Operating Instructions

M300 Monochromator

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Edinburgh Instruments Ltd., 2 Bain Square, Kirkton Campus, Livingston, EH54 7DQ. UK
T: +44 (0)1506 425300 - F: +44 (0)1506 425320 - E: eai.service@edinst.com - W: www.edinst.com

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1. Introduction

The M300 is a high quality grating monochromator in Czerny-Turner configuration designed for the UV, visible and infrared spectral range. When purged the monochromator can be used down to 175nm while a range of easily interchangeable gratings allows operation up to 30μm. All gratings are kinematically mounted so that calibration is not lost when gratings are exchanged.

A built in stepping motor and a sine drive allow wavelength scanning to be completely controlled from a remote stepping motor drive unit. When used as an integral part of the Edinburgh Instruments Ltd. spectrometer system the monochromator is generally controlled from the central control unit CD900 and can be fully operated via the spectrometer software.

The use of the standard grating of 1800 l/mm in the visible region results in very high spectral resolution and exceptional light gathering power while novel and effective internal baffling leads to particularly low level of scattered light, which can be further reduced by the use of a holographic grating. The position of the collimating mirrors avoids re-diffracted light.

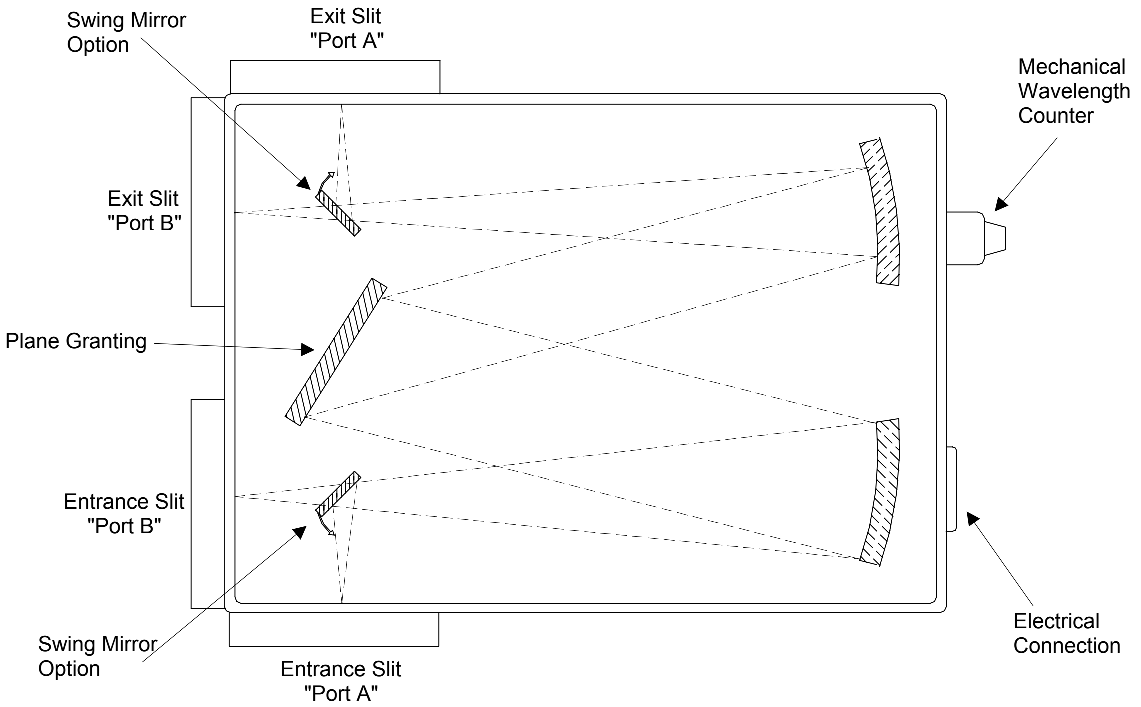
The monochromator is manufactured using a single main casting with rebated lid. This design ensures maximum robustness and light tightness.

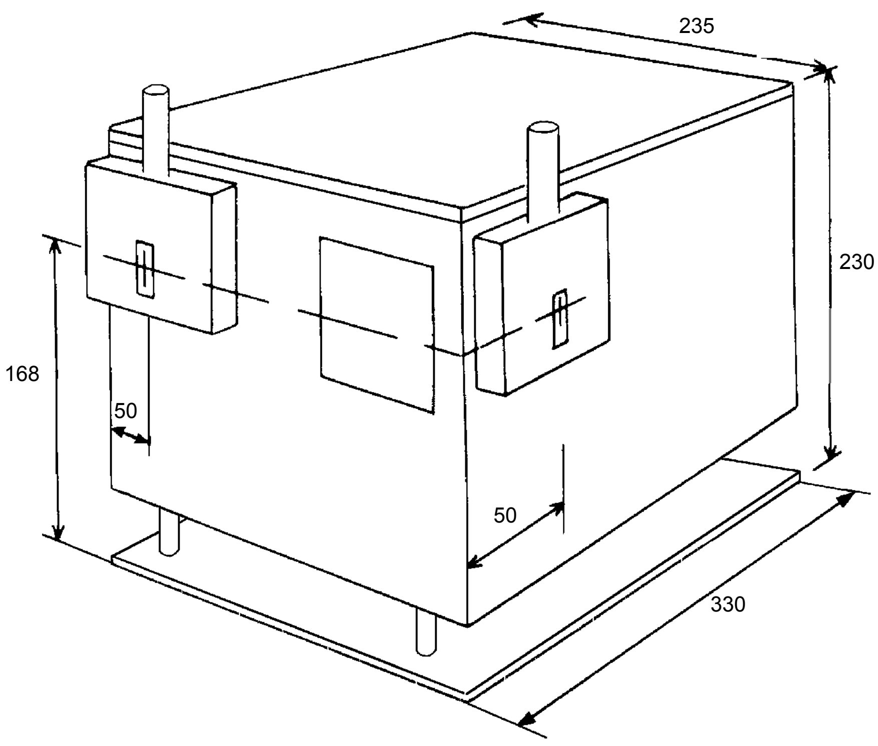
Alternative entrance and exit configurations (selected by computer controlled swing mirrors) give maximum flexibility when the monochromator is used as a module in the company's spectrometer range. It allows to couple up 2 different light sources and up to two different detectors onto the excitation and the emission monochromator, respectively.

