INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0530

The NITON® XL-800 Series Multi-Element Spectrum Analyzer (Alloy Analyzer)

Deactivation and Decommissioning
Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

April 2000

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Summary Report

The NITON® XL-800 Series Multi-Element Spectrum Analyzer (Alloy Analyzer)

OST/TMS ID 2397

Deactivation and Decommissioning
Focus Area

Demonstrated at
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

Innovative Technology Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications."

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SECTION 1
SUMMARY

Technology Summary

The United States Department of Energy (DOE) continually seeks safer and more cost-effective technologies for use in decontamination and decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology (OST) sponsors Large-Scale Demonstration and Deployment Projects (LSDDPs). At these LSDDPs, developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to the DOE's projects and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased costs of operation.

The Idaho National Engineering and Environmental Laboratory (INEEL) LSDDP generated a list of statements defining specific needs or problems where improved technology could be incorporated into ongoing D&D tasks. One of the stated needs was for an analyzer that would reduce costs and shorten D&D schedules by providing in-situ metal characterization. The NITON® XL-800 series multi-element analyzer is a hand-held, battery-operated unit that uses x-ray fluorescence (XRF) spectroscopy to analyze, detect, and quantify 15 elements and identify 300 alloys. The baseline technology consists of collecting field samples and sending the samples to a laboratory for analysis.

This demonstration investigated the associated costs and the time required to perform an analysis with the multi-element analyzer compared to the costs and time required for the baseline technology. The NITON® XL-800 Series Multi-Element Analyzer performs in-situ, real-time analyses to identify the alloy and quantify the chemical makeup of metallic material. Benefits expected from using the multi-element spectrum analyzer include:

- Reduced sampling and analysis costs of metallic material
- Reduced schedules in DOE's Decommissioning projects
- Higher scrap metal recovery costs through
  - Identification of high-value metal for segregation during dismantlement activities
  - Identification of high-value metal for segregation of material shipped to the scrap yard
- Ability to select the optimal cutting tool.

Figure 1. NITON XL-800® Series Multi-Element Analyzer analyzing a small metal part using the irregular shaped part adapter. The image on the left shows the energy spectrum the instrument is reading during the analysis process. The image on the right shows the final element concentrations and alloy determination.

Demonstration Summary

The NITON® XL-800 Series Multi-Element Analyzer was demonstrated in July 1999 at two INEEL facilities as part of the INEEL LSDDP. The analyzer technology identified the type of alloy as well as the chemical composition of metal material at various points in the Power Burst Facility (PBF). The analyzer technology was also used to identify scrap metal pieces in the Central Facilities Area (CFA) North and South scrap yards for the purpose of segregating material that had a higher scrap value from the rest of the scrap metal. For baseline comparison, metal samples were cut from scrap items in the CFA North and South scrap yards and sent to a laboratory for analysis. The NITON® XL-800 Series alloy analyzer was also tested against existing laboratory analyses. Data from the demonstration indicated that the NITON® XL-800 Series Multi-Element Analyzer provides data comparable to the laboratory data. Based on a cost saving of $954 per sample over laboratory analysis, it would require about 30 samples to recover the capital cost of the NITON® XL-800 series Multi-Element Analyzer of $28,500.

Figure 2. NITON® XL-800 Series Multi-Element Analyzer being used to analyze system piping

Contacts

Technical

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The INEEL LSDDP Internet web site address is http://id.inel.gov/lsddp

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Licensing

No specific license was required, although specific licensing may be required in some states. The NITON® XL-800 Series Multi-Spectrum Analyzer was purchased from the NITON® Corporation.

Permitting

No permitting activities were required for shipment. The NITON® XL-800 Series Multi-Element Analyzer meets the Department of Transportation requirements in 49 CFR 173.421 for excepted packages for limited quantities of Class 7 (radioactive) materials. A Class 7 (radioactive) material is one in which the activity per package does not exceed the limits specified in 49 CFR 173.425. The packaging, marking, labeling and, if not a hazardous substance or hazardous waste, the shipping papers meet the certification requirements of this subchapter and requirements of this subpart if the radiation level at any point on the external surface of the package does not exceed 0.5 mrem/hour. INEEL required that the NITON® XL-800 Series Multi-Element Analyzer instrument be stored in a Radiological Storage Area (RSA) and controlled by a source custodian. The instrument case must be affixed with a radiological symbol to designate radiological material inside and the instrument can only be checked out and used by source user trained personnel.

Other

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for the NITON® XL-800 Series Multi-Element Analyzer is 2397.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

Demonstration Goals and Objectives

The overall purpose of this demonstration was to assess the benefits that may be derived from using the NITON® XL-800 Series Multi-Element Analyzer. The analyzer was compared with the baseline technology, which is laboratory analysis on samples. The primary goal of the demonstration was to collect valid operational data to make a legitimate comparison between the NITON® Analyzer and the baseline technology in the following areas:

- Cost
- Productivity rates
- Ease of use
- Limitations and benefits.

The secondary goals of the demonstration were scrap segregation and real-time characterization data. This demonstration intended to determine if it is cost effective to segregate scrap material with higher scrap values either during dismantlement operations or when material is received at the scrap yard. It was also expected that the demonstrations would provide the D&D program with characterization data in real-time, which would allow the D&D project manager to disposition a room or facility and move forward immediately without waiting 3 months for the laboratory data needed for a decision.

Description of the Technology

The NITON® XL-800 Series Multi-Element Analyzer uses X-ray fluorescence (XRF) spectrum analysis to identify and quantify elements in metal and then compares the readings to a built-in library to determine the alloy grade. The library contains 300 alloy grades and can be customized. The basic unit uses a Cadmium-109 source, but each analyzer unit can hold up to three sources. Iron-55 and Americium-241 are available as second sources. Iron-55 provides greater sensitivity in the range between Sulphur-16 and Chromium-24; Americium-241 provides greater sensitivity in the range between Rhodium-45 and Terbium-65. Pushing a safety button on the side of the unit and placing it against a surface opens the shutter window. The unit beeps at 5, 20, and 60-second intervals, and the results are displayed when the unit is removed from the surface. The longer the instrument analyzes a surface, the more precise the analysis. The analyzer can store up to 1,000 data sets, including sample identification codes input using a barcode reader. The data is easily downloaded to a conventional personal computer when sampling has been completed. The NITON® Analyzer is a surface scanner only, so contaminants of an alloy nature and coatings can affect the readings. Surface preparation from wiping the surface clean to scraping paint or grinding off a coating may be necessary to obtain an accurate reading. The NITON® Analyzer is an 8 x 3 x 2-in. hand-held, battery-operated unit. It weighs 2.5 pounds with a price starting at approximately $28,000. Batteries are usable for 8 hours and can be charged in less than 2 hours. Conforming to 49 CFR 173.421, the NITON® Analyzer can be carried, shipped, or transported without exterior labeling.

Figure 3. Basic NITON® XL-800 Series Multi-Element Analyzer system. Shown are the NITON® analyzer, spare battery and charger system, irregular shape adapter, computer connector cable, and the waterproof, hard-sided carrying case.

System Operation

Table 1 summarizes the operational parameters and conditions of the NITON® XL-800 Series Multi-Element Analyzer demonstration.

Table 1: Operational parameters and conditions of the NITON® XL-800 Series Multi-Element Analyzer demonstration.

Working Conditions	
Work area locations	• Power Burst Facility • Central Facilities Area North and South excess yards
Work area access	Access controlled by D&D project through use of fencing and posting
Work area description	• The work area inside PBF is cordoned off and posted as a fixed contamination area. In basement room A-105, contamination was fixed below 8-ft. • The work area inside the CFA North and South Excess Yards are fenced and posted as controlled areas. Heavy machinery operates in both yards requiring safety shoes for entry. • There were no other activities at PBF during the demonstration but there were scrap shipments and other ongoing activities at the excess yards that were not related to the demonstration.
Work area hazards	PBF • Non-fixed contamination above 8-ft • Tripping hazards North and South Excess Yards • Heavy equipment operations • Tripping hazards • Cutting hazards • Temperature extremes
Equipment configuration	The NITON® Series Multi-Element Analyzer was transported to the job site by the samplers. The NITON® XL-800 is stored in a Radiological Containment Area at CFA and controlled by a source custodian. Personnel must either be source user or source custodian trained to check out the equipment.

Labor, Support Personnel, Specialized Skills, Training	
Work Crew	Minimum work crew at PBF: • 2 Sample Technicians • 1 Health Physicist Technician • 1 Project Manager Minimum work crew at CFA excess yards: • 1 Sample Technician • 2 Laborers • 1 Project Manager
Additional support personnel	• 1 Data collector • 1 Test Engineer • 1 Health and Safety Observer (periodic)
Specialized skills/training	• The NITON® Corporation provided training on the operation of the NITON® XL-800 Series Multi-Element Analyzer. • Source user or source custodian training is required to check out and operate the NITON® XL-800 Series Multi-Element Analyzer.
Waste Management	
Primary waste generated	No primary wastes were generated.
Secondary waste generated	Disposable personal protective equipment (wipe rag at PBF)
Waste containment and disposal	The laboratory disposed of metal samples.
Equipment Specifications and Operational Parameters	
Technology design purpose	To identify alloy type and chemical composition of metal material.
Specifications	• 8 x 3 x 2-in. • 2.5-lbs.
Portability	The NITON® XL-800 Series Multi-Element Analyzer is a hand-held, battery-operated unit.
Materials Used	
Work area preparation	No specific preparation was necessary for the demonstration at PBF. The D&D project already had necessary controls and preparation in place. At the CFA excess yards, 4 x 8 x 4-ft boxes were staged next to each scrap pile that was to be segregated.
Personal protective equipment (PPE)	PBF • Disposable wipe rags CFA Excess Yards • 2 pair safety glasses (Laboratory sample cutting operations only) • 3 pair safety gloves • Safety shoes
Utilities/Energy Requirements	
Power, fuel, etc.	None required specific to the technology tested.

SECTION 3
PERFORMANCE

Demonstration Plan

Problem addressed

Most DOE facilities characterize metal by cutting samples and sending the samples to a laboratory for analysis. Sample collection can take hours and analytical results from the laboratory may not be available for months. The NITON® XL-800 Series Multi-Element Analyzer can characterize the chemical composition and determine alloy type in metal material in about 20 seconds. The D&D project management can use these results in making immediate decisions on the appropriate approach to remediate a facility and segregate metal.

Demonstration site description

PBF was constructed in the 1950s to test the operational behavior of nuclear reactors and to study the safety of light-water-moderated, enriched-fuel systems. PBF consists of the Reactor Area and the portion of the Control Area not used for Waste Reduction Operations Complex support. The original reactor was decommissioned in 1964 and demolished in 1985. The current reactor was constructed in the 1970s, just north of the original reactor, to support studies of fuel behavior during various operating conditions.

