OLYMPUS®

DELTA Family
Handheld XRF Analyzer
User's Manual

Models:
DELTA 50
DELTA Premium
DELTA Professional
DELTA Classic Plus
DELTA Element

Canadian edition

103201-02EN — Rev. E
February 2015

This instruction manual contains essential information on how to use this Olympus product safely and effectively. Before using this product, thoroughly review this instruction manual. Use the product as instructed.

Keep this instruction manual in a safe, accessible location.

Olympus Scientific Solutions Americas, 48 Woerd Avenue, Waltham, MA 02453, USA

This document was prepared with particular attention to usage to ensure the accuracy of the information contained therein, and corresponds to the version of the product manufactured prior to the date appearing on the title page. There could, however, be some differences between the manual and the product if the product was modified thereafter.

The information contained in this document is subject to change without notice.

Canadian edition
Part number: 103201-02EN
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February 2015

Printed in the United States of America

Table of Contents

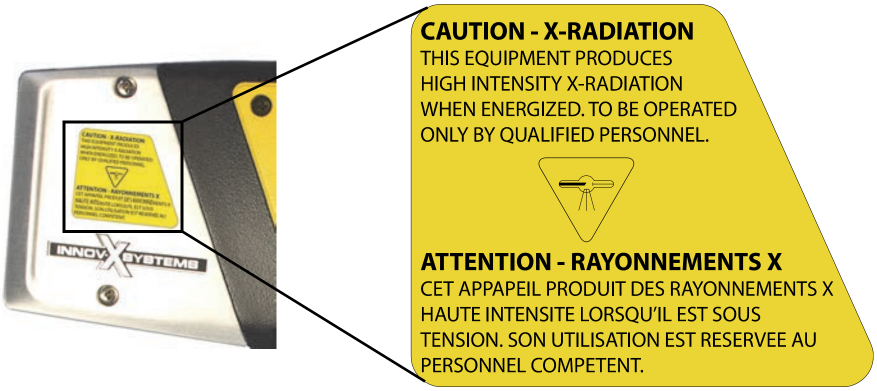
List of Abbreviations

AA	atomic absorption
AC	alternating current
ACEA	Advisory Committee on Environmental Aspects
ALARA	as low as reasonably achievable
DDS	DELTA docking station
DQO	data quality objectives
ED	energy dispersive
EFUP	environment-friendly usage period
EFUP	environment-friendly use period
FCC	Federal Communications Commission
FP	fundamental parameters
IEC	International Electrotechnical Commission
LED	light emitting diode
LOD	limit of detection
NIST	National Institute of Standards & Technology
QC	quality control
R&D	research and development
RSD	relative standard deviation
SRM	Standard Reference Material
SSCS	site-specific calibration standards
Sv	sievert
TCLP	toxicity characteristic leaching procedures
TLD	thermoluminescent dosimeter
UI	user interface
WD	wavelength dispersive
XRF	X-ray fluorescence

Labels and Symbols

Labels and symbols which are related to X-ray safety, compliance, and product identification are attached to the instrument at the locations shown in Figure i-1 on page 1, Figure i-2 on page 2, and Figure i-3 on page 2. If any or all labels or symbols are missing or illegible, please contact Olympus.

Figure i-1 Labels location



CAUTION - X-RADIATION

THIS EQUIPMENT PRODUCES HIGH INTENSITY X-RADIATION WHEN ENERGIZED. TO BE OPERATED ONLY BY QUALIFIED PERSONNEL.

ATTENTION - RAYONNEMENTS X

CET APPAPEIL PRODUIT DES RAYONNEMENTS X HAUTE INTENSITE LORSQU'IL EST SOUS TENSION. SON UTILISATION EST RESERVEE AU PERSONNEL COMPETENT.

Figure i-2 Radiation label on the side of the analyzer

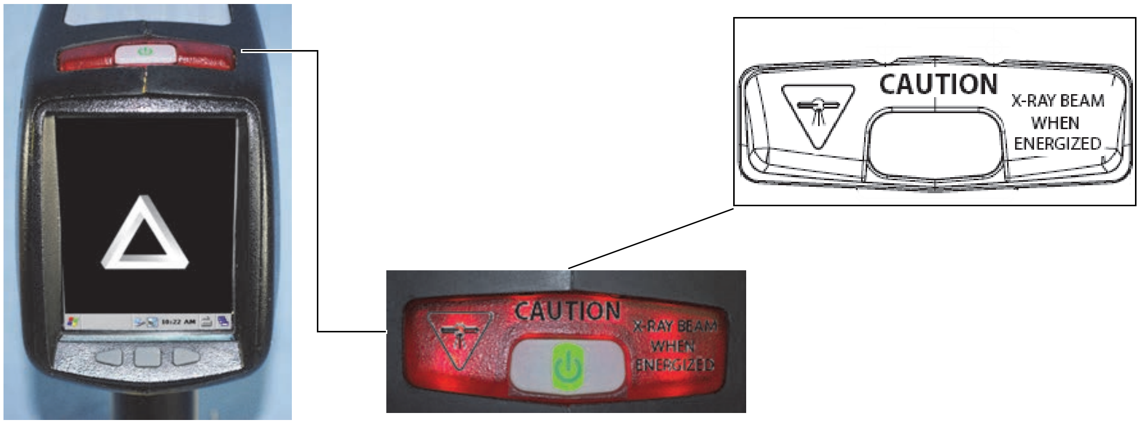


Figure i-3 Power switch and X-ray indicator

IMPORTANT

The radiation labels are required by most regulatory agencies. Do not remove them.

The label term "WHEN ENERGIZED" refers to the condition where the tube is fully energized and the filter wheel is open. This condition corresponds with the blinking red LEDs that comprise the X-ray indicator LED array.

Table 1 Content of the instrument labels

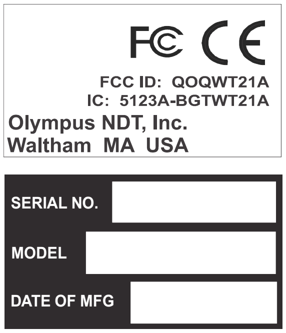
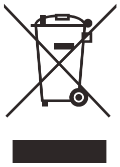
Instrument labels:	 FC CE FCC ID: QOQWT21A IC: 5123A-BGTWT21A Olympus NDT, Inc. Waltham MA USA SERIAL NO. MODEL DATE OF MFG  N438 15
EMC Compliance labels	
FC	The FCC mark indicates that the product has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. See page 11 for details.
CE	The CE marking is a declaration that this product conforms to all the applicable directives of the European Community. See the *Declaration of Conformity* for details. See also page 10 for more information.
Transmitter Registrations	FCC ID: QOQWT21A is Bluetooth® Transmitter Registration for USA. IC: 5123A-BGTWT21A is Bluetooth® Transmitter Registration for Canada. 204WW11100800 is Bluetooth® Transmitter Registration for Japan.
✓	The C-Tick label indicates that the product complies with the applicable standard and establishes a traceable link between the equipment and the manufacturer, importer, or the agent responsible for compliance, and for placing it on the Australian market.
Product Identification labels	
SERIAL NO.	The analyzer’s serial number.
MODEL	The analyzer’s model number.
DATE OF MFG	The analyzer’s date of manufacturing.
Pollution Compliance labels	
15	The China RoHS mark indicates the product’s Environment-Friendly Usage Period (EFUP). See page 10 for details.

Table 1 Content of the instrument labels *(continued)*

	The WEEE symbol indicates that the product must not be disposed of as unsorted municipal waste, but should be collected separately. See page 10 for details.

Important Information — Please Read Before Use

Intended Use

The DELTA X-ray fluorescence analyzer is designed to perform identification and analysis of elements contained within test samples, from magnesium to uranium (Mg to U), depending on the selected model.

⚠ **WARNING**

Do not use the DELTA for any purpose other than its intended use. It must never be used to inspect or examine human or animal body parts.

Instruction Manual

This instruction manual contains essential information on how to use this Olympus product safely and effectively. Before using this product, thoroughly review this instruction manual. Use the product as instructed.

Keep this instruction manual in a safe, accessible location.

IMPORTANT

Some of the details of components illustrated in this manual may differ from the components installed on your instrument. However, the operating principles remain the same.

Instrument Compatibility

Only use the DELTA analyzer with the following ancillary equipment:

- Rechargeable lithium-ion (Li-ion) battery pack (U8990853)
- Optional stand-alone external battery charger (U8990854) [varies by configuration]
- AC adaptor (U8990860) [varies by configuration]
- DELTA docking station (U8990897)

The DELTA is primarily a self-contained unit. However, it does have a series of I/O ports that can be used to connect compatible peripherals and connect it to a PC. The unit derives its required DC input power from the DELTA AC adaptor or battery pack.

⚠ **CAUTION**

Always use equipment and accessories that meet Olympus specifications. Using incompatible equipment could cause equipment malfunction and/or damage, or human injury.

Repair and Modification

The DELTA does not contain any user-serviceable parts. Opening the instrument will void the warranty.

The DELTA does not contain any user-serviceable parts, apart from one exception: the measurement window. If the measurement window is damaged, the window assembly should be replaced as soon as possible. For more details, see “Measurement Window Replacement” on page 109.

⚠ **CAUTION**

In order to prevent human injury and/or equipment damage, do not modify the DELTA X-ray fluorescence analyzer .

Safety Symbols

The following safety symbols might appear on the instrument and in the instruction manual:


General warning symbol

This symbol is used to alert the user to potential hazards. All safety messages that follow this symbol shall be obeyed to avoid possible harm or material damage.


Radiation warning symbol

This symbol is used to alert the user to the presence of potentially harmful ionizing radiation generated within the XRF analyzer. All safety messages that follow this symbol shall be obeyed to avoid possible harm.


High voltage warning symbol

This symbol is used to alert the user to potential electric shock hazards greater than 1000 volts. All safety messages that follow this symbol shall be obeyed to avoid possible harm.

Safety Signal Words

The following safety symbols might appear in the documentation of the instrument:

⚠ **DANGER**

The DANGER signal word indicates an imminently hazardous situation. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, will result in death or serious personal injury. Do not proceed beyond a DANGER signal word until the indicated conditions are fully understood and met.

⚠ **WARNING**

The WARNING signal word indicates a potentially hazardous situation. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in death or serious personal injury. Do not proceed beyond a WARNING signal word until the indicated conditions are fully understood and met.

⚠ **CAUTION**

The CAUTION signal word indicates a potentially hazardous situation. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, may result in minor or moderate personal injury, material damage, particularly to the product, destruction of part or all of the product, or loss of data. Do not proceed beyond a CAUTION signal word until the indicated conditions are fully understood and met.

Note Signal Words

The following safety symbols could appear in the documentation of the instrument:

IMPORTANT

The IMPORTANT signal word calls attention to a note that provides important information, or information essential to the completion of a task.

NOTE

The NOTE signal word calls attention to an operating procedure, practice, or the like, which requires special attention. A note also denotes related parenthetical information that is useful, but not imperative.

TIP

The TIP signal word calls attention to a type of note that helps you apply the techniques and procedures described in the manual to your specific needs, or provides hints on how to effectively use the capabilities of the product.

Safety

Before turning on the DELTA, verify that the correct safety precautions have been taken (see the following warnings). In addition, note the external markings on the instrument, which are described under "Safety Symbols" on page 6.

Warnings

⚠ **WARNING**

General Warnings

- Carefully read the instructions contained in this instruction manual prior to turning on the instrument.
- Keep this instruction manual in a safe place for further reference.
- Follow the installation and operation procedures.
- It is imperative to respect the safety warnings on the instrument and in this instruction manual.
- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment could be impaired.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Service instructions, when applicable, are for trained service personnel. To avoid the risk of electric shock, do not perform any work on the instrument unless qualified to do so. For any problem or question regarding this instrument, contact Olympus or an authorized Olympus representative.
- Do not allow metallic or foreign objects to enter the device through connectors or any other openings. Otherwise, a malfunction or electric shock may result.

⚠ **WARNING** ⚡

Electrical Warnings

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor (mains) of the power cord. The mains plug shall only be inserted into a socket outlet provided with a protective earth contact. Never negate the protective action by using an extension cord (power cable) without a protective conductor (grounding).
- If there is any possibility that the ground protection could be impaired, you must make the instrument inoperative and secure it against any unintended operation.
- The instrument must only be connected to a power source corresponding to the type indicated on the rating label.

CAUTION

If a non-approved power supply cord not dedicated to Olympus products is used, Olympus will not be able to ensure the electrical safety of the equipment.

CAUTION

- X-ray tubes and detectors in this instrument contain beryllium metal in the form of coated foil. In its as-supplied state, the beryllium poses no harm to the user. However, if a detector or tube is damaged, contact with small particles is possible if the instrument is breached (ex., window broken or during window replacement). Intact skin is sufficient protection against this situation and washing with soap and water will effectively remove any beryllium contamination. If granulated beryllium imbeds in an open wound, seek medical attention.
- Instruments where the detector or tube is damaged must be returned to your local distributor or the manufacture. Care should be taken to limit the release of beryllium from the instrument.

Battery Precautions

CAUTION

- Before disposing of a battery, check your local laws, rules, and regulations, and follow them accordingly.
- Transportation of lithium-ion batteries is regulated by the United Nations under the United Nations Recommendations on the Transport of Dangerous Goods. It is expected that governments, intergovernmental organizations, and other international organizations shall conform to the principles laid down in these regulations, thus contributing to worldwide harmonization in this field. These international organizations include the International Civil Aviation organization (ICAO), the International Air Transport Association (IATA), the International Maritime Organization (IMO), the US Department of Transportation (USDOT), and others. Please contact the transporter and confirm current regulations before transportation of lithium-ion batteries.
- For California (USA) only:

  The CR battery contains perchlorate material, and special handling may be required. Refer to http://www.dtsc.ca.gov/hazardouswaste/perchlorate.
- Do not open, crush, or perforate batteries; doing so could cause injury.
- Do not incinerate batteries. Keep batteries away from fire and other sources of extreme heat. Exposing batteries to extreme heat (over 80 °C) could result in an explosion or personal injury.
- Do not drop, hit, or otherwise abuse a battery, as doing so could expose the cell contents, which are corrosive and explosive.
- Do not short-circuit the battery terminals. A short circuit could cause injury and severe damage to a battery making it unusable.
- Do not expose a battery to moisture or rain; doing so could cause an electric shock.
- Only use the DELTA unit or an external charger approved by Olympus to charge the batteries.

- Only use batteries supplied by Olympus.
- Do not store batteries that have less than 40 % remaining charge. Recharge batteries to between 40 % and 80 % capacity before storing them.
- During storage, keep the battery charge between 40 % and 80 %.
- Do not leave batteries in the DELTA unit during instrument storage.

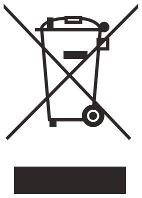
Equipment Disposal

Before disposing of the DELTA, check your local laws, rules, and regulations, and follow them accordingly.

CE (European Community)

This device complies with the requirements of both directive 2004/108/EC concerning electromagnetic compatibility and directive 2006/95/EC concerning low voltage. The CE marking indicates compliance with the above directives.

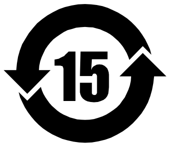
WEEE Directive



In accordance with European Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE), this symbol indicates that the product must not be disposed of as unsorted municipal waste, but should be collected separately. Refer to your local Olympus distributor for return and/or collection systems available in your country.

China RoHS

China RoHS is the term used by industry generally to describe legislation implemented by the Ministry of Information Industry (MII) in the People's Republic of China for the control of pollution by electronic information products (EIP).



The China RoHS mark indicates the product's Environment-Friendly Use Period (EFUP). The EFUP is defined as the number of years for which listed controlled substances will not leak or chemically deteriorate while in the product. The EFUP for the DELTA has been determined to be 15 years.

Note: The Environment-Friendly Use Period (EFUP) is not meant to be interpreted as the period assuring functionality and product performance.

EMC Directive Compliance

This equipment generates and uses radio-frequency energy and, if not installed and used properly (that is, in strict accordance with the manufacturer's instructions), may cause interference. The DELTA has been tested and found to comply with the limits for an industrial device in accordance with the specifications of the EMC directive.

FCC (USA) Compliance

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, might cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case you will be required to correct the interference at your own expense.

ICES-001 (Canada) Compliance

This Class A digital apparatus complies with Canadian ICES-001.

Cet appareil numérique de la classe A est conforme à la norme NMB-001 du Canada.

Agency Statement Compliance

Industry Canada

Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

User Qualifications

Canadian Federal Regulations (Radiation Emitting Devices Act) require that all Canadian users be certified according to NRC Standard CAN/CGSB-48.9712-2006 / ISO 9712:2005 in order to use this device.

For this certification information contact:

NDT Certifying Agency

CanmetMATERIALS
Minerals and Metals Sector
Natural Resources Canada
183, Longwood Road South
Hamilton (Ontario) L8P 0A5
CANADA

Tel.: 1-905-645-0653 or 1-866-858-0473
Fax: 1-905-645-0836
E-mail: ndt@nrcan-rncan.gc.ca

1-905-645-0656 for NDT application inquiries, 1-905-645-0654 for NDT re-examination inquiries, and 1-905-645-0839 for XRF/CEDO inquiries.

Additionally, Canadian users must contact their appropriate federal/provincial/territorial radiation protection agency for applicable rules of operation.

Packing and Return Shipping

If the DELTA X-ray fluorescence analyzer is not returned in its transport case, it could be damaged during shipping. Olympus reserves the right to void the warranty on instruments damaged while in transit if they are shipped without their transport case. Prior to returning any units, contact Customer Service to obtain the required RMA number(s) and any important shipping information.

Follow the steps below to return your X-ray fluorescence analyzer:

1. Pack the analyzer back into the transport case that it came in using the original packing materials.
2. Include the RMA in the case, and reference the RMA number in your shipping documents.
3. Close the transport case and either:
    - Secure it with plastic zip ties, or;
    - Pack the transport case within another box.

IMPORTANT

When shipping the Li-ion battery, be sure to follow all local transportation regulations.

Regulations for Shipping Products with Lithium-Ion Batteries

The United States and many other countries have instituted regulations that require shippers to use a special Caution label referring to a lithium-ion (Li-ion) battery. See example in Figure i-4 on page 13.

- Label must be prominently displayed on the outer shipping container of any product that contains a Li-ion battery.
- Shipper may copy the label shown below to facilitate making the warning label. Use a color copier if possible.
- The cross hatching on the label must be red.

Figure i-4 Example of Li-ion battery caution label

Warranty Information

Olympus guarantees your Olympus product to be free from defects in materials and workmanship for a specific period, and in accordance with conditions specified in the *Olympus Scientific Solutions Americas Inc. Terms and Conditions* available at http://www.olympus-ims.com/en/terms/.

The Olympus warranty only covers equipment that has been used in a proper manner, as described in this instruction manual, and that has not been subjected to excessive abuse, attempted unauthorized repair, or modification.

Inspect materials thoroughly on receipt for evidence of external or internal damage that might have occurred during shipment. Immediately notify the carrier making the delivery of any damage, because the carrier is normally liable for damage during shipment. Retain packing materials, waybills, and other shipping documentation needed in order to file a damage claim. After notifying the carrier, contact Olympus for assistance with the damage claim and equipment replacement, if necessary.

This instruction manual explains the proper operation of your Olympus product. The information contained herein is intended solely as a teaching aid, and shall not be used in any particular application without independent testing and/or verification by the operator or the supervisor. Such independent verification of procedures becomes increasingly important as the criticality of the application increases. For this reason, Olympus makes no warranty, expressed or implied, that the techniques, examples, or procedures described herein are consistent with industry standards, nor that they meet the requirements of any particular application.

Olympus reserves the right to modify any product without incurring the responsibility for modifying previously manufactured products.

Technical Support

Olympus is firmly committed to providing the highest level of customer service and product support. If you experience any difficulties when using our product, or if it fails to operate as described in the documentation, first consult the user's manual, and then, if you are still in need of assistance, contact our After-Sales Service. To locate the nearest service center, visit the Service Centers page at: http://www.olympus-ims.com.

Introduction

The DELTA X-ray fluorescence analyzers are handheld energy dispersive X-ray fluorescence spectrometers, generally referred to as XRF analyzers.

Package Content

A complete DELTA package consists of:

- A handheld analyzer using an integrated group of instrument components that are sealed in an ergonomically designed, lightweight body. These components include:
  - A processor.
  - A color touch screen (ergonomically mounted interactive display).
  - Membrane navigation keys.
  - Detectors (PIN or SDD) and tube anode material (depending on the DELTA model) to meet wide-ranging application goals.

Coordinated with these characteristics, the instrument's key feature is Olympus's proprietary control, data acquisition, and analysis software with customer-configured options.

Additional accessories (standard and optional) include:

- Two Li-ion batteries (U8990853) [standard]
- DELTA Docking Station (DDS)
  - Dedicated charging and calibration unit (U8990897) [standard]
    - It is optional for DI models
- Rugged waterproof transport case (U8990454) [standard]
- Calibration Check (CalCk) 316 reference coupon/coin (U8990448) [standard]
- Portable test stand for creating a DELTA workstation (U8990865) [optional]
- Soil foot (U8990900) [optional]
- Soil extension pole (U8990901) [optional]
- Test cup (U8996265) [optional]
- Camera [standard on all 6500 and DI-2000 analyzers, optional on all other models]
- Camera + Collimator [standard on DI-2000-PM-CC, and optional on all 6500 models]
- Battery charger (U8990854) [optional, standard with DELTA Element, DELTA inspector]
- AC adaptor (U8990860) [optional]
- Trimble Xplorer package (U8991049) [optional]
- USB data cables; kit of two (U8990455) [standard]

Main Applications

The expanded DELTA X-ray fluorescence analyzer delivers fast and precise identification and analysis of elements from magnesium to uranium (Mg to U), depending on the selected model and mode. A weatherproof/dustproof ultra-rugged design, which includes an integral heat sink, allows the user to conduct diverse analysis testing under severe operating conditions. An added convenience feature for field use is battery “Hot Swapping.”

The analyzer provides accurate chemical analysis for commercial or industrial areas, including:

- Positive material identification including precious metals and gold karating
- Mining and exploration
- Consumer safety
- Scrap processing
- Environmental testing
- Light element and aluminum analysis

Analyzer Families, Types, Models, Modes, and Calibrations

The current DELTA series is described in Table 2 on page 16. Legacy DELTA models are described in Table 3 on page 17. Each family serves from one to four application markets, and each type has a discrete model designation (see Table 4 on page 17).

Table 2 DELTA families, application markets, and models—current models

Families	Application Markets	Models
DELTA Premium	Alloy	DP-2000
	Environmental	DP-4000
	Mining	DP-6000
	RoHS	DP-6500-C
DELTA 50 Premium	Environmental	DP-4050
	RoHS	DP-6550-C
DELTA Professional	Alloy	DPO-2000
	Environmental	DPO-4000
	Mining	DPO-6000
	RoHS	DPO-6500-C
DELTA 50 Professional	Environmental	DPO-4050
	RoHS	DPO-6550-C
DELTA Classic Plus	Alloy	DCC-2000
	Environmental	DCC-4000
	Mining	DCC-6000
	RoHS	DCC-6500-C
DELTA Inspector	Alloy	DI-2000
	Precious Metals	DI-2000-PMI

Table 2 DELTA families, application markets, and models—current models *(continued)*

Families	Application Markets	Models
DELTA Element	Alloy	DE-2000

Table 3 DELTA families, application markets, and models—legacy models

Families	Application Markets	Models
DELTA Standard	Alloy	DS-2000
	Environmental	DS-4000
	Mining	DS-6000
	RoHS	DS-6500-C
DELTA Classic	Alloy	DC-2000
	Environmental	DC-4000
	Mining	DC-6000
	RoHS	DC-6500-C
DELTA Inspector	Precious Metals	DI-2000-PM-C & DI-2000-PM-CC

Table 4 on page 17 lists many possible modes.

Table 4 Modes

Modes
Alloy
Alloy Plus
Precious Metals
Soil Environmental Soil Exploration
Mining
Mining Plus
Lead Paint
RoHS
Consumer Goods
Empirical
Halogen Free
Filter Analysis
Dust Wipe

1. Analyzer Overview

This chapter provides an overview of the DELTA X-ray fluorescence analyzer and its accessories.

1.1 Unpacking the Analyzer

Most DELTA X-ray fluorescence analyzers and their accessories are shipped in industrial transport cases.

To unpack the analyzer

1. Locate the shipping papers and documentation, and then remove them from the transport case.
2. Open the case, and then remove the DELTA and all of the components.

NOTE

Please note that the case contains two layers of protective foam padding.

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3. Make sure the top layer of the foam is clear of any items, and then lift it up to expose the docking station and optional AC power adaptor.
4. Inspect all components for damage, and report any problems to Olympus immediately.

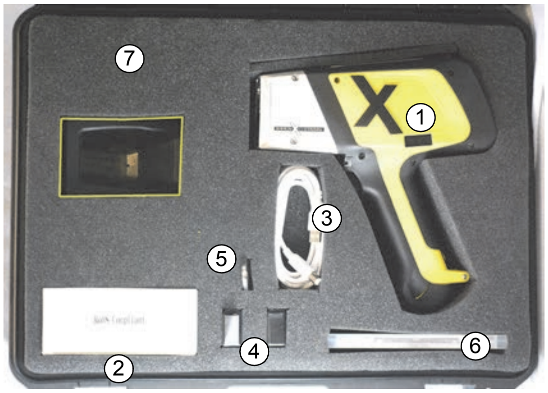
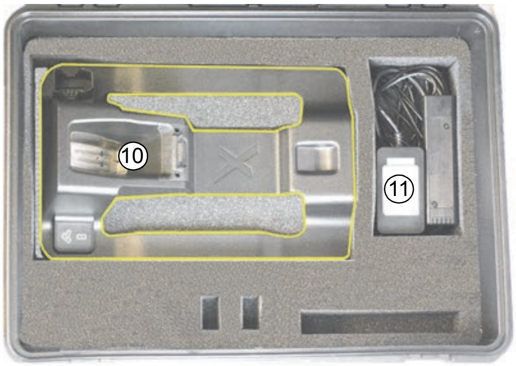
⚠ **WARNING**

If there is any damage to any of the components, do not attempt to use the analyzer.

1.2 DELTA Package

The following table lists the DELTA package components (see Table 5 on page 20).

Table 5 DELTA package components

Component key		DELTA — All models except DELTA Element and DELTA Inspector
Foam: Top layer		
1	DELTA analyzer	
2	Docking station charger	
3	USB cables (2)	
4	Li-ion batteries (2)	
5	Calibration check (Cal Check) coupon	
6	Extra windows (bag of 10)	
7	Product documentation (not shown)	
Foam: Second layer		
10	Docking station	
11	AC power adaptor (optional)	

NOTE

For the DELTA Element and DELTA Inspector, the docking station is replaced by the battery charger.

1.3 X-Ray Fluorescence Analyzer

The following table lists the DELTA X-ray fluorescence analyzer components (see Table 6 on page 21).

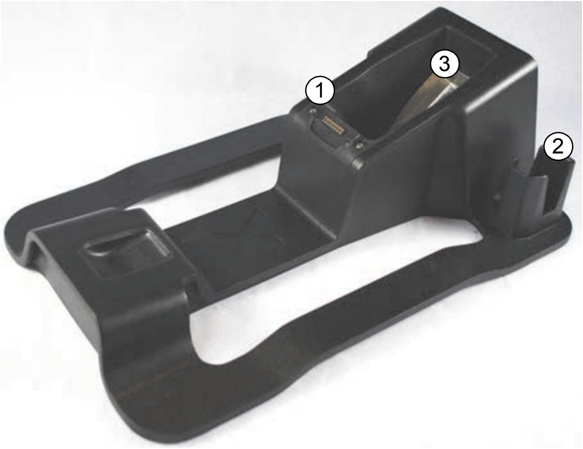
Table 6 DELTA X-ray fluorescence analyzer components

Component key		DELTA — All models
1	DELTA analyzer (Premium model shown)	
2	Probe	
3	Measurement window (Prolene or Kapton film)	
4	Hinged window plate	
5	Docking-station connector	
6	Trigger	
7	Handle — Nonslip rubber grip	
8	Battery boot	
9	Data port with rubber cover	
10	Heat sink	
11	I/O (power) switch with LED indicator	
12	X-ray warning light array	
13	User interface touch screen	
14	Navigation keys	

1.4 Docking Station

The following table lists the DELTA docking station (DDS) components (see Table 7 on page 22).

Table 7 The DELTA docking station

Component key		DELTA — All models except DELTA Element and DELTA Inspector
Docking station (empty)		
1	Analyzer signal/control connector	
2	Second battery charger socket	
3	Cal Check test cup (316 stainless steel)	
Docking station (loaded)		
5	Second battery in socket	
6	Data port(s): *a)* Docking station (rear) *b)* Analyzer (left side)	
7	Input power (12 VDC)	
8	Indicator lights: *a)* Second battery charging *b)* Analyzer engaged	

NOTE

The DELTA docking station is a standard accessory for all DELTA models except the DELTA Element and the DELTA Inspector series.

1.5 DELTA Battery Charger

The battery charger (U8990854) with an AC input and a single Li-ion battery socket comes standard with DELTA Element and DELTA Inspector models. This battery charger and its operating procedures are described in section 3.

Table 8 The DELTA battery charger

Component key		DELTA — All models (standard on the DELTA Element and DELTA Inspector)
Battery charger (empty)		
1	Input power (12 VDC)	
2	Battery cradle and connectors	
3	Charging error indicator	
4	Battery charging/charged indicator	
Battery charger (loaded)		
5	Battery in cradle	

1.6 Standard Accessories

The DELTA X-ray fluorescence analyzer comes with the following standard accessories:

- Batteries
- DELTA docking station (DDS) [optional with the DI-2000 family]

- DDS power adaptor [optional with DI-2000 family]
- I/O cables [optional with the DI-2000 family]:
  - Cable 1: USB A to USB B connectors
  - Cable 2: Mini USB B to USB A connectors
- Measurement-window films (Kapton or Prolene)
- Cal Check coupon
- Application software

1.6.1 Batteries

The DELTA X-ray fluorescence analyzer comes standard with two removable Li-ion batteries. To test the charge status, press the white button on the battery. The green lights indicate the percentage of remaining charge, which ranges from less than 25 % to 100 % (see Figure 1-1 on page 24). See “Analyzer Batteries” on page 56 for more details.

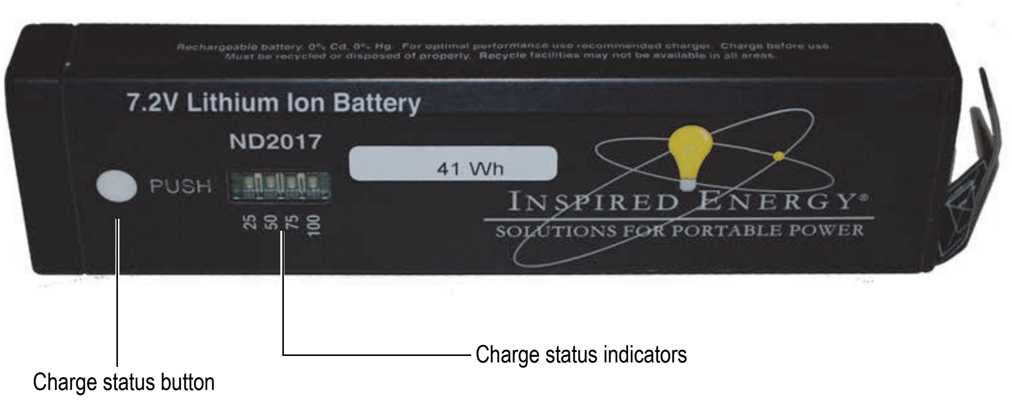


Figure 1-1 DELTA Li-ion battery

1.6.2 DELTA Docking Station (DDS)

The DELTA docking station (see Figure 1-2 on page 25) is a key accessory that performs three functions:

- Cal Check (“on demand” or automatic)
- Charging the DELTA internal battery (in handle)
- Charging an additional battery (in auxiliary socket)

For docking station components, see Table 7 on page 22. See also “DELTA Docking Station” on page 55 and “Conducting a Cal Check in the Laboratory” on page 73 for more details.

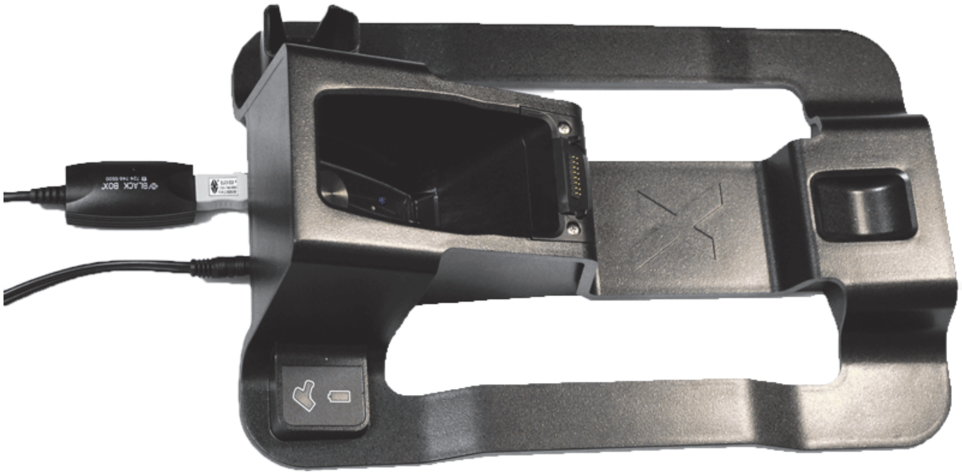


Figure 1-2 DELTA docking station

1.6.3 Docking Station Power Adaptor

The DELTA docking station is energized using a power adaptor (see Figure 1-3 on page 25).

Figure 1-3 DELTA docking station power adaptor

1.6.4 Power Cords

Region specific power cords are available for use with the docking station power adapter (see Figure 1-3 on page 25) and the AC power adaptor (see Figure 1-9 on page 29). Make sure the power cord included with your DELTA analyzer is appropriate for your region. See Table 9 on page 26 for more information.

Table 9 Region specific power cord options

Region	Plug	U8 Number
Australia	Type I	U8840005
Brazil	Type J	U8769007
China	Type I	U8769008
Denmark	Type K	U8840011
European	Type F	U8840003
Italy	Type L	U8840009
South Africa, HK, India, Pakistan	Type D/M	U8840013
South Korea	Type F	U8769009
UK	Type G	U8840007
USA	Type B	U8840015

1.6.5 Data Cables

The DELTA X-ray fluorescence analyzer comes standard with two USB data cables.

- This standard accessory set (U8990455) provides the ability to transfer information into or out of the sealed analyzer (see Figure 1-4 on page 26). It is good practice to export the current day’s testing results to your PC.

Figure 1-4 USB data cable

- This accessory is a two-part assembly (U8997413 and U8998229) that supports communication between the DELTA docking station and a PC (see Figure 1-5 on page 27).

Figure 1-5 USB repeater cable and adaptor — U8997413 and U8998228

1.6.6 Measurement-Window Films

The DELTA X-ray fluorescence analyzer comes standard with a bag of 10 window films (see Figure 1-6 on page 27). Film composition depends on the model and the application.

Figure 1-6 Kapton and Prolene windows

1.6.7 Cal Check Coupon/Coin

The Cal Check coupon is used as a reference sample to provide a test standard for a Cal Check procedure if the docking station is not available. The DELTA X-ray fluorescence analyzer indicates when a Cal Check is necessary (see Figure 1-7 on page 28). See chapter “Analyzer Operation” on page 65 for more details.

Figure 1-7 Cal Check coupon/coin

1.6.8 Application Software

The DELTA X-ray fluorescence analyzer is shipped with proprietary Olympus data acquisition and processing software, and a Windows Embedded CE operating system. The user interface employs a button-based home page graphic style (see Figure 1-8 on page 28). Factory calibration has been completed on all purchased modes. Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* for complete software details.

Figure 1-8 DELTA analyzer user interface

1.7 Optional Accessories

Optional accessories are also available for the DELTA X-ray fluorescence analyzer:

- AC power adaptor
- PC software

- XRF workstation
- Test cup
- Soil foot
- Extension pole for soil foot

1.7.1 AC Power Adaptor

The AC power adaptor (U8999515) enables you to operate the analyzer without the need of battery charge. The adaptor includes a 10 foot power cord that determines the effective range of use (see Figure 1-9 on page 29).

Figure 1-9 AC power adaptor and its power cord

NOTE

Part number U8999515 describes a power adaptor with a power cord/plug that is standard for the USA. Power cords are also available with plugs standard to other countries. See your Olympus representative for the correct part.

1.7.2 PC Software

This application package allows you to execute the Olympus software functions from a PC. You can connect the DELTA mini-USB data port to a PC USB port using the USB data cable (U8990455).

This package is optional for the X-ray fluorescence analyzer and standard for the workstation/test stand (U8990865). When used with the workstation/test stand, the proper configuration cable is the USB repeater cable and adaptor assembly (U8997413 and U8998288).

1.7.3 XRF Workstation

The DELTA XRF workstation is comprised of three major components:

- Test stand (U8990865) [see Figure 1-10 on page 30 and Figure 1-11 on page 30]
- Any DELTA analyzer
- Olympus Advanced PC software (U8990898)

The workstation offers the following features:

- Portable, lightweight, shielded enclosure
- Rugged and repeatable testing environment
- Easily erected in the laboratory or at remote field sites

In the workstation configuration, the DELTA is controlled by the Olympus Advanced DELTA PC software. The open-beam handheld analyzer is then converted into a safe closed-beam workstation.

NOTE

Refer to the document entitled *DELTA Portable Workstation Quick Start Guide* for complete instructions.

Figure 1-10 Test stand

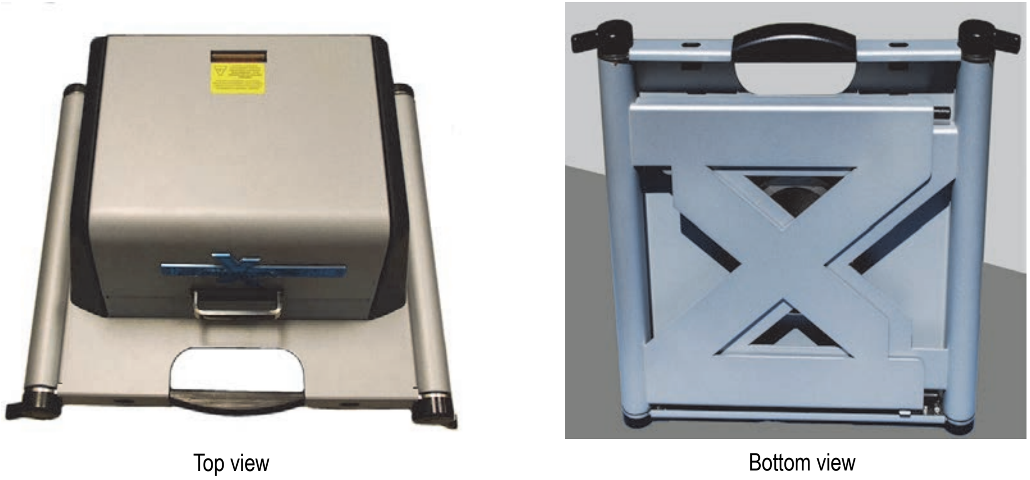


Figure 1-11 XRF workstation

1.7.4 Test Cup

This fixture (U8996265) provides a fully shielded ultra-portable test stand for bench top or field site testing (see Figure 1-12 on page 31.

