

A.R.K. (Attenuated Total Reflectance Kit)

User's Manual

Model #'s 0055-3XX, 0055-3XX(T) and 0055-2XX
Version 2.0



PN/700-0088

***SPECTRA*TECH**

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General Information

Introduction to ATR Spectroscopy

Attenuated Total Reflectance (ATR) Spectroscopy is a versatile and powerful technique for infrared sampling. Since materials are normally analyzed by ATR with either minimal or no sample preparation, ATR is a rapid technique for obtaining the infrared spectrum of a material. Materials which are either too thick or too strongly absorbing to be analyzed by transmission spectroscopy can be routinely analyzed using ATR spectroscopy. ATR is also useful when only the surface of the material is of interest.

A.R.K. Product Description

The A.R.K.* (Attenuated Total Reflectance Kit) is a horizontal attenuated total reflection accessory (ATR) designed to simplify the FT-IR analysis of liquids, powders, pastes, gels, semi-solids, and films. The unique, horizontal sampling surface permits convenient acquisition of IR spectra with minimal sample preparation. Even samples containing strongly absorbing components can be readily analyzed using the A.R.K.. A wide array of configurations and options, combined with easy operation, make this accessory suitable for use in all laboratory environments — from research to quality control.

The A.R.K. consists of the following:

- base accessory unit containing the mirrors to direct the IR beam to and from the sampling plate.
- a sampling plate containing the ATR crystal (standard = ZnSe, 45° angle of incidence).
- an *optional* pressure device for assuring uniform contact between the sample and the ATR crystal.
- purge capability

Sampling plates are available in two varieties:

1. a flush crystal mounting for sheets and films
2. a trough cell for sampling liquids, pastes, gels, soft powders and viscous smears.

The ATR crystal is rigidly mounted into the teflon-coated sampling plate. Positioning pins on the bottom of the sampling plates assure a snug, reproducible fit into the base unit, and allow easy removal of the plate for cleaning between samples. (See Figure 1)

**The A.R.K. holds U.S. Patent number 4,730,882 and is a trademark of Spectra-Tech Inc.*

General Information

A.R.K. Product Description

The A.R.K. can also include an optional pressure device (the Gripper) to provide the uniform contact between the sample and the ATR crystal needed for reproducible results (when working with solids). The Gripper provides precise pressure adjustment via an adjustment screw. It mounts onto the top plate of the base accessory via screws provided.

The Gripper is for use with the flat sample plate to assure that consistent contact is achieved between the sample and the crystal. Additionally, the Gripper can be used with the trough plate and powder press to sample soft, compressible powders that do not evenly contact the crystal.



Figure 1 The A.R.K.

General Information

Theory

Internal reflection spectroscopy is a common infrared technique in which the infrared radiation is passed through an infrared transmitting crystal of high refractive index, allowing the radiation to reflect in the crystal one or more times. In this way, an evanescent wave penetrates into the sample in contact with the crystal, producing a spectrum of the sample. In the most common application of this technique, ATR (Attenuated Total Reflectance), the sampling surface is held in a vertical orientation, with sample material placed on one or both sides of the ATR crystal. This orientation, however, makes it difficult to achieve uniform sample contact with the crystal surface - a necessity if you desire reproducible data. In addition, it is virtually impossible to sample many non-rigid materials, such as gels or pastes. The A.R.K. overcomes this difficulty by providing a horizontal, "face-up" sampling surface, to allow convenient sample handling of virtually all materials.

Figure 2 shows a simplified ray diagram for the A.R.K. to illustrate this point. In this diagram, the sampling surface is the top surface of the crystal. IR radiation from the spectrometer is directed up to the beveled, input face of the ATR crystal. It then reflects through the crystal, passing "into" the sample a finite amount with each reflection along the top surface. At the output end of the crystal, the beam is directed down to a reflecting surface and back into the normal beam path of the spectrometer. By varying the angle of the bevels and the refractive index of the crystal material, the user can alter the total number of reflections along the crystal and the depth of penetration at each reflection. In turn, this permits control over the effective pathlength of the accessory. Crystals with 30°, 40, 45, 50, 55, and 60 degree bevels are available.

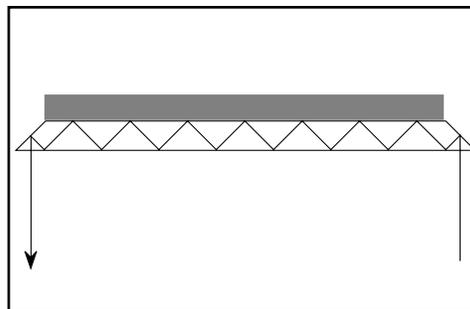


Figure 2: A.R.K. diagram.