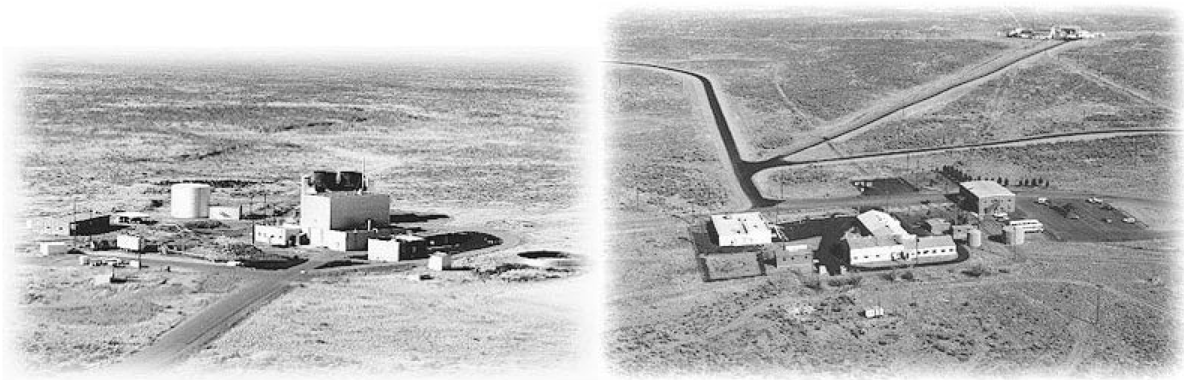


Figure 4: PBF Reactor Area (left) and Control Area (right)

The Central Facilities Area is the main service and support center for the programs located at the INEEL's other primary facility areas. Seventy-eight craft shops, laboratories, warehouses, storage facilities, service facilities, and technical and administrative support buildings are located at the CFA and comprise 653,438 square feet. The North and South excess yards are located behind building CFA 674.

Figure 5: Central Facilities Area

Primary objectives of the demonstration

The major objectives were to evaluate the NITON® Analyzer against the baseline technology in several areas including:

- Cost
- Productivity rates
- Ease of use
- Limitations and benefits.

Primary elements of the demonstration

Both the baseline technology and the NITON® Analyzer were used to identify the chemical composition and alloy of metal material. The demonstration occurred on both coated and uncoated surfaces. The coating consisted of paint and galvanized metal. Samples had to be cut from scrap material in the Excess Yards as no scraping, cutting, or dislodging of material in any form was allowed at PBF. Two stainless steel and two carbon steel samples were cut from material and sent to a laboratory for analysis. To augment the four excess yard samples sent to a laboratory for analysis, twelve pre-cut metal samples with quality assurance (QA) approved Certified Material Test Reports (CMTRs) were analyzed by the NITON® Analyzer. The intent of the NITON® Analyzer analysis was to gather information to be used by the D&D project managers in making immediate decisions on the approach to remediate an area of a facility, instead of waiting months for laboratory data. Data from the demonstration indicated that the NITON® Analyzer provides data comparable to the laboratory data. The main value of the analyzer is that it can complete each analysis in about 20 seconds and all the results can be downloaded to a computer.

Secondary objective of the demonstration

The secondary objective of the demonstration was to show the feasibility of segregating scrap metal using the NITON® Analyzer. This was done by determining the segregation cost per pound of metal.

Secondary elements of the demonstration

The current method of receiving, storing, and excessing scrap metal at the INEEL is to unload it into a designated area. There are two basic excess areas at the INEEL. One area contains stainless steel and the other contains miscellaneous scrap. Scrap material usually comes to the INEEL segregated into stainless steel and non-stainless steel piles. The demonstration occurred on both the stainless steel and non-stainless steel piles. The stainless steel was sorted into 316 stainless steel, all other stainless steel, and non-stainless steel. The non-stainless steel was segregated into carbon steel, aluminum, copper, and other. When segregation was completed, all the metal was weighed separately. The main value of the analyzer is that it is hand-portable and can identify the alloy of metal material in seconds. This provides the ability to identify high-value scrap metal material for segregation from the rest of the metal material.

Results

Both technologies were evaluated under identical physical conditions. Every attempt was made to allow work to proceed under normal conditions with no bias. All parties involved in the demonstration were requested to perform the work normally with no special emphasis on speed or efficiency. On June 10th, only the NITON® XL-800 Series Multi-Element Analyzer was demonstrated at PBF as any cutting, scraping, or removal of material in any form was not allowed. On June 23rd, 11 QA-certified samples were characterized for the purpose of comparing the analyzer's chemical make up readings of the metals with the Certified Material Test Reports of each sample. On July 8, samples were cut from four items at the CFA North and South Excess yards and sent to a laboratory for analysis.

A performance comparison between the baseline technology and the NITON® XL-800 Series Multi-Element Analyzer is listed in Table 2. A comparison between the CMTRs and the NITON® XL-800 Series Multi-Element Analyzer can be found in Appendix C. Appendix C shows that the analyzer results are comparable to the laboratory CMTRs. Of the 11 QA samples analyzed, the analyzer was unable to determine the correct alloy of samples 7 and 11. Using these results and the results from the PBF characterization, the NITON® XL-800 Series Multi-Element Analyzer had 96% accuracy in determining the material's alloy using the 20-second analysis setting. On QA sample 8, there were two analyzer results. This is because sample 8 had paint on one of the surfaces, and the painted surface was also analyzed to show the effects of coatings and surface contamination. The effects of the paint on the chemical analysis were enough to produce an erroneous alloy determination. The paint was white, thus accounting for the presence of Titanium in the second analyzer reading.

Table 2: Performance comparison between the NITON® XL-800 Series Multi-Element Analyzer and the baseline technology.

Performance Factor	Baseline Technology Cutting samples for lab analysis	NITON® XL-800 Series Multi-Element Analyzer
Personnel/equipment/ time required to obtain data or metal samples	Personnel: • 2 sample Technicians Equipment: • 1 hand-held hack saw • 1 battery operated drill with two battery packs • 4 sample bags Time: • 10 to 11 minutes to collect stainless steel sample • 8 to 9 minutes to drill and collect carbon steel sample.	Personnel: • 2 Sample Technicians Equipment: • 1 NITON® XL-800 Series Multi-Element Analyzer Time: • About 2 minutes for the NITON® Analyzer to provide results per sample.
Time required to obtain data	Equipment: • Laboratory Time: (duration not man hours worked) • 12 hours to ship samples to the lab • 90 days	Equipment: • NITON® XL-800 Series Multi-Element Analyzer Time: (duration not man hours worked) • 2 minutes to connect NITON® Analyzer to the computer and start program • 3.5 seconds per sample to download.
Preparation time	Equipment: • 1 hand-held hack saw • 1 battery operated drill with two battery packs • 4 sample bags • Contract with laboratory Time: • 24 hours to purchase or obtain equipment • 3 weeks for the Sample Management Office to set up a contract with a laboratory	Equipment: • 1 NITON® XL-800 Series Multi-Element Analyzer Time: • 10 minutes to check the NITON® Analyzer out of the Radioactive Storage Area (RSA) • 10 minutes for the analyzer to warm up and self calibrate.
Total Time per Technology	• 90 days	• 24 minutes
PPE Requirements	• Safety gloves • Safety glasses • Other job specific PPE	• Job specific PPE

Performance Factor	Baseline Technology Cutting samples for lab analysis	NITON® XL-800 Series Multi-Element Analyzer
Superior Capabilities	• Able to analyze all elements of the periodic table. The NITON® XL-800 Series analyzer is designed to detect 15 elements between Titanium (Ti) and Tungsten (W).	• The NITON Analyzer was considered much easier to use. • The NITON Analyzer takes 20 seconds to get a comparable reading and only a few minutes to download the data to a computer compared to 90 days to get data from a laboratory. • The NITON® Analyzer can analyze equipment without damaging the structure. • Data not affected by sampling method

Figure 6. NITON® XL-800 Series Multi-Element Analyzer performing self-calibration

Figure 7. NITON® XL-800 Series Multi-Element Analyzer analyzing a system valve in place.

Figure 8. NITON® XL-800 Series Multi-Element Analyzer downloading results to a PC

On June 23rd, the segregation of metal was demonstrated using the NITON® XL-800 Series Multi-Element Analyzer at the CFA North and South Excess yards. Using the baseline method to identify scrap material is impractical due to the time involved to receive laboratory results and the cost to send samples to the laboratory for analysis. In this demonstration, the NITON® XL-800 Series Multi-Element Analyzer was used to characterize and identify each piece of scrap metal. No effort was made to perform visual segregation. In a 10-hour workday, this demonstration was able to segregate 2,920 pounds of scrap with a resulting segregation cost of $0.39 per pound. The 5-second analysis mode was utilized to increase production since accurate chemical composition was not necessary.

In the North Excess yard, various pieces of stainless steel scrap were characterized and separated into piles of 316 stainless steel, non-stainless steel, and other alloys of stainless steel. Of the 1,740 pounds of stainless steel analyzed, 348 pounds were found to be 316 stainless steel, and 174 pounds were found to be non-stainless steel. Hastelloy comprised a majority of the non-stainless steel pile.

In the South Excess Yard, the scrap piles were supposed to contain carbon steel, aluminum, and copper. The NITON® XL-800 Series Multi-Element Analyzer did identify a couple of higher value material items in the piles. These items consisted of one small 316 stainless steel item and one small Hastelloy item. A total of 1,180 pounds of scrap material was segregated; 1,040 pounds of carbon steel and 140 pounds of aluminum. The weight of the higher value material items were not included as they were small and combined weighed less than 5 pounds. There was no copper wire present, as all copper wire coming into the excess yards was visually segregated for another technology demonstration.

Figure 9. Typical non-stainless steel scrap pile at the INEEL scrap yards

Figure 10. NITON® XL-800 Series Multi-Element Analyzer being used to identify and separate metal scrap

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Baseline Technology

The NITON® XL-800 Series Multi-Element Analyzer competes with the baseline technology of cutting samples and laboratory analysis.

Other competing technologies

Texas Nuclear makes an XRF instrument that can determine the chemical composition and alloy of metal material. Texas Nuclear model M-9277 has been deployed at the INEEL. The unit weighs approximately 40 pounds, requires manual calibration on start-up, and costs approximately $40,000. The M-9277 is not designed as a field portable unit; thus samples would still have to be cut from the system for analysis.

Technology Applicability

The NITON® XL-800 Series Multi-Element Analyzer is a fully developed technology that is commercially available for field analyzing metal material. Its superior performance over the baseline in almost all areas makes it a prime candidate for deployment throughout the DOE complex. It has the potential to reduce costs for field screening and characterization on any D&D project. The INEEL has deployed the NITON® XL-800 Series Multi-Element Analyzer as well as the Texas Nuclear M-9277. The Texas Nuclear M-9277 is bulkier than the NITON® XL-800, does not self-calibrate on startup, costs more, and was not designed as a field portable unit.

Patents/Commercialization/Sponsor

The NITON® XL-800 Series Multi-Element Analyzer is commercially available from the NITON® Corporation, of Bedford, MA.