WARNING

The monochromator contains delicate optics.

Do not open the monochromator lid if not needed!
Do not tough or breath over gratings!
Never try to clean the mirrors or gratings


Swing Mirror
Option
Exit Slit
"Port A"
Mechanical
Wavelength
Counter
Exit Slit
"Port B"
Plane Granting
Entrance Slit
"Port B"
Swing Mirror
Option
Entrance Slit
"Port A"
Electrical
Connection


235
230
168
50
50
330

2. Transit and Packing

In general the monochromator will be an integral part of a spectrometer system and as such it will be packed for transit in a large spectrometer crate.

If, however, the monochromator is purchased separately or if the monochromator needs to be shipped for service purposes the monochromator will be delivered in a suitable container usually comprising a inner cardboard box in which the monochromator is wrapped with foil and protected with packaging foam material, and an outer cardboard box with shock absorbing foam between the inner and the outer box.

In any case, GRATINGS ARE SHIPPED SEPARATELY. This is a precautionary measure against loosening and fall-out of the grating out of the grating holder and against damage of mechanical parts due to vibration of the relatively heavy grating. For grating removal and replacement see chapter 3.2, page 5.

Gratings are shipped with the protective cover in place, together with the leave spring. Grating and leave springs are shipped in a separate small cardboard box.

Prior to shipment the monochromator wavelength should be set to a value of less than 1/3 the maximum wavelength range. (Less than 300.0 of the mechanical wavelength counter, if fitted.)

3. Installation

3.1. Monochromator Installation

(for individually shipped monochromators only)

1. Remove the monochromator from the transit box.
2. Allow monochromator to adapt to ambient temperature, then remove slit covering tape and open monochromator lid for grating installation. (This step is particularly important at cold outside temperatures. Opening the lid of a cold monochromator in warm humid environment can cause water condensation on optical surfaces.)
3. Install the monochromator according to the purpose. This will generally be the integration into the spectrometer system, which will require the necessary flanges to be fitted to the slits and this assembly mounted to the spectrometer assembly.

3.2. Grating Installation

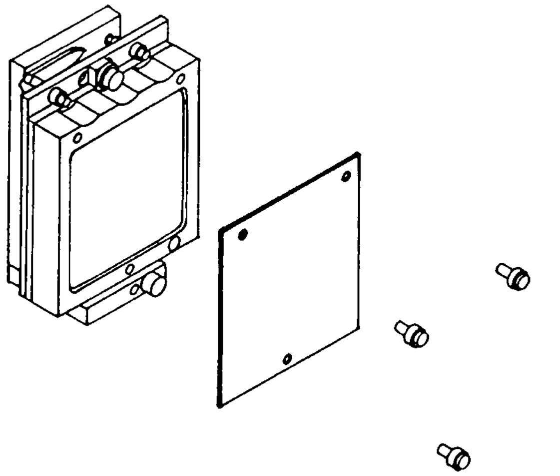
The gratings supplied for use with the monochromator are mounted on a kinematic system which allows them to be interchanged quickly and without loss of calibration.

Gratings supplied with the monochromator have been fully adjusted in manufacture and the user needs only install them as required.

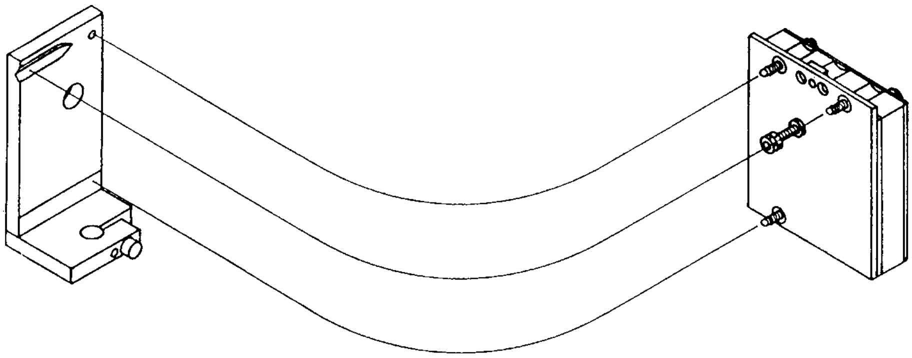
When gratings are purchased separately after delivery of the monochromator (within the spectrometer system) a once and for all grating adjustment must be made in order to achieve correct wavelength calibration. See chapter 5, page 15.

