Model 360
Flame Photometer

Operator Manual

DOMINIQUE DUTSCHER SAS

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Intended Use

This operator's manual contains complete instructions for setting up and using the Model 360. Service information for use by appropriately qualified personnel is also available.

The Model 360 is intended for use by persons knowledgeable in safe laboratory practices. If the instrument is not used in accordance with these instructions for use, the protection provided by the equipment may be impaired.

There are no user replaceable parts within the instrument. Do not remove the covers from the instrument.

Sherwood Scientific Limited and its authorized Distributors consider themselves responsible for the effects of safety, reliability and performance of the Model 360 only if: -

- Assembly operations, extensions, re-adjustments, modifications or repairs are only carried out by persons authorized by them.
- The electrical installation of the relevant room complies with IEC requirements or the local regulatory code.
- The equipment is used in accordance with the instructions for use.

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Sherwood Scientific Ltd,
1 The Paddocks,
Cherry Hinton Road,
Cambridge,
CB1 8DH,
United Kingdom

Tel +44 1223 243444
Email info@sherwood-scientific.com
www.sherwood-scientific.com

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1

Introduction

1.1 Introduction

The Model 360 is a single channel, low-temperature flame photometer. It is supplied as standard, for the determination of Sodium (Na), Potassium (K), Lithium (Li), Calcium (Ca) and Barium (Ba), working with either Propane/Butane or Natural Gas fuels.

NOTE *The fuel gas for which the gas control pod on your instrument is designed for use with is indicated by the label on the rear of the left-hand side of the instrument.*

WARNING *It is important that only the fuel gases indicated on the rear of the instrument are used; using the incorrect fuel may be dangerous, may damage the instrument and will be detrimental to the performance of the unit.*

Please refer to Section 8.2 for a complete list of spares and accessories.

The Model 360 has a fail-safe device, which automatically stops the gas flow if the flame does not ignite, or if during operation, the flame is extinguished. It also has an air pressure switch so that if the air pressure falls below a specified value the flame will not ignite or will be extinguished.

For the purposes of this manual, the terms Atomiser and Nebuliser are interchangeable.

1.2 Summary of the Test

NOTE References are listed in Appendix A.

In many applications, rapid availability of results is of prime importance. By flame photometry, both Sodium and Potassium results on a single sample can be available in less than 5 minutes of the sample reaching the laboratory. (The same is true of Lithium results, a determination that was never carried out before the advent of flame photometry). A simple dilution step is all that is required; therefore sample handling, losses and inaccuracies are at a minimum (Ref. 3-10)

Prior to the advent of flame photometry, Sodium and Potassium were typically determined gravimetrically after the precipitation of relatively insoluble salts such as Sodium Uranyl Zinc Acetate (Ref. 1) and Potassium Chloroplatinate (Ref. 2). As with all chemical methods for these two elements, there were cross interferences and also interference from other ions such as NH_4^+. Many analytical steps such as protein precipitation or ashing of the sample were involved with all the attendant losses and inaccuracies and the complete procedures required many hours.

1.3 Flame Photometry Principles of Operation

When a solution is aspirated into a low-temperature flame, in an aerosol, each droplet of water evaporates leaving a solid core of the residue of evaporation. The core further breaks down to the molecular level and provided the molecules are not too refractory, progress to form atomic species. The atom then is excited by the flame and its electron temporarily moves to a higher energy state.

When the electrons return to the ground state, they lose the excitation energy and a discrete wavelength of visible light is emitted, characteristic of the atom. The emitted light can be isolated from other light wavelengths by an optical filter. The amount of light being emitted is proportional to the number of atoms in the flame, and it follows, the concentration of that atom in the original solution. The amount of light emitted can be measured by a suitable photodetector.

The photodetector generates an electrical signal which is amplified and displayed on a digital readout.

1.4 Reagents

Sherwood Scientific supplies a wide range of reagents, including standards, diluent and maintenance solutions, for use with the Model 360 Flame Photometer.
Please refer to Section 8.3 for a complete list of the reagents.

Dilutions

Samples and standards must be diluted with the same batch of diluent, made up of 1 part Diluent Concentrate to 999 parts deionised or good quality distilled water.

The same batch of diluent should be used to zero the instrument and to prepare dilutions of standards and samples. This will prevent variations in water purity affecting the measurements.
Great care should be taken so that contamination does not occur when preparing the samples and standards. Remember that the accuracy of the instrument is dependent on the accuracy and purity of the standards used for calibration.

Storage

All solutions should be stored away from direct sunlight, in a cool place (below +25°C/+77°F), in an airtight container to prevent evaporation and discolouration. Glass containers should not be used, as they can affect Na concentration levels. Prolonged exposure to the atmosphere must be avoided to prevent evaporation of standard solutions, which could affect concentration.

Purification

No purification is required for Sherwood Scientific standard solutions.

2

Installation

2.1 Services Required

Electrical Supply

The Model 360 is powered with a universal self-adjusting power supply.

CARE should be taken to use the correct adaptor for the local supply.

Fuel

The Model 360 comes in two versions, one for use with Butane or Propane, another for use with Natural Gas. The use of Natural Gas is not advised for accurate work.

Propane/Butane

A supply of High-grade Propane, Butane or Propane/Butane mixture, free of heavy hydrocarbon deposits, regulated at the cylinder to 2.1kg/cm² (30psig), flow rate at least 0.4 litres per minute. (Calor gas is perfectly acceptable). The use of industrial quality gas is not recommended as impurities can enter the delicate gas regulators and can leave deposits of oil and dirt, which will render the instrument inoperable.

Natural Gas

Natural gas at 3 to 10 inches water gauge.

NOTE Natural Gas may give reproducibility results outside specification.

NB The positioning of Gas cylinders should conform to National and local regulations.

Air

A supply of clean, dry, oil-free air, at minimum 1kg/cm² (14psig), flow rate 6 litres per minute. Any contamination, moisture or variation in supply pressure will directly affect the performance of the instrument.
A suitable Sherwood Scientific air compressor is listed in Section 8.2.

Waste Container

A sink or waste container sited to the right of the instrument will ensure the minimum length of waste tubing. Do not use a waste container with high sides, as this will cause the drain tube to be lifted above the level of the constant head drain.

WARNING The liquid coming out of the drain will still contain any hazardous materials that were in the original samples and should be handled and disposed of with the same care. Waste liquid should always be considered to be of a pathogenic nature where the instrument is used in a clinical environment

2.2 Site Conditions

WARNING *Under no circumstances install the instrument beneath overhanging cupboards. There must be at least 1 metre of clear space above the chimney. For optimum performance, this instrument should be installed in accordance with the following conditions: -*

1. The environment must be clean and free from dust.
2. The instrument must be placed on a strong, level worktop, free from vibration. The Model 360 requires approximately 400mm x 400mm of bench space, which includes a distance of 100mm between the edge of the bench and the front of the instrument for solutions and clearance at the rear for fuel and air tubing, with clear access to the mains supply switch.
3. Avoid sites that expose the instrument to direct sunlight or draughts.
4. To meet specification the ambient temperature must be within the range 10°C to 35°C and the maximum relative humidity not greater than 85%, non-condensing.

2.3 Unpacking

1. Unpack the instrument and accessories.
   NOTE The Model 360 weighs 5.6kg, follow safe lifting techniques.
2. Check all items for damage.
3. Check that all the items on the Accessory List have been delivered. Contact your Sherwood Scientific distributor if you have any problems.
4. The Model 360 is shipped with the following items:

Accessory List

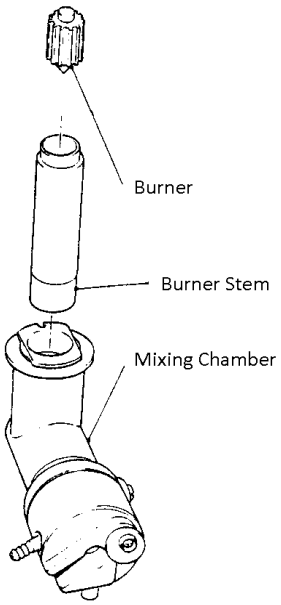
CAT. NO.	ITEM	QUANTITY
001 72 043	Air tubing, nylon reinforced	2 metres
001 72 114	Fuel tubing	2 metres
400 22 002	Tube Drain - all flames upto #20585 & after #28016	1 metre
001 53 313	Universal Multi-adapter PSU 12Vdc	1
100 99 010	Nebuliser cleaning wire, pack of 3	1 pack
420 08 102	Nebuliser	1
400 22 003	Nebuliser inlet tube, polythene, 150mm	1
360 91 001	Operators Manual, English	1
001 06 016	Hose clip 11-16mm	4
001 56 620	Flame Photometer Standard, 1000ppm Na	1 x 100ml
001 56 621	Flame Photometer Standard, 1000ppm K	1 x 100ml
001 56 622	Flame Photometer Standard, 1000ppm Li	1 x 100ml
001 56 623	Flame Photometer Standard, 1000ppm Ca	1 x 100ml
001 56 124	Flame Photometer Standard, 1000ppm Ba	1 x 100ml
360 91 000	M360 Assembly Procedure Guideline	1

2.4 Assembly

EQUIPMENT REQUIRED: -
Flat blade screwdriver.

