MSL Technical Guide 4

Ice Point Humidity Generator

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Practical and reliable humidity sources for checking hygrometers in industrial situations can be difficult to come by and use. Humidity sources such as saturated and unsaturated salt solutions offer one method of checking hygrometers, but they are time-consuming with a reliable reading taking up to 6 hours. Removing and checking the hygrometry system off site may also be undesirable.

With quality systems becoming more common, there is a need for organisations to ensure their hygrometers are checked regularly. The Ice Point Humidity Generator offers the opportunity to check hygrometers using a readily achievable reference point similar to the ice point for checking the 0 °C point on thermometers (see MSL Technical Guide 1).

This technical guide describes a procedure for producing a humidity generator that supplies humidified air with dew-point at the ice point temperature of 0.0 °C. This conditioned air can be used directly to check hygrometers that measure dew point. If the hygrometer measures relative humidity (RH), then the temperature in the immediate vicinity of the probe needs to be known accurately.

Knowledge of the dew point and chamber temperature enables calculation of the RH in the test chamber (see Table 1).

The procedure utilises a prepared ice point as the saturator temperature controlling medium.

MSL Technical Guide 1 outlines the procedure for producing a suitable ice point.

The Equipment

Saturator

Figure 1 shows the saturator coil. It consists of about 4 m of 6 mm plastic tubing wrapped around a stainless steel former. Six turns from the bottom, a small test tube is inserted in the line to act as a water trap. The air is directed to the bottom of the coil and moves up through the spirals, then exits from the top. The water trap ensures that minimal moisture is present in the tubing above the trap and prevents moisture carryover past the coil for a number of hours. The generator relies on the air supply having a dew point above 0.0 °C, ensuring that the system acts as a condensing saturator. If it is found that the dew point is below 0.0 °C, that is, the RH is less than 26 %RH at 20 °C (which is unlikely in most parts New Zealand), a damp sponge under the air pump and close to the pump inlet will help to raise the dew point of the air entering the saturator.

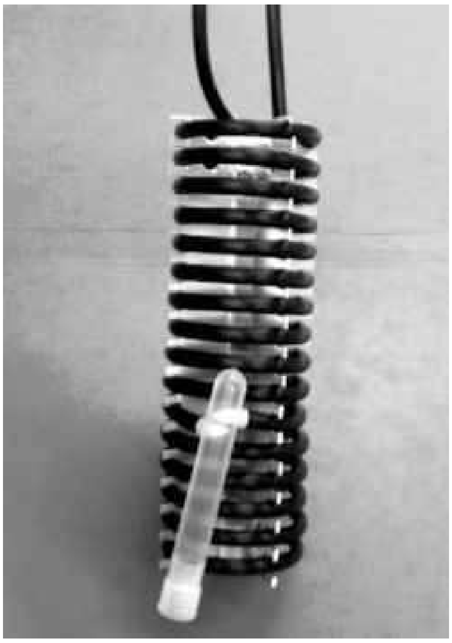

Figure 1. The saturator coil showing the water trap and inlet and outlet tubing.

Test Chamber

Figure 2 shows examples of test chambers. A small container (e.g., plastic box with an air-tight lid, or perspex tubing sealed at one end) is required in which to place the hygrometer and temperature probes. A tubing connector inserted tightly in one end of the container is connected to the outlet of the saturator coil. Small holes (e.g., 4 × 3 mm) for ventilation need to be made at the opposite end of the container away from the air inlet.

Figure 2. Examples of test chambers. Note thermometer probe and thermal insulation. Lid is removed from air-tight container for clarity.

Holes for the hygrometer and thermometer also need to be made in this end of the container. The open end of a tubular chamber serves adequately for this purpose. Insulate the chamber with foam or similar to minimise internal thermal variations within the chamber (see Appendix).

Aquarium Air Pump

An air supply of about 1 litre per minute (about 2 cubic feet per hour) is required. This can be achieved using an aquarium air pump (see Appendix). The air is pumped through the saturator coil to the test chamber, where the hygrometer probe is inserted.

