

# Positive Material Identification and Analysis of Metals and Alloys in the Petrochemical Industries

*Thermo Scientific NITON® XL3 Portable Alloy Analyzers – Simply Superior XRF*



## Introduction and Overview

It is critically important for workers in inspection, safety, and maintenance departments in refineries and petrochemical plants to prevent the accidents that can occur as a result of the installation of incorrect or out-of-specification metal alloy parts. Because XRF is nondestructive and provides immediate, accurate on-site test results, field portable XRF alloy analysis has become the standard industry method for material inspection for alloy verification (AV) and positive material identification (PMI). In the past three decades, a number of high-profile industrial accidents in refineries and petrochemical plants have raised awareness around the world to the potential dangers caused by alloy mix-ups.

With current industrial safety regulations and an atmosphere of public scrutiny, it is absolutely essential for petroleum and petrochemical plants to discover and fix these material mix-ups. As a result, petroleum refineries and petrochemical facilities worldwide are now adopting best practices and a best technology approach to PMI for verifying the safety of operating plants. As PMI testing technology has advanced, former practices of testing only a fraction of all parts and assemblies have been replaced by 100% comprehensive materials testing in thousands of plants.

## Modern PMI Technology

Today's inspectors have access to powerful new testing tools that change the way PMI is performed. Thanks to major advancements in handheld x-ray fluorescence (XRF) technology pioneered by NITON, now a part of Thermo Fisher Scientific, inspection and maintenance personnel can test miles of pipeline, piping systems, vessels, and their associated refinery alloys during a single turnaround. The performance and ease of use of the newest generation of handheld Thermo Scientific NITON XRF analyzers enables inspection and maintenance personnel to test large numbers of samples with extremely high confidence

in the integrity of the results. Just point and shoot: a two to five second analysis of an unknown metal alloy produces accurate metal identification and elemental analysis. Typical testing time is less than one second for a positive grade identification, and just a few seconds longer to obtain lab-quality chemistry. Little or no sample preparation is needed for alloy samples with relatively clean surfaces, regardless of shape or size – from single strands of 1 mm wire to finished weld beads, to valves and flanges, to complete reaction vessels.

## NITON Analyzers – Anatomy of a Revolution

In 1999, we led an industry-wide revolution with our introduction of the NITON XL-801S, the first handheld, lab-quality XRF analyzer for metal alloy analysis. Within one year of its introduction, the company had become the leading manufacturer of handheld XRF analyzers for PMI and other alloy-testing applications. Since that time, and with continuous improvement, Thermo Scientific NITON PMI analyzers have been adopted for use by hundreds of plants worldwide. Never content to rest on past accomplishments, technical staff continues to work intensively with inspectors and PMI technicians to constantly add useful new features and improve the performance and ease of use of the instruments.

### NITON XL3 Benefits At-a-Glance

- High-throughput – fast comprehensive testing
- Fastest, most accurate analysis available with a handheld XRF analyzer
- Incoming, in-stock, or in-service component testing
- Laboratory-quality composition analysis
- Hot-surface testing to 1000° F (538° C)
- Fast, simple reporting and certificate generation



Fast, reliable positive material identification (PMI) – anywhere.

### Rock-Solid Calibration and Grade Identification

One important key to the success of Thermo Scientific NITON analyzers in alloy analysis has long been the instruments' fast, stable, accurate, and precise fundamental parameters (FP) based factory calibration. Our proprietary FP sample analysis includes nearly every element of interest in nearly all types of metal alloys that require positive material inspection.

The robust FP method utilized in our analyzers provides accurate analysis for all measured elemental concentrations ranging from trace to 100 percent. No other handheld XRF analyzer can equal the accuracy and reliability of NITON XRF analyzers.

Yet, providing accurate alloy chemistry is only part of the equation. Using our extensive experience with the metals industry, we have incorporated an alloy grade library that simultaneously displays the common trade name of the alloy along with the composition. By incorporating a hybrid approach, which combines the book value alloy grade specifications with knowledge of the "as produced" chemistries of these alloys, the NITON XL3 provides unmatched accuracy in grade identification.