**30° is available only in Germanium*

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Theory

ATR Calculations (NOTE: $n_2 = 1.5 @ 1000 \text{ cm}^{-1}$)

θ	# of reflections (HATR)	ZnSe ($n_1 = 2.4$)			Ge ($n_1 = 4$)			AMTIR ($n_1 = 2.5$)		
		dp	EP	EPL(μm)	dp	EP	EPL(μm)	dp	EP	EPL(μm)
30	21	NA	NA	NA	1.2	0.842	17.68	NA	NA	NA
40	14	4.4	3.26	45.64	0.763	0.303	4.24	2.76	1.845	38.75
45	12	2.0	1.01	12.12	0.664	0.216	2.59	1.70	0.807	9.68
50	10	1.5	0.582	5.82	0.596	0.162	1.62	1.34	0.493	4.93
55	8	1.25	0.389	3.11	0.547	0.124	.992	1.14	0.339	2.71
60	7	1.11	0.277	1.94	0.510	0.096	.672	1.02	0.245	1.72
θ_c		38.68			22.02			36.87		

Table 1: Number of Reflections as a Function of the Crystal Angle

Depth of Penetration

A useful relationship in ATR spectroscopy which can be used as a qualitative measure of the depth which the evanescent wave extends into the sample is defined as the depth of penetration, dp. The depth of penetration is the distance from the crystal-sample interface where the intensity of the evanescent wave decays to 1/e (approximately 37%) of its original value. It is calculated by:

$$dp = \frac{\lambda}{2\pi n_1 (\sin^2 \theta - n_{21}^2)^{1/2}}$$

where λ is the wavelength of infrared radiation, n_{21} is the ratio of the refractive indices of the sample and the ATR crystal, and θ is the angle of incidence (see Table above). If the calculation takes into consideration the polarization of the sample and the ATR crystal the electric field amplitudes of the crystal are different for equal incident amplitudes of perpendicular and parallel polarization. The effective penetration (EP) are mathematically different for the two polarizations. The relative effective penetration (EP) for an isotropic medium for perpendicular and parallel polarizations are:

General Information

Theory

$$EP_{\perp} = \frac{\lambda n_{21} \cos \theta}{\pi(1 - n_{21}^2)(\sin^2 \theta - n_{21}^2)^{1/2}}$$

and

$$EP_{\parallel} = \frac{\lambda n_{21} \cos \theta (2 \sin^2 \theta - n_{21}^2)}{\pi(1 - n_{21}^2)[(1 + n_{21}^2) \sin^2 \theta - n_{21}^2](\sin^2 \theta - n_{21}^2)^{1/2}}$$

where λ is the wavelength of infrared radiation, n_{21} is the ratio of the refractive indices of the sample to the ATR crystal, and θ is the angle of incidence. The values in the table (see previous page) are the average of the parallel and perpendicular polarizations, or

$$EP = (EP_{\perp} + EP_{\parallel}) / 2.$$

The depth of penetration (as calculated above) is useful for comparing the effects of the ATR crystal refractive index, the angle of incidence and the state of polarization. However, the experimental sampling depth has been found to be 2 to 3 times the theoretical depth of penetration.

Effective Pathlength

The Effective Pathlength (EPL) can be used as an approximate comparison between the expected absorbance of an ATR spectrum and a transmission spectrum. In a spectrum obtained by transmission, the pathlength is the thickness of the sample which is directly related to the absorbance. In ATR, the effective pathlength is calculated as:

EPL = Effective Penetration x Number of Reflections (N), where:

$N = l/t \cot \theta$; l = length of crystal, t = thickness of crystal and θ = angle of incidence
For horizontal ATRs divide N by 2. The EPL is directly related to the absorbance in that, an increase in either the effective penetration or the number of reflections will increase the absorbance intensity of the spectrum.

General Information

ZnSe Information

Optical Characteristics:

ATR Range: $>10,000\text{ cm}^{-1}$ to 650 cm^{-1}	Useful Temperature Range (trough): 60°C
Solubility: Insoluble in water	Density: 5.27 g/cm^3
Knoop Hardness #: 150	Refractive index @ 1000 cm^{-1} : 2.4
Useful pH Range: 5 - 9	

Note: Avoid the use of any chlorinated solvents, such as methylene chloride and chloroform.

The A.R.K. is equipped with a Zinc Selenide crystal (as the standard option). ZnSe is the material of choice for many advanced FT-IR sampling technologies, having replaced KRS-5.

Please observe the following precautions to extend the operating life of your ZnSe crystal:

- Do not use ZnSe to analyze solutions containing strong acids or alkalies. The preferred pH range is 5-9.
- Do not wash or clean the crystal with solutions of strong acids, alkalies or oxidizing agents.
- ZnSe is hard, yet brittle and should not be subjected to mechanical and/or thermal shock. Do not apply undue pressure to the crystal during an ATR measurement. Do not drop the accessory/crystal nor wash it in solvents at temperatures above those at which the sample has just been analyzed.
- The surface(s) of the crystal must be cleaned gently, using soft materials in conjunction with a suitable solvent, cotton swabs or cotton balls are recommended. Surface scratches will reduce the optical throughput.
- The trough plates, which use a bonded ZnSe crystal, must not be cleaned in an ultrasonic cleaner.
- Sudden temperature changes greater than 5°C can damage the ZnSe crystal.

