WINTER STEADY-STATE RELATIVE HUMIDITY AND MOISTURE LOAD PREDICTION IN DWELLINGS

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ABSTRACT

With the increasing concerns about indoor air quality and energy use, of which relative humidity is a factor, it is important for building designers, heating contractors, and engineers to be able to predict what the interior relative humidity will be in houses. This allows the condensation risk and the health and energy considerations associated with moisture to be properly addressed. There is a need for a convenient model for residential relative humidity prediction.

A model for predicting the average steady-state winter interior relative humidity in dwellings has been developed. All required input variables have been defined and methods for their quantification outlined. A method for estimating the occupant moisture generation value other than the generic "family of four" value has been created as part of the model. Also, the ASHRAE equation for calculating the humidifier moisture load in dwellings has been enhanced by providing a table and a curve-fit equation for finding the monthly outside absolute humidity for more than 300 sites in the United States. In addition to the complete "equation form" models, nomographs have been created for relative humidity prediction and load calculation, which provide a very convenient, yet accurate, method of solution.

INTRODUCTION

The interior relative humidity in houses during winter affects the well-being and health of the occupants. Health complications from bacteria, viruses, and asthma increase with low and with high interior relative humidities (Sterling et al. 1985). Respiratory infections increase with low humidities, and fungi and mite growth increase with high humidities (Sterling et al. 1985; Kelly 1982). Noxious odor perceptions and formaldehyde emissions increase with higher relative humidities. With higher relative humidities, structural integrity may be damaged with low and with high interior relative humidities (Sterling et al. 1985). Respiratory infections increase with higher relative humidities, structural integrity may be damaged with low and high interior relative humidities (Sterling et al. 1985). Respiratory infections increase with low and with high interior relative humidities (Sterling et al. 1985). Respiratory infections increase with low and with high interior relative humidities (Sterling et al. 1985). Respiratory infections increase with low and with high interior relative humidities (Sterling et al. 1985).

Figure 1 illustrates how large errors will occur if a universal outside $\omega_p$ value is assumed when predicting interior relative humidity. Figure 1 compares the interior relative humidity prediction for various sites across the upper half of the United States for a typical dwelling and occupancy scenario. The "universal" value for outside absolute humidity offered by ASHRAE equates to Salt Lake City.
and results in an inside relative humidity of 31%. Using this ω₀ value in a drier climate, such as Fargo, North Dakota, would again result in a prediction of 31%, over-predicting the humidity by 9 humidity points (%) from a prediction using the actual site’s absolute humidity. In Cincinnati it would underpredict the relative humidity by 4 points.

The ASHRAE equation “as is” in Equipment is intended for humidifier load calculation. It is not in the form to give the interior relative humidity without major algebraic manipulation and thermodynamic conversion; thus it is not in a usable form for this purpose.

The other main weakness of the published methods is that they offer no way to determine an input value for the interior moisture generation from occupants unless one is dealing with a “family of four.”

OBJECTIVE

It is the objective of this paper to present the development of a model to predict monthly average steady-state winter interior relative humidity in dwellings. For use with the model, a table of outside air moisture content values (dew-point temperatures) for 300 sites across the United States will be provided as well as a model of interior moisture generation for dwellings with 1 to 10 occupants. In addition, a humidifier load prediction method will also be provided. These prediction methods will be given in useful nomograph form as well as by equations with required curve fits for use with computers.

MODEL DEVELOPMENT

Interior relative humidity is a function of the following variables: the number of occupants and the amount of moisture they generate, other interior moisture sources (diffusion from soil under the house, indoor plants, gas combustion), the volume of the house, the air change leakage rate of air into and out of the house, the amount of moisture in the outside air (the absolute humidity), moisture recovery from any heat recovery ventilators, and for transient hourly predictions, vapor diffusion through the structure shell to the outside and the amount of moisture absorbed and released by building components.

Vapor diffusion through the structure shell to the outside is proportionately small enough to be neglected (Tenwolde 1987; ASHRAE 1988). The moisture storage effects into the building components (absorption and desorption) necessary for dynamic simulations can be ignored for monthly average steady-state predictions (Tenwolde 1987, 1990; Barringer and McGugan 1989).

