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API LC/MS/MS TurboIonSpray Ion Source Manual

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TurboIonSpray Ion Source Manual

About This Manual

This manual contains the instructions required to operate the API TurboIonSpray ion source.

Conventions



Within this manual, the following conventions are used:

WARNING! Indicates an operation that may cause personal injury if precautions are not followed.

CAUTION! Indicates an operation that may cause damage to the instrument if precautions are not followed.

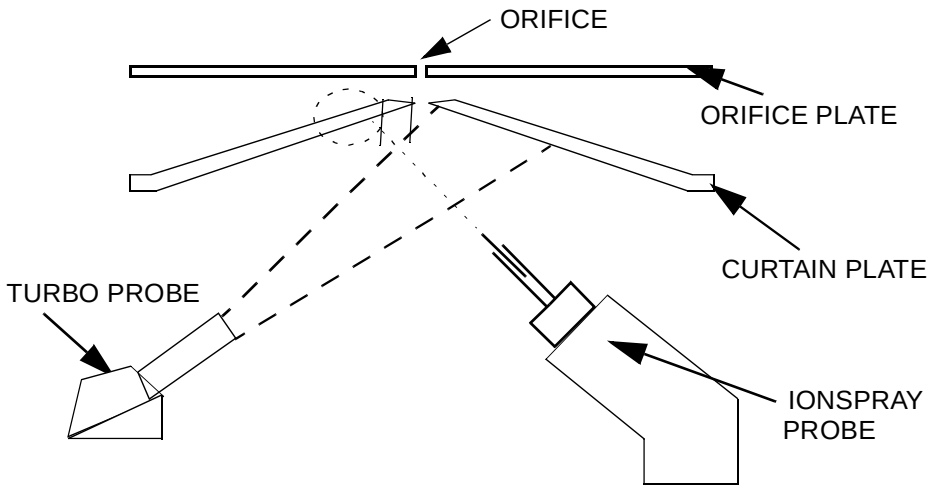
NOTE: Emphasizes significant information in a procedure or description.

Introduction

TurboIonSpray extends the rugged and versatile technique of IonSpray to accept higher flow rates with improved sensitivity. TurboIonSpray will accept flows from 5 to 1000 µL/min of solvent compositions from 100% aqueous to 100% organic, such as acetonitrile, without splitting. This allows the use of 1 mm, 2 mm, and 4.6 mm analytical columns with or without splitting.

TurboIonSpray consists of the IonSpray probe used in conjunction with a heated TurboProbe. The TurboProbe directs a jet of heated dry gas (up to approximately 500°C) at the spray produced by the IonSpray. The heated gas is sprayed across the orifice at an angle of approximately 45° with respect to the Curtain Plate. The liquid spray emerging from the TurboIonSpray is directed at an angle of about 45° from the opposite direction (or 135°). The TurboIonSpray effluent and the heated dry gas intersect at an angle of approximately 90° near the orifice. This interaction helps focus the TurboIonSpray stream and increases the rate of droplet evaporation resulting in an increased ion signal.

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TurboIonSpray Setup

TurboIonSpray is ideally suited for LC/MS/MS quantitative analyses. The sensitivity increases that are achieved with this technique are both flow rate and analyte dependent. In the conventional IonSpray source sensitivity decreases with increased flow rate, while the TurboIonSpray increases ionization efficiency, especially at the higher flow rates.This results in improved sensitivity. Sensitivity is compound dependent and compounds of extremely high polarity and low surface activity usually show the greatest sensitivity increases. The TurboIonSpray technique is mild enough to be used with labile compounds such as peptides, proteins, and thermally labile pharmaceuticals.

NOTE: The difference between Conventional IonSpray and TurboIonSpray is that in the TurboIonSpray, the ionization of the sample is achieved with additional heater gas delivered to aid in the desolvation of the spray. Typically the TurboIonSpray is used at higher flow rates (greater than or equal to 40 µL/min).

Features

The following list outlines the features of the TurboIonSpray ion source:

- Able to function as conventional IonSpray source when the Heater Gas (Gas 2) is turned off.
- Able to function with flow rates from 40µL/min to 1000µL/min.
- Able to vaporize 100% aqueous to 100% organic solvents.

TurboIonSpray Components

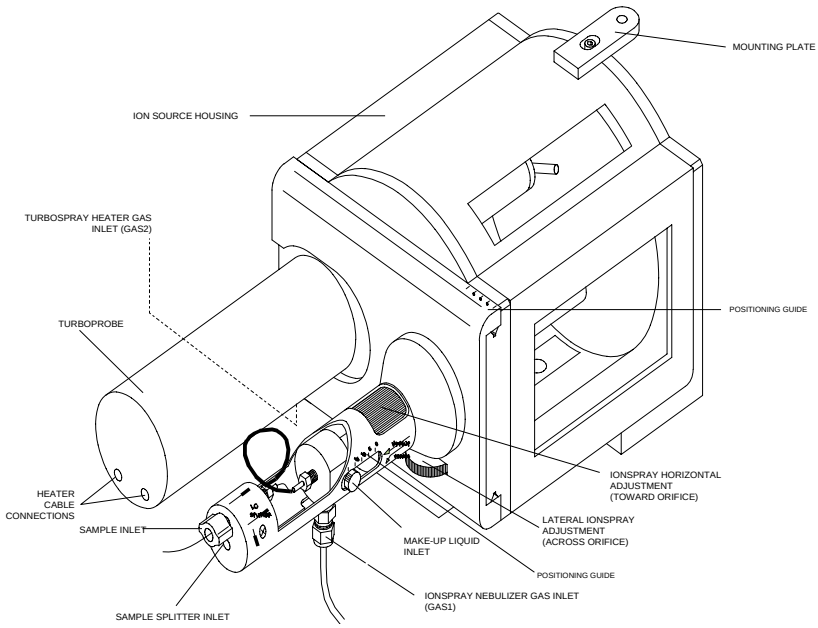
The inlet requires that the Source Exhaust system of the API Mass Spectrometer be **ON** and operating to specification. If the Source Exhaust system is not working properly, the instrument power supplies are disabled. Further explanation of the Source Exhaust system is found in both the Operators' and Reference Manuals.

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The TurboIonSpray Ion Source consists of:

- IonSource housing
- TurboIonSpray Probe with heater
- Computer adjustable temperature control circuit board
- Flow meter for control of Turbo Heater Gas (Gas 2)
- Optional manifold

.



TurboIonSpray Ion Source

Specifications

Temperature Range

- Probe temperature from 0° to 500°C

Liquid Chromatograph

- Interfaces to any liquid chromatograph system

TurboIonSpray Nebulizer Gas (Gas 1)

- Zero grade air regulated to 90 psi

TurboIonSpray Heater Gas (Gas 2)

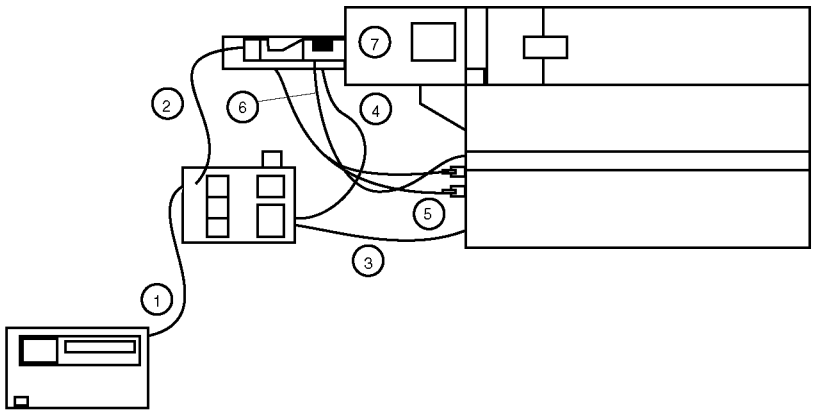
- Zero grade air regulated to 90 psi

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Inlet Description

TurboIonSpray consists of two units: the Optional Manifold, and the TurboIonSpray Source. The optional manifold contains a mount for the flow meter. The flow meter controls the flow of Turbo Heater Gas (Gas 2).