SECTION 5
COST

Methodology

This section estimates the cost of performing characterization work using the NITON® XL-800 Series Multi-Element Analyzer and compares this cost with the cost of performing characterization based on laboratory analysis. Additionally, this section estimates the cost for sorting scrap metal and screening for recyclable metals using the NITON® Analyzer and determines the added value needed to recover characterization and sorting cost.

Characterization costs for the innovative and the baseline technologies are derived from work observed during the demonstration at the PBF and the test engineer's judgement and experience. The sorting of scrap metals and screening costs for NITON® Analyzer are based on observed work at the CFA. This sorting and screening cost is compared with the increased value of recyclable material. This is primarily based on national scrap values for stainless steel-316. Recyclers will only pay the lowest price for a pile of metal. Thus, if stainless steel-316 is grouped with other grades of stainless steel, then the recycler will pay the lowest recycle value for the entire scrap pile. Obvious mixes such as a combination of stainless steel, aluminum, copper, and carbon steel will be valued by estimating the quantity of each metal type and paying a conservative price based on the quantity estimates. Costs for contracting and handling the recyclable materials are ignored as they are daily overhead items common to both technologies. The demonstration was performed using INEEL workers and costs assume Government ownership of the equipment and its operation by INEEL site personnel.

The demonstration included 32 samples (plus four quality-control samples) that were taken by the innovative technology at the CFA location, and 247 samples by the innovative technology and four samples by the baseline methodology taken at the PBF location. This cost analysis of the characterization work assumes 36 samples that were extrapolated from the "as-demonstrated" quantity using the observed production rates.

The number of persons involved in the demonstration varied from 8 to 10 persons, and is not representative of normal work. The cost analysis assumes a crew consisting of two engineer technicians for the NITON® Analyzer characterization. The baseline lab sample collection and analysis is assumed to require two engineering technicians. The crew for sorting and screening using the NITON® Analyzer is assumed to require an Industrial Hygienist and two laborers. The labor rates are based on standard rates for the INEEL site. The equipment rates are based on the amortized purchase price and maintenance costs. Additional details of the cost analysis are shown in Appendix B.

Cost Analysis

Costs to Procure Vendor-Provided Equipment

The innovative technology equipment is available from the vendor with optional components. The purchase prices, rental rate, and lease rate of the basic equipment and optional features used in the demonstration are shown in Table 3.

Table 3: Acquisition and Maintenance Costs – Inn0ovative Technology[1]

Option	Item Description	Cost - $
Purchase[1]	NITON XL-801S Alloy Analyzer – Cd-109 Source	28,495
	NITON XL-841S Alloy Analyzer – Cd-109 and Fe-55 Sources	33,495
	NITON XL-801S Alloy Analyzer – Cd-109 and Am-241 Sources	33,495
Rental[2]	NITON XL-801S Alloy Analyzer – Cd-109 Source	$3,900/mo
Lease[3]	NITON XL-801S Alloy Analyzer – Cd-109 Source	$1,850/mo
Maintenance	Maintain/Replace Cd-109 Source (every 15-24 months)	2,600
	Replacement of Both Cd-109 and Fe-55 Sources (every 15-24 months)	4,200
	Maintain/Replace Fe-55 Source (every 30-48 months)	3,400

[1]/ Costs per NITON® Corporation, Bedford MA, domestic price list dated July 26, 1999
[2]/ Three-month rental cost per Don Sackett of NITON® Corporation, Bedford MA, September 13, 1999
[3]/ One-year lease cost per Don Sackett of NITON® Corporation, Bedford MA, September 13, 1999

Comparative Unit Costs for the Two Technologies

Derived unit costs for characterization sampling at PBF are shown in Tables B-2 and B-3 of Appendix B. The characterization unit costs derived were $19.72 per sample for the innovative technology and $1,192.12 per sample for the baseline technology. These results are presented as the bar charts of Figures 12 and 13.

The longest bars in each of the figures represent those components of the demonstration effort with the highest cost contributions. Of the 15 activities in Figure 12 (innovative technology), the longest bars are those for “Productivity Loss,” (time lost with “No Match” readings, and other losses), “Perform Analysis,” and “Equipment Setup,” having respective percentage contributions to cost of 29%, 17%, and 17%. By contrast, the bars of longest length in Figure 13 are those for “Sample Analysis” and “Sample Validation,” each having, respectively, percentage cost contributions of 87% and 9%.

Activities on the order of 1-5% of the total cost have little effect on the total cost, even if these activities have the potential for large variation. However, a moderate variation in cost of those activities that are 15% or more of the total unit cost will have a significant impact on the total cost.

Furthermore, the relative cost contribution of once-per-job type of activities will vary with project size. Site-specific conditions that can significantly affect the cost of the activity are identified on the right–hand side of the respective figures.

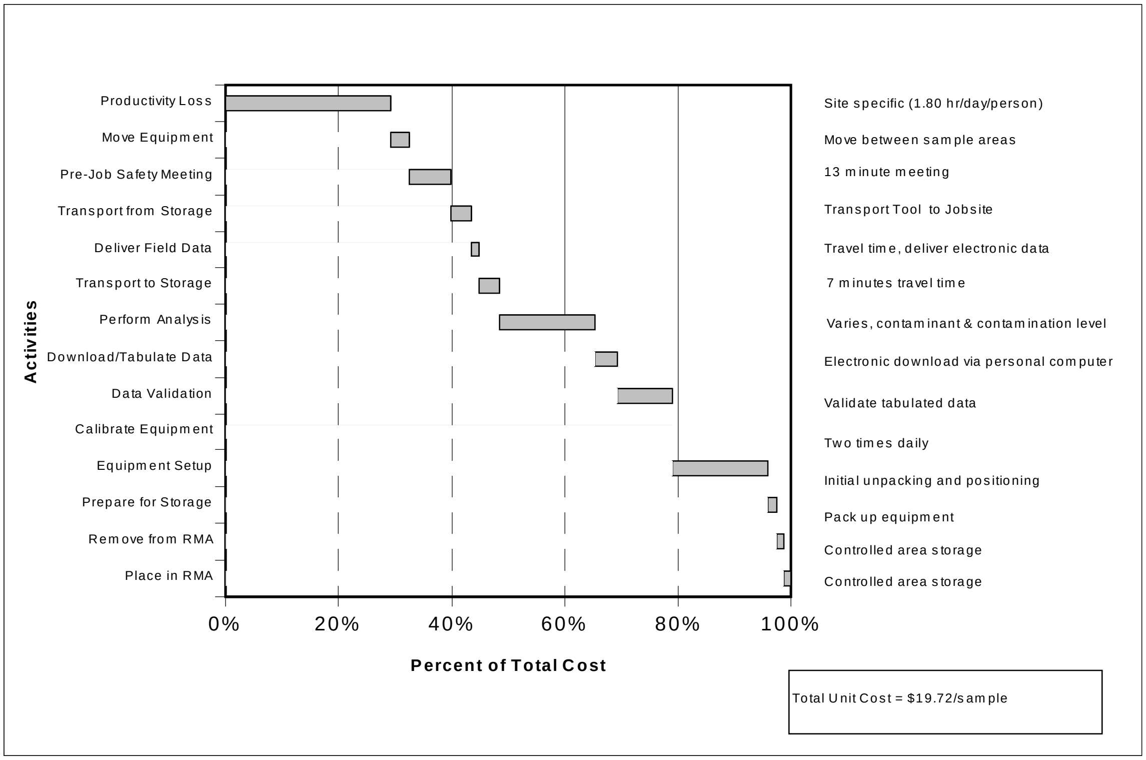


Figure 12. Breakdown of Innovative Technology Unit Cost for Characterization

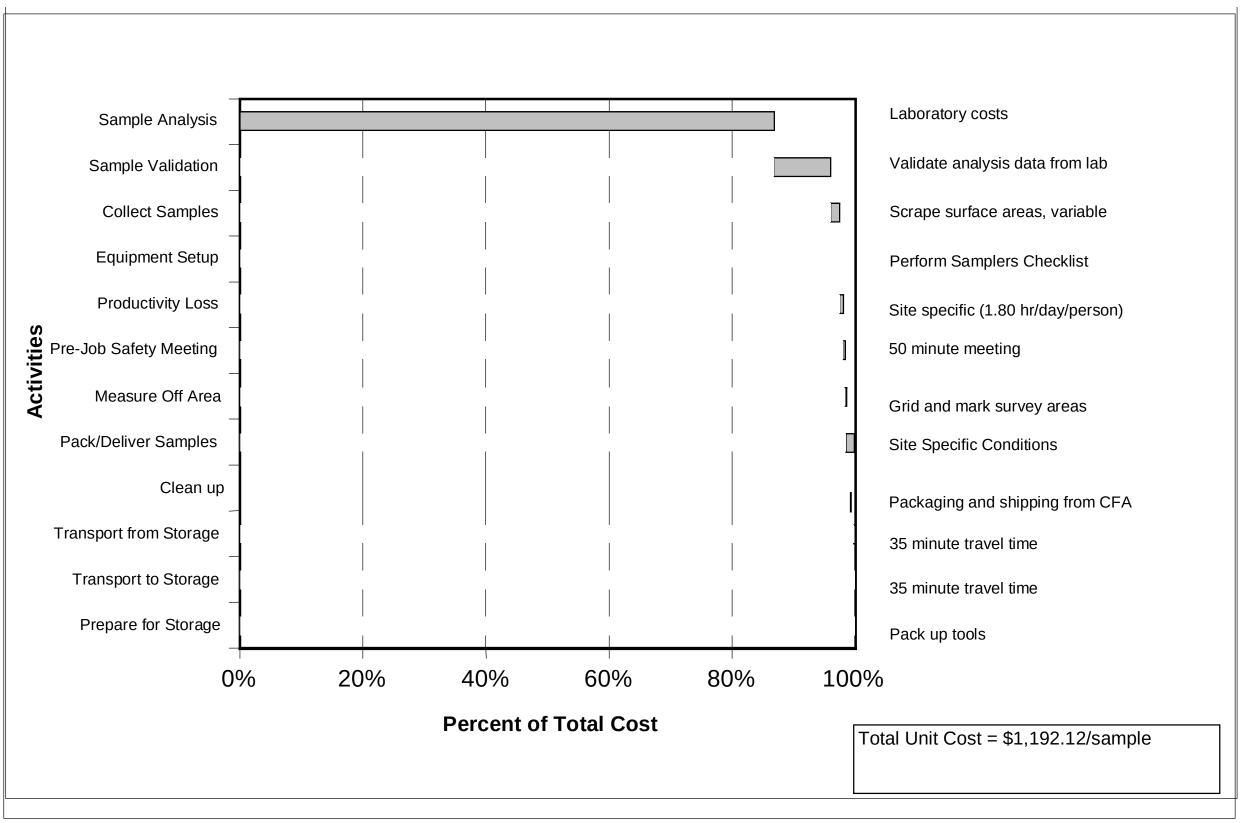


Figure 13. Breakdown of Baseline Technology Unit Cost for Characterization

Payback Period

For the characterization portion of the demonstration, the innovative technology saves approximately $34,336 ($42,916 - $8,580) per job over the baseline for a job size of 36 sample areas or approximately $954 per sample. The amount will vary depending on site-specific conditions. At this rate of savings, the purchase cost is recovered after approximately 30 samples.

