

Intensity in *Action*

ThermoFisher
S C I E N T I F I C

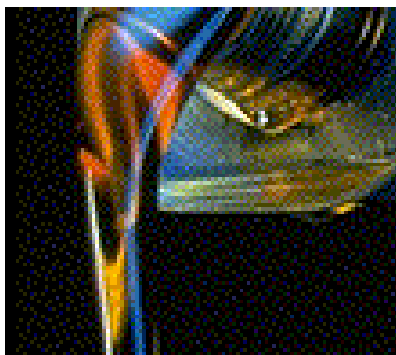
The world leader in serving science

Designer XRF
Building a WD System for Your Application

XRF Applications
Thermo Fisher Scientific
SID

WDXRF technique is used for the analysis of a wide variety of materials

Environmental
Petrochemical
Coatings
Geological



Cement
Process Control
Metals
Polymer



Liquids
Solids
Powders



With so many options – how do you satisfy all?

WDXRF

The Instruments

Power and Performance in WDXRF: Product versus Application

ARL Optim'X - Low power 50W

- Dedicated applications (S, Si, Pb) - Refineries
- No peripheral dependence (no water, no gas, only small UPS)
- Easy to use and maintain; Lowest Cost per Analysis



ARL Advant'X Medium power 1200W/2500W

- Excellent performance for any lab involved in the analysis of liquids, powders, solids, coatings, etc
- Best blend of sensitivity, stability and throughput requirements



ARL Advant'X High power 3600W/4200W

- Performance and flexibility for demanding applications in a central laboratory
 - oils, polymers, catalysts, geological materials and other organic matrices

ARL 9900/Workstation

- Speed and performance for production laboratory environment
 - Cements facilities, contract labs, high throughput areas



Low Power WDXRF with High Analytical Flexibility

50W Sequential with optional Multichromators



SmartGonio F-U

(Sequential: Peaks, Bkgs, Internal Standards)



MultiChromators

(Simultaneous: higher throughput)

No chiller for cooling and no special high power electrical supply

Optim'X can be a sequential system, a fully simultaneous 8 channel system or a combination of both

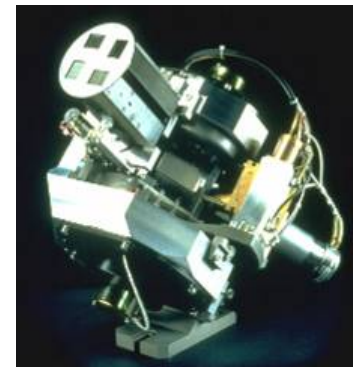
The Advant'X Advantage:

Central Laboratory, Method Development, Advanced Applications, Workhorse



Universal Goniometer B-U

- Up to 9 crystals
- Up to 4 collimators
- Up to 2 detectors
- Boron to uranium



SmartGonio F-U

- Up to 3 crystals
- Fixed collimator
- Up to 2 detectors
- Sodium to uranium



4 power systems 1.2 2.5 3.6 4.2 kW

2 Tube Selections - 75 micron window - standard applications
- 50 Micron for light element sensitivity

No Chiller 1200W Optional 2500W Chiller 3600W, 4200W

Many Combinations – all field upgradable

The Advant'X Advantage:

Central Laboratory, Method Development, Advanced Applications, Workhorse



Software – OXSAS, QuantAS, UniQuant
PetroilQuant, Various Applications

Sample Changer Options
Manual, 12, 14, 49, 98, 176

Analysis Medium Vac/He
Helium Shutter

Many Combinations – all field upgradable

ARL 9900 X-ray WorkStation

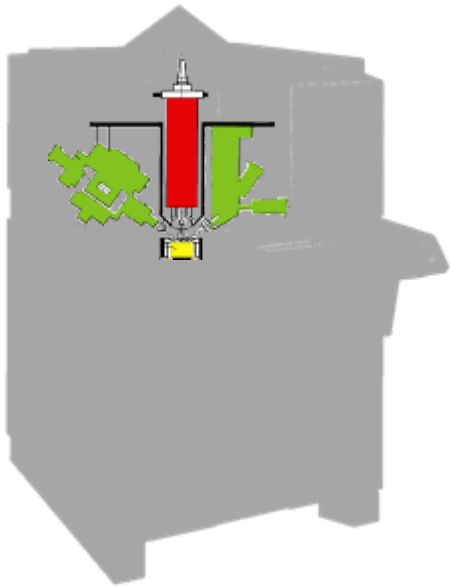
A complete X-ray laboratory in one instrument!



The only route to consider for full XRF and full XRD analysis!