You may wish to refer to the M360 Assembly Procedure sheet in addition to the following:

1. Unpack the instrument and accessories, removing all packaging.
2. Insert the Burner Stem into the Mixing Chamber Assembly and the Burner into the Burner Stem.



Then fit this into the shaped hole in the chimney tray, turning it 90° clockwise to lock it in position.

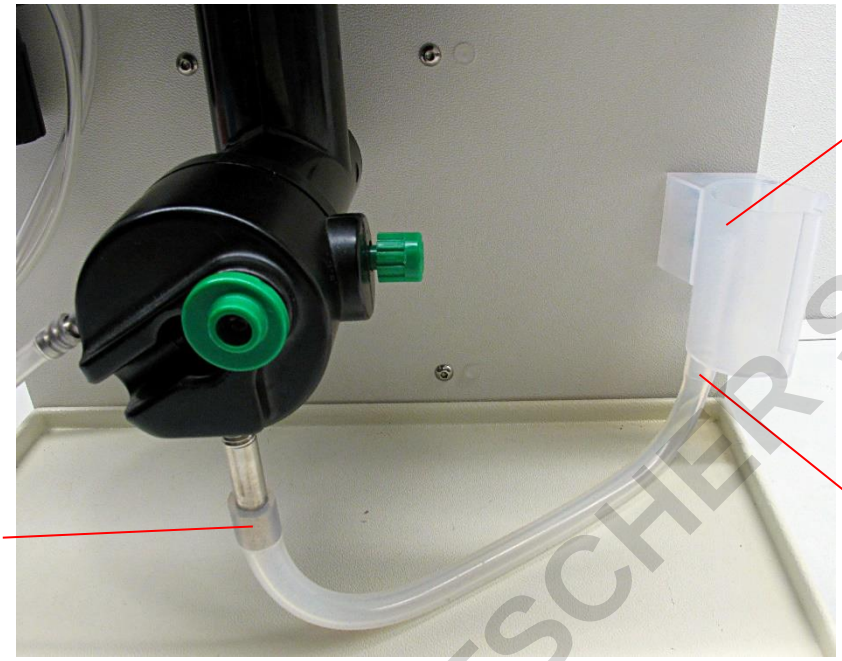


Attach the 6mmOD tube (item 6, Figure 2.4) from the Gas Pod to the side port of the Mixing Chamber Assembly.

Installation continued

2.4 Assembly continued

3. Slide the Constant Head and Drain over the screws on the right-hand side of the Vanity/Rear Panel. Connect the 'U' Tube (item 5, Figure 2.4) to the bottom outlet of the Mixing Chamber Assembly.



4. Place the Glass Inner Chimney centrally on the Upper Shelf.

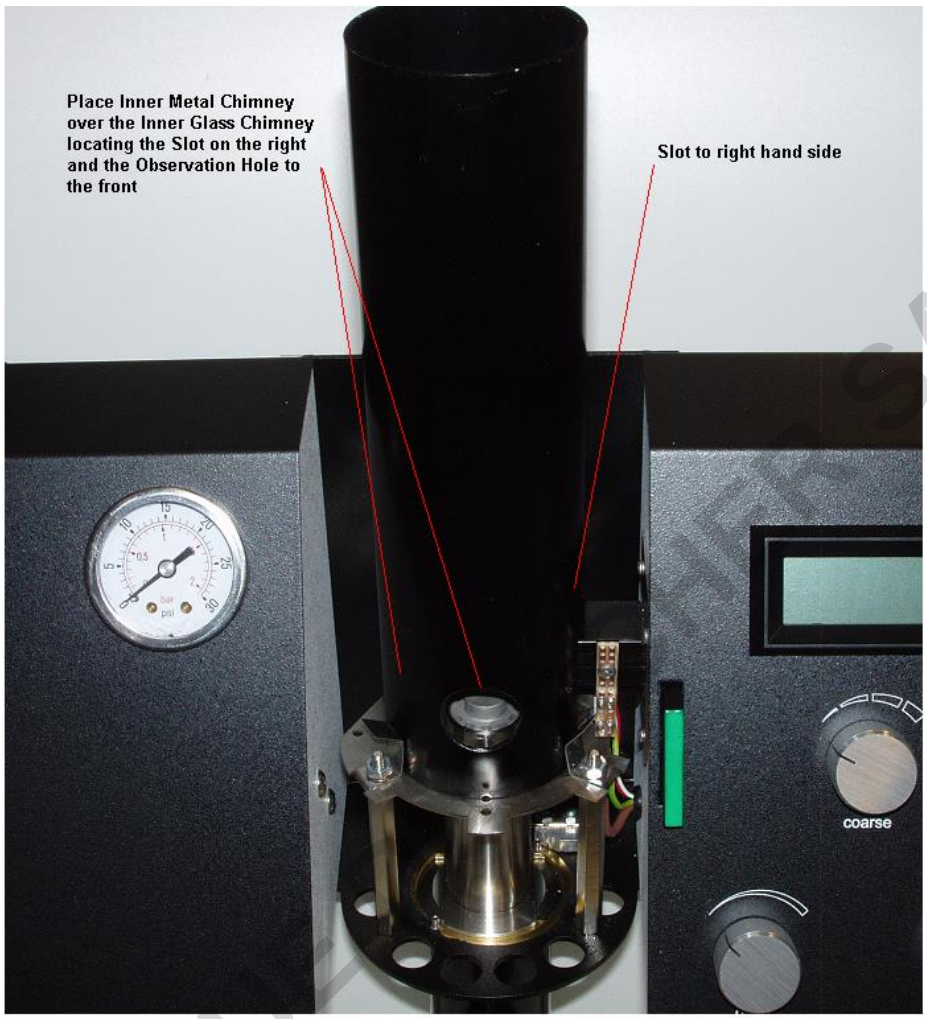


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Installation continued

2.4 Assembly continued

5. Slide the Metal Inner Chimney over the Glass Inner Chimney, locating it within the three spring clips.



6. Place the Outer chimney around this and secure it to the chimney tray with two thumbscrews from underneath.



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Installation continued

2.4 Assembly continued

7. Remove the nebuliser from its box and push the nebuliser barb into the air tubing (item 3, Figure 2.4). Fit the nebuliser, with its flat sealing washer, to the mixing chamber and position the retainer to lock it into position (item 2, Figure 2.4). Fit the nebuliser inlet tube (item 7, Figure 2.4), making sure that it is pointing downwards.