CAUTION: Do NOT use KimWipes™ to clean the crystal surfaces. This will cause severe scratching of the crystal surface.

General Information

Crystal Information

	ZnSe	ZnS	Ge	AMTIR
Transmission Range (cm ⁻¹)	20,000-650	17,000-950	5500-800	11,000-625
Refractive index @ 1000 cm ⁻¹	2.4	2.2	4.0	2.5
Density (g/cm ³)	5.27	4.08	5.32	4.40
Hardness (Knoop #)	150	354	1150	170
Cleaning Agents	acetone, H ₂ O	acetone, alcohol	toluene, H ₂ O	toluene, H ₂ O
Solvents which attack material	acids, strong alkalies	acids	hot H ₂ SO ₄ , aq. regia	alkalies
Useful pH Range	5-9	7-14	1-14	1-7
Remarks	<i>hard, easily cracked</i>	<i>withstands thermal or mechanical shock</i>	<i>hard and brittle, reflection losses</i>	<i>relatively hard, brittle</i>

For a complete description of the theory of Attenuated Total Reflectance please refer to Spectra-Tech's FT-IR Technical Note #1: *Introduction to Attenuated Total Internal Reflectance (ATR) Spectroscopy*.

The Manual

This manual is designed as a tutorial to guide you through the installation of the A.R.K. and through a typical A.R.K. analysis. If you have any questions, please contact a Spectra-Tech Technical Representative.

Installation & Alignment

Base Optical Unit

All A.R.K.s for use with Nicolet instruments are pre-aligned and tested in a Nicolet FT-IR spectrometer prior to shipment. Additionally, most versions of the A.R.K. are shipped with the Baseplate pre-attached to the accessory for rapid and reproducible installation. This baseplate attaches to the floor of your spectrometer sample compartment and provides properly positioned mounting holes for the A.R.K.. Therefore, only minor adjustments to the transfer mirrors should be required to maximize energy throughput. **Read all installation and alignment instructions before proceeding with any adjustments to the optics of your A.R.K..**

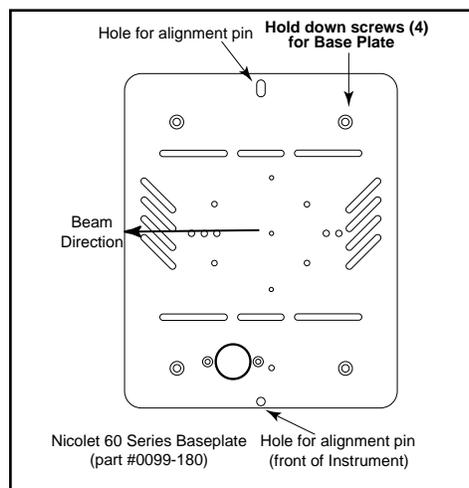
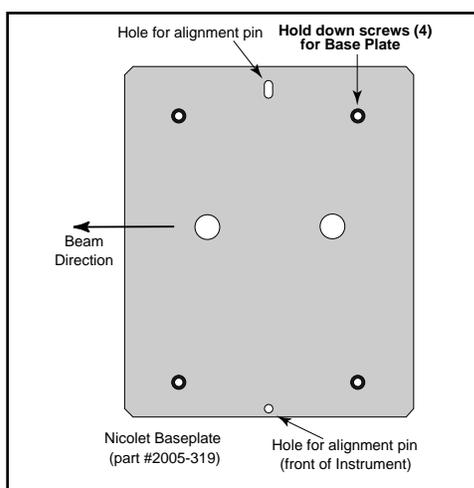
CAUTION: The mirrors used in the A.R.K. are aluminum-coated glass. These mirrors are durable, however, their surface is relatively soft and difficult to clean without scratching. It is advisable to use care when handling the accessory and when placing samples on the accessory to avoid dropping materials on the mirror surface. Use compressed air or translucent tape to clean dust from the surface of the mirrors.

Remove the baseplate

Locate the four (4) hold down screws (8-32) on the Baseplate of your Nicolet spectrometer.

Remove the 4 screws with a 1/8" ball driver or hex key.

Remove the Baseplate completely from the sample compartment.



Installation & Alignment

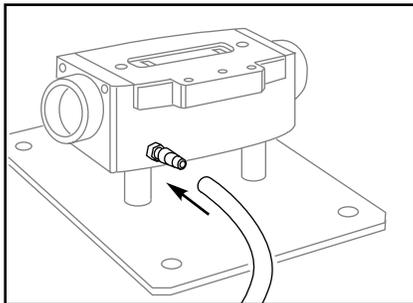
Base Optical Unit

Record the open beam energy

Record the open beam energy of your spectrometer by monitoring either the throughput energy number or the height of the centerburst of the interferogram.

Note this value for later use.

