At-Line Sampling Module Flow Path

Figure 1 below shows a simplified diagram of the flow path of the At-Line Sampling Module and Lonestar in use.

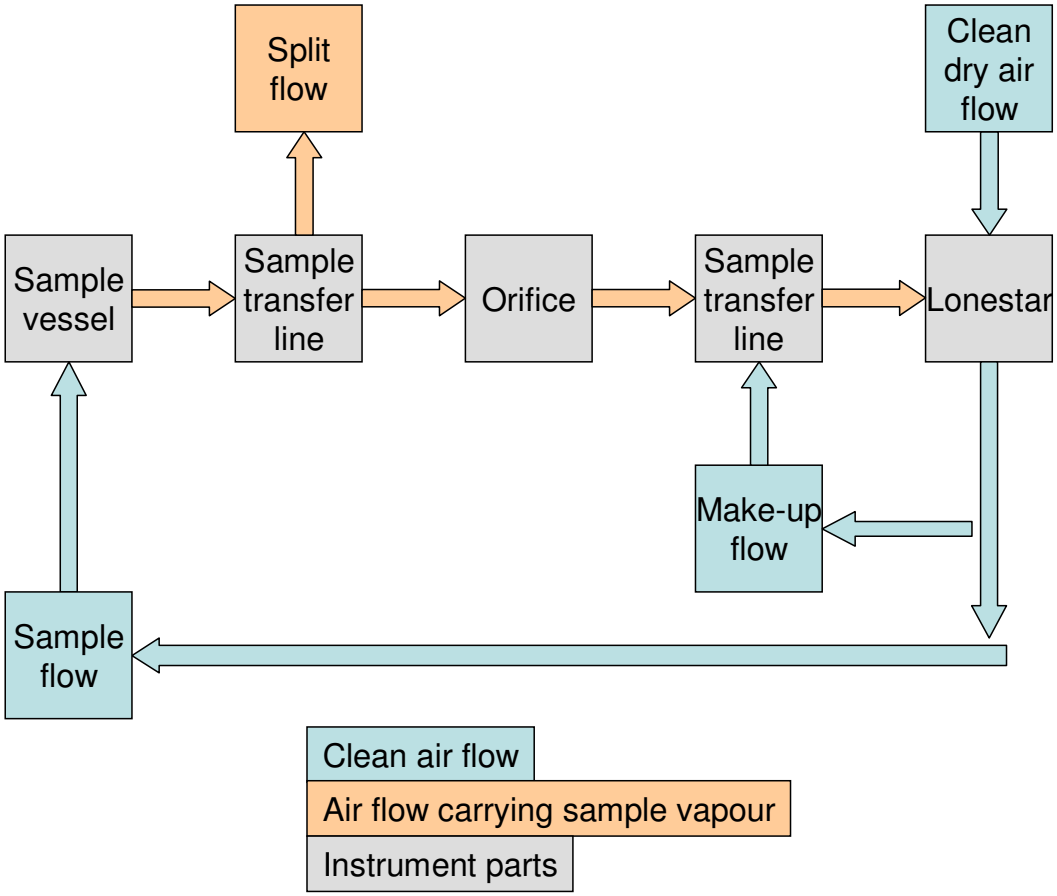

Figure 1 Block diagram of At-Line Sampling Module flow path

There are three heated sections in the At-Line Sampling Module, as described in Table 1 below.

Table 1: Heated sections of At-Line-Sampling Module

	Section	Suggested initial temperature / ℃
Temp 1	**Sample holder**	30
Temp 2	**Deactivated and heated sample transfer line**	85
Temp 3	**Deactivated and heated particulate filter and sample transfer line**	130

The flow path of the At-Line Sampling Module is as follows.