The TurboIonSpray source consists of a fixed angle adjustable IonSpray probe and a fixed position TurboProbe (see figure of TurboIonSpray Setup in the Introduction section). The TurboProbe has the Turbo Heater gas (Gas 2) connection located on the bottom of the probe and the heater cable connection underneath the probe. The heater cable is connected to the Heater Control connection on the Ion Source panel. The Turbo heater temperature is set at the Applications Computer using the TUNE software by modifying the TEM parameter in the State Window. The correlation between the parameter value of TEM and the actual heater temperature is direct (for example TEM 350 is equal to 350°C at the heater). The TurboIonSpray gas is connected to Gas 2 through the options manifold and is zero grade air at flow rates of up to 8 L/min.



1. LC PUMP CONNECTED TO OPTIONS BRACKET INJECTOR MANIFOLD
2. INJECTOR MANIFOLD CONNETED TO IONSPRAY SAMPLE INLET
3. TURBOSPRAY GAS CONNECTED TO FLOW METER ON OPTIONS BRACKET
4. FLOW METER IS CONNECTED TO TURBO PROBE GAS CONNECTION
5. TURBO PROBE CABLES CONNECTED TO HEATER CONTROL ON ION SOURCE PANEL
6. IONSPRAY NEBULIZER GAS SUPPLIED FROM GAS 1 CONNECTION ON ION SOURCE PANEL
7. HIGH VOLTAGE CONNECTION TO BOTTOM OF ION SOURCE HOUSING AND CONNECTED TO ION SOURCE PANEL

TurboIonSpray Connection Overview

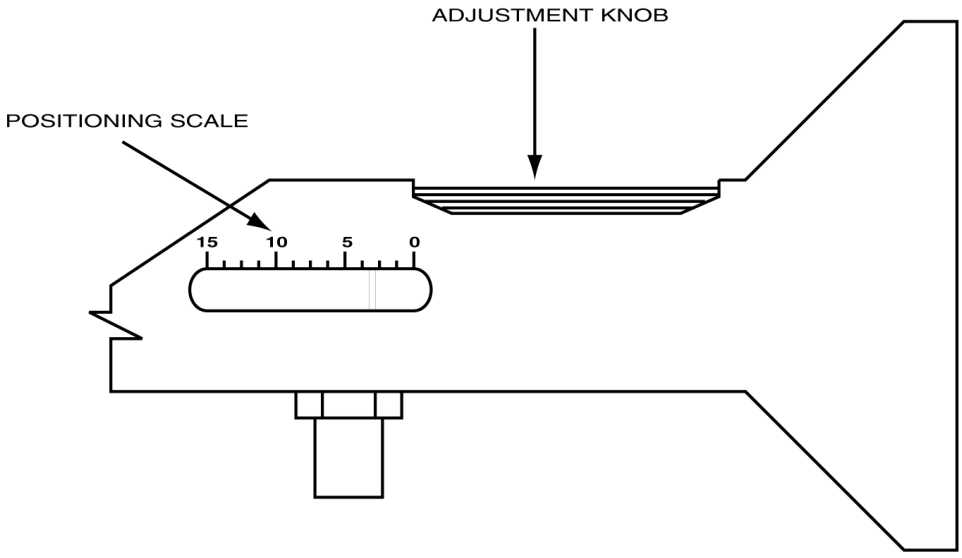
The TurboProbe temperature, which is set at the Applications Computer, is maintained by the Temperature Control Board (TCB) mounted behind the IonSource panel (below the IonSource housing). The TCB adjusts the flow of power to the heater element as a function of the difference between the actual heater temperature and the temperature setting at the Applications Computer. The probe temperature is monitored by a thermocouple connected directly to the heater element which maintains the temperature within ±5 degrees of the Applications Computer Setting. The operating range for the probe is from 100° to approximately 500° C.

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NOTE: The temperature is controlled by monitoring the output of a thermocouple connected to the heater surrounding the metal tube. At the temperature control board the thermocouple output is compared with the temperature setting, the difference determines the power flow to the heater.

The operating temperature should be adjusted relative to LC mobile phase composition and flow rate. In general, a combination of heat and gas flow that just allows the liquid spray to reach dryness before reaching the curtain plate will provide optimum performance.

The TurboIonSpray probe is adjustable in two directions: towards the orifice from a scale of 0 to 15 (adjusted by the horizontal black adjusting ring mounted on the TurboIonSpray probe) and side to side across the orifice from ±5 to 0 by the Lateral Adjustment control on the back of the Ion Source Plate. See the figure *Horizontal Adjustment*.



Horizontal Adjustment

Turbo gas flows of approximately 6 L/min can be considered optimum for conditions where heat is required. Ionization efficiency is improved with the input of heat for all liquid flow rates. However, at lower flow rates (<20 µL/min) the gains are small. Heat inputs may be desirable under low flow conditions for the additional reason of enhancing in-source (orifice-skimmer) fragmentation. Temperatures as low as 80°-100°C have proven useful for enhancing this capability (phosphopeptide mapping for instance) when operating at low flow rates.

Installation

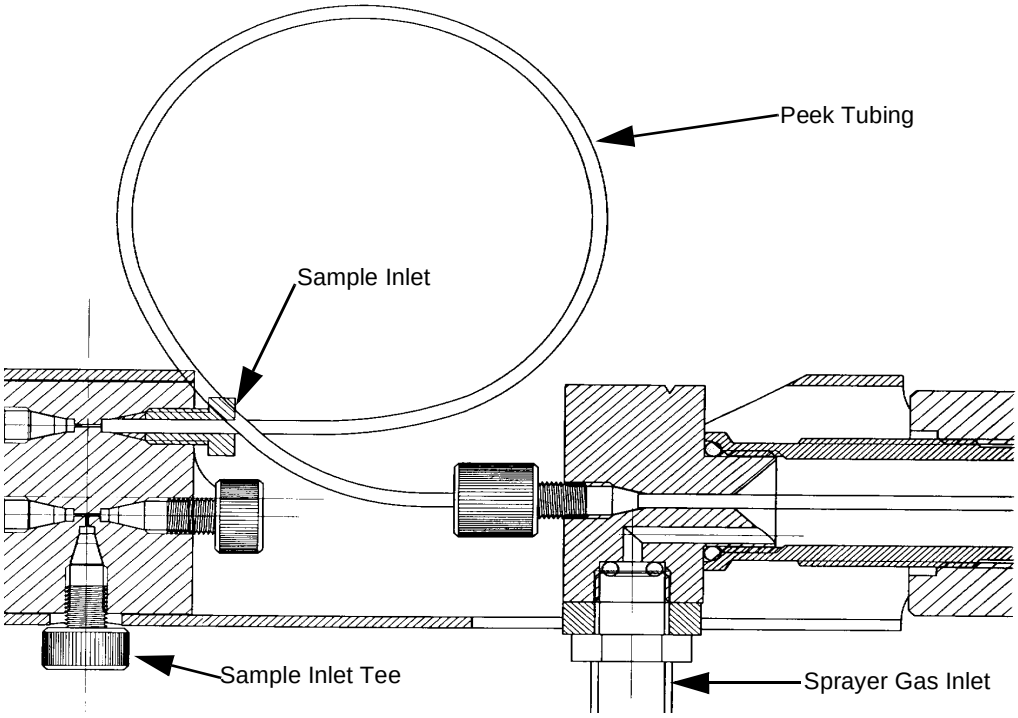
The TurboIonSpray hooks via the mounting plate to the top of the Vacuum Interface housing. Two thumbscrews mounted in the Vacuum Interface housing screw into the TurboIonSpray to secure it in position against the Vacuum Interface.