The procedure for grating installation is as follows:

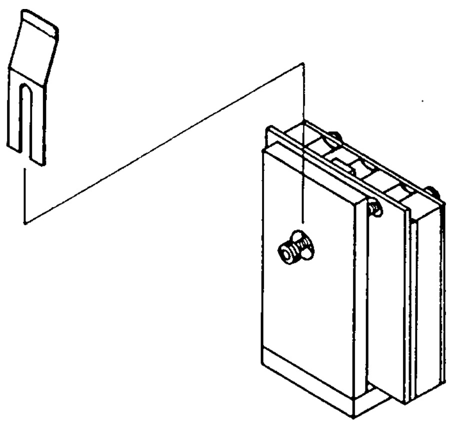
1. Remove the lid of the monochromator by unscrewing the four M4 socked head screws.
2. Using silk or felt gloves, remove the protecting cover of the grating to be fitted by unscrewing the 3 M3 nylon knurled head screws. TAKE CARE NOT TO TOUCH THE FRONT SURFACE OF THE GRATING.



3. Insert the grating into its mount making sure that the locating screws are properly seated in the moults / grooves on the kinematic plate.



4. Fix the grating by inserting the leave spring on the back side of the kinematic grating mount between the plate and retaining nut of the mounting screw.



5. Check for a second time that the locating screws are properly seated in the moults / grooves of the kinematic plate.
6. Replace and fix the monochromator lid.
7. Store the grating cover and the nylon screws at a save place.

If gratings are due to be exchanged, e.g. exchange of a grating for the visible spectral range against a grating covering the near infrared range, and visa versus, follow the procedure above in reverse for grating removal and analogously for grating replacement.

4. Operation

The operation of the M300 monochromator is partly made via the spectrometer software (wavelength settings, port selection by swing mirrors) and partly made manually (slit settings). The definition of the stepper motor parameters is exclusively made by software. For instructions on how to operate the monochromator within the spectrometer assembly via software the user is referred to the relevant software instruction manual.

For best accuracy always approach the desired wavelength setting in an increasing direction. In spectral scans this is done automatically as spectral scans are always made from shorter to longer wavelengths. In pre-scan and pre-measurement signal checks the wavelength can be set starting from longer or from shorter wavelengths. This is generally not a problem if the spectral features of the sample or the spectral bandwidths defined by the monochromator slit width setting are not critical. For narrow band spectral features and narrow spectral bandwidths, however, attention must be drawn to the possible backlash and the decreased accuracy when approaching a wavelength from either shorter or longer wavelengths.

The monochromator is fitted with a high precision initialisation point recognition system. This initialisation point will be about 5 to 50nm (standard grating) above the maximum wavelength. During initialisation procedure the monochromator will move upwards towards longer wavelength until the initialisation point is found and will than move to the start wavelength defined by the software. Beside the fact that the software would not allow wavelength to be selected below zero order and above the maximum wavelength, additional limit-switches would be activated and their message recognised by the software if for some reason the monochromator would try to move outside the allowed wavelength range.

If a mechanical wavelength counter is fitted to the monochromator this counter should not be used to manually operate the wavelength settings. These counters are “add-on’s” and give only an additional information about the actual wavelength selected and demonstrated by means of the software. The counter display reads in Å (= 1/10 nm) for monochromators fitted with the standard grating. For other gratings the reading has to be converted (see specification table, chapter 6.2, page 18).

4.1. Slits and Spectral Resolution

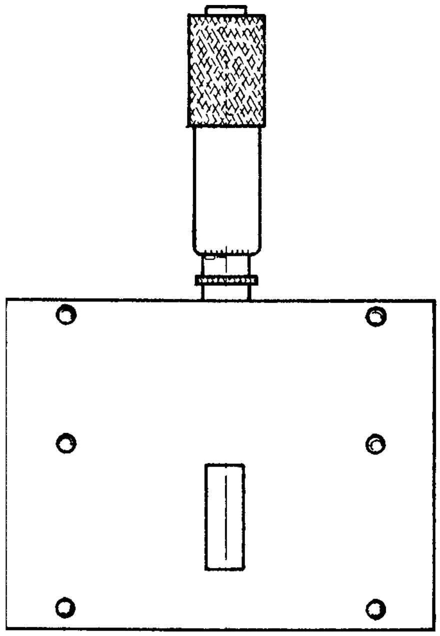
The monochromator is fitted with continuously variable bilateral straight slits to set up the spectral resolution of the monochromator. The slit width is set by the micrometer screw and is variable between 0 and 10mm.

The slit jaws cannot be damaged by overthightening but excessive force could result in misalignment of the zero position and damage to the slit mechanism. The slits cannot be damaged by opening beyond 10mm.

One division on the rotating barrel of the micrometer screw corresponds to a slit width of 10μm. One rotation of the micrometer screw corresponds to 0.5mm.

The following table can be used as a guide for adjusting the slits for the requested spectral bandwidth. Note that in general both entrance and exit slit should be adjusted to the same slit widths.