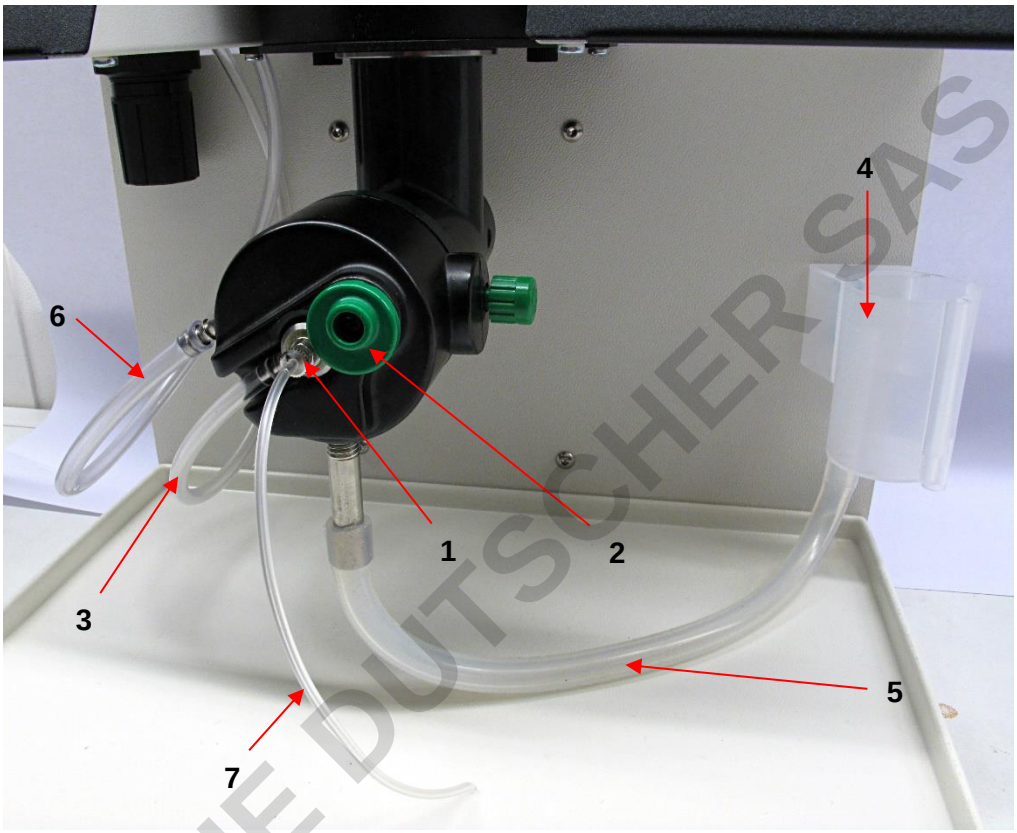


Figure 2.4 Mixing Chamber

1. Nebuliser, 2. Nebuliser retainer. 3. Air tubing. 4. Constant head & drain, 5. 'U' tube, 6. Fuel tubing, 7. Inlet tube.

8. Connect the length of rubberised fuel tubing, (001 72 114) supplied, between the fuel inlet connector (item 3, Figure 4.2) on the rear of the Gas Pod, and the cylinder regulator outlet connector. Secure with Hose tubing clamps (001 06 016), supplied.

NOTE The connection at the cylinder end of the tube must comply with National regulations.

9. Turn on the fuel supply and check all connectors for leaks, using soap solution. Do not use the instrument until you are satisfied that the installation is leakproof.

10. Connect the length of reinforced Nylon hose (001 72 043), supplied, between the air compressor outlet and the air inlet connector (item 4, Figure 4.2) on the rear panel. Secure both ends with Hose tubing clamps (001 06 016), supplied.

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Installation continued

2.4 Assembly continued

11. Fit the length of drain tubing (400 22 002) to the outlet on the Constant Head and Drain. If necessary shorten the tube or connect a suitable length of tubing (not supplied), to extend the drain tubing to carry waste to a sink or other drain receptacle. The downward flow of waste must not be restricted.

12. *Make sure* that the Constant Head Drain is pushed fully down on its locating screws. Use a wash bottle to fill the 'U' Tube with deionised water. Sufficient water should be used to purge the tube of air. Allow excess water to flow back into the drain.

    IMPORTANT Do not continue until you are satisfied that the 'U' tube has been completely filled with water, and is purged of air.

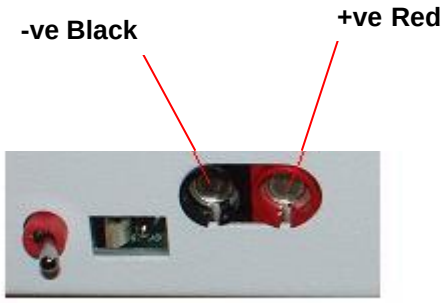
13. If necessary, set the *power switch* (rear of the instrument) to the off position. Connect the Power Supply Unit to the *power* receptacle on the rear panel and connect the plug to a convenient supply socket.

14. If a chart recorder is to be used with the instrument continue with Section 2.5. If not, continue with Section 4, Operating Instructions.

2.5 Connecting a Chart Recorder

1. Connect the black (-ve) recorder input lead to the black data output socket on the rear panel of the instrument.

2. Connect the red (+ve) recorder input lead to the red data output socket on the rear panel of the instrument.



3. If the chart recorder has an input-shorting link fitted, connect it between the black (negative) input and the earth input. This may reduce interference and produce a better trace.

4. Continue with Section 4, Operating Instructions.

3

Performance Characteristics and Specification

3.1 Readout

3½-digit light emitting diode (LED) display
Display range 0 to 1999.

NOTE If negative values are displayed the instrument is operating outside of the recommended measurement range.

3.2 Limits of Detection

Na	0.1ppm
K	0.1ppm
Li	0.1ppm
Ca	2.0ppm
Ba	20ppm*

These are sample concentrations directly entering the flame photometer after dilution.

* May not be achievable if fuel gas used is Natural Gas.

3.3 Specificity

Interference from Na, K and Li when equal in concentration to the test element will be less than 0.5%.
When determining Ca, interference will be seen if Sodium is present in the samples. You should determine the level of that interference at the concentration being determined in your samples. When determining Barium you should be aware that there is potential for a very considerable interference from Potassium if any is present in the sample. For Potassium determinations there is negligible interference from Barium.

3.4 Accuracy

Linearity Better than ± 2% when measured at mid-point of a 3ppm solution of Na or K or Li set to a display of 100.
e.g. 3ppm Na calibrated to 100 on the display will read 48 to 52 at mid-point.

NOTE A minimum 30 minutes warm up aspirating blank solution must be allowed to meet the drift specification, refer to Section 3.5.

Drift

Better than 2% over 30 minutes when continuously aspirating 3ppm K set to read 300. With the same sensitivity settings zero drift better than 2% over one hour. (Warm up time required).

Reproducibility

NOTE The following specification is correct for use on Propane or Butane. If Natural Gas is used the reproducibility may be poorer.

≤ 1.5% CV (coefficient of variation) for 20 consecutive readings from an aqueous standard of 10ppm Potassium set to 1000. Readings taken 20 seconds after the introduction and with a Blank aspirated for 10 seconds between each standard reading.

≤ 1.0% CV for 20 consecutive readings taken at 20-second intervals without removing the uptake tube from a 10ppm Potassium solution set to 1000.

NB CV is defined as $\frac{\text{Sample Standard Deviation}}{\text{Mean Reading}} \times 100$

3.5 Warm Up

To achieve the stated specification the flame must be alight for a minimum of 30 minutes, ***with diluent being aspirated***.

3.6 Sample Requirement

Type

Dependent on the application. However, samples should be water-based and not highly viscous nor non-homogeneous.

Organic solvents affect the air/fuel ratio, could attack the mixing chamber materials and can affect the safety operation of the Gas Trap (constant head drain) and should be used with great caution.

Method of presentation

The sample is presented to the nebuliser from a sample cup, test-tube, or other suitable container.

NOTE Aspiration efficiency can change depending on the vertical distance between the sample and the nebuliser capillary, the depth of submersion of the sample uptake tube and shape of the sample vessel. This means that small reading differences can be noted if samples and standards are moved around significantly during aspiration. Also, differences may occur if sequential samples are not consistently located or if long term repeatability tests are being conducted from one vessel and the sample level drops significantly during the duration of the test. A low form, the wide mouthed vessel is preferred.

Volume

The minimum practical diluted sample volume required for 20 seconds aspiration is 2.5ml.

Performance Characteristics and Specification continued

3.7 Chart Recorder Output

Nominal 100mV signal output per 1000 display units.

3.8 Environmental Conditions

Temperature

Operating +10°C to +35°C; Transportation -40°C to +45°C

Humidity

Operating	85% maximum at +35°C
Transportation	95% maximum at +45°C (Non-condensing)

The instrument specification will be unaffected by an ambient temperature change of 4°C (or less) per hour, within the range +10°C to +35°C, with a maximum of 7°C shift during 8 hours.

Installation Category

Installation Category 1

3.9 Power Requirements

The Model 360 is provided with a Universal Power Supply accepting input voltages over the range 100-240 V AC, 50/60Hz 0.6A with output to the instrument of 12V DC 1.25A.

3.10 Size

Overall, including chimney and rear panel connectors,
500mm high x 300mm wide x 230mm deep.

(We recommend placement of the unit 100mm back from the front edge of the bench upon which the instrument is sited).

3.11 Weight

5.6kg, instrument only.

4

Operating Instructions

4.1 Controls and Indicators (See Figure 4.1).

Power on

LED which illuminates when the instrument is switched on.

Flame on

LED which is illuminated when the flame is alight. The instrument has a fail-safe system if the flame is extinguished the LED will flash and the fuel supply is shut off.