1.1. Sample flow (purge flow)

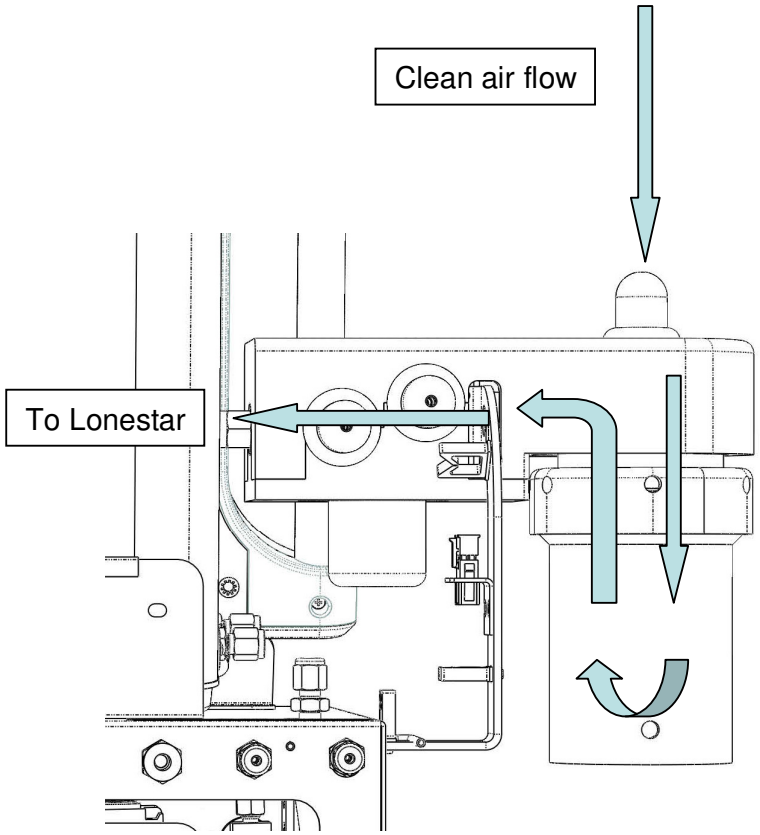

Figure 2: Sample flow path superimposed on rear of the At-Line Sampling Module

- If no split or make-up flows are used (see below), then the sample flow is the total flow through the At-Line Sampling Module and the Lonestar. The pressure of the sample flow is set by adjusting the inlet pressure to the Lonestar, and the flow rate is set by adjusting the needle valve on the exhaust of the Lonestar. The flow rate and pressure at the detector are displayed on the dashboard of the Lonestar software.
- Clean air leaves the Lonestar via the port labelled Clean Air Out. This air has travelled through the Lonestar's integral scrubber and then through a length of PTFE tubing within the body of the Lonestar.
- The sample flow then travels into the At-Line Sampling Module at the left. It flows through the dip tube and into the headspace of the glass sample bottle. Here, the clean, dry air picks up analytes and water vapour from the sample.
- The sample flow then passes along the first heated sample transfer line, through the particulate filter and along the second heated sample transfer line. The flow carries the analytes into the Lonestar detector.
- After passing through the detector, the air flow exits the Lonestar at the port labelled Exhaust.
- **Caution! The exhaust flow should always be vented appropriately. If toxic or harmful compounds are present in the sample, the exhaust flow must be vented into a fume hood.**

The second heated and deactivated sample transfer line has two ports in it, each with an 1/8" Swagelok connector. They may be blanked off or used to split and make up the sample flow as described below.

