailings and screen checks
- Document findings for evaluation
- Document maintenance of screens/sifting devices
- Documentation of evaluations and necessary action steps

Metal Detectors

- Use electronic field to detect metallic objects
- Detection capability
  - ferrous materials easiest
  - stainless steel hardest
  - non-ferrous metals (e.g. copper, lead, aluminum) fall in between

Detector Principles

- Balanced three coil system
  - center coil transmitter
  - two coils on either side act as receivers
  - coils identical distance from transmitter pick up the same strength of signal
  - metallic particle moving through the aperture changes signal strength
  - change is amplified and processed electronically to produce ‘detection’

Sensitivity Factors

- environmental conditions
- product moisture
- salinity/pH
- temperature
- operating speed
- throughput rate
- variation in product size
- type of metal
- shape of metal
- orientation of metal
- aperature dimensions
- position of metal in aperature

Detector Spheres

- The standard method of checking sensitivity
- Constant shape within the aperture opening
- Easily described- clarifies communication

Detector Function

- Two parts to successful operations
  - sensitivity achieved
  - rejection of material or other operational confirmation
    - Collect rejects for evaluation
    - Use ‘Fail Safe’ installation

Great, but...

- Orientation effects on long contaminants
- May not be 100% effective
- Drift on sensitivity or reject device can change capability
- Operators may not know ‘standards’ or check procedures
- Product effect may limit sensitivity

Ball Size and Wire Size

Spherical Sensitivity (Fe Ball)	Steel Paper Clip Dia 0.95mm (0.037")	Tinned Copper Wire Dia 0.91mm (0.036")	Copper Wire Dia 1.37mm (0.054")	Stainless Steel EN58E Dia 1.60mm (0.063")
1.2 mm	1.5 mm long (0.06")	3.5 mm long (0.14")		
1.5 mm	3.0 mm long (0.12")	9.0 mm long (0.36")	3.0 mm long (0.12")	8.0 mm long (0.31")
2.0 mm	6.0 mm long (0.24")	26.0 mm long (1.02")	8.0 mm long (0.31")	24.0 mm long (0.96")
2.5 mm	11.0 mm long (0.44")	55.0 mm long (2.17")	18.0 mm long (0.72")	64.0 mm long (2.52")

Each Item Drawn to Scale

Product Effects

- Dry products allow higher frequency operation- better stainless detection
- Wet products require lower frequency operation- geared to ferrous detection
- Moisture/salinity and shape may show large product effect

