Quickly Identify and Source Foreign Material Contaminants Found in Food Products with Handheld XRF

Bruker Nano Analytics Webinar
July 1, 2021

Speakers

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Webinar Agenda

01 Introduction

02 Objectives

03 Managing the prevention of physical contaminants in food products

04 How handheld XRF technology helps quickly ID and source foreign objects

05 Creating a spectral fingerprint library with handheld XRF

06 Matching contaminants with a spectral fingerprint library and Artax PC software

07 Food Contaminant characterization with micro-XRF technique

08 Summary

09 Questions & Answers

02 Objectives

Webinar: Quickly Identify and Source Foreign Material Contaminants Found in Food Products with Handheld XRF

Objectives

No manufacturer wants physical contaminants found in their products, but it happens. The faster you can identify it and determine if it is from faulty equipment, starting material, or even a false claim, the faster you can get production going again and minimize costs.

- Illustrate how handheld XRF can decrease the time required to ID a physical contaminant and locate its source
- Describe nondestructive handheld XRF technology and how it is used
- Explain how XRF spectral fingerprinting works to help find the source of contaminants in complex situations
- Describe best practices in creating a production floor ID data library of XRF spectral fingerprints
- Illustrate best practices in identifying contaminants with XRF spectral fingerprint matching software

03

Managing the prevention of physical contaminants in food products

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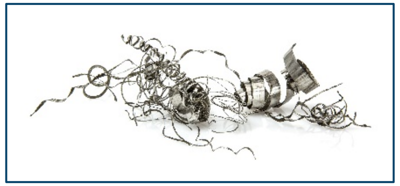
Physical contaminants can be found in food products

Metal slivers and shards



Plastic and rubber pieces

Glass fragments

Stone and ceramic chips

Managing prevention of physical contaminants in end products

Typical prevention

1. **Inspect** food material with X-ray or metal detector
2. **Detect** foreign body
3. **Remove** product containing foreign body

Enhanced prevention

1. **Identify** found contaminant to determine its source
2. **Correct** issue based on source of the contaminant

Potential sources of metal contaminants in manufactured foods

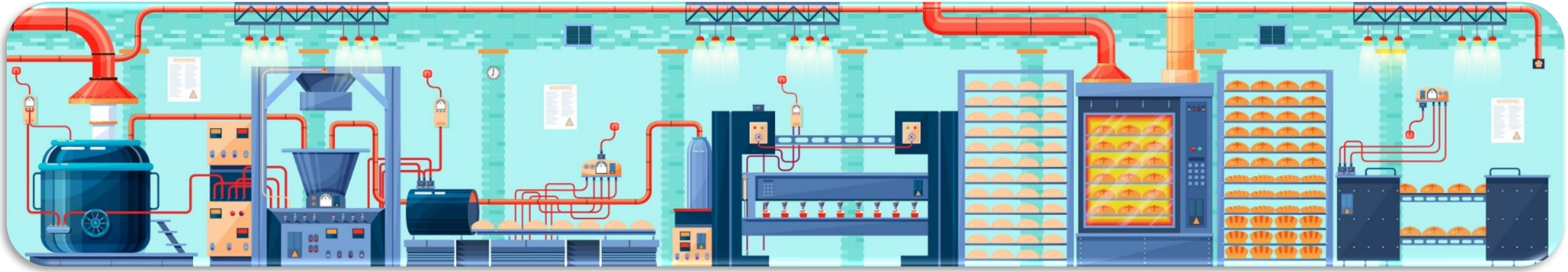
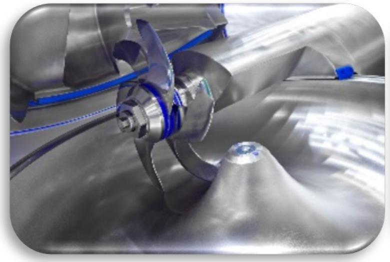


Illustration of baking production line equipment

Auger

Conveyor

Grinder/cutter

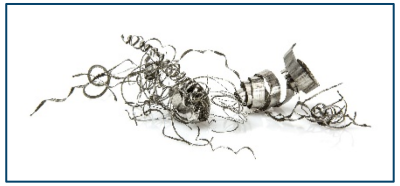


Mixer

Roller mill

Sorter/packager

Identification of the contaminant is critical


Metal


Glass


Plastic and rubber


Stone and ceramic

- Enhances physical contaminant QA/QC programs
- Monitors equipment for maintenance
- Reduces future delays in production
- Increases confidence in suppliers
- Assists with false claim investigations
- Helps optimize overall risk management

04 How handheld XRF technology helps quickly ID and source foreign objects

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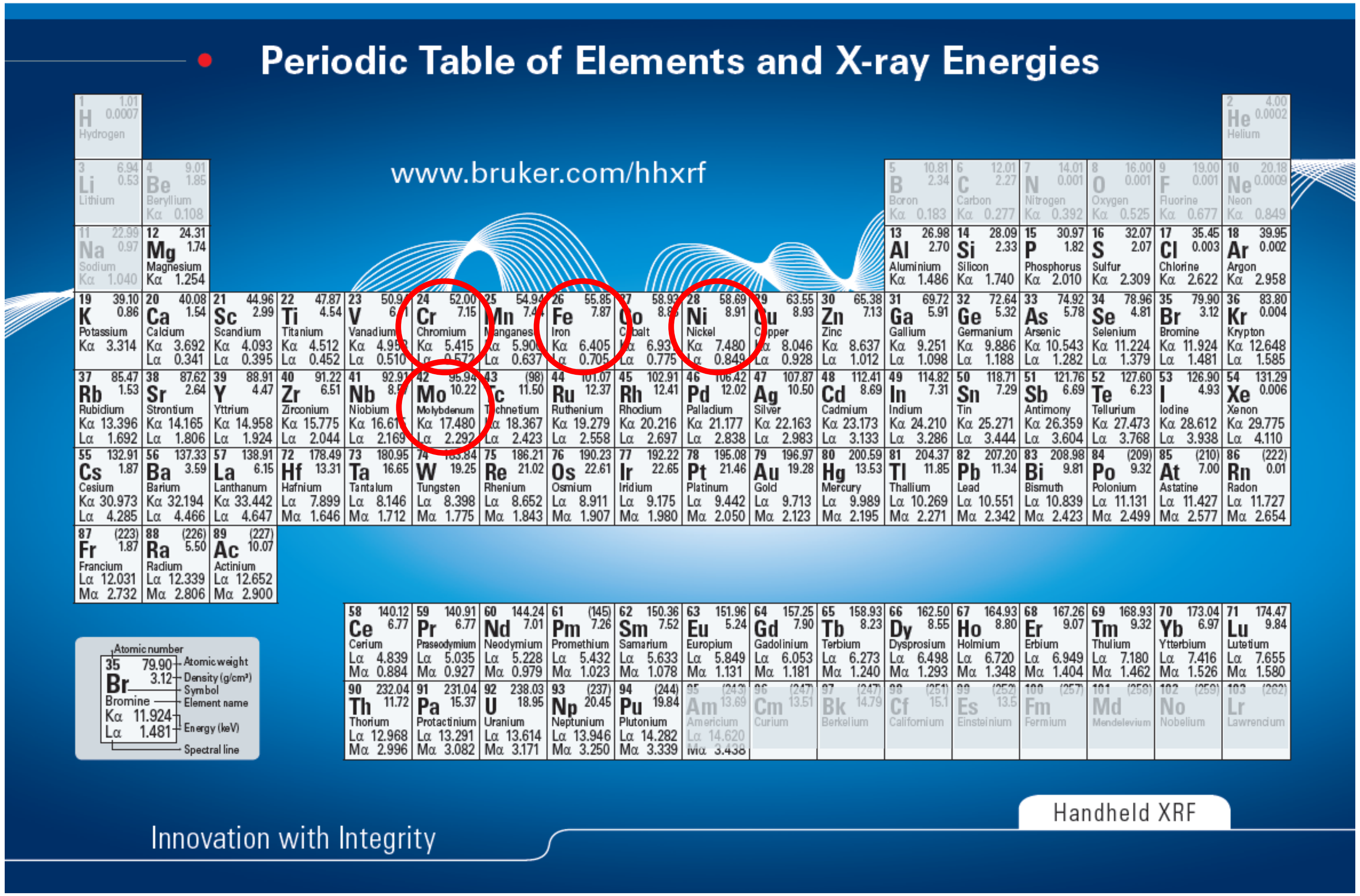
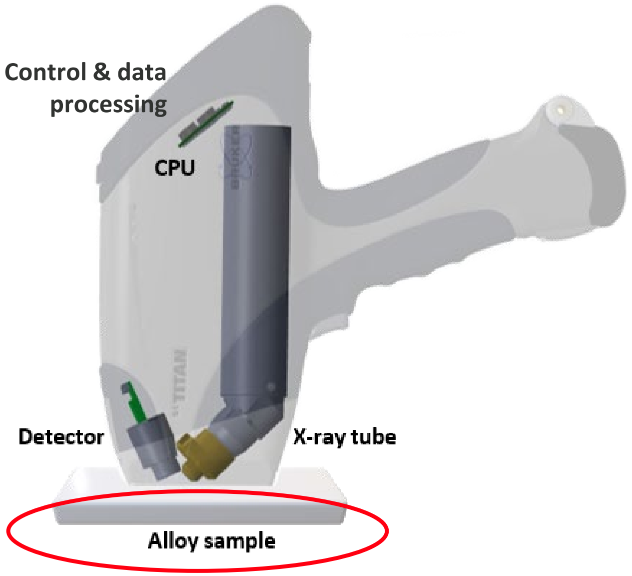
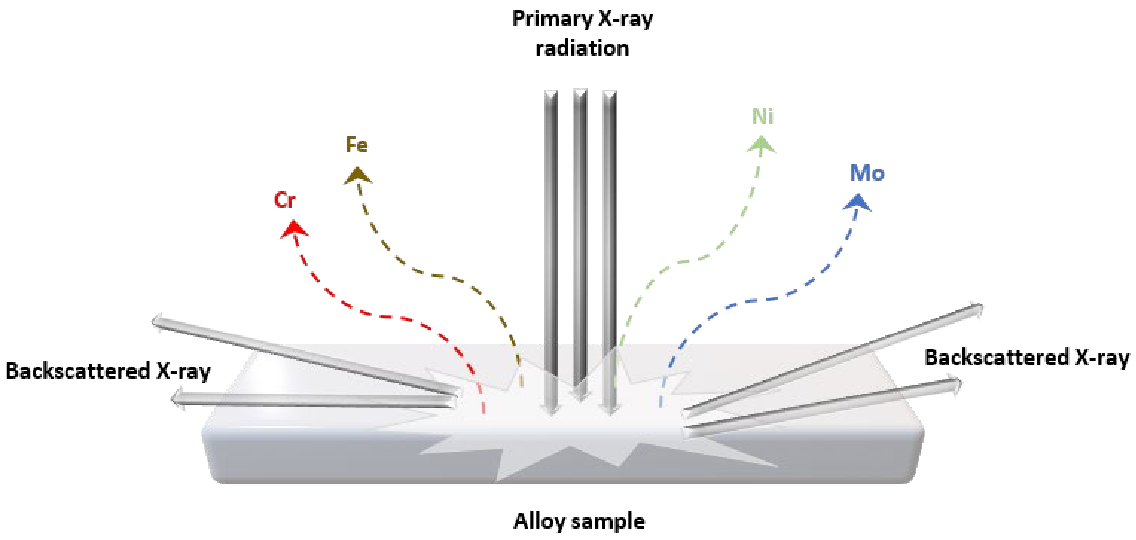
Handheld XRF technology