Spectral Resolution [nm]	Slit width [mm]			
	2400 l/mm Grating	1800 l/mm Grating	1200 l/mm Grating	600 l/m Grating
1.0	0.74	0.55	0.37	0.19
2.0	1.48	1.11	0.74	0.37
3.0	2.22	1.67	1.11	0.55
4.0	2.96	2.22	1.48	0.74
5.0	3.70	2.78	1.85	0.93
6.0	4.44	3.33	2.22	1.11
7.0	5.18	3.88	2.59	1.30
8.0	5.92	4.44	2.96	1.48
9.0	6.66	5.00	3.33	1.67
10.0	7.41	5.55	3.70	1.85
11.0	8.15	6.11	4.07	2.04
12.0	8.88	6.66	4.44	2.22
13.0	9.63	7.22	4.81	2.41
14.0	10.37	7.77	5.18	2.59
15.0		8.33	5.55	2.77
16.0		8.88	5.92	2.96
17.0		9.44	6.30	3.15
18.0		10.00	6.66	3.33
19.0			7.04	3.52
20.0			7.41	3.70



The black knurled ring at the base of the micrometer can be used to lock the micrometer position.

By use of a small “G” wrench with it’s pin inserted into the black painted hole above the knurled ring the curson of the micrometer can be rotated. This allows to adjust the “zero line” to any position for convenient reading and provides a means for fine-adjustment of the zero position. Crude adjustment of the zero position is made by loosing the screw on the top of the micrometer (1 turn) and adjusting the rotating barrel to zero when the micrometer is physically at zero.

4.2. Correct Illumination

The first spherical mirror of the monochromator has an effective width of 69mm and a focal length of 300mm. The aperture ratio (to be used for correct illumination) is therefore 300 / 69 = 4.3.

a) Correct illumination of the monochromator optics is achieved when the image of the light source to be analysed is at the position of the monochromator entrance slit (focused by means of lens or mirror optics).
b) the centre of light source, the centre of entrance slit, and the centre of first spherical mirror are in one optical axes.
c) the aperture ratio of the lens (or mirror) optics used to image the source to the entrance slit (= ratio between the distance of the last element of the focusing optics to the entrance slit and effective diameter of the last optical element) matches the aperture ratio of the monochromator.

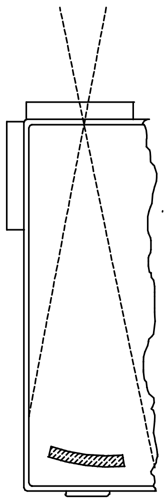
Provided that these conditions are fulfilled the first spherical mirror will be homogeneously illuminated, the light beam between spherical mirror and grating will be parallel (and roughly of the diameter of the spherical mirror), and the grating will be homogeneously illuminated, too.

In praxis some little compromises often have to be made taking into account that for extended light sources and for narrow entrance slit widths the illuminated area at the first spherical mirror is not a sphere but rather an ellipses.

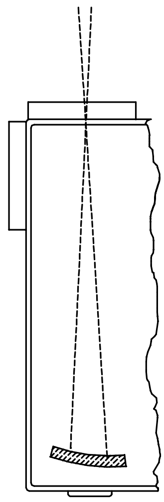
If the monochromator comes as a module of an Edinburgh Instruments Ltd. spectrometer system the focusing optics and the light source will be supplied as well and the system would be fully optically matched in order to achieve highest performance. However, it is necessary to check the correct illumination after accidental misalignment of the xenon lamp or after exchange of the xenon lamp bulb.

Alignment examples:

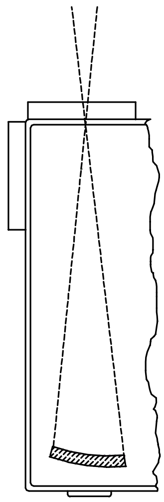
<u>Spherical mirror illumination</u>



wrong
(external aperture ratio too small)

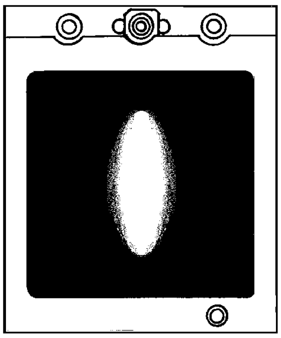


wrong
(external aperture ratio too large)

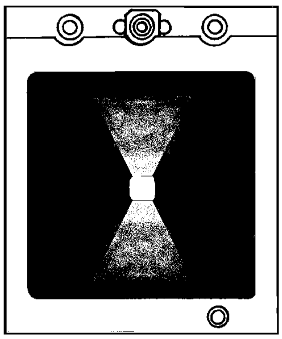


correct

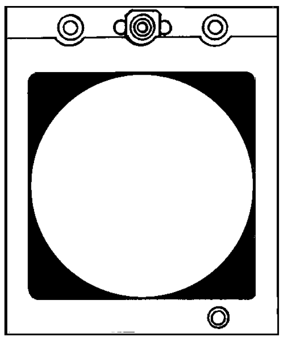
<u>Grating illumination</u>



wrong
(focus before monochromator entrance slit)



wrong
(focus behind monochromator entrance slit)



correct

5. Wavelength Calibration

The wavelength calibration for each monochromator and for at the date of order specified gratings was carefully made at manufacture. If for some reason the monochromator seems to be out of calibration the reason should be carefully investigated before attempting re-calibration. Please contact Edinburgh Instruments Ltd. before undertaking any trouble shooting action.

A calibration procedure will be necessary if a new grating was purchased at a later date.