Flame alight & air pressure OK	=	LED constantly on
Flame out & air pressure OK	=	LED flashing
Flame out & air pressure low	=	LED flashing

Blank

This control is used to set the display to zero while aspirating a blank solution.

Fine and Coarse

These two controls are used to set the display to an appropriate concentration reading while aspirating a standard solution. The *coarse* control is a four position rotary switch and the *fine* control is a 10-turn potentiometer.

Na, K, Li, Ca & Ba LED

The Filter Stick is pulled out or pushed in to select the filter for the analyte to be determined and the appropriate LED is illuminated.

Hold

This touch control is depressed to retain the reading displayed and is indicated by the illuminated LED.

Operating Instructions continued

4.1 Controls and Indicators continued

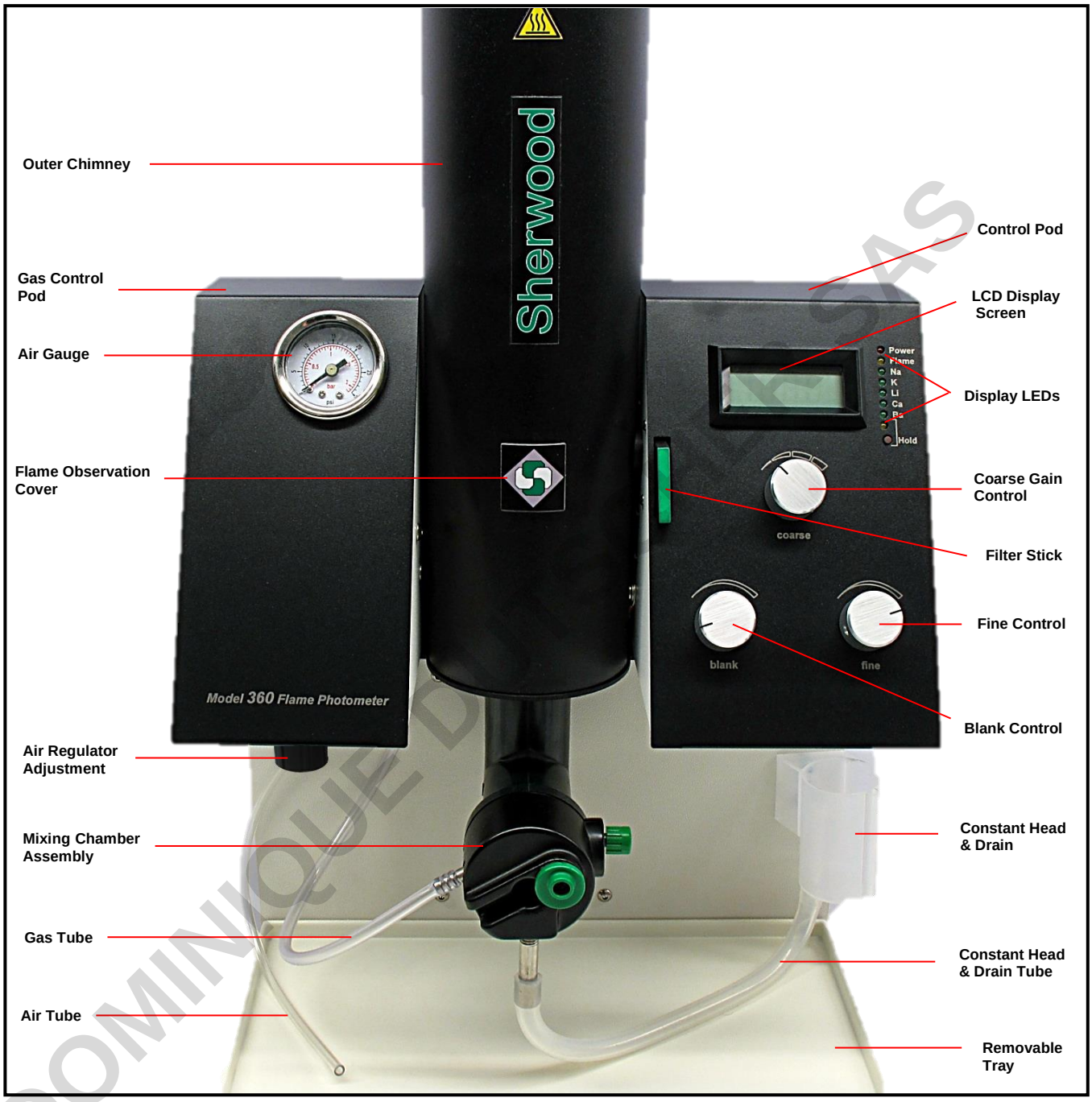


Figure 4.1 Controls

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4.2 Rear Controls and Connectors

Power

The switch (item 1, Figure 4.2) turns the power supply on and off. When the instrument is switched on (1), the *power on* LED is illuminated, and an ignition cycle is initiated. When switched off (0), the flame is extinguished, the fuel supply is shut off and the power supply to the instrument is switched off.

Data output

Two colour coded chart recorder sockets (item 2, Figure 4.2). The range is 0V to +200mV, the output signal is on the red socket with respect to the black socket.

Gas

Ø7mm fuel inlet connector (item 3, Figure 4.2). For attaching the fuel gas tubing to the instrument from the cylinder regulator outlet; Refer to Section 2.1 for details of fuel type, pressure and flow rate.

Air

Ø7mm connector (item 4, Figure 4.2). For attaching the air inlet tubing to the instrument from the air compressor outlet; See Section 2.1 for pressure and flow rate specifications.



Figure 4.2 Rear Panel

Operating Instructions continued

4.3 Initial Adjustment

NOTE The following instructions assume that the air compressor is switched on and supplying the instrument with air.

1. Check that the air pressure gauge (on the left panel) indicates a reading between 11 and 13psi. If it does not, lower the air regulator locking ring and adjust the regulator for a reading of 11 psi on the air pressure gauge. Raise the locking ring to lock the air regulator adjuster.

   WARNING The air compressor should always be switched on *before* the flame is ignited. The gas will not flow without sufficient air pressure

2. Check the Gas Trap ‘U’ tube is filled with water; (ref. Section 2.4, paragraph 12).

   WARNING Always check that the gas installation is leak-proof before initiating an ignition cycle.

5. Turn on the fuel supply at source.
6. Operate the *power* switch on the instrument rear. The *power on* LED will illuminate, and an ignition cycle will commence.
7. If the *flame on* LED has not illuminated before the end of the ignition cycle, switch off and wait ten seconds. Then switch on again to initiate another ignition cycle.
8. If the *flame on* LED does not flash during the ignition cycle, check that the air pressure is 11psi.
9. Repeat this cycle twice to allow sufficient time for the fuel to reach the burner then continue to paragraph 10.
10. If the *flame on* LED is not continuously illuminated at the end of the ignition cycle, switch off the *power* switch and refer to Section 7.2, Troubleshooting.
11. When the *flame on* LED continuously illuminates proceed with Section 4.4, Operating Instructions, paragraph 4.

4.4 Operating Instructions

NOTE For greatest accuracy and stability Sherwood Scientific recommend that a batch of diluent is made up from 1 part Diluent Concentrate and 999 parts deionised or good quality distilled water. Using diluent for setting blank and for dilution of samples and standards means that all solutions presented to the instrument contain the stability promoting ingredients contained in the diluent. Always use the same batch of diluent for the blank and the dilution of samples and standards. Store the diluent in a sealed container for not more than *five* days.

WARNING Always check that the gas installation is leakproof before initiating an ignition cycle.

1. Turn on the fuel supply at source. Switch on the Air Compressor.
2. Flick the *power* switch to switch on the instrument. The *power on* LED will be illuminated, and an ignition cycle will commence.
3. If the *flame on* LED is not continuously illuminated at the end of the ignition cycle, refer to Section 4.3.
4. Set the filter selector to the required position.
5. Insert the nebuliser inlet tube in a beaker containing approximately 300ml of diluent and allow 30 minutes for the operating temperature to stabilize. This will ensure a stable burner temperature when solutions are aspirated, after the warm up period.
6. During the warm up period prepare a set of calibration solutions to cover the required measurement range. To obtain optimum performance Sherwood Scientific recommends that the highest standard concentration does not exceed 10ppm for Na, K and Li, 100ppm for Ca and 1000ppm for Ba. Please see Appendix B for further comments about standard and sample concentrations.
7. While aspirating diluent, adjust the *blank* control so that the display reads 000.
8. Aspirate the highest concentration standard.
9. Allow 20 seconds for a stable reading and then adjust *coarse* and *fine* controls for a convenient reading, e.g.10ppm Na can be set to read 100 on the display.
10. Remove the standard solution, wait 10 seconds, then aspirate a blank solution of diluent for 20 seconds. Adjust the *blank* control for a 0.0 reading. Remove the blank solution and wait 10 seconds.
11. Repeat paragraphs 8, 9 and 10 until the blank reading is 000 (within ±002) and the calibration reading is within ±1%. If a chart recorder is being used set zero on the blank solution and set span while aspirating the calibration standard.
12. Without touching the fine and coarse controls aspirate each of the remaining calibration standards for 20 seconds (starting with the lowest concentration to avoid carry over) again allowing 10 seconds between measurements. Note the value of each standard and plot the results on a graph against standard concentration on linear graph paper. Refer to the example shown in Figure 4.4.