Purge Installation

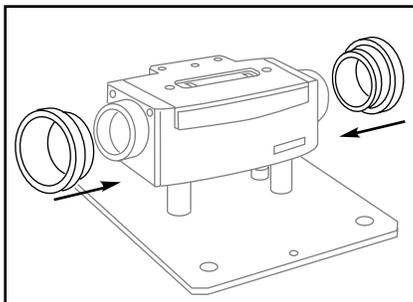


Attach hosing

Attach the open end of the plastic hosing (provided) to the purge nipple on the A.R.K..

For Nicolet systems with purge capabilities: Attach the other end of the tubing to the socket in the sample compartment.

For all other instruments: Remove the fitting and attach the other end of the hose to an external dry, CO₂ free air source.

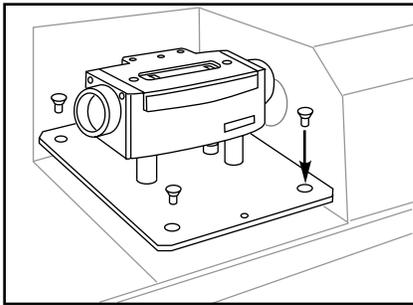


Attach foam purge rings

Attach the foam purge rings to both ends of the A.R.K. accessory. Once the unit is placed in the sample compartment, adjust the rings until they create a seal with the wall of the sample compartment.

Installation & Alignment

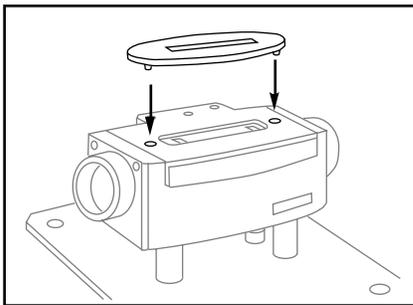
Base Optical Unit



Place A.R.K. in compartment

Place the A.R.K. in the sample compartment of the spectrometer with the Spectra-Tech logo facing towards you.

Replace the enclosed hold down screws and tighten them gently.



Install sampling plate

Place either the trough or flat sampling plate (depending on your application), on the top of the base optical unit. Make sure both alignment pins are lined up with the appropriate holes in the base optical unit. There is an orientation to the crystal plates. To keep the proper crystal orientation one of the positioning pins is larger than the other. The plate will only fit into the A.R.K. one way.

Installation & Alignment

Base Optical Unit

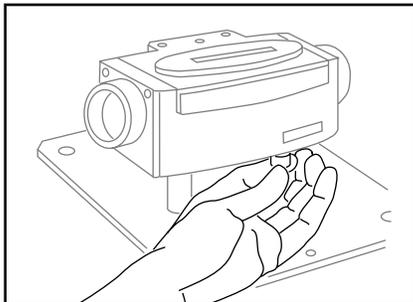
Record energy

Record the energy throughput of the accessory by monitoring either the throughput energy number or the height of the centerburst of the interferogram.

Compare this value with the value for the open beam energy throughput, recorded prior to installing the A.R.K..

If the accessory throughput (with a new ZnSe crystal) is greater than 21% of the open beam throughput, then no further adjustments are required. At this level, the accessory will provide sufficient energy to permit good signal-to-noise ratios using a DTGS detector and moderately short acquisition times (less than one minute).

NOTE: With a Ge crystal, the energy throughput will be lower. For example, 45° Ge crystals can show throughput of approximately 10-15%.



If the energy throughput is below 21%, begin to gently move the transfer mirror block using the three thumb screws on the bottom of the A.R.K..

Adjust the left thumb screw first. Look for an increase in energy.

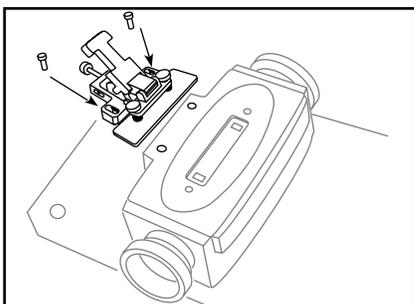
Once you've attained peak energy, move to the back right thumb screw. Adjust this thumb screw until the energy is maximized.

Adjust the front right thumb screw. Once peak energy is achieved repeat the sequence for all three thumb screws, trying to keep the adjustments consistent (level) for all three thumb screws.

Installation & Alignment

The Gripper

The acquisition of ATR spectra requires intimate optical contact between the ATR crystal and the sample. The Gripper clamp is designed to achieve optimum contact between samples of varying overall thickness and the crystal assembly. Initial sample contact with the crystal is achieved by adjusting the compression springs. Optimum optical contact is achieved through to the adjustment screw.

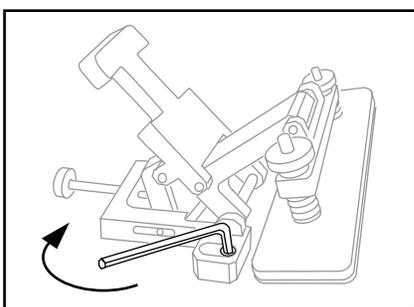


Place Gripper on the A.R.K.