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To install the TurboIonSpray on the API instrument:

1. Place the mounting plate of the TurboIonSpray source housing over the hook on the top of the vacuum interface and secure the thumbscrews. It may require gentle pressure on the back of the ion source housing to tighten and secure the thumbscrews.
2. Connect the TurboIonSpray Heater Gas (Gas 2) from the flow meter on the options manifold.
3. Connect the TurboIonSpray Nebulizer Gas (Gas 1) from the Ion Source panel to the connections on the TurboIonSpray Ion Source.

NOTE: In order to reduce the band broadening of sample with solvent, thus maximizing sensitivity, the use of 0.005” ID stainless steel, peek, or fused silica tubing between the TurboIonSpray and the injector is recommended.



TurboIonSpray Configuration

4. Connect the injector tubing to the Zero Volume fitting on the sample inlet end of the IonSpray probe. Ensure that all fittings are properly seated in order to minimize dead volumes.
5. Connect the High Voltage (HV) cable to the connector on the bottom of the Ion Source housing, and to the Ion Source Voltage connection on the Ion Source panel.
6. Connect the other end of the HV cable to the Instrument Bulkhead (HU) connector.
7. Connect the three-prong thermocouple plug and the heater plug into the sockets on the Ion Source panel.
8. Ensure that the exhaust tube is connected to the Source Exhaust port.

You have installed the TurboIonSpray Ion Source. To remove the TurboIonSpray Ion Source, complete the next procedure.

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To remove the TurboIonSpray from the API instrument:



WARNING! High Voltage Risk. Remove the high voltage connector from the instrument prior to removing high voltage connector from the Ion Source housing.

1. Stop all scans and place the instrument in **Standby** or **Overnight Quit** status.
2. Disconnect the three-prong thermocouple plug and the heater plug from the sockets on the Ion Source panel.
3. Disconnect the injector tubing from the Zero Volume fitting on the sample inlet end of the IonSpray probe.
4. Disconnect the TurboIonSpray Nebulizer Gas (Gas 1) from the Ion Source panel and the connections on the TurboIonSpray Ion Source.
5. Turn off the Gas 2 supply from the regulated supply.
6. Disconnect the TurboIonSpray Heater Gas (Gas 2) from the flow meter on the options manifold.



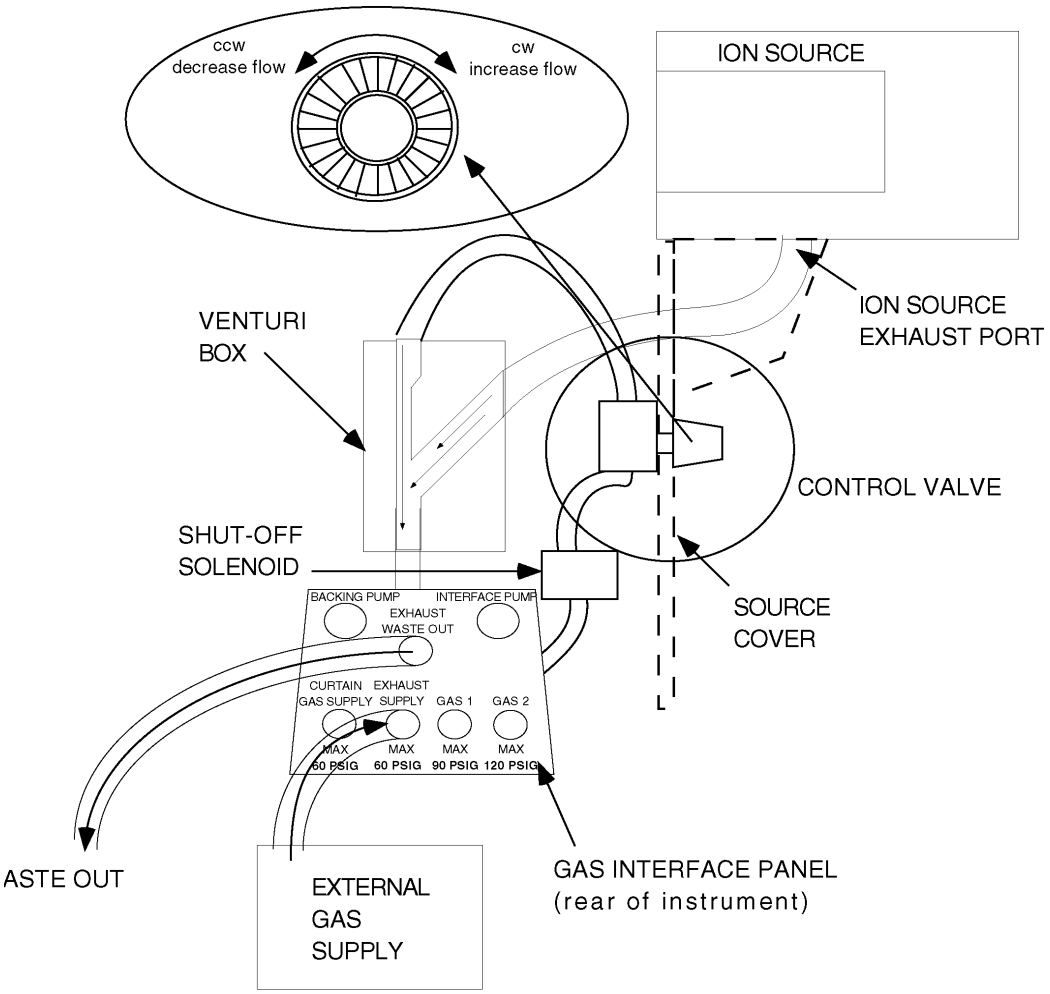
WARNING! The Ion Source may be hot for several minutes after it is removed from the instrument.

7. Remove the two thumbscrews in the Vacuum Interface housing and lift the TurboIonSpray Ion Source housing from over the hook on top of the Vacuum Interface.

You have now removed the TurboIonSpray Ion Source.