Figure 1-12 Test cup

1.7.5 Mining Accessories

The soil foot (U8990900) and the extension pole (U8990901) provide a comfortable method for testing soils while walking or standing in the field. The extension pole features a remote trigger (see Figure 1-13 on page 31).

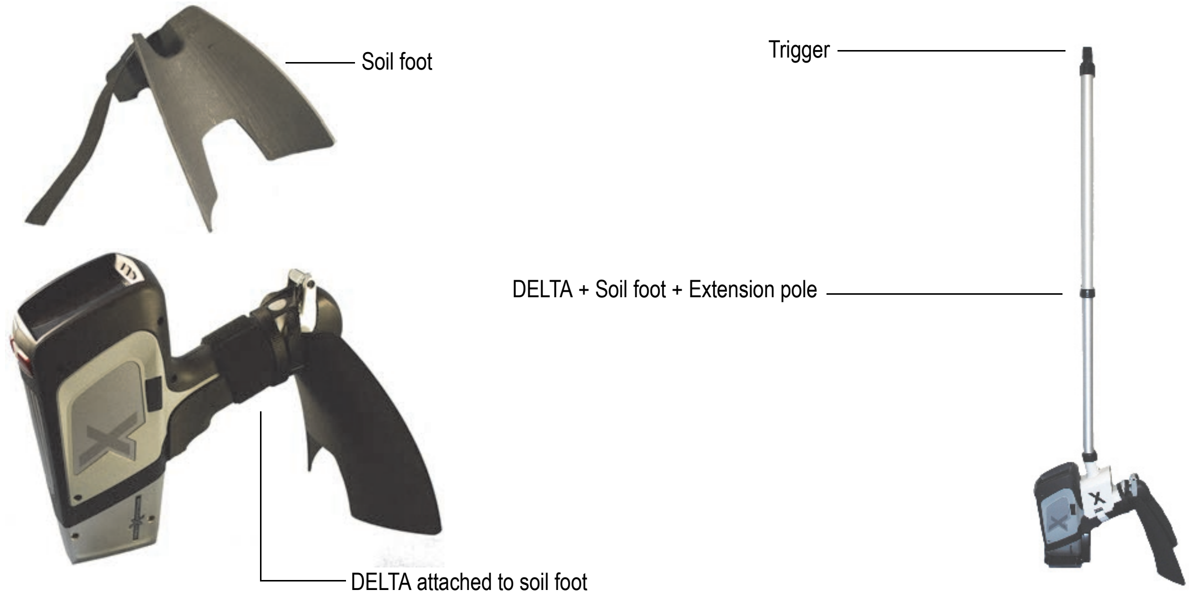


Figure 1-13 Soil foot with extension pole

2. Safety Information

This chapter contains important safety information for using the DELTA X-ray fluorescence analyzer.

2.1 Radiation Safety Information

IMPORTANT

Always make operational safety your highest priority.

The DELTA X-ray fluorescence analyzer is a secure and dependable instrument when used according to Olympus's recommended testing techniques and safety procedures. However, this instrument produces ionizing radiation, and as such should only be used by individuals trained in correct operating techniques and authorized to use X-ray producing devices.

The radiation detected on any outside surface (excluding the Prolene or Kapton window area) is below limits for an unrestricted area.

- Heed all warning labels and messages.
- Observe the safety interlock features.

⚠ **WARNING**

X-ray tubes in DELTA X-ray fluorescence analyzer can emit dangerous levels of ionizing radiation. Prolonged exposure can cause serious illness, injury, or death. It is the responsibility of Olympus customers to follow the operating instructions and safety recommendations in this manual and good radiation control practices.

2.2 Radiation Safety Program

Olympus strongly recommends that organizations using DELTA X-ray fluorescence analyzers implement a formal radiation safety program that includes:

- Dose monitoring of critical personnel
- Monitoring of area radiation levels
- Information specific to the site and application of the XRF system
- An annual review (and update, if necessary)

"Safety Administration" on page 49 provides a more comprehensive safety discussion for operators and managers.

2.3 X-Ray Safety

X-ray safety is a priority at all times and in all testing situations.

⚠ **WARNING**

- Olympus analyzers must be used by trained and authorized operators in accordance with proper safety procedures. Improper usage may circumvent safety protections and could potentially cause harm to user.
- All users shall be certified in accordance with the requirements of NRC Standard CAN/CGSB-48.9712-2006 / ISO 9712:2005.
- Pay attention to all warning labels and messages.
- Do not use the instrument if there is any chance that it could be damaged or unintentionally emit stray radiation. In such cases, arrange for qualified personnel to perform a radiation safety test. Contact Olympus or its authorized service representative to repair any damage to the analyzer.

2.4 Safety Interlock Structure

To control X-ray emissions, and thereby minimize the possibility of accidental exposure, the Olympus X-ray fluorescence analyzer has a standard safety interlock structure consisting of the three features listed below:

1. Software proximity sensor

   Within two seconds of starting a test, the analyzer detects the sample in front of the measurement window. If no sample is detected, the test aborts to prevent accidental exposure, the filter wheel returns to the 0 position, and the X-rays shut off. The tube current decreases to 0.0 µA, and the red light stops blinking. Also, if the probe/nose is pulled away from the sample while a test is in progress, testing stops within approximately one second.

2. Software trigger lock

   After a five minute lapse between tests (default time), the trigger automatically locks. To unlock it, tap the Lock button (🔒).

3. Safeguards

   As an owner of an Olympus X-ray fluorescence analyzer, your safeguards include the items indicated below:

   - Limited access

     Keep the instrument in a controlled location to which only trained and authorized users have access.

   - Trained operators

Post a sign near the analyzer indicating that it must only be used by operators who have completed a training course provided by your company, or who have attended an Olympus training course and comply with any other requirements stipulated by local regulatory authorities. When the Olympus instrument is turned on, the user interface touch screen displays a message indicating that the instrument should only be used by authorized personnel.

- Shielding issues

  An Olympus X-ray fluorescence analyzer emits a tightly collimated beam of X-ray radiation. Although attenuation occurs, the beam trajectory may extend up to many meters through open air.

IMPORTANT

Refer to governing regulations for compliance requirements applicable to the installation area, dose limits, etc. Requirements may differ from province to province. Do not rely solely on this manual for instructions.

Adequate shielding is achieved by:

- Establishing a no-access zone at a sufficient distance from the instrument's measurement window, which will allow air to attenuate the beam.
- Enclosing the beam working area with protective panels (3.0 mm stainless steel panels are capable of attenuating the beam to background levels).

Contact your Olympus representative for assistance and recommendations on interlocks and applications that limit radiation exposure.

- Trigger issues

  The deadman trigger protocol requires the user to pull and hold the trigger for the duration of the test. Releasing the trigger prematurely will abort the test.

IMPORTANT

Canadian regulations require mandatory use of a deadman trigger at all times. Do not disable this feature.

2.5 General Precautions

Apply these general safety guidelines when managing or operating the DELTA:

- Retain and follow all product safety and operating instructions.
- Comply with all warnings on the product and in the operating instructions.

Comply with the precautions indicated in this chapter to reduce the following risks:

- Users
  - Physical injury
  - Electric shock
  - Radiation exposure
- Equipment damage

- — Measurement window
- — Overheated electronics and other internal components

2.6 Service Considerations

Except as expressly noted in this document, do not service any Olympus product yourself. Opening or removing the external housings may expose you to electric shock and subject the instrument to mechanical damage, and also voids the warranty.

IMPORTANT

Any required servicing must be performed by Olympus, or one of its authorized service representatives. Failure to observe this condition could result in voiding of the warranty. The ONLY EXCEPTION to this rule is the replacement of a damaged measurement window. See chapter "Measurement Window Replacement" on page 109 for more details about measurement-window replacement.

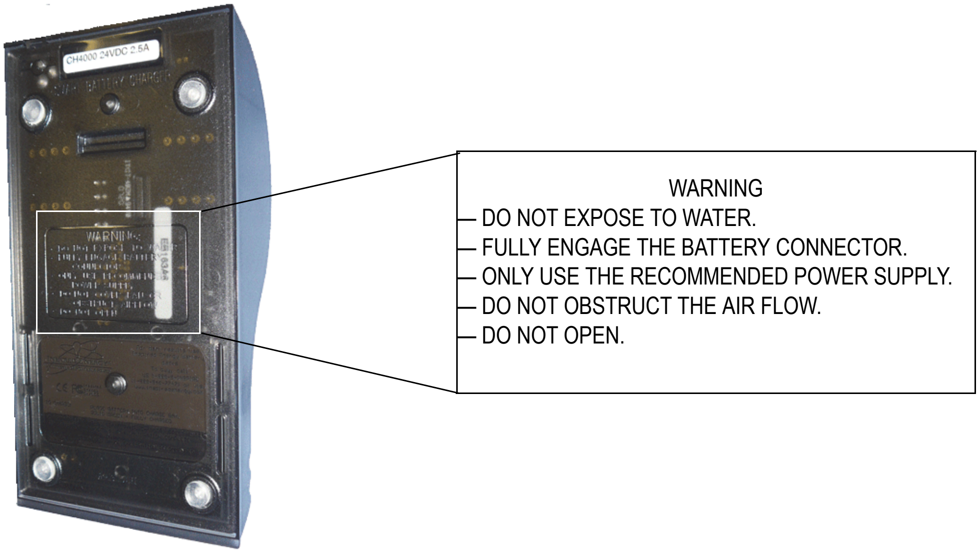
Types of problems or conditions that require service are, but not limited to:

- Damaged power cords.
- Excessive spills or corrosive liquids on the instrument or accessories.
- A battered, dropped, or physically damaged instrument.
- Noticeable signs of overheating.
- An instrument or docking station that does not operate normally when operating instructions are followed.

2.7 Electrical Precautions

The following list of guidelines is essential for safe electrical operation of the DELTA X-ray fluorescence analyzer and its accessories:

- Use the correct battery or AC power adaptor.
- Install the battery or AC power adaptor carefully. Do not damage the connections.
- Use the correct external AC power source for the DELTA Docking Station (DDS) [battery charging and Cal Checking] and the AC power adaptor:
- Make sure that the voltage is appropriate (100–240 V/ 50–60 Hz) for operation of either accessory. See Appendix "Specifications" on page 119 for electrical specifications.
- Do not overload the electrical outlet, power strip, or convenience receptacle.
- Do not exceed 80 % of the branch circuit rating.
- Comply with the warning messages indicated on the underside of the optional battery charger (see Figure 2-1 on page 37). Similar precautions should be observed for the DELTA docking station (DDS).



WARNING
- DO NOT EXPOSE TO WATER.
- FULLY ENGAGE THE BATTERY CONNECTOR.
- ONLY USE THE RECOMMENDED POWER SUPPLY.
- DO NOT OBSTRUCT THE AIR FLOW.
- DO NOT OPEN.

Figure 2-1 Warning messages on the optional battery charger

2.7.1 Cables and Cords

The DELTA X-ray fluorescence analyzer and the DELTA docking station are delivered with:

- One AC power adaptor for the docking station (standard)
- One AC power adaptor for the analyzer (optional) as a replacement to battery power

Each device has a standard IEC 3 conductor power cord that includes a safety grounding plug. The power cord and plug are chosen in compliance with local electrical codes and standards.

Two USB data cables are supplied with a parts kit (U8990455):

- Cable 1: USB A connector to USB B connector
- Cable 2: USB A connector to mini USB B connector

To ensure safety and proper equipment performance

- Connect the power cords to a properly grounded and easily accessible power outlet.
- Use a surge protector device, if possible.
- Do not defeat or bypass the ground conductor.
- Do not pull on cords or cables. Grasp the plug housing when removing the cord from the electrical outlet.
- Install all cords in accordance with applicable regulations.
- If substituting a USB cable, make sure that the length does not exceed 10 feet.

2.7.2 Docking Station and Li-Ion Batteries

To use the DELTA docking station (and optional battery charger, when applicable), you must plug it into a grounded electrical outlet that is easily accessible at all times.

Handle battery packs properly. Do not:

- Disassemble
- Crush
- Puncture
- Short external contacts
- Dispose of in fire or water
- Expose to temperatures higher than 60 °C (140 °F)

⚠ **WARNING**

- The battery must only be replaced with an Olympus-designated model. Using an incompatible battery could cause an explosion.
- Used batteries may be returned to Olympus for disposal. When returning batteries, or equipment with batteries installed, the shipping container must be labelled with a special caution warning (see “Regulations for Shipping Products with Lithium-Ion Batteries” on page 12).

NOTE

For instructions regarding batteries, the battery charger, or the AC power adaptor, see “Analyzer Batteries” on page 56.

2.8 Indicators and Statuses

The DELTA X-ray fluorescence analyzer has several indicators that alert the operator as to the status of the unit.

2.8.1 Power Switch with Integral Indicator Light

The power switch is located on the upper rear portion of the analyzer (see Figure 2-2 on page 39).

To power on

◆ Press the power switch to turn on the power.

A green LED indicator illuminates.

NOTE

The power switch DOES NOT turn on the X-ray tube. Tube power cannot be supplied until the Olympus software is launched.

To power off

◆ Press and hold the power switch for more than three seconds.

The instrument turns off (see "Shutdown Procedures" on page 83 for more shutdown information).

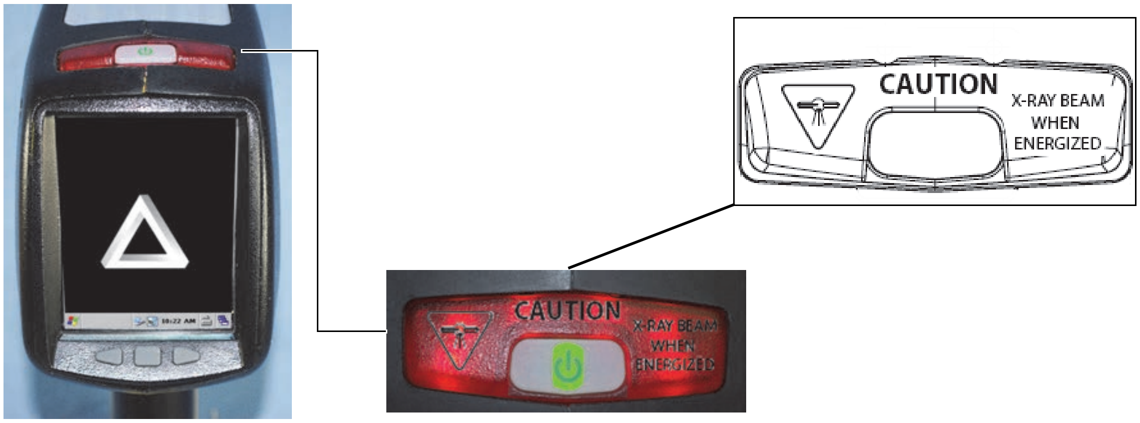


Figure 2-2 Power switch and X-ray indicator

2.8.2 X-Ray Indicator

An X-ray indicator alerts the operator when the tube is receiving power and when X-rays are emitted from the analyzer through the measurement window. The X-ray indicator is located on the upper rear portion of the analyzer (see Figure 2-2 on page 39). This indicator consists of a six-element red LED array, and provides two key functions:

X-ray indicator continuously ON (solid red LED array)

This signifies that:

- The X-ray tube is enabled.
- There is no radiation exposure to you or bystanders.

The instrument can be carried or set down safely in this condition.

X-ray indicator flashing ON (blinking red LED array)

This signifies that:

- The X-ray tube is powered to full operational capacity.
- The analyzer is emitting X-ray radiation through the measurement window.

In this condition, the analyzer must be pointed toward a test sample.

2.8.3 Test Screen

During Cal Checks and while samples are being tested, the test screen's lower status bar provides a progress indicator (see Figure 2-3 on page 40). Once the task is completed, a **Ready** indicator is displayed (ready for next operation).

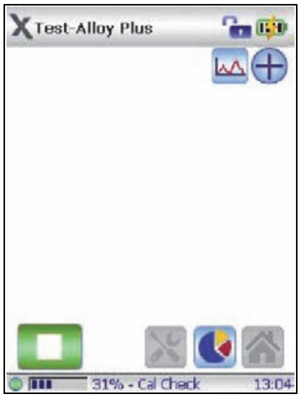


Figure 2-3 Test screen status bar

2.8.4 Audible Alarm Protocol

As a warning, the audible signal emits three tones when the X-ray tube is about to emit X-rays. During the subsequent testing period, the audible alarm maintains a "chirping" signal throughout the duration of the test. This feature is **mandatory** in Canada. Customers in other countries can order this item as an additional safety option.

2.9 Analyzer Usage Scenarios

The DELTA X-ray fluorescence analyzer can be used in several testing configurations. This chapter explains how to use the analyzer correctly.

2.9.1 Practical Safety Guidelines

The practical safety guidelines listed below must be followed at all times.

WARNING

- DO NOT POINT the unit toward yourself or any other person during operation.
- When performing tests, never use your fingers or the palm of your hand to hold the sample in place.
- Always wear both a ring-style and a badge-style dosimeter.

2.9.2 Correct Usage

Test targets can include pipes, valves, large pieces of scrap metal, soil, or any sample large enough to be tested without handling.

In this configuration, the proper procedure is as follows:

To perform a test on a large stationary object

1. Always observe the practical safety guidelines shown in “Practical Safety Guidelines” on page 40.
2. Point the analyzer at the sample, ensuring that no part of your body (including hands and/or fingers) is near the measurement window.
3. Make sure that the DELTA’s nose (with window) is firmly placed on the target.
4. Perform the test using one of the following methods:
    - On the user interface (UI), tap **Start**.
      OR
      Pull the trigger (this toggles the instrument to On state)
      OR
      Pull and hold the trigger, keeping the deadman trigger activated.

This procedure ensures that none of the operator’s body parts are exposed to excess radiation exposure. The radiation detected at user interface areas is less than 5 μSv/h.

WARNING

During testing, make sure that no personnel are located within one meter (three feet) of the DELTA probe head’s X-ray beam. Provided that the window is completely covered, only minimal radiation is emitted in the area surrounding the sample.

Testing can also be performed on small components, such as metal turnings, weld rods, wires, fasteners, nuts, and bolts. To analyze these types of components, follow the procedure below.

To perform a test on a small component

WARNING

Do not test samples while seated at a desk or table. If the sample is placed on a desk made of wood or any other nonmetallic material, some radiation will penetrate the desk, subjecting your legs or feet to exposure.

---

1. Always observe the practical safety guidelines (see “Practical Safety Guidelines” on page 40).
2. Place the sample on a flat surface (see Figure 2-4 on page 42), or use a clamp to hold the sample in place for effective and safe analysis of small and irregular shaped samples (see Figure 2-5 on page 43).
3. Make sure that the DELTA’s nose (with window) is firmly placed over the sample.

NOTE

If the sample does not completely cover the window, make sure that your background surface does not contain metals (not even trace levels of metals), because the XRF may report the presence of additional metals, which could affect the accuracy of the XRF result.

---

4. Perform the test, keeping the trigger depressed and held, and the deadman trigger activated.

Figure 2-4 Sample on a flat surface

Figure 2-5 Sample held by a clamp

2.9.3 Incorrect and Unsafe Usage

This section describes testing techniques that must be avoided to ensure safe and correct usage of the analyzer.

WARNING

Never hold a sample in your hand to ensure that no part of your body is exposed to X-ray beams. Testing samples in this way may subject your fingers and other parts of your body to significant radiation exposure.

Unsafe Testing Techniques

In the following example (see Figure 2-6 on page 44), the analyst is using her fingers to hold the sample up to the measurement window. The sample does not completely cover the window.

Although the analyst is wearing a ring dosimeter, this is an unsafe testing technique.

In this situation, the only value provided by the ring is to validate the level of unnecessary radiation exposure received.

Figure 2-6 Unsafe testing technique

In the following example (see Figure 2-7 on page 44), the analyst is using her fingers to hold the sample up to the measurement window. In addition, the sample is not covering the window completely.

To compound the danger, the analyst is not wearing a ring dosimeter, so there is no way of knowing how much radiation exposure was received.

Figure 2-7 Bad testing technique — Without dosimeter

2.9.4 Radiation Doses under Several Scenarios

This section presents data, concrete examples of use and misuse of the DELTA X-ray fluorescence analyzer, and common questions and answers encountered when training personnel on safe use of the analyzer. The goal of these scenarios is to explain the difference between “safe” and “unsafe” usage.

⚠ **WARNING**

In terms of X-ray energy emitted by portable XRF analyzers (8–60 keV region), bones in the fingers absorb radiation at a rate about 3 to 5 times higher than soft tissue, and therefore bone is more susceptible to radiation risk than soft tissue.

For this reason, fingers must not be used to hold test specimens in front of the window, and must be kept outside of the direct beam. In addition, the beam must not be directed at any part of the human body.

Table 10 on page 45 presents radiation doses under normal operating conditions. Olympus provides installation training that includes detailed radiation safety training and documentation to prevent misuse of the analyzer.

NOTE

Although the doses shown below are derived from experiments with thermoluminescent dosimeters (TLD), and may or may not represent the actual absorbed doses in human tissue and bone under each scenario, these examples do represent the level of X-ray radiation emitted from the device.

The message is simple: USE CAUTION AND PROPER TECHNIQUES when operating the device.

Table 10 Radiation doses — Normal operation

Examples of normal operation	Radiation exposure and comments
Example 1: Dose to hand The user analyzes samples in accordance with the standard operating procedures described in this manual. Assumption: The operator is using the system with the X-ray tube On 8 hours/day, 5 days/week, 50 weeks/year (alloy sample).	The operator's hand (where it touches the trigger) receives the highest level of exposure, which corresponds to < 1 mSv/h. Annual exposure to hand is therefore < 2 mSv. Maximum exposure under ICRP regulations is 500 mSv for radiation workers, and 50 mSv for the general public. As such, continuous analyzer operation leads to a dose 250 times under the maximum applicable to radiation workers, and 25 times under the maximum applicable to the general public.
Example 2: Dose to torso The analyzer is used under the same operating conditions described above.	Exposure to the torso is so low that it cannot be measured (essentially background levels). To be conservative, we use the 0.5 mSv/h value at the trigger (< 0.5 mSv/h). Annual exposure based on the above operating conditions is therefore estimated at less than 1 mSv. Under ICRP, the maximum allowable radiation dose is 20 mSv for radiation workers (1 mSv for general public).

Table 11 on page 46 presents examples of radiation doses associated with misuse, and even extreme misuse, of the analyzer.

⚠ **WARNING**

The examples described below are associated with misuse. DO NOT employ these methods. Exposure resulting from misuse can cause serious illness, injury, and/or death.

Table 11 Radiation doses — Misuse

Examples of misuse	Radiation exposure and comments
Example 1 The operator uses his/her fingers to hold samples in front of window, leaving them directly exposed to the primary beam. In this example, the sample is not blocking any radiation.	The highest radiation dose to the fingers in the primary beam at the window is 20,000 mSv/hr. If we assume that an operator is performing a 10-second test (typical), the dose of radiation to the operator's fingers or hand would be $20{,}000 \times \left(\frac{10}{3{,}600}\right) = 55 \text{ mSv}$ If the operator repeats this process just ten times per year, he/she will exceed the maximum allowable annual dose of 500 mSv, and by a significant amount. Take the time to test a sample on a surface, or use a test stand. Note: If the operator takes shortcuts by placing his/her fingers within the primary X-ray beam at the window, he/she will exceed the annual dose rate.
Example 2 The operator places the analyzer against his/her body and pulls the trigger to start a test. Unless the operator pulls the trigger again, the analyzer will execute the tests at the preset testing time (usually ten seconds). This example assumes that the analyzer is in direct contact with the operator or a bystander.	The dose at the exit of the sampling window is 20,000 mSv/h. The dose for a ten-second exposure with the analyzer in direct contact with torso is 55 mSv. If an operator performs this action a single time, he/she will exceed the maximum annual safe dose to the torso, which is 20 mSv/year, and by a significant amount. Note: The maximum dose of 20 mSv/year is a whole-body limit, which is not completely applicable in this case, because the X-ray beam size is small (about a 25 mm² area at the port). The application of correction factors for the beam size is complex, and beyond the scope of this manual. An important point to be noted is that for proper operation, there is no reason to ever expose any part of the human body directly to the X-ray source. This example serves to provide an estimated exposure in the event that this situation occurs.

Table 11 Radiation doses — Misuse *(continued)*

Examples of misuse	Radiation exposure and comments
Example 3 The operator initiates a test for ten seconds under normal soil mode, and exposes a bystander who is standing 10 cm away from the analyzer port to radiation. What level of exposure was received by the bystander? Note: The proximity sensor would automatically shut down the X-ray tube immediately, so this is an extremely unlikely occurrence that would result from a malfunction of the instrument. This safety feature is NOT modifiable. Note 2: The equations provided to the right can be used to scale this scenario to others that involve longer or shorter tests with the bystander located at distances other than 10 cm.	The dose received by a bystander at 10 cm is 215 mSv/hr. For a ten-second exposure, the dose is 0.6 mSv. This is 33 times lower than the maximum annual allowable dose to a nuclear worker. This situation would have to be repeated up to 33 times before the worker or bystander would have obtained the maximum allowable dose. The formula required to calculate other scenarios is shown below: $\text{Dose (in mSv)} = \frac{6T}{D^2}$ where: D = distance from the port in centimeters T = testing time Example: The bystander is 30 cm away from the port for the duration of a 30 s test. In this case, the dose is calculated as: $\text{Dose} = \frac{6 \times 30}{30^2} = 0.2\text{ mSv}$

Table 12 on page 47 lists the radiation doses from typical exposures to ionizing radiation.

Table 12 Radiation doses from typical exposures

Activity	Typical dose
Smoking	2.8 mSv per year
Dental X-ray	100 μSv per X-ray
Chest X-ray	80 μSv per X-ray
Drinking water	50 μSv per year
Cross-country round-trip by air	50 μSv per trip
Mammogram	1–2 mSv per examination
Yearly exposure from background[a] radiation	3.6 mSv

[a] Depends on geographic location

2.9.5 Radiation Safety FAQ

This section lists the frequently asked questions (FAQ) about radiation safety.

Question:

When I am shooting a piece of pipe or valve on a rack or on a table top, will there be any exposure to people standing several feet away from the analyzer?

Answer:

Even a thin amount of a dense metal sample (3 mm to 4 mm thickness, not aluminum alloy) is enough to completely attenuate the emitted X-ray beam. Shooting a piece of material that covers the sampling window on the analyzer completely shields any bystanders from radiation exposure. However, adopt good practices: maintain a buffer zone of at least 0.9 m to 1.2 m in front of the analyzer, and do not allow access to this area.

Question:

If I forget to lock the trigger, and accidentally pull it while picking up the analyzer, is there danger to nearby personnel?

Answer:

No, this example of misuse is not dangerous, but it may expose nearby personnel to a non-negligible amount of radiation. For exposure to occur, the following events must occur.

First, you must be holding the analyzer in such a way that there is a bystander in the direct path of the X-ray beam being emitted. Otherwise, it is totally safe to be near to the analyzer.

Second, failure of the proximity hardware and software would need to occur.

Third, the bystander must be within 1 meter of the analyzer nose to receive any appreciable dose. If all of these conditions are met, the dose received by the bystander will still be extremely low. For more information, please see Misuse Example 3 in the table above.

Question:

Do I need to create restricted areas within the area where the analyzer is being used?

Answer:

No. Provided that you are following normal operating procedures, there is no reason to restrict access to an area where the analyzer is being used. However, the operator should keep any personnel at a distance beyond 0.9 m from the sampling window of the analyzer as a precautionary measure in the event of accidental misuse such as that detailed above. If the operator is testing small samples, they should also make sure that no personnel are standing within 0.9 m to 1.2 m of the sampling window.

Question:

How does the X-ray tube in the Olympus analyzer compare to a radiography system used to take images of metal parts?

Answer:

The X-ray tube used in the Olympus analyzer produces between 1,000 and 10,000 times less power than most radiography systems (0.5 W to 1 W versus multiple kW). Portable XRF analyzers are designed to perform surface analysis of alloys and other samples, whereas radiography systems are designed to shoot X-rays entirely through metal components in order to obtain an image on the other side of the test object. For example, many tube-based radiography systems use a 300 kV to 400 kV tube and currents in the tens to hundreds of milliamperes (mA). The DELTA uses a tube operating at a maximum of 40 kV, and typically 6 mA to 10 mA.

The radiation levels produced by the DELTA are thousands, or tens of thousands times lower than a radiography unit.

Question:

Should we use dosimeter badges with the Olympus analyzer?

Answer:

Dosimeter badges are required by some regulatory agencies, and optional for others. Olympus recommends that operators wear badges during at least the first year of operation as a general precaution that can serve to identify any misuse of the analyzer. Dosimeters are available in badge, lanyard, and ring format.

The best solution is to wear the ring badge on a finger of the hand opposite to the one holding the analyzer to ensure that the most common source of accidental exposure (due to grasping small samples during analysis) is recorded.

NOTE

These badges generally have a threshold of 10 μSv (1 mR/h), and are renewed monthly. As such, several instances of misuse must occur to obtain a reading on a typical badge. When purchasing badges, select the type used for X-ray and low-energy gamma ray radiation.

2.10 Safety Administration

This section provides information regarding:

- "Radiation Safety Training Recommendations" on page 49
- "Dosimeter Badges" on page 50
- "Dosimeter Safety Program" on page 51
- "Dosimeter Suppliers" on page 52
- "Registration Requirements" on page 52

2.10.1 Radiation Safety Training Recommendations

Respective countries or regions have specific regulations and guidelines for using ionizing radiation generated by X-ray tubes.

NOTE

For the convenience of clients, Olympus has compiled a list of recommendations. These recommendations:

- Provide generic guidance on the ALARA (as low as reasonably achievable) approach to radiation safety.
- Do not replace specific policies of any government entity or organization.

Personal Monitoring

Radiation control regulations may require implementation of a radiation monitoring program, in which each instrument operator wears a film badge or thermoluminescent dosimeter (TLD) for an initial period of one year to establish a baseline exposure record. Continued radiation monitoring after this period is recommended, but may be discontinued if accepted by radiation control regulators. See “Dosimeter Suppliers” on page 52 for a list of film badge providers.

Proper Usage

Never point the instrument toward another person. Never perform tests with the analyzer pointing into the air. Never hold samples in your fingers or hands during analysis.

Establishment of Controlled Areas

Restrict access to the analyzer storage location and limit usage to reduce potential exposure to ionizing radiation. During operation, the target should not be handheld and the area at least three feet beyond the target should remain unoccupied.

Specific Controls

When the analyzer is not in use, store it in a locked case or cabinet. During operation, make sure that the analyzer remains under the direct control of a factory-trained, certified operator.

Time, Distance, and Shielding Policies

Operators should limit the amount of time they spend around the energized analyzer, maximize their distance from the analyzer window, and shoot into high-density materials whenever possible.

Preventing Exposure to Ionizing Radiation

All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, and shielding, should be implemented to limit radiation exposure to as low as reasonably achievable (ALARA).

2.10.2 Dosimeter Badges

A dosimeter consists of a radiation-sensitive material, generally an aluminum-oxide crystalline layer, which is packaged in a small container (see Figure 2-8 on page 51). The dosimeter is generally attached to a person’s clothing or shirt pocket, or worn on parts of the body that most closely replicate the pattern of a potentially absorbed dose.

The dosimeter is also available in a plastic-ring format (see Figure 2-8 on page 51) In this case, the detection material is lithium fluoride crystal. Wearing a badge that is secured to a ribbon-style lanyard is another convenient way to measure individual radiation exposure (see Figure 2-8 on page 51).

Figure 2-8 Dosimeters — Various styles

These devices record individual workers' accumulated radiation exposure over a specific period of time. Dosimeters monitor individuals who work with devices that emit ionizing radiation, or who work in close proximity to someone else working with such devices.

When purchasing badges or rings, always select the type used for X-ray and low-energy gamma radiation.

IMPORTANT

Dosimeter badges are required in some countries or regions, and are optional in others. Olympus recommends that all DELTA analyzer operators wear a dosimeter (badge or ring) for at least the first year of operation of their analyzer(s).

Olympus recommends that the ring badge be worn on a finger of the hand opposite to the one holding the analyzer to ensure that the most common source of accidental exposure (due to grasping small samples during analysis) is recorded.

NOTE

Every country (including each region, state, or province within a country) may have different regulations. Always consult your local Radiation Protection Authority or Olympus for information and recommendations.

2.10.3 Dosimeter Safety Program

A typical dosimeter-based safety program follows the steps listed below:

1. The company develops a dosimeter program with an independent service contractor.

   Together, they establish the quantity of badges needed and the frequency of analysis (a monthly or quarterly interval).
2. The company receives the first lot of badges, and distributes them to its analysts/operators.
3. At the end of the interval:

   a) The company collects the badges and returns them to the service contractor for analysis.
   b) At the same time, the service contractor delivers another lot.

4. The company distributes the new set of badges, thereby maintaining a continuous protection/monitoring program for its employees.
5. The service contractor prepares a report for the company. The report tabulates any X-ray dose received, and identifies any personnel with readings that exceed typical background radiation.
6. The safety monitoring cycle is repeated from steps 1 to 5.

NOTE

The service contractor's written records are very important to a company's overall safety documentation plan.

2.10.4 Dosimeter Suppliers

Dosimeter service companies currently approved by Canadian Federal, Provincial, and Territorial Radiation Protection committees are listed below (see Table 13 on page 52):

Table 13 Dosimeter suppliers

Company	Location	Telephone
Global Dosimetry Solutions	Irvine, CA	1-800-251-3331
Landauer	Glenwood, Il	1-708-755-7000
National Dosimetry Services (Health Canada)	Ottawa, Canada	1-800-261-6689

2.10.5 Registration Requirements

Contact Olympus for assistance with locating registration requirements.

- Canada
  - To use the DELTA as an "open beam" XRF analyzer, the Natural Resources Canada government agency requires that operators be licensed to its standards. Note that neither the instrument itself nor its location need to be licensed.
  - When the DELTA is used as a "closed beam" system (for example, in a workstation/test stand environment), the operator does not need to be licensed.
  - See "Agency Statement Compliance" on page 11 for Agency Statement of Compliance information and relevant contact points.

Typical Device Registration Information

The following information is usually requested by a licensing agency:

Purpose of device

Analytical or industrial. See “Agency Statement Compliance” on page 11 for operating and qualification requirements.

Radiation safety officer

List the person who monitors training and safe use, and who controls access to the system.

Authorized users

List the analysts/operators who have been trained and authorized to operate the XRF equipment by the instrument owner and/or regulatory agency.

Operating parameters of the DELTA **XRF analyzer**

8–40 kV; 5–200 µA max.

Type of system

Handheld/portable.

User training specification

Indicate that only individuals who have received manufacturer training documented by a manufacturer’s training certificate can operate the system. Additional training may be required. Contact local regulatory agencies to determine the level and type of training required.

Personal monitoring

Many government-agency registration forms ask you to indicate whether or not you intend to perform dosimeter monitoring.

NOTE

See “Dosimeter Safety Program” on page 51 for information regarding typical personal radiation monitoring.

IMPORTANT

Always keep the following documentation on hand at the job site:

- A copy of License Registration
- Other pertinent government-agency documentation
- Copies of any dosimeter analysis reports
- A copy of the user manual for this equipment

3. Analyzer Setup

This chapter provides information about configuring the DELTA X-ray fluorescence analyzer and its companion DELTA docking station. Topics include:

- Docking station cable configuration
- Various methods of charging Li-ion batteries
- Changing batteries, including "hot swap" techniques.

WARNING

Read the "Safety Information" chapter carefully before handling the DELTA analyzer. Misuse of the analyzer can cause serious illness, injury, and/or death.

3.1 DELTA Docking Station

The DELTA docking station (DDS) serves several key functions:

- Supports an automatic or on-demand Cal Check procedure.
- Charges the main battery located in the analyzer's handle.
- Simultaneously charges a second battery in an auxiliary socket.
- Provides control information so that the status of both batteries can be monitored.
- Enables data communication from the DELTA to a PC using a powered USB cable.

Before using the DELTA analyzer, you should configure the DDS with the power and communication cables (see Figure 3-1 on page 56).

To configure the docking station (see Figure 3-1 on page 56)

1. Plug the AC power adaptor's line cord (1) into a suitable AC outlet.
2. Plug the AC power adaptor's DC jack (2) into the 12 VDC socket at the back of the docking station.
3. Optional: Insert connector B (3) into the docking station DATA port.
4. Optional: Insert connector A (4) into a PC USB port.

P/N: 103209 and 103210

DDS power adaptor

Figure 3-1 Docking station cable configuration

3.2 Analyzer Batteries

This section explains how to use and charge the Li-ion batteries of the DELTA X-ray fluorescence analyzer.

3.2.1 Battery Status

To test the charge status of the Li-ion battery, press the white button on the battery pack (see Figure 3-10 on page 60). The green lights indicate the percent of remaining charge, with a range of less than 25 % to 100 %. If the battery's charge is less than 25 %, use the docking station to charge it to full capacity.

3.2.2 Charging Batteries Using the Docking Station

The DELTA analyzer comes with a multipurpose tool: a docking station (see "Docking Station" on page 21 for hardware details). In addition to conducting automatic Cal Checks, the docking station performs two charging functions:

- Charging the installed Li-ion battery, which is located in the instrument's handle.

- Simultaneously charging a second battery in its special battery charging socket.

The charge status is shown in real time on the DELTA's display screen (see Figure 3-2 on page 57).

The status of the second docked battery (charging = red / full = green) is also shown in the battery icon located on the rear left-hand side of the docking station.

Figure 3-2 Battery charge status

NOTE

Each analyzer is shipped with two fully charged Li-ion batteries. Therefore, you do not need to charge the battery before using the analyzer.

To charge the analyzer batteries using the docking station

1. Make sure that the DC power adaptor is plugged into the DELTA docking station (see "DELTA Docking Station" on page 55).
   The indicator lights are off (see Figure 3-3 on page 57).

Figure 3-3 Indicator lights turned off

2. Make sure that the analyzer is turned off, and then place it on its cradle.
3. Make sure that the Analyzer indicator light is on (green) [see Figure 3-4 on page 58].

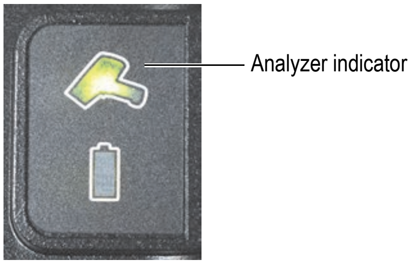


Figure 3-4 Analyzer indicator turned on

The main battery in the handle is charging, but the battery indicator is off.

If the DELTA is turned on, the battery status screen will appear.

4. Place a spare battery in the second battery socket.

   The Battery indicator light will turn red (unless fully charged) [see Figure 3-5 on page 58].

Figure 3-5 Battery indicator turned on (red)

Both batteries will charge simultaneously while their real-time charge status is displayed. When both batteries are fully charged, the indicators turn green (see Figure 3-6 on page 58).