Locate the 10-32 x 1/2" screws provided for mounting the Gripper assembly.

Align the mounting holes on the Gripper with the holes on the A.R.K..

Note: The Gripper should be placed with the adjustment screw facing towards the rear of the A.R.K..



Secure Gripper to A.R.K.

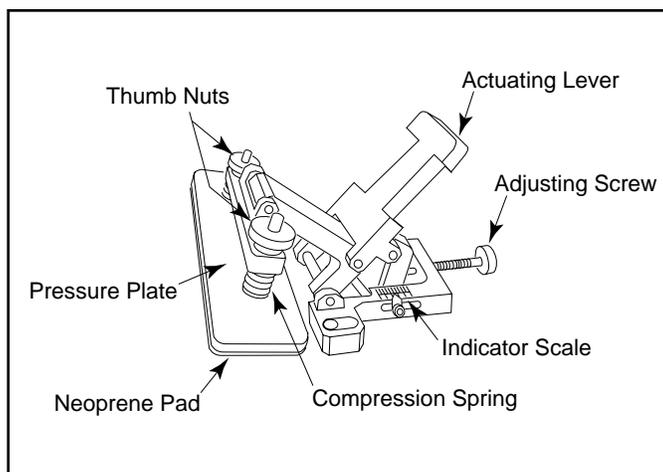
Secure the Gripper to the A.R.K. using the mounting screws.

Tighten with the 5/32 allen wrench provided.

Note: The Gripper is shipped preset to apply pressure to analyze a polymer film to a flat crystal assembly (45 degree ZnSe is the standard option, others are available.). This is a satisfactory setting for most applications (with the noted exception of compressible powders in the trough). The adjustment screw can be used to apply higher pressures (e.g for compressible powders in the trough plate).

Installation & Alignment

The Gripper



Adjust Gripper for lower pressures

Move the actuating lever up to raise the compression pad. The pad should swing freely from its mount.

Turn the adjustment screw to the end of the scale (counter clockwise all the way out).

Adjust the thumbnuts until the pad just contacts the crystal assembly evenly when the lever is down.

Release the clamp and make a small incremental increase in the adjustment screw setting. If the spectrum is too weak, release the clamp and further tighten the adjustment screw.

The Gripper should always be in the unclamped position when making adjustments.

CAUTION: If you find considerable force is necessary to overcome the resistance.
STOP!! Reconsider this technique for the sample.

Operation

Liquid Samples

The A.R.K. is designed to be extremely easy to operate and to offer highly reproducible data. To maximize the performance of your system, follow the steps outlined in this section when acquiring spectra using the A.R.K..

NOTE: The A.R.K., like any other analytical tool, should be operated under standard "good laboratory practices" guidelines. Recommended procedures include the following:

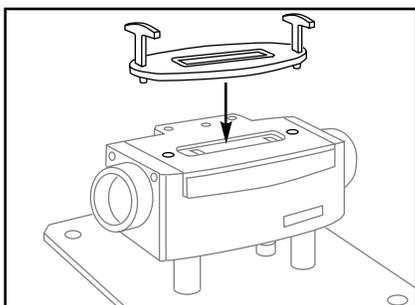
- Before first use, and at regular intervals thereafter, record the energy throughput of your accessory with no sample on the crystal and with a standard sample on the crystal. This data, including recorded spectra, should be kept on file as a diagnostic tool in case of an accessory or instrument service problem.

NOTE: For **Liquid samples** observe the following **precautions**:

- make sure that your sample will not attack the crystal material. (see page 9)
- If your material is messy or there is a high probability of spilling the sample, remove the sampling plate from the base assembly before placing the sample on the plate.
- For best, reproducible results, the sample should cover the entire crystal surface.
- **Be careful not to thermal shock the crystal.** Applying a very hot or very cold sample directly to the crystal may cause the crystal to crack.
- When analyzing volatile materials, you should use the volatiles cover to prevent sample evaporation during the analysis.

Operation

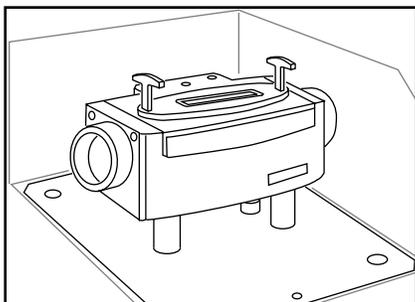
Liquid Samples



Install sampling plate

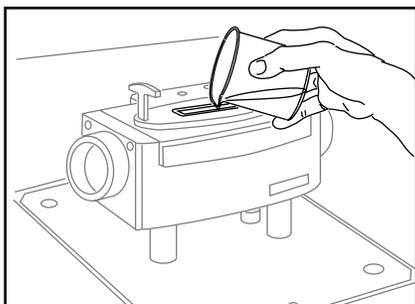
Place the trough sampling plate on the top of the A.R.K. being careful that the positioning pins are properly seated in the holes provided, and that the plate is flush against the top of the base assembly.