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Ventilation



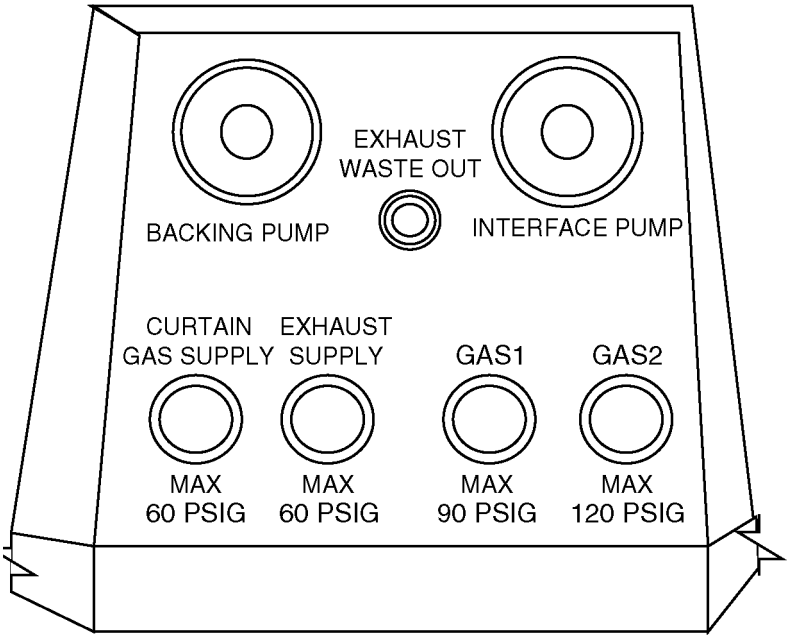
Source Exhaust System

The TurboIonSpray Source requires that the Source Exhaust system (see figure) is properly connected and functioning. A filtered nitrogen, or air gas supply (free from pump oil) is delivered to the Source Exhaust Pump at 60 psig pressure at a flow of at least 8L per minute. The Source Exhaust pump is used to vent solvent vapors which develop in the Ion Source plenum. It is recommended that these vapors be passed through a trap vented to a fume hood or outside port.



WARNING! Failure to provide proper ventilation of the ion source can result in hazardous vapors being released into the laboratory environment.

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Gas Connection Panel

Optimizing the TurboIonSpray

The following section outlines the practical considerations which must be considered when optimizing the TurboIonSpray performance. It is intended to provide the qualitative information necessary to aid the operator in quantifying the separate operating parameters.

TurboIonSpray performance depends on the following factors:

- Sprayer position.
- TurboIonSpray (IS) voltage
- Nebulizer gas
- Curtain gas
- Heater Gas flow and Temperature
- Declustering Potential and Focusing Potential voltage (compound dependent)
- Solvent Composition
- Source Exhaust

Optimum performance on standard compounds is relatively easy to achieve and little adjustment or tuning is required once the Source is optimized.

With experience, the operator will develop a personal optimization method which works best. In general, once the sprayer is set up and optimum factors have been determined, little or no readjustment of the values is required on a day-to-day basis. If the sprayer is removed, it is recommended that it be re-optimized after it is reinstalled.

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CAUTION! For tuning purposes a compound with a known molecular ion should be introduced either by continuous infusion or flow injection. Infusion is preferred because it provides a continuous flow of sample. The tuning compound should have characteristics similar to the sample to be analyzed during normal operation and should be introduced at the same liquid flow rate.

CAUTION! When optimizing the Sprayer position make certain not to spray directly down the orifice. Spraying down the orifice may contaminate the Vacuum Interface and Vacuum Chamber ion optics and could impact instrument performance.

CAUTION! To avoid possible damage to the sprayer tip, always view the sprayer tip through the side and top ports when adjusting its position.

CAUTION! If the TurboIonSpray voltage is set too high a blue glow can be seen at the tip of the TurboIonSpray indicating a corona discharge. This will result in decreased sensitivity and stability of the ion signal.

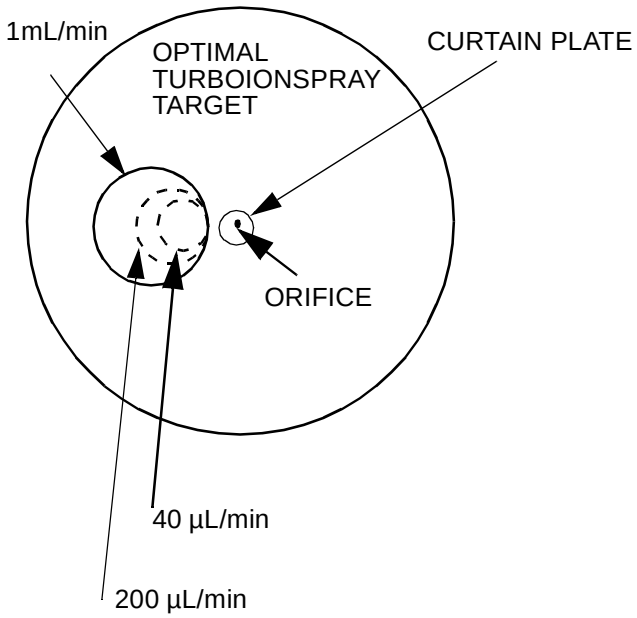


WARNING! If unattended user operation is intended through the use of sample control. Ensure that LC shut-off is in use to prevent flooding of the plenum chamber.

TurboIonSpray Probe Position

The position of the TurboIonSpray Probe relative to the Orifice and to the Heater Probe is an important factor in optimizing the TurboIonSpray performance. The probe should point between 5 and 10 mm off axis with respect to the center of the orifice. The distance of the Heater Probe from the orifice plane is fixed, but the TurboIonSpray can be adjusted using the scale on the side of the Sample inlet arm. Changing from low solvent flow rates (40µl/min) to high solvent flow rates (1mL/min) requires that the TurboIonSpray be repositioned further away from the orifice to prevent solvation penetration through the orifice into the mass spectrometer.

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TurboIonSpray Positioning Across the Orifice

Also as the aqueous composition of the carrier solvent increases at high flow rates (1 mL/min), the more visible the spray becomes and the further away from the orifice it should be directed. Refer to the figure *TurboIonSpray Positioning Across the Orifice*, where the areas indicated in the figure for the different flow rates are the optimum target areas for the TurboIonSpray liquid spray. The circle immediately around the orifice (for example the part of the orifice plate which is visible when viewing the front of the interface) should remain clear of solvent or solvent drops at all times.

The best position is usually a few millimeters off axis to the left of the curtain plate aperture. Multiply charged proteins and peptides introduced at a few microliters per minute usually require the sprayer to be less than 1 cm from the Curtain Plate.

TurboIonSpray Voltage (IS)

Positive mode, singly charged compounds usually require a high probe voltage between 4000 to 5500 V. Negative mode compounds usually require a lower voltage -3000 to -4500þV.

Nebulizer Gas (Gas 1)

Optimize for signal stability and sensitivity. Typically a value of 5 to 15 is used as applied by the Applications Computer.

Curtain Gas Flow

The Curtain Gas ensures a stable clean environment for the sample ions entering the mass spectrometer. The gas curtain prevents air or solvent from entering the analyzer region of the instrument while permitting the sample ions to be drawn into the vacuum chamber by the electrical fields generated between the Vacuum Interface and the TurboIonSpray needle. The presence of the solvent vapor or moisture in the analyzer region of the mass

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spectrometer contaminates the QØ Rod Set causing a reduction in resolution, stability, sensitivity, and an increase in chemical background noise. As a general rule, the Curtain Gas flow should be set as high as possible without reducing the signal significantly (for example start at a lower value and increase the flow until the signal starts to decrease).

In order to prevent instrument contamination the **Curtain Gas flow should be optimized at the highest possible setting but never below 6** that does not result in a significant reduction in signal intensity. Refer to the System Reference Manual for further details of Vacuum Interface operation.

NOTE: It is suggested that the TurboIonSpray be operated with curtain gas settings adjusted to the highest flow rate possible (never below 6) without signal loss.