Figure 3-6 Both batteries fully charged

3.2.3 Charging Batteries Using the Battery Charger

This section describes the procedure used to charge the Li-ion batteries when the DELTA docking station is not available, and requires a single-socket standalone battery charger (U8990854). The battery charger is a standard accessory with the DELTA Element and DELTA Inspector models. It is an optional accessory for all other models.

NOTE

This part number (U8990854) describes a battery charger with a standard North American power cord/plug. Standard power cords and plugs are also available for other regions. See your Olympus representative for assistance in obtaining the appropriate part.

To charge a battery using the charger assembly

1. Insert the male end of the three-prong power cord into the AC receptacle (see Figure 3-7 on page 59).

Figure 3-7 AC adaptor power cord

2. Insert the female end of the three-prong power cord into the male end of the AC adaptor.
3. Plug the AC adaptor connector labeled CH4500 24 VDC (see Figure 3-8 on page 59) into the charger connector labeled SWC (see Figure 3-9 on page 60).

Figure 3-8 AC adaptor connector labeled CH4500 24 VDC

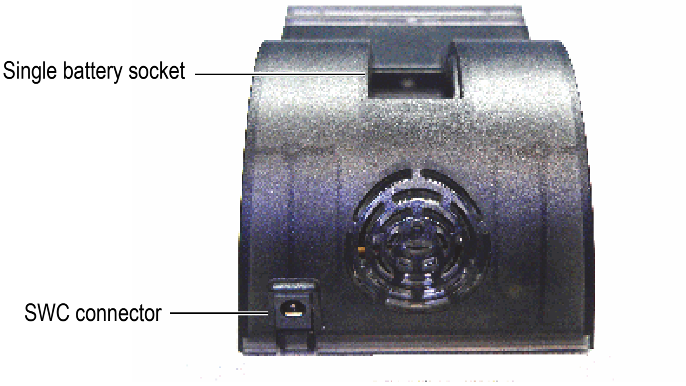


Figure 3-9 Battery charger SWC connector

4. Align the contacts on battery with the contacts on charger, and then insert the battery into the charger (see Figure 3-10 on page 60 and Figure 3-11 on page 61).

CAUTION

Inserting the battery incorrectly could cause damage to the contacts or destroy the battery.

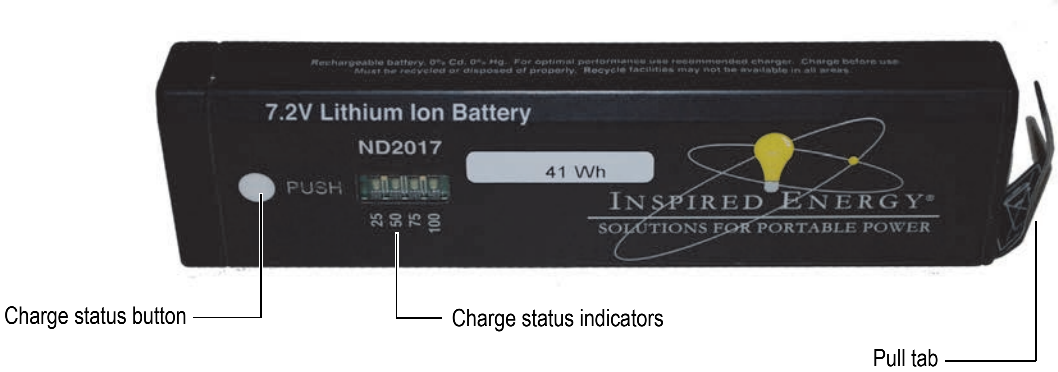


Figure 3-10 Li-ion battery (front view)

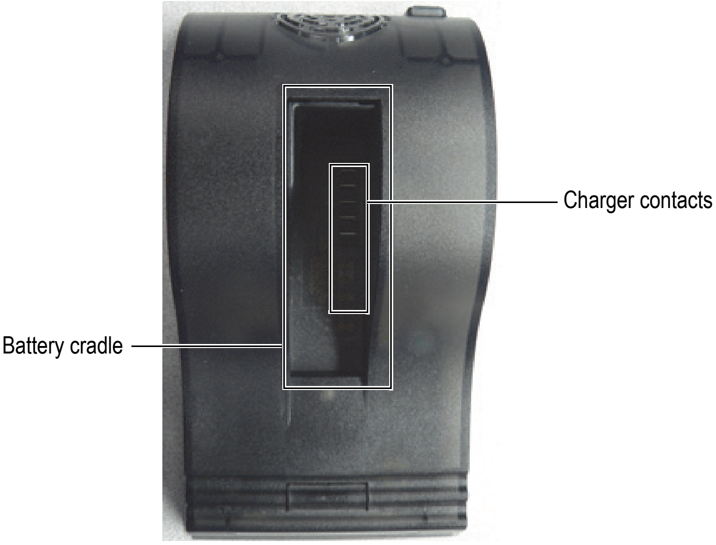


Figure 3-11 Battery charger cradle

The unit takes about two hours to completely charge a battery.

The battery's charge status is indicated by two lights on the power adaptor (see Table 14 on page 61).

Table 14 Battery charger status lights

Left light (green only)	Right light (red only)	Status 
On — Flashing	Off	The battery is charging.
On — Solid	Off	The battery is charged.
Off	On — Solid	Error. Remove the battery, and then place it back on the charger. If the error persists, call Olympus Technical Support.
Off	Off	There is no battery on the charger.

3.2.4 Hot Swap for the DELTA Battery

Battery hot-swapping capability is a standard feature of the DELTA analyzer. Batteries can be removed and replaced without the need to shut down, restart, or perform a Cal Check.

A "shutdown" status display indicates the percentage of internal battery charge remaining when the battery is removed from the analyzer (see Figure 3-12 on page 62). If the internal charge falls to 0, insert a new battery, and then use the I/O switch to restart the analyzer. If the red X-ray indicator lights are flashing, the battery voltage is too low.

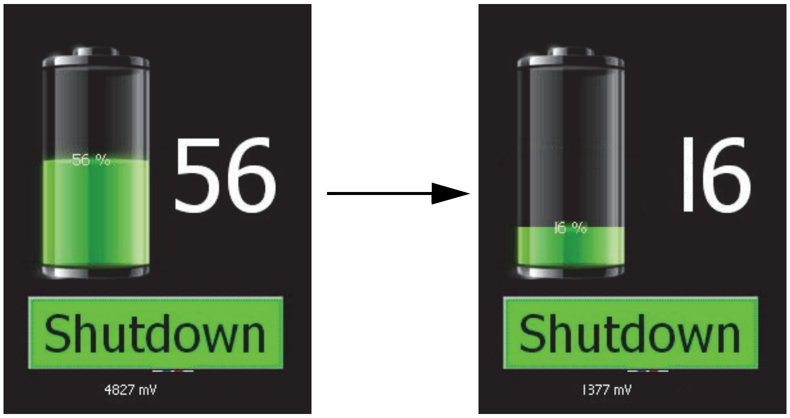


Figure 3-12 Shutdown status

3.2.5 Replacing the Battery

Perform the following procedure to replace the battery of the XRF analyzer. See also Figure 3-13 on page 62.

To replace the battery

1. Hold the instrument with the nose pointing away from you.
2. Pull the rubber latch and lift up the battery cover.
3. Pull the tab to remove the current battery.
4. Align the battery contacts with the contacts on the charger, and then insert the battery into the charger. The battery slot is keyed so that the battery can only be inserted one way.

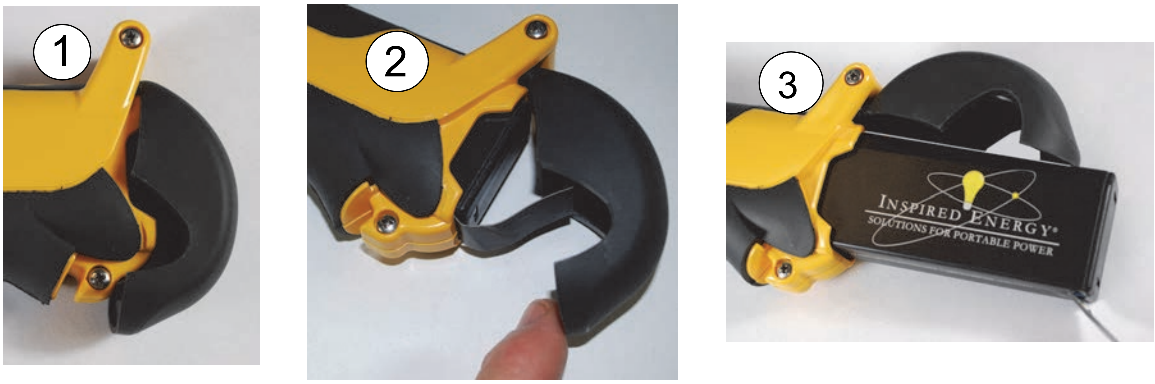


Figure 3-13 Battery replacement

3.2.6 Powering the DELTA Without Batteries

The DELTA can also be powered using an AC power adaptor, which enables you to operate the analyzer without a battery. This part (U8999515) is described in “AC Power Adaptor” on page 29.

WARNING

To avoid overloading circuits and causing a fire hazard, and to prevent electrical shock from using an ungrounded outlet, make sure that each AC supply circuit has adequate capacity and is connected to a grounded AC receptacle.

To use the AC power adaptor

1. Connect the three-prong male end of the power cord into the receptacle (see Figure 3-14 on page 63).

Figure 3-14 AC adaptor power cord

NOTE

The part number (U8999515) describes a power adaptor with a standard North American power cord/plug. Standard power cords and plugs are also available for other regions. See your Olympus representative for assistance in obtaining the appropriate part.

2. Insert the three-prong female end of the power cord into the switching AC adaptor's male receptacle (see Figure 3-15 on page 63).

Figure 3-15 Switching AC adaptor's male receptacle

3. Align the contacts on the battery module with the contacts on analyzer, and then insert the battery module into the analyzer (see Figure 3-16 on page 64). The module is keyed so that it can only be inserted one way.

Figure 3-16 Battery module

The analyzer can now be used without battery power, although the range of motion is restricted by the length of the power cord.

4. Analyzer Operation

This chapter presents an overview of the DELTA analyzer's user interface. Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* for a complete description.

⚠ **WARNING**

Read the "Safety Information" chapter carefully before handling the DELTA analyzer. Misuse of the analyzer could result in serious illness, injury, or death.

All functions of the DELTA analyzer are managed from the user interface. This chapter provides the following information:

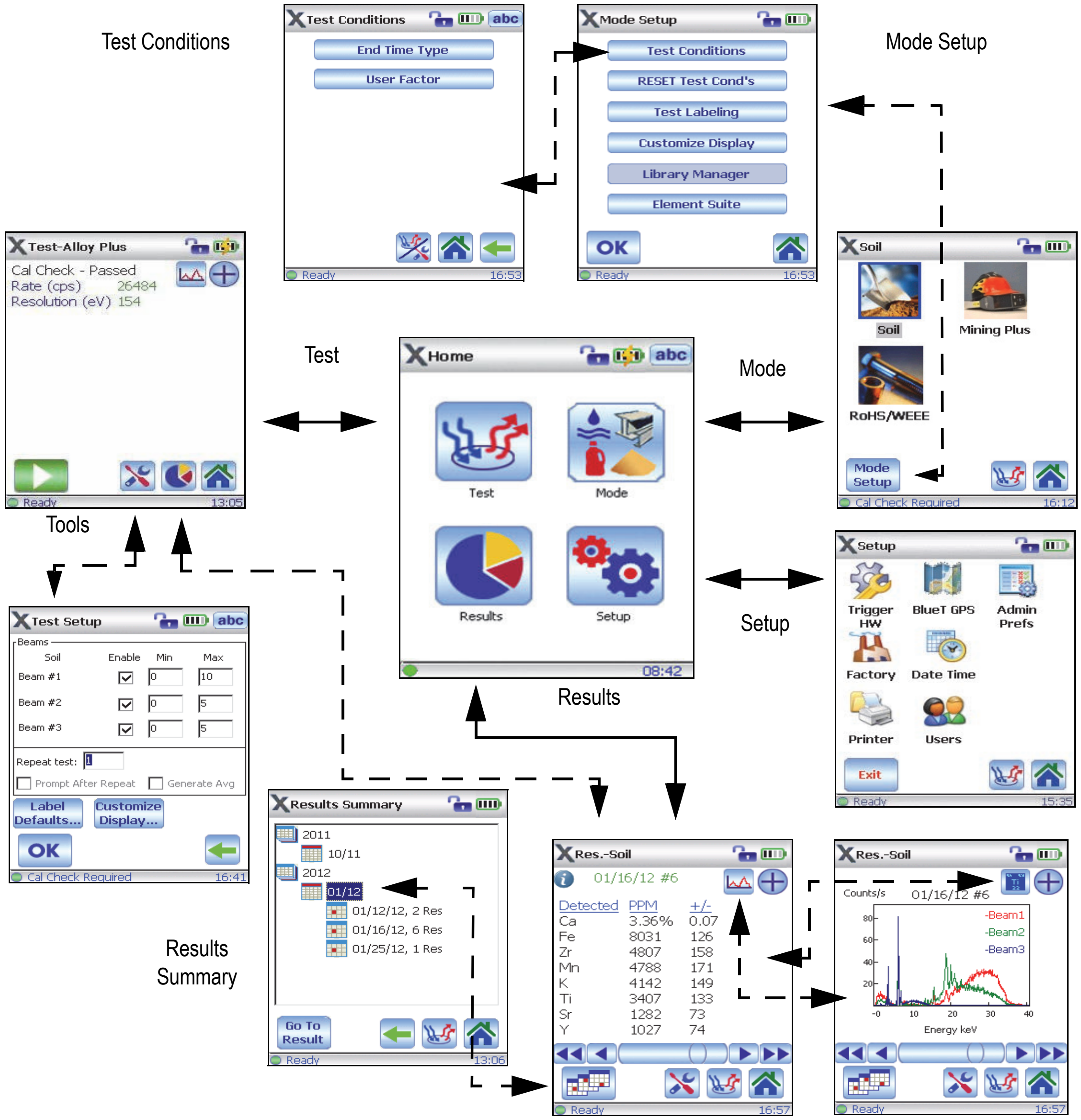
- A snapshot of the UI (user interface), including major screens and buttons.
- A typical procedure for sample testing
  - — Start-up (H/W) and safety confirmation (UI)
- Pretest options — Three important items to review:
  - — Calibration Check procedures
    - In the field
    - In the laboratory with the DELTA Docking Station (DDS)
  - — Changing modes
  - — Examining and changing test parameters
    - Alloy mode
    - Soil, Mining, and RoHS modes
- Best practices for testing in various modes
- Testing procedures
- Turning off the analyzer

NOTE

Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* for comprehensive information about the operational features of the entire DELTA user interface, including the **Home**, **Mode**, **Setup**, **Test**, and **Results** screens, and the attendant functions.

4.1 DELTA User Interface

The DELTA user interface starts up with the start-up radiation safety and initialization screens. The main operations are accessible from the **Home** screen (see Figure 4-1 on page 66).



Cal Check - Passed
Rate (cps) 26484
Resolution (eV) 154

Beams

Soil	Enable	Min	Max
Beam #1	☑	0	10
Beam #2	☑	0	5
Beam #3	☑	0	5

Repeat test: 1

☐ Prompt After Repeat ☐ Generate Avg

- 2011
  - 10/11
- 2012
  - 01/12
    - 01/12/12, 2 Res
    - 01/16/12, 6 Res
    - 01/25/12, 1 Res

01/16/12 #6

Detected	PPM	+/-
Ca	3.36%	0.07
Fe	8031	126
Zr	4807	158
Mn	4788	171
K	4142	149
Ti	3407	133
Sr	1282	73
Y	1027	74

Figure 4-1 DELTA user interface

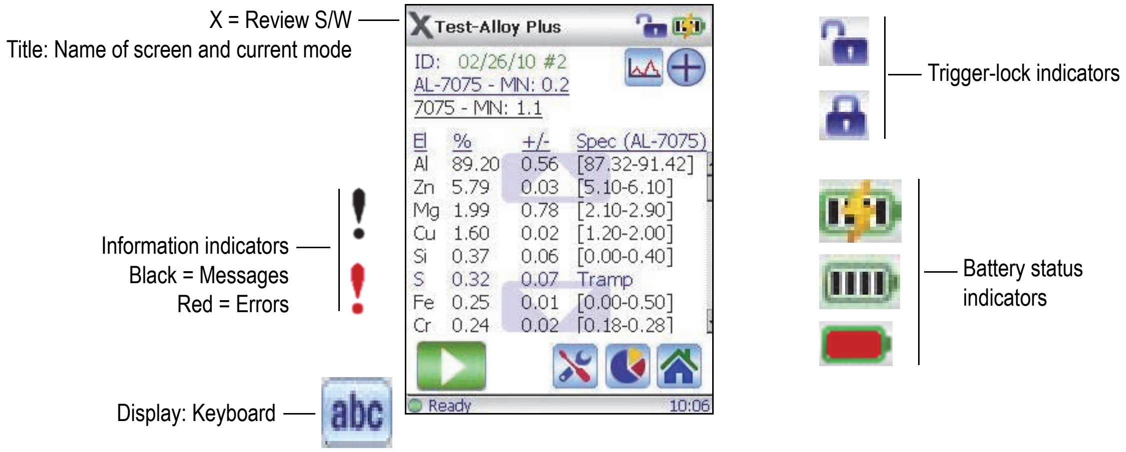
4.1.1 Buttons

This section displays the DELTA user interface buttons (Figure 4-2 on page 67).

Figure 4-2 Buttons

4.1.2 Indicators

This section outlines the DELTA user interface indicators (see Figure 4-3 on page 67).



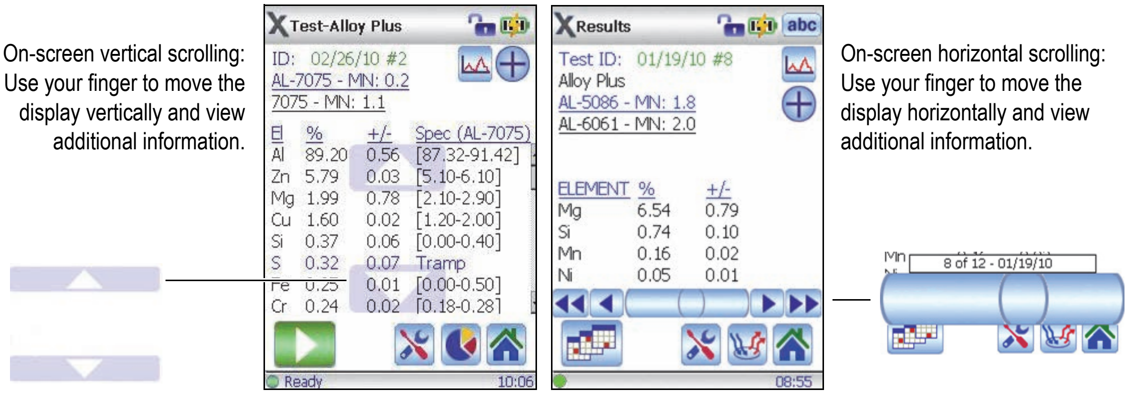
ID: 02/26/10 #2
AL-7075 - MN: 0.2
7075 - MN: 1.1

El	%	+/-	Spec (AL-7075)
Al	89.20	0.56	[87.32-91.42]
Zn	5.79	0.03	[5.10-6.10]
Mg	1.99	0.78	[2.10-2.90]
Cu	1.60	0.02	[1.20-2.00]
Si	0.37	0.06	[0.00-0.40]
S	0.32	0.07	Tramp
Fe	0.25	0.01	[0.00-0.50]
Cr	0.24	0.02	[0.18-0.28]

Figure 4-3 User interface indicators

4.1.3 Horizontal and Vertical Scrolling

This section outlines the DELTA user interface horizontal and vertical scrolling functionality (see Figure 4-4 on page 68).



On-screen vertical scrolling: Use your finger to move the display vertically and view additional information.

Test-Alloy Plus

ID: 02/26/10 #2
AL-7075 - MN: 0.2
7075 - MN: 1.1

El	%	+/-	Spec (AL-7075)
Al	89.20	0.56	[87.32-91.42]
Zn	5.79	0.03	[5.10-6.10]
Mg	1.99	0.78	[2.10-2.90]
Cu	1.60	0.02	[1.20-2.00]
Si	0.37	0.06	[0.00-0.40]
S	0.32	0.07	Tramp
Fe	0.25	0.01	[0.00-0.50]
Cr	0.24	0.02	[0.18-0.28]

Ready 10:06

Results

Test ID: 01/19/10 #8
Alloy Plus
AL-5086 - MN: 1.8
AL-6061 - MN: 2.0

ELEMENT	%	+/-
Mg	6.54	0.79
Si	0.74	0.10
Mn	0.16	0.02
Ni	0.05	0.01

08:55

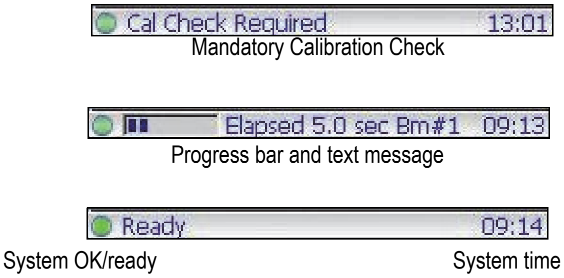
8 of 12 - 01/19/10

On-screen horizontal scrolling: Use your finger to move the display horizontally and view additional information.

Figure 4-4 Scrolling tools

4.1.4 Lower Status Bar

This section describes the DELTA user interface's lower status bar (see Figure 4-5 on page 68).



Cal Check Required 13:01

Mandatory Calibration Check

Elapsed 5.0 sec Bm#1 09:13

Progress bar and text message

Ready 09:14

System OK/ready

System time

Figure 4-5 Lower status bar

4.1.5 Time-Out Feature

All user interface (UI) screens have an automatic time-out (power-saving) attribute that causes the screen to dim after 90 seconds of inactivity if the following conditions are met:

- The UI is not accessed.
- The instrument is not moved.

The analyzer remains On. Tap the screen to exit the power-saving mode, or move the instrument.

4.2 Turning on the Analyzer

To turn on the analyzer

1. Insert a charged battery or battery module (with the AC power adaptor) into the analyzer handle (see "Analyzer Batteries" on page 56).
2. Turn on the analyzer using the I/O switch.

   The DELTA's user interface starts up with the start-up radiation safety and initialization screens.

3. Read the radiation safety notice screens (see Figure 4-6 on page 69), and then confirm that you are a certified user.

CAUTION! - ATTENTION!

CAUTION--X-RADIATION. This Equipment produces high intensity X-radiation when energized. To be operated only by qualified personnel.

Cet appareil produit des rayonnements X haute intensité lorsqu'il est sous tension. Son utilisation es réservée au personnel compétent.

CAUTION! - ATTENTION!

Canadian Federal Regulations (Radiation Emitting Devices Act) require that all Canadian users must be certified according to NRC adopted standard ISO 20807 in order to use this device.
For this certification contact: Natural Resources Canada, Manager Nondestructive Testing Certification, CANMET, 568 Booth St., Ottawa, ON, K1A 0G1; Tel: (613) 943-0583; Fax: (613) 943-8297.

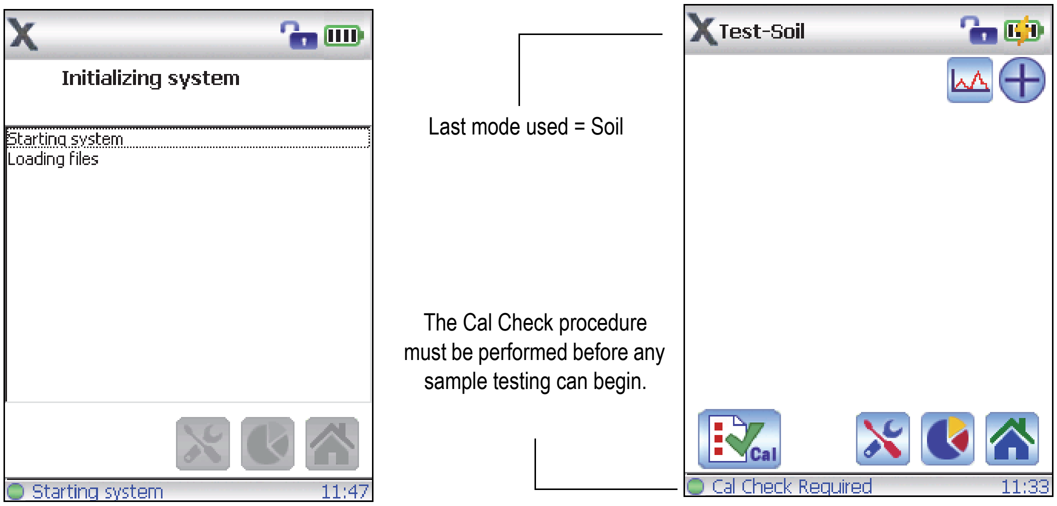
CAUTION! - ATTENTION!

Users are advised to contact their appropriate federal/provincial/territorial radiation protection agency for applicable rules of operation.

Select START if you are a certified user.

Figure 4-6 Radiation safety notice screens

System initialization begins immediately after confirmation. The analyzer launches a test screen using the previously selected mode (see Figure 4-7 on page 69).



Initializing system

Starting system
Loading files

Starting system 11:47

Cal Check Required 11:33

Last mode used = Soil

The Cal Check procedure must be performed before any sample testing can begin.

Figure 4-7 System initialization and the opening test screen

4.3 Checklist for Pretest Options

Before sample testing can begin, review the following items.

1. Cal Check
   - Indicator: When the lower status bar displays the “Cal Check Required” message.
   - Action: See “Calibration Check” on page 70 for information and instructions.
2. Mode check
   - Indicator: If the “last mode used” is NOT the mode required for the current testing session, select the desired mode.

   - Action: See “Changing Modes” on page 76 for instructions.
3. Testing parameters check
   - Indicator: If the testing parameters need to be examined or changed.
   - Action: See “Examining or Changing Testing Parameters” on page 77 for instructions.
     This procedure is normally used if:
     - a different mode has been selected, or;
     - different types of samples are to be examined.

4.4 Calibration Check

When the “Cal Check Required” message is present, a successful Cal Check procedure must be performed.

During a calibration check (or Cal Check), the analyzer collects a spectrum on a known standard (alloy 316 stainless steel). The analyzer then compares a variety of parameters with the factory preset values. When comparisons are within preset tolerances, the unit confirms that it is properly calibrated.

General facts about Cal Check:

- The Cal Check must be performed when the analyzer requests the procedure (the default time-out is 10 hours).
- The Start Test button (▶) and trigger are disabled until a successful Cal Check is achieved.
- The Cal Check can be run any time during Olympus software operation, except during a test.
- When the Cal Check is in progress, the X-ray indicator light assembly blinks. This indicates that the X-ray tube is energized, and that the filter wheel is operational.
- In addition, a status bar indicating the percentage of completion value appears on the UI display.
- The Cal Check procedure takes 15 seconds.

The Cal Check procedure can be performed in the field or in a testing laboratory.

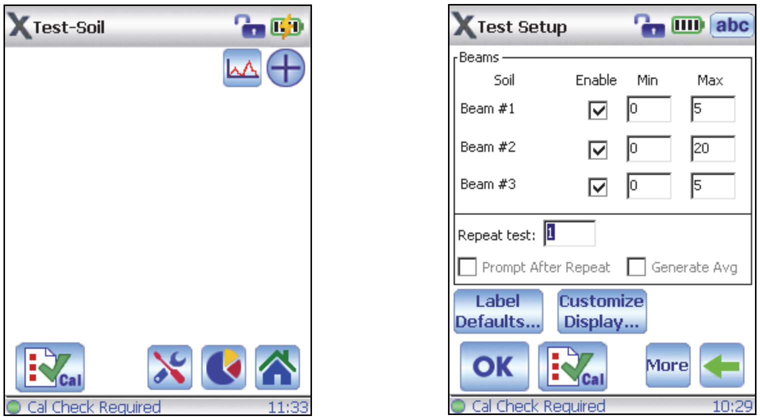
4.4.1 Conducting a Cal Check in the Field

There are three different ways to perform a Cal Check procedure:

- Standard — No extra safety features enabled
- Deadman trigger enabled
- Two-hand operation enabled

To perform a standard Cal Check

1. Place the Cal Check coupon (316 stainless steel) on a flat surface.
2. Place the instrument’s measurement window directly over the coupon.
3. Navigate to a **Test** screen, or any screen that displays the Cal Check button (see Figure 4-8 on page 71).



Beams

Soil	Enable	Min	Max
Beam #1	☑	0	5
Beam #2	☑	0	20
Beam #3	☑	0	5

Repeat test: 1

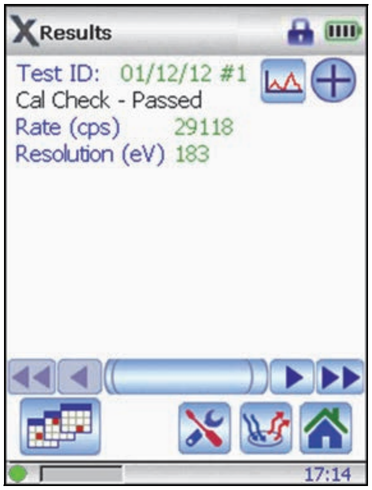
☐ Prompt After Repeat ☐ Generate Avg

Figure 4-8 The Test and Test Setup screens: Ready for Cal Check procedure

4. Tap the Cal Check button ( ).

   The red X-ray indicator light starts blinking to indicate that X-rays are being emitted.

The Cal Check takes less than 15 seconds to complete. The **Results** screen displays the status of the test (see Figure 4-9 on page 71).



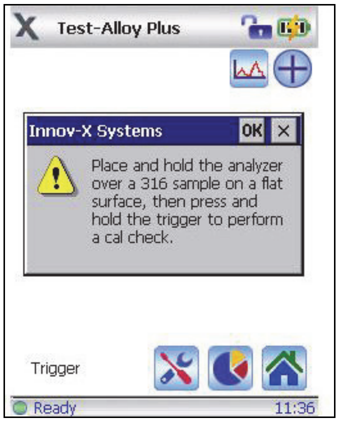
Test ID: 01/12/12 #1
Cal Check - Passed
Rate (cps) 29118
Resolution (eV) 183

Figure 4-9 Results screen: Successful Cal Check

To perform a Cal Check with the deadman trigger enabled

1. Tap the Cal Check button ( ).

   A dialog box appears on the **Test** screen.
2. Read the dialog box instructions (see Figure 4-10 on page 72). Do NOT press **OK**.



Place and hold the analyzer over a 316 sample on a flat surface, then press and hold the trigger to perform a cal check.

Figure 4-10 Instructions for the Cal Check procedure: Deadman trigger enabled

3. Make sure that the instrument's measurement window is directly over the coupon.
4. Pull and hold the trigger for the duration of the test.

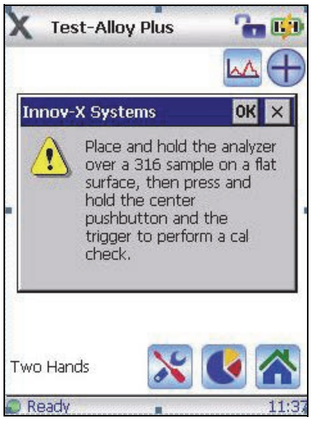
   The red X-ray indicator light starts to blink to indicate that X-rays are being emitted.

A Cal Check takes less than 15 seconds to complete. The **Results** screen displays the status of the test (see Figure 4-9 on page 71).

To perform a Cal Check procedure with two-hand operation enabled

1. Tap the Cal Check button (Cal).

   A dialog box appears on the **Test** screen.
2. Read the dialog box instructions (see Figure 4-11 on page 72). Do NOT press **OK**.



Place and hold the analyzer over a 316 sample on a flat surface, then press and hold the center pushbutton and the trigger to perform a cal check.

Figure 4-11 Instructions for Cal Check procedure: Two-hand operation enabled

3. Make sure that the instrument's measurement window is directly over the coupon.
4. Press and hold the instrument's center push button for the duration of the test (see Figure 4-12 on page 73).

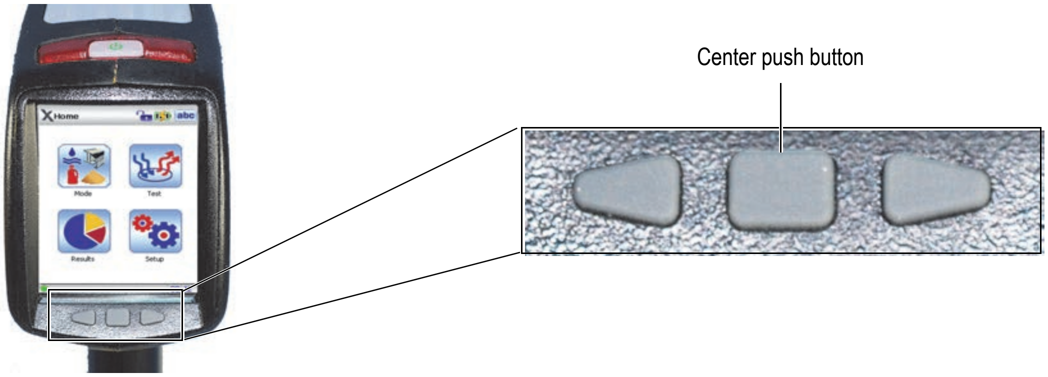


Figure 4-12 DELTA special function push buttons

5. Pull and hold the trigger for the duration of the test.

   The red X-ray indicator light starts to blink to indicate that X-rays are being emitted.

The Cal Check takes less than 15 seconds to complete. The **Results** screen displays the test status (see Figure 4-9 on page 71).

If the “Cal Check — Passed” message appears on the **Results** screen (see Figure 4-14 on page 75), the analyzer is ready for sample testing.

If the Cal Check fails

1. Make sure that the coupon is positioned correctly.
2. Make sure that the X-ray indicator blinks during the procedure.
3. Make sure that you have waited several seconds before starting the procedure.
4. Retry the Cal Check procedure.

If the Cal Check fails again

1. Shut down the DELTA software.
2. Turn off and restart the analyzer.
3. Initiate another Cal Check.

NOTE

If the Cal Check fails repeatedly, contact Olympus customer service or your local distributor.

4.4.2 Conducting a Cal Check in the Laboratory

When testing in a laboratory, you can use the DELTA Docking Station (DDS) to conduct a Cal Check. After inserting the analyzer into the DDS cradle, there are two options available:

Manual (see “To perform a manual Cal Check” on page 74).

Automatic (see “To perform an automatic Cal Check” on page 75).

To perform a manual Cal Check

1. Make sure that the DELTA docking station is connected to a DC power cable, with the power applied.
2. Place the analyzer in the DDS cradle (see Figure 4-13 on page 74).

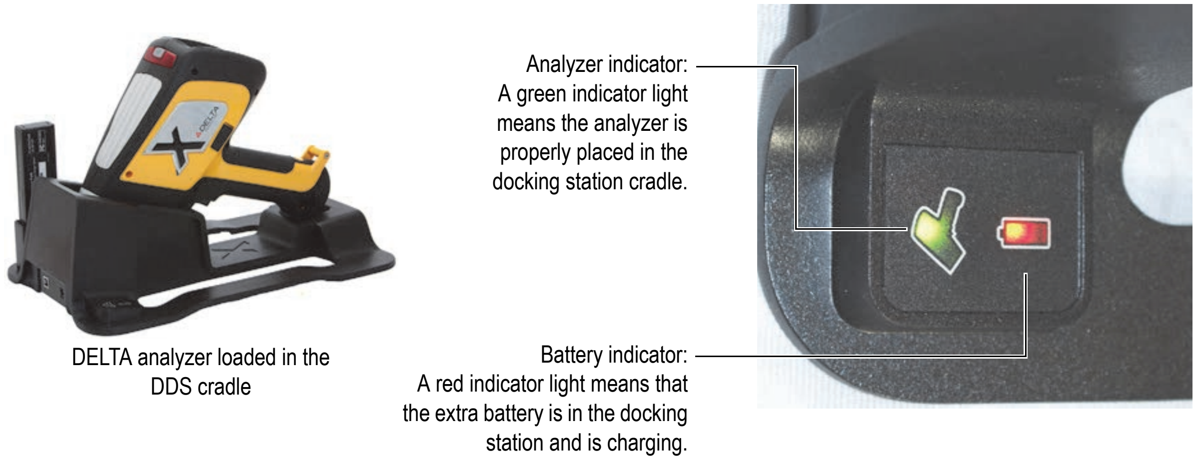


Figure 4-13 DELTA loaded in docking station

3. Make sure that the DELTA indicator light is turned on, which signals that the analyzer is properly seated in the cradle.
4. Turn on the analyzer using the I/O switch.

   The radiation safety notice appears after a few seconds.
5. Read the radiation safety notice screens (see Figure 4-6 on page 69), and then confirm that you are a certified user.

   System initialization begins immediately with the following messages:
   - Initializing system
   - Starting system
   - Loading files

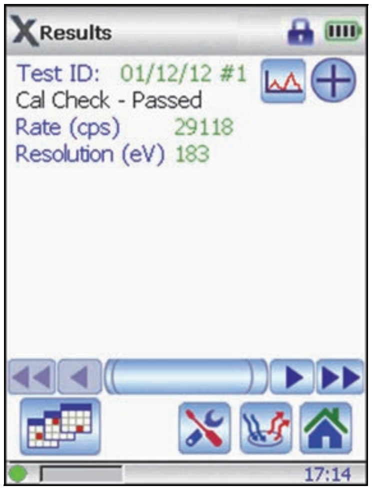
   The analyzer launches a **Test** screen using the previously selected mode.
6. Return to a **Test** or **Test Setup** screen.

   The “Cal Check Required” message displays.
7. Tap the Cal Check button (✓Cal).

The procedure begins immediately. The red X-ray indicator starts flashing, and shuts off within less than 15 seconds.

NOTE

The deadman trigger and two-hand operation protocols are overridden when the analyzer is mounted in the docking station. If necessary, unlock the software trigger lock by tapping the Lock button at the top of the screen.



Test ID: 01/12/12 #1

Cal Check - Passed

Rate (cps) 29118

Resolution (eV) 183

Figure 4-14 Results screen: Successful Cal Check

If the "Cal Check — Passed" message appears on the **Results** screen (see Figure 4-14 on page 75), the analyzer is ready for sample testing.

If the Cal Check fails

1. You must wait several seconds before starting the procedure.
2. Retry the Cal Check procedure.

If the Cal Check fails again

1. Shut down the DELTA software.
2. Turn off and restart the analyzer.
3. Initiate another Cal Check.

NOTE

If the Cal Check fails repeatedly, contact Olympus customer service or your local distributor.

To perform an automatic Cal Check

1. Make sure that the DELTA docking station is connected to a DC power cable, with the power applied.

NOTE

The indicator lights do not illuminate unless there is a battery in the second battery charger socket.

2. Make sure that the analyzer is turned on, and then place it in the DDS cradle.
3. Make sure that the DDS Analyzer indicator is on (green) [see Figure 4-13 on page 74].

   If the DELTA is On, the battery charge status appears (see Figure 4-15 on page 76).

Figure 4-15 Battery status screen

4. Make sure that the battery charge status screen remains on.
5. The DDS automatically initiates a Cal Check after a four-minute delay.

After a successful Cal Check, the analyzer is ready for use.