- Easy to use
- Nondestructive
- Instant result
- Portable
- Used on site
- Cost effective
- Accurate



Handheld XRF technology

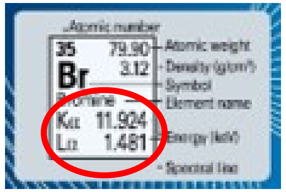


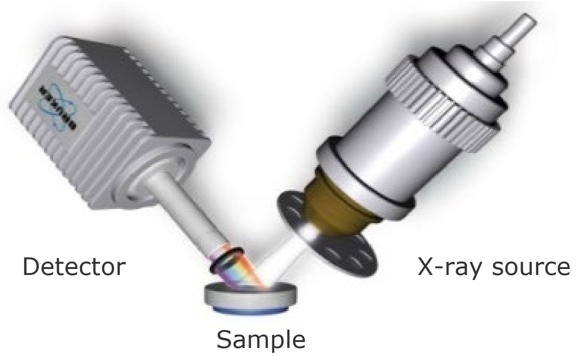


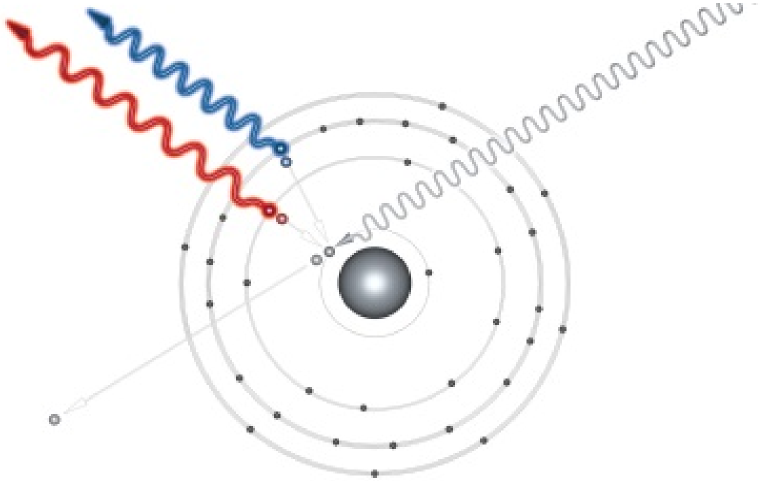
Handheld XRF technology

Energy Dispersive (ED)
X-ray Fluorescence (XRF) Spectroscopy

- Energy from an X-ray source aimed at a sample can eject electrons from an element's inner atomic orbital
- Outer electrons move into the voids to regain stability
- While moving in, the outer electrons generate energy characteristic of the element
- These characteristic energies are the fluorescent X-rays of the element



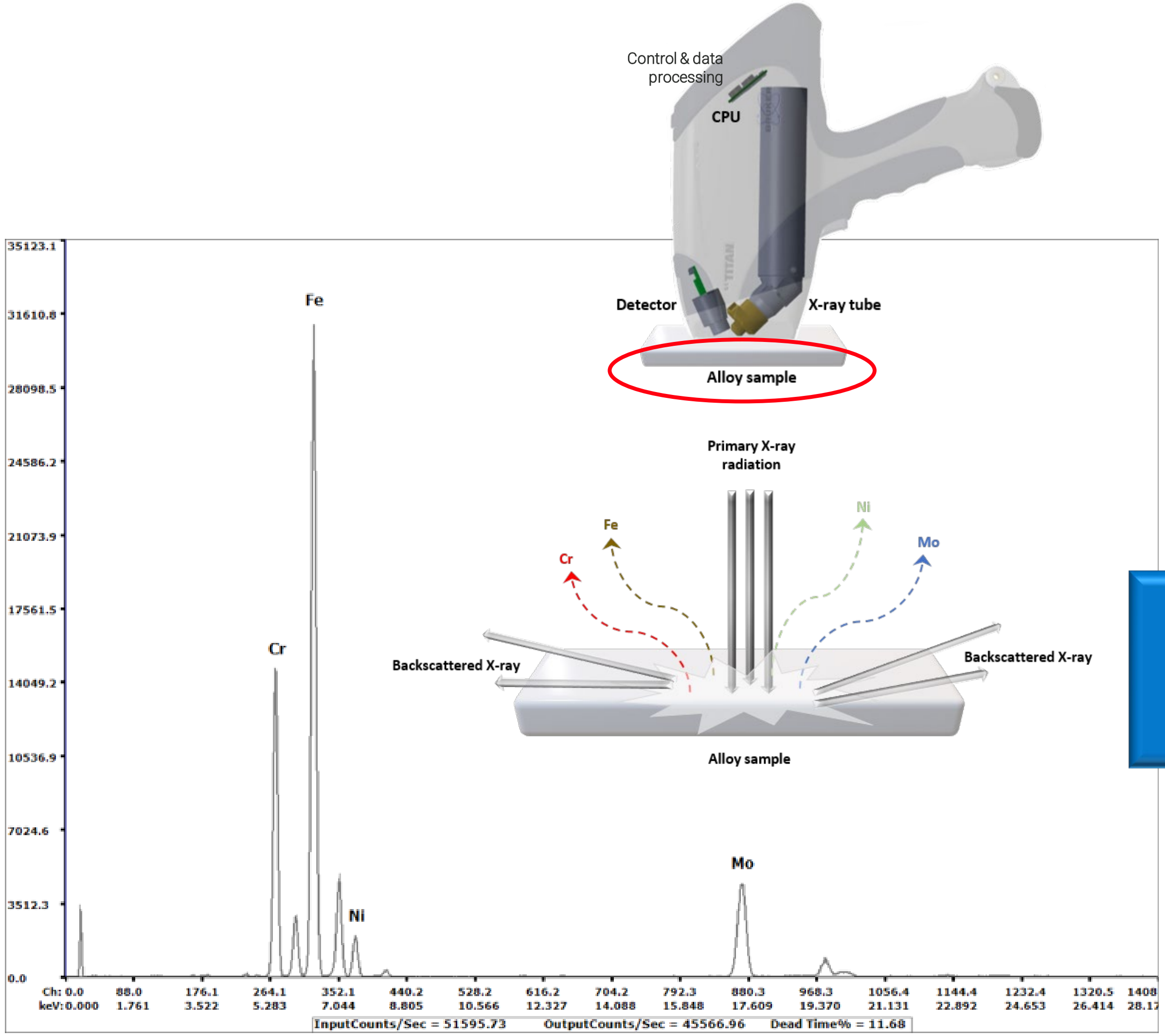


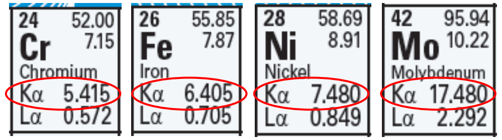


Electron orbitals of element's atom

Handheld XRF results

XRF Spectrum





316SS

124 Match 9.8 11-24 17:26
Time 46.0 | HiZ SS Fe |

El	Min	%	Max	+/- [*2]
Fe	60.00	70.40	75.00	1.07
Cr	16.00	16.25	18.00	0.45
Ni	10.00	11.40	14.00	0.50
Mo	2.00	1.63	3.00	0.10
Sn		0.21		0.09
Nb		0.11		0.06
Ti	0.00	< LOD	0.00	0.14
Mn	0.00	< LOD	2.00	0.24