For the scrap sorting and screening portion of the demonstration, approximately 1,740 pounds of stainless steel was segregated from 2,920 pounds of scrap. The stainless steel consisted of approximately 348 pounds of 316 stainless steel valued at about $0.39 per pound and approximately 1,392 pounds of other less-valuable grades of stainless-steel valued at about $0.29 per pound. The value of the scrap steel is approximately $0.01 per pound, and savings generated by the higher value of the stainless-steel over the common scrap is:

348-lbs x ($0.39/lb 316 stainless - $0.01/lb scrap) + 1,392-lbs x ($0.29/lb common stainless - $0.01/lb scrap) = $522.

This $522 would represent the best case increase in salvage value as it assumes all the mixed scrap would be sold for the lowest possible value. The cost of segregating the scrap is $926 (see computation of cost shown in Appendix B, Table B-1). Consequently, there is a net loss for each pound of scrap processed. This cost does not include costs for contracting for the recycling or handling of the recycling, as they are common overhead costs for both technologies. The scrap values can vary by a large amount over time and from location to location, but for the scrap values used in this computation and quantity of stainless steel observed in this demonstration, the cost of purchasing the NITON® XL-800 Series Multi-Element Analyzer would never be recovered.

Segregating the metal material during the dismantlement process may provide for a payback in increased salvage value. The manpower cost to segregate at the scrap yard was too much for the increased return value. Of course, this may only work if the metal material is cut out of a facility. This was not tested at the INEEL as only selected areas of metal are cut out to make room for other jobs such as asbestos removal. At the INEEL, the buildings are explosively collapsed and the metal material segregated by large equipment and visual inspection.

Observed Costs for Demonstration

Figure 14 summarizes the characterization costs observed for the innovative and baseline technology for the 36 samples. The details of these costs are shown in Appendix B, specifically Tables B-2 and B-3, which can be used to compute site-specific costs by adjusting for different labor rates, crew makeup, lab costs, etc.

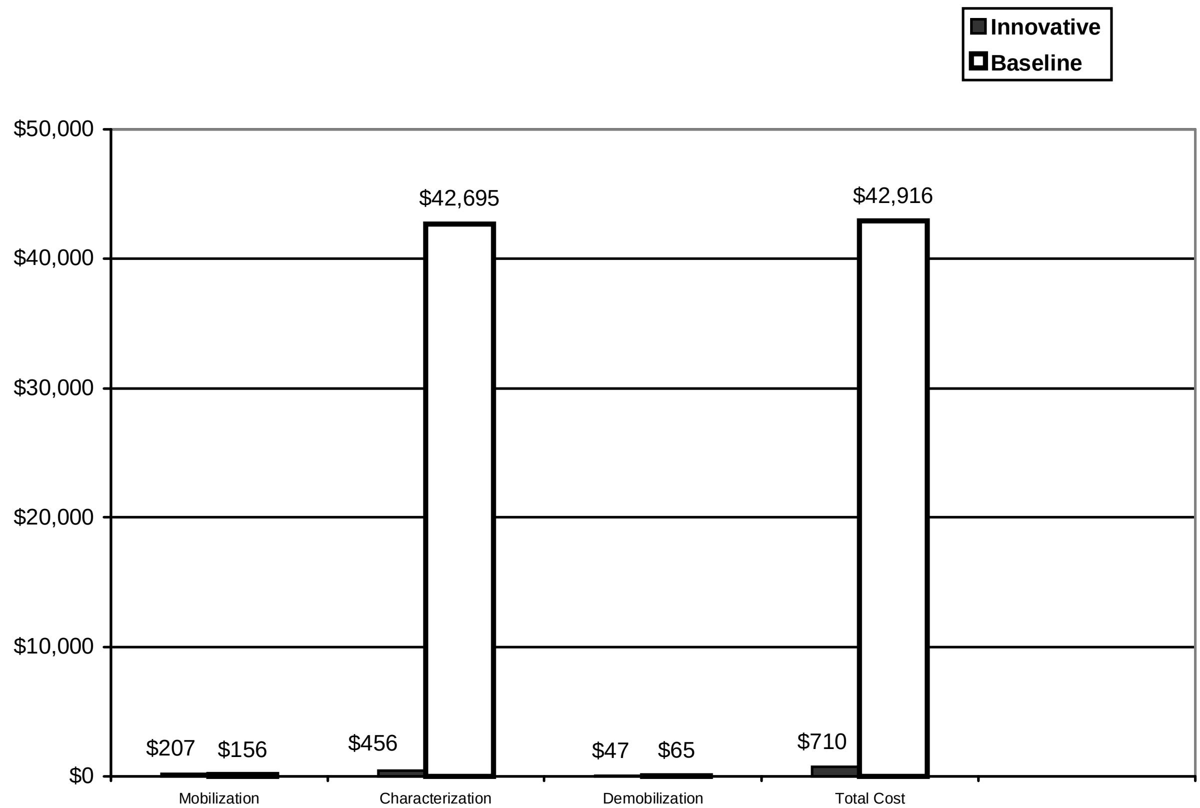


Figure 14. Summary of PBF Sampling Costs

Cost Conclusions

The unit cost of the innovative technology is approximately 2 percent of the unit cost of the baseline technology for this demonstration.

The single most significant cost factor in the comparison of the innovative and baseline characterization costs is the laboratory analysis cost. The scenario used in this demonstration would be typical for field characterization work. Different types of analyses may be used with other situations and affect the cost comparison.

The production rates affect the cost comparison, but to a much smaller degree than the laboratory analysis costs. The observed characterization production rate was 35 samples/hr for the innovative technology and 5 samples/hr for the baseline technology. This production rate may increase or decrease depending upon the work conditions such as sample locations that are out of reach and require use of a ladder. This site-specific productivity variation will not significantly affect the cost comparison but does affect the cost of performing the work.

The number of “No Match” instrument readings for the NITON XL-800 Series Multi-Element Analyzer will vary from one situation to the next and may affect the cost comparison if a laboratory sample analysis was required to replace the “No Match.”

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

The NITON® XL-800 Series Multi-Element Analyzer meets the Department of Transportation requirements for 49 CFR 173.421 excepted packages for limited quantities of Class 7 (radioactive) materials. The INEEL requires the NITON® XL-800 Series Multi-Element Analyzer to be stored in a Radiological Storage Area with a source custodian. A radiological symbol sticker must be affixed to the case used for transporting the analyzer out of the RSA and only source user or source custodian trained personnel can check out and use the analyzer. For this demonstration, a test plan and safe work permit covered the use of the NITON® XL-800 Series Multi-Element Analyzer under the INEEL LSDDP.

Safety, Risks, Benefits, and Community Reaction

The safety issue associated with the use of the NITON® XL-800 Series Multi-Element Analyzer is primarily radiation hazards. The risks are mitigated by use of proper monitoring, storage, transport, and training. The risks associated with the use of the NITON® XL-800 Series Multi-Element Analyzer are routinely acceptable to the public.

SECTION 7
LESSONS LEARNED

Implementation Considerations

The NITON® XL-800 Series Multi-Element Analyzer is a mature technology that performed well during the INEEL demonstration. The analyzer required no special skills to use and the workers found the analyzer to be much easier to use than the baseline technology. Items that should be considered before implementing the NITON® Analyzer include:

- The NITON® Analyzer needs to be sent back to the manufacturer (NITON® Corporation) every 2 years for routine maintenance and to have the Cadmium-109 source replaced and software upgraded.
- The INEEL's Radioactive Source Coordinator and Radiological Safety Engineers requires the NITON® Analyzer (which contains a radioactive source inside the instrument) to be controlled and accounted for at all times.
- In some instances, it may be necessary to supplement the NITON® Analyzer analysis with confirmatory laboratory analysis.
- By more appropriate selection of alloys for the NITON® Analyzer during the purchase process, (e.g. that conform to DOD/DOE alloys expected to be encountered) the percentage of No-Match's can be mitigated.

Technology Limitations and Needs for Future Development

The NITON® XL-800 Series Multi-Element Analyzer performed well during this demonstration. Surface contaminants of an alloy nature, coatings and paints can have an effect on the accuracy of the analyzer's analysis. Due to the physics of XRF technology, the analyzer can not determine elements below chlorine on the periodic table, thus preventing the detection of organic material present in metallic material. The lighter elements are also difficult for the analyzer to detect. Improvements in energy detection should greatly increase the accuracy of the analytical results. This technology is currently not approved by the regulators as an alternative to laboratory analysis. Until approved by the regulators as an alternative to lab analysis, the potential benefit of this technology will be limited to screening activities that will in some cases require confirmatory sample analysis.

Technology Selection Considerations

Based on the INEEL demonstration, the NITON® XL-800 Series Multi-Element Analyzer is a better choice than the baseline technology for the analysis of metal material. The analyzer is easier to use and more cost effective. The analyzer can provide the field data to support making immediate decisions on the appropriate approach to remediate an area of a facility.

The data obtained by the NITON® Analyzer is comparable to laboratory analysis. In this demonstration, it was shown how the presence of coatings could effect the NITON® Analyzer readings. Thus, proper surface preparation is necessary. The real-time data can be very useful in making immediate decisions such as the proper tooling for cutting the metal during dismantlement.

The labor costs outweighed the salvage value increase for this demonstration, thus this instrument was not shown useful in scrap segregation activities. Again, the real-time data could be used to segregate the metal during dismantlement activities where the labor increase would be minimal. This aspect of segregating during dismantlement was not demonstrated at the INEEL as that is not how facilities are dismantled.

APPENDIX A
REFERENCES

USACE, 1996, *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS).

Office of Management and Budget (OMB), Circular, *Cost Effectiveness Analysis*, No. A-94.

APPENDIX B
Cost Comparison Details

Basis of Estimated Cost

The activity titles appearing in the tables of Appendix B were developed based on field observation of the work. To ensure consistency with established national standards, they were structured based on *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS) (USACE 1996), a work breakdown structure developed by an interagency group. Hourly rates were computed based on the following assumptions:

- All equipment is Government-owned.
- Rates for Government ownership are computed by amortizing the purchase price of the equipment and adding a procurement cost of 5.2 percent of the purchase price and annual calibration costs.
- A service life of 10 years.
- An annual usage of 500 hours per year for both the innovative and baseline equipment.
- Costs for Government ownership per general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, *Cost Effectiveness Analysis*.
- Standard labor rates per INEEL, inclusive of salary, fringe, departmental overhead, material handling markups, and facility service center markups.
- No General & Administrative (G&A) markups since this varies by DOE site (this allows decision-makers seeking site-specific costs to apply their site's G&A rates to this analysis without having to first back-out INEEL rates).
- No costs for oversight engineering, quality assurance, administrative costs for the demonstration, or work plan preparation.
- A 10-hour work day.