IMPORTANT

- Do not exit the battery charge status screen. If you do so, the automatic Cal Check function will not work.
- At any time during or after a testing session, you may insert the analyzer into the DDS cradle. Again, an automatic Cal Check will be initiated after a four-minute delay.
- If you decide to leave the DELTA in the DDS for an extended period, a Cal Check will be performed at ten-hour intervals.

4.5 Changing Modes

To change modes

1. Tap the Home button (🏠).
2. In the Home screen, tap the Mode button ( ).
3. In the mode screen (see Figure 4-16 on page 77), select the desired mode.

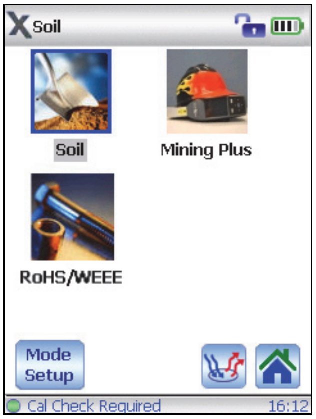


Figure 4-16 A typical mode screen

4.6 Examining or Changing Testing Parameters

The instruction sequence varies between the various Alloy modes and the Soil, Mining, and RoHS modes.

To select the Alloy Plus mode

1. In the mode screen, tap **Mode Setup**.
2. In the **Mode Setup** screen, tap **Test Conditions** (see Figure 4-17 on page 77).

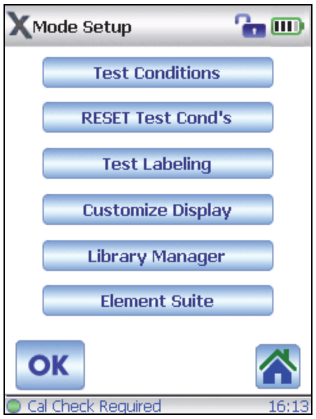
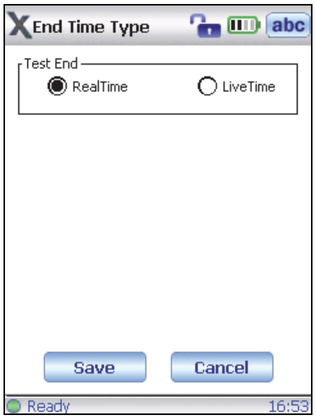


Figure 4-17 The Mode Setup screen

3. In the **Test Conditions** screen, tap **End Time Type** (see Figure 4-18 on page 78).

Figure 4-18 The Test Conditions screen

4. In the **End Time Type** screen, select the desired **Test End** parameter (see Figure 4-19 on page 78).

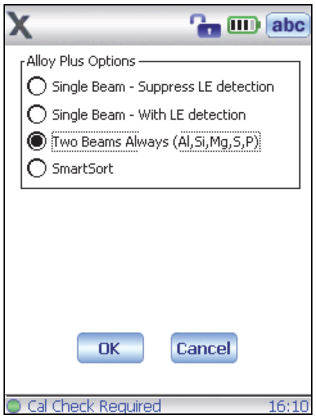


Test End

● RealTime ○ LiveTime

Figure 4-19 The End Time Type screen

5. Tap **Save**.
6. In the **Test Conditions** screen, tap **Alloy Plus Options** (see Figure 4-18 on page 78).
7. In the **Alloy Plus Options** area, select the appropriate option (see Figure 4-20 on page 79), and then tap **OK**.



Alloy Plus Options

○ Single Beam - Suppress LE detection

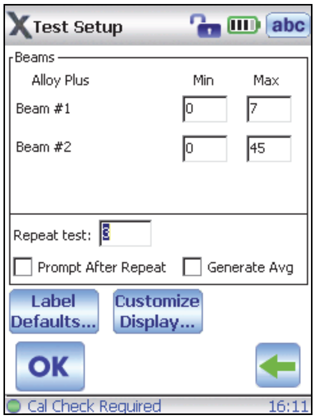
○ Single Beam - With LE detection

● Two Beams Always (Al,Si,Mg,S,P)

○ SmartSort

Figure 4-20 Alloy Plus Options

8. In the **Test Conditions** screen, tap the Test/Tools button (🛠) [see Figure 4-18 on page 78].
9. In the **Test Setup** screen (see Figure 4-21 on page 79), enter the desired beam and other testing parameters using the virtual keyboard.



Test Setup

Beams

Alloy Plus	Min	Max
Beam #1	0	7
Beam #2	0	45

Repeat test: 3

☐ Prompt After Repeat ☐ Generate Avg

Figure 4-21 The Test Setup screen

10. Tap **OK**.

11. In the **Test Conditions** screen (see Figure 4-18 on page 78), tap the Back button (←) to return to the **Mode Setup** screen.
12. Continue with other options, or navigate to the **Home** and **Test** screens.

To select the Soil, Mining, and RoHS modes

1. In the mode screen, tap **Mode Setup**.
2. In the **Mode Setup** screen, tap **Test Conditions** (see Figure 4-22 on page 80).

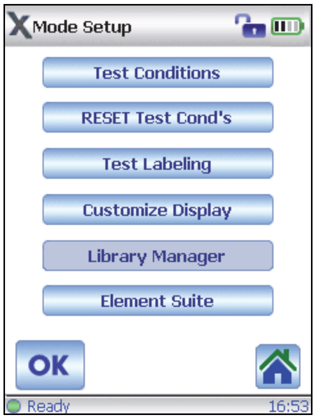


Figure 4-22 The Mode Setup screen

NOTE

The **Library Manager** option is only available for Alloy modes.

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3. In the **Test Conditions** screen, tap **End Time Type** (see Figure 4-23 on page 80).

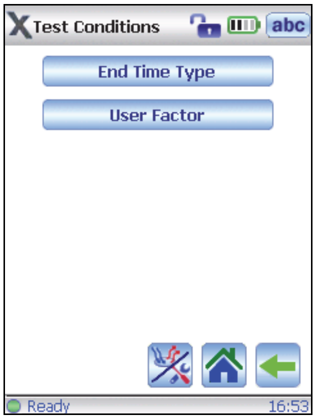
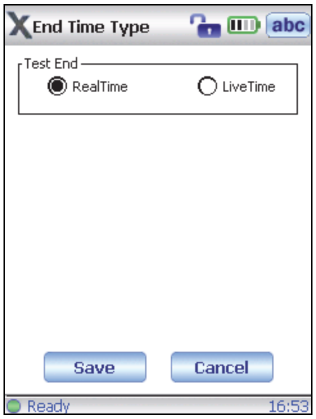


Figure 4-23 The Test Conditions screen

4. In the **End Time Type** screen, select the desired **Test End** parameter (see Figure 4-24 on page 81).

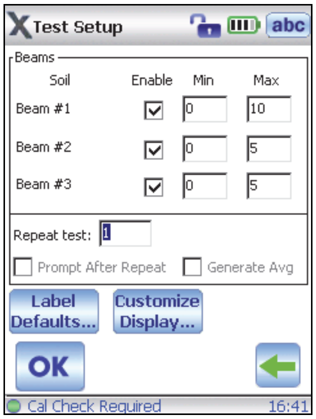


Test End

● RealTime ○ LiveTime

Figure 4-24 The End Time Type screen

5. Tap **Save**.
6. In the **Test Conditions** screen, tap the Test/Tools button (🛠) [see Figure 4-18 on page 78].
7. In the **Test Setup** screen (see Figure 4-25 on page 81), enter the desired beam and other testing parameters using the virtual keyboard.



Beams

Soil	Enable	Min	Max
Beam #1	☑	0	10
Beam #2	☑	0	5
Beam #3	☑	0	5

Repeat test: 1

☐ Prompt After Repeat ☐ Generate Avg

Figure 4-25 The Test Setup screen

8. Tap **OK**.
9. In the **Test Conditions** screen (see Figure 4-18 on page 78), tap the Back button (←) to return to **Mode Setup** screen.
10. Continue with other options, or navigate to the **Home** and **Test** screens.

4.7 Testing Procedure

Prior to beginning a testing session, it is useful to look at the best practices information for recommendations and tips about analysis techniques (see “Testing Best Practices” on page 86).

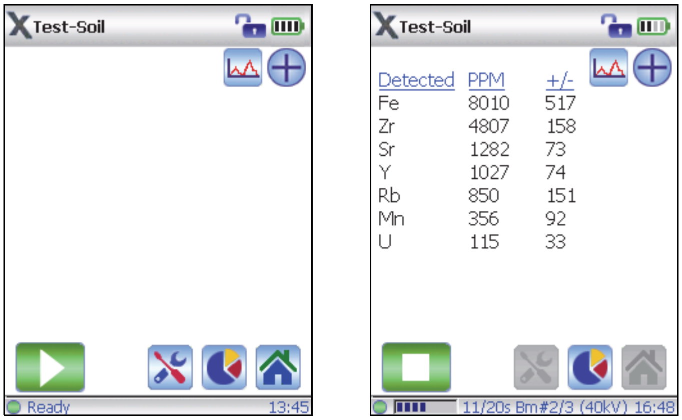
WARNING

To avoid potential radiation exposure:

- DO NOT POINT the unit toward yourself or any other person during operation.
- When performing tests, never use your fingers or the palm of your hand to hold sample in place.
- Always wear both a ring-style and a badge-style (either clip-on or lanyard) dosimeter.

To perform a typical sample test in Soil mode

1. Navigate to the **Test** screen (see Figure 4-26 on page 82).



Detected	PPM	+/-
Fe	8010	517
Zr	4807	158
Sr	1282	73
Y	1027	74
Rb	850	151
Mn	356	92
U	115	33

Test results with the status bar displaying the progress.

Figure 4-26 Test start and in-progress screens

2. Make sure that the instrument's measurement window is directly over the test sample cup.
3. Start the test:

IMPORTANT

There are three different ways to perform a test. The appropriate method will vary from location to location depending on regulations. If a certain option is required in you area, your analyzer should be factory-configured for that option.

- Standard — No extra safety features enabled
- Deadman trigger enabled
- Two-hand operation enabled

a) Standard method: Tap the Start Test button (▶).

OR

Pull the trigger.

b) Deadman trigger enabled: Pull and hold the trigger

c) Two-hand operation: Pull the trigger, and then tap the Start Test button ( ).

The lower status bar displays the test progress.

NOTE

The results are displayed immediately upon test completion.

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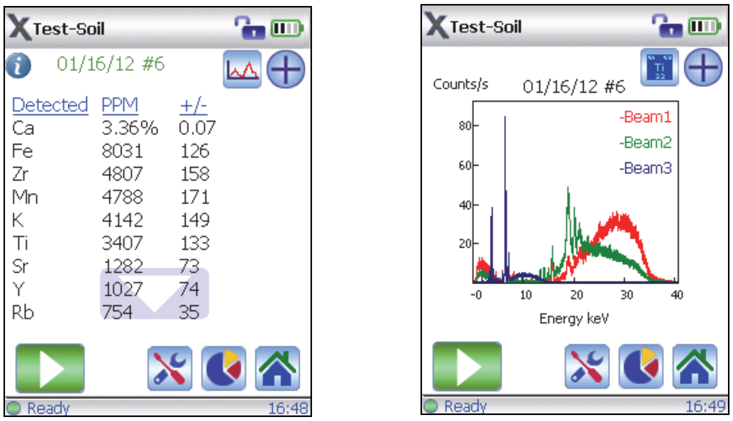
4. Tap the Spectral Plot button ( ) to view the spectrum results (see Figure 4-27 on page 83).



Test-Soil

01/16/12 #6

Detected	PPM	+/-
Ca	3.36%	0.07
Fe	8031	126
Zr	4807	158
Mn	4788	171
K	4142	149
Ti	3407	133
Sr	1282	73
Y	1027	74
Rb	754	35

Complete test results with a list of the elements.

The Spectrum screen for these results.

Figure 4-27 Results screens

5. Optional: Export the session results to a PC using the data port and USB cable.

NOTE

At the end of the session, it is good practice to export the session's results to a PC. Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* for details about the export procedure.

4.8 Shutdown Procedures

There are several ways to turn off the DELTA analyzer. These techniques can be categorized according to whether the action is taken under normal or emergency conditions. An additional option for normal shutdown involves using the docking station. "Turned off" means that the analyzer cannot emit any X-rays.

4.8.1 Shutdown Under Normal Conditions

To mechanically shut down the analyzer

1. Release the trigger (if the deadman trigger is activated).
   OR

   Tap the Stop Test button (□).
2. Press and briefly hold the I/O power switch to ensure that the On/Off LED turns off.

To shut down the analyzer through the user interface

1. Go to the **Home** screen.
2. Tap the **Setup** button.
3. In the **Setup** screen, tap **Exit**.
   The main exit screen appears (see Figure 4-28 on page 84).

Figure 4-28 Main exit screen

4. Tap the Power OFF button (⏻).
5. In the confirm message box (see Figure 4-29 on page 85), tap **Yes**.

DeltaShell

Are you sure you want to shutdown?

Figure 4-29 The confirm message box

6. Once the shutdown procedure is completed, store the unit in a secure location.

To shut down the analyzer using the docking station's automatic option

1. Place the analyzer in the DDS cradle.
2. Make sure that the DELTA is turned on.
3. Make sure that the DDS is turned on.
4. Do not exit the battery charge status screen.

   The analyzer initiates a Cal Check after a four-minute idle time, and every ten hours thereafter. The analyzer's battery is maintained at a fully charged level.

4.8.2 Shutdown Under Emergency Conditions

To turn off the analyzer under emergency conditions

NOTE

If the red LED remains illuminated or blinking, and you believe that the analyzer is "locked up" in an On state, follow the instructions listed below.

1. Press the I/O power switch. If the power does not turn off, continue to step 2.
2. Open the battery cover and remove the battery immediately.
3. If you are using the AC power adaptor:
   - Remove the battery eliminator from the DELTA's handle.

     OR

     Pull the AC cord from the AC power adaptor.

     OR

     Pull the plug from the receptacle.

NOTE

Due to the DELTA analyzer's special circuitry, which permits battery "hot swapping," the system power may stay on for more than 30 seconds when these measures are taken. However, the tube voltage returns to zero within one second.

4.9 Testing Best Practices

This section outlines the best practices to follow when using different testing modes.

4.9.1 Alloy Mode

Prior to a test session, analysts should have an understanding of Olympus's implementation of:

- Grade libraries: Populated by alloy grades. Their chemistry is characterized by Grade Tables. See Appendix "Alloy Grade Libraries" on page 143 for library management procedures.
- Match issues, including the concept and use of match numbers (see "Match Number Concept" on page 90).

Prior to initiating a test, make sure that the following tasks are complete:

- The analyzer does not require a Cal Check procedure.
- The analyzer's measurement window is properly positioned over or in front of the test sample.

Testing Tips for Alloy Mode

- Place the analyzer's window on/over the test specimen; cover the window completely.
- Familiarize yourself with the safety information (see chapter "Safety Information" on page 33) to ensure your own personal safety.
- Take care not to damage the film window, especially when testing "metal turnings" or hot surfaces.

4.9.2 Mining and Soil Modes

Check Standards

- Measure a check standard after each Cal Check, and periodically throughout the day. Test for a recommended minimum period of one minute.
- See Appendix "Soil Testing" on page 127 for a description of recommended quality assurance details. The standards provided with the analyzer are placed in XRF sample cups. These containers have a window on one side through which the soil can be viewed, and a solid cap on the other side.

NOTE

Always measure samples through the sample cup's window.

Sample Presentation

In situ testing

In situ testing is performed by pointing the analyzer toward the ground. Clear away any grass or large rocks, and hold the analyzer, keeping the front of the probe head flush with the ground. Gently wipe the window clean after each analysis to remove any dirt from the analyzer window. Make sure the window is not ripped or punctured.

Bagged or prepared sample testing

Place prepared samples in sample cups, and then perform the analysis through the sample cup window. Place the analyzer's measurement window directly over the film side of the sample cup. Preparation considerations include:

- Avoid measuring very thin samples, which can affect results. Prepare the sample cups with at least 15 mm (usually 4 grams to 8 grams) of packed sample.
- When analyzing bagged samples, make sure that there is sufficient sample material in the bag to create a minimum sample thickness of 15 mm for a spot size larger than the analyzer's measurement window.
- When using bags, cheaper bags with thinner plastic walls are better than more expensive ones with thicker plastic walls.

Testing Tips for Mining and Soil Modes

- Place the analyzer's measurement window directly over the film side of the sample cup.
- Specify the altitude or atmospheric pressure in order to gain increased accuracy of light elements.
- Confirm that the testing time and other parameters are properly selected.
- Take care not to damage the film window, especially when testing uneven surfaces.

4.9.3 Consumer Mode — RoHS Best Practices

Check Standards

Olympus recommends that a check standard be measured after each Cal Check procedure, and periodically throughout the day. Two certified standards are provided for verification.

- At least one standard should be measured for a minimum of two minutes.
- Standards provided are placed in XRF sample cups with a window on one side through which the plastic pellets can be viewed, and a solid cap on the other side.
- Samples should be measured through the sample cup window.

Sample Presentation

Since many pieces of the plastic analyzed for RoHS compliance are very small, take care to measure them in a safe and accurate manner.

See the IEC-ACEA recommendation for minimum test sample thicknesses in “IEC Quantitative Screening Requirements” on page 105.

Testing Tips for Consumer (RoHS) Mode

- In order for XRF testing to be quantitative, samples must:
  - Be homogeneous
  - Have a certain minimum sample thickness or depth:
    - 5 mm for polymers and light alloys
    - 15 mm for liquid samples
    - 1 mm for other alloys

If samples are heterogeneous, too thin, or too small, only qualitative screening is possible.

5. Alloy Analysis Modes

The DELTA series of X-ray fluorescence analyzer currently supports three unique modes for alloy analysis (see Table 15 on page 89). The core analytical analyzer modes/types are:

- Alloy mode:
  - — DELTA Classic, Classic Plus and Inspector (PIN detector-based)
- Alloy Plus mode:
  - — DELTA Standard and Professional (SDD detector-based)
  - — DELTA Premium and Premium Plus (SDD detector-based)

All models can support additional alloy-oriented modes and features, such as:

- Precious Metals (Alloy addition) mode
- Pass/Fail (feature)

Table 15 Alloy analysis modes

Modes	Use with	Description
Alloy	Classic Classic Plus Inspector	• Supports: Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Pd, Ag, Cd, Sn, and Sb. • Fundamental parameters analysis for metal alloys. • Alloy library including 300+ grade specifications, common tramp limits, including full editing capabilities.
Alloy Plus	Premium Plus Premium Professional Standard	• Supports: Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Pd, Ag, Cd, Sn, Sb **PLUS** Mg, Al, Si, P, and S. • Fundamental parameters analysis for metal alloys. • Optimized beam condition for extended light-element performance. • Alloy library including 300+ grade specifications and common tramp limits, including full editing capabilities.
Precious Metals (Alloy addition)	All models	• Adds Ir, Pt, Au, and Rh to the Analytical Analysis.
Some Alloy customers use a specialized mode designated “Pass/Fail.” The features of this mode are described in the *DELTA Family Handheld XRF Analyzer User Interface Guide*.		

5.1 Introduction to Alloy Analysis Modes

Alloy analysis uses a fundamental parameters (FP) algorithm to determine elemental chemistry. This method calculates chemistry from the spectral data without the requirement for stored fingerprints. The Alloy FP calibration is done at the factory, and requires no user setup or recalibration. The software also searches through an alloy grade library to produce a grade match based on the calculated chemistry. Alloy mode can provide a grade ID and chemistry in as little as one second, with increased precision for longer test times.

5.1.1 Grade Identification

Analysis modes use a Factory Grade library consisting of a set of minimum and maximum values for each element in an alloy.

NOTE

There is a specific Alloy Factory Grade library for each DELTA model.

See Appendix "Alloy Grade Libraries" on page 143 for a listing of the alloys that are contained in each Factory Grade library. Please note that the listings may be incomplete, because grades are continually being added to the library.

Additionally, every analyzer is shipped with a "Tramp" library comprised of seven base alloys. The Tramp library lists allowable, but not specified, elements. This prevents the Grade Match from being penalized when the tramp elements are detected. These seven items with their min/max element values are increasingly valuable for fast and accurate sorting.

The libraries can be searched individually or together. All libraries, including each Factory Grade library, can be edited by the user. However, Olympus strongly recommends that users do NOT edit the Factory Grade library. Instead, copy the Factory Grade library to a USER library, then make any edits to it.

5.1.2 Match Number Concept

After calculating chemistry using the fundamental parameters algorithm, Olympus compares the chemical composition values to grade tables stored in a Grade library. The application calculates the value for a parameter called "match number". This calculation provides an indication of how close the measured alloy's chemistry is to the library specification.

- The lower the match number, the better the match.
- A match number of 0 is an exact match, meaning that the calculated chemistry for all elements falls within the grade table specifications.

5.1.3 Match Possibilities

There are three match determination possibilities provided within the Alloy modes:

Exact Match

An unknown alloy is matched to one of the grades contained in the Grade libraries, and a Grade ID appears on the **Results** screen. Often, other grades are listed with their accompanying match numbers. The analyst has the opportunity to view their elemental chemistries, and to see how they differ from an exact match.

Multiple Matches

In some cases, several grades are shown as possible matches. This can signify one of two conditions:

- There was not enough statistical information to definitively separate two or more alloys. The actual identification of the unknown alloy is one of the grades listed. Often, increasing the testing time makes it possible to separate the alloys.
- There was sufficient statistical information, but the test sample did not meet any of the existing specifications with enough precision to obtain an exact match identification.

No Match

If no matches are found within the libraries, the words “NO MATCH” appear. There are several causes for a “NO MATCH” result:

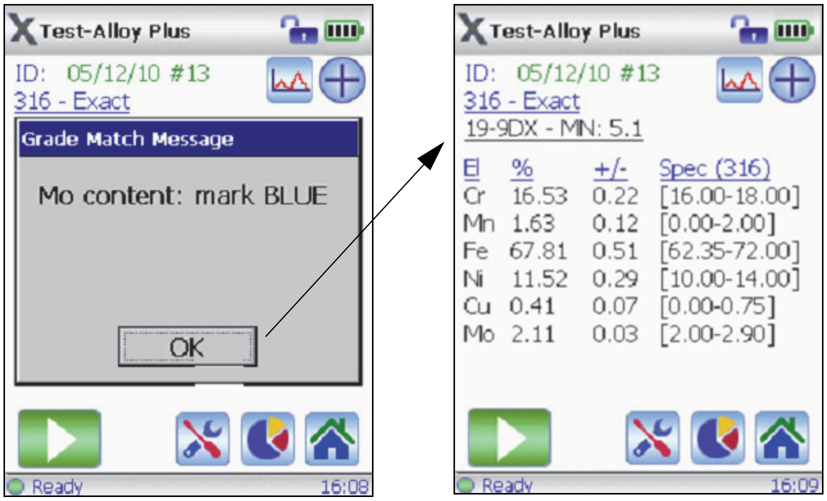
- The test sample does not meet any of the specifications in the Grade library.
- The test sample is coated; remove the coating by grinding, filing, or sanding, and then repeat the test.
- The testing time was too short. Increase the testing time, and measure the sample again.
- The match number is too low. If possible, increase the match number

5.1.4 Scrap and Recycling Features

DELTA analyzers in Alloy or Alloy Plus modes support many new features that specifically enhance scrap processing by maximizing speed and accuracy.

5.1.5 Grade Match Messaging (GMM)

The user or yard manager can assign messages to specific alloy grades (see Figure 5-1 on page 92).



Test-Alloy Plus

ID: 05/12/10 #13

316 - Exact

Grade Match Message

Mo content: mark BLUE

Test-Alloy Plus

ID: 05/12/10 #13

316 - Exact

19-9DX - MN: 5.1

El	%	+/-	Spec (316)
Cr	16.53	0.22	[16.00-18.00]
Mn	1.63	0.12	[0.00-2.00]
Fe	67.81	0.51	[62.35-72.00]
Ni	11.52	0.29	[10.00-14.00]
Cu	0.41	0.07	[0.00-0.75]
Mo	2.11	0.03	[2.00-2.90]

Figure 5-1 Message example

Tap the Start Test button () to immediately start the next test, or tap **OK** to view the chemistry details.

Grade match messaging offers:

- Immediate sorting instructions
- Less operator training
- More efficiency and higher throughput

5.1.6 SmartSort

This feature promotes automated sorting decisions that allow users to maximize speed and sorting accuracy. Some features include:

- Short test times (approximately three seconds) for most grades.
- Specific grades set up to automatically extend testing time for proper analysis.
- Maximize efficiency for speed testing by automatically extending test time for light elements (Mg, Al, Si, P, and S), thereby eliminating unnecessary long tests.

5.1.7 Nominal Chemistry

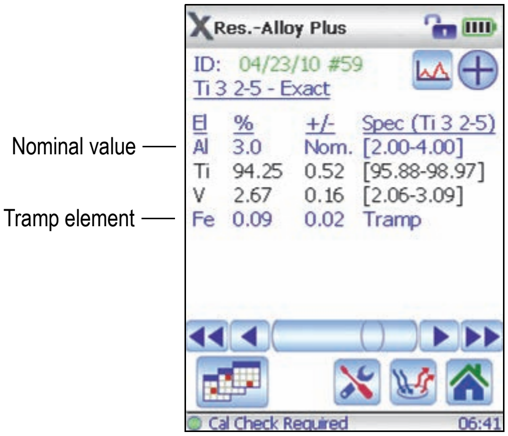
Nominal chemistry looks for “invisible” elements based on grade ID, including:

- Elements not tested under an active beam, (like Al in Beam 1)
  OR
  XRF invisible elements (like Be or C)

5.1.8 Tramp Library

Analyzers with Alloy or Alloy Plus mode come preloaded with a tramp library based on industry standards.

- Operators may assign other “tramp” elements with max tolerated concentration for individual elements in seven unique graded families (see Figure 5-2 on page 93).
- Analyzers can report tramp material (optionally), and simplify grade match by not counting small, expected amounts of tramp elements against the grade match.



ID: 04/23/10 #59
Ti 3 2-5 - Exact

El	%	+/-	Spec (Ti 3 2-5)
Al	3.0	Nom.	[2.00-4.00]
Ti	94.25	0.52	[95.88-98.97]
V	2.67	0.16	[2.06-3.09]
Fe	0.09	0.02	Tramp

Figure 5-2 Example of a tramp element

NOTE

See Appendix “Alloy Grade Libraries” on page 143 for a discussion of the Tramp library concept, including:

- How the Olympus Tramp library works
- Practical advantages of the tramp-element approach
- List of seven tramp-base alloys

5.1.9 Test Sample Considerations

Coated or painted samples

XRF is a surface analysis technique, in which X-rays penetrate into most alloy samples at a very short distance. Therefore, the analyzer detects what is on the surface of an alloy rather than the bulk material it is composed of. If a material has been coated, plated, painted, or has had some sort of surface treatment, such as heat treating, it may be misidentified.

For example, a steel piece painted in grey may show high concentrations of titanium from the paint, and may be misidentified as a titanium alloy. In another example, large amounts of metal dust or turnings on a surface may be detected by the analyzer.

To ensure proper identification of coated materials, grind an area slightly larger than the analyzing window in order to remove the coating. It is important to select the correct grinding material to prevent interference with the analysis.

NOTE

Do not use silica-based abrasives to grind coated test materials when performing silicon analysis.

It may not be necessary to completely clean and polish all materials; however, remove obvious metal dust.

Mixed samples, heterogeneous materials

Finished metal pieces may consist of more than one type of metal. In addition, you may wish to measure mixed turnings, or an assortment of small pieces. In such cases, remember that the analyzer measures the entire area covered by the analyzing window, and reports an average chemistry. This is useful for turnings, because the analyzer provides an average composition. However, if two or more pieces of metal cover the window, the result is just an average reading, and may tell very little about the composition of one piece or the other.

NOTE

When shooting metal pieces or welds, make sure that only the metal of interest is covering the measurement window.

Small and irregularly shaped samples

To measure samples smaller than the analyzing window, you should:

- Increase the testing time.
- Maximize the material in contact with the window.

Because the signal from smaller samples is less intense than from samples that completely cover the window, the analysis precision for small parts measurements is reduced. If possible, analyze the largest, flattest side of an irregularly shaped object.

NOTE

- See “Testing Procedure” on page 81 for a description of a test sequence.
- Take care to prevent small, sharp objects from puncturing the analyzer’s window; such objects can cause damage that is expensive to repair.
- Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* for a complete description of the Olympus application’s user interface.

5.2 Alloy and Alloy Plus Modes

The Alloy mode (DELTA Classic, Classic Plus and Inspector) supports Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Pd, Ag, Cd, Sn, and Sb.

In addition to the element core list of the Alloy mode, the Alloy Plus mode (DELTA Standard, Professional, Premium, and Premium Plus) supports Mg, Al, Si, P, and S (light elements).

DELTA Standard, Professional, Premium and Premium Plus analyzers expand the limits of detection range, permitting operators to analyze these light elements without a vacuum or helium purge requirement.

Alloy and Alloy Plus modes have an Air Pressure Correction feature, which automatically corrects calibrations for air density based on barometric pressure.

5.3 Pass/Fail

The Pass/Fail feature is designed for high-throughput alloy sorting and quality control. This feature is described in the *DELTA Family Handheld XRF Analyzer User Interface Guide*.

6. Mining Modes

The DELTA X-ray fluorescence analyzer currently supports three unique modes for mining analysis (see Table 16 on page 97). The core analytical analyzer modes/types are:

- Mining mode:
  - DELTA Classic and Classic Plus (PIN detector-based)
- Mining Plus mode:
  - DELTA Standard and Professional (SDD detector-based)
  - DELTA Premium and Premium Plus (SDD detector-based)
- Car Catalyst application calibration:
  - All models

Table 16 Mining analysis modes

Modes	Use with	Description
Mining P6000PA	All models	• Supports Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, and Sb (elements may be customized on request). • Fundamental parameters-based calibration for ore grading, and percent-level analysis of processed bulk samples. • Suitable for measurement of percentage-level analyte concentrations, 0.5 % and greater.

Table 16 Mining analysis modes *(continued)*

Modes	Use with	Description
Mining Plus P6000DB	Rh anode tube models: DPM 2000 DPM 6000 DPO 2000 DP 2000 DP 6000	• Supports Mg, Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, and Sb (elements may be customized on request). • Mining mode optimized for SDD-based systems. Rh anode provides the best possible Mg sensitivity, and optimum Al and Si performance.
	Ag anode tube models: DPO 6000 DS 2000 DS 6000	• Supports Mg, Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, and Sb (elements may be customized on request).
	Premium Ta/Au anode tube models: DPM 4000, 4050 DPM 6500, 6550 DP 4000, 4050 DP 6500, 6550	• Supports Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, and Sb (elements may be customized on request).
	Standard and Professional Ta/Au anode tube models: DS 4000, 4050 DS 6500, 6550 DPO 4000, 4050 DPO 6500, 6550	• Supports Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb, Bi, Zr, Mo, Ag, Cd, Sn, and Sb (elements may be customized on request).
Car Catalyst	All models	• Supports Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, and Sb, PLUS Rh, Pt, and Pd. • Accurate analysis of bulk recycled catalyst materials.

These modes use a fundamental parameters algorithm which automatically corrects for interelement effects.

The units can analyze:

- *In situ* (directly on the ground).
- Prepared soil samples (in sample cups).
- Bagged samples.

6.1 Check Standards

It is good practice to measure a check standard after each Cal Check, and periodically throughout the day, to ensure that the data remains as accurate as possible.

The standards provided with DELTA instruments are contained in special XRF sample cups. These cups have film windows on one side through which the soil can be viewed and analyzed, and solid caps on the other side.

6.2 Sample Presentation

***In situ* testing**

In situ testing is performed by pointing the analyzer toward the ground. Clear away any grass or large rocks, and hold the analyzer, keeping the front of the probe head flush with the ground. Gently wipe the window clean after each analysis to remove any dirt from the analyzer window. Make sure that the window is not ripped or punctured.

Bagged or prepared sample testing

Place prepared samples in sample cups, and then perform the analysis through the sample cup window. Place the analyzer's measurement window directly over the film side of the sample cup.

Preparation considerations include:

- Avoid measuring very thin samples, which can affect results. Prepare the sample cups with at least 15 mm of packed sample.
- When analyzing bagged samples, ensure that there is sufficient sample material in the bag to completely cover the window (a minimum sample thickness of 15 mm is required).
- When using bags, cheaper bags with thinner plastic walls are better than more expensive ones with thicker plastic walls.

Optional Accessories

Accessories that complement Mining mode testing are listed below:

- Soil Foot (U8990900)
- Soil Extension Pole (U8990901)
- DELTA Workstation (U8990865)
  - Portable, fully shielded, closed-beam test stand for bench top or remote-controlled testing.
- Trimble Xplorer (JUNO SD) package 1 (U8991049)
- Trimble Xplorer (Nomad 900GLC) package 2 (U8991050)
- Trimble Xplorer (Yuma tablet) package 3 (U8991051)

6.3 User Factors

In Mining modes, test length is user-defined. The Mining modes also allow you to create your own set of factors focusing on particular elements of interest, or correcting for matrix effects. You can make several different factor tables, allowing for analysis of a variety of samples.

Example

A group of samples covering the full concentration range for each element of interest are identified. Each sample is homogenized and split. A portion of each sample is sent to an outside lab for analysis. The other portion is analyzed with the analyzer. For best results, make sure that the samples are very well homogenized and characterized to ensure a consistent correlation.

To set the user factors, first plot the data.

IMPORTANT

Make sure that you respect the following order:

1. Olympus data on X-axis
2. Lab data on Y-axis

Determine the linear best fit with both the slope and intercept for each element. The slope and intercepts for these graphs are entered directly into the analyzer. In many cases, it is sufficient to enter a correction for the slope only, because the intercept is almost zero. In other cases, enter the slope and intercept. You can enter multiple sets of user factors for different applications, or different ore bodies. A group of factors is given a name, and then the factors are entered. The factor set can then be selected by name.

7. Soil Modes

The DELTA X-ray fluorescence analyzer currently supports two unique modes for soil analysis (see Table 17 on page 101). Each mode has a possibility of two default element suites: Environmental and Exploration. The core analytical analyzer modes/types are:

- Soil Environmental:
  - — All models
- Soil Exploration:
  - — All models

Table 17 Soil analysis modes

Modes	Use with	Description
Soil Environmental	All models	• Supports K, Ca, S, P, Cl, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Hg, As, Pb, Se, Rb, Sr, Zr, Mo, Ag, Cd, Sn, Sb, and Ba (elements may be customized on request). • Compton normalization algorithm designed for achieving the lowest limit of detection (LOD) possible for soil and bulk samples.
Soil Exploration	All models	• Supports K, Ca, S, P, Cl, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hg, As, Pb, Bi, Se, Th, Rb, U, Sr, Y, Zr, Mo, Ag, Cd, Sn, and Sb (elements may be customized on request). • Compton normalization algorithm designed for achieving the lowest limit of detection (LOD) possible for exploration samples.

7.1 Check Standards

Measure a check standard after each standardization, and periodically throughout the day, for a minimum period of one minute. Elemental concentrations for elements of interest (in the range expected at the site, plus or minus the standard deviation) should be within 20 percent of the standard value. Appendix “Soil Testing” on page 127 describes recommended quality assurance considerations in detail.

The standards provided with the analyzer are placed in XRF sample cups. These containers have a film window on one side through which the soil can be viewed, and a solid cap on the other side. Always measure samples through the film window.

7.2 Sample Preparation

Preparation considerations include:

- Avoid measuring very thin samples, which can affect results. Prepare the sample cups with at least 15 mm (usually 4 grams to 8 grams) of packed sample.
- When analyzing bagged samples, ensure that there is sufficient sample in the bag to create a minimum sample thickness of 15 mm for a spot size larger than the analyzer's measurement window.
- When using bags, cheaper bags with thinner plastic walls are better than more expensive ones with thicker plastic walls.

8. Consumer Goods Analysis Modes

The DELTA X-ray fluorescence analyzer currently supports three unique modes for consumer goods analysis (see Table 18 on page 103). The core analytical analyzer modes/types are:

- RoHS:
  - All models
- Consumer Products:
  - All models
- Halogen free
  - NOT AVAILABLE on Rh anode analyzers or any DELTA Classic model.

Table 18 Consumer goods analysis modes

Modes	Use with	Description
RoHS	All models	• RoHS regulated elements- Cr, Hg, As, Pb, Br, Cd, PLUS Cl, Ti, Fe, Co, Ni, Cu, Zn, Sn, Sb, and Ba. • Analysis software for measurement of restricted elements in electronics and consumer goods. Built-in auto-compensation for metal, polymer, and mixed matrices.
Consumer Products	All models	• Analysis software designed for CPSIA and Prop 65 testing. Pb content displayed as Pass/Fail, based on regulated limits. • Additional elements: Cl, Ti, Cr, Fe, Co, Ni, Cu, Zn, Hg, As, Br, Cd, Sn, Sb, and Ba are also reported.
Halogen free	NOT AVAILABLE on Rh anode analyzers or any DELTA Classic model	• Tests plastics and mixed materials for the presence of bromine (Br) and chlorine (Cl). • Evaluates results based on total halogen limit.

8.1 Introduction to RoHS Mode

Toxic metals in consumer electronics are the focus of EU regulations with worldwide application. These new directives currently include:

- Restriction of Hazardous Substances (RoHS)
  - Designates maximum allowable levels of Pb, Cd, Cr6+, Hg, and certain Br-containing flame retardants (PBB and PBDE) in new electrical and electronic equipment sold within the EU.

The suggested limits for RoHS elements in a typical screening program would be:

- <0.1 % Pb, Cr6+, Hg, and Br (as flame retardants, PBB, and PBDE)
- <0.01 % Cd

The Olympus analyzer is a screening tool for RoHS compliance, and is used to:

- Directly analyze the amount of toxic metals in electronics
- Quickly identify whether a plastic is made of or contains:
  - PVC
  - Brominated flame retardant

XRF measures total elemental composition, regardless of speciation of the element. Therefore, it reports:

- Total chromium, including the concentration of hexavalent chromium plus any other forms of Cr.
- Total bromine, however XRF cannot distinguish the type of brominated flame retardant present in analyzed materials, or in other bromine-containing compounds.

In order for XRF to be quantitative, samples must be:

- Homogeneous
- Have a certain minimum sample thickness or depth:
  - 5 mm for polymers and light alloys
  - 15 mm for liquid samples
  - 1 mm for other alloys

If samples are heterogeneous, too thin, or too small, only qualitative screening is possible.

The IEC-ACEA (International Electrotechnical Commission – Advisory Committee on Environmental Aspects) recommends XRF screening.

8.2 Test Overview

The DELTA X-ray fluorescence analyzer controlled by the Olympus PC application software (in RoHS mode) automatically executes a test sequence to determine:

- Whether a sample is an alloy, polymer, or mixed.
  - "Mixed" indicates heterogeneous samples consisting of both polymer and alloy, such as wires or circuit boards.
- Whether each RoHS element passes, fails, or is inconclusive when compared with a set of stored criteria.

- — These criteria are either recommended by the IEC, or added by the user.

The sequence begins with the instrument utilizing tube settings appropriate for analysis of a polymer sample. The following logic applies:

- If the sample is determined to be a polymer or mixed, the test continues, and a calibration based on a polymer matrix is used.
- If the sample is found to be a metal alloy, the analyzer switches to a secondary test using an alloy matrix calibration in order to determine correct alloy concentrations.