Refer to the Theory section of this manual for a discussion of crystal angle and material.



Acquire a background spectrum

Acquire a background single-beam spectrum with the *empty* trough sampling plate in place.

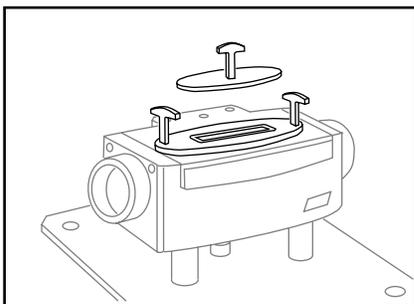


Place sample in trough

Place your sample in the trough sampling plate *observing the precautions listed on page 16.*

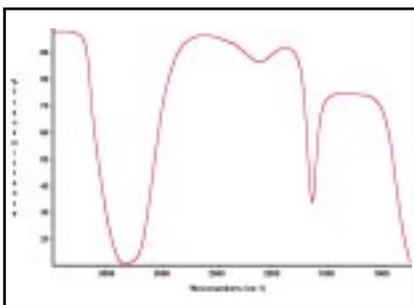
Operation

Liquid Samples



Use Volatile liquid cover

If your sample is a volatile liquid place the cover over the trough plate.

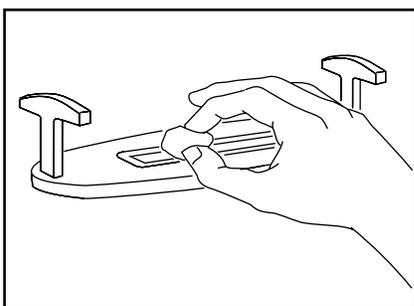


Acquire a sample spectrum

Acquire a sample single-beam spectrum.

Ratio it against the previously acquired reference single-beam spectrum.

Note: The background and sample spectra MUST be acquired using the same crystal.



Clean the crystal

If necessary remove the volatile liquid cover.

Remove the trough sampling plate.

Clean the sample off the crystal using a cotton ball or cotton swab moistened with an appropriate solvent.

The entire crystal plate may be immersed in a suitable solvent for short periods of time for cleaning purposes*.

***CAUTION:** Avoid prolonged immersion in solvents such as chlorinated solvents as this can affect the adhesive used to bond the crystal to the holder. Do not use an ultrasonic bath to clean the trough.

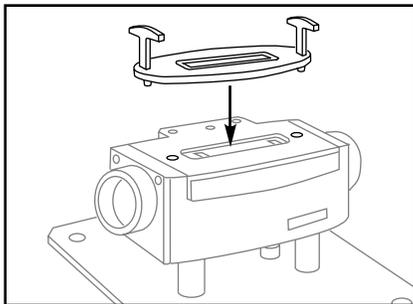
Operation

Powder Samples

NOTE: For **Powder samples** observe the following **precautions**:

- The sample should consist of a fine particle size, soft, compressible powder.
- For best results, the sample should cover the entire crystal surface.
- When analyzing powders, use of the powder press and Gripper is recommended to maintain even and intimate contact between the sample and the crystal.
- Make sure that your sample will not attack the crystal material.
- Only use enough sample to cover the crystal surface.

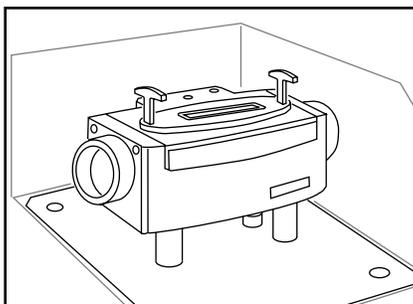
The use of too much powder can result in crystal damage.



Install sampling plate

Place the trough sampling plate on the top of the A.R.K. being careful that the positioning pins are properly seated in the holes provided, and that the plate is flush against the top of the base assembly.

Refer to the Theory section of this manual for a discussion of crystal angle and material.

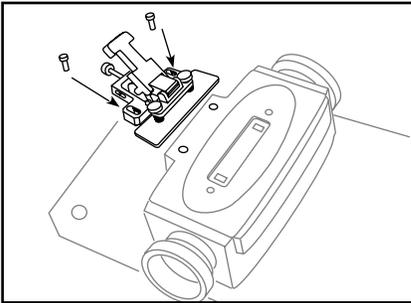


Acquire a background spectrum

Acquire a background single-beam spectrum with the *empty* trough sampling plate in place.

Operation

Powder Samples

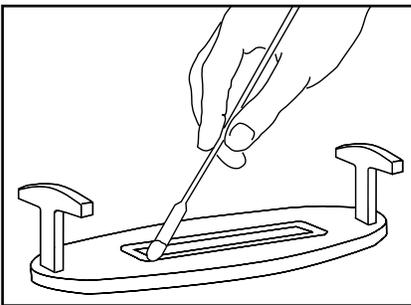


Install Gripper

Follow installation procedure pages 14-15.