Spectrum

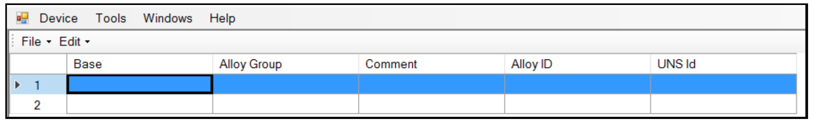
Handheld XRF metal alloy results

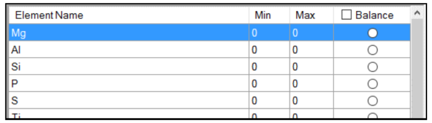
- Handheld XRFs configured with an Alloy Calibration include libraries with pre-defined alloy grades
- Alloy grades are defined based on their known chemical compositions
- An unknown metal sample is identified based on comparing its measured composition to those stored in the on-board alloy grade libraries

On-board Grade Libraries:
Bruker's handheld XRF Alloy Calibration includes extensive grade libraries for accurate alloy identification with more than 1,000 grade definitions covering various international standards. User selectable libraries include: EN-DIN, JIS, GB and other standards. They cover the following classes:

- Low alloy steels
- Cr-Mo steels
- Tool steels
- Stainless steel
- Zirconium alloys
- Specialty alloys
- Nickel alloys
- Brasses
- Bronzes
- Cobalt alloys
- Zinc alloys
- Aluminum
- Titanium
- Exotic alloys

Alloy grade libraries can be edited, including the addition of other alloy definitions





Handheld XRF testing of a foreign metal object

- Small physical contaminants found in food products can be tested on the production floor or in the lab with handheld XRF analyzers
- As shown in previous slides, a found metal object can be identified by determining its composition, the type of metal alloy, and the alloy grade name
- There are 4 simple steps to ID small metal contaminants with handheld XRF

1. Prepare found object

2. Select "Alloys" App

3. Position with camera

4. Press trigger & view results

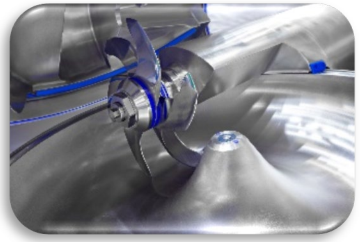
Handheld XRF sourcing of a foreign metal object

Once you have identified the foreign material, in this case an alloy sample, the equipment or components made with that alloy grade can be inspected for wear and tear as the potential source.

Auger

Conveyor

Grinder/cutter



Mixer

Roller mill

Sorter/packager

If many components are all made of the same alloy grade, a little more work is needed to help determine its source.

05 Creating a spectral fingerprint library with handheld XRF

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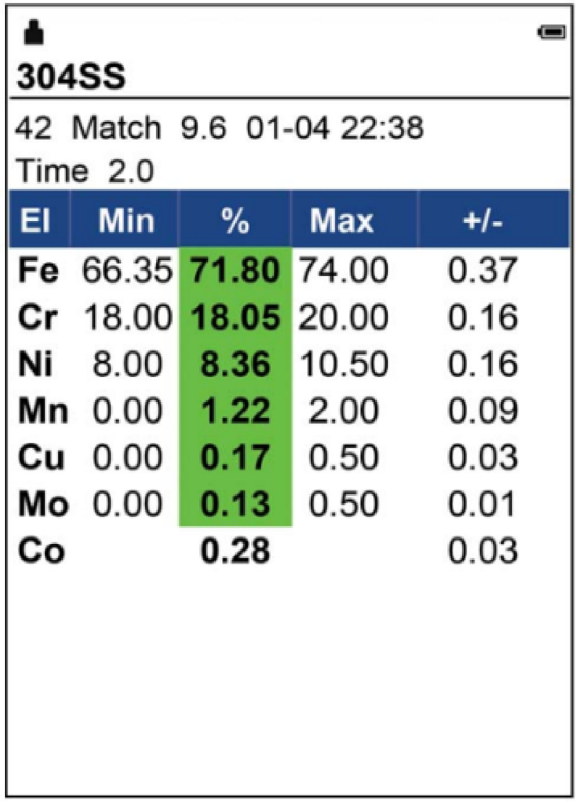
Why create a spectral fingerprint library?

Typical Steels Found in Food Production Equipment

Types	Typical Applications
420 (martensitic)	Cooks and professional knives, spatulas etc
430 (ferritic)	Table surfaces, equipment cladding, panel (ie components requiring little formability or weldability). Used for moderately corrosive environments (e.g. vegetables, fruits, drinks, dry foods, etc).
304 (austenitic)	Vats, bowls, pipework, machinery parts (i.e. components requiring some formability or weldability). Corrosion resistance superior to 430.
316 (austenitic)	Components used with more corrosive foods (e.g. meat/blood, foods with moderate salt contents), which are frequently cleaned, with no stationary solids and not under excessive stress.
1.4539 (austenitic)	Used with corrosive foods (e.g. hot brine with solids that act as crevice forms, stagnant and slow moving salty foods).
1.4462 (duplex)	Used with corrosive foods (e.g. hot brine with solids, stagnant and slow moving salty foods). Higher strength than austenitics. Good resistance to stress corrosion cracking in salt solutions at elevated temperatures.
6%Mo. types (austenitic)	Used with corrosive foods (e.g. hot brine with solids, which act as crevice formers, stagnant and slow moving salty foods). Good resistance to stress corrosion cracking in salt solutions at elevated temperatures. Used in steam heating and hot work circuits, hot water boilers, etc



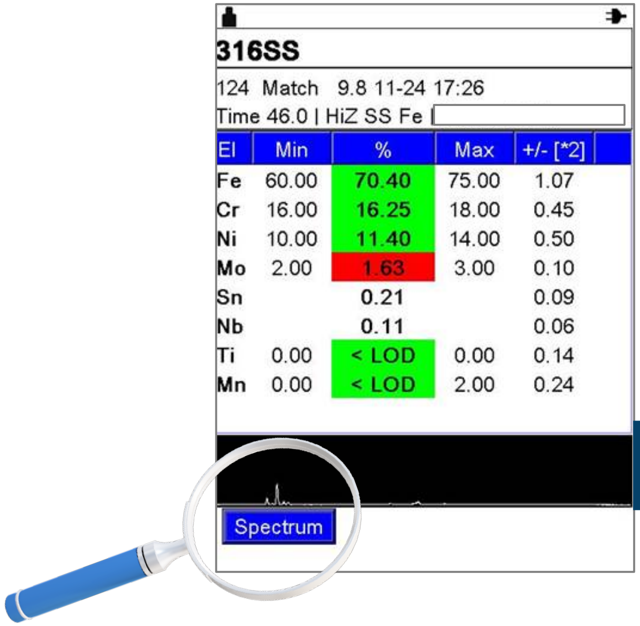
304SS

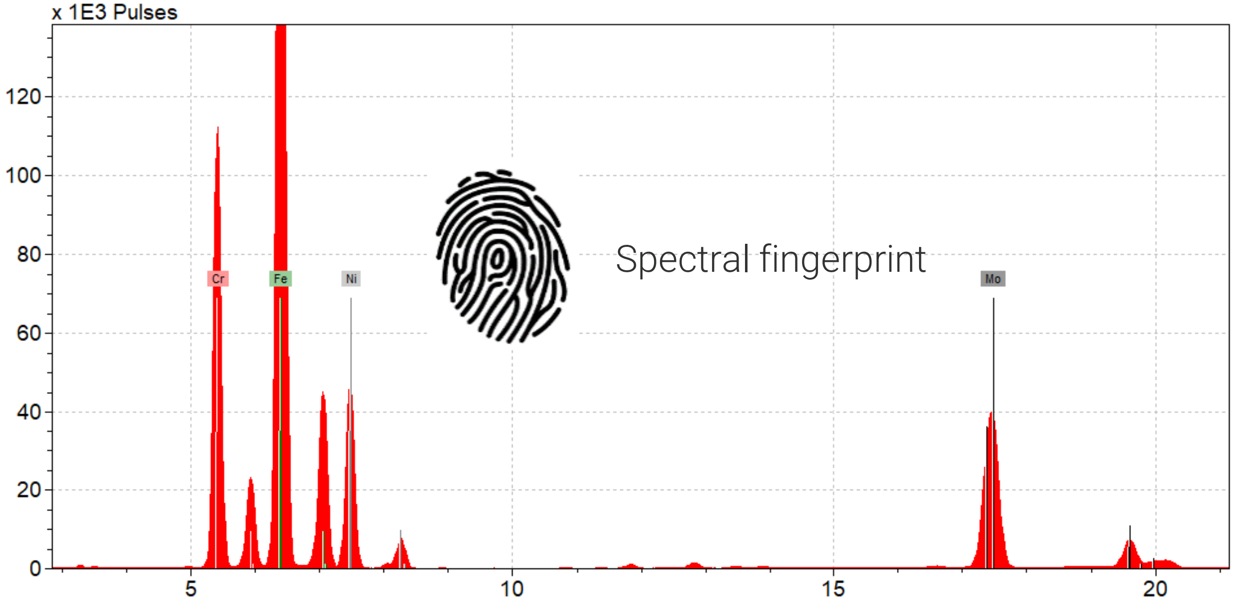
42 Match 9.6 01-04 22:38

Time 2.0

El	Min	%	Max	+/-
Fe	66.35	71.80	74.00	0.37
Cr	18.00	18.05	20.00	0.16
Ni	8.00	8.36	10.50	0.16
Mn	0.00	1.22	2.00	0.09
Cu	0.00	0.17	0.50	0.03
Mo	0.00	0.13	0.50	0.01
Co		0.28		0.03

Spectral fingerprint matching





Identification using spectral fingerprint matching

- Identification is based on library of reference spectra
- Very selective, can differentiate samples with similar Grade ID
- Works well for small samples down to 1mm (0.04”) in size
- Works for all types of materials, including metals, plastics and ceramics
- More complicated to use than standard alloy grade ID

Creating a spectral fingerprint library

1

Create food contact material library

- Create a spectral fingerprint library of all food contact devices and components
- This library contains XRF spectra of these materials

This stage takes significant time to set up and collect data for; but once it's done, sourcing a contaminant is fast. And, the library can be added to whenever needed.