Heater Gas (Gas2) Flow

The Heater Gas (Gas 2) aids in the evaporation of solvent which aids in increasing the ionization of the sample. The higher the liquid flow or the higher the aqueous composition of the solvent, the higher the Heater Gas temperature and gas flow required. However, too high a temperature can cause premature vaporization of the solvent, and result in a high chemical background noise, while too high a Heater Gas flow can produce a noisy, or unstable signal.

The table on the next page provides recommended operating conditions for the TurboIonSpray at three different flow rates. For each flow rate, the Curtain Gas flow rate (from setting 6 to 15 at the application's computer) should be as high as possible. The solvent composition used for optimization (see TurboIonSpray Suggested Operating Settings Table) was 1/1þWater/Acetonitrile. These conditions represent a starting point from which to optimize TurboIonSpray. By an iterative process, the various settings can be optimized using Flow Injection Analysis to obtain maximum signal-to-noise for the compound of interest.

TurboIonSpray Suggested Operating Settings Table

Flow Rate	TurboProbe Temp. (°C)	Heater Gas (GAS2) Flow (L/min)	Nebulizer Setting (GAS1)	Position	
				L	H
40 µL/min.	300 (200 to 500)	6 (4 to 8)	10 (8-15)	5	5
200 µL/min.	425 (300 to 500)	7 (4 to 8)	10 (8-15)	8	10
1 mL/min.	475 (450 to 500)	8 (4 to 8)	10 (8-15)	10	15
L = Lateral position H = Horizontal position					

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Turbo Temperature

The quantity and type of sample affects the optimal TurboIonSpray temperature. At higher flow rates the optimal temperature increases. A more significant factor is the composition of the solvent. As the organic content of the solvent increases the optimal probe temperature should decrease. With solvents consisting of 100 percent methanol or acetonitrile the probe performance may optimize as low as 300°C. Aqueous solvents consisting of 100 per cent water at flows approximately 1mL/min require a minimum probe temperature of 425°C. Normal optimization is usually performed in increments of 25°.

The TurboIonSpray is normally used with sample flow rates of 40 µL/min to 1000 µL/min. The heat is used to increase the rate of evaporation and this improves ionization efficiency resulting in increased sensitivity. See TurboIonSpray Suggested Operating Settings Table for recommended temperatures.

CAUTION! Do not operate the TurboIonSpray with probe temperatures greater than 500 ^{o}C.

Declustering Potential (DP) and Focusing Potential (FP) Voltages

Optimal Declustering Potential and Focusing Potential operating conditions with the TurboIonSpray source should be set high enough to reduce the chemical noise but low enough to avoid fragmentation. Start with the Declustering Potential DP) at 300V and the Focusing Potential (FP) at 30V.

NOTE: The fragmentation energy of a compound is a function of its structure and molecular weight. Generally lower molecular weight compounds require less energy - lower Declustering Potential and Focusing Potential voltages to induce fragmentation. For some labile compounds, DP values of between 5 to 10 may be required with the TurboIonSpray.

In general terms, the higher the Declustering Potential and Focusing Potential voltages the greater the energy imparted to the ions entering the analyzing region of the mass spectrometer. The energy helps to decluster the ions and to reduce the chemical noise in the spectrum resulting in an increase in sensitivity. Increasing the voltages beyond optimal conditions can induce fragmentation before the ions enter the mass filters resulting in a decrease in sensitivity. In some instances this fragmentation can prove a valuable tool providing additional structural information.

Solvent Composition

Commonly used solvents and modifiers are acetonitrile, methanol, propanol, water, acetic acid, formic acid, ammonium formate and ammonium acetate. The modifiers such as TEA, sodium phosphate, TFA and dodecyl sodium sulfate are not commonly used because they complicate the spectrum with their ion mixtures and cluster combinations. They may also suppress the strength of the target compound ion signal. The standard concentration of ammonium formate or ammonium acetate is from 2 to 10 millimole per liter for positive ions and 2 to 50 millimole per liter for negative ions. The concentration of the organic acids is 0.01% to 0.5% by volume.

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Source Exhaust Pump

The Source Exhaust system is required for TurboIonSpray operation. The exhaust pump draws the solvent vapors from the enclosed source chamber and delivers them to a trap at the rear of the instrument chassis where they can be collected. The Source Exhaust system is interlocked to the system electronics, such that if the source exhaust pump is not operating to specification the instrument electronics are disabled.

The exhaust system lowers the pressure in the source slightly below atmospheric. If the pressure in the source rises beyond a trip point, the instrument High Voltage Power Supply is disabled. The adjustment of the source exhaust can affect the TurboIonSpray operation.

The sample pump should be optimized at the flow rate to be used for a particular sample by adjusting the Exhaust flow control regulator located on the Ion Source Panel.

Operating Tips

1. When running the TurboIonSpray, with or without the TurboProbe on, run the Curtain Gas at as high a flow rate as possible. The Curtain Gas should optimize about 30% higher when TurboIonSpray is in use. This will help;
   a) prevent penetration of the Curtain Gas which can produce a noisy signal,
   b) prevent contamination of the orifice, and
   c) increase the overall signal to noise ratio.
2. The liquid spray from the TurboIonSpray should be directed away from the orifice in order to;
   a) prevent contamination of the orifice,
   b) prevent piercing of the Curtain Gas which can create an unstable signal, and
   c) prevent electrical shorting due to the presence of the liquid.
3. The higher the liquid flow or the higher the aqueous composition of the solvent, the higher the temperature and Heater Gas (Gas 2) flow required. However, too high a temperature can cause thermal degradation of the compound, and result in a high chemical background, while too high a heater gas flow can produce a noisy, or unstable signal.

Changing The Peek Tubing Transfer Line

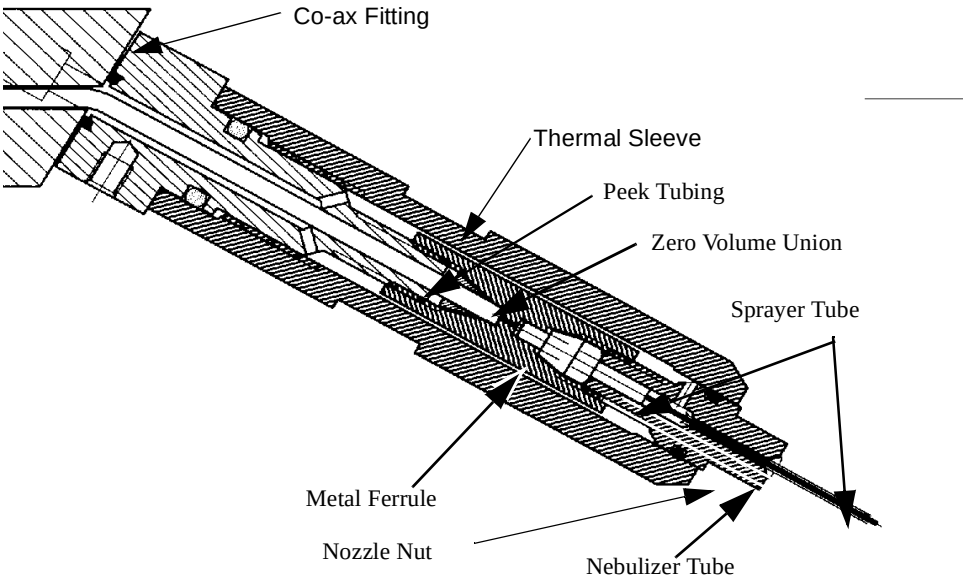
A Peek tubing transfer line is used to carry the sample and solvent from the Sample Inlet to the metal sprayer tube where it is nebulized and ionized. The standard TurboIonSpray set-up uses a 0.005” (125 µm) ID Peek tubing transfer line which is suitable for LC flow rates equal to and above 200 µL/min. The optional 0.0025” (75 µm) Peek tubing supplied in the consumables kit is recommended for LC flow rates below 200 µL/min in order to reduce dead volumes which may degrade chromatographic performance.