1. Preparation:

For calibration of the grating assembly a medium or low-pressure mercury lamp, a focusing lens, a detector (preferably one of the spectrometer assembly), M4 and M2.5 Allen keys are required. The fine adjustment of the grating is best made using the Edinburgh Instruments Ltd. spectrometer operating software, but can also be made by means of the mechanical wavelength counter.

Remove the lid of the monochromator by unscrewing the four M3 socked head screws.

Adjust the entrance and the exit slit widths to give maximum resolution. The minimum slit width will depend on the power of the light source used for calibration. It should, however not be larger than 0.2mm.

2. Rough Alignment:

Flood the entrance slit with light from a medium or low-pressure mercury lamp.

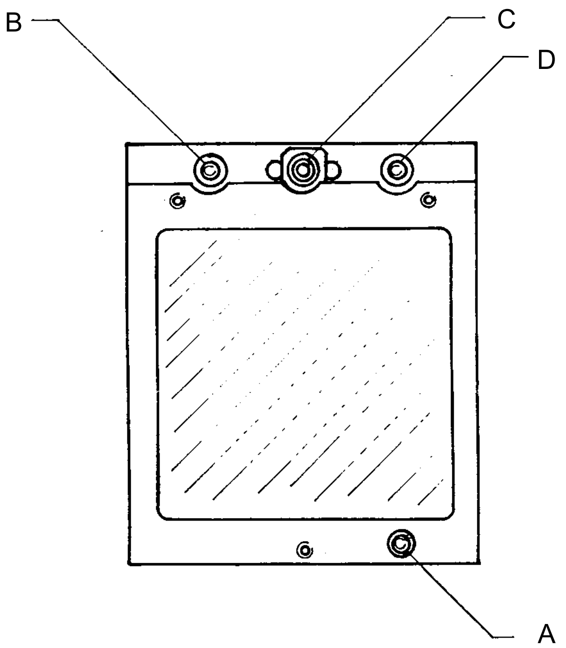
WARNING
Mind the ultraviolet radiation from the mercury lamp.
Avoid exposure of skin and eyes.

Check that the lamp is so positioned and focused in such a manner that the grating is uniformly flooded with light (see chapter 4.2, page 12).

By means of the software (or by the mechanical wavelength counter) adjust the wavelength to 546.1nm. This is one of the brightest visible wavelengths emitted by the mercury lamp: green (546.074nm), see Appendix 2 for a selection of calibration lines.

Using screws A and B align the image of the entrance slit with the exit slit. (Screw A moves the image vertically, screw B horizontally.)

If the image of the entrance slit is not aligned vertically with the exit slit, loosen screw C and using the Allen key as a lever in the holes next to screw C adjust the rotation of the grating to align the image. Tighten screw C.



3. Fine Adjustment:

This is best done with the detector fixed to the exit port and the mercury lines monitored by means of emission scans. This also guarantees that the wavelengths are always approached from the shorter wavelength side.

With the slit size adjusted for maximum resolution (and for an appropriate light level) scan a range of approximately 10nm with step size of 0.05nm (or the smallest for a non-standard grating). The 546.1nm line should now appear in the scan although it may not be at the exact position.

By slightly adjusting screw B the peak of this line can now be shifted. Repeat the scan and the adjustment of screw B until the line has its peak at 546.1nm.

The above procedure allows to adjust the wavelength offset only. Generally there should be no problem with non-linearity. Non-linearity can be tested by measuring alternative mercury lines:
365.01nm, 365.40nm, 366.30nm (mercury triplet), 404.66nm, 435.84nm, 576.95nm, 579.07nm (mercury doublet), see also appendix 2.

If the non-linearity is unsatisfactory screw D can be turned and the fine-adjustment procedure needs to be repeated.

6. Technical Specification

6.1. General Monochromator Specification

Optical Configuration: Symmetrical Czerny-Turner with alternative slit positions (see diagram on previous page).

Focal Length: 300mm.

Aperture Ratio (1): f/4.2

Stray Light: 0.0018 @ 1.5 bandwidths from laser line
0.00025 @ 3.0 bandwidths from laser line
0.00004 @ 10.0 bandwidths from laser line
(Measurements were made with an 1800 l/mm holographic grating at full aperture with a 1nm bandwidth.)

Gratings: 69mm x 69mm plain diffraction gratings. Each grating is mounted on a quick-change kinematic mount allowing grating changeover without loss of calibration.

Wavelength Range: Dependent on grating, see specifications on the next page.

Slits: Continuously variable, bilateral straight slits. Slits widths is variable between 10μm and 10mm by direct reading micrometer screw gauge. The slit height is 20mm.

Wavelength Scanning: By stepper motor fitted below the floor of the monochromator. The motor is directly linked to the lead screw c controlling the kathete of the sine bar mechanism. Limit switches at both ends of the lead screw prevent overscanning.

Construction: Single aluminium casting with rebated lid.

Physical Size: 230mm (h) x 235mm (w) x 330mm (d) (see diagram on previous page)

Optical Height: (in spectrometer configuration) 168mm

Weight: 12.4kg (complete with grating).