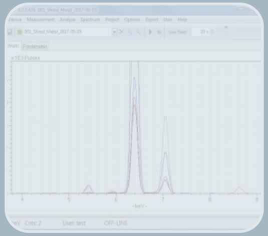
2

Measure Food Contaminant

- Collect and clean the contaminant sample
- Measure contaminant sample to acquire XRF spectrum

This stage takes just a few minutes at most.

3

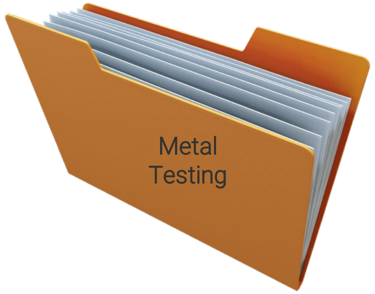


Identify Food Contaminant

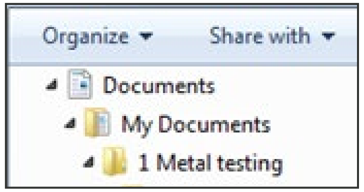
- Compare library spectra with contaminant spectra
- Find best match to determine source of the contamination

This stage can take up to 5 minutes; but, it significantly decreases the time needed to determine if a metal contaminant is from the production line or not; and, if so, what the source is.

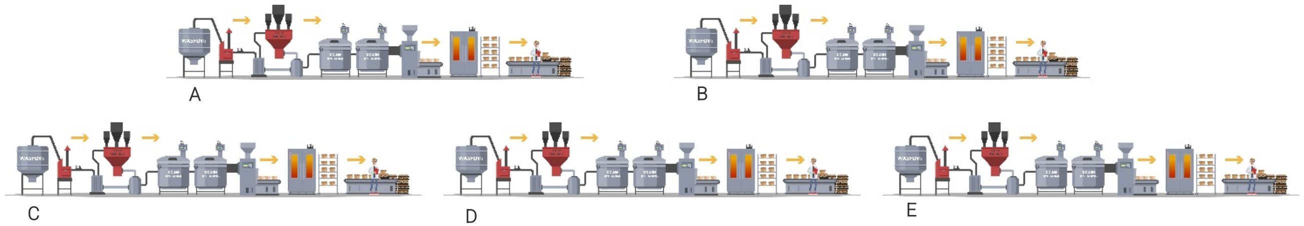
Best practices in setting up a spectral fingerprint library system

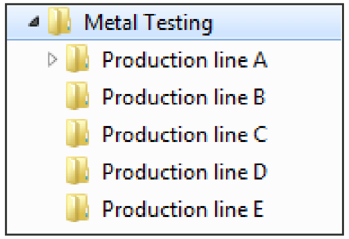


1. Create a main folder for all of the test data

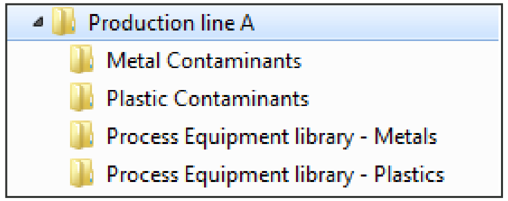


2. Create a sub folder for each of the production lines





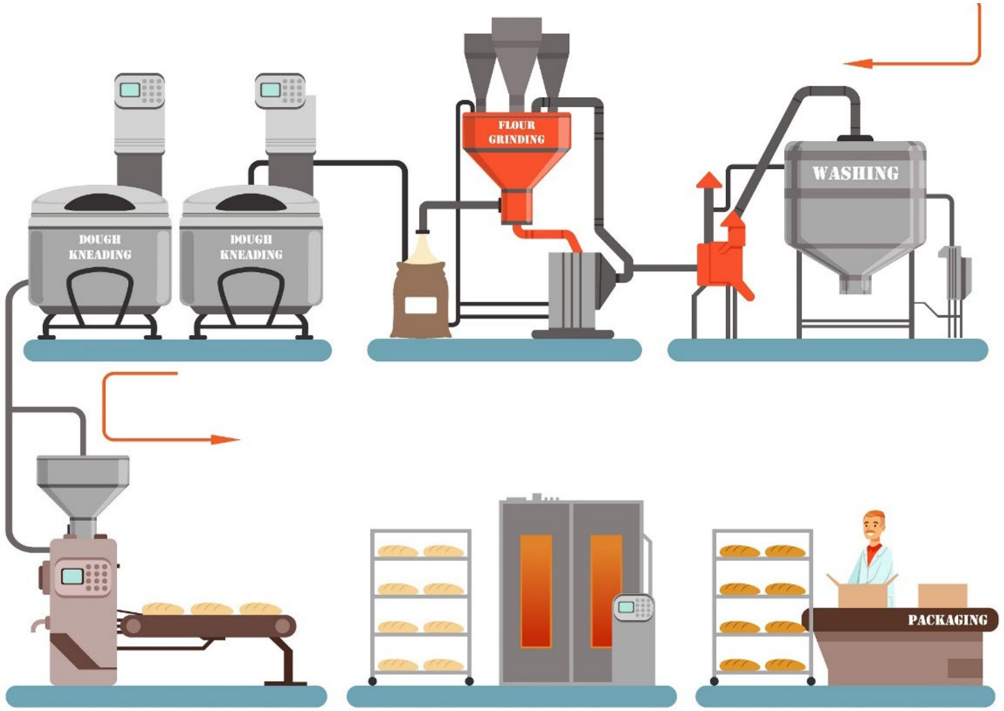
3. For each production line folder, create subfolders for both process equipment libraries and for physical contaminant tests



Best practices in setting up a spectral fingerprint library system

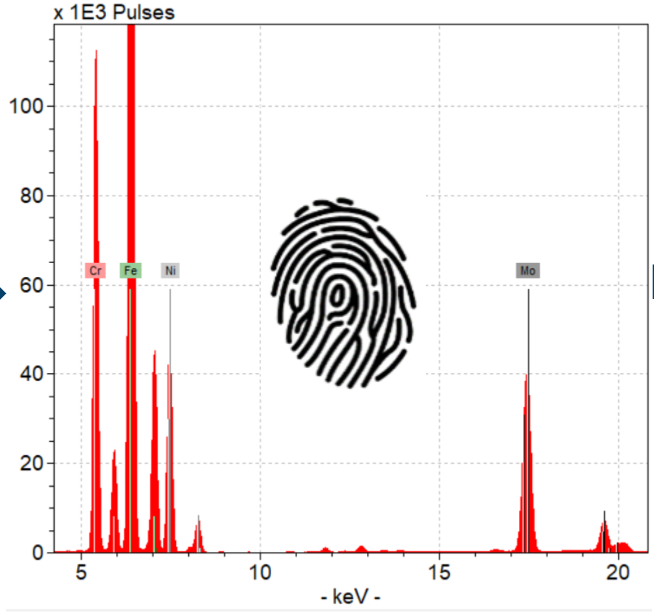
4. Determine a naming convention for each piece of process equipment tested to store its spectral fingerprint

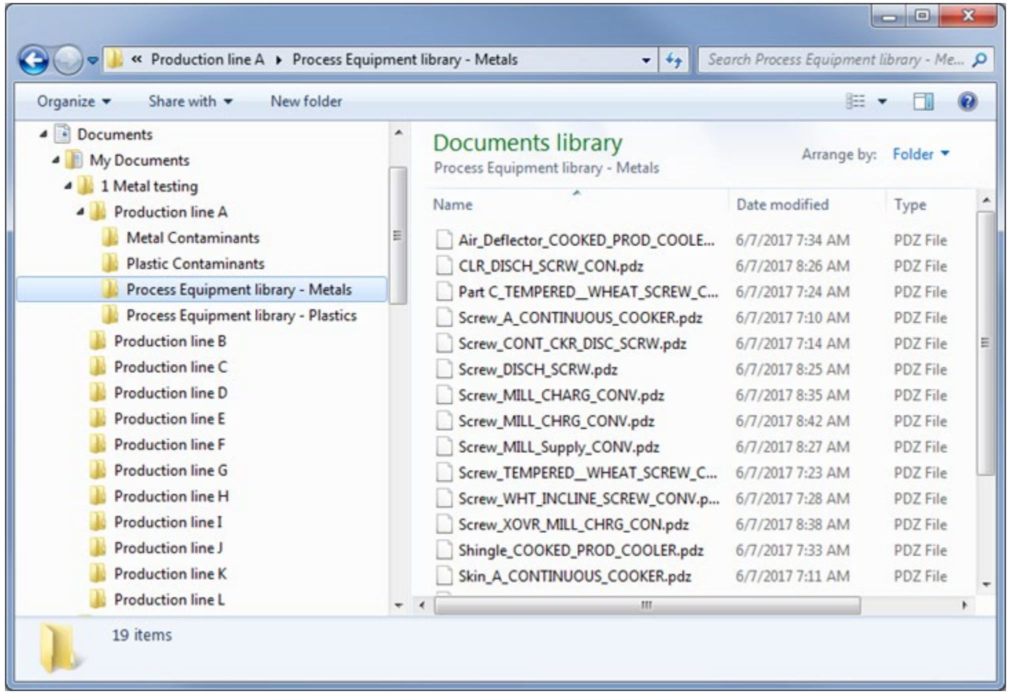
- Air_Deflector_COOKED_PROD_COOLER.pdz
- CLR_DISCH_SCRW_CON.pdz
- Part C_TEMPERED__WHEAT_SCREW_CONV.pdz
- Screw_A_CONTINUOUS_COOKER.pdz
- Screw_CONT_CKR_DISC_SCRW.pdz
- Screw_DISCH_SCRW.pdz
- Screw_MILL_CHARG_CONV.pdz
- Screw_MILL_CHRG_CONV.pdz
- Screw_MILL_Supply_CONV.pdz
- Screw_TEMPERED__WHEAT_SCREW_CONV.pdz
- Screw_WHT_INCLINE_SCREW_CONV.pdz
- Screw_XOVR_MILL_CHRG_CON.pdz
- Shingle_COOKED_PROD_COOLER.pdz
- Skin_A_CONTINUOUS_COOKER.pdz
- Skin_CONT_CKR_DISC_INCLINE_SCRW.pdz
- Skin_MILL_CHARG_CONV.pdz
- Skin_MILL_SUP_SCRW_CONV.pdz
- Skin_WHT_INCLINE_SCREW_CONV.pdz
- Skin_XOVR_MILL_CHRG_CON.pdz



Best practices in setting up a spectral fingerprint library system

5. Test each piece of process equipment and store its spectral fingerprint in the correct folder





Best practices in measuring a food contaminant

1

Create food contact material library

- Create a spectral fingerprint library of all food contact devices and components
- This library contains XRF spectra of these materials

This step takes significant time to set up and collect data for; but once it's done, sourcing a contaminant is fast. And, the library can be added to whenever needed.