Operating Instructions continued

4.4 Operating Instructions continued

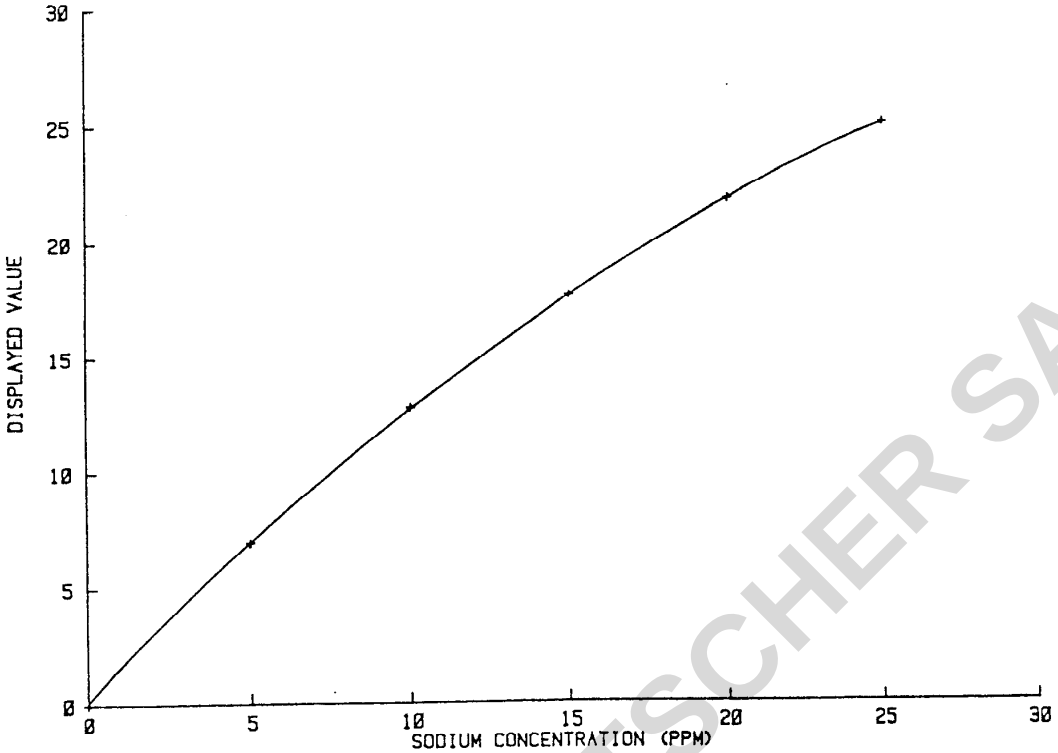


Figure 4.4 Typical Calibration Curve

13. Check calibration standards and blank readings.
14. Dilute the unknown solutions with diluent to give a concentration of the element under test within the range of the calibration standards. Several attempts might be necessary to determine the correct dilution ratio.
15. Aspirate each of the diluted unknowns for 20 seconds, and then note the reading. The concentration of the element in the unknown sample can be calculated by reading the sample concentration from the calibration curve and multiplying it by the dilution factor.
16. Recalibrate the instrument by carrying out paragraphs 8 to 12. Experience in use will determine how frequently the calibration needs to be checked.

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Operating Instructions continued

4.5 Shutdown Procedure

1. Aspirate Cleaning Solution diluted 1 in 100 with deionised water, for one minute.
2. Aspirate diluent for two minutes.
3. For a short-term shutdown (maximum two hours) switch off the instrument *power* switch and switch off the compressor.
4. For a longer term shutdown (overnight) turn off the fuel supply at source. When the *flame on* LED is extinguished, switch off the *power* switch, and the compressor. This ensures that the fuel pressure in the fuel tubing is at a minimum.

4.6 Operating Hints

1. The deionised or high quality distilled water used when making a batch of diluent must be free from contaminating elements. It is recommended that the same batch of diluent is used to prepare all solutions and to set blank on the instrument.
2. Greatest accuracy will be obtained by using the same dilution equipment for both standard and sample preparation.
3. Always use suitable standards for calibrating the instrument. Remember that the accuracy of the results obtained from the Model 360 depends on the accuracy and purity of the calibration standard that is used.
4. The nebuliser is a precision assembly, contributing more than any other single item to the effectiveness of your Flame Photometer. To keep it in good condition, it is essential that it is flushed with distilled water after use. This ensures that no solid matter remains in the assembly. If this procedure is carried out regularly no difficulties should be experienced.
5. Experimentation with air pressure may in some situations allow improvement in detection limits to be achieved.

5

Operational Precautions and Limitations

5.1 General

1. Always dilute samples and standards with the same batch of diluent (made up of 1 part Diluent Concentrate and 999 parts of deionised or good quality distilled water), which contains non-ionic wetting agents.
2. The samples should be homogeneous and not be highly viscous. If possible, samples likely to contain sediment should be filtered and then mixed to obtain a representative result.
3. Always use soap solution when checking for leaks in fuel or air lines. Do not allow fuel to flow in the presence of unguarded flames, e.g. cigarettes.
4. Always use genuine Sherwood Scientific replacement parts. Do not, for example, replace the 'U' tube with one of different material, bore or length as this will cause deterioration in the instrument's performance.
5. Always carry out the maintenance schedules as detailed in Section 6.
6. *Do not* leave the flame observation cover open during calibration and measurement, as this will allow stray light to enter the chimney.
7. The front panel of the Model 360 is impervious to a wide range of chemicals. However, strong acids and organic solvents may affect the finish. Any spillage should be thoroughly wiped away as soon as possible. If necessary, clean the instrument with warm, soapy water - *do not* use abrasives.

5.2 Hazards

1. All electrical instruments are potentially hazardous. There are no user-maintainable parts inside the Model 360 covers. Never remove covers from the instrument, unless specific maintenance instructions are being followed.
2. Propane, butane and natural gas are highly flammable and potentially explosive gases. Propane and butane are stored as a liquid, under pressure in a cylinder, for use with the Model 360. Such a cylinder should never be subjected to heat or mechanical shock. When handled correctly and connected to the instrument as instructed, the fuel gas is quite safe. Check hosing joints with a soap solution before allowing any naked flame in the vicinity. Never open a cylinder valve to the atmosphere even on a supposedly empty cylinder.
3. The top of the chimney and the area above the chimney can become very hot and are capable of causing severe burns. *Never view the flame from the top of the chimney, always use the observation port*. We recommend the instrument be placed 100mm back from the front edge of the bench on which it is sited.
4. Make sure that the air compressor is connected to the power supply and switched on before starting a flame ignition sequence. Failure to observe this precaution may result in a build up of fuel gas, which may cause a flame to appear above the chimney.

6

Maintenance

6.1 General

Under the Daily, Weekly, Monthly and Six-Monthly Maintenance headings are summaries of the work and equipment required. The tasks are detailed from Section 6.6 onwards.

For maintenance of the air compressor, dilutor and chart recorder, if used, refer to the instructions supplied with the equipment.

6.2 Daily Maintenance

EQUIPMENT REQUIRED: - *None.*

1. Empty waste container, if used.
2. Check air line for condensation, and drain if necessary.
3. Check 'U' tube is filled with deionised water.
4. Rinse nebuliser with distilled water after use.

6.3 Weekly Maintenance

EQUIPMENT REQUIRED
10 ml beaker; Stop watch; Nebuliser cleaning wire; Enzymatic Cleaner/Disinfectant; Nebuliser tube and Balance.

1. Carry out Daily Maintenance procedure.
2. If measuring clinical samples deproteinise the system (Section 6.9).
3. Check the operation of the nebuliser (Section 6.6).