Activity Descriptions

The scope, factors used to compute production rates, and assumptions (if any) for each work activity is described in this section. See the tables of Appendix B for field measurements of elapsed time. Some times may be based on the test engineers' best judgement. Times to perform this work at sites other than INEEL may vary from those cited in this report.

Mobilization (WBS 331.01)

Remove from RMA: The NITON® Multi-Element Analyzer will be stored in a Radioactive Material Area (RMA), because it contains a radioactive source. Because the RMA is a controlled and secured area, it takes time to remove it. The estimated time is based on the judgement of the test engineer.

Transport from Storage: The baseline equipment will be stored in a sample equipment/supplies storage area. The time required to transport the equipment to the work area is based on the judgement of the test engineer. The transportation time for the innovative equipment is assumed to be the same as for the baseline. The baseline equipment includes miscellaneous small tools such as a metal basin, wall scrapers, heat gun, tape measure and a pedestal. The innovative equipment includes only the multi-purpose analyzer (small tools are negligible).

Pre-Job Safety Meeting: The duration for the pre-job safety meeting is based on the judgement and experience of the test engineer. The labor costs associated with this and all activities in this report are based on a theoretical crew, rather than the actual demonstration crew, and the theoretical crew is reflective of conditions at the INEEL site only.

Equipment Setup: This activity consists of unpacking the equipment and assembling the components for the innovative technology. The duration is based on the observed time for the demonstration. The baseline activity accounts for performing the “Sampling Checklist” at the supply shop before traveling to the job site. It includes chain of custody requirements, paperwork, label preparation, tool organization, etc. The duration is based on the judgement and experience of the test engineer.

Characterization (WBS 331.17)

Move Equipment: This activity accounts for moving the NITON® analyzer between sample areas. For NITON® XL-800 Series Multi-Element Analyzer use at other DOE sites, times may vary from those cited in this report, and thus should be tailored to the individual sample area transit times at those sites.

Position NITON® XL-800 Series Multi-Element Analyzer: This activity accounts for the time necessary to re-position the NITON analyzer between each reading, within the specific sample area.

Perform Analysis: In the case of the sort and segregate portion of the demonstration, the metal is sorted according to metal type plus sample removal and instrument removal time. The time taken to conduct this work was not separately recorded – these times are included in the generic “Perform Analysis” times shown in Table B-1. In the case of characterization, the “Perform Analysis” times include removal of coatings from specimens to be sampled and instrument reading time. For the baseline technology, samples are analyzed in an independent laboratory (see sample analysis). The assumed sample quantity is 36 samples (32 samples plus 4 quality-control samples). The production rate used in the analysis is the average number of samples observed (36) taken over a period of 62 minutes, or 34.8 samples per hour. The crew assumed for characterization is 2 engineering technicians, while the crew for screening scrap is 1 hygienist. The production rate is 94.3 samples per hour as sorting and screening of scrap is performed.

Calibrate Equipment: The NITON® XL-800 Series Multi-Element Analyzer is calibrated twice daily.

Deliver Field Data: In this activity, the field crew delivers the NITON® XL-800 Series Multi-Element Analyzer data back to an engineering office for download to microcomputer.

Download/Tabulate Data: In this activity, one Industrial Hygienist electronically downloads NITON® XL-800 Series Multi-Element Analyzer data to a microcomputer in database format for tabulation.

Data Validation: In this step the tabulated data is validated.

Productivity Losses: Minor productivity losses are associated with both the baseline and innovative technologies. Those associated with the innovative technology include time lost due to “No Match” readings, time for coatings removal, and time for equipment setup and familiarization. The major cause for losses with the baseline technology is equipment failure.

Sample Analysis: (This step applies only to the baseline technology). In this step, samples procured via the baseline technology are subjected to analysis by the U.S. Environmental Protection Agency’s Contract Laboratory Program (CLP) List of Metals protocol at an approximate cost of $1,034 per sample. Again, field screening or confirmatory sampling such as via the innovative technology will entail other types of sample analysis. All will depend on the requirements of the specific DOE site at which the sampling is being performed.

Demobilization (WBS 331.21)

Prepare for Storage: Time for this activity includes time to break down the equipment, cleaning as needed, and storage in equipment cases.

Transport to Storage: Similar to "Transport from Storage" above.

Place in RMA: Similar to Remove from RMA.

Equipment Rate Computation

Hourly Rates for Government-Owned Equipment

The hourly rate computation for the Government to own and operate the NITON® XL-800 Series Multi-Element Analyzer is based on general guidance contained in Office of Management and Budget Circular No. A-94, entitled *Cost Effectiveness Analysis* (A-94), and includes amortization of the initial purchase price and shipping cost over the service life of the equipment using the discount rate of 5.8% prescribed in A-94.

It is unlikely that the NITON® XL-800 Series Multi-Element Analyzer would have salvage value at the end of its service life: any potential salvage value would be absorbed by costs to decontaminate the instrument prior to free-release. Thus it is anticipated that the NITON® XL-800 Series Multi-Element Analyzer would be disposed of at the conclusion of its useful life.

The 10-year useful life cited for the innovative technology unit price computation is based on a verbal quotation from the manufacturer. Historical experience shows that some of the radiological survey instruments currently in use have actually been in service for the past 15 years.

Computation of Production Rate

Following are the computed production rates for sampling (see Tables B-1 through B-3). The times and rates are based on daily field log notations. Sampling rates are given in those tables directly as a production rate, or they can indirectly be derived as the number of samples divided by expended time.

<u>Baseline Technology</u> –

Characterization

Number of samples = 4
Cumulative time to collect 4 samples = 45 minutes
Average production rate = 5.33 samples per hour

Innovative Technology -

Characterization

Number of samples = 36
Cumulative time to sample = 62 minutes
Average production rate = 34.8 samples per hour

Sorting and Screening Scrap

Number of samples = 247
Cumulative time to sample = 2.6 hours
Average production rate = 94.3 samples per hour

Production rates are based on data appearing on data collection forms completed during field sampling. See additional productivity data appearing in each of the tables of Appendix B, such as that concerning time for calibration, time to position the analyzer, and time to perform individual analyses.

Computation of Productivity Loss

In actual field sampling work, delays and inefficiencies will add to the overall duration of the job and will result in added project cost. In this appendix are discussed some of these delays, inefficiencies, and miscellaneous minor activities (that are not accounted for in those primary cost elements that comprise the estimate) that are typical of actual sampling work. These productivity losses come directly from daily field logs recorded in real-time during the demonstration as well as observations made by the test engineer.

Baseline Technology

Productivity losses for the baseline technology were minimal, as would be expected for a manual and rudimentary process such as this. The main loss of concern was that associated with equipment failure – two instances of equipment failure were noted during the 86-minute hand sampling event: in the first occurrence a pair of metal cutting shears broke, and later, a drill bit had to be replaced.

Innovative Technology

The most significant productivity loss associated with the innovative technology is that for sampling instances when the instrument registers a "No Match" reading, indicating that the alloy being tested does not match with anything in the instrument's internal alloy library. PTC reviewed the sampling logs for the innovative technology to gauge the frequency at which "No Match" readings occurred over the PBF sampling round. Of the 32 samples taken, a "No match" reading occurred 10 times, leaving only 69% of the NITON® XL-800 Series Multi-Element Analyzer readings valid.[1] Each time this occurs, all of the precursor setup and preparation time for that sampling event is lost, and the sample remains unidentified.

[1] This No-Match indication is a function of the specific alloy grades factory loaded into the XL-800 grade library. By more appropriate selection of alloy (e.g. that conform to DOD/DOE alloy expected to be encountered) that No-Match percentage will drop specifically. Also, the demonstration was not able to remove surface coatings by any method, thus most of the No-Match's were due to insufficient or no bare metal to analyze.

Other productivity losses associated with the innovative technology included:

- Learning-curve losses associated with first-time users familiarization with the instrument: (time not quantified on field logs).
- Battery replacement and subsequent instrument re-calibration: 20 minutes per 8-hour interval.

Cost Estimate Details

Cost analysis details are summarized in Tables B-1, B-2, and B-3. In each table, crew members labor rate, equipment used, equipment rate, activity duration, and production rates are broken out so that site-specific differences for these items can be identified and a site-specific cost estimate may be determined.

Table B-1
CFA Innovative Technology Cost Summary – Scrap Sorting and Screening

Work Breakdown Structure	Unit	Unit Cost $/Unit	Quan-tity	Total Cost	Computation of Unit Cost: Prod Rate (samp/hr)	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement								**TOTAL COST PER SAMPLE =**				**$ 3.75**
Mobilization (WBS 331.01)										Subtotal =		$ 126.07
Remove from RMA	ea	9.36	1	$ 9.36		0.208	1IH	34.32	MAA on standby	10.67		Controlled area
Transport from Storage	ea	26.23	1	$ 26.23		0.583	1IH	34.32	MAA on standby	10.67		Travel Time
Pre-Job Safety Meeting	ea	51.68	1	$ 51.68		0.250	1IH, 2RT, 1JS, 1ET	196.06	MAA on standby	10.67		
Equipment Setup	ea	38.80	1	$ 38.80		0.333	1IH + 2 RT	105.86	MAA	10.67		Extra time req'd for familiarization. Included initial calibration.
Characterization (WBS 331.17)										Subtotal =		$ 752.93
Move Equipment	ea	58.27	1	$ 58.27		0.5	1IH + 2 RT	105.86	MAA on standby	10.67		1 move to CFA - South was made, elapsed time is assumed
Position Alloy Analyzer	ea	1.24	1	$ 1.24	94.3		1IH + 2 RT	105.86	MAA	10.67		
Remove Coatings	ea	17.70	1	$ 17.70		0.167	1IH + 2 RT	105.86	Small tools	0.33		As required
Perform Analysis	ea	1.24	247	$ 305.23	94.3		1IH + 2 RT	105.86	MAA	10.67		
Calibrate Equipment	ea	46.61	2.00	$ 93.22	2.5		1IH + 2 RT	105.86	MAA	10.67		
Replace Battery	ea	13.63	1.00	$ 13.63		0.117	1IH + 2 RT	105.86	MAA	10.67		
Deliver Field Data	ea	5.26	1.00	$ 5.26		0.117	1IH	34.32	MAA on standby	10.67		
Download/Tabulate Data	ea	14.31	1	$ 14.31		0.417	1IH	34.32				
Data Validation	ea	34.32	1.00	$ 34.32		1	1IH	34.32				
Productivity Loss	man day	209.75	1.00	$ 209.75		1.800	1IH + 2 RT	105.86	MAA on standby	10.67		Assume 10 hour man day
Demobilization (WBS 331.21)										Subtotal =		$ 46.83
Prepare for Storage	ea	11.25	1	$ 11.25		0.250	1IH	34.32	MAA on standby	10.67		
Transport to Storage	ea	26.23	1	$ 26.23		0.583	1IH	34.32	MAA on standby	10.67		
Place in RMA	ea	9.36	1	$ 9.36		0.208	1IH	34.32	MAA on standby	10.67		