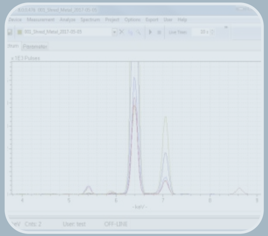
2

Measure Food Contaminant

- Collect and clean the contaminant sample
- Measure contaminant sample to acquire XRF spectrum

This step takes just a few minutes at most.

3



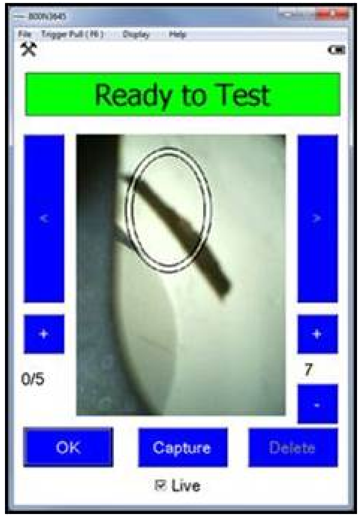
Identify Food Contaminant

- Compare library spectra with contaminant spectra
- Find best match to determine source of the contamination

This step can take up to 5 minutes; but, it significantly decreases the time needed to determine if a metal contaminant is from the production line or not; and, if so, what the source is.

Best practices in testing a small food contaminant

- Isolate and clean the contaminant
- For small samples, use of XRF sample cups is recommended as it makes positioning and storing the sample easy
- Use the camera view to ensure optimal sample positioning
- Use of desktop stand is recommended for accuracy, ease-of-use and safety



06

Matching contaminants with a spectral fingerprint library and Artax PC software

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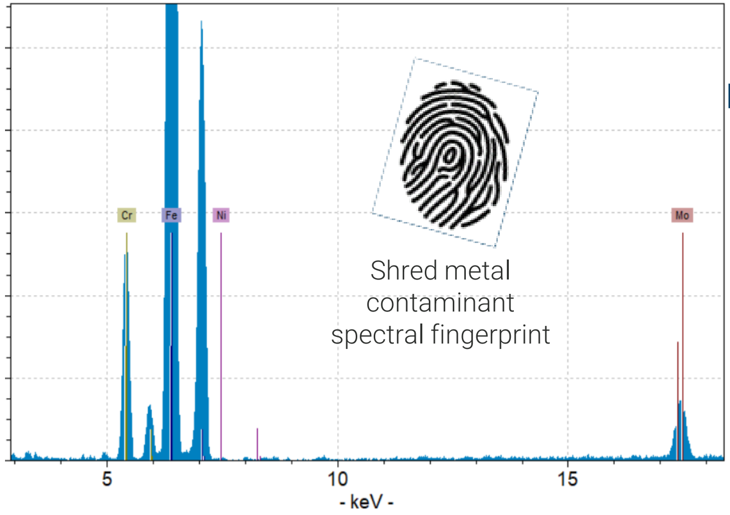
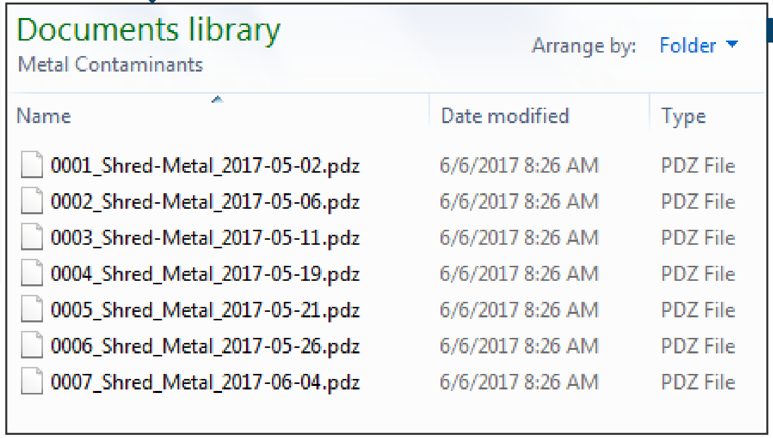
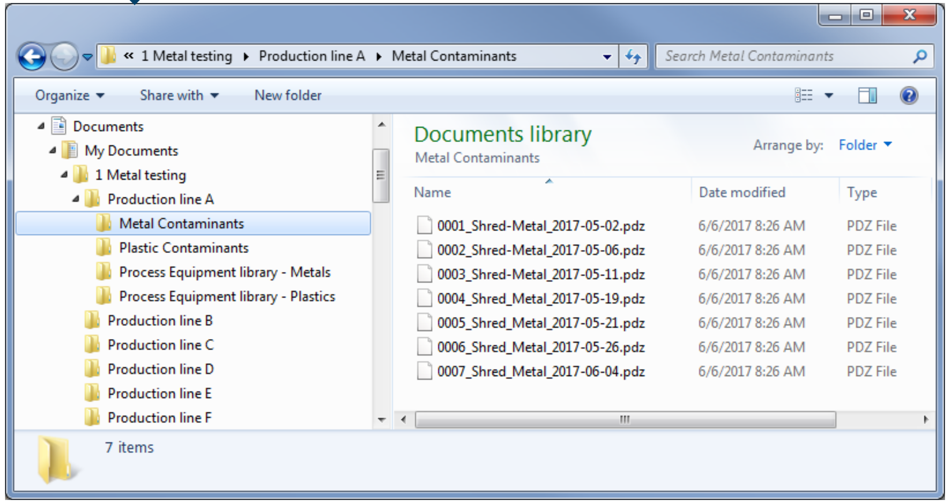
Matching a contaminant with the library and Artax PC software

- Transfer all the contaminant spectra from instrument into the relevant folder







Matching a contaminant with the library and Artax PC software

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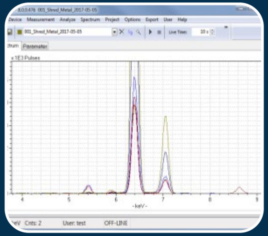