6.2. Grating Specific Monochromator Specification

	2400 l/mm	1800 l/mm	1200 l/mm	600 l/mm	Unit
Wavelength Range (2)	z. o. - 675	z. o. - 900	z. o.-1350	z. o.-2700	nm
Dispersion (3)	1.35	1.8	2.7	5.4	nm/mm
Resolution (4)	0.038	0.05	0.075	0.15	nm
Min. Wavelength Step Size (5)	0.0375	0.05	0.075	0.15	nm
Maximum Scan Speed (5)	18.75	25	37.5	75	nm/s
Wavelength Repeatability (6)	± 0.038	± 0.05	± 0.075	± 0.15	nm
Wavelength Accuracy (7)	± 0.15	± 0.2	± 0.3	± 0.6	nm
Grating Replacement Accuracy (8)	± 0.22	± 0.3	± 0.45	± 0.9	nm
Wavelength Back-Lash (9)	≤ 0.22	≤ 0.3	≤ 0.45	≤ 0.9	nm
Light Gathering Capability (10)	0.84	0.63	0.42	0.21	
Wavelength Counter Readout (11)	x 3 / 4	x 1(direct readout)	x 3 / 2	x 3	

The grating with 1800 l/mm is the standard grating in the Edinburgh Instruments Ltd. spectrometer range. This standard grating can either be holographic optimised at 250nm for use in excitation monochromators or ruled blazed at 500nm for use in emission monochromators. The other gratings are on special request for either specific UV options or for use in the near infrared spectral range. See also Appendix 1 for grating efficiency curves.

Remarks and Definitions:

(1) Aperture Ratio: Calculated using the focal length of the monochromator and the effective area of the first spherical mirror.

(2) Wavelength Range: The table shows the theoretical wavelength range, which depends on the grating in use. In praxis the wavelength range is restricted by the grating efficiency range and software constrains. (z.o. refers to zero order)

(3) Dispersion: This figure, when multiplied by the slit width (equal on both entrance and exit slit) gives the approximate full width at half height of the spectral band pass function (bandwidth) provided that the bandwidth being demanded does not approach the limiting resolution.

(4) Resolution: The maximum obtainable resolution is limited by mis-focus. The monochromators are set up to achieve the specified resolution before delivery.

(5) Minimum Wavelength Step Size / Maximum Scan Speed: These figures are given by the electro-magnetical / mechanical properties of the stepper motor and the mechanical characteristics of the sine-bar mechanism.

(6) Wavelength Repeatability: The error (standard deviation) when setting a defined wavelength by approaching this wavelength from the same direction. Figure valid over the whole theoretical wavelength range.

(7) Wavelength Accuracy: The absolute error of the wavelength readout figure in respect to the true wavelength. This figure therefore contains the errors due to mis-alignment of the offset and the monochromator nonlinearity. The figure is valid for the full theoretical wavelength range.

(8) Grating Replacement Accuracy: The wavelength accuracy achieved after removal and refitting of the grating.

(9) Wavelength BackLash: The wavelength error for approaching one and the same wavelength from the shorter wavelength range and from the higher wavelength range. The monochromator is set up (is calibrated) for approaching the chosen wavelength from shorter wavelengths.

(10) Light Gathering Capability: This is a quantitative measure for the monochromator light throughput.
Light Gathering Capability = slit height / (f-number ^{2} x dispersion)

(11) Wavelength Counter Readout: For those monochromators fitted with an external mechanical wavelength counter the selected wavelength is given by the counter readout multiplied by the figure given in the table.

7. Warranty

1 a) The Company guarantees the equipment forming the subject of the contract/quotation against defective materials and workmanship for a period of one year from the date of delivery to the Purchaser.
b) In the case of sub-assemblies of equipment not manufactured by the Company, but incorporated in the equipment ordered, the Purchaser will be entitled only to the benefit and/or limitations of any guarantee given by the makers of such assemblies.
c) In no event shall the Company be liable for any consequential loss or damage arising from failure of the equipment under warranty.
d) At the end of the one year period referred to herein, all claims upon all liability of the Company shall be absolutely at an end.

2 a) The Company also warrants that the equipment conforms to specifications contained in current brochures or to extra specifications confirmed in writing at the time of order acknowledgement.
b) No warranty is made or implied as to the suitability of any equipment for the Purchaser's intended use beyond such performance specifications as form part of the contract.

3. The purchaser warrants:
a) That he will carefully examine and list all parts of the equipment supplied by the Company and notify the Company in writing of any shortage, defect or failure to comply with the contract, which is or ought to be apparent upon such examination and test, within 48 hours of the equipment being delivered to or collected by the Purchaser.
b) The equipment will be operated in accordance with the instructions and advice detailed in the appropriate operating instructions manual, or any other instructions which may be provided by the Company. The Company shall not be held responsible for any defect arising from the Purchaser's failure to comply with these recommendations and instructions or from damage arising from negligence or exposure to adverse environmental conditions.

4. The warranty is effective when:
a) Any defects in the equipment supplied are notified immediately by the Purchaser to the Company.
b) The equipment is returned to the Company at its Edinburgh premises, transportation and insurance prepaid, and undamaged by the failure to provide sufficient packaging.
c) The Purchaser has made payment in full for the contract in accordance with the Company's normal trading terms, i.e. 30 days from date of invoice.

5. The warranty covers:
a) Engineer's time costs during inspection and repair.
b) Any materials or components, which require to be replaced.
c) Return carriage costs to the Purchaser

6. However, if the Purchaser requests a service engineer to carry out the necessary inspection and repair of the equipment covered by the warranty on site, the Purchaser will be liable, at the Company's discretion, for:
a) Engineer's travelling time costs.
b) Engineer's travelling and accommodation expenses.