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The procedure outlined below should be used to exchange the Peek tubing transfer lines in the TurboIonSpray in the event of blockage of the existing line or where it is necessary to tailor the Peek tubing to match the flow rates.

To change the Peek tubing transfer line

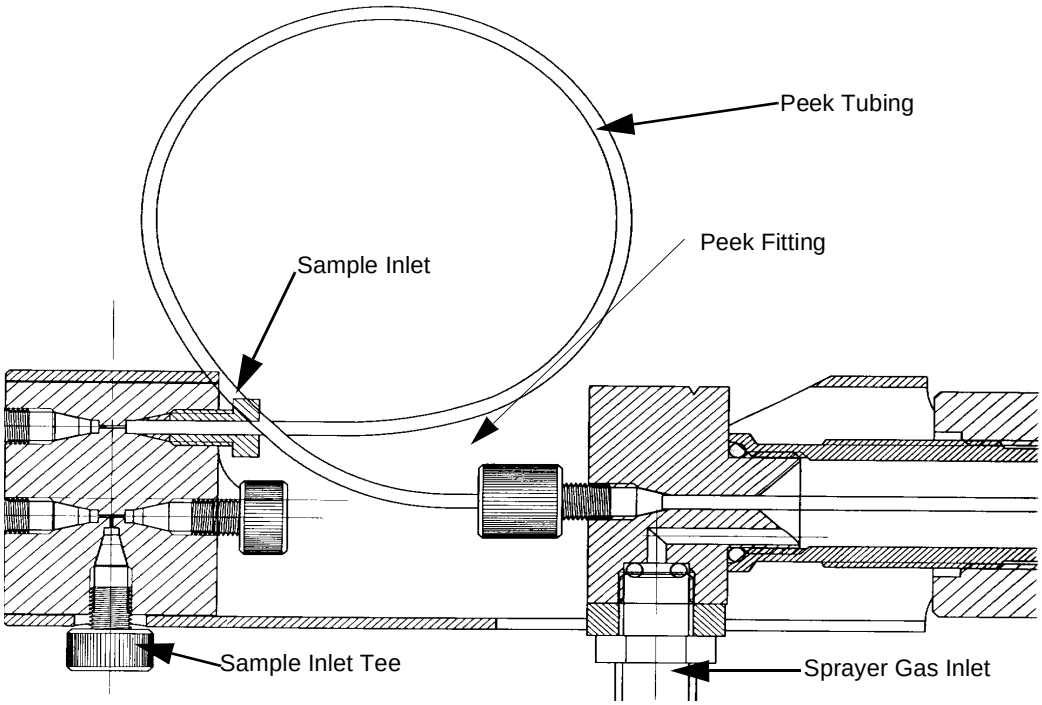
1. Set the TurboIonSpray body on its side, with the larger window to the top, on a clean flat surface.
2. Unscrew the Nozzle nut from the end of the Thermal Sleeve and set aside.



Cutaway Details of Turbo Probe

3. Unscrew and remove the Thermal Sleeve from the TurboIonSpray Probe.
4. Unscrew and remove the Zero Volume Union.
5. Disconnect the Peek tubing from the Sample Inlet. It may be necessary to cut one end of the Peek tubing and remove the swagged ferrule so the tubing can be pulled out.
6. To remove the old Peek tubing, loosen the Peek fitting to allow the old Peek tubing to slide through.
7. Swage a metal ferrule on one end of the pre-cut length (48 cm) of the new Peek tubing.
8. Insert the unswaged end of the Peek tubing through the Co-ax fitting and back through the probe assembly until the Ferrule is flush with the end of the Co-ax fitting and the other end of the Peek exits out via the Peek fitting.

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TurboIonSpray Peek Threading

9. Screw on the Zero-Volume Union and make sure that the union is tight.
10. Screw on the Thermal sleeve and finger tighten it snug.
11. Replace the Nozzle nut removed in Step 2 and tighten it at the end of the Thermal Sleeve.
12. Make sure that the peek tubing is pulled taut and then tighten the Peek Fitting finger-tight to lock the Peek tubing in place.
13. Insert the Sample inlet nut and a ferrule on the other end of the peek tubing.
14. Loop the peek tubing around as shown, Insert it into the Sample Inlet and tighten finger-tight. Tighten the nut a further quarter turn to swage the ferrule and to make a leak proof connection.

You have now changed the Peek tubing transfer line.

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Appendix A: Temperature Controller

Temperature Controller

The Temperature Controller monitors and maintains the temperature of the heater probe in both the Heated Nebulizer and TurboIonSpray inlets. The Temperature Controller consists of a 420 W (8.5 Ω) heating element in the Heated Nebulizer and the TurboIonSpray probes, the Temperature Control Board (TCB) and a transformer which provides the power for both the heater and the TCB. A thermocouple attached to the heating element probe returns the actual heater temperature signal to the TCB.

A switch on the TCB cycles power to the heater element, to maintain the probe temperature within ± 5 degrees of the temperature set by the operator at the Applications computer. The operating temperature range for the probe is 250° to 550°C.

CAUTION! When using the TurboIonSpray, do not set the TurboProbe temperature setting beyond 500°C.

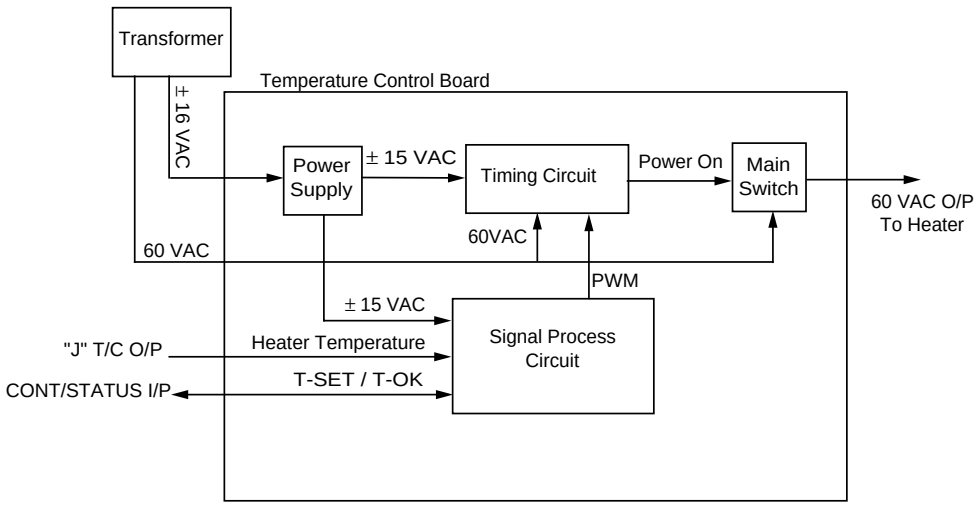
The line reduction transformer mounted on instrument chassis behind the Q1 coil box reduces the 207 to 242 VAC power from the AC Distribution Board to the 60 VAC required by the heater and the ±16 VAC for the TCB circuitry.

The transformer and the Temperature Controller Board are standard features included with the system.