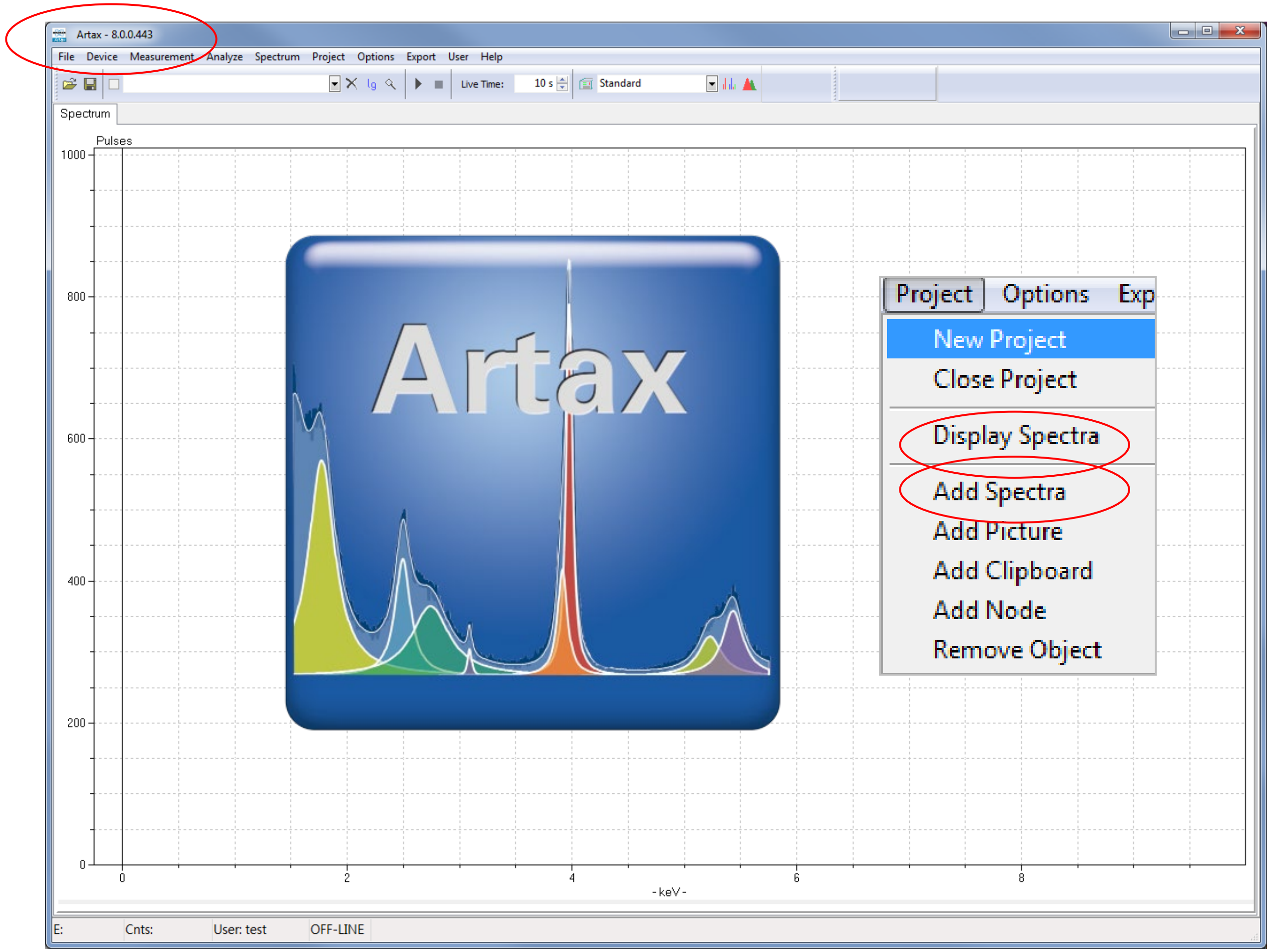
Identify Food Contaminant

- Compare library spectra to contaminant spectra
- Find best match to determine source of the contamination

This step can take up to 5 minutes; but, it significantly decreases the time needed to determine if a metal contaminant is from the production line or not; and, if so, its source.

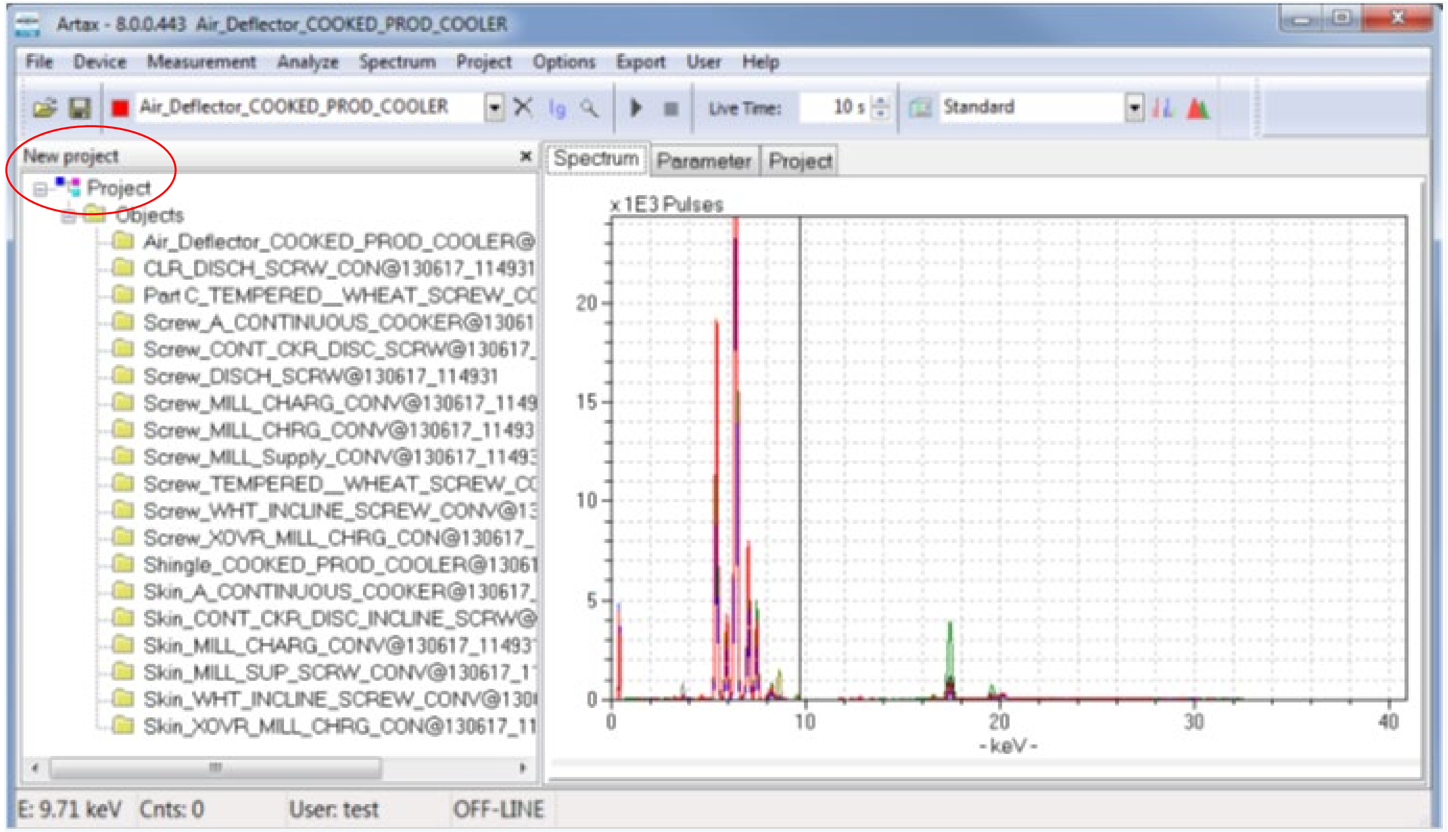
Matching a contaminant with the library and Artax PC software

- Spectral fingerprinting matching for complex situations is performed with Artax PC software.
- Artax is an advanced spectral viewing, matching and data analysis software package.
- Artax is used to both store and link information; it makes the management of large data sets easy.

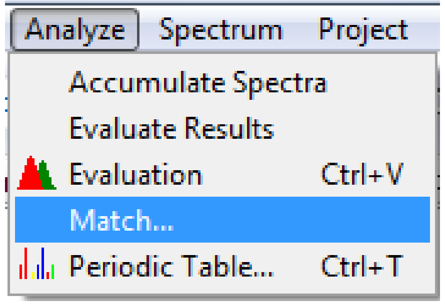


Matching a contaminant with the library and Artax PC software

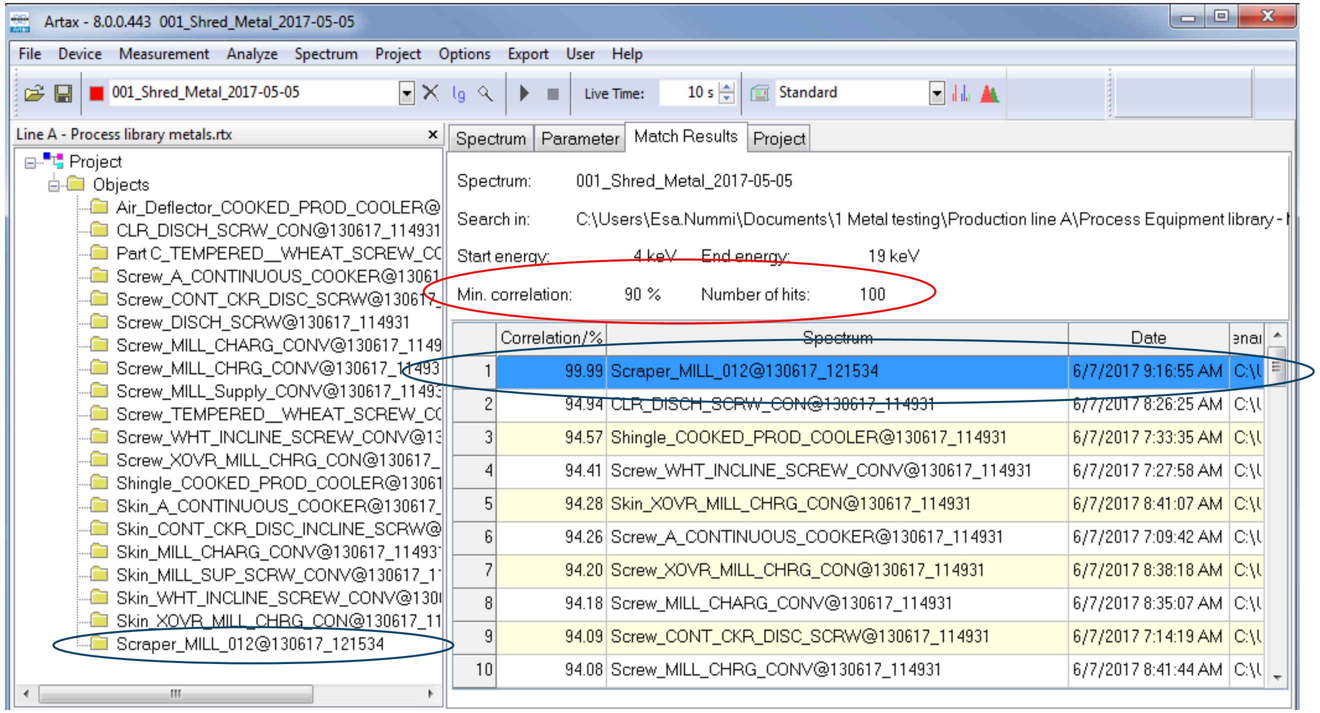
- After the spectral fingerprint folders for a given production line are populated with data, those folders are transferred into an Artax "Project" folder to be used as a library reference set for a found physical contaminant.