8.2.1 Check Standard

Olympus recommends that a check standard be measured after each Cal Check procedure, and periodically throughout the day.

Two certified standards are provided for verification.

- At least one standard should be measured for a minimum of two minutes.
- Concentrations for target elements (plus or minus the error on the reading) should be within 20 % of the standard value.
- Standards provided are placed in XRF sample cups with a window on one side through which the plastic pellets can be viewed, and a solid cap on the other side.
- Samples should be measured through the sample cup window.

8.2.2 Sample Presentation

Since many pieces of the plastic analyzed for RoHS compliance are very small, take care to measure them in a safe and accurate manner. See the IEC-ACEA recommendations for minimum test sample thicknesses.

8.3 IEC Quantitative Screening Requirements

RoHS requirements are derived from *Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment*.

IMPORTANT

- At of this User Manual’s release date, no mandatory requirements have been published. The series of six key regulated substances remains the same for Electrotechnical products — lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ethers. The limits provided in Table 19 on page 106 are meant to be an example for a typical screening program.
- Olympus strongly advises that users have their own compliance departments determine the current status of the requirements that they must meet.

Table 19 Proposed screening limits for RoHS elements

RoHS elements	Pass[a]	Lower limit	Inconclusive[b]	Upper limit	Fail[c]
Polymer elements					
Cd	P	≤ (70 – 3 s)	< x[d] <	(130 + 3 s) ≤	F
Pb	P	≤ (700 – 3 s)	< x <	(1300 + 3 s) ≤	F
Hg	P	≤ (700 – 3 s)	< x <	(1300 + 3 s) ≤	F
Br	P	≤ (300 – 3 s) <	x		
Cr	P	≤ (700 – 3 s) <	x		
Metallic materials					
Cd	P	≤ (70 – 3 s)	< x <	(130 + 3 s) <	F
Pb	P	≤ (700 – 3 s)	< x <	(1300 + 3 s) <	F
Hg	P	≤ (700 – 3 s)	< x <	(1300 + 3 s) <	F
Br			N/A		
Cr	P	≤ (700 – 3 s) <	x		
Electronics					
Cd	P	LOD	< x export	(150 + 3 s) ≤	F
Pb	P	≤ (500 – 3 s)	< x <	(1500 + 3 s) ≤	F
Hg	P	≤ (500 – 3 s)	< x <	(1500 + 3 s) ≤	F
Br		≤ (250 – 3 s) <	x		
Cr	P	≤ (500 – 3 s) <	x		

a. Pass = Results for all elements are lower than the limits shown in this table.
b. Inconclusive = Result of the quantitative analysis, for any of the Hg, Pb, or Cd elements, is in the region defined as intermediate, OR if the result of the elements Br and Cr is higher than the higher limits shown in this table, the analysis is inconclusive. Additional investigation must be performed.
c. Fail = Results for any elements higher than the higher limits shown in this table.
d. x = Concentration value

8.4 Introduction to Consumer Products Mode

This mode is dedicated to testing items for lead (Pb) content.

The result output is Pass/Fail, based on the regulated limits specified in the following Acts:

- CPSIA (the Consumer Products Safety Improvement Act of 2008)
- Prop 65 — Refers to California Proposition 65 enacted in 1986

Additional elements that may be reported are:
Cl, Ti, Cr, Fe, Co, Ni, Cu, Zn, Hg, As, Br, Cd, Sn, Sb, and Ba

Regulatory limits vary from state to state and country to country, and by governing body. European Union nations generally use the RoHS limits and testing practices.

The regulatory limits for Pb are:

- CSPIA: 100 ppm for substrates; 90 ppm for paint layers
- RoHS: see Table 19 on page 106

NOTE

- See “Testing Procedure” on page 81 for a description of a typical test sequence.
- Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* for a complete description of the Olympus application’s user interface.

9. Measurement Window Replacement

This chapter explains how to replace a measurement window on a DELTA X-ray fluorescence analyzer (all models). The cost of replacement windows is quite low. To obtain optimum test results, Olympus recommends changing the measurement window if it is dirty or contaminated.

IMPORTANT

- Immediately replace any broken or torn window.
- Never conduct any test using a broken window.

Window assemblies are made from either Prolene or Kapton film (see Figure 9-1 on page 109). You must specify the proper material to match your DELTA X-ray fluorescence analyzer.

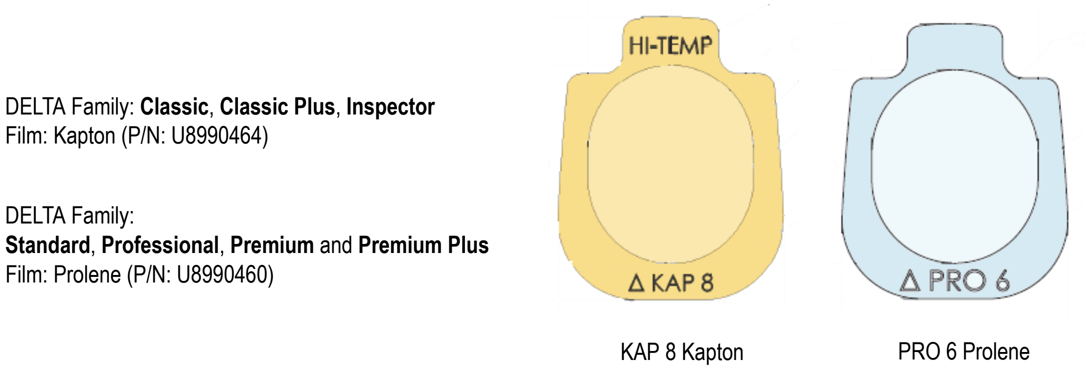


Figure 9-1 Window types

The selected film is applied to one side of a polyester backing plate. This creates a “front” and “back” surface.

- The “back” surface is completely covered with film (see Figure 9-2 on page 110).
- The “front” surface shows a circular ridge where only the film is present, and shows through the center hole of the backing plate. This front surface also has a part-type designator.

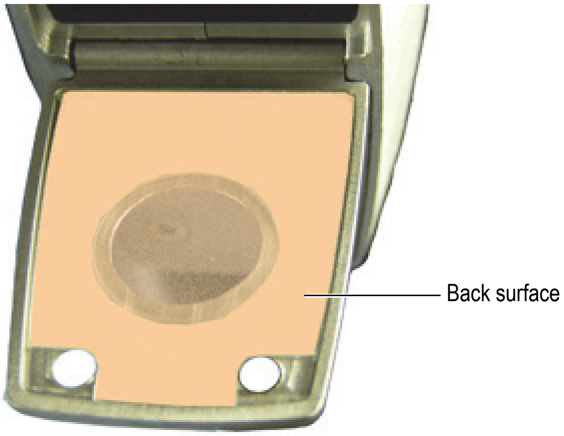


Figure 9-2 Window back surface

To replace the measurement window, you will need the following tools:

- Small Phillips head screwdriver (required)
- Tweezers or needle-nose pliers (recommended)
- Lint-free wipes or swabs (as needed)

To remove the window

CAUTION

- To avoid analyzer damage, comply with the instructions below:
- Do not touch or damage any internal components.
- Do not insert anything into the analyzer.
- Keep dust and foreign materials out of the analyzer.
- Make sure that your hands are clean.
- Orient the analyzer with the nose pointing sideways so that any debris or loose screws will not fall into the analyzer.
- Do not touch the film in the center opening.

---

1. Turn off the analyzer.

CAUTION

When using the screwdriver, keep a finger or thumb between the tool and the X-ray window. This prevents the tool from accidentally puncturing the film, and causing internal damage.

---

2. Using the Phillips head screwdriver, remove the two hinged plate screws (see Figure 9-3 on page 111).

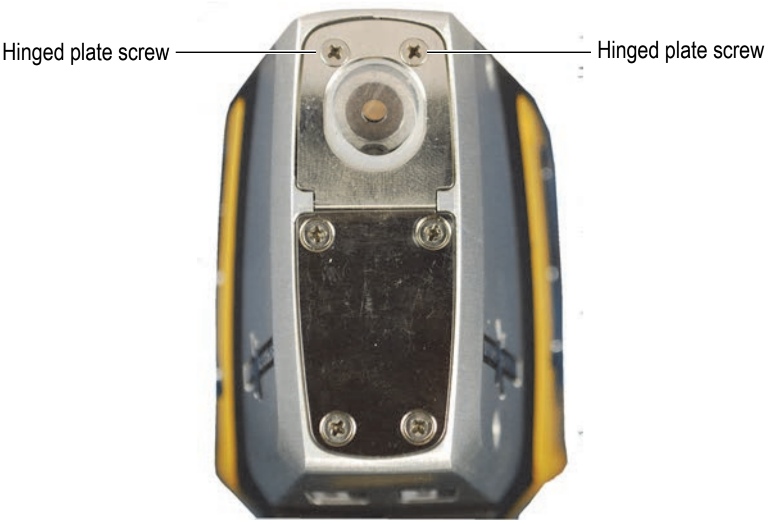


Figure 9-3 Hinged plate screws

3. Swing the hinged face plate outward to expose the film window (see Figure 9-4 on page 111).

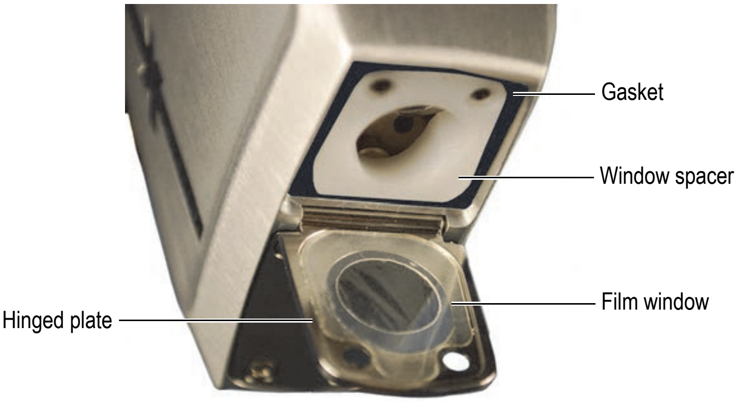


Figure 9-4 Film window exposed

4. Remove the old window.
5. Make sure that the white plastic window spacer and the black rubber gasket are properly placed.

To install the new window

1. Remove the new window assembly from the shipping envelope.
2. Handle the window by its edges, or using tweezers.
3. Place the window assembly on the hinged plate, with the back surface of the film facing upward (see Figure 9-4 on page 111).
4. Center the window, avoiding the screw holes.
5. Carefully rotate the hinged plate upward to secure the window assembly.

⚠ **CAUTION**

Do not overtighten the screws. Doing so could strip the threads.

6. Insert the two screws, and tighten only to the snug position.

TIP

Olympus recommends placing the analyzer in the docking station when not in use. This keeps the window clean and prevents accidental damage to the film window.

10. DELTA Radiation Profile

The current radiation profile is shown in Figure 10-1 on page 113, in Table 20 on page 115, and in Table 21 on page 117.

Figure 10-1 DELTA radiation profile — Handheld instruments

NOTE

In this chapter, the even-number pages (left hand pages) are intentionally left blank.

Table 20 Radiation profile[a] — Aluminum probe head[b]

Model: DELTA Series							**Date: Oct. 2012 and Jan. 2013**		
Survey instrument		Ludlum Model 3 44-7 probe		Ludlum Model 2241 44-172 probe		Performed by: F. Cook R. Nasella	Validated by: M. L. Tremblay		
Probe head: Aluminum									
Measured dose rate in μSv/h[c] — Secondary radiation (scatter)									
Mode(s)	**Substrate**	**Voltage (kV)**	**Amperage (μA)**	**Filter**	**Trigger — T**	**Close — F**	**5 cm — F1**	**10 cm—F2**	**30 cm (calculated)**
Alloy Plus, Mining, Mining Plus, GeoChem 1, 3-Beam Soil 2, HalFree 1, RoHS 1 (plastic)	316 stainless	40	100	Aluminum	BK[d]	7	6	BK	BK
	Al (319 AA)				7	300	120	30	4
	EC 680K				45	900	500	320	19
	Soil (SiO_2)				20	400	250	70	9
RoHS 1, 4-Beam RoHS 1 (plastic), RoHS 2, 4-Beam RoHS 2 (alloy)	PVC-Blank	50[e]	80	Copper	10	840	400	250	15
	EC 680K				16	1800	800	500	30
	71X SR2 (solder)				BK	5	1	BK	BK
Alloy, Mining	316 stainless	35	100	Aluminum	BK	2	2	BK	BK
	Soil (SiO_2)				5	130	60	20	
Alloy Plus 3	316 stainless	8	200	Open	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	BK	BK	BK
Alloy Plus 2	316 stainless	13	200	Open	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	BK	BK	BK
Alloy 2	316 stainless	15	200	Iron	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	BK	BK	BK
3-Beam Soil 1, Mining Plus	Soil (SiO_2)	50[e]	80	Copper	25	1500	800	450	30
3-Beam Soil 1	Soil (SiO_2)	40	100	Copper	10	400	220	70	8
RoHS 2 (alloy)	PVC-Blank	40	100	Copper	5	200	90	30	3
	EC 680K				4	700	420	300	16
Geochem 2, Mining Plus 2	Soil (SiO_2)	10	200	Open	BK	BK	BK	BK	BK
3-Beam Soil 3	Soil (SiO_2)	15	200	Thin aluminum	BK	BK	BK	BK	BK
Lead 2	71X SR2 (solder)	18	200	Aluminum	BK	BK	BK	BK	BK
Lead 1	71X SR2 (solder)	25	100	Aluminum	BK	BK	BK	BK	BK
HalFree 2	EC 680K	10	200	Open	BK	8	1	BK	BK
HalFree 2	EC 680K	12	200	Open	BK	70	13	4	BK

a. Table revision D, January 2013.

b. Aluminum probe head only, no probe shield in place.

c. To convert measurements to mR/h, divide results by 10.

d. BK = Background reading (< 1 μSv/h).

e. All 50 kV readings are taken with standard probe shield in place.

Table 21 Radiation profile[a] — Brass probe head[b]

Model: DELTA Series						**Date: Oct. 2012 and Jan. 2013**
Survey instrument	Ludlum Model 3 44-7 probe	Ludlum Model 2241 44-172 probe		Performed by: F. Cook R. Nasella		Validated by: M. L. Tremblay
Probe head: Brass alloy						

Measured dose rate in μSv/h[c] — Secondary radiation (scatter)														
Mode(s)	**Substrate**	**Voltage (kV)**	**Amperage (μA)**	**Filter**	**Trigger — T**		**Close — F**		**5 cm — F1**		**10 cm—F2**		**30 cm (calculated)**	
					Probe head only[d]	Probe shield[e]	Probe head only	Probe shield	Probe head only	Probe shield	Probe head only	Probe shield	Probe head only	Probe shield
Alloy Plus, Mining, Mining Plus, GeoChem 1, 3-Beam Soil 2, HalFree 1, RoHS 1 (plastic)	316 stainless	40	100	Aluminum	BK[f]	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	5	BK	BK	BK	BK	BK	BK	BK
	EC 680K				50	7	1500	950	700	370	400	160	26	14
	Soil (SiO_2)				20	4	850	300	500	280	200	110	19	10
RoHS 1, 4-Beam RoHS 1 (plastic), RoHS 2, 4-Beam RoHS 2 (alloy)	PVC-Blank	50	80	Copper	25	5	650	400	600	200	120	60	22	7
	EC 680K				60	9	1500	1000	1500	1000	750	200	56	37
	71X SR2 (solder)				BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Al (319 AA)				1	BK	25	15	10	10	6	5	BK	BK
Alloy, Mining	316 stainless	35	100	Aluminum	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Soil (SiO_2)				BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
Alloy Plus 3	316 stainless	8	200	Open	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	4	BK	BK	BK	BK	BK	BK	BK
Alloy Plus 2	316 stainless	13	200	Open	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	4	BK	BK	BK	BK	BK	BK	BK
Alloy 2	316 stainless	15	200	Iron	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
3-Beam Soil 1	Soil (SiO_2)	50	80	Copper	70	7	1000	500	750	350	300	50	28	13
		50 #	60 #	Copper	30	5	750	370	550	500	170	110	21	19
3-Beam Soil 1	Soil (SiO_2)	40	100	Copper	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
RoHS 2 (alloy)	316 stainless	40	100	Copper	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
	Al (319 AA)				BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
Geochem 2, Mining Plus 2	Soil (SiO_2)	10	200	Open	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
Mining Plus	Soil (SiO_2)	50	80	Copper	100	10	1750	750	750	350	300		28	13
		50 #	15 #	Copper	15	4	300	170	160	100	80	40	6	4
3-Beam Soil 3	Soil (SiO_2)	15	200	Thin aluminum	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
Lead 2	71X SR2 (solder)	18	200	Aluminum	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
Lead 1	71X SR2 (solder)	25	100	Aluminum	BK	BK	BK	BK	BK	BK	BK	BK	BK	BK
HalFree 2	EC 680K	10	200	Open	BK	BK	3	BK	1	BK	BK	BK	BK	BK
HalFree 2	EC 680K	12	200	Open	BK	BK	3	BK	1	BK	BK	BK	BK	BK

a. Table revision D, January 2013.

b. Brass probe head for DELTA models sold in Japan, and 50 kV models sold in Canada.

c. To convert measurements to mR/h, divide results by 10.

d. Probe head only = No shield in place.

e. Probe shield = Standard probe shield in place.

f. BK = Background reading (< 1 μSv/h).

Appendix A: Specifications

This Appendix outlines the specifications for the DELTA X-ray fluorescence analyzer, its docking station, and its accessories (see Table 22 on page 119 to Table 23 on page 120).

Table 22 DELTA X-ray fluorescence analyzer specifications

	Specifications
Weight	1.52 kg [base wt.]; 1.74 kg with battery
Excitation source	4-watt X-ray tube — Au, Ag, Rh, or Ta anode (application optimized), 8–40 keV, 5–200 µA, eight filter positions (DELTA Element is equipped with a single fixed filter)
Detector	Various: Si PIN diode or Si Drift detector, thermoelectrically cooled, high resolution
Power	Removable Li-ion batteries, or AC power unit
Battery life	Battery life varies depending on usage patterns.
Display	Color “transflective” touch screen (800 × 600) with 16-bit LCD interface
Cal Check coupon	316 stainless steel alloy (see also docking station specifications)
Power requirements for AC adaptor	110–220 VAC, 50–60 Hz, 600 W max (P/N: U8999389)
Pressure correction	Built-in barometer for automatic altitude correction
Operating environment	Temperature: –10 °C to 50 °C Humidity: 10 % to 90 % relative humidity, non-condensing Altitude rating: 2,000 m Note: Operating specifications are posted as nominal.
Operating system	Windows Embedded CE
Application software	Olympus proprietary data acquisition and processing package
USB interface	USB 2.0
Camera (optional)	CMOS, full VGA
Collimation check sample for camera	Part U8996829 is supplied only with instruments that have selected camera and collimation features.
Data storage	1 GB SD card

Table 23 Accessory specifications

	Specifications
AC battery charger	U8990854 (Standard item with DELTA Element)
Workstation (not compatible with the DELTA 50 analyzer)	U8990865: • A portable equipment stand providing a fully shielded closed-beam system. • Uses Advanced PC software.
Workstation (compatible with the DELTA 50 analyzer)	U8995379: • A portable equipment stand providing a fully shielded closed-beam system. • Uses Advanced PC software.
Soil foot	U8990900: • Attaches to the handle of the DELTA analyzer. • Keeps the analyzer level on the ground for hands-free, extended *in situ* testing.
Soil extension pole	U8990901: • An ergonomic extension pole facilitating soil analysis performed by a mobile operator. • Includes a soil foot.
Probe shield	U8995563: • Provides maximum shielding; suggested for extended handheld use of the DELTA 50 analyzer. • Probe shield included as standard with the DELTA 50 analyzers.
AC power adaptor	U8990860
PC software	U8990896 (Basic): • Facilitates remote analyzer control, data download, spectral overlay and review, and report generation. • Comes standard with all DELTA analyzers. U8990898 (Advanced): • Advanced PC software for more comprehensive data analysis and calibration model control. • Includes DELTA PC SOFTWARE – BASIC capabilities (comes bundled with a portable workstation).
Test cup	U8996265: • Fully shielded, ultraportable workstation for bench top analysis of soil and powder cups, in addition to small metal and plastic samples

Appendix B: X-Ray Fluorescence Spectrometry Overview

Although most commonly known for diagnostic applications in the medical field, X-rays are the basis of many powerful analytical measurement techniques, including X-ray fluorescence (XRF) spectrometry.

XRF spectrometry determines the elemental composition of a material. This method identifies elements in a substance and quantifies the amount of those elements present. An element is defined by its characteristic X-ray emission wavelength (λ) or energy (E). The amount of an element present is determined by measuring the intensity of its characteristic line.

All atoms have a fixed number of electrons (negatively charged particles) arranged in orbitals around their nucleus. The number of electrons in a given atom is equal to the number of protons (positively charged particles) in the nucleus. In the classic Periodic Table of Elements, the Atomic Number is designated by the number of protons. Each Atomic Number is assigned an elemental name, such as Iron (Fe), with Atomic Number 26.

XRF Spectrometry typically uses activity in the first three electron orbitals: the K, L, and M lines, where K is closest to the nucleus. Each electron orbital corresponds to a specific and different energy level for a given element.

In XRF spectrometry, high-energy primary X-ray photons are emitted from a source (X-ray tube or radioisotope), and strike the sample. The primary photons from the X-ray source have enough energy to knock electrons out of the innermost K or L orbitals. When this occurs, the atoms become unstable ions. Electrons seek stability; therefore, an electron from an outer orbital (L or M) moves into the newly vacant space at the inner orbital. As the electron from the outer orbital moves into the inner orbital space, it emits an energy known as a secondary X-ray photon.

This phenomenon is called fluorescence (see Figure B-1 on page 122).

The secondary X-ray produced is characteristic of a specific element.

The energy (E) of the emitted fluorescent X-ray photon is determined by the difference in energies between the initial and final orbitals of the individual transitions. This is described by the following formula.

$$E = \frac{hc}{\lambda}$$

where:

h = Planck’s constant

c = velocity of light

λ = characteristic wavelength of the photon

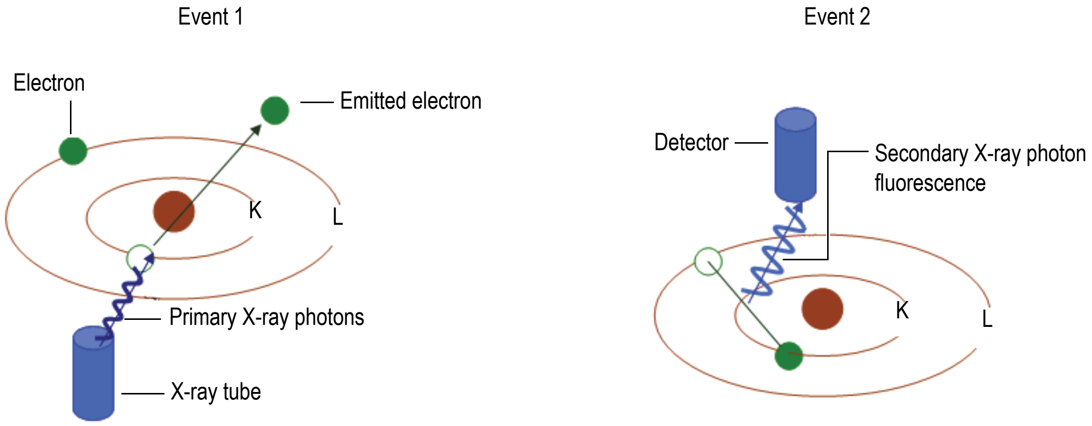


Figure B-1 Fluorescence principle

Creating a Secondary X-ray: Photon Fluorescence

Wavelengths are inversely proportional to the energies; they are characteristic for each element.

For example, the Ka energy for Iron (Fe) is approximately 6.4 keV. The number of element-specific characteristic X-rays produced in a sample over a given period of time, or the intensity, is measured. This determines the quantity of a given element in that sample.

Typical spectra for EDXRF Spectrometry appear as a plot of Energy (*E*) versus the Intensity (*I*) [see Figure B-2 on page 122].

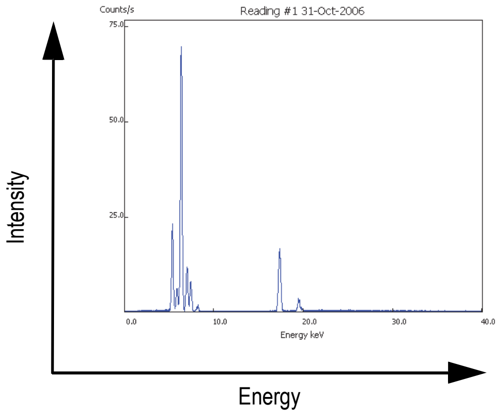


Figure B-2 Typical spectrum plot: Energy vs intensity

B.1 Timeline of Spectrometry

This section outlines the timeline of spectrometry.

- Wilhelm Röentgen discovered X-rays in 1895.

- Henry Moseley first published methods for identifying and quantifying elements using XRF in 1913.
- XRF research and development continued, especially during WWII.
  - — Critical developments in the aircraft, automotive, steel, and other metals industries increased the need to identify alloys quickly and reliably.
- The first commercial XRF spectrometers became available in the early 1950s. These systems were based on Wavelength Dispersive (WD) XRF technology.
  - — The characteristic wavelength of an element was measured one element at a time.
  - — WDXRF systems were useful for elemental analyses; however, the equipment possessed the following properties:
    - Large size
    - High initial cost
    - A need for highly skilled operators for operations and maintenance.
- In the late (1960s, Energy Dispersive (ED) XRF technology emerged as a viable commercial choice:
  - — EDXRF measured the characteristic energy of an element.
  - — Improvements in solid state detectors offered better energy resolution of the signal.
  - — EDXRF offered the potential to collect and display information on all of the elements in a sample at the same time.
- Many of the early EDXRF systems used radioisotopes for excitation and had the following properties:
  - — Required changing sources to determine all the elements of interest.
  - — Did not easily resolve multiple elements in a single analytical run.
- The current state-of-the-art EDXRF is the result of:
  - — Advancements in technology (particularly X-ray tubes, solid state components, electronics, computers, and software).
  - — Application of the technology by instrument manufacturers, research scientists, engineers, and industrial users.
- Now a mature technology, XRF spectrometry is routinely used for R&D, QC, production support, and regulatory compliance.

B.2 Elemental Analysis

Investigators involved with elemental analysis generally have two working instrument techniques: wet chemistry and XRF spectrometry, which can be operationally compared as described below.

B.2.1 Wet Chemistry

Important considerations are:

- Instrument techniques are time-consuming. It often takes twenty minutes to several hours for specimen preparation and analysis.
- The specimen is destroyed.
- It is often necessary to employ concentrated acids or other hazardous materials.
- Requires disposal of waste streams generated during the analytical process.

- Relatively high cost per sample.

However, wet chemistry instrument techniques are necessary if the primary measurement requirement involves elemental concentrations in the PPB (or lower) range.

B.2.2 XRF Spectrometry

Important considerations are:

- Easily and quickly identifies and quantifies elements over a wide dynamic concentration range, from PPM levels up to nearly 100 % by weight.
- Does not destroy the sample.
- Overall sample turnaround time is fast.
  - Requires little, if any, specimen preparation.
  - Results are often available within seconds or minutes for some details.
- Relatively low cost per sample.

B.2.3 Interferences

All elemental analysis techniques are susceptible to chemical and physical interferences. These interferences must be corrected or compensated for in order to achieve adequate analytical results.

Wet Chemistry Issues

Most techniques are susceptible to interferences that can only be corrected by extensive and complex specimen-preparation techniques.

XRF Spectrometry Issues

The primary interference is from other specific elements in a substance that can influence (matrix effects) the analysis of the target element(s) of interest. However, this interference type is well known and documented.

Both types of analyzer techniques benefit from:

- Instrumentation advancements
- Mathematical corrections in the system’s software

In certain cases, the geometry of the sample can effect XRF analysis. This is compensated for by:

- Grinding or polishing the sample.
- Pressing a pellet.
- Making glass beads.

B.2.4 Quantitative Analysis

XRF spectrometry-supporting quantitative analysis typically employs one of the following two software applications:

- Empirical Methods

Uses calibration curves derived from standards similar in property to the target (unknown) sample.

- Fundamental Parameters (FP)

  FP is frequently preferred, because it allows elemental analysis to be performed without standards or calibration curves. The analyst can use the system immediately. Modern computers support this no-standard mathematical analysis (FP) accompanied by stored libraries of known materials. These systems quickly determine not only the elemental composition of an unknown material, but also identify the unknown material itself.

B.3 EDXRF Spectrometers

An EDXRF analyzer typically has three major subsystems (see Figure B-3 on page 125).

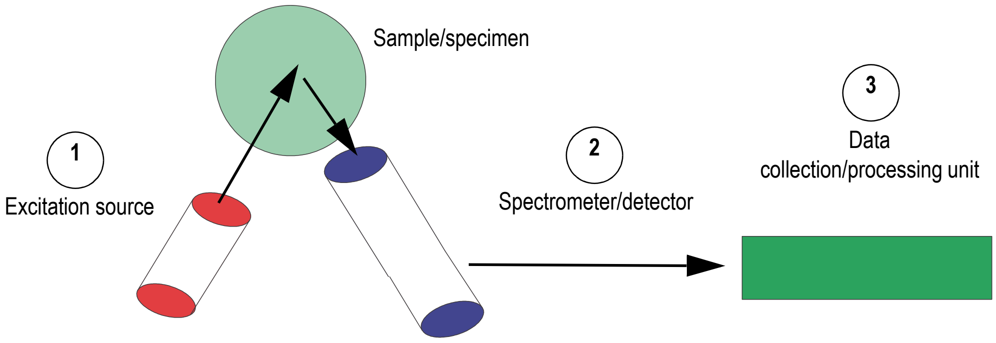


Figure B-3 EDXRF analyzer subsystems

EDXRF analyzers are mechanically very simple; there are no moving parts in the excitation and detection subsystems. However, a benchtop analyzer can have moving parts.

When compared to WDXRF systems, EDXRF systems exhibit the following attributes:

- Ease of use
- Rapid analysis time
- Lower initial purchase price
- Substantially lower long-term maintenance costs

EDXRF analysis equipment is useful for many applications, including:

Environmental analysis

- RoHS/WEEE compliance
- Scrap alloy sorting
- Forensic science
- Archaeometry

Appendix C: Soil Testing

This appendix describes how to operate all company handheld portable analyzers that come with Soil mode installed.

This appendix provides instructions, procedures, and regulations, in addition to useful reference material regarding:

- Portable XRF equipment usage in accordance with accepted methods
- Basic overview of the technique of X-ray fluorescence (XRF)
- Appropriate data quality assurance protocols
- Sample preparation steps for operators charged with analyzing prepared soil samples.
- Tables of certified values for selected standards

If LEAP mode is enabled, refer to the configuration help information in the *DELTA Family Handheld XRF Analyzer User Interface Guide*.

C.1 Commonly Accepted Methods for Field-Portable XRF

A commonly accepted method is shown: *Field-Portable XRF Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment*.

Features of this method are:

- It is a field-screening method for analysis of *in situ* or bagged samples.
- The method provides basic quality assurance methods, including calibration verification, determination of instrument precision, accuracy, and limit of detection.
- The method recognizes that some XRF instruments do not require site-specific calibrations by the operator; that is, the factory calibration provides appropriate data quality.
- The method recommends that a minimum of 5 % to 10 % of samples tested by XRF be confirmed by an outside laboratory, using a total-digestion EPA analytical reference method.

NOTE

The purpose of this method is NOT to replace laboratory analysis.

The two primary sources of error that can occur when assessing a site for metal concentration are analytical error and sampling error.

Analytical Error

An error in the analysis of any one sample by whatever technique is used, for example XRF, ICP, or AA.

Sampling Error

This arises when too few samples are collected and tested.

In this case an incomplete picture of the extent of metal contamination may be obtained. Although any one sample may be analyzed with very high analytical accuracy, measuring too few samples may result in contamination plumes being misjudged in terms of size or depth within the soil. In extreme cases, contamination can be missed entirely.

Methods have been developed to reduce sampling errors by increasing the number of samples measured. In general, a large number of screening-level measurements provides a better characterization of contamination than a small number of measurements produced by sample removal and analytical analysis. A large number of *in situ* samples provides detailed data on contamination profiles, depth (provided surface soil is set aside), and approximate contamination levels. Portable XRF can provide results with a high degree of analytical accuracy on any given sample.

C.2 Field Usage Overview

Field-portable XRF generally uses three different methods to test for metals in soil:

- *In situ* soil testing
- Bagged soil-sample testing
- Prepared soil-sample testing

***In situ* soil testing**

The XRF analyzer is placed directly on the ground for soil testing. Operators remove any plant growth or other foreign objects to ensure that the analyzer probe is flush with the soil.

Bagged soil-sample testing

A soil sample is collected in a thin plastic bag (a baggie), and testing occurs directly through the baggie. With the exception of a few elements —namely Cr, V, and Ba— testing through the thin plastic bag has little effect on the test result. However, results for Cr, V, and Ba will be lower by 20 % to 30 %.

Prepared soil-sample testing

Prepared sample testing ensures that the operator will obtain the maximum possible accuracy. Prepared sample tests require that a sample be collected, dried if necessary, sieved, and ground into a powder. The prepared sample is then placed in a baggie or XRF cup for analysis.

Sample prep procedures are provided in “Sample Preparation Procedures and Testing Protocols” on page 139.

ALL analytical methods, require a uniform, homogenous sample for the best results, and XRF is no different.

The methods generally used, namely *in situ* and bagged sample testing, are considered field-screening methods. Although considered a field-screening method, *in situ* testing is a valuable technique, because it generates a great deal of data very quickly. Prepared soil samples generally offer the best accuracy, albeit with several minutes of sample preparation required per sample.

C.3 Data Quality Objectives

It is important to understand your data quality objectives (DQO) in order to determine the appropriate mix of field screening and prepared-sample testing.

In situ testing usually provides only screening-level data quality. This is because analytical testing always requires a uniform, homogeneous sample matrix. A laboratory achieves this by digesting the sample in a hot acid prior to analysis. Testing directly on the ground does not ensure that uniformity is met. Preparing a sample provides a uniform sample, and likely better analytical data quality, although several minutes of testing time is required.

Most portable XRF operators use a mixture of *in situ* and prepared sample testing. The exact mixture of *in situ* and prepared sample testing depends upon the objectives of soil testing. The examples below serve as guidelines.

Example 1: Initial site investigation to provide detailed contamination data and efficient use of laboratory analysis costs.

Problem

The site needs to be assessed for metal contamination. Little information is available as to what metals are present—likely contamination levels or geographic profile of contamination.

The goal of testing is to determine what metals are present at what levels, both in terms of area and depth in soil. Additionally, testing will locate possible contamination plumes, and/or possible sources of contamination.

Recommended testing plan

This example uses predominately *in situ* testing. The analyst will perform *in situ* testing and gather samples into plastic bags for XRF analysis. A testing grid should be established every several feet in two or three dimensions. XRF tests can be taken at each location, or bagged samples can be collected from each location for later analysis. The *in situ* data for each element analyzed may be plotted in a two-dimensional grid (X, Y coordinates versus elemental concentration) in order to profile a site. These concentration profiles are ideal for showing contamination patterns, boundaries, and plumes. Combining this data with historical use data from the site often enables the operator to deduce sources of contamination. Obtaining this level of geographic data with purely laboratory analysis would produce excessive analytical costs.

Prepared sample analysis should also be performed in order to confirm the regions where *in situ* data indicates low or undetected levels of metal contaminant. There is little need to prepare areas where *in situ* testing indicates high concentration levels.

Olympus recommends the following procedure:

For locations where *in situ* tests indicate low or undetected concentrations, calculate the total number of *in situ* tests, and then collect 5 % of this number of tests from the various locations. Prepare these samples according to the instructions in “Sample Preparation Procedures and Testing Protocols” on page 139. Use these prepared samples to confirm the findings of the *in situ* testing. Send a subset of these prepared samples to a laboratory for confirmatory results.

Cost Justification

Adequate characterization of a site may require 100 to 200 samples/acre to ensure that the contaminated areas are firmly established. This work may be performed with *in situ* testing in order to generate laboratory savings of $5000 to $10 000/acre, depending upon the number of elements being analyzed. The cost reduction in off-site analysis often justifies the price of the XRF.

Example 2: Monitor remediation efforts, and ensure that clearance levels are met before contractors leave the site.

Goal

Minimize remediation costs by only treating contaminated soil, and obtain immediate verification that various site locations meet clearance objectives.

Recommended Testing Plan

This type of project uses numerous rounds of both *in situ* and prepared sample testing. Use *in situ* testing to thoroughly delineate contamination regions in terms of both area and depth. To determine depth profiles, test surface soil by removing at least 1 ft to 2 ft, and then retest. Repeat this step as needed in order to profile contamination depth and guide remediation activities (XRF is a surface technique, and only performs analysis on the first few millimeters of soil sample). As part of clearance, collect several samples from cleared area. Prepare samples according to “Sample Preparation Procedures and Testing Protocols” on page 139.

Test with portable XRF

If XRF indicates that concentration levels are in excess of clearance requirements:

- Continue remediation efforts.

If XRF indicates that concentration levels are below clearance requirements:

- Discontinue remediation efforts, and send a subset of the samples to an analytical laboratory for confirmation of the results. Most operators safely assume that the cleanup requirements have been met for the elements in question, but await final analysis from the laboratory.

If the XRF analysis lists concentration levels as undetected, but the reported detection level exceeds clearance requirements, send samples to a laboratory for confirmation of final results.

Cost Justification

In situ results are used to guide remediation efforts with the objective of obtaining maximum efficiency. Efficiency is produced because contamination boundaries are firmly established, thus avoiding remediation efforts with clean soil. Prepared sample testing is used to assure that clearance requirements are met on-site in near real time (pending laboratory confirmation). Cost savings are generated by avoiding clearance failures. The contractors can leave the site earlier, and do not have to be called back to the site for additional cleanup.

IMPORTANT

Never clear a site based solely on *in situ* testing. Always use well-prepared samples to guide clearance decisions.

Example 3: Minimize the volume of hazardous waste for treatment or disposal.

Goal

For some cleanup projects, the cost of disposing soil in a hazardous waste landfill is much greater than disposing it in a standard landfill. Testing soil samples with XRF may minimize the amount of clean soil inadvertently shipped to hazardous-waste landfills.

Recommended Testing Plan

This example is based almost entirely on prepared sample testing. Representative samples are removed from the soil being hauled to the landfill. Obtaining accurate analysis of the samples is crucial for making a hazardous versus nonhazardous determination. For this reason, prepared sample testing is strongly recommended.

IMPORTANT

These types of samples are subject to Toxicity Characteristic Leaching Procedures (TCLP) for landfill determination. In general, 20 times the XRF result should be less than the allowable limit for the metal in question. Please contact Olympus for more details on testing samples versus TCLP regulatory requirements.

C.4 Quality Assurance

Detailed quality assurance requirements for proper operation of the analyzer and proper verification of data quality for *in situ* testing are provided. All operators should perform the quality control (QC) procedure, regardless of their data quality objectives. Strict requirements for quality assurance must be met. Additionally, Olympus encourages operators to verify the data quality of *in situ* test results if they are using *in situ* data to guide their reporting or remediation decisions. The procedures are listed below.