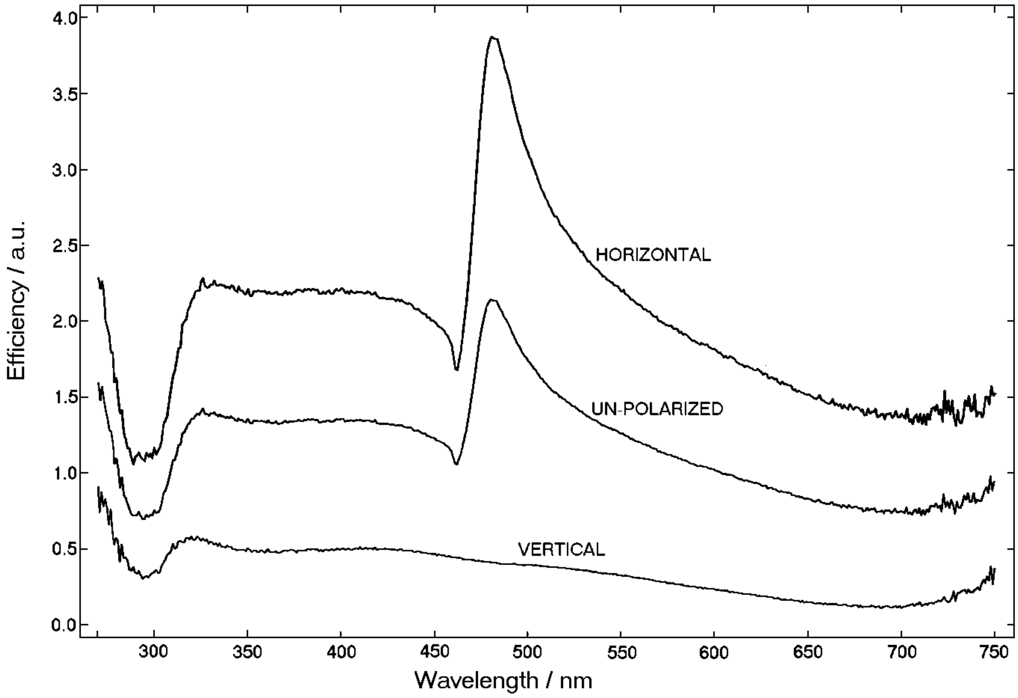
The timing of the inspection and repair of the equipment will be determined entirely at the discretion of the Company.

8. CE Declaration of Conformity

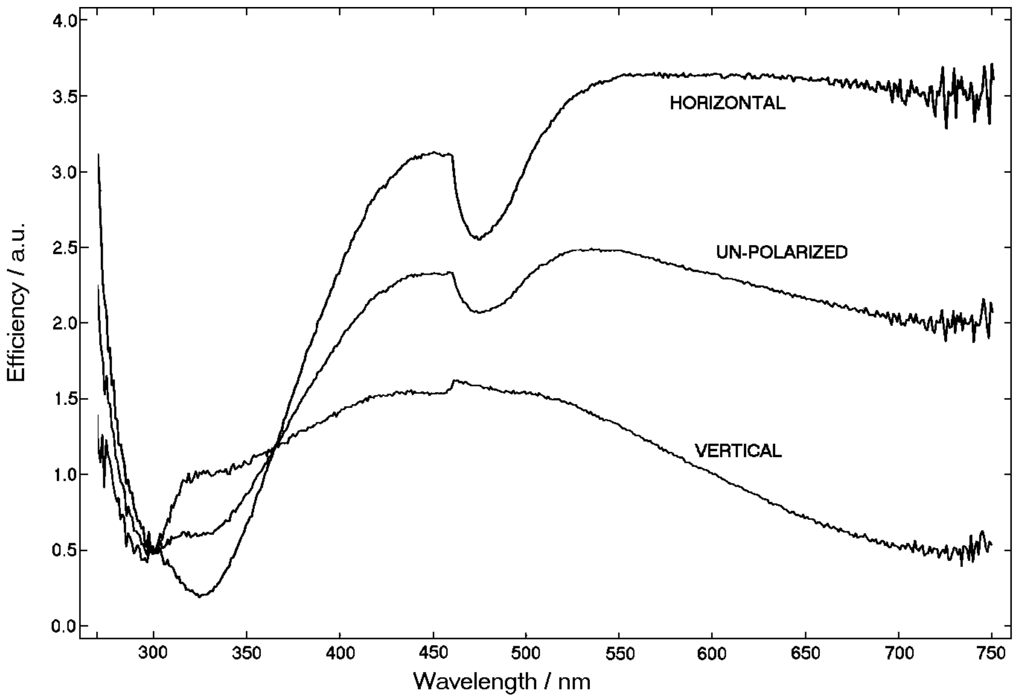
Manufactured by:	Edinburgh Instruments Ltd. 2 Bain Square Livingston EH54 7DQ Tel.: + 44 1506 425 300 Fax.: + 44 1506 425 320	
Applicable Standards:	Generic Immunity	EN 50082-1 : 1992
	Generic Emission	EN 50081-1 : 1992
	Electrical Safety Standards	EN 61010-1 : 1993

Edinburgh Instruments Ltd. certify that this equipment conforms with the protection requirements of the above Directives.