NOTE: When using the **Gripper** observe the following **precautions**:

- Excessive pressures can crack and permanently damage the sampling crystal. Do not use the Gripper to crush samples. Do not apply pressure to the crystal for extended periods of time as cracking of the measurement crystal can occur.
- The sampling crystals of the A.R.K. are delicate optical components. When applying pressure with the Gripper, you should use 2 hands - one to adjust the position of the pressure plate, the other to position the lever. This assures that excessive pressures will not accidentally be applied to the crystal.



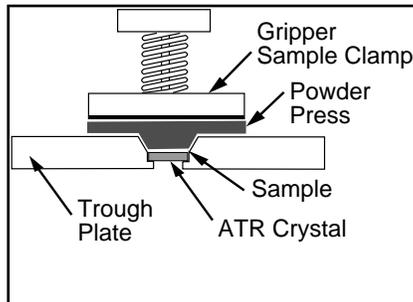
Place sample in trough

Place your sample in the trough sampling plate *observing the precautions listed on page 19.*

Note: It is not necessary to fill the trough to the top with your powder. Best results are usually obtained by placing a thin layer of the powder on the crystal with the powder press on top to compress the sample.

Operation

Powder Samples



Optimize Gripper setting

Using the actuating lever, clamp the Gripper down on the sample.

Make sure that the pressure plate contacts the crystal evenly.

Optimize Gripper setting

Obtain a sample spectrum.

Release the clamp.

Increase the pressure using the adjustment screw.

Reclamp and repeat the measurement.

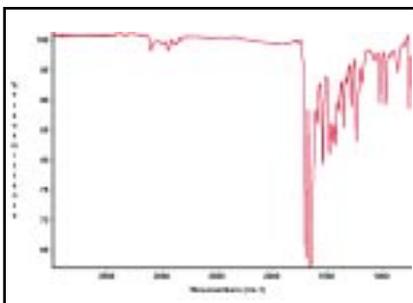
Continue increasing the pressure until no noticeable change in the spectrum occurs (or until a fair amount of force is required to press the Gripper lever down - see "Note" Page 14).

This will be the optimal setting. Record the value for future use.

CAUTION: Powder samples produce weak spectra even with maximum pressure - be careful not to break the crystal by applying too much pressure. Samples must be compressible. Do not attempt to analyze hard plastics. The Spectra-Tech Diffuse Reflectance accessory (the Collector™) would be more appropriate for the analysis of "hard" samples.

Operation

Powder Samples

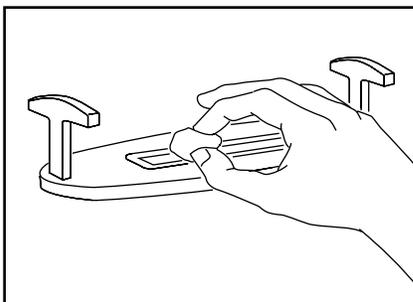


Acquire a sample spectrum

Acquire a sample single-beam spectrum.

Ratio it against the previously acquired reference single-beam spectrum.

Note: The background and sample spectra MUST be acquired using the same crystal.



Clean the crystal

Release the Gripper.

Remove the trough sampling plate.

Most powder samples can be brushed out of the trough. Any remaining sample can be cleaned off the crystal using a cotton ball or cotton swab moistened with an appropriate solvent.

The entire crystal plate may be immersed in a suitable solvent for short periods of time for cleaning purposes*.

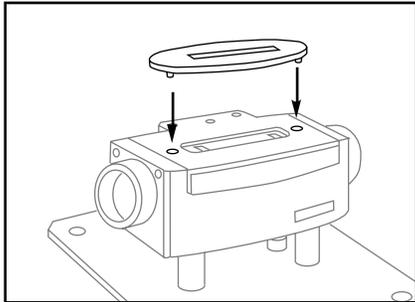
***CAUTION:** Avoid prolonged immersion in solvents as this can affect the adhesive used to bond the crystal to the holder. Do not use an ultrasonic bath to clean the trough.

Operation

Films/Irregular Samples

NOTE: For **Films/Irregular samples** observe the following precautions:

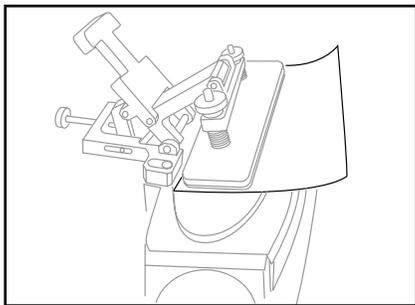
- For best results, the sample should cover the entire crystal surface.
- When analyzing films and irregular samples, use of the Gripper is recommended to maintain even and intimate contact between the sample and the crystal.
- Make sure that your sample will not attack the crystal material.
- Irregular samples can apply uneven pressure to the crystal causing it to break if too much pressure is applied.



Install sampling plate

Place the flat sampling plate on the top of the A.R.K. being careful that the positioning pins are properly seated in the holes provided, and that the plate is flush against the top of the base assembly.