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Metal Alloy Analyzer	10.67	MAA			
IH Technician	34.32	IH									
Radiologic Control Tech.	35.77	RT									
Engineering Technician	38.67	ET									
Laborer	34.32	LB									

$925.84/2,920 pounds = $0.32 per pound of scrap

Table B-2
PBF Innovative Technology Cost Summary – Characterization

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Prod Rate (samp/hr)	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement							**TOTAL COST PER SAMPLE =**				**$**	**19.72**
Mobilization (WBS 331.01)										Subtotal =	$	207.35
Remove from RMA	ea	9.36	1	$ 9.36		0.208	1IH	34.32	MAA on standby	10.67		Controlled area
Transport from Storage	ea	26.23	1	$ 26.23		0.583	1IH	34.32	MAA on standby	10.67		Travel Time
Pre-Job Safety Meeting	ea	52.31	1	$ 52.31		0.217	2IH+ 2RT + 1JS + 1ET	230.38	MAA on standby	10.67		
Equipment Setup	ea	119.46	1	$ 119.46		0.717	2IH+ 1RT + 1JS	155.94	MAA	10.67		Extra time req'd for familiarization. Included initial calibration.
Characterization (WBS 331.17)										Subtotal =	$	455.75
Move Equipment	ea	11.51	2	$ 23.02		0.100	2IH+ 1RT	104.41	MAA on standby	10.67		
Position Alloy Analyzer	ea	3.31	0	$ -	34.8		2IH+ 1RT	104.41	MAA	10.67		Included in analysis
Perform Analysis	ea	3.31	36	$ 119.05	34.8		2IH+ 1RT	104.41	MAA	10.67		Variable, see details
Calibrate Equipment	ea	46.03	0.00	$ -	2.5		2IH+ 1RT	104.41	MAA	10.67		Calibration performed at initial set up.
Deliver Field Data	ea	9.28	1.00	$ 9.28		0.117	2IH	68.64	MAA on standby	10.67		
Download/Tabulate Data	ea	28.62	1	$ 28.62		0.417	2IH	68.64				
Data Validation	ea	68.64	1.00	$ 68.64		1.000	2IH	68.64				
Productivity Loss	man day	207.14	1.00	$ 207.14		1.800	2IH+ 1RT	104.41	MAA on standby	10.67		Assume 10 hour man day
Demobilization (WBS 331.21)										Subtotal =	$	46.83
Prepare for Storage	ea	11.25	1	$ 11.25		0.250	1IH	34.32	MAA on standby	10.67		
Transport to Storage	ea	26.23	1	$ 26.23		0.583	1IH	34.32	MAA on standby	10.67		
Place in RMA	ea	9.36	1	$ 9.36		0.208	1IH	34.32	MAA on standby	10.67		

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Metal Alloy Analyzer	10.67	MAA			
IH Technician	34.32	IH									
Radiologic Control Tech.	35.77	RT									
Engineering Technician	38.67	ET									

$7
09.94/36 = $19.72 per sample

Table B-3
PBF Baseline Technology Cost Summary - Characterization
(Extrapolated to 36 Samples/Day)

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Prod Rate (samp/hr)	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement								**TOTAL COST PER SAMPLE =**			**$**	**1,192.12**
Mobilization (WBS 331.01)										Subtotal =	$	156.40
Equipment Setup	ea	3.88	1	$ 3.88		0.050	2ET	77.34	ST on standby	0.33		
Transport from Storage	ea	45.28	1	$ 45.28		0.583	2ET	77.34	ST on standby	0.33		Travel Time
Pre-Job Safety Meeting	ea	107.24	1	$ 107.24		0.830	2ET + 1JS	128.87	ST on standby	0.33		
Characterization (WBS 331.17)										Subtotal =	$	42,695.05
Measure Off Area	ea	2.59	2	$ 5.18	30		2ET	77.34	ST	0.33		Grid and Mark
Collect Samples	ea	17.57	36	$ 632.60	5.33		2ET	77.34	ST	0.33	3.00	Sample Jars @ $36/dozen
Pack/Deliver Samples	ea	17.05	36	$ 613.93		0.050	2ET	77.34	ST	0.33	13.17	Includes shipping cost
Clean up	ea	3.87	2	$ 7.73		0.050	2ET	77.34	ST	0.00		
Sample Analysis	ea	1,034.00	36	$ 37,224.00							1,034.00	Laboratory costs
Sample Validation	ea	3,932.00	1	$ 3,932.00		80	1CH	49.15				Assume 8 hour day
Productivity Loss	man day	139.81	2.00	$ 279.61		1.800	2ET	77.34	ST	0.33		Assume 10 hour man day
Demobilization (WBS 331.21)										Subtotal =	$	64.70
Prepare for Storage	ea	19.42	1	$ 19.42		0.250	2ET	77.34	ST on standby	0.33		
Transport to Storage	ea	45.28	1	$ 45.28		0.583	2ET	77.34	ST on standby	0.33		

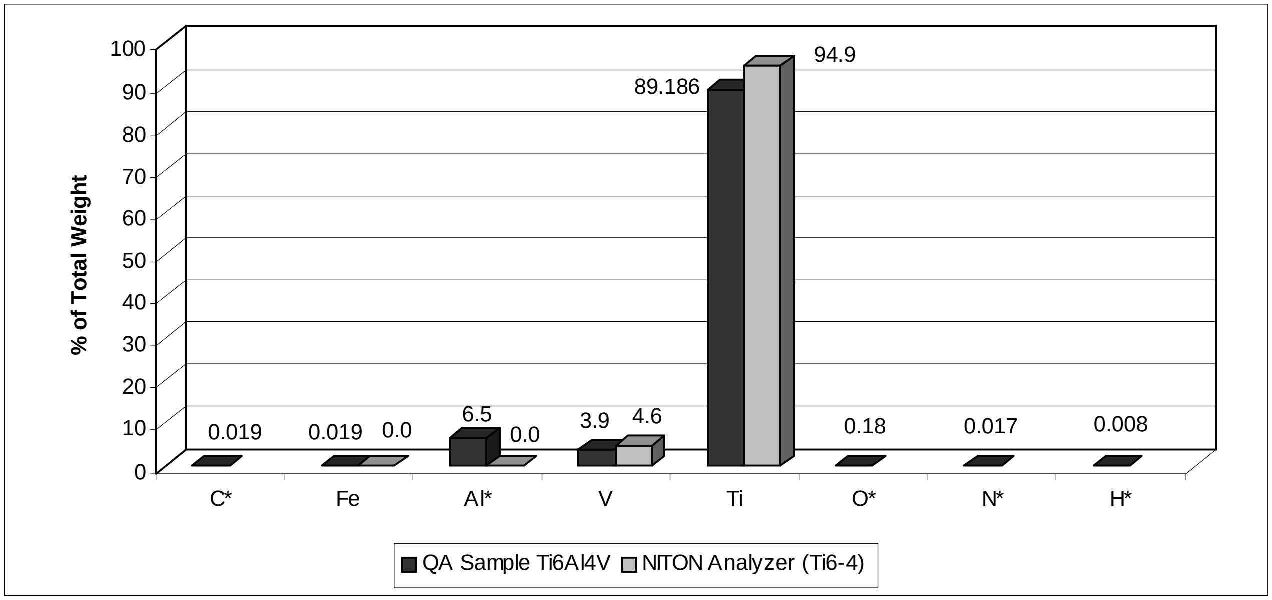
Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Small Tools	0.33	ST			
Engineering Technician	38.67	ET									
Chemist	49.15	CH									

$42,916.15/36 = $1,192.12 per sample

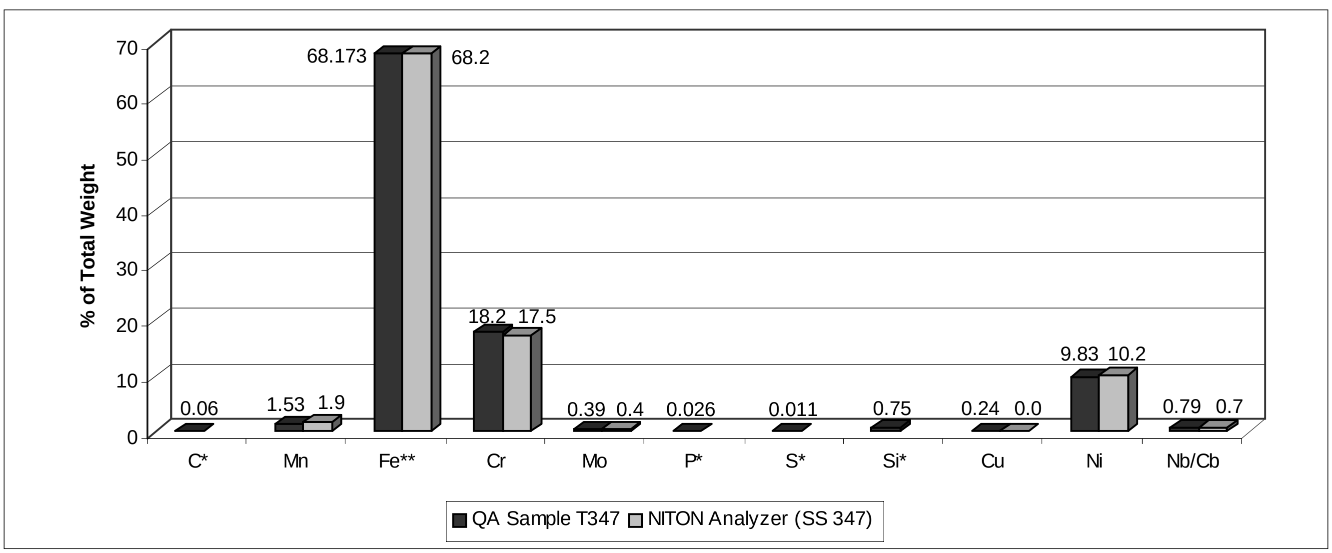
APPENDIX C
Sample Analysis Comparison

QA Sample #1 Comparison



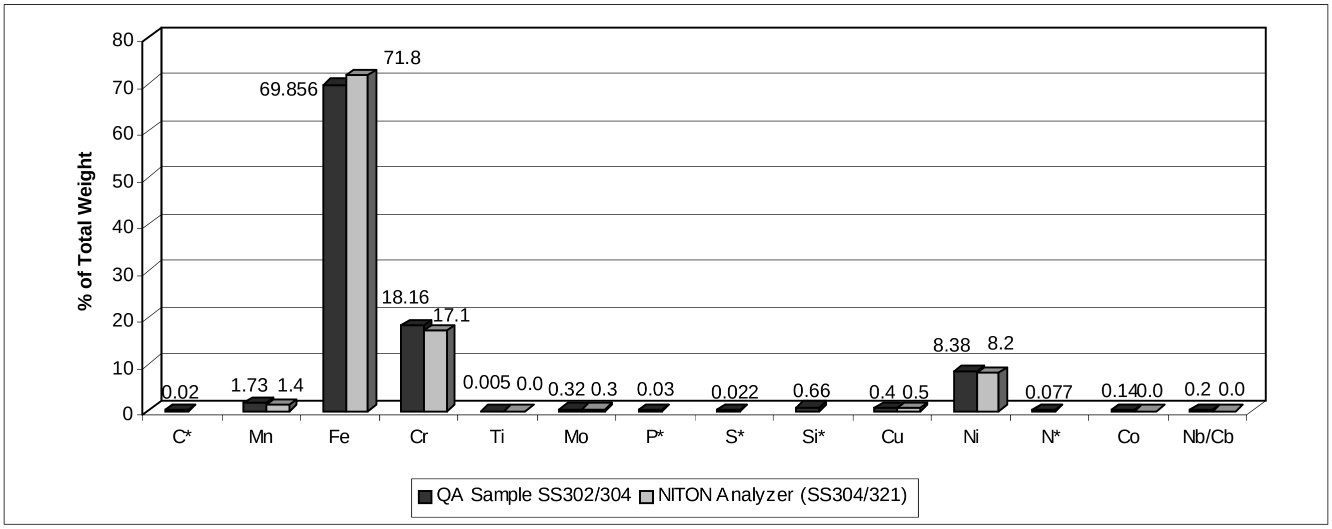
*Elements that the NITON® analyzer cannot detect.

