New Advances using Handheld XRF Technology for the Prevention of Flow-Accelerated Corrosion (FAC)

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Agenda

- **Flow-accelerated (FAC) Power Generation**
- **XRF Historical Background**
- **The Latest Developments**
- **New Detector Technology**
- **Increased Sensitivity**
- **Questions??**

FAC

- Well known problem
- Degrading of carbon steel piping and components
- Flowing water or steam water w/ low-dissolved oxygen
- Thins the pipes wall resulting in catastrophic failures
- 20+ years of research devoted to understanding the cause and methods of prevention

FAC - Variables

- The composition of the steel – chromium (Cr), copper (Cu) and Molybdenum (Mo)
- The water chemistry in use – pH at temperature in the water, dissolved oxygen, and temperature
- The flow variables – fluid velocity, diameter, fitting geometry, and upstream influences

*****Material Composition Exerts the Most Influence*****

FAC - Prevention

- Small quantities of alloying elements, greatly reduce the rate of FAC – (Cr) in particular
- Higher levels of trace Cr (above ~ 0.1%) changes the oxide structure
- Substitution of Cr atoms for Fe atoms occurs in the oxide layer much less soluble than the normal oxide layer
- Monitoring trace alloy content has become industry convention when inspecting for FAC

FAC - Prevention

- Traditionally, chemical analysis performed by laboratory analysis of filings or spark-based optical emission spectroscopy (OES)
- Need for detection of very low levels of Cr (~0.02%)
- OES although reliable dose pose numerous difficulties
  - Difficulty of transport
  - Sample preparation
  - Damage of sample
  - User expertise

FAC - Prevention

- Advancements in Handheld XRF
- Dramatically improved detection limits
- Vast improvements in sensitivity and speed
- Valid alternative method for FAC analysis application

XRF History

1967:TN 9200
1st commercial field portable XRF; used non-dispersive scintillation detectors with x-ray filters

1975:TN 9266 Alloy Analyzer
1st portable XRF with *dedicated application calibrations for alloy analysis;* non-dispersive detectors; x-ray filters

1994:NITON XL-309
1st *one piece,* handheld XRF with real-time digital signal processing and silicon PIN diode detectors

2009:Thermo NITON XL3
1st handheld XRF with *50kV Au anode* x-ray tube and automatic parameter optimization

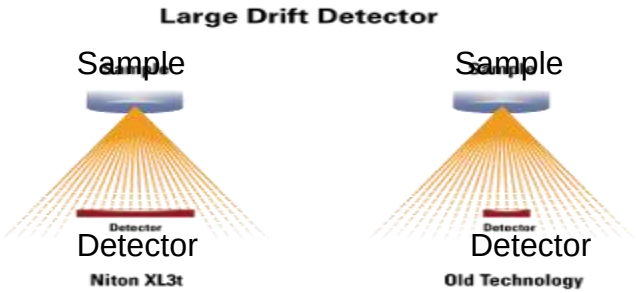
Latest Developments

- One piece, handheld (3-4lbs)
- 25 elements simultaneous (30 total)
- Variable excitation conditions (Filters)
- Hundreds of alloys
- Ultra high speed
- Lab-quality performance
- Field hardened

Handheld Thermo Scientific Niton XRF analyzer being used to inspect piping system

Detector Technology

- Silicon Drift Detector (SDD)
- Higher count rate
- Higher resolution
- Excellent signal/noise ratio
- Light element analysis (Al, Mg, Si, S and P)
- Helium purge or vacuum not required