Refer to the Theory section of this manual for a discussion of crystal angle and material.

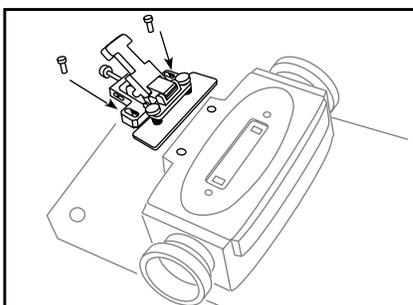


Acquire a background spectrum

Acquire a background single-beam spectrum with the *empty* flat sampling plate in place.

Operation

Films/Irregular Samples

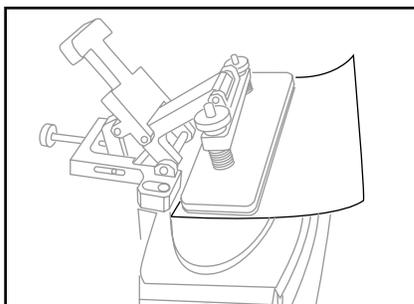


Install Gripper

Follow installation procedure pages 14-15.

NOTE: When using the **Gripper** observe the following precautions:

- Excessive pressures can crack and permanently damage the sampling crystal. Do not use the Gripper to crush samples. Do not apply pressure to the crystal for extended periods of time as cracking of the measurement crystal can occur.
- The sampling crystals of the A.R.K. are delicate optical components. When applying pressure with the Gripper, you should use 2 hands - one to adjust the position of the pressure plate, the other to position the lever. This assures that excessive pressures will not accidentally be applied to the crystal.

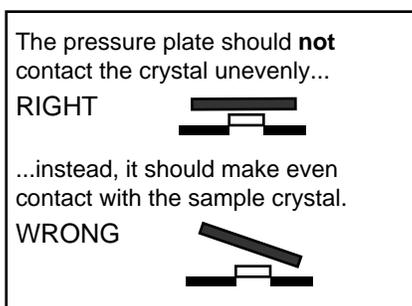


Place sample on flat sampling plate

Place your sample on the flat sampling plate.
Cover the entire crystal with your sample.

Operation

Films/Irregular Samples



Optimize Gripper setting

Place the black foam piece (included) between the sample and the Gripper to distribute the pressure for better sample-crystal contact.

Using the actuating lever, clamp the Gripper down on the sample.

Make sure that the pressure plate contacts the crystal evenly.

Optimize Gripper setting

Obtain a sample spectrum

Release the clamp

Increase the pressure using the adjustment screw.

Reclamp and repeat the measurement.

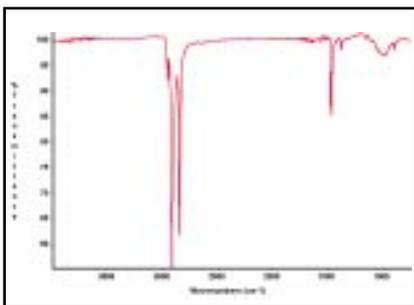
Continue increasing the pressure until no noticeable change in the spectrum occurs (or until a fair amount of force is required to press the Gripper lever down - see "Note" Page 14).

This will be the optimal setting. Record the value for future use.

NOTE: For repeated use of the Gripper with samples which require high pressure, we have included a **foam pad** to more evenly distribute the pressure. This should be inserted between the Gripper and the sample. To accommodate the extra thickness of the foam pad the spring height will have to be compressed further.

Operation

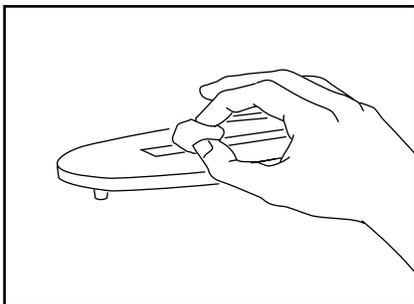
Films/Irregular Samples



Acquire a sample spectrum

Acquire a sample single-beam spectrum.

Ratio it against the previously acquired reference single-beam spectrum.



Clean the crystal

Release the Gripper.

Remove the flat sampling plate.

Clean the sample off the crystal using a cotton ball or cotton swab moistened with an appropriate solvent.

Appendix A

Replacement Parts

Crystals

PART NUMBERS 0055-XXX

Angle	ZnSe		Ge		ZnS		AMTIR	
	Flat	Trough	Flat	Trough	Flat	Trough	Flat	Trough
30°	NA	NA	714	614	NA	NA	NA	NA
40°	702	602	712	612	-	632	NA	NA
45°	703	603	713	613	733	633	NA	643
50°	707	607	-	-	-	-	NA	NA
55°	706	606	-	-	-	-	NA	NA
60°	705	605	715	615	735	635	NA	645
70°	708	608	-	-	-	-	NA	NA

Parts

Foam Purge Rings	2005-318
Quick-Fit Purge Assembly	0056-501

Notes

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