### Thermo Scientific NITON XL3 Series Analyzers – Simply Superior Alloy Analysis

Thermo Fisher continues to lead the handheld alloy analysis field with technology that responds directly to the needs and requests of the petroleum refining and petrochemical industries. The NITON XL3 800 Series offers the latest in a series of rugged, dependable tools with improved ergonomics, speed, and performance, while retaining the point-and-shoot simplicity that has been a hallmark of NITON analyzers.

Available in x-ray tube source (NITON XL3t) and radioisotope source (NITON XL3p) configurations, the NITON XL3 800 Series is the only handheld XRF analyzer that allows customers to select the x-ray source that best suits their business needs.

By combining advanced electronics and materials technology with the most powerful x-ray tubes ever used in handheld XRF instruments (up to 50 kV), the NITON XL3t is in a class by itself. With multiple primary filters for optimal sample excitation and a helium-purge option to target light elements from magnesium (12) to sulfur (16), the NITON XL3t provides the greatest analytical range, speed, and precision of any handheld XRF instrument.

Meanwhile, the groundbreaking NITON XL3p features our patented Infiniton™ technology, which consistently provides fast, reliable, nondestructive alloy ID with accuracy that compares favorably to lab XRF instrumentation, in a rugged, dependable Infiniton radioisotope configuration that is virtually maintenance-free.

No matter which configuration you choose, the NITON XL3 Series features a high-performance thermoelectrically cooled detector, 80 MHz real-time digital signal processing, and dual state-of-the-art embedded processors for computation, data storage, communication, and other functions.

From the integrated VIP™ tilting color touch-screen display to the customizable menus for ease of use, NITON XL3 Series analyzers are appropriate for use under all environmental conditions, both indoors and out. Couple these features with integrated Bluetooth™, USB, and serial communications, and cumbersome download procedures of PDA synchronization become a thing of the past. What's more, all Thermo Scientific NITON analyzers use third-generation lithium-ion batteries, providing the longest usage cycle of any handheld XRF analyzer.

### NITON XL3 Series Performance

Thermo Scientific NITON XL3 800 Series analyzers provide alloying chemistry for up to 30 of the most common elements in tens of thousands of alloy grades, with additional elements available on request. Families of alloys that can be accurately analyzed with a standard system include:

- Stainless Steels
- 12 Cr Steels
- Chromium-Molybdenum (Cr-Mo) Steels including V stabilized versions
- Low alloy Steels such as 4140, 4340, etc.
- Nickel (Ni) alloys such as Hastelloy® and Inconel®
- Tool Steels
- Copper (Cu) alloys
- Titanium (Ti) alloys
- Wrought Al alloys

Additional grades that can be accurately sorted with the addition of the Helium (He) Purge Light Element Analysis package include:

- Zecor™ SS alloys containing 5-6 % Si
- Monel®, including direct measurement of Al in Monel 500
- Ti alloys including direct measurement of Al content
- Aluminum (Al) and Silicon (Si) Bronzes
- Aluminums for Si and Mg content

Examples of sample surfaces that may require sample preparation (generally minimal grinding):

- Zn coated or galvanized surfaces
- Painted, coated or plated surfaces
- Process scale or heavy oxidation
- Grease and/or significant dirt build-up
- Any non-representative surface

## Evaluating Performance

When potential users are evaluating the performance of analytical instrumentation, they are generally concerned with two criteria: speed and accuracy. What many do not understand is that there are two distinct factors to consider when asking “How accurate is it?”:

- Precision – This is a measure of repeatability, or the degree of agreement between individual measurements of a set of measurements, all of the same quantity.
- Accuracy – This is a measure of reliability, and is the difference between the *true value* of a measured quantity and the *measured value*.

Most analytical instrumentation reports statistical precision data along with the quantitative measurement results. Precision is a function of the statistical analysis of the raw data. Accuracy however, must be determined by testing samples with known values, and comparing the measured results to the known values. Because even the best laboratory methods used to provide these values have statistical limitations in both precision and accuracy, *true value* is never known, even in a “certified standard.”

Regarding XRF instrumentation, the time of measurement improves the precision. With XRF analysis, each fourfold increase in measurement time improves the precision for each element by a factor of two. At some point, however, increase of measurement time will reach a point of diminishing returns.