ARL 9900 X-Ray WorkStation

2 instruments in 1



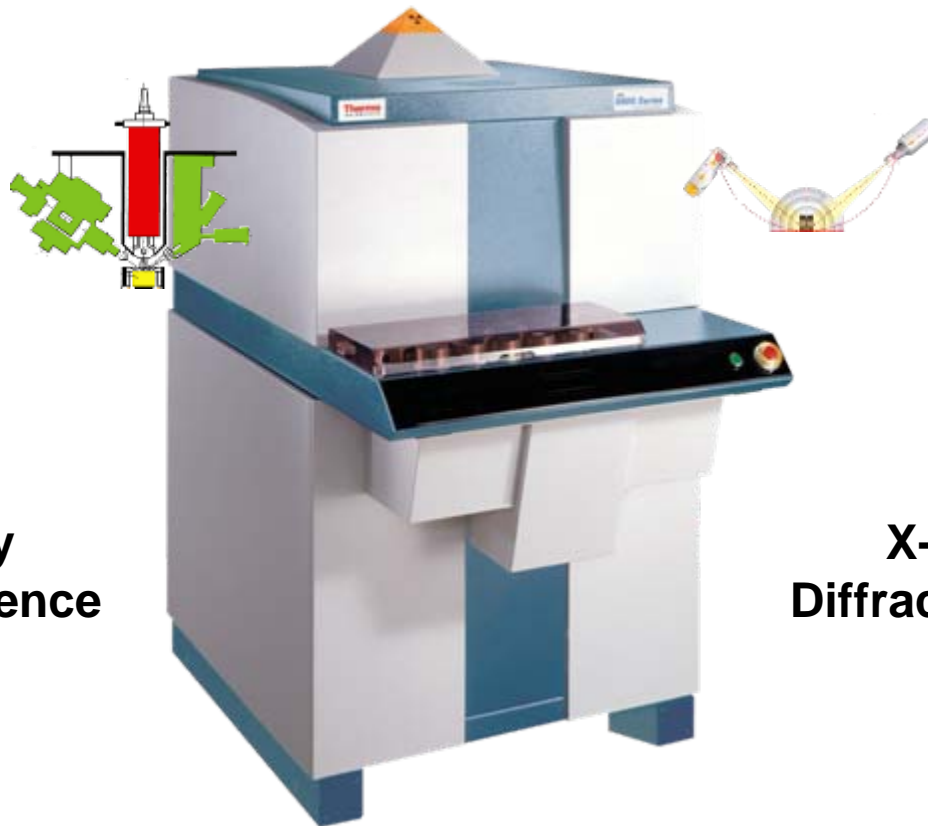
**X-Ray
Fluorescence**



**X-Ray
Diffractometry**

ARL 9900 X-Ray WorkStation

2 techniques in 1



**X-Ray
Fluorescence**

**X-Ray
Diffractometry**

ARL 9900 X-Ray WorkStation

Ultimate materials analysis

Full chemical and phase analysis at the same time!

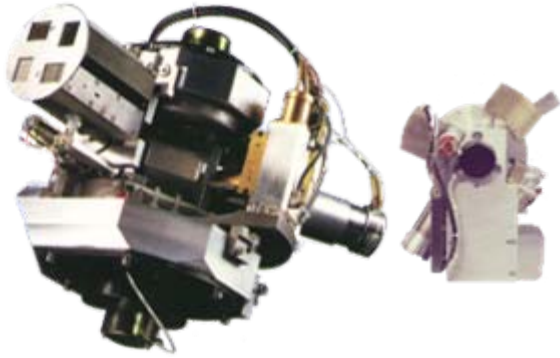


**X-Ray
Fluorescence**

**X-Ray
Diffractometry**

ARL 9900 X-ray WorkStation

Various Configurations



XRF Goniometers
Flexible, versatile,
elemental analysis



Full XRD system
Complete Phase &
Mineral analysis



XRF Monochromators
Rapid, dedicated
routine analysis



Powerful software packages

- OXSAS
- ClinkerQuant™
- UniQuant®
- Visual Crystal

ARL 9900 Total X-ray Analyzer – The Workstation

A complete analysis laboratory in a single machine



Tube-Above Geometry
Simultaneous
Sequential

- Universal/SmartGoni

4 Power levels

Compact XRD Component

- for known phases

Full XRD Component

- for unknown phases

XRF information automatically passed to XRD component

ARL 9900 X-ray WorkStation

IntelliPower™ 1200W or 2500W → WITHOUT external water cooling

IntelliPower™ 3600W or 4200W → for ultimate performance

« **Full XRF & full XRD Inside** »
under vacuum in
one instrument

OXSAS Software
for both XRF and
XRD analysis



**Integrated
Quantitative
Phase Analysis**

**Automation
capabilities from
OEM-XY to
ARL SMS-3000**

Summary

- With all the variations possible there is no system which cannot be tailored to a specific application
- Should needs change then adjust the system to fit
- The next obvious question is ‘how well do these units perform?’
- The following examples have been arranged to try to cover a number of different matrices and preparation methods to better show the possibilities
- Lastly – please note the LLDs for these examples – they also indicate that you do not necessarily have to start at a high powered system to achieve low level detection