Temperature Control Board Design

The Temperature Controller maintains the heater temperature by varying the flow of power to the heater element within a fixed period, termed the pulse frame. The TCB circuit schematic outlines the TCB control of the heater temperature.

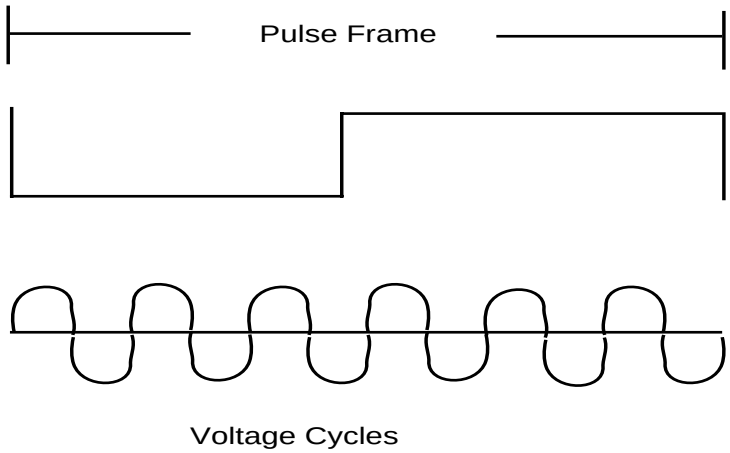
The Timing Circuit on the TCB provides the timing mechanism for the controller, generates the pulse frame and produces the Power On signal which switches power to the heater.



Temperature Controller Board Block Diagram

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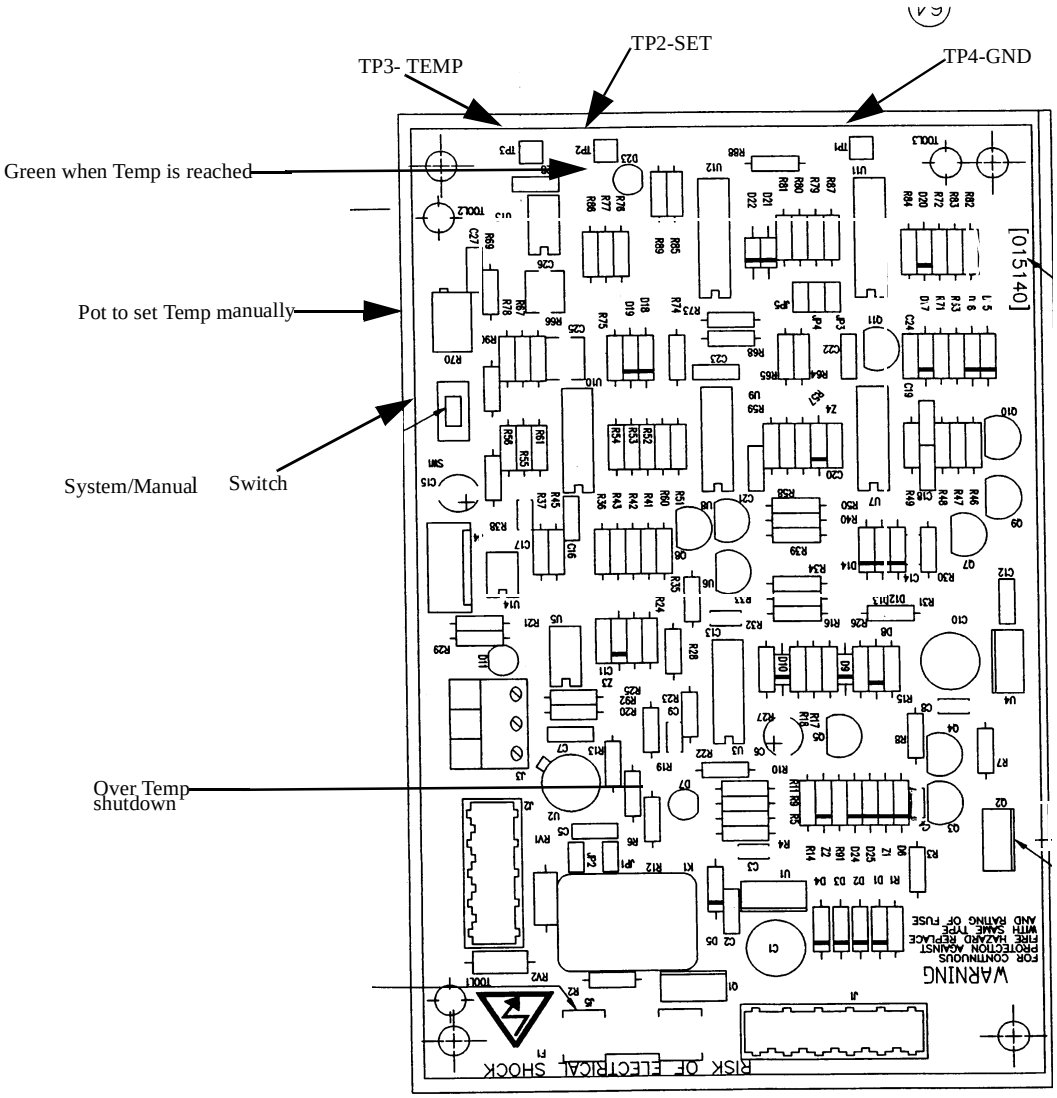
The pulse frame and the voltage cycle frequency are a function of the 207 to 242 VAC main line frequency. For a 60 Hz supply the fixed pulse frame is 100ms (50 Hz 120 ms). Each pulse frame contains six complete voltage cycles which can be switched to the heater element. The number of cycles switched to the element per pulse is a function of the difference between the TMP voltage, which represents the actual probe temperature and the T-SET voltage, which represents the temperature setting. The larger the difference, the larger the number of voltage cycles per pulse frame switched to the heater element.



TCB Pulse Frame - Voltage Cycles

The Signal Processing Circuit compares the TMP voltage to the T-SET voltage and sends the Pulse Width Modulator (PWM) signal, which determines the power flow to the heater element, to the Timing Circuit (see Temperature Controller Board Block Diagram). The PWM output is a voltage signal which can vary between 0 and 10 volts depending on the difference between TMP and T-SET. If PWM is 10 volts, all six voltage cycles of each pulse frame are switched to the heater element. If PWM is 0 volts, then none of the voltage cycles are switched to the heater element.

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Heater Controller Board

The T-OK signal is relayed to the System Controller 25 seconds after the heater temperature reaches the set temperature; T-SET ± 5. The delay allows the heater temperature to stabilize within the specified temperature range.

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There are three LED indicators on the Temperature Control Board, as shown in the Temperature Controller Board LED Indicators Table.

Temperature Controller Board LED Indicators Table

TMP LED (D23)	Indicates the heater temperature status. Red indicates the heater temperature is outside the T-SET ± 5 setting. Green indicates that TMP is within T-SET ±5.
T/C OC LED (D11)	Indicates that the thermocouple is an open circuit, e.g. the thermocouple connections are faulty. The fault will cause the main switch to be shutdown.
OVER TMP SHUTDOWN LED (D7)	Indicates that main switch bypass was activated to divert power from the heater. This happens when full power is directed to the heater element for more than 3.5 minutes. It will cause a current surge which will blow the fuse F4. It indicates a likely short across the thermocouple or a short in the main TRIAC switch.

Test Points

The TMP and T-SET voltages can be checked at test points on the TCB. The voltages are scaled such that 10 mV is equivalent to 1^{o}C. A voltmeter reading between ground and the test point TP1 reads the heater temperature. Likewise, a voltmeter reading between ground and TP2 reads the temperature setting T-SET.