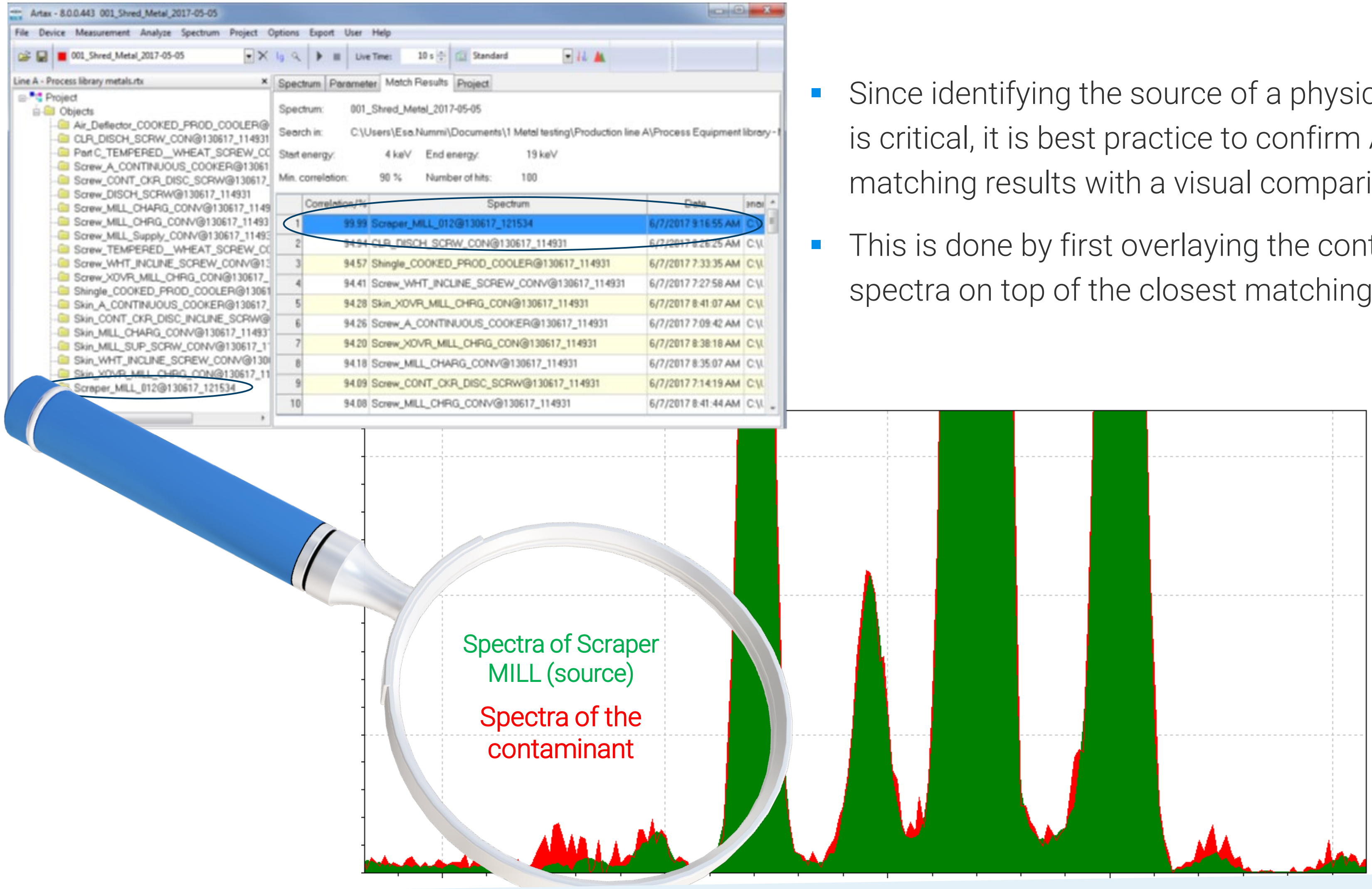
Matching a contaminant with the library and Artax PC software



- Fingerprint spectra is then analyzed using the Artax "Match" program to find the most likely source of the contaminant.
- In the case below, Artax found 100 "hits" with a correlation of 90% or better.
- One Artax Match "hit" had a correlation of 99.99%



Matching a contaminant with the library and Artax PC software



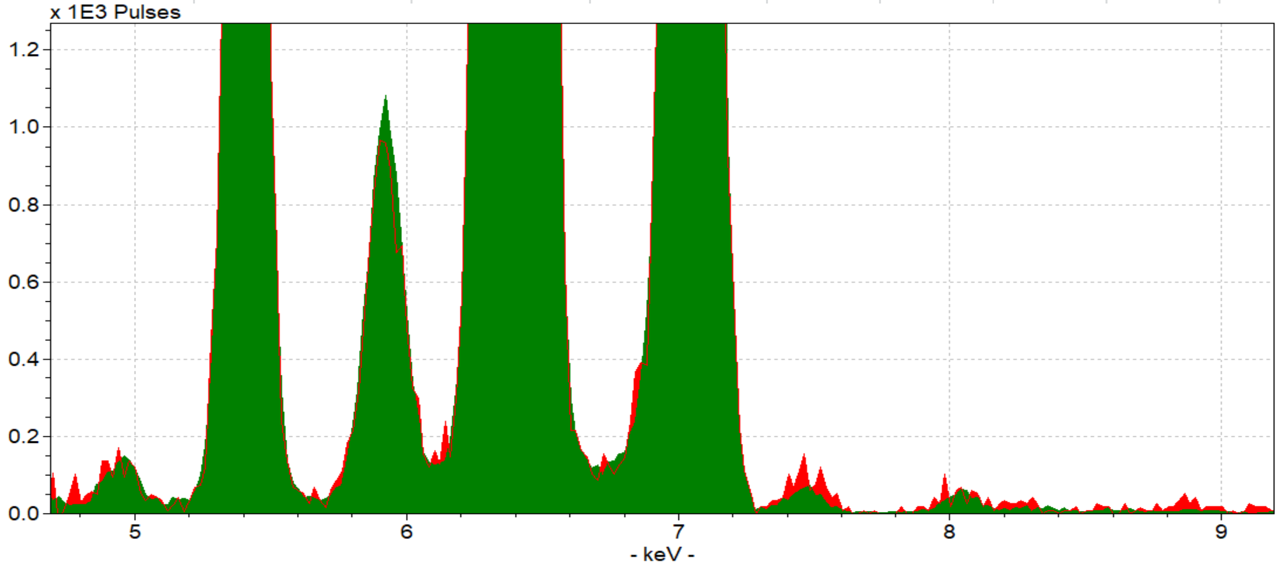
- Since identifying the source of a physical contaminant is critical, it is best practice to confirm Artax spectral matching results with a visual comparison.
- This is done by first overlaying the contaminant spectra on top of the closest matching library spectra.

Matching a contaminant with the library and Artax PC software

- Finally, it is straightforward to copy-paste Artax spectral match information to Windows programs for reporting purposes.

Spectrum:	0004_Shred_Metal_2017-05-19		
Search in:	Metal testing\Production line A\Process Equipment library - Metals		
Start energy:	4 keV	End energy:	19 keV
Min. correlation:	98%	Number of hits:	10

Correlation/%	Spectrum	Date	Filename
99.99	Scraper_MILL_012	6/7/2017 9:16	Production line A\Process Equipment library - Metals\Line A - Process library metals.rtx
98.94	CLR_DISCH_SCRW	6/7/2017 8:26	Production line A\Process Equipment library - Metals\Line A - Process library metals.rtx
98.57	Shingle_COOKED	6/7/2017 7:33	Production line A\Process Equipment library - Metals\Line A - Process library metals.rtx



05

Food Contaminant characterization with micro-XRF technique

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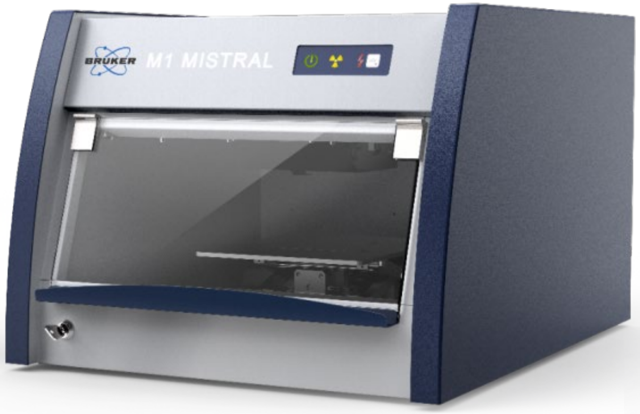
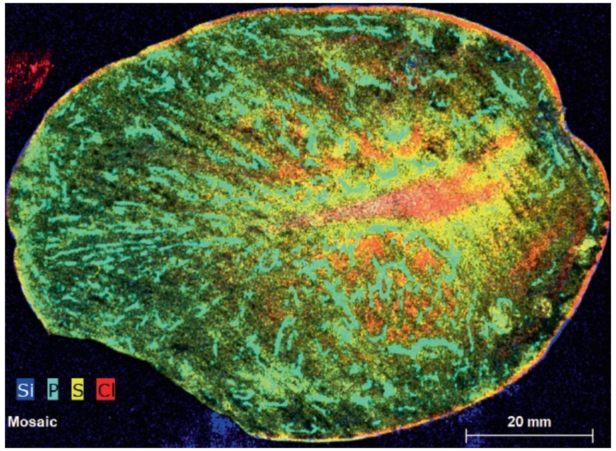
Characterizing pieces less than 1 mm in size

- Bruker's handheld XRF can measure pieces as small as 1 mm in size
- Bruker's benchtop M1 MISTRAL micro-XRF can measure pieces as small as 100 µm in size
- Bruker's laboratory M4 TORNADO micro-XRF can measure pieces as small as 20 µm in size