Analysis of Traces in Polymers

LOD (ppm) in 100s counting time

Element	High Power (3.6kW)	Low Power (1.2kW)
Mg	0.86	1.5
Al	0.23	0.4
P	0.16	0.27
Cl	0.3	0.8
Ca	0.14	0.53
Ti	0.1	0.18
Cr	0.11	0.2
Fe	0.07	0.12



Limits of Detection in Oils

ARL Optim'X Fixed Channel and SmartGonio Comparison

		Smart Gonio
Element	SmartGonio configuration	LOD [ppm] 120s
Al	PET/FPC	4.2
Si	PET/FPC	4
P	PET/FPC	2
S	PET/FPC	1.7
K	LIF200/FPC	1.4
Ca	LIF200/FPC	1.5
V	LIF200/FPC	1
Cr	LIF200/FPC	1
Mn	LIF200/FPC	1
Fe	LIF200/FPC	1.1
Ni	LIF200/SC	0.6
Cu	LIF200/SC	0.8
Zn	LIF200/SC	0.6
Pb	LIF200/SC	1.7

	Fixed channel
Element	LOD [ppm] 120s
Mg	8
Al	3.1
Si	3.2
P	1.5
S	1.2
Ca	1.7
Fe	0.8
Pb	1

Limits of Detection in Oils: Low, Mid and High Power

	Detector	High Power	Mid power	Low Power
		3600 W	1200 W	50 W
Mg	AX06/FPC	2.2	3.74	
Al	PET/FPC	0.67	1.14	4.2
Si	PET/FPC	0.38	0.65	4
S	GE111/FPC	0.25	0.43	1.7
Ca	LIF200/FPC	0.17	0.29	1.5
Cr	LIF200/FPC	0.14	0.24	1
Mn	LIF200/FPC	0.14	0.24	1
Fe	LIF200/FPC	0.15	0.26	1.1
Cu	LIF200/SC	0.12	0.2	0.8
Zn	LIF200/SC	0.11	0.19	0.6
Sn	LIF200/FPC	0.57	0.97	
Pb	LIF200/SC	0.14	0.24	1.7

Smart Goni

120 S

3 sigma - 100s counting time - 6 micron PP film

Food Products

The limits of detection that can be achieved for all our sequential XRF instruments in food products and notably milk powders are shown. As can be seen, all elements of these typical ranges can be determined even with an ARL Advant'X (1200W system) or ARL Optim'X (using a longer counting time), Note Cr, Mo and Se in infant formula will be very difficult or even impossible.



- *Cd requires the use of a primary beam filter that can be fitted only in the ARL Advant'X series.

- Nitrogen: we have never obtained samples of milk powder with Nitrogen concentrations to be able to make a calibration curve, but the limit of detection should be in the order of 400 ppm in 100s counting time with Advant'X 3600 and 5GN tube.

- When the sign ~ is shown, the limit of detection is an estimation.

- The limit of quantification corresponds generally to 3 times the limit of detection.

Element	Conc	Limits of detection ARL Advant'X 3600 (ppm in 30s counting time)	Limits of detection ARL Advant'X 1200 (ppm in 30s counting time)	Limits of detection ARL Optim'X SmartGonio (ppm in 60s counting time)
Ca	ppm	4	7	10
Fe	ppm	1	1.7	2.1
K	ppm	3.5	6.1	2
Mg	ppm	7.2	12.5	26
Na	ppm	9.3	16.1	48
P	ppm	1.2	2.1	4.4
N	%	~400 in 100s	~700 in 100s	Not possible
Cr	ppm	~0.3	~0.5	~1.5
Mo	ppm	~0.1	~0.2	~0.6
Se	ppm	0.06	0.1	0.24
Zn	ppm	0.9	1.6	2
Cu	ppm	0.3	0.5	0.6
Mn	ppm	0.3	0.5	1.2
Cl	ppm	3	5.2	10
Cd*	ppm	~1.2	~2	Not possible
I (La)	ppm	~0.5	~0.9	~3
Pb	ppm	~0.4	~0.7	~4
As	ppm	~1	~1.7	~10
Al	ppm	~0.5	~0.9	~3