QA Sample #2 Comparison



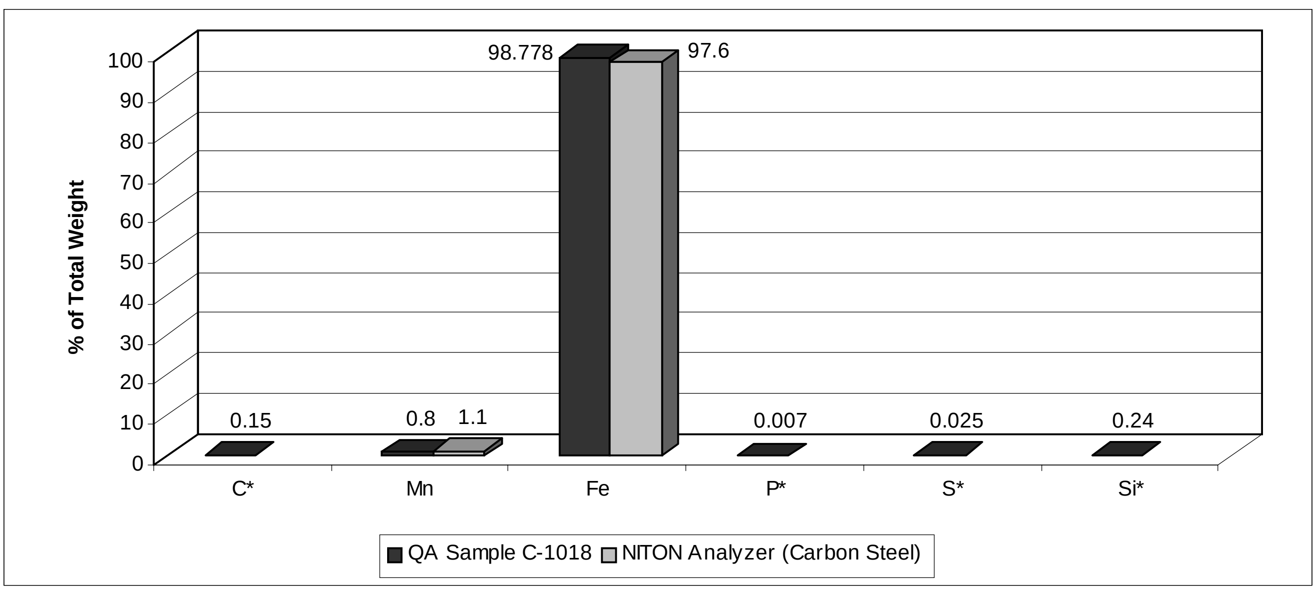
*Elements the NITON® analyzer cannot detect
**The CMTR listed this element concentration as "remainder," thus this is actually a calculated number.

QA Sample #3 Comparison



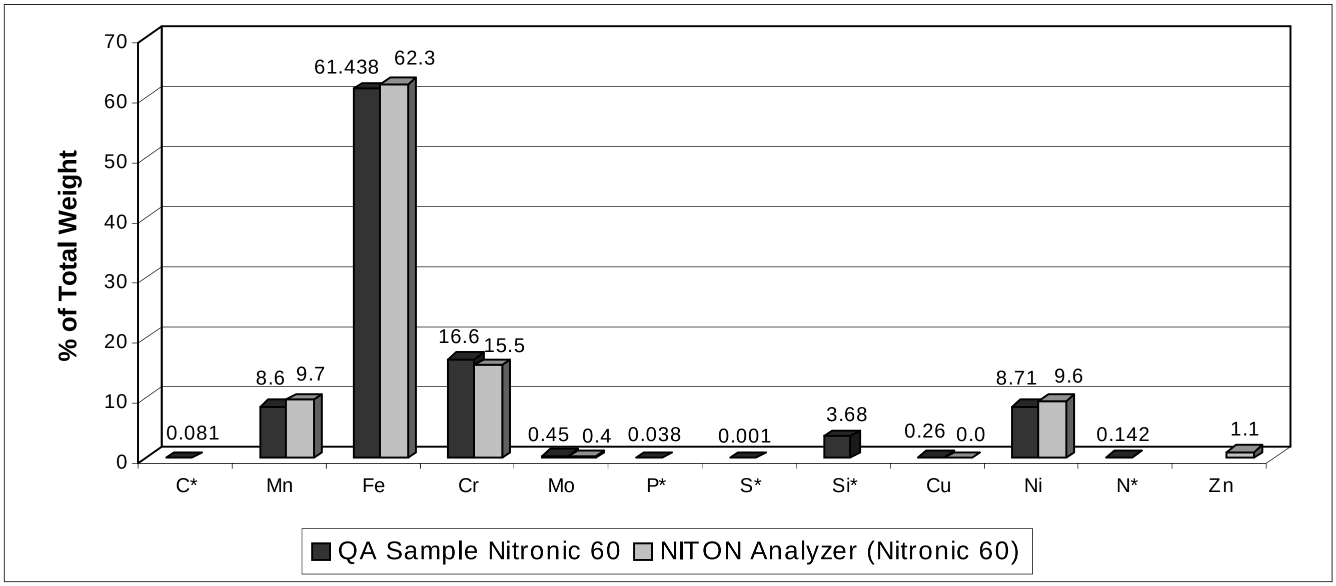
*Elements the NITON® analyzer cannot detect

QA Sample #4 Comparison



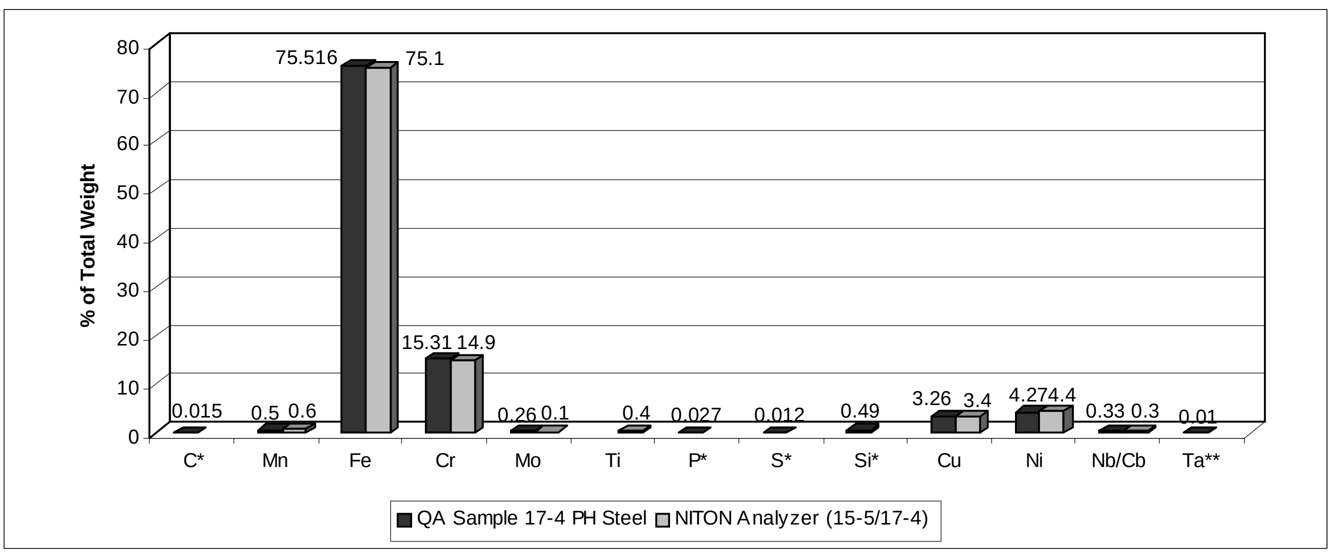
*Elements the NITON® analyzer cannot detect

QA Sample #5 Comparison



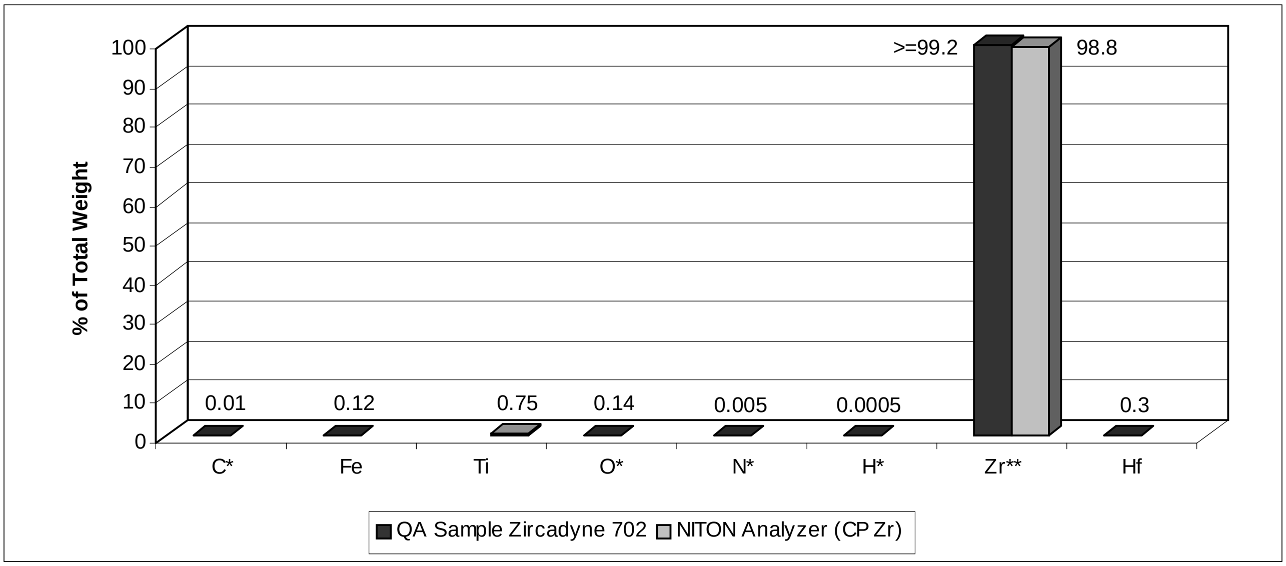
*Elements the NITON® analyzer cannot detect