6.4 Monthly Maintenance

EQUIPMENT REQUIRED
As for weekly maintenance.

1. Carry out Daily and Weekly Maintenance procedures.
2. Check the constant head drain, mixing chamber, 'U' tube and drain tube and clean if necessary (Section 6.7). Check that the 'U' tube is refilled with deionised water on reassembly.

6.5 Six-Monthly Maintenance

EQUIPMENT REQUIRED
As for weekly maintenance, plus the following: -
'U' tube and drain tube, Methanol; tissues; Soft lint-free cloth; Cotton buds.

1. Carry out the Daily and Weekly Maintenance procedures.
2. Clean the mixing chamber, burner tube, burner and constant head & drain (Section 6.7).
3. Replace nebuliser tube, 'U' tube and drain tube.
4. Clean the optical filters and the glass inner chimney (Section 6.8).
5. Check the air and fuel tubing and connectors for leaks, using soap solution. Check for signs of stress cracking especially at the connectors.

Maintenance continued

6.6 Nebuliser

EQUIPMENT REQUIRED

Stop watch; 10ml beaker; Cleaning wire; Cleaning Solution; Balance and Nebuliser inlet tube.

Operational Check

1. Turn off the fuel supply at source.
2. Switch on the M360 and air compressor. Check that the *flame on* LED is off.
3. Fill the beaker with deionised water and weigh it.
4. Present the beaker of deionised water to the nebuliser tube for an accurately timed minute.
5. Reweigh the beaker and calculate the aspiration rate. If it is between 3 and 6g per minute, no further action is required. If it is too low, continue with paragraph 6. If it is too high contact your Sherwood Scientific Distributor. Do not attempt to adjust the nebuliser, as the capillary position is fixed during manufacture, and is not adjustable.

Cleaning the Nebuliser

6. Release the Nebuliser Retainer (item 1, Figure 6.6) and withdraw the Nebuliser (item 2, Figure 6.6).
7. Remove the Nebuliser Inlet Tube. Insert a Cleaning Wire into the capillary tube at the rear of the Nebuliser and pull right through.
8. Insert the Cleaning Wire into the Nebuliser Inlet Tube and pull right through. Inspect the Nebuliser Inlet Tube; replace if signs of wear or accumulation of particles are apparent.
9. With the Nebuliser Inlet Tube removed, but with the Nebuliser attached to the Air Tubing, place a finger over the Nebuliser Outlet Nozzle, turn on the air supply to force any residue out of the Nebuliser's capillary tube.
10. Repeat steps 7, 8 and 9 until the aspiration rate is constant and between 3 and 6g per minute.
11. Replace the nebuliser and rinse with distilled water.

NOTE Before despatch each nebuliser is adjusted for optimum performance. This adjustment is critical and under no circumstances should you attempt to readjust or dismantle the assembly. If adjustments are made to the atomiser Sherwood shall not accept responsibility for poor performance from your Flame Photometer.

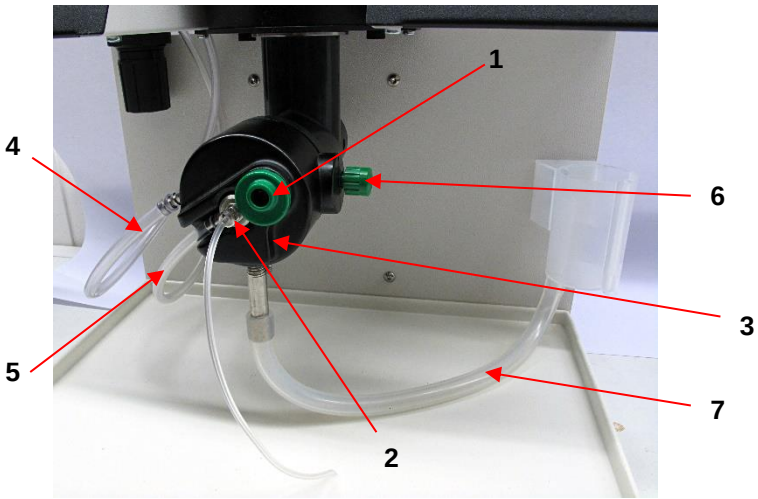


Figure 6.6 Mixing Chamber

1. Nebuliser retainer. 2. Nebuliser. 3. End cap. 4. Fuel tubing. 5. Air tubing. 6. End cap securing screw. 7. 'U' tube.

Maintenance continued

6.6 Nebuliser continued

12. Fit a new length of nebuliser inlet tubing to the nebuliser. Recheck the aspiration rate, paragraphs 3, 4, and 5.
13. If nebuliser operation is still outside the specification, unscrew the air line connector and remove the nebuliser inlet tubing.
14. Soak the nebuliser in a 1 in 100 dilution of Cleaning Solution, agitating it periodically.
15. Rinse thoroughly in deionised water and shake dry.
16. Refit the nebuliser inlet tubing and the air line. Recheck aspiration rate.
17. If the nebuliser operation is still unsatisfactory, fit a new nebuliser. Do not attempt to adjust the nebuliser, as the capillary position is fixed during manufacture, and is not adjustable.

6.7 Cleaning the Mixing Chamber, Burner and Drain

EQUIPMENT REQUIRED
Flat blade screwdriver, blade width 8 mm; Cleaning Solution; Tissues.

1. Check that the *flame on* LED is off, the fuel is turned off at the source, and the instrument and compressor are switched off.
2. Release the nebuliser retainer and withdraw the nebuliser (items 1 and 2, Figure 6.6).
3. Disconnect the fuel tubing (item 4, Figure 6.6) from the end cap connector (item 3, Figure 6.6) using a twisting movement. *Do not* pull the tubing, as this will make it grip the connector more tightly.

   WARNING Use a heat resistant glove when handling the burner and burner tube if the flame has been alight within the preceding 30 minutes. Do not proceed until all the parts within the chimney are at a safe handling temperature.
4. Remove the chimney cover and lift out the inner chimney and glass inner chimney.
5. Disconnect the mixing chamber from the chimney assembly by twisting it to the right, through 90 degrees. Lower the mixing chamber and burner assembly.
6. Lift the burner tube from the mixing chamber and remove the burner.
7. Unscrew the end cap securing screw (item 6, Figure 6.6). Grasp the end cap (item 3, Figure 6.6) and remove it from the mixing chamber, with a slight twisting action. Lift the end cap to allow the water in the ‘U’ tube to flow into the constant head drain. Disconnect the ‘U’ tube from the end cap and constant head drain.
8. Slide upwards the constant head drain and disconnect the drain tube.
9. Soak all the items removed from the instrument in a 1 in 100 dilution of Cleaning Solution, agitating it periodically.
10. Rinse the parts thoroughly in deionised water and dry with clean tissues.
11. Fit the burner tube to the mixing chamber, ensuring that the locating slot in the burner tube engages with the locating pin in the mixing chamber.
12. Fit the burner *pointed end downwards* into the burner tube. Rotate the burner to ensure that it is fully inserted.

Maintenance continued

6.7 Cleaning the Mixing Chamber, Burner and Drain continued

13. Check the condition of the end cap '0' ring seal (001 31 076). If necessary, replace the seal.
14. Replace the end cap, using a twisting movement. Align the hole with the mixing chamber screw fixing. Fit the screw (item 6, Figure 6.6).
15. *Carefully position the mixing chamber, with the burner tube inside the chimney. With the burner tube fully inserted, twist the mixing chamber to the left, through 90 degrees, to lock it in position.*
16. Refit the glass inner chimney and the inner and outer chimneys.
17. Mount the constant head drain in position.
18. *Connect the fuel tubing to the mixing chamber end cap. Connect the 'U' tube between the mixing chamber end cap and the constant head drain. Fit the drain tube to the constant head drain.*
19. Fit the nebuliser with its flat sealing washer into the end cap and position the retainer to lock it.
20. Use a wash bottle to fill the 'U' tube with deionised water. Sufficient water should be used to completely fill the 'U' tube and purge it of air.

6.8 Cleaning the Optical Filters and Glass Inner Chimney

EQUIPMENT REQUIRED
Soft lint-free cloth; Cotton buds; Tissues; Cleaning Solution.

1. Check that the *flame on* LED is off, the fuel is turned off at the source, and the Model 360 and compressor are switched off.

   WARNING Do not proceed until all the parts within the chimney are at a safe handling temperature.

2. Remove the filter stick by carefully pulling it out and place carefully on the lint free cloth so that the coloured sides of the filters are uppermost.