## NITON Analyzers Measure Up

NITON XRF instruments report a two-sigma precision along with the result for each element. This represents an error band of two standard deviations on either side of the result. The two sigma precision represents a 95 percent confidence interval for the data. Note the precision, or +/- error band, is not an indication of accuracy, but a measurement of repeatability around a most probable value. Accuracy must be assessed by comparing the measured result and precision to known values from a reference standard.



Nondestructive – reliable analysis of incoming or in-service parts..

SS 321	BNRM-85C				
	Cert	5 Sec	+/-	20 Sec	+/-
Grade ID		321		321	
Cr	17.68	17.90	0.31	17.85	0.14
Ni	10.01	9.97	0.46	9.99	0.22
Mn	1.63	1.65	0.30	1.66	0.14
Ti	0.45	0.41	0.09	0.40	0.04
Cu	0.30	0.30	0.13	0.32	0.06
Mo	0.33	0.34	0.03	0.35	0.01

Table 1: Performance data for Stainless Steel 321

SS 304	BS 81E				
	Cert	5 Sec	+/-	20 Sec	+/-
Grade ID		321		321	
Cr	18.31	18.36	0.32	18.39	0.14
Ni	9.52	9.57	0.45	9.55	0.21
Mn	1.73	1.81	0.30	1.80	0.14
Mo	0.38	0.40	0.03	0.40	0.01
W	0.13	0.14	0.10	0.13	0.05

Table 2: Performance data for Stainless Steel 304

Hast C-276	BS H2B				
	Cert	5 Sec	+/-	20 Sec	+/-
Grade ID		C-276		C-276	
Cr	15.43	15.03	0.36	15.07	0.17
Mo	15.54	15.99	0.33	16.01	0.16
Fe	6.52	6.50	0.40	6.58	0.21
W	4.13	4.42	0.47	4.47	0.23
Mn	0.57	0.63	0.34	0.66	0.17
Co	0.39	0.39	0.23	0.40	0.11
Ni	56.75	56.49	0.64	56.33	0.32

Table 3: Performance data for Hastelloy C-276

## Unparalleled Accuracy

In our performance testing, each alloy sampled was measured under the same conditions. The performance data listed can be considered typical of the instrument configuration used to produce it. Performance of individual instruments of this configuration under varying conditions may differ slightly from those shown here.

Tables 1 through 3 illustrate both the outstanding accuracy and the precision of our NITON XL3t 800 Series alloy analyzer against the values of certified reference materials\* for stainless steel (SS) 304, SS 321, and nickel-based alloy Hastelloy C-276. The indicated times are the seconds of measurement per filter.

The measurement accuracy coupled with the NITON XL3's unparalleled speed means high throughput with real-time traceable results you can depend on.

## Four Times Faster – Twice as Precise

For comparison testing against another instrument, we measured ourselves against the best – the previous generation Thermo Scientific NITON XLt 898. The graphical comparisons in Figures 1 and 2 compare

*\*Note that the certified values of each standard are those provided by the supplier(s) of the individual reference materials. Neither Thermo Fisher Scientific nor its subsidiaries make any guarantee, expressed or implied, as to the accuracy of the certification data of the materials used in this configuration.*

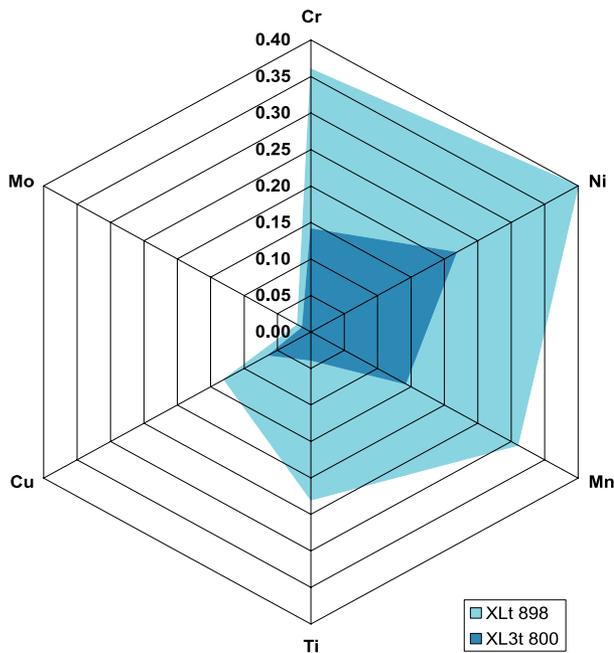


Figure 1: Instrument error comparison for Stainless Steel 321. Note especially the improvement for Ti, as the fraction of a percentage of Ti is the only difference that separates SS 321 from SS 304.