1.2. Make-up flow

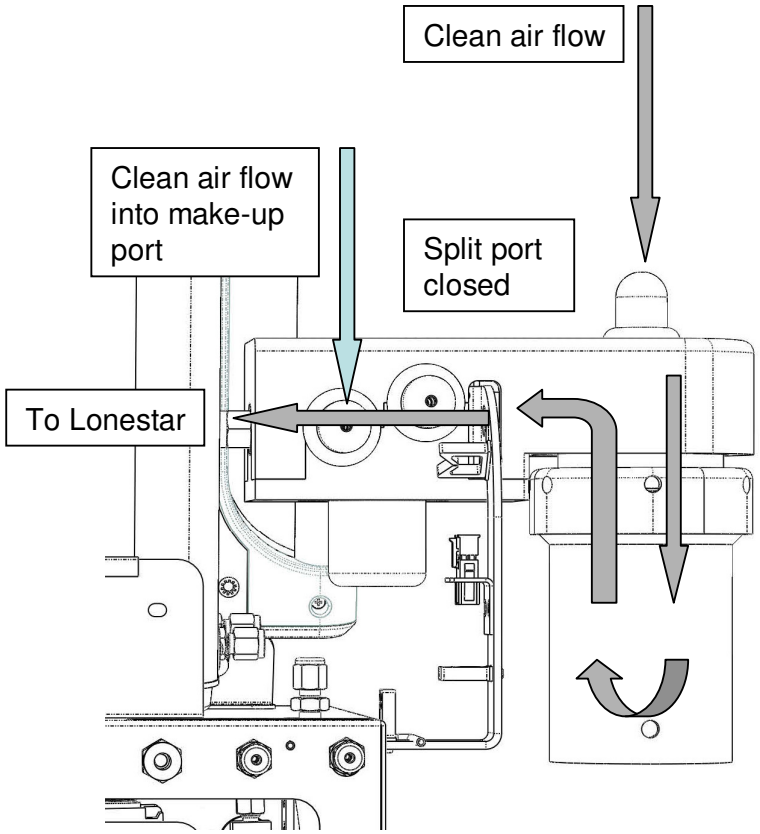

Figure 3: Make-up flow path (blue) superimposed on rear of the At-Line Sampling Module

- The make-up flow is a flow of clean, dry air that has not passed through the headspace of the sample. It is used to supplement the sample flow in the following circumstances:
    - When a split flow is being used;
    - Instead of a split flow, to dilute the sample flow and prevent saturation of the detector;
    - If a flow restriction aperture is in place in the particulate filter block, restricting the rate of the sample flow.
- In all of these cases, the make-up flow is used to bring the total flow through the Lonestar detector to a value that will ensure good operation (1.5-3.0 l/min).
- The make-up flow comes from the Clean Air port on the Lonestar and is split off from the sample flow by means of a Swagelok tee.
- The make-up flow should be connected to the second port in the sample transfer line, after the sample flow has passed through the particulate filter.
- As with the split flow, the make-up flow rate may be controlled by a rotameter or mass flow controller. Alternatively, a flow-restriction aperture may be used (see Apertures section below).
- While running the Lonestar with a make-up flow, the sample flow may also be controlled by a rotameter or mass flow controller inline (before the inlet to the sample bottle). Alternatively, a flow restriction aperture may be installed in the particulate filter block (see Apertures section below).
- Please note that if an aperture is installed in the particulate filter block, the sample flow rate by itself may not be large enough to ensure good operation of the Lonestar detector (1.5-3.0 l/min). To switch back to running the Lonestar without a make-up flow, it will be necessary to remove the aperture from the block.