QA Sample #6 Comparison



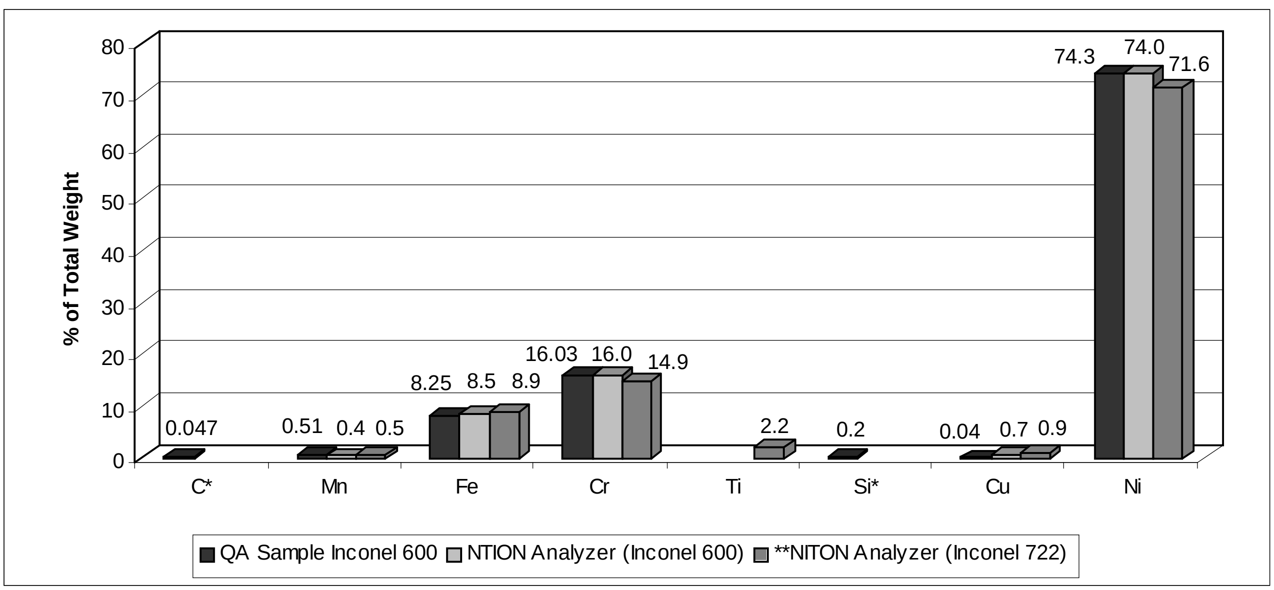
*Elements the NITON® Analyzer cannot detect
**Element the NITON® Analyzer has not been programmed to detect

QA Sample #7 Comparison



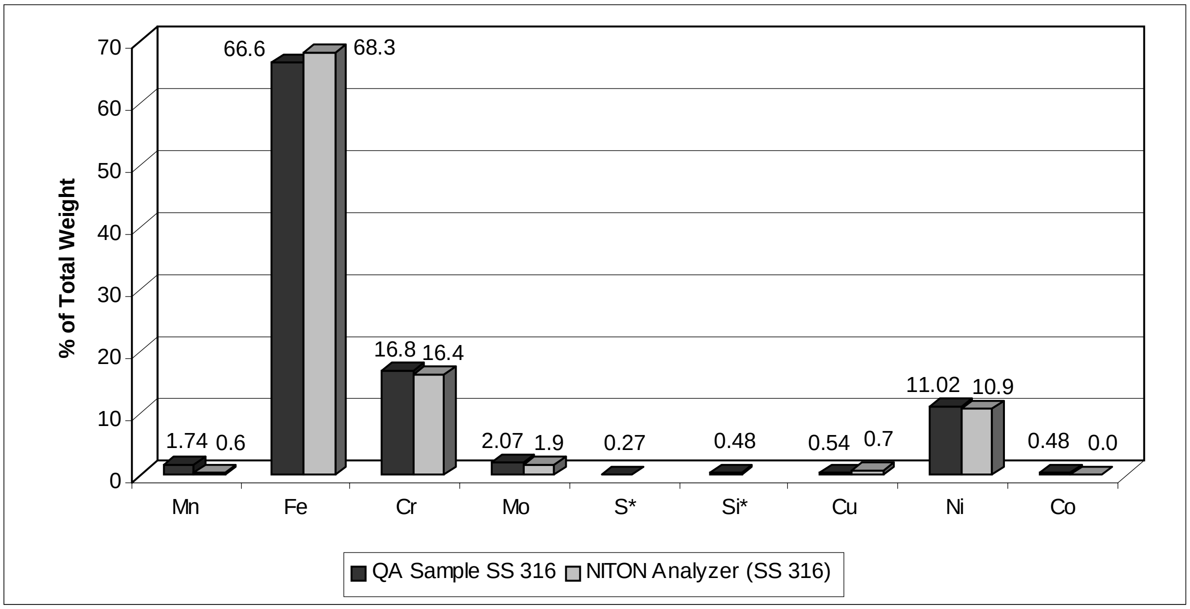
*Elements the NITON® analyzer cannot detect
**CMTR only lists this concentration as greater than or equal to 99.2% by weight.

QA Sample #8 Comparison

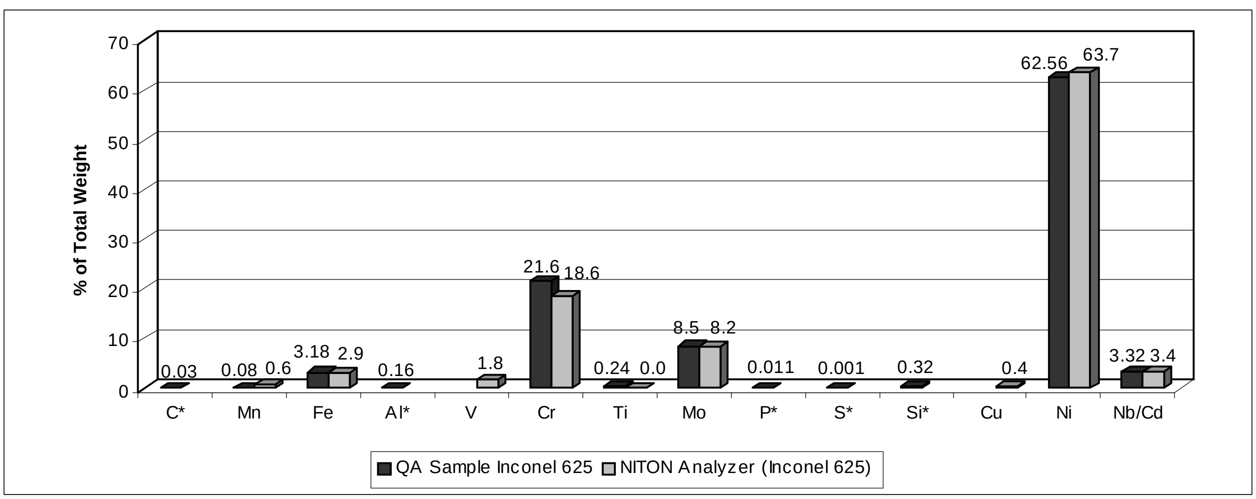


*Elements the NITON® analyzer cannot detect
**Analysis results of painted side of sample

QA Sample #9 Comparison



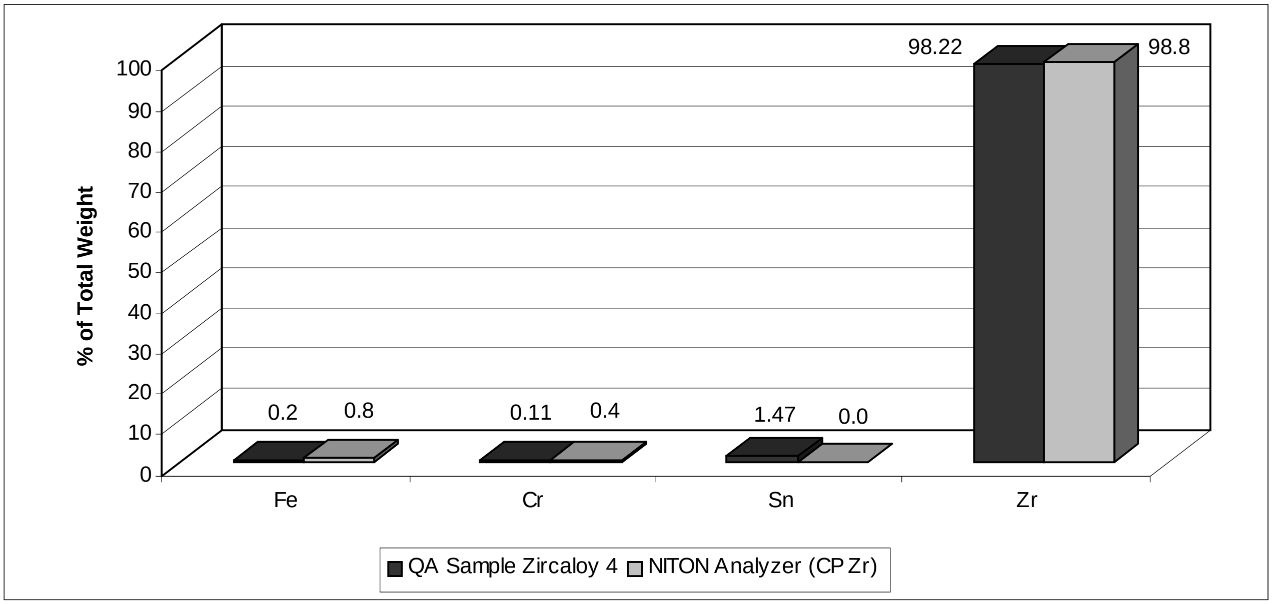
*Elements the NITON® analyzer cannot detect



QA Sample #10 Comparison

*Elements the NITON® analyzer cannot detect

QA Sample #11 Comparison



APPENDIX D
ACRONYMS AND ABBREVIATIONS

CFA	Central Facilities Area
CMTRs	Certified Material Test Reports
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DOE	The United States Department of Energy
G&A	General & Administrative
HTRW RA WBS	Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure
INEEL	Idaho National Engineering and Environmental Laboratory
LSDDP	Large-Scale Demonstration and Deployment Project
OMB	Office of Management and Budget
OST	Office of Science and Technology
PBF	Power Burst Facility
QA	Quality Assurance
RSA	Radiological Storage Area
USACOE	United States Army Corp of Engineers
XRF	X-ray Fluorescence