Insulating Container

An insulating container, such as a vacuum insulated flask or polystyrene flask (e.g. yoghurt maker), 300 mm to 400 mm deep and 80 mm to 100 mm diameter is ideal.

The Procedure

It is essential that the saturator coil is clean of contaminants before building the generator. The tubing must be completely dry and sealed before insertion into the ice point. Flush the coil and tubing with clean water. Dry the coil and tubing by blowing filtered dry air from an industrial compressor and by gently heating the outside of the coil with a heat-gun. Air from a compressor will usually have a dew point well below 0.0 °C, ensuring no condensation will occur during drying and initial cooling.

1. Remove the water trap plug before blowing drying air through the tubing. (Removal prevents a blow-out of the water trap fittings.)
2. Inject drying air into both free ends of the tubing until dry. Let the air exit the water trap plug hole. When dry, replace the plug and connect the inlet and outlet together with a tube joiner.
3. Refer to Figure 3. Precool the flask with ice. Empty and put 50 mm to 75 mm of shaved ice into the flask. Place the bottom of the coil on the shaved ice and hold it vertically and centrally in the flask. Pack more ice around and in the coil until about half the coil is covered.
4. Sprinkle about 100 mL of clean water over and around the ice in the flask.
5. Pack more shaved ice in and around the coil until it is well covered. Sprinkle another 100 mL of water over the ice.
6. Drain the water from the bottom of the flask using the siphon.
7. Cut and fit a piece of insulating foam and place it into the top of the flask and around the inlet and outlet tubes and siphon tube.
8. Separate the ends of the coil and plumb the inlet tube of the saturator coil to the aquarium pump outlet.
9. Turn the pump on.
10. Plumb the outlet of the saturator coil to the small container (test chamber) that will house the hygrometer probe. The saturator will take about 1 hour to stabilise.
11. Insert the humidity and temperature probes and wait until stable readings are achieved. The time for a stable reading will depend on the type of probe. Ensure sufficient time is allowed for the first few checks.
12. Calculate the relative humidity from a humidity calculator or from Table 1.

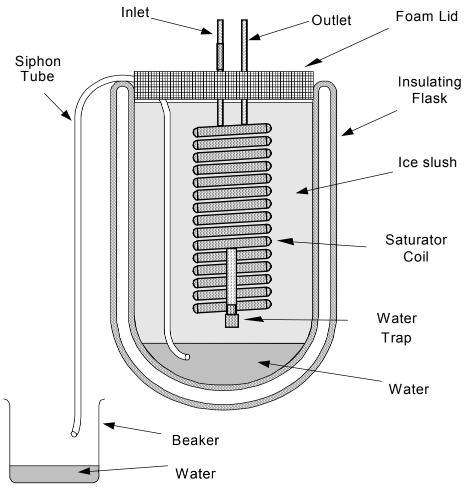

Figure 3. An Ice Point Humidity Generator for checking hygrometers.

Operational Tips

A properly prepared generator should last at least 12 hours. This will depend on the atmospheric humidity, with higher humidity causing the trap to fill quicker. Usually a filled water trap and subsequent carry over will be indicated by a rise in the measured dew point and RH. If results begin to appear suspect, rebuild the generator.

Empty the trap, flush the coil and trap with clean water, dry the coils, and rebuild the ice point generator for each day of use. Contaminated moisture in the tubing will tend to lower the generated dew point. Add ice to keep it well packed in the flask and drain the excess water with the siphon every 2 hours or so.

The length of tubing from the saturator coil to the test chamber is usually sufficient to raise the conditioned air close to ambient temperature. To test this, compare the test chamber temperature with the general ambient temperature. If the chamber is cooler, increase the length of the saturator coil outlet tube by 500 mm.

Saturator Coil Kit

An assembled saturator coil is available from MSL. Check the website for details of costs: http://msl.irl.cri.nz.

Prepared by R S Mason, August 2002.

Table 1. Relative humidity at test chamber temperature. Dew point of conditioned air is assumed to be 0.0 °C.