1.3. Split flow

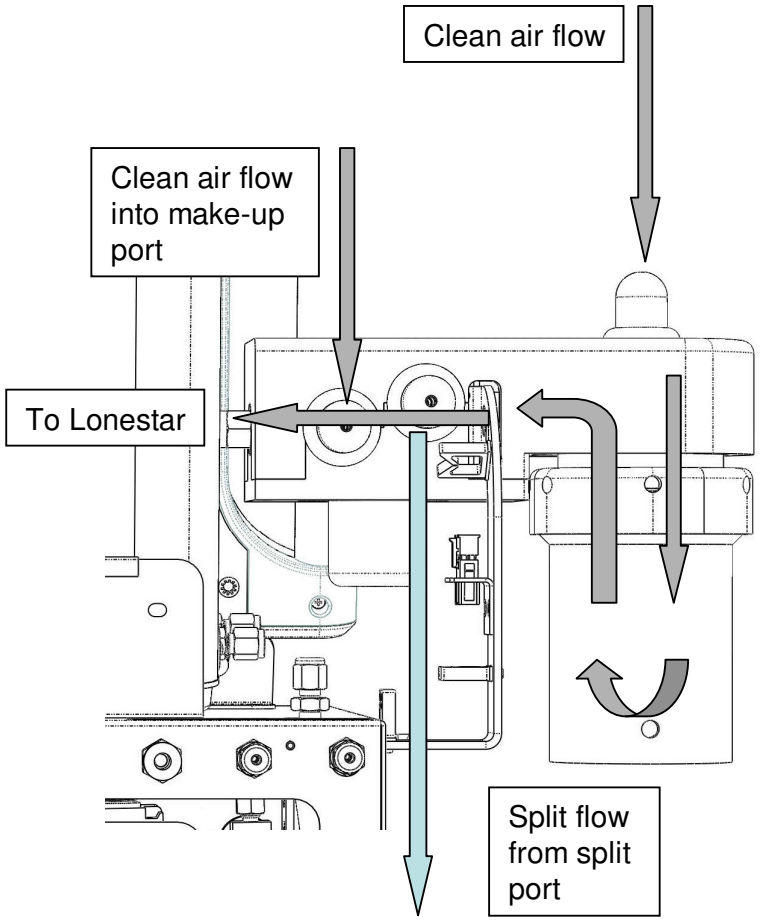

Figure 4: Split flow path (blue) superimposed on rear of the At-Line Sampling Module

- If large amounts of analyte from the sample are saturating the Lonestar detector, it may be useful to split off some of the sample flow and vent it away from the detector.
- It may also be helpful to do this if the humidity of the sample flow is too great and this is suppressing the sensitivity of the Lonestar detector to the desired analytes.
- **Caution! The split flow should always be vented appropriately. If toxic or harmful compounds are present in the sample, the split flow must be vented into a fume hood.**
- The split flow should be taken from the first port in the sample transfer line, before the flow has passed through the particulate filter.
- The flow rate may be controlled by a needle valve, rotameter or mass flow controller. Alternatively, a flow restriction aperture may be inserted into the port (see below).

1.4. Apertures

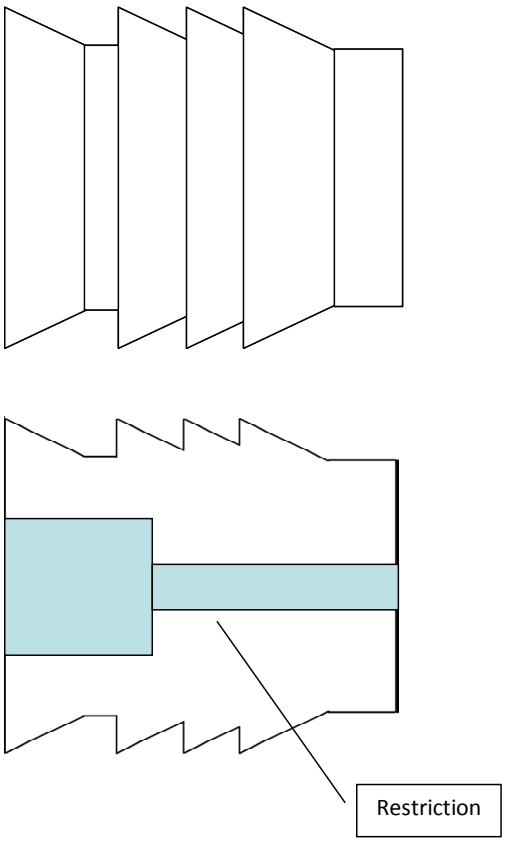

Figure 5: Outer view and cross-section of push-in orifice, showing flow restriction

- The apertures used with the At-Line Sampling Module are 2.5 mm press-in orifices in stainless steel from Lee Co.
- Apertures may be used to control the sample flow, split flow or make-up flow. Putting and aperture in a flow path will set the flow to a constant value as long as the pressure is constant.
- Different sizes of aperture are available, which will restrict the flow by different amounts.
- During method development, controlling the flow rates with a mass flow controller or rotameter may be more convenient, as this allows for greater flexibility. Once a method has been defined, however, using apertures to control the flows gives good repeatability.
- To control the sample flow, an orifice should be inserted into the particulate filter block, as shown in the At-Line Sampling Module Manual.
- To control the split or make-up flow, the orifice should first be pushed into an equal length of 1/8" PTFE tubing and then inserted fully into the relevant port.