the error bands of the older XLt 898 instrument to the NITON XL3t 800. Note that the area of uncertainty (or average statistical precision) of the NITON XL3t 800, represented in the darker blue, shows a two-fold improvement or better for most elements over that of our older generation XLt 898, represented in light blue. Since measurement time relates directly to precision, the NITON XL3t 800 is literally four times faster, or twice as precise when compared to the XLt 898.

### Service and Support

Thermo Scientific NITON XL3 800 Series analyzers are designed to be the most dependable analyzers in the history of handheld XRF. From the rugged Lexan® EXL plastic instrument body to the high-performance semiconductor x-ray detector, each individual component has been carefully designed and engineered. When routine service is required, Thermo Fisher Scientific has more than 30 service centers located on six continents to provide the world-class support expected from the industry leader.

### Configurations and Accessories

Providing the optimum alloy analysis systems for almost any organization's analytical and budgetary requirements, Thermo Scientific NITON analyzers offer the widest range of options in excitation, configurations, and accessories.

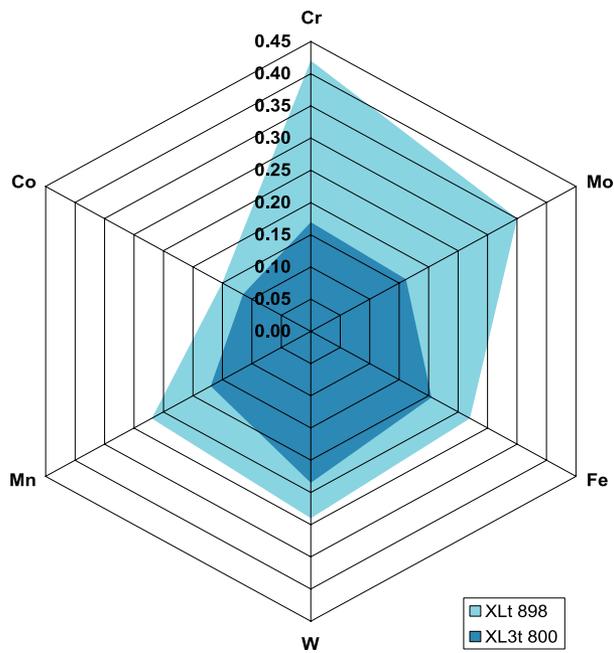


Figure 2: Instrument error comparison for Nickel-based alloy Hastelloy C-276. Note the greatly improved precision for both Cr and Mo.

With the choice of the most powerful x-ray tubes ever offered in a handheld XRF instrument or the new second generation Infiniton with dramatically higher performance, these powerful tools are revolutionizing the PMI inspection business.

All Thermo Scientific NITON XRF analyzers come with a shielded, waterproof carrying case, shielded belt holster, and PC-compatible NITON Data Transfer (NDT®) software for remote operation, file transfer, data management and advanced data analysis. Optional items include test stands, welding masks, hot surface adaptors and extension handles.

### The NITON XL3 – for All Your PMI Needs

The bottom line is that NITON analyzers provide the versatility, the greatest number of options, and the best alloy ID performance and throughput in the industry. With users performing more than 1000 readings in an 8-hour shift, confidence in the correct ID is absolutely critical. PMI inspectors have never had a faster, more accurate, or more productive testing tool than a Thermo Scientific NITON XL3 800 Series analyzer.

The best-selling handheld XRF instruments for almost a decade, NITON analyzers continue to set new benchmarks for the industry. The result is maximum productivity, minimum downtime, and expert training and support when you need, where you need it, anywhere in the world.

In addition to these offices, Thermo Fisher Scientific maintains a network of representative organizations throughout the world.

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Specifications, terms and pricing are subject to change. Not all products are available in all countries. Please consult your local sales representative for details.

All competitive references are based on an internal direct comparison of commercially available handheld XRF analyzers, July 2007.

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