Al Metal Matrix

Al Matrix

ELEMENT	LINE	CRYSTAL/ DETECTOR	TYPICAL LoD [PPM] IntelliPower™			
			1200W	2500W	3600W	4200W
Na	K α	AX03/FPC	5.9	4.1	3.4	3.1
Mg	K α	ADP/FPC	11.3	7.8	6.5	6.0
Si	K α	PET/FPC	4.0	2.8	2.3	2.1
Ca	K α	LiF200/FPC	0.9	0.6	0.5	0.5
Ti	K α	LiF200/FPC	1.0	0.7	0.6	0.6
V	K α	LiF200/FPC	1.0	0.7	0.6	0.6
Cr	K α	LiF200/FPC	1.4	1.0	0.8	0.7
Mn	K α	LiF200/FPC	1.2	0.8	0.7	0.6
Fe	K α	LiF200/FPC	1.6	1.1	0.9	0.8
Co	K α	LiF200/FPC	1.0	0.7	0.6	0.6
Ni	K α	LiF200/Sc	0.9	0.6	0.5	0.5
Cu	K α	LiF200/Sc	0.9	0.6	0.5	0.5
Zn*	K α	LiF200/Sc	0.7	0.5	0.4	0.4
Ga*	K α	LiF200/Sc	0.5	0.4	0.3	0.3
As	K β	LiF220/Sc	2.9	2.0	1.7	1.6
Zr	K α	LiF200/Sc	0.3	0.2	0.2	0.2
Ag*	K α	LiF200/Sc	3.1	2.2	1.8	1.7
Cd*	K α	LiF200/Sc	3.1	2.2	1.8	1.7
Sn	K α	LiF200/Sc	3.6	2.5	2.1	1.9
Hg	L α	LiF200/Sc	1.2	0.8	0.7	0.6
Pb*	L α	LiF200/Sc	0.7	0.5	0.4	0.4
Pb*	L β	LiF200/Sc	1.4	1.0	0.8	0.7
Bi*	L α	LiF200/Sc	0.5	0.4	0.3	0.3

Graphite Powder

Graphite

EL (PPM) (100s)	LINE	TYPICAL LOD [PPM] INTELLIPOWER™			
		1200 W	2500 W	3600 W	4200 W
Al	K α	0.69	0.48	0.4	0.37
As	K β	1.04	0.72	0.6	0.56
Ca	K α	0.26	0.18	0.15	0.14
Co	K α	0.26	0.18	0.15	0.14
Cr	K α	0.26	0.18	0.15	0.14
Cu	K α	0.26	0.18	0.15	0.14
Fe	K α	0.26	0.18	0.15	0.14
Mg	K α	1.56	1.08	0.9	0.83
Mo	K α	0.17	0.12	0.1	0.09
Ni	K α	0.21	0.14	0.12	0.11
Pb	L β	0.35	0.24	0.2	0.19
Sb	L α	1.04	0.72	0.6	0.56
Si	K α	0.69	0.48	0.4	0.37
Sn	L α	1.04	0.72	0.6	0.56
V	K α	0.26	0.18	0.15	0.14

Table 3: Typical limits of detection (3 sigma) in 100s counting time per element

Count Time Effects on LOD using a 3.6kW Advant'X

Graphite

EL	LINE	LOD (PPM) (100s)	LOD (PPM) (10s)
Al	K α	0.4	1.26
As	K β	0.6	1.9
Ca	K α	0.15	0.47
Co	K α	0.15	0.47
Cr	K α	0.15	0.47
Cu	K α	0.15	0.47
Fe	K α	0.15	0.47
Mo	K α	0.1	0.32
Ni	K α	0.12	0.38
Pb	L β	0.2	0.63
Sb	L α	0.6	1.9
Si	K α	0.4	1.26
Sn	L α	0.6	1.9
V	K α	0.15	0.47

Table 4: Typical limits of detection at 3600 W for different counting time

Thermo X-ray product portfolio :

From Basic to High End – A Product For All Your Analytical Needs

XRF: Elemental analysis

ARL 9900 Series
Integrated XRF-XRD



ARL ADVANT'X Series:
High Performance
Sequential XRF



ARL OPTIM'X:
Economic WDXRF



ARL QUANT'X-Top
performance EDXRF

XRD: Analysis of

- **Structure-crystallography**
- **Phase or compound**



ARL X'TRA:

High performance
Powder XRD

Thank You