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1.5. Humidifying the make-up flow

- An increase in humidity is used to increase separation of analyte peaks in the DF matrices produced by the Lonestar.
- One way of doing this is to take the make-up flow from another source, for example an Owlstone Humidity Generator (OHG).
- **Very important:** As the make-up flow enters the At-Line Sampling Module after the particulate filter, it is very important that the air is clean (<0.1 ppm methane) and free of particulates.
- Another way of humidifying the make-up flow is to pass the flow through the headspace of a vessel containing deionised water. See Figure 6 for an illustration of this. The final humidity of the air flow will depend on several factors, including the air flow rate and the temperature of the water.

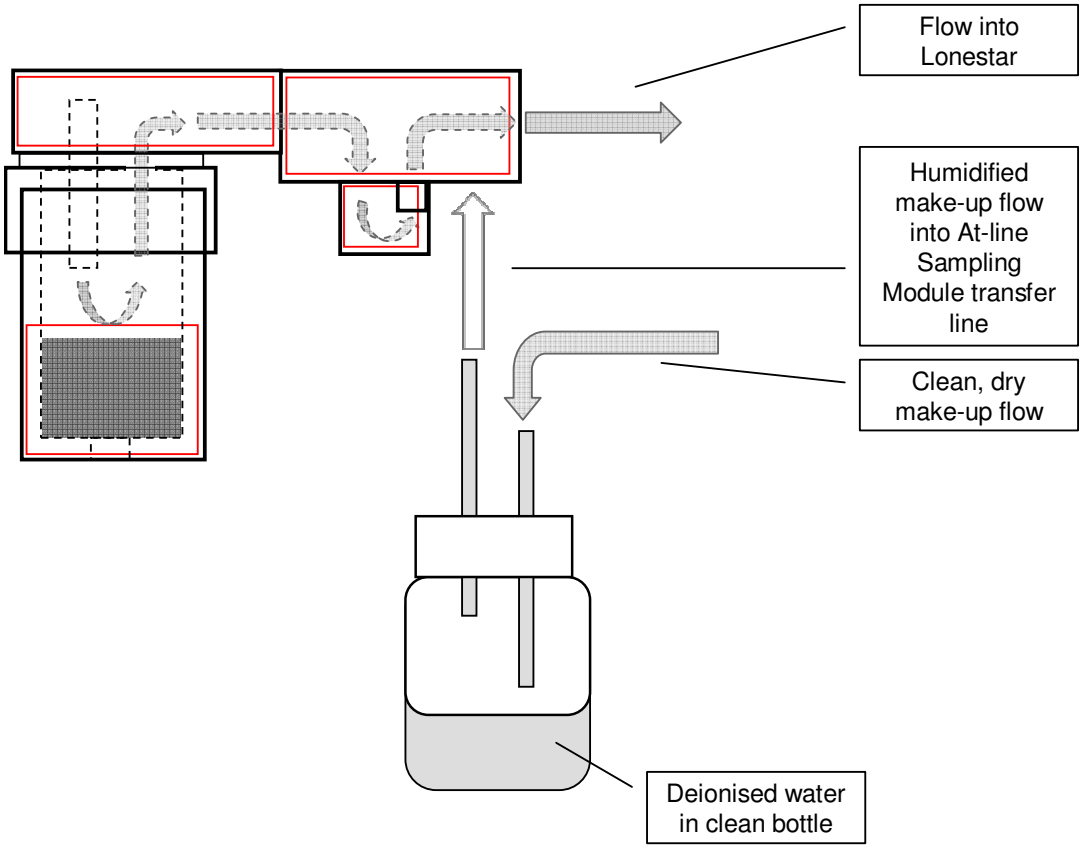

Figure 6: Humidifying make-up flow by passing it through water headspace