C.4.1 Proper Verification of Instrument Operation

Quality assurance in this context consists of testing known standards to verify calibration, in addition to testing blank standards to determine limits of detection, and check for sample cross-contamination or instrument contamination. We recommend a detailed procedure, which is provided below in abbreviated form.

Components of instrument QC:

- An energy calibration check sample at least twice daily
- An instrument blank for every 20 environmental samples
- A method blank for every 20 prepared samples
- A calibration verification check sample for every 20 samples

- A precision sample at least once per day
- A confirmatory sample for every 10 environmental samples

Energy calibration check

The Olympus analyzer performs this automatically; this is the purpose of the standardization check when the analyzer is started. The software does not allow the analyzer to be used if the standardization is not completed.

Instrument blank

The operator should use the SiO2 (silicon dioxide) blank provided with the analyzer. The purpose of this test is to verify that there is no contamination on the analyzer window or any other component penetrated by the X-rays. We recommend running an instrument blank at least once per day, preferably every 20 samples. For either *in situ* or prepared sample testing, the operator should test the SiO2 blank to ensure that there are no reported contaminant metals.

Method blank

The purpose of the method blank is to verify that cross-contamination is not introduced into samples during sample preparation. We recommend following the sample-preparation procedures with clean SiO2 blank once every 20 prepared samples. If the operator is not preparing samples, this QC step is not required.

Cal Check

Olympus provides standard reference samples for Cal Checks performed by the operator. The operator should perform a two-minute test on a standard. The difference between the XRF result for a given element and the value of the standard should be 20 % or less. A Cal Check should be performed at instrument start-up, and periodically during testing.

NOTE

Olympus recommends performing a Cal Check every four hours. Some users perform a calibration check every 20 samples. Reference standards are generally applicable for Pb, As, Cr, Cu, and Zn. Olympus provides additional reference standards for priority pollutant metals, including Cd, Se, Ag, Hg, Ba, Sn, Sb, and Ni.

Precision verification

It is good practice to perform a minimum of one precision sample run per day by conducting 7 to 10 replicate measurements of the sample. The precision is assessed by calculating a relative standard deviation (RSD) of the replicate measurements for the analyte. The RSD values should be less than 20 % for most analytes, with the exception of chromium, for which the value should be less than 30 %.

Confirmatory sample

We recommend running one confirmatory sample for every 10 samples collected. It is good practice to have confirmatory samples collected from the same sample material being analyzed on-site, and to send the samples to an off-site laboratory for formal analysis. The purpose of a confirmatory sample is to judge the accuracy of the data obtained through on-site analysis, and to allow for any necessary corrections.

IMPORTANT

Olympus recommends that customers compare prepared sample results with laboratory results. To do so, collect and prepare a sample in accordance with the protocols provided in "Sample Preparation Procedures and Testing Protocols" on page 139. Take a subsample, and then submit it to the laboratory for analysis. The single largest error in XRF analysis is lack of sample preparation. To obtain the best comparison, always use prepared samples.

C.4.2 Determining the Data Quality of *In Situ* Testing

It is important for operators who rely extensively on *in situ* testing to determine the data quality of this testing at any given site. This protocol is not intended for every sample, but rather for a small percentage of samples considered representative of the site. If the operator can demonstrate that quantitative data is achieved with little or no sample preparation, then the site characterization will be completed much more quickly, and with greater accuracy.

For example, an operator may be able to demonstrate that the XRF result changes considerably when samples are passed through a 2 mm sieve, but that the XRF results do NOT change appreciably upon finer sieving. In this case, the operator would be able to conclude that good XRF data is achievable with only 2 mm sieving. Sieving only to this level requires far less time than it would with more robust sample preparation.

To determine the appropriate level of sample preparation

1. Delineate a region of soil measuring approximately 10 cm × 10 cm.
2. Perform several *in situ* tests in this area, or collect the top 6 mm (0.25 in.) or so of soil from this region, then bag the soil and perform a test through the bag. In both cases, average the results.
3. If you did not bag the *in situ* test sample, collect the top 6 mm or so of soil from this region, and then pass it through the 2 mm sieve provided. If you did bag the *in situ* test sample, pass it through the sieve.
4. Thoroughly mix the sieved sample, and then place some of the sieved material into an XRF cup and perform a test on this sample.

If the results of this prepared sample differ by less than 20 % from the average *in situ* result:

- This indicates that the soil in this region is reasonably homogeneous. The data quality in this case is probably at the semi-quantitative level, as opposed to just screening data.

If the results of this prepared sample differ by more than 20 %:

- This indicates that the soil is not very homogeneous, and that there are serious particle-size effects influencing your *in situ* measurements.

  In this case, sieve the sample through the ~250 µm sieve. Mix this sample, and then place a subsample into an XRF cup for testing. If this result differs from the previous result by less than 20 %, at the very minimum 2 mm sieving is required to achieve higher data quality.

  If this result differs by more than 20 % from the sample with 2 mm sieving, this indicates that particle-size effects are still influencing the XRF result. In this case, samples should be sieved through a 125 µm sieve to ensure data quality at the quantitative level.

C.5 X-Ray Fluorescence Analyzer Calibration

The Olympus X-ray fluorescence analyzer is capable of running three different calibration methods, as described below.

Compton Normalization

The Compton normalization method of calibration consists of analyzing a single, well-characterized standard, such as an SRM or SSCS. The standard data is normalized to the Compton peak. The Compton peak is produced from incoherent backscattering of X-ray radiation from the excitation source, and is present in the spectrum of every sample. The matrix affects the way in which source radiation is scattered off the samples. This scatter is directly related to the intensity of the Compton peak. For this reason, normalizing to the Compton peak can reduce matrix effect problems that vary among samples. Compton normalization is similar to the use of internal standards for analysis of organic analytes.

In the majority of cases, customers use the Compton normalization method. This method (recognized in EPA 6200) offers speed, ease of use, and fairly good accuracy for concentration ranges from the ppm level up to 2 % to 3 % concentrations. Because most field testing is conducted to remediate or locate environmental contaminants, the upper limit of the calibration (2 % to 3 %) is generally not a limitation.

Fundamental Parameters (FP)

The fundamental parameters (FP) calibration method is a standardless calibration technique. As opposed to establishing a unit's calibration curve by measuring its response to standards that contain analytes of known concentrations, FP calibration relies on the known physics of the spectrometer's response to pure elements in order to set the calibration. Built-in mathematical algorithms are used to adjust the calibration for analysis of soil samples, and to compensate for the effects of the soil matrix. The FP calibration is performed by the manufacturer, but the analyst can adjust the calibration curves (slope and y-intercept) on the basis of results of analyses of check samples (such as SRMs), which are analyzed in the field.

If customers require a calibration corresponding to up to 100 % concentration (in other words, a pure element), Olympus recommends that they also include the Fundamental Parameters (FP) software module with the analyzer. The FP module may be added at the time of purchase, or as an upgrade at a later date.

NOTE

In general, customers do not need to calibrate Olympus analyzers for soil testing. The analyzer is delivered with a factory calibration largely based on the Compton normalization (CN) method. Over the past several years, the CN method has been proven to provide a robust calibration largely independent of site-specific soil-matrix chemistry.
All customers should follow the QC procedure described in "Quality Assurance" on page 131, which includes a calibration check.

Empirical calibration

The empirical calibration method requires the use of a number of site-specific calibration standards (SSCS) in order to establish calibration parameters. The instrument response to known analytes is measured and used to create calibration curves. Empirical calibration is effective, because the samples used closely match the sample matrix. SSCSs are well-prepared samples collected from the site of interest, and which contain concentrations of analytes that have been determined by inductively coupled plasma (ICP), atomic absorption (AA), or other methods.

The standards should contain all the analytes of interest, in addition to the interfering analytes. Manufacturers recommend that 10 to 20 calibration samples be used to generate a calibration curve. The empirical method is the least desirable calibration method, because it requires that new standards and curves be generated for each site that is analyzed.

In the case of empirical calibration, customers run standards to generate calibration curves for various elements in specific soil matrices. With a well-prepared sample, the empirical method generally yields the most accurate result. In our experience, the accuracy gains obtained by switching from Compton normalization to the empirical mode are minimal, and not worth the extra effort of setting up calibration curves.

The empirical calibration module is an optional software package that can be purchased as an upgrade option with the instrument, or at a later date.

NOTE

The greatest source of error in in-field XRF soil analysis is lack of adequate sample preparation. As such, there is little gained by developing a sophisticated empirical calibration if the operator does not grind and homogenize all measured samples.

Calibration Requirements

The concentration of an element in a soil sample is well described by the following formula:

$$\omega_i = \left(\frac{k_i}{M(Z,I)}\right) I_i$$

where:

k_i = calibration constant for element i

ω_i = concentration of element *i* — the quantity being measured

I_i = measured X-ray intensity from element i

$M(Z,I)$ = soil matrix value

The factory calibration determines the value of the calibration constants (ki) for each element, and a typical value *M(Z,I)*. The calibration method —either CN, fundamental parameters, or empirical— performs the necessary corrections to the value *M(Z,I)* that are important for the site-specific soil chemistry. The XRF analyzer uses the measured intensity of each element’s fluorescence from the sample, and the calibration data, to produce elemental concentrations.

C.6 Effects of Moisture on XRF Results

Sample moisture has two effects on XRF results:

- It alters the soil chemistry, since water is another chemical compound in the soil matrix.
- It impedes the ability to properly prepare samples.

There is a further testing consideration:

- Laboratory results are provided on a dry-weight basis.

C.6.1 Effect on Soil Chemistry

While the presence of significant moisture does impact the soil chemistry, modern XRF analyzers all perform automatic corrections for site-to-site variations in soil chemistry. Indeed, such variations are expected, which is the reason why analyzers use Compton normalization or fundamental parameters to correct for moisture content changes and other differences in soil geochemistry.

It is known that moisture content above 20 % may cause problems, because moisture alters the soil matrix for which the FPXRF has been calibrated. However, the Compton normalization or fundamental parameters method is implemented to automatically correct results for changes to the soil matrix. Thus, we believe that changes to the moisture content do not have a significant effect on accuracy, with the exception of the dilution effect, which can cause discrepancies in laboratory results, as described below.

C.6.2 Sample Preparation Issues

We believe that the inability to adequately prepare a wet sample is the single biggest source of error when testing wet samples. It is very difficult to grind or sieve a wet sample. The highest quality XRF results are generally obtained from prepared samples.

Laboratory tests on dry-weight basis

Laboratories always dry samples prior to analysis. They report percentage weight content based on a dry sample. Portable XRF is often used to analyze wet samples in the field, and as such, the results reported include moisture content. Thus, if all other factors are the same, the laboratory results will report higher levels than portable XRF. The results will be higher in proportion to the amount of moisture content in the sample. For example, laboratory results will be 10 % higher as compared with the XRF results if the sample contains 10 % water by weight when tested with XRF. Please note, this applies to samples for which other possible sources of error are the same or negligible.

C.7 Comparing XRF Results to Laboratory Results

Olympus strongly recommends that operators compare prepared sample results with laboratory results, because prepared sample results yield the best possible accuracy with portable XRF. Moreover, the most common source of error is due to nonuniform samples. No analytical technique, and that includes XRF, can properly account for nonuniform sample types.

To perform a comparison between XRF results and laboratory results

1. Collect a sample and prepare it in accordance with instructions provided in the sample preparation guide provided in “Sample Preparation Procedures and Testing Protocols” on page 139.
2. Take a subsample (5–10 grams) of the fully prepared sample, and then place it in an XRF cup.

3. Perform a minimum one-minute long test on that sample.
4. Send the tested sample to the laboratory for wet chemistry analysis.

IMPORTANT

Instruct the laboratory to use a total-digestion method. If the laboratory does not use this method, they may not succeed in extracting all of the elemental metal from the sample. In such case, the lab result will be lower than the XRF result. Incomplete sample digestion is one of the most common sources of laboratory error, thus it is very important to request a total-digestion method.

Example of error

The operator collects a bag of sample, performs XRF analysis on one part of the bag, and then sends the bag, or a portion of the sample in the bag, to a laboratory for analysis. The value reported by the laboratory is significantly different than the value obtained by the operator using XRF.

Problem

Since the sample is very nonhomogeneous, the operator's result was not representative of the entire bag of sample. The lab analyzed a different part of the sample, and obtained a very different result due to the nonuniformity of the sample. The most basic solution to this problem would be to test several locations in the bag of sample and report the average value. It would also be advisable to note any differences between the tests, as such differences are indicative of the nonuniformity of the sample. The operator should send the entire bag of sample to the lab, and instruct the lab to prepare the sample before removing the subsample for lab analysis.

Best Practice

The operator should homogenize and prepare the entire bag of sample, and then collect a subsample for XRF testing. After testing, the tested sample should be sent to the lab.

C.8 Common Interferences

Interference occurs when the spectral peak from one element either partially or completely overlaps with the spectral peak of another.

Case 1 Conditions

If calibrated for both elements, one causing the interference and the other affected by it, the instrument should be capable of correctly handling the interference. In such case, the element being interfered with may be measured with a lower detection limit or less precision; however, the analytical results should still be acceptable for field-portable XRF.

Example: Lead and arsenic

Most XRFs are calibrated for lead and arsenic. Lead interferes with arsenic (although not vice-versa). The net effect is a lower detection limit for arsenic, and less precision. The XRF handles the correction automatically, but precision is affected, although this loss of precision is reported by the XRF.

NOTE

Refer to the Olympus applications sheet entitled: *Arsenic and Lead in Soil* (formerly *In-field Analysis of Lead and Arsenic in Soil Using Portable XRF)* for more details.

Case 2 Conditions

If the XRF is not calibrated for the element causing the interference, the instrument may report either the presence of elements that are not within the sample, or greatly elevated concentrations of elements that may or may not be within the sample.

Example: Bromine

There is bromine within the sample, but the XRF is not calibrated for bromine. Bromine, is a fire retardant that is being turning up in more and more soil and other types of samples. For this reason, Olympus analyzers include Br in the calibration data. If the analyzer is not calibrated for Br, but it is present within the sample, the analyzer will report highly elevated levels of Pb, Hg, and As. The levels will vary depending on the concentration of Br in the sample.

Interferences between elements can be broadly categorized into two types:

- Z, Z–1, Z+1 interferences

  Occur when high levels of an element of atomic number Z are present. This can cause elevated levels of elements with atomic number Z–1 or Z+1. Generally speaking, portable XRFs have good correction methods, so these interferences only cause problems when there are very high levels of the element in question. Example: High concentrations of Fe (Z = 26) in excess of 10 % may cause elevated levels of Mn or Co (Z = 25 or Z = 27 respectively).

- K/L interferences

  Occur when the L-shell line of one element overlaps with the K-shell spectral line of another element. The most common example is lead/arsenic interference, in which the L-alpha line of lead is in almost the exact same location as the K-alpha line of arsenic.

C.9 Sample Preparation Procedures and Testing Protocols

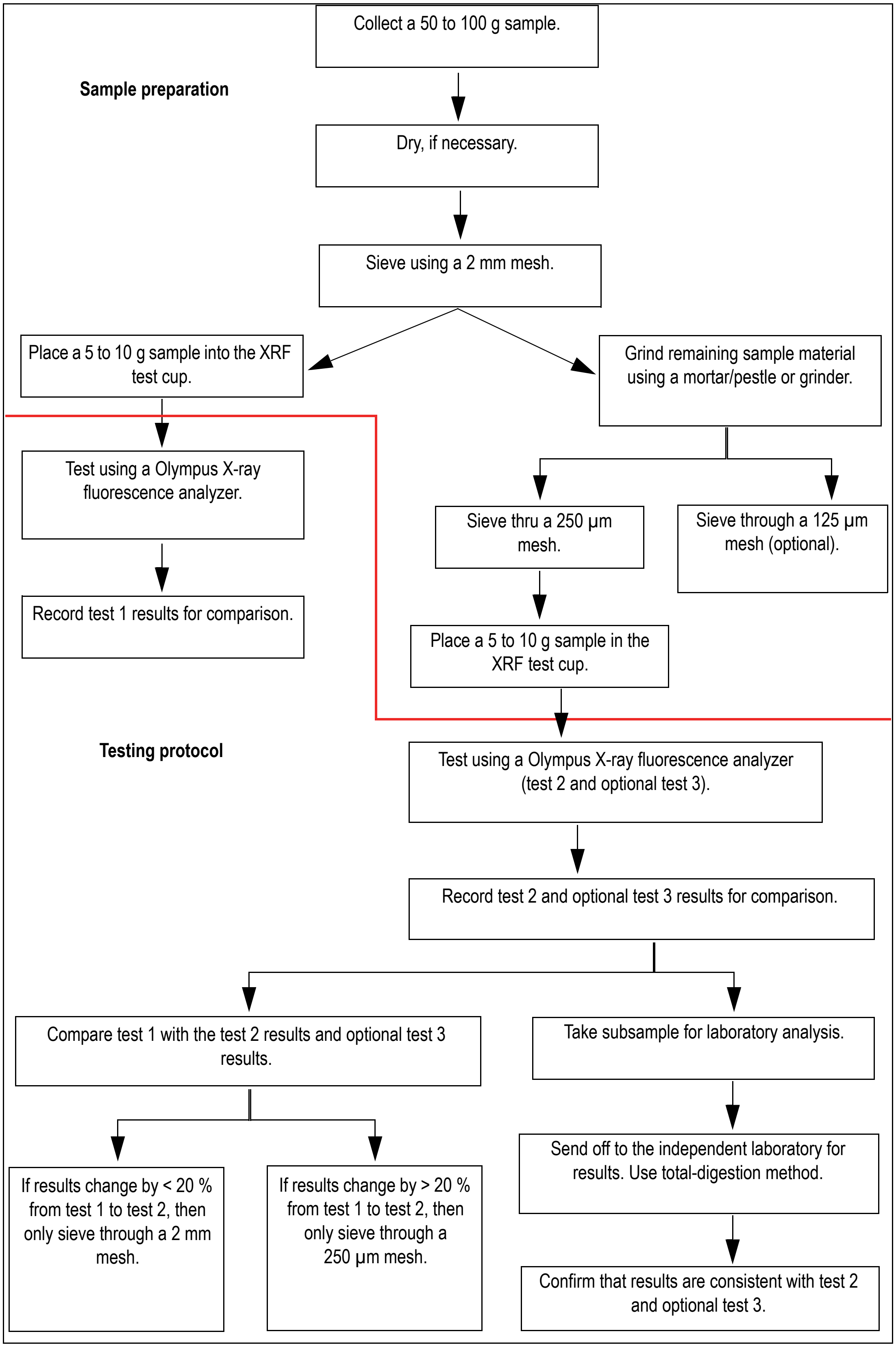
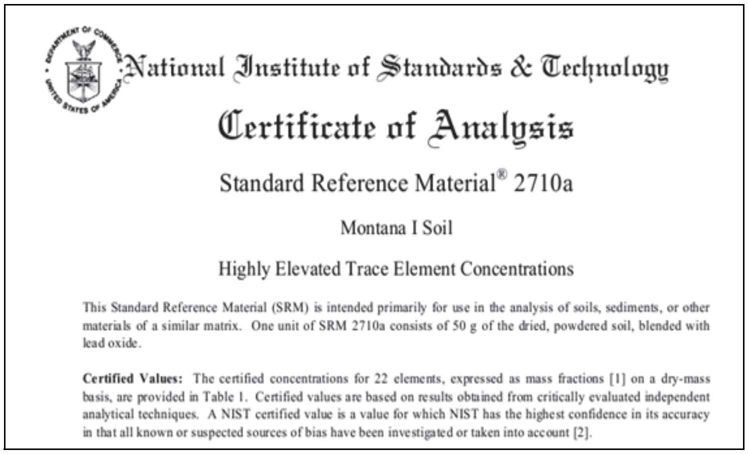


Figure C-1 Sample preparation procedures and testing protocols

C.10 NIST Certificates of Analysis

Olympus systems provides three National Institute of Standards and Technology (NIST) standards (subject to change with availability): SRM2710a, SRM2711a, and SiO2. Each standard's certified values are provided in Table 1, and reference values are provided in Table 2. Figure C-2 on page 140 outlines the Standard Reference Material (SRM) 2710a.



Standard Reference Material (SRM) 2710a

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2710a

Montana I Soil

Highly Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. One unit of SRM 2710a consists of 50 g of the dried, powdered soil, blended with lead oxide.

Certified Values: The certified concentrations for 22 elements, expressed as mass fractions [1] on a dry-mass basis, are provided in Table 1. Certified values are based on results obtained from critically evaluated independent analytical techniques. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [2].

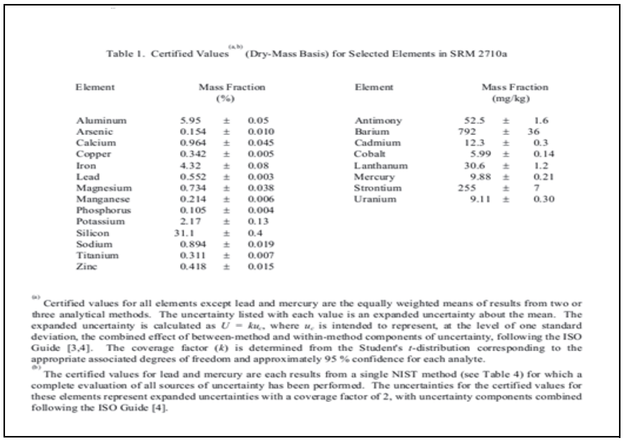


Table 1. Certified values

Table 1. Certified Values[a,b] (Dry-Mass Basis) for Selected Elements in SRM 2710a

Element	Mass Fraction (%)			Element	Mass Fraction (mg/kg)		
Aluminum	5.95	±	0.05	Antimony	52.5	±	1.6
Arsenic	0.154	±	0.010	Barium	792	±	36
Calcium	0.964	±	0.045	Cadmium	12.3	±	0.3
Copper	0.342	±	0.005	Cobalt	5.99	±	0.14
Iron	4.32	±	0.08	Lanthanum	30.6	±	1.2
Lead	0.552	±	0.003	Mercury	9.88	±	0.21
Magnesium	0.734	±	0.038	Strontium	255	±	7
Manganese	0.214	±	0.006	Uranium	9.11	±	0.30
Phosphorus	0.105	±	0.004				
Potassium	2.17	±	0.13				
Silicon	31.1	±	0.4				
Sodium	0.894	±	0.019				
Titanium	0.311	±	0.007				
Zinc	0.418	±	0.015				

[a] Certified values for all elements except lead and mercury are the equally weighted means of results from two or three analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean. The expanded uncertainty is calculated as $U = ku_c$, where u_c is intended to represent, at the level of one standard deviation, the combined effect of between-method and within-method components of uncertainty, following the ISO Guide [3,4]. The coverage factor (k) is determined from the Student's t-distribution corresponding to the appropriate associated degrees of freedom and approximately 95 % confidence for each analyte.

[b] The certified values for lead and mercury are each results from a single NIST method (see Table 4) for which a complete evaluation of all sources of uncertainty has been performed. The uncertainties for the certified values for these elements represent expanded uncertainties with a coverage factor of 2, with uncertainty components combined following the ISO Guide [4].

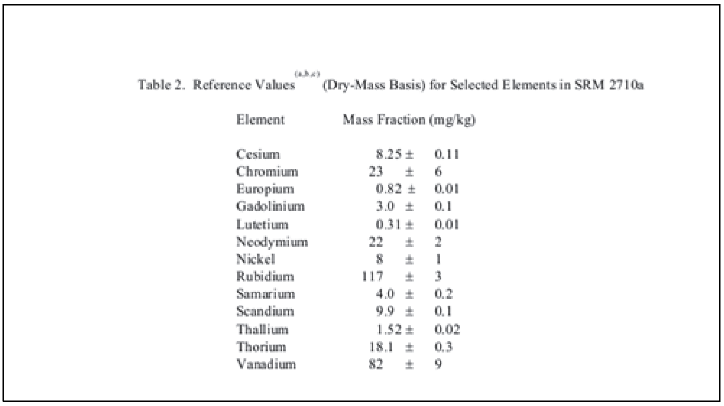


Table 2. Reference values

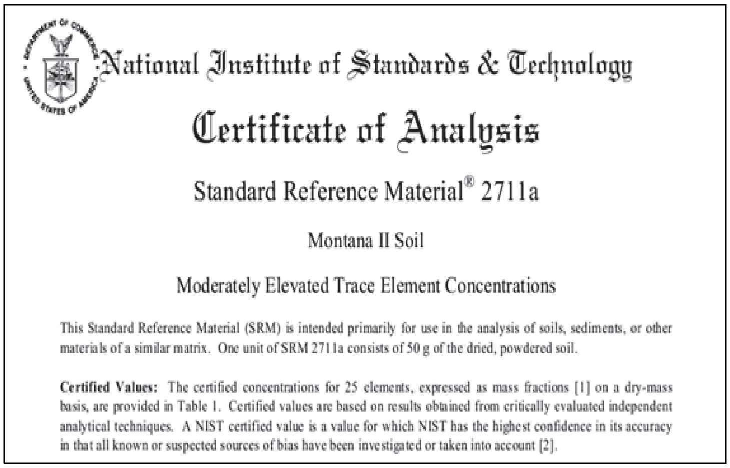
Table 2. Reference Values[a,b,c] (Dry-Mass Basis) for Selected Elements in SRM 2710a

Element	Mass Fraction (mg/kg)		
Cesium	8.25	±	0.11
Chromium	23	±	6
Europium	0.82	±	0.01
Gadolinium	3.0	±	0.1
Lutetium	0.31	±	0.01
Neodymium	22	±	2
Nickel	8	±	1
Rubidium	117	±	3
Samarium	4.0	±	0.2
Scandium	9.9	±	0.1
Thallium	1.52	±	0.02
Thorium	18.1	±	0.3
Vanadium	82	±	9

Figure C-2 Standard Reference Material (SRM) 2710a

Figure C-3 on page 141 outlines Standard Reference Material (SRM) 2711a.

Standard Reference Material (SRM) 2711a



National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2711a

Montana II Soil

Moderately Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. One unit of SRM 2711a consists of 50 g of the dried, powdered soil.

Certified Values: The certified concentrations for 25 elements, expressed as mass fractions [1] on a dry-mass basis, are provided in Table 1. Certified values are based on results obtained from critically evaluated independent analytical techniques. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [2].

Table 1. Certified values

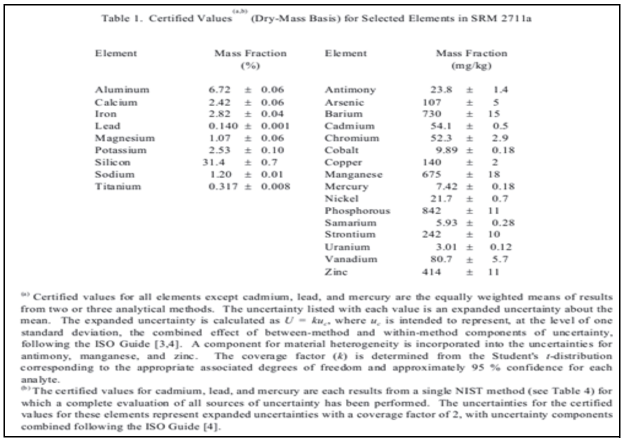


Table 1. Certified Values[(a,b)] (Dry-Mass Basis) for Selected Elements in SRM 2711a

Element	Mass Fraction (%)	Element	Mass Fraction (mg/kg)
Aluminum	6.72 ± 0.06	Antimony	23.8 ± 1.4
Calcium	2.42 ± 0.06	Arsenic	107 ± 5
Iron	2.82 ± 0.04	Barium	730 ± 15
Lead	0.140 ± 0.001	Cadmium	54.1 ± 0.5
Magnesium	1.07 ± 0.06	Chromium	52.3 ± 2.9
Potassium	2.53 ± 0.10	Cobalt	9.89 ± 0.18
Silicon	31.4 ± 0.7	Copper	140 ± 2
Sodium	1.20 ± 0.01	Manganese	675 ± 18
Titanium	0.317 ± 0.008	Mercury	7.42 ± 0.18
		Nickel	21.7 ± 0.7
		Phosphorous	842 ± 11
		Samarium	5.93 ± 0.28
		Strontium	242 ± 10
		Uranium	3.01 ± 0.12
		Vanadium	80.7 ± 5.7
		Zinc	414 ± 11

(a) Certified values for all elements except cadmium, lead, and mercury are the equally weighted means of results from two or three analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean. The expanded uncertainty is calculated as $U = ku_c$, where u_c is intended to represent, at the level of one standard deviation, the combined effect of between-method and within-method components of uncertainty, following the ISO Guide [3,4]. A component for material heterogeneity is incorporated into the uncertainties for antimony, manganese, and zinc. The coverage factor (k) is determined from the Student's t-distribution corresponding to the appropriate associated degrees of freedom and approximately 95 % confidence for each analyte.

(b) The certified values for cadmium, lead, and mercury are each results from a single NIST method (see Table 4) for which a complete evaluation of all sources of uncertainty has been performed. The uncertainties for the certified values for these elements represent expanded uncertainties with a coverage factor of 2, with uncertainty components combined following the ISO Guide [4].

Table 2. Reference values

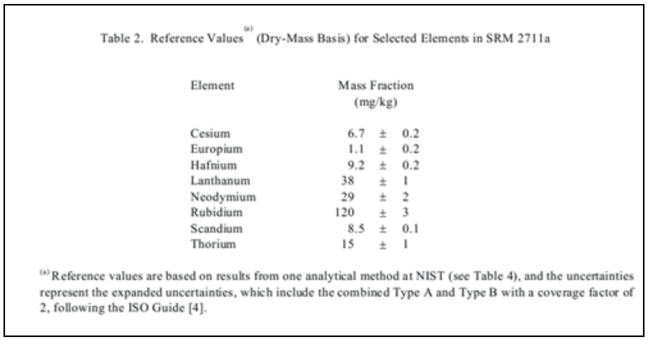


Table 2. Reference Values[(a)] (Dry-Mass Basis) for Selected Elements in SRM 2711a

Element	Mass Fraction (mg/kg)
Cesium	6.7 ± 0.2
Europium	1.1 ± 0.2
Hafnium	9.2 ± 0.2
Lanthanum	38 ± 1
Neodymium	29 ± 2
Rubidium	120 ± 3
Scandium	8.5 ± 0.1
Thorium	15 ± 1

(a) Reference values are based on results from one analytical method at NIST (see Table 4), and the uncertainties represent the expanded uncertainties, which include the combined Type A and Type B with a coverage factor of 2, following the ISO Guide [4].

Figure C-3 Standard Reference Material (SRM) 2711a

Appendix D: Alloy Grade Libraries

Every DELTA X-ray fluorescence analyzer is supplied with four libraries:

- The Factory library unique to every model (see the following pages for tables showing model/factory grade names).
- The Tramp library.
- User library #1 (the user can store over 500 grade names).
- User library #2 (the user can store over 500 grade names).

NOTE

Libraries are editable. However, Olympus does not recommend that users edit the Factory Grade library.

D.1 Tramp Library

Every analyzer is shipped with a Tramp library comprised of seven base alloys (see Table 24 on page 144). The Tramp library supports other grade libraries.

Tramp limits can be set, element by element, alloy base by alloy base, to meet specific requirements.

A single click can globally select/deselect the Tramp features.

How the Tramp library works

1. Tramp grades are matched to alloy bases rather than specific grades.
    - Each sample is determined to be one of seven possible base alloys (see list below).
    - The analyzer applies the Tramp grade/base-specific tramp limits from the matching Tramp grade.
2. These Tramp or “alloy-base-specific” limits are applied when an element is detected in a specific grade.
    - But, the nearest grade match has no specification for that element, and;
    - The concentration of the sample is less than the max limit specified by the matching Tramp grade.
3. Once the conditions for step 2 are met, the element is reported on the user interface screen in blue:
    - Is labeled as a Tramp material in the grade comparison table
    - The grade match; however, is not penalized.

Practical Advantages of the Tramp Element Approach

- Faster sorting
- Fewer ambiguous or incorrect matches
- Improved grade library integrity
- Prominent labeling of tramp elements

Table 24 Tramp library base alloys

Alloy base	Common Tramp elements
_AlAlloyBase	Pb, Bi, Sn, Fe, Cu, and Zn.
_CoAlloyBase	Al, Ti, V, Cu, Nb, Ta, and Zr.
_CuAlloyBase	S, As, Ag, Sb, and Sn; not as common Pb, Co, and Ni.
_FeAlloyBase	V, Co, Cu, Ni, and As; sometimes Si, W, and Nb.
_GenericAlloyBase	V, Co, Cu, Ni, and As; sometimes Si, W, and Nb.
_NiAlloyBase	V, Co, W, Zr, and Nb; sometimes Ta, Mo, Cr, and Cu.
_TiAlloyBase	Fe is common; Cu and Si show up at low levels.

D.2 DELTA Classic, Classic Plus, Inspector, and Element Factory Grade library

Table 25 Aluminum, cobalt alloys, and speciality grades

Aluminum	Cobalt alloys	Speciality grades
2007	Alloy 686	60Sn-40Pb
2011	AlnicoVIII	63Sn-37Pb
2018	Cobalt	96-4
2117	Elgiloy	AZ31B
2618	F75	AZ91A or C
4032	FSX-414	SAC 300
5454	Haynes188	SAC 305
6040	Haynes36	SAC 400
6061	HS-1	SAC 405
6070	HS-12	97-3
6253	HS-19	Ag
6262	HS-21	Au
7005	HS-25-L605	Bi
7016	HS-31	Cb 103

Table 25 Aluminum, cobalt alloys, and speciality grades *(continued)*

Aluminum	Cobalt alloys	Speciality grades
7019	HS-4	CP Ta
7039	HS-6B	Cr
7050	Jetalloy	Densalloy
7072	MarM302	Hf
7075	MarM509	Mn
7104	MarM905	Mo
1100-plus	MP35N	Nb
2024-plus	MPN159	Ni
2098-2195	Star J	Pb
2219-2519	Ultimet	Pd
3003 or 4 or 5		Re
355-2		Sb
5052-plus		Se
5086-plus		Sn
6063-plus		TungCarb C
7049-149-249		TungCarb S
		V
		W
		Zn
		Zr
		Zr 2 or 4
		Zr 702
		Zr 704
		Zr 705

Table 26 Copper and nickel alloys

Copper alloys			Nickel alloys		
C 110	C 510	C 864	B 1900	I-617	MarM421
C 172	C 524	C 867	B-1900 Hf	I-625	Monel400
C 194	C 534	C 868	C-1023	I-690	Monel411
C 210	C 544	C 875	GMR235	I-700	MonelK500

Table 26 Copper and nickel alloys *(continued)*

Copper alloys			Nickel alloys		
C 220	C 623	C 8932	GTD222	I-702	MuMetal
C 260	C 630	C 903	Hast BC1	I-706	Ni 200
C 270	C 655	C 922	HastB	I-713	NichromeV
C 310	C 667	C 932	HastB2	I-718	Nim101
C 314	C 673	C 937	HastB3	I-720	Nim263
C 330	C 675	C 955	HastC2000	I-722	Nimonic75
C 332	C 706	C194HiCu	HastC22	I-725	Nimonic80A
C 340	C 710	C197HiCu	HastC276	I-738	Nimonic90
C 342	C 715	Elec Cu	HastC4	I-750	PWA1480
C 360	C 745	Muntz	HastF	I-792	PWA1484
C 377	C 752	NarloyZ	HastG	I-800	RA333
C 425	C 814	SeBiLOYI	HastG2	I-801	Rene125
C 443	C 836	SeBiLOYII	HastG3	I-825	Rene142
C 464	C 857	SeBiLOYIII	HastG30	I-901	Rene220
C 482			HastN	I-903	Rene41
C 485			HastR	I-907-909	Rene77
			HastS	I-939	Rene80
			HastW	IN100Mar	Rene95
			HastX	M002	Supertherm
			Haynes230	MarM200	Udimet500
			HR160	MarM246	Udimet520
			HyMu80	MarM247	Udimet700
			I-102I-49		Waspaloy
			I-600		
			I-601		

Table 27 Low-alloy and chrome-moly steels

Low-alloy steels	Chrome-moly steels
3310	1 1-4 Cr
4130	2 1-4 Cr
4140	5 Cr

Table 27 Low-alloy and chrome-moly steels *(continued)*

Low-alloy steels	Chrome-moly steels
4340	9 Cr
8620	P91
9310	
12L14	
A10	
Carb 1-2 Moly	
Carbon Steel	
20Mo4	

Table 28 Stainless, Ti, and tool steels

Stainless grades			Ti grades	Tool steels
201	21-6-9	Haynes556	Cp Ti	A2
203	25-4-4	Incoloy840	Cp Ti Pd	A6
304	254SMO	Invar 36	Ti 12	A7
309	26-1	Kovar	Ti 17	D2 or D4
310	29-4	M152	Ti 3 2-5	D7
316	29-4-2	Maraging350	Ti 6-22-22	H-11
317	29-4C	MaragingC200	Ti 6-2-4-2	M1
321	302HQ	MaragingC250	Ti 6-2-4-6	M2
329	410 Cb	MaragingC300	Ti 6-4	M4
330	410-16-20	N-155	Ti 6-6-2	M42
347	904L	Ni-hard#1	Ti 8	O1
422	A-286	Ni-hard#4	Ti 8-1-1	O2
430	AL6XN	Ni-Span902	Ti 10-2-3	O6
431	Alloy42	Nitronic40	Ti 15-3-3-3	S1
434	AlnicoII	Nitronic50	Ti 3-11-13	S5
440	AlnicoIII	Nitronic60	Ti 5 - 2-5	S6
441	AlnicoV	RA330	Ti 6-2-1-1	S7
446	AMS350	RA85H	TiBetaC	T1
2003	AMS355	Zeron100		
2101	CD4MCU			

Table 28 Stainless, Ti, and tool steels *(continued)*

Stainless grades			Ti grades	Tool steels
2507	Custom450			
13-8 Mo	Custom455			
15-5 PH	Duplex2205			
15Mn7Cr	E-bite			
17-4 PH	Ferallium255			
17-7 PH	GreekAscoloy			
19-9DL	H12			
19-9DX	H13			
20Cb3				
20Mo6				

D.3 DELTA Standard and Professional Factory Grade library

Table 29 Aluminum, cobalt alloys, and speciality grades

Aluminum	Cobalt alloys	Speciality grades
319	Alloy 686	60Sn-40Pb
333	AlnicoVIII	63Sn-37Pb
380	Cobalt	96-4
383	Elgiloy	AZ31B
384	F75	AZ91A or C
2007	FSX-414	SAC 300
2011	Haynes188	SAC 305
2018	Haynes36	SAC 400
2024	HS-1	SAC 405
2117	HS-12	97-3
2618	HS-19	Ag
3004	HS-21	Au
4032	HS25-L605	Bi
5042	HS-31	Cb 103
5052	HS-4	CP Ta
5083	HS-6B	Cr