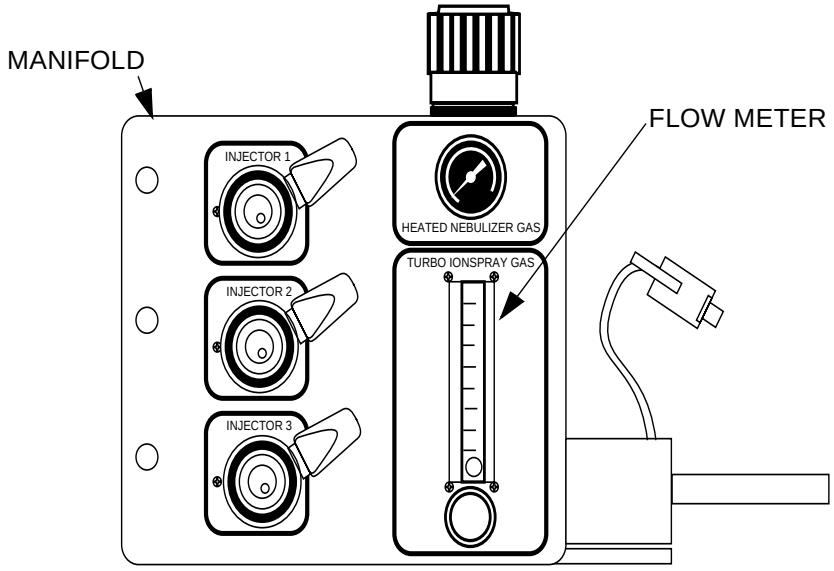
Temperature Controller Board Test Points Table

Test Point 1 (TP1)	Voltage across TP1 and Ground measures Heater Temperature. (10mV= 1^{o}C)
Test Point 2 (TP2)	Voltage across TP2 and ground measures the temperature setting T-SET. (10mV= 1^{o}C)

The T-SET temperature can also be set manually at the Temperature Controller Board. To set the target heater temperature locally, toggle switch SW1 from System to Local, and adjust potentiometer R68 to the desired setting. Monitor the temperature setting by measuring the voltage at TP2.

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Options Manifold



Options manifold (WC021218)

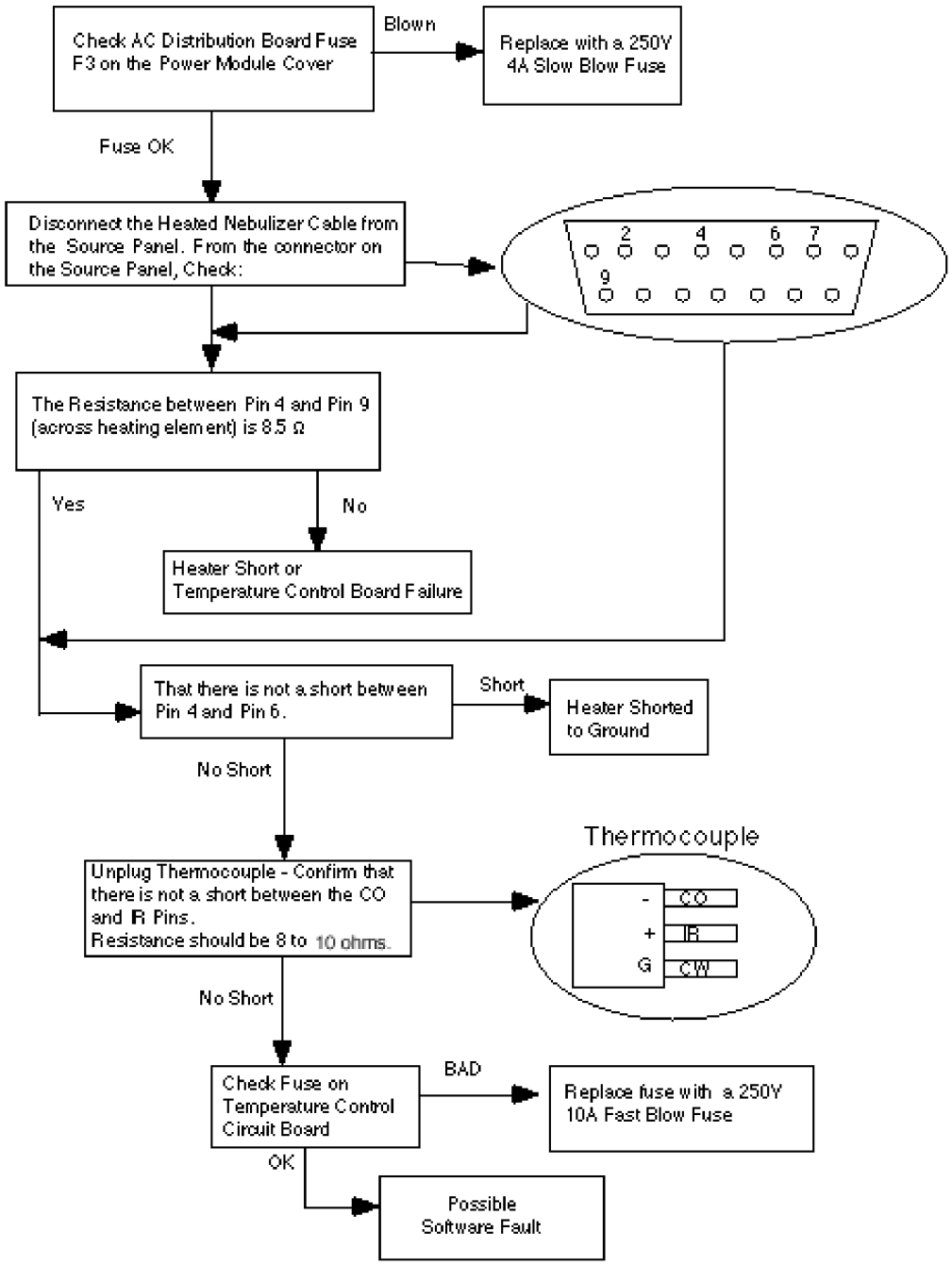
The Options Manifold is a plate which is configured to contain the Flow Controller, Regulator Valve, and up to 3 injectors. This manifold is highly recommended for the operator to easily arrange and organize components which are part of the Heated Nebulizer, and TurboIonSpray Ion Sources. Each component to be mounted on the manifold should come with its own mounting hardware.

The Manifold also has a connection cable which is connected to the Ion Source Panel Injector Manifold connection (RJ 9 connection) to allow for automatic injection control through Sample Control.

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Appendix B: Troubleshooting

Heater Failure



Trouble shooting flow chart

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Appendix C: Consumable Parts

The following is a list of parts included in the Kit of consumable parts supplied with the TurboIonSpray assembly.

Item	Part No.	Description	(Quantity)
1	016327	Assembly, Electrode -	TIS
2	016316	Tube 1/16” OD -.005 ID Peek	(50 cm)
3	016485	Tube 1/16” OD -.0025 ID Peek	(50 cm)
4	016325	Fitting, PEEK 10/32 x 1/16”	(2)
5	014439	Tube 1/8 OD x 1/64 wall, Polyprop.	(60 cm)
6	AS3605	Nut, Hex 1/8	(4)
7	014824	Ferrule, Back 1/8” OD Tube SS	(4)
8	010352	Fuse, 4A - 250V, Slo-Blo	(2)
9	013629	Fuse, 10A - 250V, FB	(2)

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