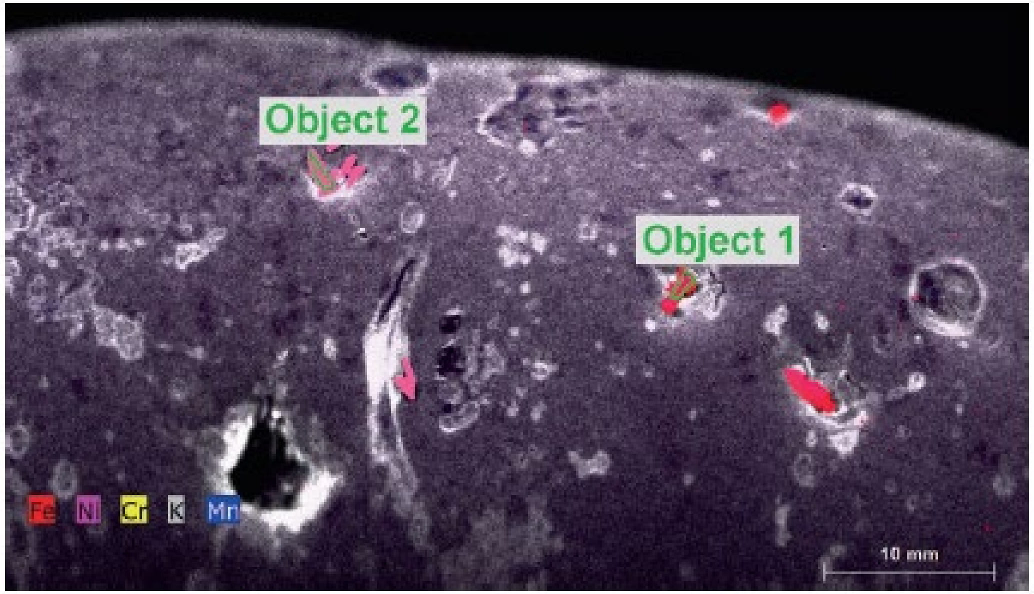


M4 TORNADO Plus Micro-XRF analyzer

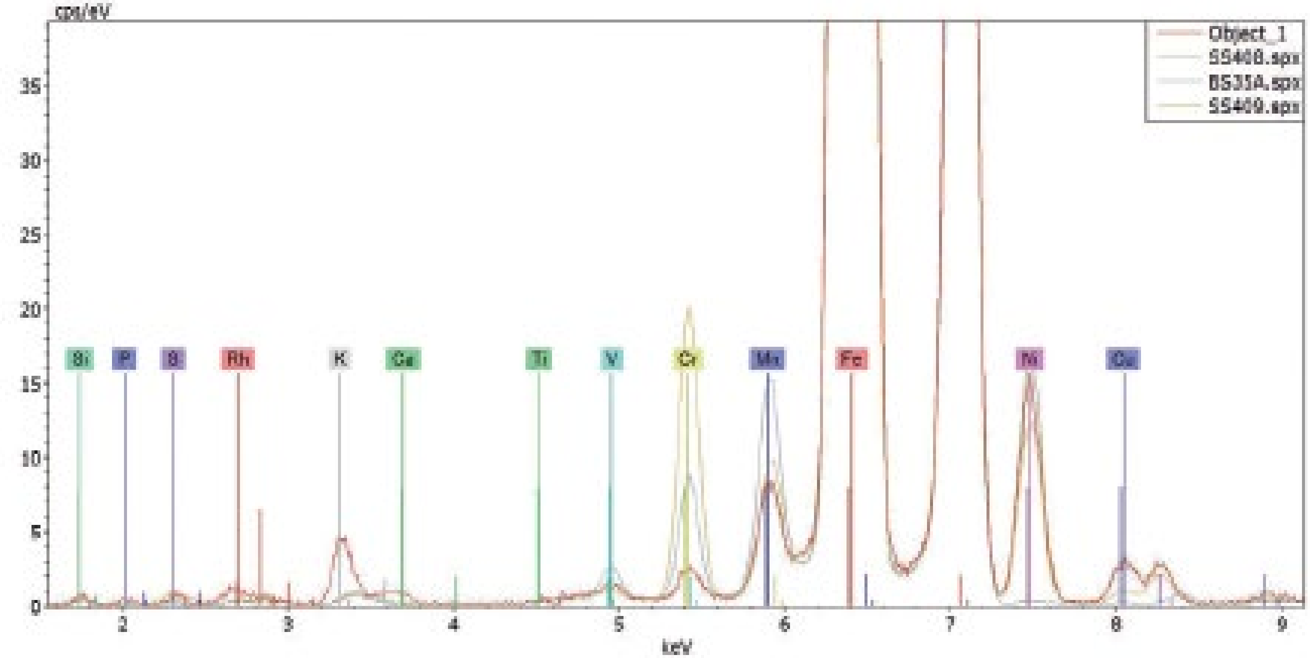
- Advanced Micro-XRF with the ability to record spectra, line scans and maps of the complete element range starting from carbon
- Micro-focus X-ray source with polycapillary lens < 20 µm spot size and high excitation intensity
- Measure solids, particles and liquids
- Fast XYZ stage for “on-the-fly” element distribution analysis with 20 x 16 cm range and 4 µm resolution
- Vacuum sample chamber with adjustable pressure
- Helium purge allows light element measurement of wet and fresh organic samples
- Dual optical microscopes for sample view and positioning with
- Advanced mapping and image processing features



M4 TORNADO Micro-XRF
Elemental distribution maps



Elemental distribution map of a potato with different metal contaminants



Spectrum of Object 1 overlaid with possible alloy database matches

M4 TORNADO Micro-XRF
Metal contaminant identification

Particles of different sizes

Particle inclusion

Quantification and discrimination of low-alloy steel particles

Element	Cr	Mn	Fe	Co	Ni	Cu	Nb	Mo
Reference	0.6	0.7	96.5	0	1.2	0.1	0	0.1
Isolated particle	0.6	1.2	96.3	0.6	1.1	0.1	0.2	0.1
Embedded particle	0.6	1.0	94.7	0.8	1.4	0.1	0.3	0.2

M4 TORNADO Micro-XRF
Glass fragment identification

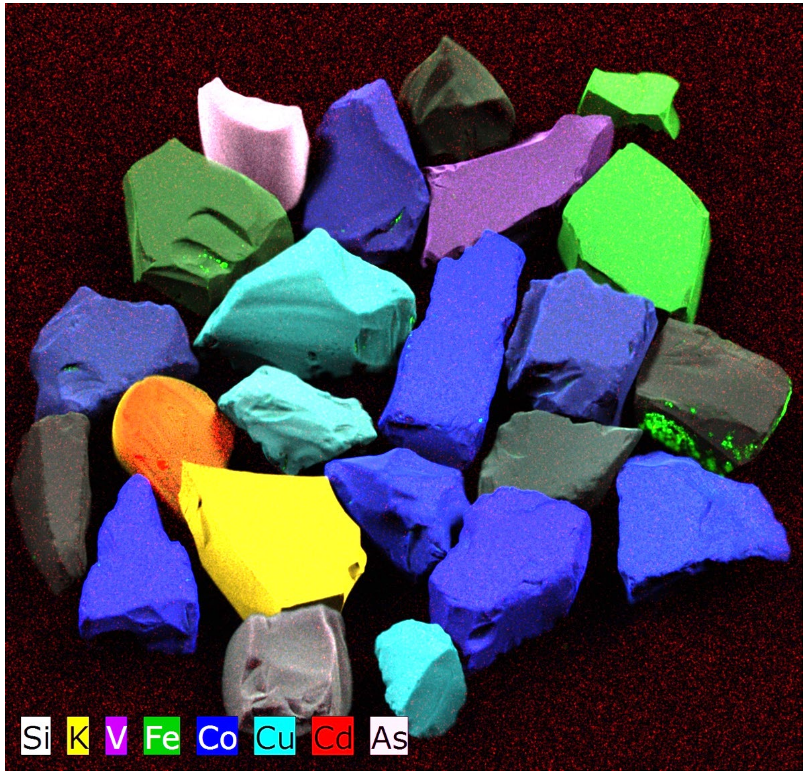
Glass fragment

Reference jar

wt. %	Fragment	Reference jar	Analytical error
SiO_2	71.9	71.9	± 0.5
Al_2O_3	1.7	1.7	± 0.2
Na_2O	12.5	12.5	± 0.5
K_2O	1.2	1.3	± 0.1
MgO	< 0.5	< 0.5	± 0.2
CaO	12.1	11.9	± 0.2
$SO_{3}tot$	0.23	0.22	± 0.03
$Fe_2O_{3}tot$	0.06	0.07	± 0.01
TiO_2	0.02	0.03	± 0.01

M4 TORNADO Micro-XRF
Glass particle identification

Glass fragments optical image



Glass fragments elemental map

- At-a-glance classification of glass fragments based on selected marker elements
- Elemental maps of various glasses can be created to save in a library for comparison to found glass fragment contaminants.

07 Summary

Webinar: Quickly Identify and Source Foreign Material Contaminants Found in Food Products with Handheld XRF

Summary

Handheld XRF can decrease the time required to ID a physical contaminant and locate its source which can result in significant cost savings by taking the following steps:

- Develop a food contact library structure for each production line
- Take measurements of all the components on that production line and populate the library
- Measure the foreign material contaminant
- Determine the most likely source of the contaminant by matching the foreign material contaminant's spectral fingerprint to those in the production line's library using Artax PC software
- If a sample is less than 1 mm in size, use a micro-XRF to identify the material
- Inspect the identified component on the production floor for wear and tear

08 Questions & Answers

Webinar: Quickly Identify and Source Foreign Material Contaminants Found in Food Products with Handheld XRF

Any Questions?

Please write us: info.bna@bruker.com

Thank you!

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