Table 29 Aluminum, cobalt alloys, and speciality grades *(continued)*

Aluminum	Cobalt alloys	Speciality grades
5086	Jetalloy	Densalloy
5154	MarM302	Hf
5454	MarM509	Mn
6040	MarM905	Mo
6061	MP35N	Nb
6070	MPN159	Ni
6253	Star J	Pb
6262	Ultimet	Pd
7005		Re
7016		Sb
7019		Se
7039		Sn
7050		TungCarb C
7072		TungCarb S
7075		V
7104		W
1100-plus		Zn
2014-17 std		Zr
2024-plus		Zr 2 or 4
2098-2195		Zr 702
2219-2519		Zr 704
3003 or 4 or 5		Zr 705
3003 or 5		
355-2		
356-57-std		
5052-plus		
5056-82		
5086-plus		
6063-plus		
7049-149-249		

Table 30 Copper and nickel alloys

Copper alloys			Nickel alloys		
C 110	C 510	C 864	20Mo4	I-102	MarM247
C 172	C 524	C 867	B 1900	I-49	MarM421
C 194	C 534	C 868	B-1900 Hf	I-600	Monel400
C 210	C 544	C 875	C-1023	I-601	Monel411
C 220	C 623	C 8932	Colmonoy 6	I-602	MonelK500
C 260	C 630	C 903	GMR235	I-617	MuMetal
C 270	C 655	C 922	GTD222	I-625	Ni 200
C 310	C 667	C 932	Hast BC1	I-690	NichromeV
C 314	C 673	C 937	HastB	I-700	Nim101
C 330	C 675	C 955	HastB2	I-702	Nim263
C 332	C 706	C194HiCu	HastB3	I-706	Nimonic75
C 340	C 710	C197HiCu	HastC2000	I-713	Nimonic80A
C 342	C 715	Elec Cu	HastC22	I-718	Nimonic90
C 360	C 745	Muntz	HastC276	I-720	PWA1480
C 377	C 752	NarloyZ	HastC4	I-722	PWA1484
C 425	C 814	SeBiLOYI	HastF	I-725	RA333
C 443	C 836	SeBiLOYII	HastG	I-738	Rene125
C 464	C 857	SeBiLOYIII	HastG2	I-750	Rene142
C 482			HastG3	I-792	Rene220
C 485			HastG30	I-800	Rene41
			HastN	I-801	Rene77
			HastR	I-825	Rene80
			HastS	I-901	Rene95
			HastW	I-903	Supertherm
			HastX	I-907-909	Udimet500
			Haynes214	I-939	Udimet520
			Haynes230	IN100	Udimet700
			HR160	MarM002	Waspaloy
			HyMu80	MarM200	
				MarM246	

Table 31 Low-alloy and chrome-moly steels

Low-alloy steels	Chrome-moly steels
3310	1 1-4 Cr
4130	2 1-4 Cr
4140	5 Cr
4340	9 Cr
8620	P91
9310	
12L14	
A10	
Carb 1-2 Moly	
Carbon Steel	
P20	
135 N	

Table 32 Stainless, Ti, and tool steels

Stainless grades			Ti grades	Tool steels
201	17-7 PH	H12	Cp Ti	A2
203	19-9DL	H13	Cp Ti Pd	A6
303	19-9DX	Haynes556	Ti 12	A7
304	20Cb3	Incoloy840	Ti 17	D2 or D4
309	20Mo6	Invar 36	Ti 3 2-5	D7
310	21-6-9	Kovar	Ti 6-22-22	H-11
316	25-4-4	M152	Ti 6-2-4-2	M1
317	254SMO	Maraging350	Ti 6-2-4-6	M2
321	26-1	MaragingC200	Ti 6-4	M4
329	29-4	MaragingC250	Ti 6-6-2	M42
330	29-4-2	MaragingC300	Ti 8	O1
347	29-4C	N-155	Ti 8-1-1	O2
410	302HQ	Ni-hard#1	Ti 10-2-3	O6
416	410 Cb	Ni-hard#4	Ti 15-3-3-3	S1
420	410-16-20	Ni-Span902	Ti 3-11-13	S5

Table 32 Stainless, Ti, and tool steels *(continued)*

Stainless grades			Ti grades	Tool steels
422	904L	Nitronic40	Ti 5 - 2-5	S6
430	A-286	Nitronic50	Ti 6-2-1-1	S7
431	AL6XN	Nitronic60	TiBetaC	T1
434	Alloy42	RA330		
440	AlnicoII	RA85H		
441	AlnicoIII	Zeron100		
446	AlnicoV			
2003	AMS350			
2101	AMS355			
2205	CD4MCU			
2205	Custom450			
2507	Custom455			
13-8 Mo	E-bite			
15-5 PH	Ferallium255			
15Mn7Cr	GreekAscoloy			

D.4 DELTA Premium and Premium Plus Factory Grade library

Table 33 Aluminums, cobalt alloys, and speciality grades

Aluminums	Cobalt alloys	Speciality grades
319	Alloy 686	60Sn-40Pb
333	AlnicoVIII	63Sn-37Pb
356	Cobalt	96-4
357	Elgiloy	AZ31B
380	F75	AZ91A or C
383	FSX-414	SAC 300
384	Haynes188	SAC 305
1100	Haynes36	SAC 400
2007	HS-1	SAC 405
2011	HS-12	97-3
2018	HS-19	Ag

Table 33 Aluminums, cobalt alloys, and speciality grades *(continued)*

Aluminums	Cobalt alloys	Speciality grades
2024	HS-21	Au
2117	HS25-L605	Bi
2618	HS-31	Cb 103
3002	HS-4	CP Ta
3003	HS-6B	Cr
3004	Jetalloy	Densalloy
3005	MarM302	Hf
3105	MarM509	Mn
4032	MarM905	Mo
5005	MP35N	Nb
5042	MPN159	Ni
5052	Star J	Pb
5083	Ultimet	Pd
5086		Re
5154		Sb
5454		Se
5657		Sn
6040		TungCarb C
6061		TungCarb S
6063		V
6070		W
6253		Zn
6262		Zr
7005		Zr 2 or 4
7016		Zr 702
7019		Zr 704
7039		Zr 705
7050		
7072		
7075		

Table 33 Aluminums, cobalt alloys, and speciality grades *(continued)*

Aluminums	Cobalt alloys	Speciality grades
7104		
1100-plus		
2014-17		
2024-plus		
2098-2195		
2219-2519		
3003 or 4 or 5		
355-2		
5052-plus		
5056-82		
5086-plus		
6063-plus		
7049-149-249		

Table 34 Copper and nickel alloys

Copper alloys			Nickel alloys		
C 110	C 510	C863	20Mo4	I-102	MarM246
C 172	C 524	C 864	B 1900	I-49	MarM247
C 194	C 534	C 867	B-1900 Hf	I-600	MarM421
C 210	C 544	C 868	C-1023	I-601	Monel400
C 220	C 623	C 875	Colmonoy 6	I-602	Monel411
C 240	C 630	C 8932	GMR235	I-617	MonelK500
C 260	C642	C 903	GTD222	I-625	MuMetal
C 270	C 655	C 922	Hast BC1	I-690	Ni 200
C 310	C 667	C 932	HastB	I-700	NichromeV
C 314	C 673	C 937	HastB2	I-702	Nim101
C 330	C 675	C 954	HastB3	I-706	Nim263
C 332	C 687	C 955	HastC2000	I-713	Nimonic75
C 340	C 706	C194HiCu	HastC22	I-718	Nimonic80A
C 342	C 710	C197HiCu	HastC276	I-720	Nimonic90
C 360	C 715	Elec Cu	HastC4	I-722	PWA1480

Table 34 Copper and nickel alloys *(continued)*

Copper alloys			Nickel alloys		
C 377	C 745	Muntz	HastF	I-725	PWA1484
C 425	C 752	NarloyZ	HastG	I-738	RA333
C 443	C 814	SeBiLOYI	HastG2	I-750	Rene125
C 464	C 836	SeBiLOYII	HastG3	I-792	Rene142
C 482	C 857	SeBiLOYIII	HastG30	I-800	Rene220
C 485	C 861		HastN	I-801	Rene41
			HastR	I-825	Rene77
			HastS	I-901	Rene80
			HastW	I-903	Rene95
			HastX	I-907-909	Supertherm
			Haynes214	I-939	Udimet500
			Haynes230	IN100	Udimet520
			HR160	MarM002	Udimet700
			HyMu80	MarM200	Waspaloy

Table 35 Low-alloy and chrome-moly steels

Low-alloy steels	Chrome-moly steels
3310	1 1-4 Cr
4130	2 1-4 Cr
4140	5 Cr
4340	9 Cr
8620	P91
9310	
12L14	
A10	
Carb 1-2 Moly	
Carbon Steel	
P20	
135 N	

Table 36 Stainless, Ti, and Tool steels

Stainless grades			Ti grades	Tool steels
201	17-4 PH	H12	Cp Ti	A2
203	17-7 PH	H13	Cp Ti Pd	A6
303	19-9DL	Haynes556	Ti 12	A7
304	19-9DX	Incoloy840	Ti 17	D2 or D4
309	20Cb3	Invar 36	Ti 3 2-5	D7
310	20Mo6	Kovar	Ti 6-22-22	H-11
316	21-6-9	M152	Ti 6-2-4-2	M1
317	25-4-4	Maraging350	Ti 6-2-4-6	M2
321	254SMO	MaragingC200	Ti 6-4	M4
329	26-1	MaragingC250	Ti 6-6-2	M42
330	29-4	MaragingC300	Ti 8	O1
347	29-4-2	N-155	Ti 8-1-1	O2
410	29-4C	Ni-hard#1	Ti 10-2-3	O6
416	302HQ	Ni-hard#4	Ti 15-3-3-3	O7
420	410 Cb	Ni-Span902	Ti 3-11-13	S1
422	410-16-20	Nitronic40	Ti 5-2-5	S5
430	904L	Nitronic50	Ti 6-2-1-1	S6
431	A-286	Nitronic60	TiBetaC	S7
434	AL6XN	RA330		T1
440	Alloy42	RA85H		
441	AlnicoII	Zeron100		
446	AlnicoIII			
2003	AlnicoV			
2101	AMS350			
2205	AMS355			
2205	CD4MCU			
2507	Custom450			
13-8 Mo	Custom455			
15-5 PH	E-bite			
15Mn7Cr	Ferallium255			

Table 36 Stainless, Ti, and Tool steels ***(continued)***

Stainless grades			Ti grades	Tool steels
	GreekAscoloy			

Appendix E: Probe Shield

The DELTA 50 Premium model (DP-4050 or DP-6550-C) is shipped with a probe shield (U8995563) as a standard accessory (see Figure E-1 on page 159). The probe shield provides an increased measure of radiation safety protection by reducing the X-ray backscatter created during a test.

Figure E-1 Probe shield installed on a DELTA 50 Premium analyzer

The DELTA 50 is shipped in a configuration that permits the probe shield to operate at voltages above 40 kV.

There are several ways to configure the DELTA 50 (see “Alloy and Alloy Plus Modes” on page 94):

- The instrument can be operated above 40 kV only in a workstation.
- The instrument can be operated above 40 kV as a handheld device only with a probe shield or in a workstation.
- The user can operate the analyzer as a handheld device at any voltage with warnings based on maximum allowable dose and time operated over 40 kV.

NOTE

An integrated camera is included as a standard feature for DP-6550-C models, and is an optional factory-configured feature for DP-4050 analyzers.

E.1 Installing the Probe Shield

To install the probe shield

1. Locate the set screw inside the probe-shield cavity.

CAUTION

Make sure that the set screw does not protrude into the cavity (see Figure E-2 on page 160), because it could scratch the nose of the analyzer.

---

2. If the set screw does protrude:
   a) Insert a 0.125-in. hex wrench through the access hole (see Figure E-2 on page 160).
   b) Loosen the set screw until its tip does not protrude from the cavity surface.

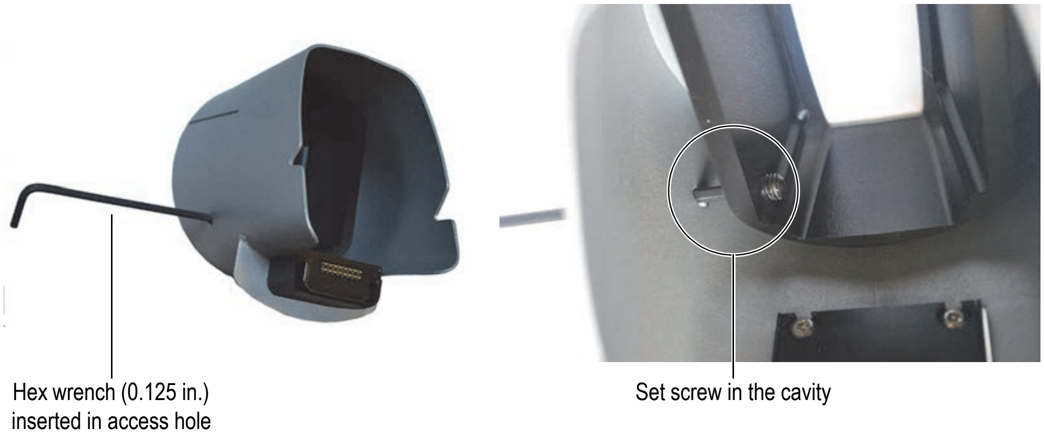


Figure E-2 Probe-shield set screw

3. Place the probe shield on a flat surface (desk or bench) with the nose facing downward (see Figure E-3 on page 160).

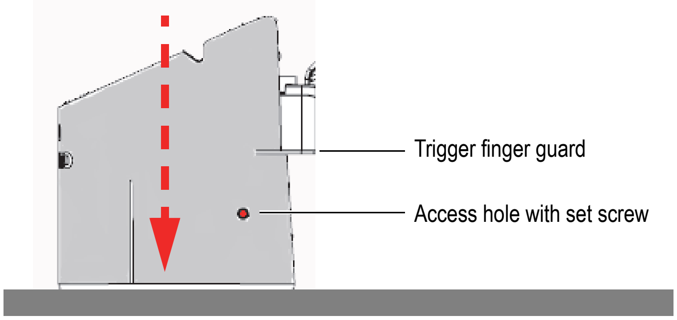


Figure E-3 Probe shield facing down

4. Make sure that the analyzer is turned Off.

5. Carefully slide the analyzer into the probe shield until the interlock connector is seated (see Figure E-4 on page 161).

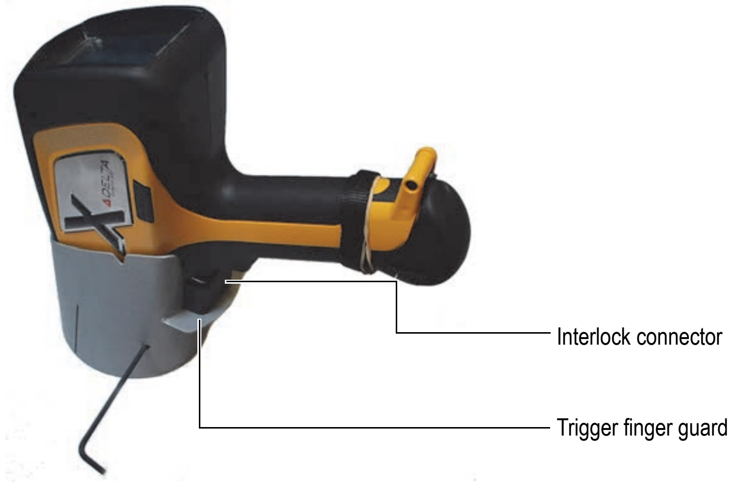


Figure E-4 Probe-shield interlock connection

6. Press the analyzer into the probe shield until it is firmly seated.

CAUTION

The probe shield is secured using this single set screw. To avoid damage to the equipment, do not overtighten the set screw.

---

7. Rotate the hex wrench clockwise to lock the two parts together (see Figure E-5 on page 161).

Figure E-5 Analyzer properly seated and fastened

8. Make sure that the nose of the analyzer stays flush with the front surface of the probe shield (see Figure E-6 on page 162).

Figure E-6 Analyzer flush with the probe shield

E.2 Removing the Probe Shield

To remove the probe shield

1. Insert the hex wrench into the probe-shield access hole.
2. Loosen the set screw (see Figure E-7 on page 162).

Figure E-7 Loosening the set screw

CAUTION

Make sure that the set screw does not protrude into the cavity, because it could scratch the nose of the analyzer.

CAUTION

Do not tamper with the two screws located on the front surface of the probe shield.

E.3 Operation

When the probe shield is installed, the DELTA 50 Premium analyzer is employed in the same manner as other analyzers in the DELTA family. Refer to the *DELTA Family Handheld XRF Analyzer User Interface Guide* and the *DELTA Family Handheld XRF Analyzers Quick Start Guide* for specific information. Pay particular attention to the best radiation safety practices described in these documents.

TIP

- The camera is useful for aiming the instrument at small items, or small areas of a test sample. The camera comes standard with DP-6550-C, and we recommend adding this feature to DP-4050 units.
- Make sure that the measurement window is flush with the target.
- Do not press too hard, because doing so could damage the measurement window film.

NOTE

"User Interface Issues" on page 163 provides special information (screens and instructions) for managing the 50 kV options.

E.4 User Interface Issues

Operating the DELTA 50 Premium analyzers requires attention to certain user interface (UI) screens.

E.4.1 Regulatory Level

The **Regulatory Level** screen reports the maximum annual dose limit for your regulator (in either mR or mSv). The value should be entered by your compliance officer.

NOTE

The lower screen area displays the worst-case running total usage for this 50 kV analyzer (assuming the user is testing samples that cause significant scatter).

To access the Regulatory Level screen

1. On the **Setup** page, tap **Trigger HW** (see Figure E-8 on page 164).

Figure E-8 The Trigger HW button in the Setup page

2. In the **Safety/Hardware** menu, tap **Regulatory Level** (see Figure E-9 on page 164).

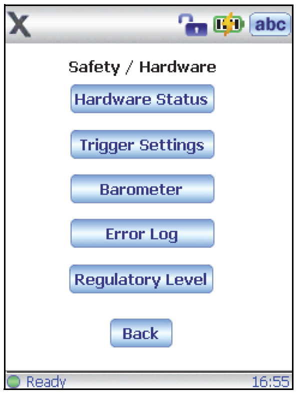
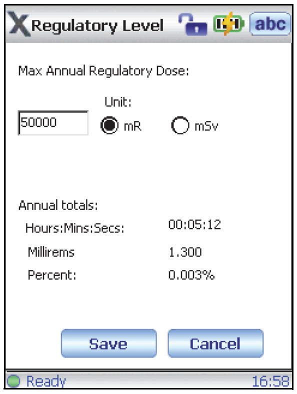


Figure E-9 The Safety/Hardware menu

The **Regulatory Level** screen appears (see Figure E-10 on page 164).



Max Annual Regulatory Dose:

50000 Unit: ● mR ○ mSv

Annual totals:

Hours:Mins:Secs:	00:05:12
Millirems	1.300
Percent:	0.003%

Figure E-10 Regulatory Level information

E.4.2 50 kV Options

The 50 kV options can be adjusted to change the operating requirements of the DELTA 50 analyzer.

CAUTION

You must ONLY select the **50 kV Options** button. Making other selections can effect the analyzer and force you to return the analyzer to the factory for recalibration or reconfiguration.

To access the 50 kV Options screen

1. In the **Setup** screen, tap **Factory** (see Figure E-11 on page 165).

Figure E-11 The Factory button in the Setup screen

2. Enter your password, and then tap **OK** (see Figure E-12 on page 165).

Enter Factory Password

*****

Figure E-12 Password entry

CAUTION

You must ONLY select the **50 kV Options** button. Making other selections can effect the analyzer and force you to return the analyzer to the factory for recalibration or reconfiguration (see Figure E-13 on page 166).

3. Tap **50 kV Options** (see Figure E-13 on page 166).

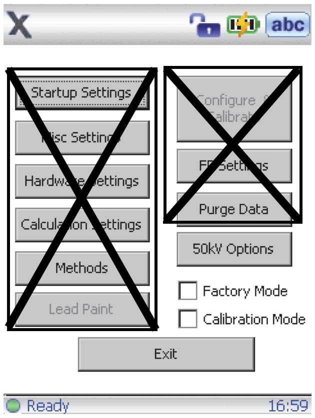
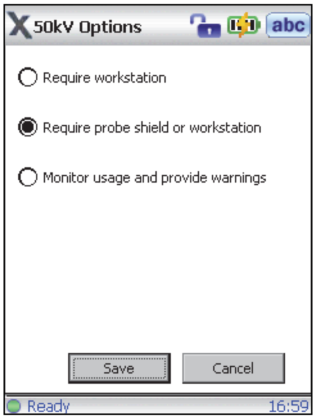


Figure E-13 The 50 kV Options button

4. In the **50 kV Options** screen, select the desired option (see Figure E-14 on page 166).



○ Require workstation

● Require probe shield or workstation

○ Monitor usage and provide warnings

Figure E-14 The 50 kV Options screen

NOTE

The probe shield may be required by some users.

E.4.3 Safety Interlock

The DELTA 50 is shipped in a configuration that requires the probe shield to operate at the 50 kV tube capability.

A safety interlock is installed between the accessory and the analyzer. If the probe shield is missing or incorrectly installed when a test is initiated, a warning message appears in the lower status bar (see Figure E-15 on page 167).

● 50kV Interlock Required 12:06

Figure E-15 Message in the lower status bar

The current test run is aborted. Testing cannot proceed until the probe shield is correctly placed.

NOTE

For probe-shield installation, see “Installing the Probe Shield” on page 160

Appendix F: DELTA Portable Workstation

F.1 Product Overview

The DELTA Portable Workstation provides a fully shielded, rugged test stand for benchtop or remote-controlled testing. It is comprised of:

- An A020-D workstation (U8990865)
- Any DELTA X-ray fluorescence analyzer model

NOTE

In this configuration, the DELTA is controlled by the Olympus DELTA PC software. The open-beam handheld analyzer is then converted into a safe closed-beam workstation.

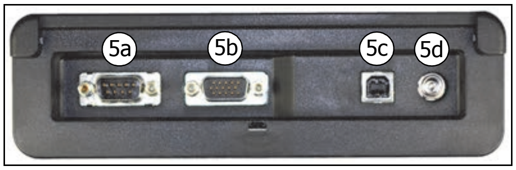
F.1.1 Portable Workstation

Components of the DELTA Portable Workstation appear in Table 37 on page 169.

Table 37 DELTA Portable Workstation components

Component Key		DELTA Portable Workstation — All models
1	Hinged lid	
2	Test chamber	
3	Locking levers	
4	Hinged leg	

Table 37 DELTA Portable Workstation components *(continued)*

Component Key		DELTA Portable Workstation — All models
5	I/O panel: • Serial 9-pin D-Subminiature connector (5a) • 15-pin D-Subminiature connector for the probe adaptor (5b) • USB port (5c) • AC power port (5d)	

F.1.2 Accessories

Components of the DELTA Portable Workstation's accessories appear in Table 38 on page 170.

Table 38 DELTA Portable Workstation's accessories

Component Key		DELTA Portable Workstation — All models
1	DELTA probe adaptor with integrated interface cable (P/N: U8990809)	
2	USB cable (mini USB B to USB A connector) [P/N: U8990455]	
3	Cal Check coupon (316 stainless steel) [P/N: U8990448]	

Table 38 DELTA Portable Workstation's accessories *(continued)*

Component Key		DELTA Portable Workstation — All models
4	AC adapter (18 VDC, 3.9A)	

F.2 Safety Information

F.2.1 Radiation Safety Information

The DELTA Portable Workstation is a secure and dependable system when used in accordance with recommended testing techniques and safety procedures. The radiation detected in the area outside the closed workstation is below the prescribed limit for unrestricted areas.

⚠ **WARNING**

- Olympus analyzers must only be used by trained and authorized operators in accordance with proper safety procedures. Improper use may impair safety protection and cause potential harm to the user.
- Read all warning signs and labels.
- DO NOT USE the workstation if it exhibits any sign of damage, as doing so could result in unintentional emission of stray radiation. If any damage is found or suspected, have a qualified professional perform a radiation safety test and repair the workstation.

F.2.2 AC Adapter

Use only the included AC adapter (18 VDC) to power the DELTA Portable Workstation (see Figure F-1 on page 171).

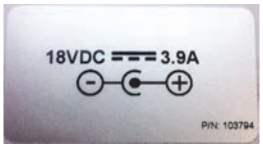


Figure F-1 DELTA Portable Workstation voltage label

CAUTION

Using incompatible equipment could cause malfunction and/or equipment damage.

F.2.3 Safety Interlock Structure

This mandatory feature ensures that the DELTA Portable Workstation functions as a closed-beam X-ray system. To establish a radiation-safe test chamber, the lid must be completely closed over the test platform. Until this condition is met, no test analysis or Cal Check procedures can be initiated.

Examples of the safety interlock structure:

- If the lid is not closed (the safety interlock structure is not engaged for X-ray emission), the Cal Check button or Start Test button is disabled (grayed out). It is not possible to force the X-ray On condition.
- If the lid is opened during an active test, the X-ray tube turns off immediately, and a “Test Aborted” message is displayed. The instrument turns off.

F.2.4 X-Ray Indicator

The X-ray indicator is located on the top of the workstation (see Figure F-2 on page 172). This indicator consists of a four-element amber LED array and has two key functions:

X-ray indicator continuously On (solid amber LED array)

This signifies that the X-ray tube is enabled.

X-ray indicator flashing On (blinking amber LED array)

This signifies that the analyzer is emitting X-ray radiation through the measurement window.

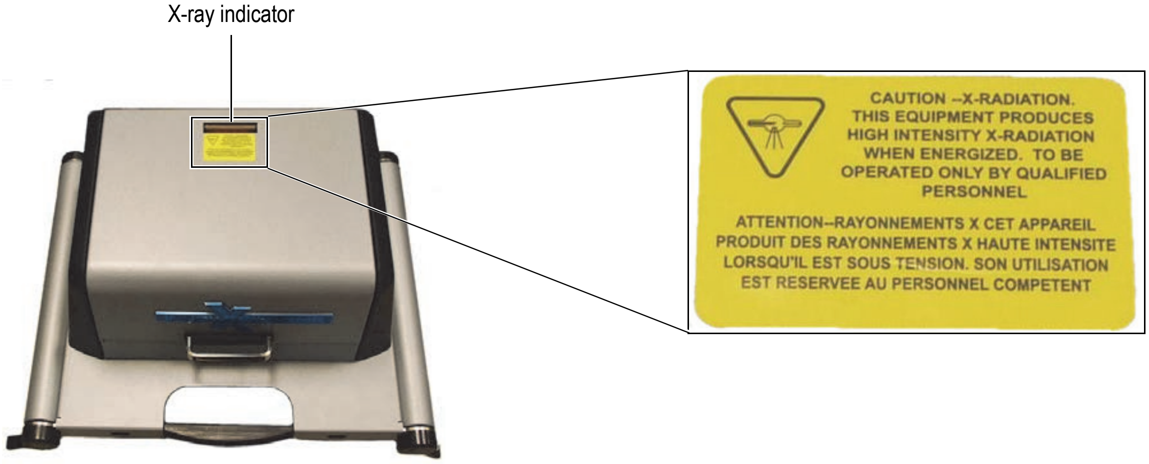


Figure F-2 Caution radiation label on top of workstation

F.2.5 Software Proximity Sensor

Within one second of the start of a test, the analyzer detects the sample in front of the measurement window. If no sample is detected, the X-rays automatically turn off.

F.2.6 Shut Down Under Emergency Conditions

If you believe that the analyzer is locked up in an On condition, and the amber LED array continues to blink, perform the following procedure.

To shut down the analyzer in case of an emergency

◆ Press the Stop Test button on the user interface.

OR

Unplug the probe adaptor cable from the 15-pin D-Subminiature connector on the workstation (see “Portable Workstation” on page 169).

OR

Raise the lid.

NOTE

Opening the lid will not compromise the integrity of the test data.

F.3 Physical Planning

F.3.1 Workstation Footprint

The DELTA Portable Workstation weighs 8.9 kg with the probe adaptor, analyzer, and battery included.

To make a minimum footprint for the workstation, add at least 5.1 cm to the actual 52.1 cm width and 37.5 cm depth. Plan for a 70 cm height when the lid is fully open (see Figure F-3 on page 174). You should be able to comfortably access the analyzer’s lid latch and test chamber.

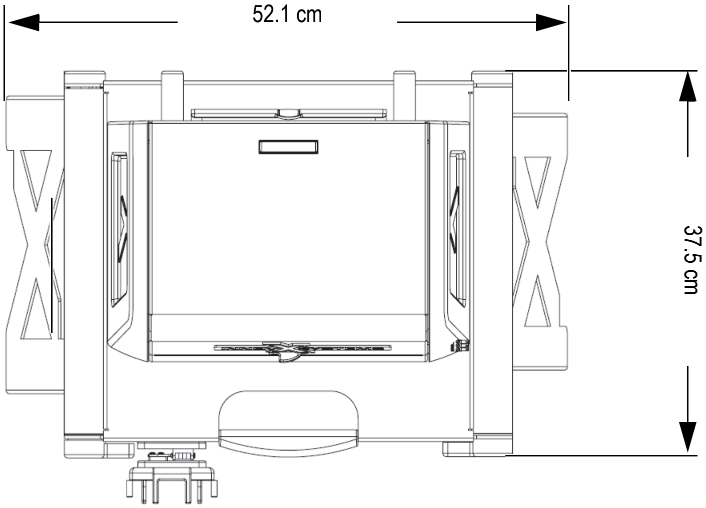


Figure F-3 Workstation: Top view (looking straight down)

F.3.2 Test Chamber Dimensions

Dimensions of the test chamber components appear in Table 39 on page 174.

Table 39 Test chamber dimensions

	Component key	cm	in.
1	Width (side wall to side wall)	24.8	9.75
2	Depth (front to back)	15.6	6.125
3	Center of window to front wall	9.5	3.75
4	Center of window to rear wall	7	2.75
5	Internal height (lid closed) [not shown]	12.4	4.875

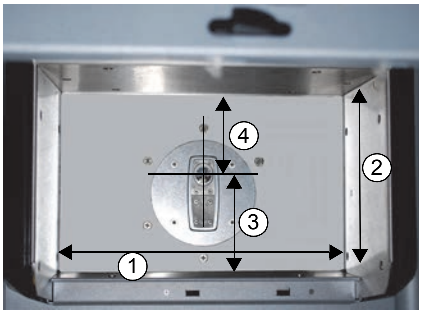


Figure F-4 Test chamber: Top view (looking straight down)

F.3.3 Electrical Requirements

You can use either the removable Li-ion battery (standard) or an AC adaptor (optional). You may also want to use the DELTA docking station or a standard battery charger in the workstation area.

NOTE

Both of the charging accessories require an AC power source.

F.4 Assembling the Workstation

To assemble the workstation

CAUTION

To avoid equipment damage, make sure that there is sufficient clearance when assembling the workstation (see “Workstation Footprint” on page 173).

1. Place the workstation on a table or a bench with its legs facing toward you (see Figure F-5 on page 175).
2. Make sure that the locking levers are open (see Figure F-5 on page 175).

Figure F-5 Folded workstation

3. Swing the legs out to their fully extended position.
4. Lock the legs into place using the two locking levers (see Figure F-6 on page 176).

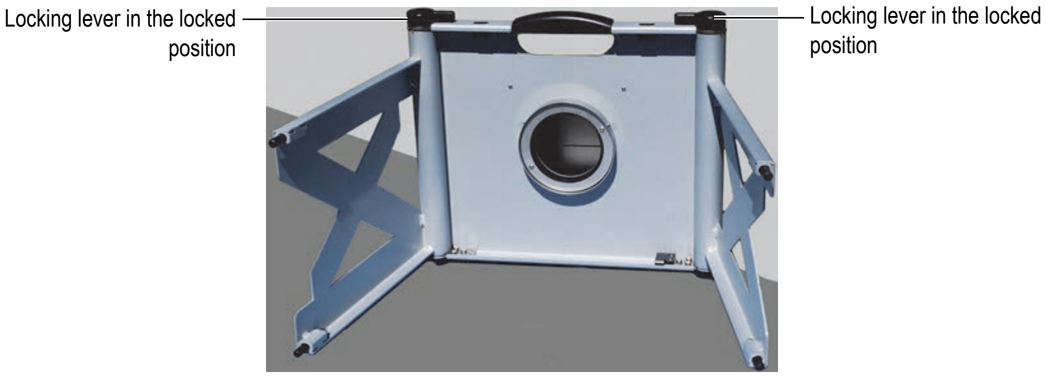


Figure F-6 Legs locked into position

5. Place the workstation upright.
6. If necessary, use leveling feet to stabilize the workstation.
7. Slide the latch (see Figure F-7 on page 176) to the right and open the lid.

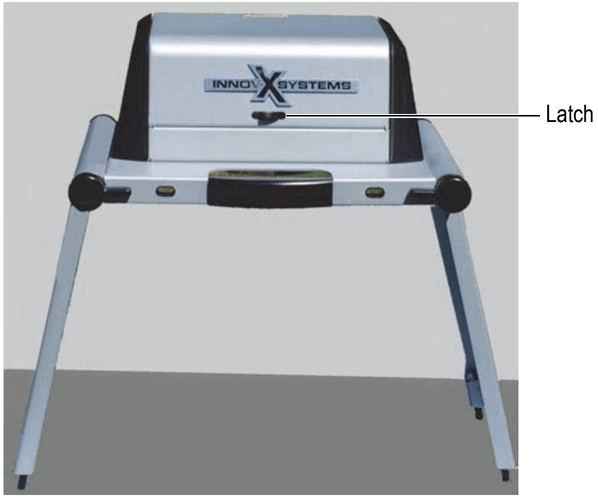


Figure F-7 Lid latch

F.5 Disassembling the Workstation

Before disassembling the workstation, complete the following:

- Turn off the DELTA analyzer.
- Unplug the AC adapter.
- Remove the analyzer-adaptor assembly from the workstation.

CAUTION

Turn OFF the DELTA analyzer before removing the probe adapter from the workstation. Failure to turn OFF the analyzer could result in unintentional operation during removal.

1. Place the workstation on a table or a bench with its legs facing toward you (see Figure F-8 on page 177).

Figure F-8 Legs locked into position

2. Set locking levers to release position (see Figure F-9 on page 177).

Figure F-9 Folded workstation

3. Swing the legs in to their folded position.
4. Lock the legs into place using the two locking levers.

F.6 Configuring the Workstation

Before using the workstation, complete the following:

- Turn off the DELTA analyzer.
- Install the DELTA analyzer on a probe adaptor.
- Install the analyzer-adaptor assembly on the workstation.

CAUTION

Turn off the DELTA analyzer before installing the probe adapter in the workstation. Failure to turn off the analyzer could result in unintentional operation during assembly.

To install the probe adaptor onto the DELTA analyzer

1. Loosen the two probe-adaptor thumbscrews.
2. Connect the DELTA analyzer to the probe adaptor's 16-pin connector (see Figure F-10 on page 178).

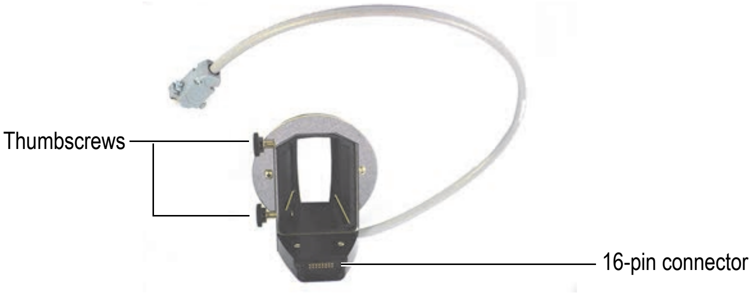


Figure F-10 Probe adaptor

3. Make sure that the DELTA measurement window is flush with the probe-adaptor faceplate (see Figure F-11 on page 178).

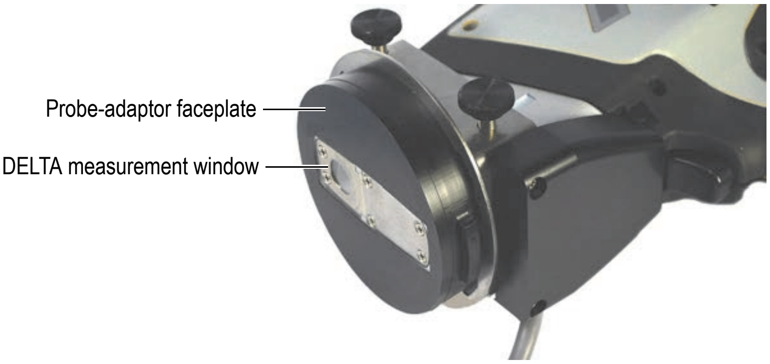


Figure F-11 DELTA measurement window flush with the probe-adaptor faceplate

4. Tighten the two thumbscrews, making sure that the measurement window stays flush with the probe-adaptor faceplate.
5. Install the analyzer-adaptor assembly on the workstation (see "To install the analyzer-adaptor assembly onto the workstation" on page 178).

To install the analyzer-adaptor assembly onto the workstation

1. Unfold the workstation (see "To assemble the workstation" on page 175).

2. Position the workstation so that the locking fixture is accessible (see Figure F-12 on page 179).

Figure F-12 Test-stand locking fixture

3. Align the large tab of the probe adaptor with the large notch of the locking fixture (see Figure F-13 on page 179).

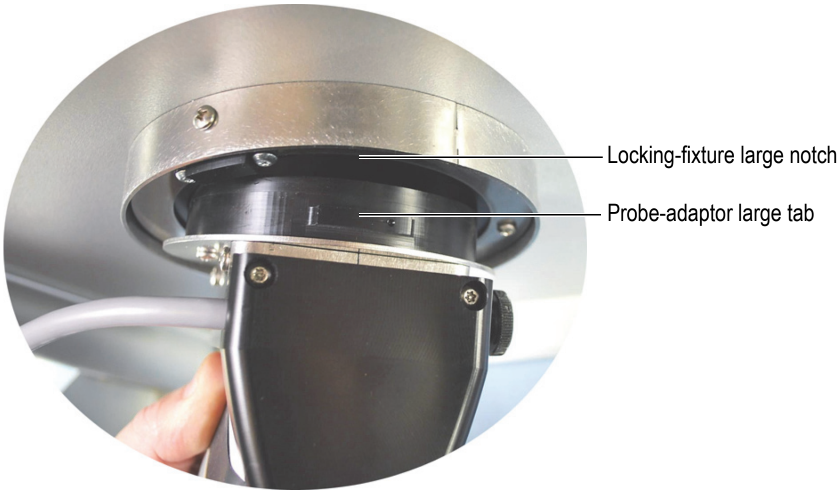


Figure F-13 Alignment with locking fixture

4. Make sure that the probe-adaptor faceplate is flush with the test chamber floor.
5. Carefully turn the analyzer-adaptor assembly counterclockwise until it locks.
6. The probe-adaptor plastic housing must be centered with the locking-fixture alignment screw (see Figure F-14 on page 180).

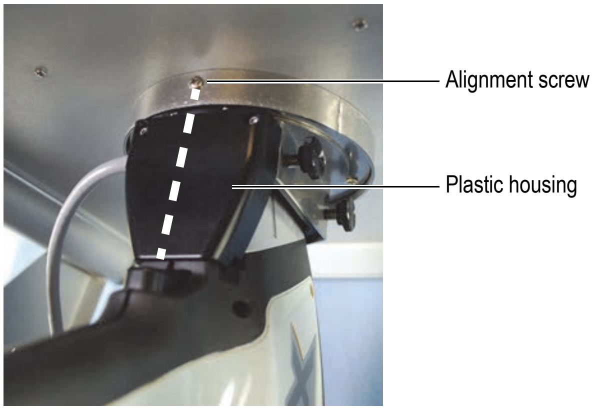


Figure F-14 Analyzer-adaptor assembly installed on the workstation

7. Place the workstation in the upright position
8. Connect the workstation to your PC (see “To connect the workstation to a PC” on page 180).