   CAUTION *Never* touch the faces of the optical filters, handle only by the edges.

3. Carefully wipe each filter on both sides with a cotton bud or lens tissue.
4. Unscrew the two thumb screws on the underside of the chimney.
5. Lift off the outer chimney and place to one side.
6. Lift off the inner metal chimney and place to one side.
7. Lift off the glass inner chimney and soak in a 1 in 100 dilution of Cleaning Solution, agitating it periodically.
8. Rinse the glass inner chimney thoroughly in deionised water and dry with clean tissues.
9. Refit the glass inner chimney and the inner metal chimney taking care to position the inner metal chimney such that it locates in the spring clips.
10. Re-fit the outer chimney and secure with the two thumb screws.
11. Refit the Filter Stick into position and slide it fully in. Check that all five positions can be selected.

6.9 Deproteinising or Disinfecting Procedure

NOTE If using biological samples, to deproteinise the system use Enzymatic Cleaner/Disinfectant, for other types of sample simply disinfect the system using Tubing Disinfectant.

EQUIPMENT REQUIRED
Deproteinising Solution or Tubing Disinfectant.

1. Light the flame as detailed in Section 4.4.
2. Present a beaker of Enzymatic Cleaner/Disinfectant solution (prepared as instructed on the product label) or Tubing Disinfectant to the nebuliser for 5 minutes.
3. After 5 minutes have elapsed; replace the beaker of the solution with a beaker of deionised water. Flush the system for two minutes. Then with a fresh beaker of deionised water aspirate for a further 10 minutes.
4. Shutdown the instrument as detailed in Section 4.5.

For disassembled components e.g. mixing chamber, burner, burner stem, nebuliser – soak, completely immersed in the warm solution. Afterwards rinse thoroughly, first in one batch of deionised water, followed by a second batch.

7

Troubleshooting

7.1 Power on LED not illuminated

Check that the instrument is connected to a working a.c. supply via the universal PSU, and that the power switch is in the ON position.

If fault persists contact your Sherwood Scientific Distributor.

7.2 Flame on LED not illuminated

General

Ensure that the 'U' tube is filled with deionised water, refer to Section 2.4.

Burner must be fitted with pointed end downwards, refer to Section 6.7.

Air Supply

Air compressor must be connected to an a.c. supply, and working correctly delivering the requirements detailed in Section 2.1.

Check the air tubing connections from the air compressor to the instrument; refer to the air compressor manual.

Fuel Supply

There must be a compressed air flow otherwise, the air pressure switch will not allow the gas to flow into the instrument.

Check that there is an adequate supply of fuel.

Fuel supply must be turned on at the source. If using a long length of fuel tubing, try repeating the ignition sequence a few times to allow the fuel to fill the tubing.

Propane/Butane

If the fuel is propane or butane check that the regulator at the cylinder is adjusted for 2.1kg/cm² (30psig).

Natural Gas

For instruments working with Natural Gas, check the pressure to the instrument is at 3 to 10 inches water gauge.

If fault persists contact your Sherwood Scientific Distributor.

7.3 Unable to set display to zero

Check that diluent is being aspirated.

The deionised water supply may be contaminated, use a better grade of deionised water.

The burner may be encrusted with salt deposits. Clean the burner as detailed in Section 6.7.

If using a chart recorder check that the data output connections are correct.
If fault persists contact your Sherwood Scientific Distributor.

Troubleshooting continued

7.4 Unable to set display to standard reading

Check the concentration of the standard being aspirated, and that the dilution ratio of this standard is correct.

Use fresh deionised water and recalibrate zero. If using low-grade deionised water the background levels may be too high.

Make sure the correct filter has been selected.

The nebuliser may be blocked. Check the nebuliser, refer to Section 6.6.

Check the glass chimney is clean, refer to Section 6.8.

If the atmosphere surrounding the instrument, or air compressor inlet, is contaminated (e.g. smoke) incorrect readings may result.

If fault persists contact your Sherwood Scientific Distributor.

7.5 Unstable results

Do not use compressed air from a "communal" source or "Air Line" as this may be contaminated with oil, which will ruin the performance of the Model 360. Use a dedicated Compressor such as the Sherwood Model 851 or Model 855.

Check the concentration of the solutions being aspirated. The solutions should all contain 1 in 1000 dilution of Diluent Concentrate, refer to Section 4.4.

Check the fuel supply is adequate. Refer to Section 2.1.

The use of Natural Gas from a "communal source" will fluctuate as other users turn on or turn off their gas taps. Wherever possible, use bottled gas.

The nebuliser may be blocked. Check the nebuliser, refer to Section 6.6.
The 'U' tube or drain tubing may be blocked or partially obstructed.

If the air supply tubing show signs of condensation, drain the air tubing. If this problem recurs frequently use a Model 855 air compressor with water separator.

Make sure the air compressor filter is changed regularly, refer air compressor manual.
If the atmosphere surrounding the flame photometer, or air compressor inlet, is contaminated (e.g. smoke) unstable readings may result. A similar effect may be observed if the instrument is sited in a draught. If fault persists contact your Sherwood Scientific Distributor.

7.6 Non-linear results

Check the concentration of the solutions being aspirated. The solutions should all contain 1 in 1000 dilution of Diluent Concentrate, refer to Section 4.4. Make up fresh solutions and recheck calibration curve.

Check that the fuel supply is adequate. Refer to Section 2.1.

The nebuliser may be blocked. Check the nebuliser, refer to Section 6.6.

The 'U' tube or drain tubing may be blocked or partially obstructed.

Use fresh deionised water and recalibrate zero. If using low-grade deionised water the background levels may be too high.

If fault persists contact your Sherwood Scientific Distributor.

8

Spares and Accessories

8.1 Ordering Information

When ordering spares or accessories for your instrument, please give the following information to your Sherwood Scientific distributor.

Instrument Serial No.

Catalogue No. of Part (Cat. No.)

Description

Quantity required

This will ensure that your order is dealt with quickly and efficiently.

The number is shown in the third column (Quantity) is the quantity of items that are supplied against the stated Catalog Number. If the quantity is greater than 1, then only multiples of that quantity can be supplied.

8.2 Spares and Accessories

Serial Number	Item	Quantity
420 08 102	Nebuliser	1
410 26 001	Mixing chamber and burner	1
402 12 001	End Cap Assembly	1
400 02 013	Retainer, End Cap	1
401 11 001	Constant Head & Drain (moulded)Large	1
400 22 003	Tube, Nebuliser Inlet	1
001 26 033	Sample pot, plastic, in packs of 50	1 pack
001 08 439	Butane primary regulator (182H) for 32lb Calor/Caravan cylinder	1
001 08 732	Butane primary regulator for ‘Gaz’ type cylinder	1
001 72 043	Air tubing, nylon reinforced	per metre
001 72 114	Fuel tubing	per metre
001 72 116	Air tubing	per metre
360 72 002	‘U’ Tube for M360 #28016 on	1
400 22 002	Tube Drain - all flames upto #20585 & after #28016	1 metre
001 06 016	Hose clip 11-16mm	1
100 99 010	Nebuliser cleaning wire, pack of 3	1 pack
851 01 001	Model 851 Air Compressor, 230V	1
851 01 000	Model 851 Air Compressor, 115V	1
855 01 001	Model 855 Air Compressor, 230V complete with water separator	1
855 01 000	Model 855 Air Compressor, 115V complete with water separator	1
360 89 001	Service Manual	1
001 26 074	Disposable sample cups, 1,5ml, pack of 1000	1 pack
001 26 033	Disposable sample cups, 25ml, pack of 50	1 pack
001 92 492	Guide to Flame Photometry	1

Spares and Accessories continued

8.3 Standard Solutions

NOTE The following solutions are available.