Dry-Bulb Temperature / °C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Relative Humidity / %RH									
10	49.8	49.4	49.1	48.8	48.5	48.1	47.8	47.5	47.2	46.9
11	46.6	46.2	45.9	45.6	45.3	45.0	44.7	44.4	44.2	43.9
12	43.6	43.3	43.0	42.7	42.4	42.2	41.9	41.6	41.3	41.1
13	40.8	40.5	40.3	40.0	39.7	39.5	39.2	39.0	38.7	38.5
14	38.2	38.0	37.7	37.5	37.2	37.0	36.8	36.5	36.3	36.1
15	35.8	35.6	35.4	35.1	34.9	34.7	34.5	34.3	34.0	33.8
16	33.6	33.4	33.2	33.0	32.8	32.6	32.3	32.1	31.9	31.7
17	31.5	31.3	31.1	30.9	30.7	30.5	30.4	30.2	30.0	29.8
18	29.6	29.4	29.2	29.0	28.9	28.7	28.5	28.3	28.2	28.0
19	27.8	27.6	27.5	27.3	27.1	26.9	26.8	26.6	26.5	26.3
20	26.1	26.0	25.8	25.6	25.5	25.3	25.2	25.0	24.9	24.7
21	24.6	24.4	24.3	24.1	24.0	23.8	23.7	23.5	23.4	23.2
22	23.1	23.0	22.8	22.7	22.5	22.4	22.3	22.1	22.0	21.9
23	21.7	21.6	21.5	21.3	21.2	21.1	21.0	20.8	20.7	20.6
24	20.5	20.3	20.2	20.1	20.0	19.9	19.7	19.6	19.5	19.4
25	19.3	19.2	19.0	18.9	18.8	18.7	18.6	18.5	18.4	18.3
26	18.2	18.1	18.0	17.8	17.7	17.6	17.5	17.4	17.3	17.2
27	17.1	17.0	16.9	16.8	16.7	16.6	16.5	16.4	16.3	16.2
28	16.2	16.1	16.0	15.9	15.8	15.7	15.6	15.5	15.4	15.3
29	15.2	15.2	15.1	15.0	14.9	14.8	14.7	14.6	14.6	14.5
30	14.4	14.3	14.2	14.1	14.1	14.0	13.9	13.8	13.7	13.7

Appendix

Notes on Equipment

Tubing replacement: The tubing is 6 mm OD irrigation tubing available from most garden centres. A hot-air gun is useful for straightening the tubing and moulding it onto and around the former to minimise tube buckling. Coil all the tube onto the former and then cut into the sixth row from the bottom to insert the water trap.

Useful connectors, fittings and air pumps are available from pet shops and aquarium suppliers. It is worthwhile to buy a pump that has adjustable flow. Make sure that the pump has a capacity of at least 1 litre per minute (2 cubic feet per hour). The flow rate should be adjusted to approximately 1 litre per minute. This can be checked by making a soap bubble on a small length of tube and adjusting the flow so that a 6 cm diameter bubble is formed in about 6 seconds. Too fast a flow means the air may not have sufficient time to condition in the saturator.

A good rule is to have 4 to 5 changes per minute in the test chamber. This means the volume of the test chamber should be less than 250 mL. Long thin tubes may be larger, but large box-like test chambers may cause flushing problems.

It is important that the test chamber is insulated so that the probe and the chamber are not affected too much by ambient temperature changes. Foam blocks cut to fit are useful for this.

For chilled mirror hygrometers the conditioned air may be plumbed directly from the saturator to the hygrometer bypassing the test chamber.

Expanded Uncertainty in Relative Humidity

The expanded uncertainty of the generated dew point is estimated to be 0.2 °C. This leads to an uncertainty in RH of approximately 0.5 %RH at 20 °C test chamber temperature. Additional uncertainty in RH arises due to the uncertainty in the test chamber temperature. This additional uncertainty in RH at test chamber temperatures can be inferred from Table 1.

For example, if the expanded uncertainty of the chamber temperature is 1 °C, the uncertainty in RH due to chamber temperature is approximately 1.6 %RH.

A calibrated thermometer is essential to ensure an accurate estimation of the RH.

MSL is New Zealand's national metrology institute, operating within Industrial Research Limited under the authority of the New Zealand Measurement Standards Act 1992.