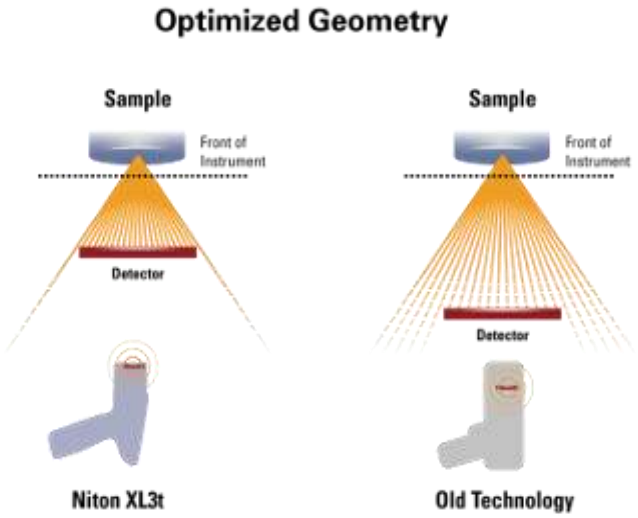


NEW Technology

OLD Technology

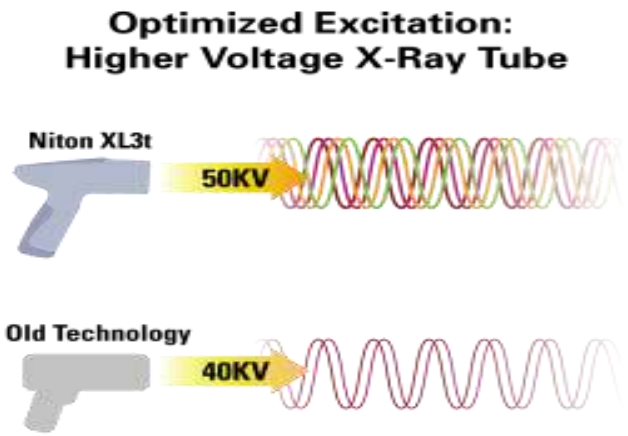
Detector Technology

- Geometrically Optimized
  - Reduced path length from sample to detector
  - Allows ~2X more X-rays to reach the detector with ½ the power
- Large-Area Drift Detector
  - Light element detection
  - Increased sensitivity on trace/tramp elements (Cr – FAC)
  - Double the speed
  - Enhanced performance on difficult (twin) alloy separation



Increased Sensitivity

- New miniature 50kV X-ray tube, gold anode, excitation source that provides higher sensitivity



Complete System Optimization

- Synergy of complete system approach
  - SDD Detector
  - 50 kV Tube
  - Optimized geometry, and….
  - On the fly parameter optimization (main to low filter)
- Produces overall 10X performance than regular Si-Pin diode systems

3 Sigma: Ti, Fe, Cu; All Units %wt

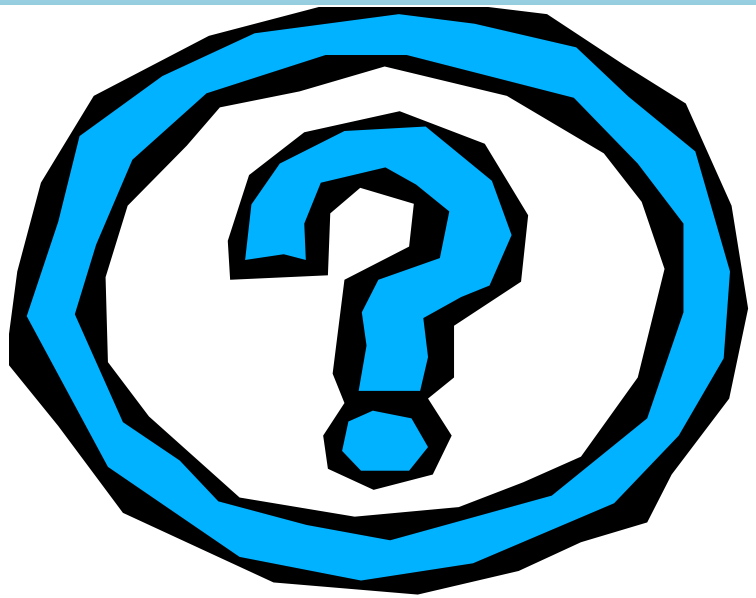
TIME	60s per filter	60s per filter	60s per filter
Element	**Ti Base Wt. %**	**Fe Base Wt. %**	**Cu Base Wt. %**
Sb	0.005	0.006	0.008
Sn	0.005	0.008	0.015
Pd	0.005	0.006	0.010
Mo	0.002	0.002	0.002
Nb	0.002	0.002	0.003
Zr	0.002	0.002	0.003
Bi	0.002	0.002	0.003
Pb	0.002	0.009	0.003
Se	0.002	0.002	0.002
W	0.015	0.015	0.015
Zn	0.005	0.005	0.030
Cu	0.008	0.009	N/A
Ni	0.012	0.020	0.011
Co	0.008	0.080	0.005
Fe	0.015	NA	0.007
Mn	0.017	0.020	0.007
Cr	0.015	0.003	0.005
V	0.060	0.003	0.003
Ti	N/A	0.003	0.003
P	0.025	0.030	0.040
S	N/A	0.050	0.060
Si	0.070	0.075	0.080
Al	0.375	0.500	0.700

OLD Vs NEW / Repeatability

	OLD	NEW

Test	Mo	Cu	Cr
Avg.	**0.0150**	**0.1090**	**0.1190**
Std. Dev.	**0.0013**	**0.0063**	**0.0026**
Given	**0.0160**	**0.1090**	**0.1170**

QUESTIONS



Thank You!

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