Appendix 1: Monochromator Efficiency

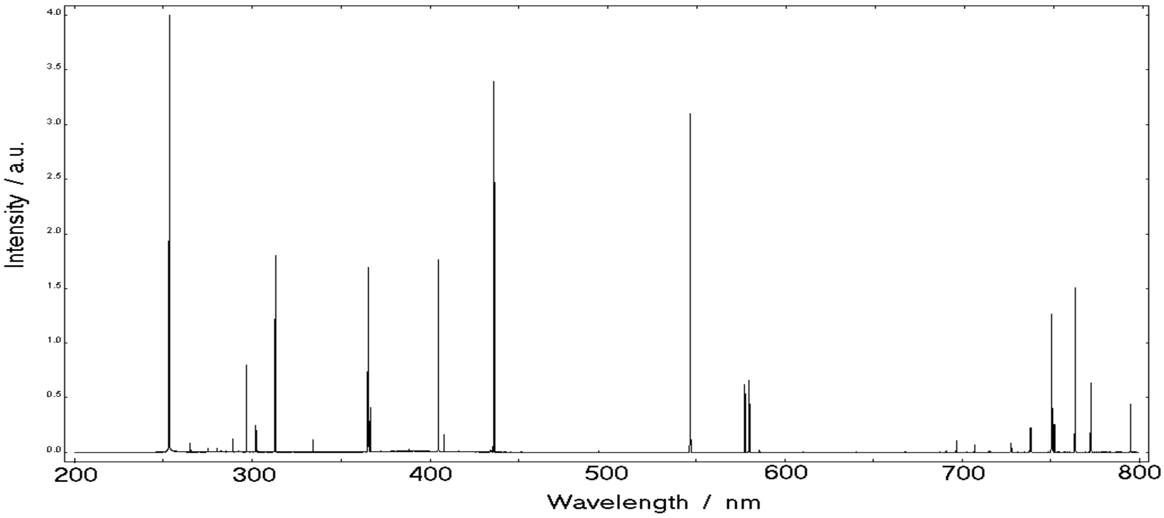


Typical efficiency curve of M300 monochromator fitted with 1800g/mm, 250nm optimised, holographic grating



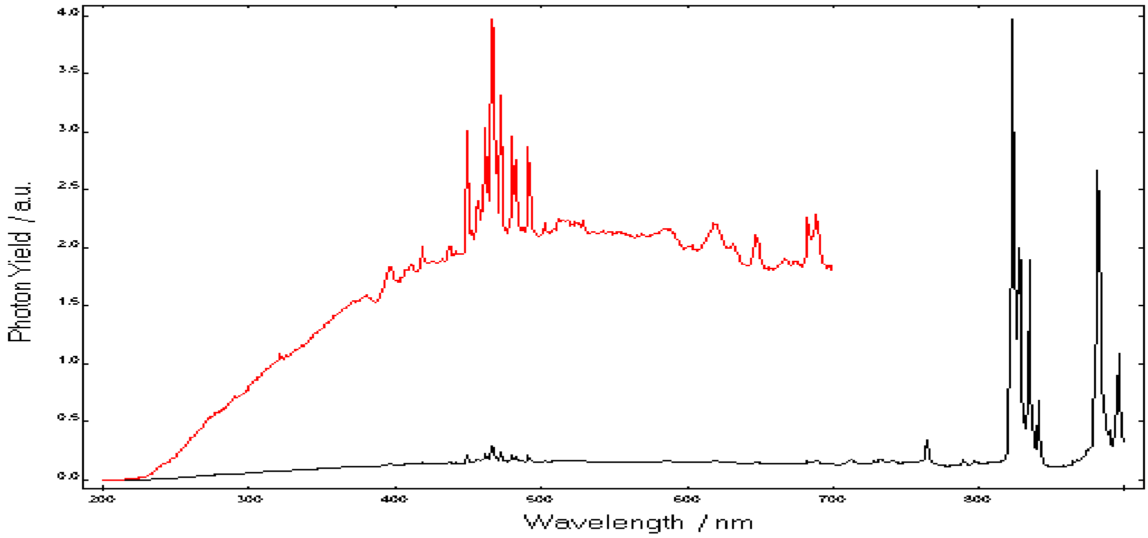
Typical efficiency curve of M300 monochromator fitted with 1800g/mm, 500nm blazed, ruled grating

Appendix 2: Suitable Calibration Lines



Calibration lines (in nm) of a low pressure Mercury / Argon calibration lamp. Note: The graph demonstrates the lamp function only, it does not include the monochromator efficiency.

Mercury						Argon	
253.652		326.406		404.656		738.398	
296.728		365.015	UV-triplet	435.833	blue	750.387	NIR doublet
312.567	UV doublet	365.484	UV-triplet	546.074	green	751.466	NIR doublet
313.155 /	UV doublet	366.288 /	UV-triplet	576.960	yellow doublet	763.511	
313.184	UV doublet	366.328	UV-triplet	579.074	yellow doublet	772.421	
320.820						794.818	



Spectrum of a high-pressure xenon lamp (Xe900). Due to the high pressure in the lamp the lines are broadened, but some may be used for calibration test purposes:

Appendix 3: Spectral Resolution

Mercury Triplet

Mercury Doublet