To connect the workstation to a PC

1. Connect the probe-adaptor interface cable (15-pin D-Subminiature connector) to the workstation I/O panel (see Figure F-15 on page 180 and Figure F-16 on page 180).

Figure F-15 Probe-adaptor interface cable

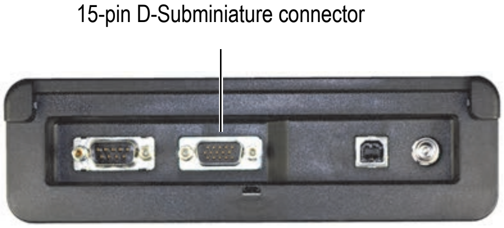


Figure F-16 Test-stand I/O panel

2. Plug the mini USB connector into the DELTA Portable Workstation USB port.
3. Plug the USB connector into a PC USB port.

Appendix G: DELTA Sync

DELTA Sync allows the transfer of test data from the DELTA X-ray fluorescence analyzer to a personal computer (PC). The advantages offered by DELTA Sync include the following robust data streaming capabilities:

- The ability to collect results into automated systems for fast processing and increased throughput.
- Minimization of batch processing errors caused by manual data entry.

DELTA Sync establishes a Bluetooth® connection between Windows CE running on the DELTA and Windows Mobile Device Center running on a PC desktop. This setup provides the same functionality as a USB connection between the DELTA and a PC (although Bluetooth® is slower than USB).

Before you can run DELTA Sync, you must pair the DELTA with a PC or laptop computer so that the DELTA recognizes the computer. Then you can create a shortcut on the DELTA desktop that allows the DELTA to quickly connect with the PC.

NOTE

Pairing the DELTA with a PC is a one-time setup.

G.1 Computer Requirements

- Microsoft Windows 7
- Windows Mobile Device Center V. 6.1.6965 (can be downloaded from www.microsoft.com)
- Bluetooth® adaptor (most laptops have this built in)
- The correct driver installed for the Bluetooth® adaptor

To check for the correct driver

1. On your computer, click the **Start** button (⊞).
2. In the **Search programs and files** box, type **devmgmt.msc**.
   The **devmgmt** icon will appear (see Figure G-1 on page 182).

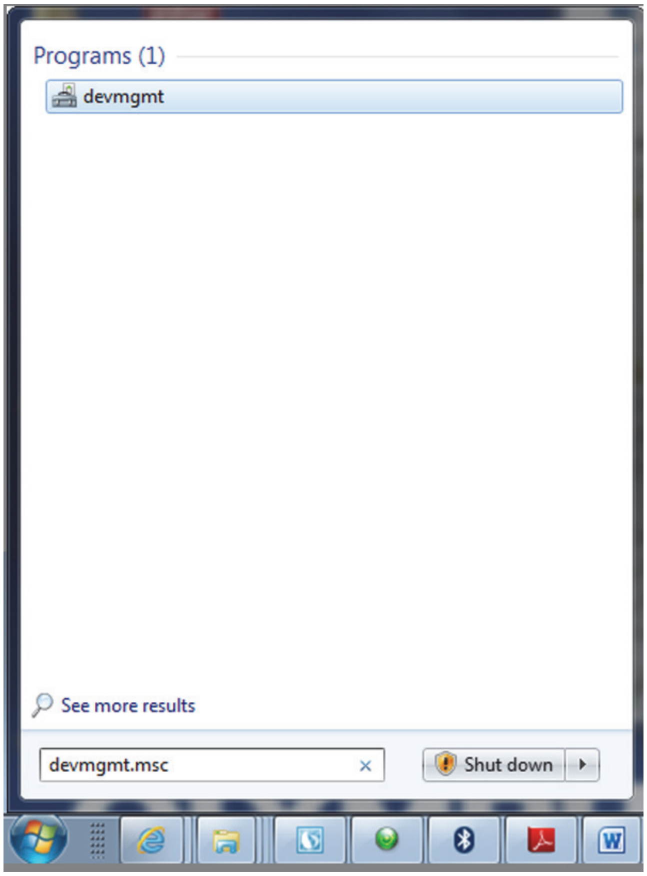


Figure G-1 Using search to find the devmgmt icon

3. Click the **devmgmt** icon to open the **Device Manager** window.
4. Click the **Bluetooth Radios** icon to display the available Bluetooth® adaptors (see Figure G-2 on page 183).
5. Click to select a “named” Bluetooth® adaptor; do not select a generic type of adaptor.

   Microsoft, Broadcom, or Widcom often appear in the list of acceptable Bluetooth® hardware adaptors.

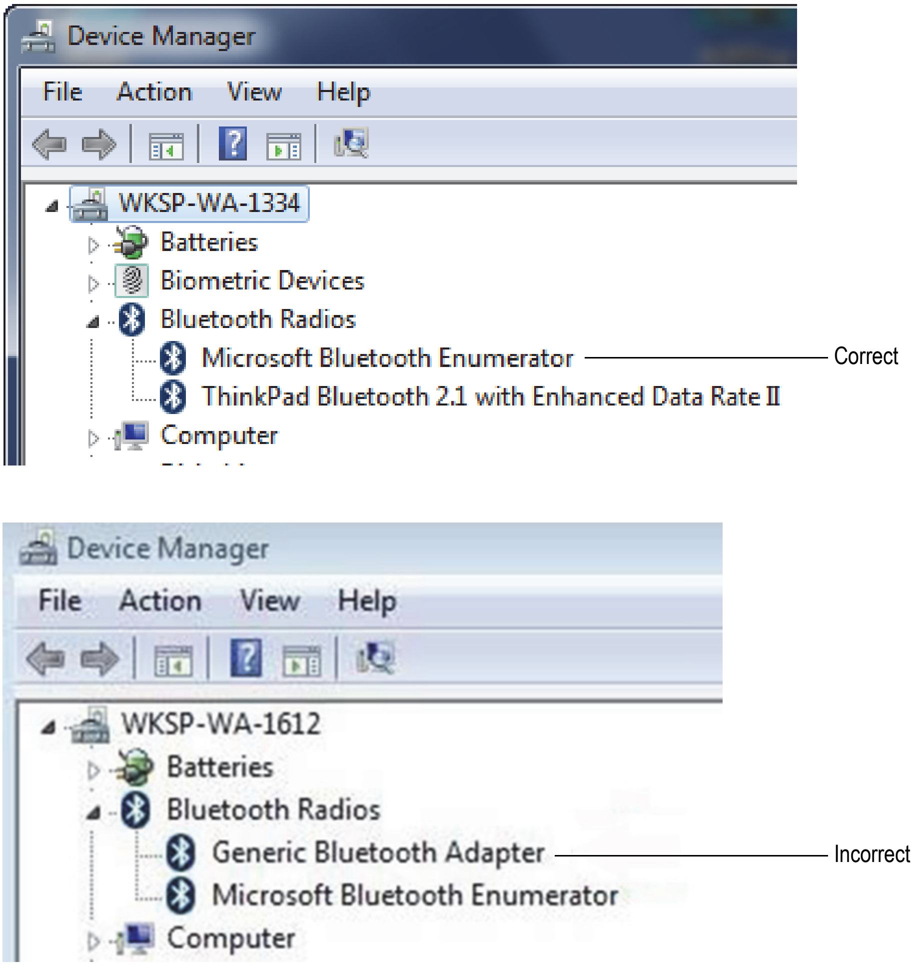


Figure G-2 Select the correct Bluetooth® adaptor

G.2 Pairing Procedures

Pairing the DELTA and a computer is a one-time procedure.

To ensure the computer is ready to pair

1. Right click the Bluetooth® icon ( ) in the notification area on the right side of the Windows taskbar and select **Open Settings** (see Figure G-3 on page 184).
   You may first have to click the small up arrow in the notification area if the Bluetooth® icon is hidden.

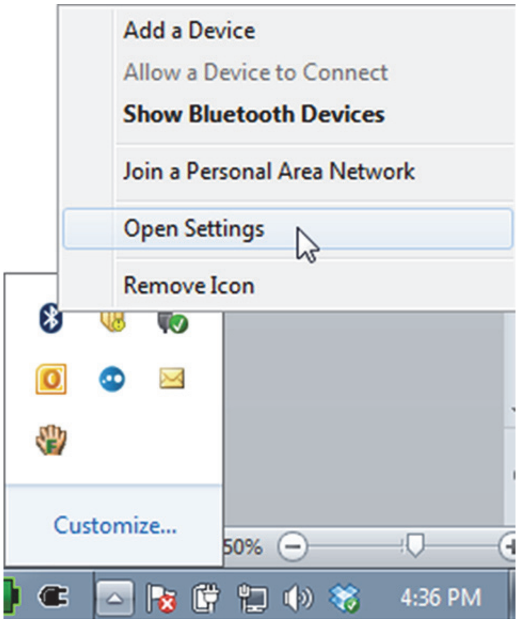
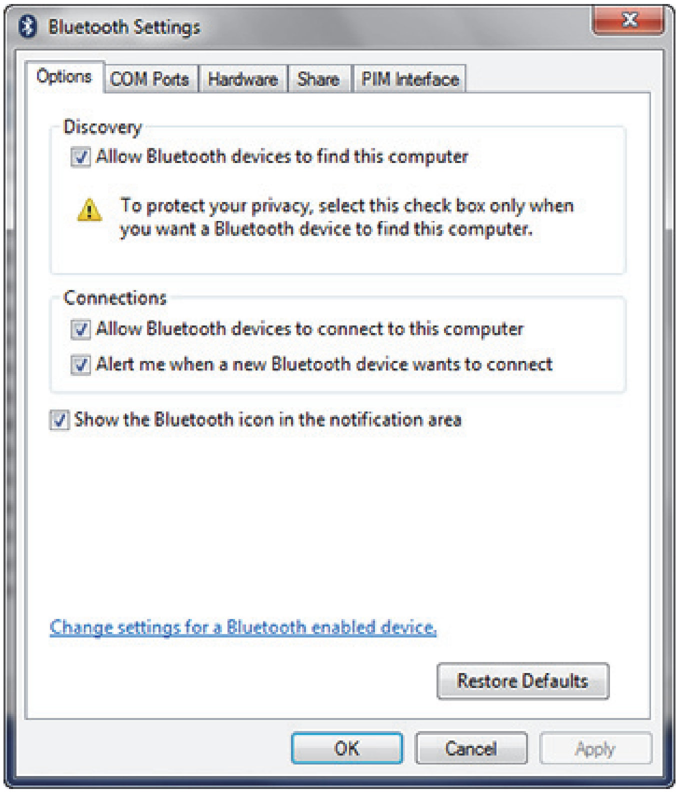


Figure G-3 Opening the Bluetooth® settings box

2. Make sure that all the boxes in the **Options** tab are selected, and then click **OK** (see Figure G-4 on page 184).



Discovery

☑ Allow Bluetooth devices to find this computer

To protect your privacy, select this check box only when you want a Bluetooth device to find this computer.

Connections

☑ Allow Bluetooth devices to connect to this computer

☑ Alert me when a new Bluetooth device wants to connect

☑ Show the Bluetooth icon in the notification area

Change settings for a Bluetooth enabled device.

Figure G-4 Bluetooth® Settings — Options tab

To prepare the DELTA for pairing

1. Tap Home (⌂) on the DELTA to display the **Home** screen.
2. Tap Setup (⚙) to display the **Setup** screen.
3. Tap Exit (Exit) to exit the system software and display the Shutdown screen (see Figure G-5 on page 185).
4. Tap the Windows icon in the lower-right corner of the screen to display the DELTA desktop.

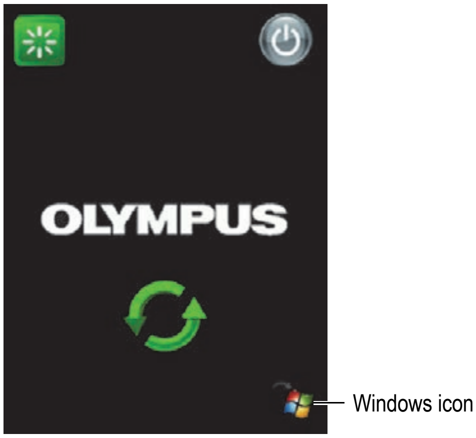


Figure G-5 DELTA Shutdown screen

5. Tap the Windows icon in the lower-left corner of the desktop to open the Startup menu (see Figure G-6 on page 185), and then tap **Settings > Control Panel**.

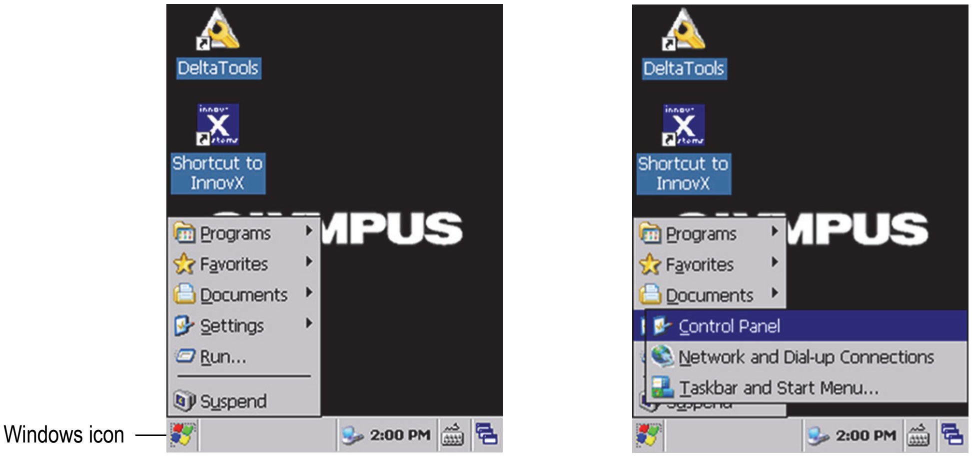


Figure G-6 DELTA desktop: Settings > Control Panel

6. Double-tap the Bluetooth® icon (Bluetooth Device Properties) in the Control Panel (see Figure G-7 on page 186).

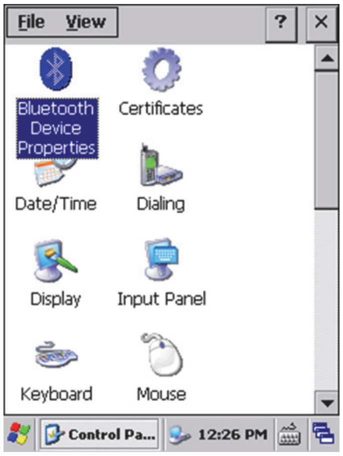
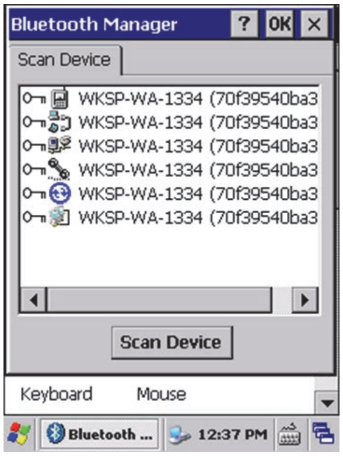


Figure G-7 DELTA Control Panel

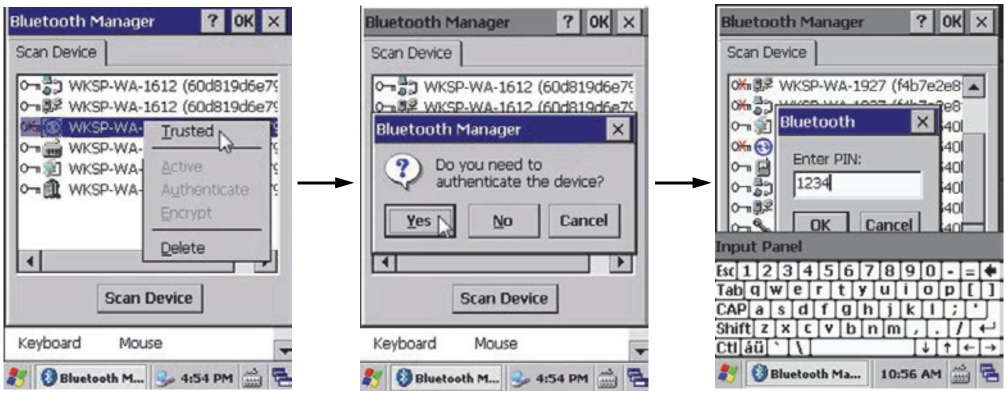
7. Tap the **Scan Device** button (see Figure G-8 on page 186).
8. Double-tap the blue Active Sync icon () for the computer you want to pair with the analyzer.



WKSP-WA-1334 (70f39540ba3
WKSP-WA-1334 (70f39540ba3
WKSP-WA-1334 (70f39540ba3
WKSP-WA-1334 (70f39540ba3
WKSP-WA-1334 (70f39540ba3
WKSP-WA-1334 (70f39540ba3

Figure G-8 Bluetooth® Manager

9. Tap the **Trusted** menu selection, and then tap **Yes** in the message box (see Figure G-9 on page 187).
10. Tap the keypad icon () in the lower-right corner of the screen, and then tap **Keyboard**.
11. Enter **1234** in the **Enter PIN** box, and then tap **OK** (see Figure G-9 on page 187).



Do you need to authenticate the device?

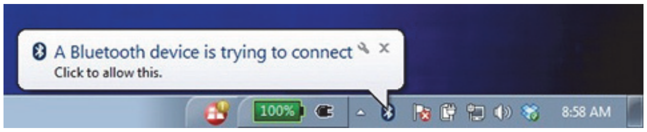
Enter PIN: 1234

Figure G-9 Computer authentication process

12. Tap the keypad icon (⌨) in the lower-right corner of the screen, and then tap **Hide Input Panel**.

To pair the DELTA and the computer

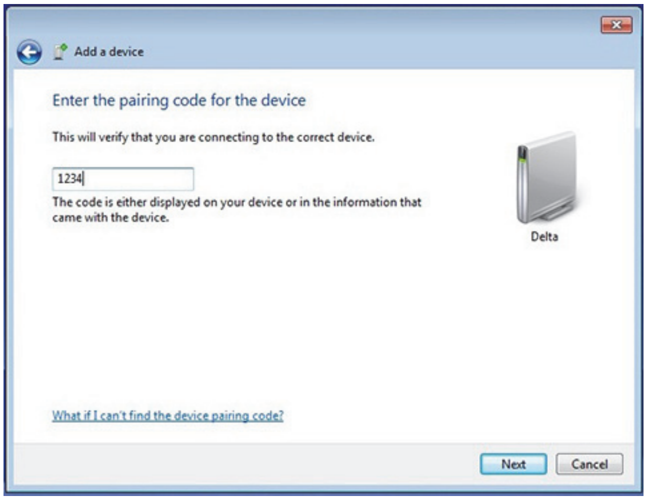
1. On the computer, point to the Bluetooth icon in the notification area of the taskbar, and then click on the balloon that appears over the taskbar (see Figure G-10 on page 187).



A Bluetooth device is trying to connect
Click to allow this.

Figure G-10 Balloon over the Bluetooth® icon

2. Enter **1234** in the pairing code box, and then click **Next** (see Figure G-11 on page 187).



Add a device

Enter the pairing code for the device

This will verify that you are connecting to the correct device.

1234

The code is either displayed on your device or in the information that came with the device.

What if I can't find the device pairing code?

Figure G-11 Add a device dialog box

3. When the “This device has been successfully added to this computer” message appears, click **Close**.
4. On the DELTA desktop, double-tap the blue Active Sync icon ( ) in the user interface.
5. In the menu, select **Active**, and then tap **OK** at the top of the window.

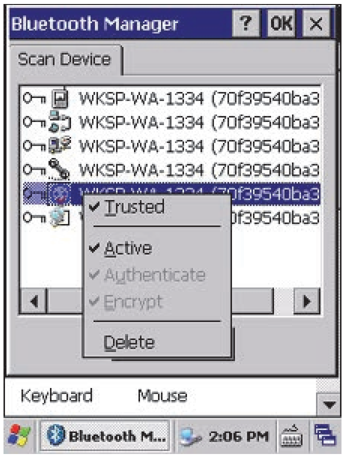


Figure G-12 Bluetooth® Manager

G.3 Creating a Connection Shortcut on the DELTA

When you turn off the DELTA, the active connection with the computer is lost. The DELTA and the computer are no longer connected although they are still paired (so you do not have to enter a password to reconnect). When you turn on the paired DELTA, it does not automatically reconnect with the computer. The following procedure shows you how to create a shortcut (on the DELTA) that you can configure to connect the DELTA with the computer.

To create a connection shortcut

1. In the **Control Panel**, scroll down to the **PC Connection** icon (see Figure G-13 on page 189) and double-tap it to display the **PC Connection Properties** screen.

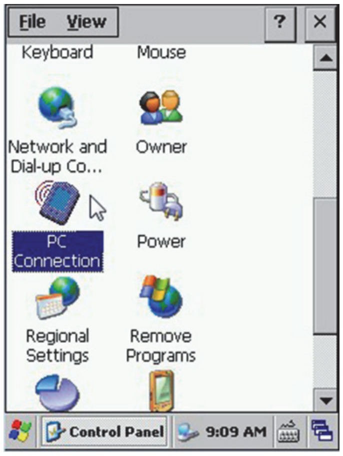
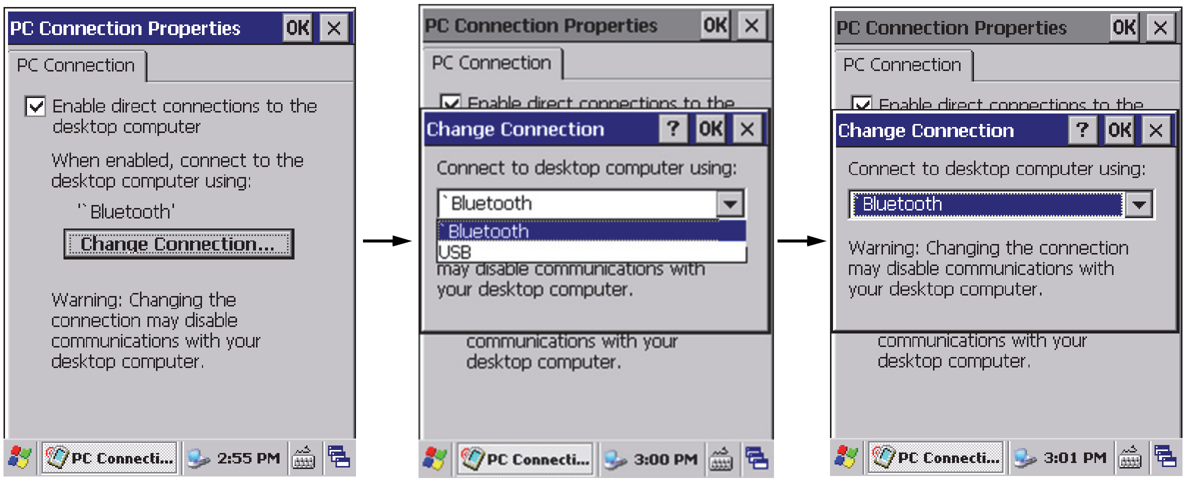


Figure G-13 Control Panel — PC Connection icon

2. Tap **Change Connection**, and then select **Bluetooth** on the menu (see Figure G-14 on page 189).
3. Tap **OK**.



☑ Enable direct connections to the desktop computer

When enabled, connect to the desktop computer using:

'`Bluetooth'

Warning: Changing the connection may disable communications with your desktop computer.

Connect to desktop computer using: `Bluetooth

Warning: Changing the connection may disable communications with your desktop computer.

Figure G-14 Sequence to set the connection type to Bluetooth®

4. Tap **OK** to close the **PC Connection Properties** screen, and then tap the close button (×) to close the Control Panel.

5. Tap the windows icon () at the bottom left of the DELTA desktop, and then tap **Programs > Windows Explorer** (see Figure G-15 on page 190).

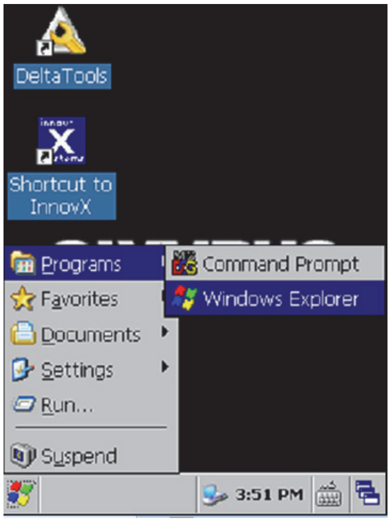


Figure G-15 DELTA Desktop: Programs > Windows Explorer

6. If icons appear on your screen, click **View > Details** to view the folders as a list (see Figure G-16 on page 190).

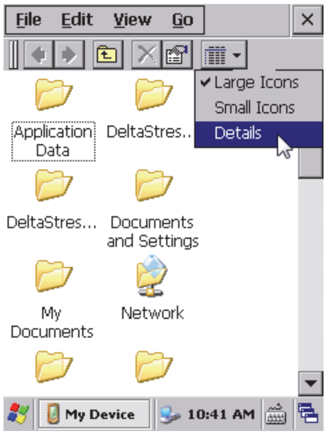


Figure G-16 Changing from icon view to detail view

7. Double-tap the **Windows** folder, and then scroll down to the **repllog.exe** file (see Figure G-17 on page 191).
8. Tap **repllog.exe** once to highlight it, and then tap **File > Send To > Desktop as Shortcut**.

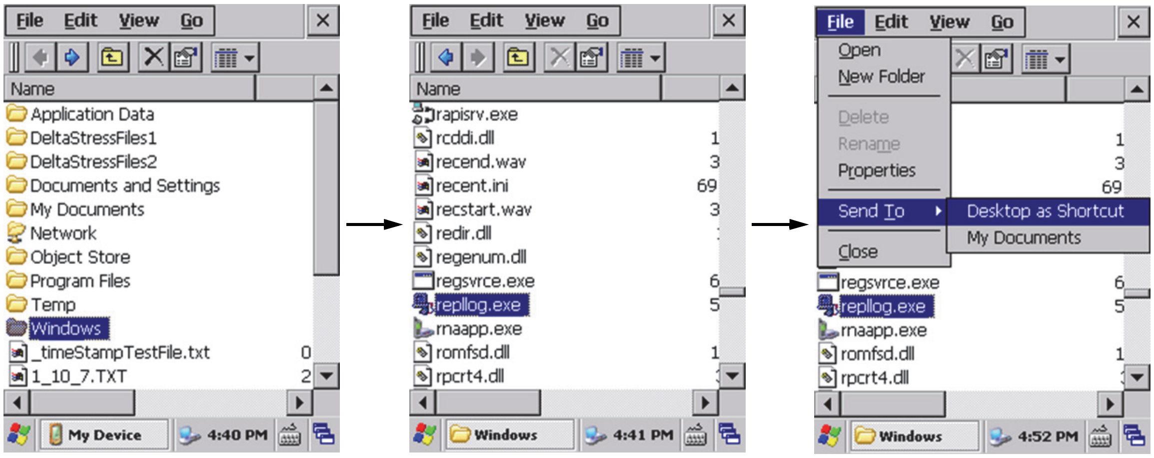
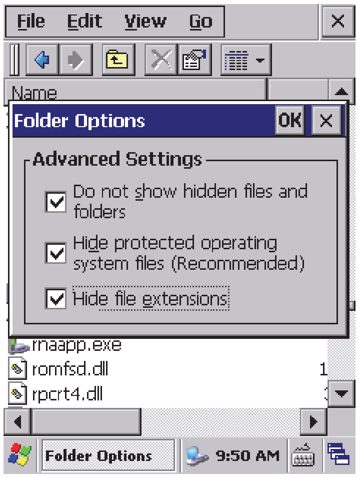


Figure G-17 Making a shortcut from repllog.exe

9. Tap **View > Options**, and then recheck all three boxes under **Advanced Settings** (see Figure G-18 on page 191).
10. Tap **OK**, and then close the explorer screen.



Advanced Settings

☑ Do not show hidden files and folders

☑ Hide protected operating system files (Recommended)

☑ Hide file extensions

Figure G-18 All Advanced Settings checked

On the DELTA desktop, you will now see the **Shortcut to repllog** icon (see Figure G-19 on page 192).

11. Double-tap the **Shortcut to repllog** icon to connect with the PC (see Figure G-19 on page 192).

    The Windows Mobile Device Center window should open on the PC desktop, indicating that the DELTA and the PC are connected (see Figure G-20 on page 192).

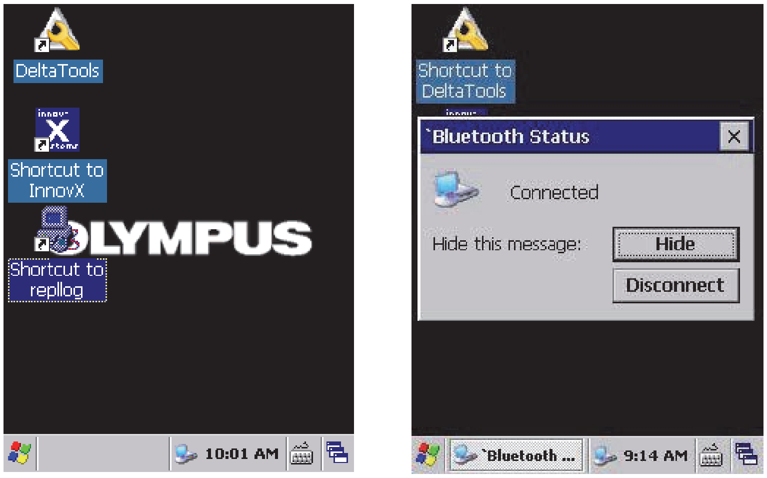


Figure G-19 Tap shortcut to make Bluetooth® connection

Figure G-20 Windows Mobile window

G.3.1 Renaming the Shortcut

You may want to rename the **repllog** shortcut to make it more easily recognizable.

To rename the repllog shortcut

1. On the DELTA desktop, tap and hold the **Shortcut to repllog** icon and then tap **Rename**.
2. Use the keyboard to enter a new name (see "Bluetooth Connection" in the example in Figure G-21 on page 193).
3. Close the keyboard to finish.

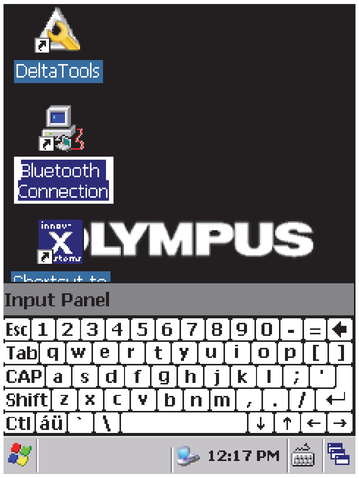


Figure G-21 Renaming the repllog shortcut

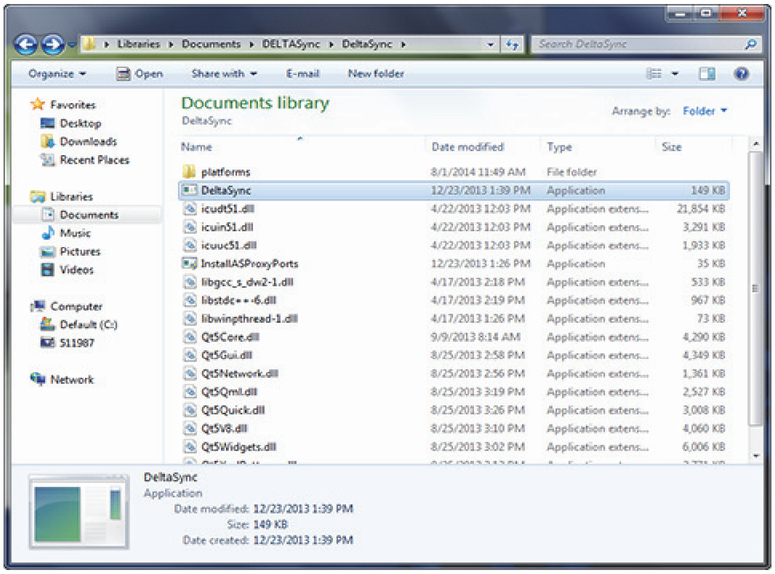
G.4 Installing and Using the DELTA Sync Application

The DELTA Sync application software runs on your computer. DELTA Sync allows you to stream test data over a Bluetooth® connection to a computer. DELTA Sync collects and parses the streamed data and generates both an XML file and a CSV file. Each new test generates a new set of XML and CSV files.

To install the DELTA Sync application

1. Copy the **DeltaSync-n.n.zip** file (n.n represents the version number) from the flash drive to your computer.
2. Extract the archive to the folder of your choice.
3. Double-click the **DeltaSync** file to start the application (see Figure G-22 on page 194).

   A heart icon should appear in the notification area of the taskbar. You may have to click the small up arrow to see all icons in the notification area (see Figure G-23 on page 194).



Name	Date modified	Type	Size
platforms	8/1/2014 11:49 AM	File folder	
DeltaSync	12/23/2013 1:39 PM	Application	149 KB
icudt51.dll	4/22/2013 12:03 PM	Application extens...	21,854 KB
icuin51.dll	4/22/2013 12:03 PM	Application extens...	3,291 KB
icuuc51.dll	4/22/2013 12:03 PM	Application extens...	1,933 KB
InstallASProxyPorts	12/23/2013 1:26 PM	Application	35 KB
libgcc_s_dw2-1.dll	4/17/2013 2:18 PM	Application extens...	533 KB
libstdc++-6.dll	4/17/2013 2:19 PM	Application extens...	967 KB
libwinpthread-1.dll	4/17/2013 1:26 PM	Application extens...	73 KB
Qt5Core.dll	9/9/2013 8:14 AM	Application extens...	4,290 KB
Qt5Gui.dll	8/25/2013 2:58 PM	Application extens...	4,349 KB
Qt5Network.dll	8/25/2013 2:56 PM	Application extens...	1,361 KB
Qt5Qml.dll	8/25/2013 3:19 PM	Application extens...	2,527 KB
Qt5Quick.dll	8/25/2013 3:26 PM	Application extens...	3,008 KB
Qt5V8.dll	8/25/2013 3:10 PM	Application extens...	4,060 KB
Qt5Widgets.dll	8/25/2013 3:02 PM	Application extens...	6,006 KB

DeltaSync
Application
Date modified: 12/23/2013 1:39 PM
Size: 149 KB
Date created: 12/23/2013 1:39 PM

Figure G-22 DeltaSync application file selected

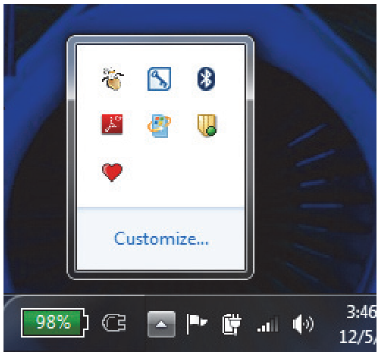
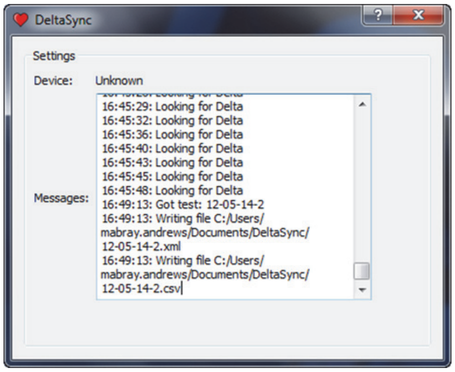


Figure G-23 Heart icon in notification area

To use DELTA Sync

1. Click the heart icon (❤), and then select **Settings** to display the Delta Sync update window.

   When you run a test, the update window will display the file information for the captured data (see Figure G-24 on page 195).



Device: Unknown

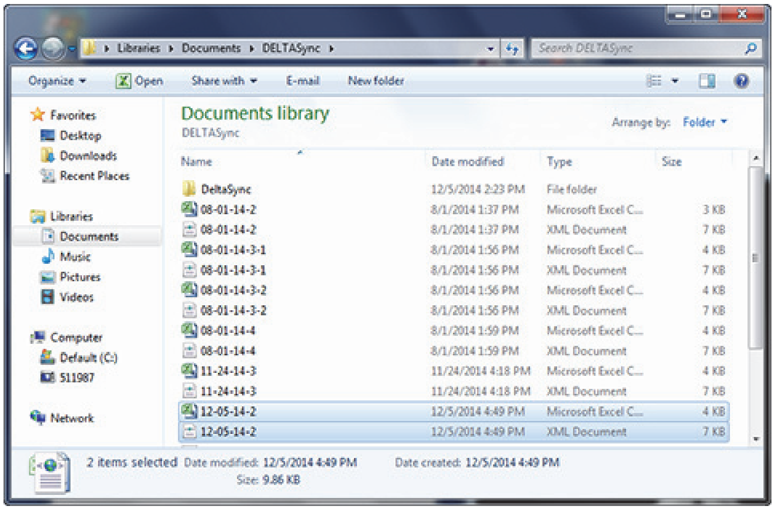
Messages:

```
16:45:29: Looking for Delta
16:45:32: Looking for Delta
16:45:36: Looking for Delta
16:45:40: Looking for Delta
16:45:43: Looking for Delta
16:45:45: Looking for Delta
16:45:48: Looking for Delta
16:49:13: Got test: 12-05-14-2
16:49:13: Writing file C:/Users/
mabray.andrews/Documents/DeltaSync/
12-05-14-2.xml
16:49:13: Writing file C:/Users/
mabray.andrews/Documents/DeltaSync/
12-05-14-2.csv
```

Figure G-24 Delta Sync update window

The existing data files are located one directory level above the location of the application executable (see Figure G-25 on page 195).

2. Use Excel or an XML reader to view the formatted file content.



Name	Date modified	Type	Size
DeltaSync	12/5/2014 2:23 PM	File folder	
08-01-14-2	8/1/2014 1:37 PM	Microsoft Excel C...	3 KB
08-01-14-2	8/1/2014 1:37 PM	XML Document	7 KB
08-01-14-3-1	8/1/2014 1:56 PM	Microsoft Excel C...	4 KB
08-01-14-3-1	8/1/2014 1:56 PM	XML Document	7 KB
08-01-14-3-2	8/1/2014 1:56 PM	Microsoft Excel C...	4 KB
08-01-14-3-2	8/1/2014 1:56 PM	XML Document	7 KB
08-01-14-4	8/1/2014 1:59 PM	Microsoft Excel C...	4 KB
08-01-14-4	8/1/2014 1:59 PM	XML Document	7 KB
11-24-14-3	11/24/2014 4:18 PM	Microsoft Excel C...	4 KB
11-24-14-3	11/24/2014 4:18 PM	XML Document	7 KB
12-05-14-2	12/5/2014 4:49 PM	Microsoft Excel C...	4 KB
12-05-14-2	12/5/2014 4:49 PM	XML Document	7 KB

2 items selected Date modified: 12/5/2014 4:49 PM Date created: 12/5/2014 4:49 PM
Size: 9.86 KB

Figure G-25 Generated data files

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