Ball Size and Wire Size

Safeline PowerPhase Metal Detector

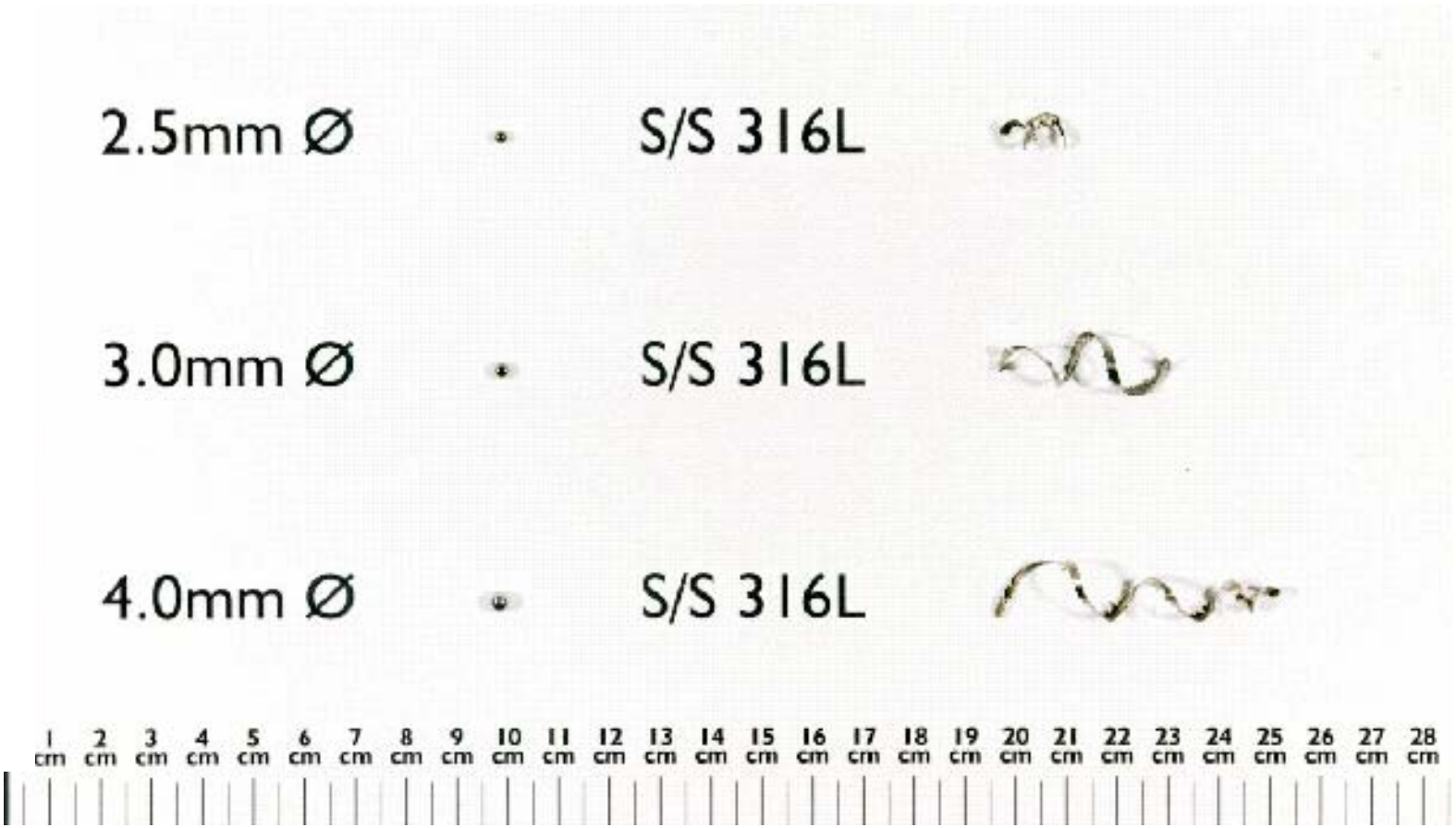
at 0° Phase

Ferrous Ball Size Sensitivity	Length of 2.3mm SS Wire Worst Orientation	Length of 2.3mm SS Wire Best Orientation
2.5mm	16 mm	8 mm
3.0 mm	34 mm	17 mm
3.5 mm	74 mm	37 mm
4.0 mm	- *	65 mm
4.5 mm	- *	95 mm

Low Frequency Operation

* - When wire length becomes longer than Metal Detector Coil Pitch it will no longer be detectable in this orientation

Size of Swarf v.s. Fe Ball Sensitivity



Detection Program

- Confirm operation of checks
- Confirm documentation of checks and findings
- Documentation of actions taken and investigation results

X-Ray Devices

- Operates on differential absorption
- Absorption related to product density and thickness
- Density of ‘targets’ and substrate affect detection/identification

X-Ray Devices

- Principle of operation
  - x-ray fan beam projected onto diode array
  - scintillator converts to visible photons
  - photodiodes register pass-through energy
  - absorption of energy measured to create ‘picture’
  - electronically compared to ‘standard’
  - ‘reject’ or signal triggered

X-Ray Devices

- Units available for linear transfer or enclosed liquid systems
- Has capability to detect some sizes of contaminants (i.e. metals, glass, maybe bone, etc.)
- Software program to interpret image is critical component

Capability

- Sensitivity determined by number of photodiodes in array
- Resolution affected by product speed through detector
- Absorption affected by density differential between ‘contaminant’ and substrate
- Software enables differentiation

Capability Advantages

- Sees through aluminum materials
- No freeze/thaw effects
- Salty/wet/variable fat content- no effect

Selection Considerations

- Requires larger foot-print
- Not for drop-thru application
- Must know application- expected contaminants (density)
- Line speeds operate lower than metal detectors (up to 400fpm vs. 700fpm)
- Contaminant shape and orientation affects capability

Density Values (water=1.0)

Metallics:	Aluminum	2.7
	Bismuth	9.8
	Brass	8.5
	Bronze	8.8
	Copper	8.9
	Lead	11.3
	Stainless steel	7.9
	Mild steel	7.8
	Titanium	4.5

Density Values (water=1.0)

Non-metallic:	Bone	1.8
	Concrete	2.4
	Epoxy resin	1.1
	Crown glass	2.6
	Flint glass	4.2
	Nylon	1.15
	Polyethylene	0.94
	Polypropylene	0.90
	Rubber	0.9

Orientation Effect

- Location of object within product
  - On top easier to find
  - Buried within product more difficult
- Objects smaller than test sphere
  - If on edge- needs to be as deep
  - Flat pieces need to have necessary depth

Software Enables Capability

- Dependent on each application situation
- Manipulation of grayscale values allows multiple factor evaluation
- Software allows analysis by programmed shapes- round, long, etc.

Foreign Material Control

- Sources within facilities are many and varied- e.g. ingredients, systems, people
- Required to assure compliance
- PREVENTION of issues is key
- Many factors determine selection
- Active documented monitoring and evaluation procedures are required

Conclusion

- Detection equipment is required
- Prior planning makes it work better
- All parts of the program must work-include employee training
- Proper operation and documentation must be expected
- Findings require evaluations, follow-up
- Records are important