Serial Number	ITEM	QUANTITY
001 56 620	Flame Photometer Standard, 1000ppm Na	6 x 100ml
001 56 621	Flame Photometer Standard, 1000ppm K	6 x 100ml
001 56 622	Flame Photometer Standard, 1000ppm Li	6 x 100ml
001 56 623	Flame Photometer Standard, 1000ppm Ca	6 x 100ml
001 56 124	Flame Photometer Standard, 1000ppm Ba	1 x 100ml
001 56 184	Cleaning Solution, 500ml	1 bottle
001 56 681	Diluent Concentrate	6 x 100ml
001 56 682	Tubing Disinfectant,	6 x 100ml
001 56 182	Enzymatic Cleaner/Disinfectant, 6 x 5g	1 pack

Appendix A

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Appendix B

Guidelines on Standards and Samples

When preparing standards the following points may be useful:

1. Standards must always contain the constituents that are present in the samples in the same concentration ratios; i.e. if samples are prepared in 0.1M Acid then the standards should also contain 0.1M of the same acid
2. The range of standard concentrations used should encompass the expected range of analyte concentration with the samples
3. Standards should be prepared so as to ensure that the region in which measurements are made coincide with the concentrations that produce the optimum performance from the flame photometer, i.e.
   - when measuring sodium, the top standard is ideally 10ppm,
   - when measuring potassium, the top standard is ideally 10ppm,
   - when measuring calcium, the top standard is ideally 100ppm,
   - when measuring barium, the top standard is ideally 1000ppm,
   - when measuring lithium, the top standard is ideally 10ppm,

These figures do not preclude the operator from working at concentrations above those stated. At whatever concentration it is decided to carry out determinations, some preliminary work should be done to establish the response curve over the required concentration range for the analyte of interest. In addition, any possible interference should be considered and blanks and standards prepared accordingly.

A minimum of five standards should be prepared to enable an accurate calibration curve to be constructed.

NOTE The blank and standards used should contain all the constituents of the sample solutions except the element being measured.

Customers working in medical environments are quite likely to be using the S.I. unit of mmol/l to report their results. The relationship between mmol/l and ppm is shown below:

Sodium	1ppm Na = 0.0435mmol/l	1mmol/l Na = 22.99ppm
Potassium	1ppm K = 0.0256mmol/l	1mmol/l K = 39.10ppm
Lithium	1ppm Li = 0.1441mmol/l	1mmol/l Li = 6.94ppm
Calcium	1ppm Ca = 0.0250mmol/l	1mmol/l Ca = 40.08ppm
Barium	1ppm Ba = 0.0073mmol/l	1mmol/l Ba = 137.3ppm

This relationship means that Na and K samples in the normal clinical range for blood serum samples of 136-145mmol/l Na and 3.5-5.0mmol/l K would typically be pre-diluted 1 in 200 to get optimum results from the flame photometer following the construction of suitable calibration graphs.

Appendix B continued

Dilution

In order to obtain samples and standards of the right concentration for aspiration into the flame, various levels of dilution will often be necessary. Good quality deionised water should normally be used for carrying out these dilutions and it is recommended that the same batch of water should be used for diluting the samples and standards. We also recommend use of diluent concentrate as mentioned in Section 1.4

Standard Curve Generation

1. Aspirate a blank solution and set the readout to 000 using the **Blank** control.
2. Aspirate the highest standard solution and set the readout to an appropriate reading using the **Fine** and **Coarse** sensitivity controls. Re-check the blank setting and adjust if necessary. Once adjusted and giving the required displayed reading for both blank and top standard, the controls are not touched again until a recalibration is required.
3. Aspirate the remaining standard solutions (if used), note the displayed reading and construct the calibration graph (curve) by plotting readings versus concentration.
4. Unknown samples can now be aspirated and the displayed readings noted. Results may be taken directly from the instrument readout, or by deriving the concentrations from the calibration curve.
5. Calibration needs to be checked periodically by aspirating the blank and standard solutions. Initially, this check should be carried out after every 10 samples. Experience and increased confidence in the 360 will enable you to best judge the frequency of this check since the environment within which the instrument is placed will influence this.

Standards should be stored in sealed, plastic vessels and in high concentrations, (e.g. as a stock 1000ppm solution) out of direct sunlight in a cool place (ideally at temperatures below 25ºC). Working standards or dilutions should be prepared as required. The long-term storage of low concentration standards is not recommended. Glass should not be used for storage as it may affect Sodium concentration levels.

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Appendix B continued

Sample preparation

There are several practical points regarding sample preparation, which should be adhered to in order to achieve the required accuracy in your analysis:

1. Avoid handling samples with fingers. This leads to serious contamination, e.g. if a finger is immersed in 20ml of deionised water the resulting Na concentration will exceed that of a 10ppm standard.
2. All analyses involve the use of a diluent, which is almost always deionised water. This should be of the highest quality for accurate flame analysis. Sodium, Potassium and Calcium are present in high concentrations in tap water and thus efficient deionisation is essential.
3. Species that cause interference should be removed from samples or the equivalent concentration of the interferent should be present in the standards so as to avoid erroneous results, e.g. if a sample of approximately 10ppm Ca contains approximately 10ppm Na, then Ca analysis will need to be corrected for the presence of the Sodium. This may be achieved by setting the zero against a blank containing the same amount of Sodium as the sample prior to determining the Calcium content. For samples containing a much higher Sodium concentration than Calcium, precipitation of the Ca with oxalate/oxalic acid, centrifugation, decanting the Sodium and re-dissolving the Calcium prior to the determination may be required.
4. Always try to follow a well-documented analytical procedure, which should contain information pertaining to interference removal when applicable.
5. Standards and samples should not be exposed to the atmosphere for long periods due to contamination from airborne particles and the evaporation of the solvent that could lead to elevated concentrations.

Sample extraction

The sample should be an aqueous solution, with no solid matter present, to be suitable for direct introduction into the flame photometer. That may be achieved as follows:

- Extracting salts from solid samples using deionised water or suitable extractants e.g. saturated CaSO4 for sodium in soil. Extraction is more successful using a blender, macerator or shaking machine.
- If the sample is organic then the organic material should be removed by ashing. The remaining oxides are then dissolved using strong acids.
- Filtration/centrifugation is used to remove solid debris.
- When aqueous, the sample can then be diluted to a known, accurately measured volume using deionised water. If it is a concentrated sample then the dilution ratio should be increased. If the sample concentration is low then a small volume of diluent and initial extractant should be used. Whichever method of extraction is used, the resultant solution must always be free of any particulate matter that could cause blockages in the sample uptake tube or nebuliser capillary tube.

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Sherwood Scientific Limited
Product Warranty Statement

Warranty Term: 12 Months

Sherwood Scientific Ltd (Sherwood) warrants, subject to the conditions itemised within this document, through either Sherwood personnel or personnel of its authorised distributors, to repair or replace free of all charges, including labour, any part of this product which fails within the warranty time specified above, appertaining to this particular product. Such failure must have occurred because of a defect in material or workmanship and not have occurred as a result of the operation of the product other than in accordance with procedures described in the instructions furnished with this product.

Conditions and specific exceptions that apply to the above statement are as follows:

1. End-user warranty time commences on the date of the delivery of product to end-user premises.

2. 'Free of all charges' statement applies only in areas recognised by Sherwood as being serviced either directly by its own personnel, or indirectly through personnel of an authorised distributor. Products purchased outside these areas requiring service during the warranty period will incur charges relative to the travel/transit costs involved. However, products purchased in such areas will be serviced during the warranty period free of all charges providing they are returned, carriage paid, to either Sherwood or by pre-arrangement to an authorised Sherwood distributor.

3. All maintenance (other than operator maintenance as described in the instructions), repairs or modifications have been made by Sherwood or Sherwood authorised personnel.

4. This product has where applicable been operated using Sherwood specified supplies and reagents.

5. Sherwood reserves the right to make any changes in the design or construction of future products of this type at any time, without incurring any obligation to make any changes whatsoever to this particular product.

6. Reagents, supplies, consumables, accessories and user maintenance items are not included in this warranty.

7. Repairs or replacement of any part failing due to abnormal conditions including the following, are excluded from this warranty:
    a. Flood, lightning, earthquake, tornado, hurricane, or any other natural or man-made disaster.
    b. Fire, bombing, armed conflict, malicious mischief or sprinkler damage.
    c. Physical abuse, misuse, sabotage or electrical surge.
    d. Damage incurred in moving the product to another location.

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Product Warranty Statement (continued)

8. User agrees to permit Sherwood personnel or personnel of its authorised distributor to make changes in the product which do not affect results obtained but do improve product reliability.

Representations and warranties purporting to be on behalf of Sherwood made by any person, including distributors and representatives of Sherwood, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitations of the liability of Sherwood as set forth above), shall not be binding upon Sherwood unless reduced to writing and approved by an officer of Sherwood Scientific Ltd.

Except for the obligations specifically set forth in this warranty statement, in no event shall Sherwood be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort or any other legal theory and whether advised of the possibility of such damages.

Neither Sherwood nor any of its third party suppliers makes any other warranty of any kind, whether expressed or implied, with respect to Sherwood Products.

Sherwood Scientific Ltd,
1 The Paddocks,
Cherry Hinton Road,
Cambridge,
CB1 8DH,
England

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