### Base Equation

The accepted ASHRAE equation for humidifier load calculations, a simple mass balance relation (ASHRAE 1988, Chapter 5, Equation 1) was chosen over other available forms since the ASHRAE equation required looking up fewer values from meteorological tables. Also, after manipulation, the ASHRAE equation will take into account elevation and specific volume differences between inside and outside air. The ASHRAE equation was solved for the interior relative humidity, with the humidifier load and diffusion and storage losses set to zero. Also, the specific volume was separately applied to the outside and inside air, rather than using an average. The derivation follows:

**ASHRAE Equation 1:**

\[
Q_m = (VAc/v)(\omega_i - \omega_o) - Q_e + D. \tag{1}
\]

With \( Q_m \) and \( D = 0 \), using \( \eta \) and \( \nu \) instead of an average \( v \), Equation 1 becomes

\[
\omega_i = (Q_\nu/v)/(VAc) + (\nu_i \omega_o/v_o). \tag{2}
\]

The standard thermodynamic relations (ASHRAE 1989),

\[
\omega_i = .622 P_w/(P - P_w) \tag{3}
\]

\[
P_w = \phi P_{atm} \tag{4}
\]

\[
RH = 100\phi \tag{5}
\]

when combined and solved for \( \omega_i \) and substituted into Equation 2, which is then solved for \( RH_f \), yield:

\[
RH_f = 100P((Q_\nu/v)/(VAc)) + \omega_\nu/v)P_{atm}((Q_\nu/v)/(VAc)) + (\omega_\nu/v + .622)). \tag{6}
\]

Equation 6 is the basis for average monthly relative humidity prediction in this paper.
**Determination of Base Equation Input Values**

The values needed in order to use Equation 6 in predicting the monthly average interior relative humidity in winter are now given. This detailed prediction method takes into account elevation and different specific volumes between inside and outside air. These factors are not extremely significant but cause no trouble for computation by computer.

From the relation \( P_r = RT \) for dry air, the specific volume \( v \) of the inside and outside air for the respective monthly average temperatures is found by

\[
v = 0.3738(t + 460)/P. \tag{7}\]

It is noted that Equation 7 for dry air will give specific volumes within 1% of those from the more complex relation required to account for the actual moist air being considered.

The total pressure \( P \) is given by a curve fit as a function of altitude from Table 3, Standard Atmospheric Data (ASHRAE 1989):

\[
P = 14.7077(0.999963^{(4.8)}). \tag{8}\]

(Technically \( P \) and \( v \) cannot be found independently as per Equations 7 and 8 but would require iterating to come to convergence. However, the error is negligible for this application.)

The inside saturation vapor pressure \( P_{sat} \) is a function of inside temperature. Table 2, Thermodynamic Properties of Water at Saturation (ASHRAE 1989), has been curve fit:

\[
P_{sat} = 0.00661^{0.4996}(1.0272^t). \tag{9}\]

This curve-fit equation is the dew-point temperature curve vs. the absolute humidity values on the standard psychrometric chart. The outside absolute humidity \( \omega_o \) in Equation 6 is given as a function of outside mean dew-point temperature \( t_d \), since the average monthly dew-point temperatures for many sites across the United States are compiled in meteorological tables but \( \omega_o \) values are not. Equation 10 is a curve fit of \( \omega_o \) vs. \( t_d \) from Table 1, Thermodynamic Properties of Moist Air (ASHRAE 1989). The curve fit was possible because the table gives the absolute humidity at saturation for the given dry-bulb temperature, which is the corresponding dew-point temperature. Dew-point temperatures are found in Table 2 in the appendix.

\[
\omega_o = 0.1978 e^{4.9([(t_d - 213.82)^2]/(-8286.82))}. \tag{10}\]

The interior house volume \( V \) is computed by standard means: floor area times ceiling height. The air exchange rate \( Ac \) between the inside and outside varies considerably depending on the general geographical area, local conventional practice, and the particular builder. As a general rule, new dwellings in the upper half of the United States will have an average winter rate of about 0.4 to 0.7 air changes per hour (ach). This includes all sources of air change—natural leakage and mechanical and occupants' effects. ASHRAE (1988) assumes somewhat higher air change rates than this, but the author's own experience and considerable research on the subject (Stum 1987) give more support to the lower values. Canadian houses are built somewhat tighter. However, any houses built with a natural air exchange rate below 0.3 ach are normally fitted with ventilation systems that keep the total exchange rate between 0.3 and 0.5 ach.

If the house is going to have a heat recovery ventilator (HRV) that recovers moisture from the outgoing airstream, the total air change \( Ac \) in Equation 6 should be substituted with \( Ac_{net} \) to account for this reduction in moisture loss from air exchange:

\[
Ac_{net} = Ac - (Ac_{HRV}f) \tag{11}\]

where \( f \) is the fraction of the moisture recovered from the outgoing airstream by the HRV, typically about .5 to .7 (Tech. Note 1983; Barringer and McGugan 1989b).

**Moisture Generation Model**

The overall value for interior moisture generation \( Q_g \) is generally given only for a family of four, or it is listed individually by moisture generated per activity. A convenient model for other than four occupants was needed. Using moisture generation values itemized per activity from a number of sources (Boyd et al. 1988; Kronvall 1986; ASHRAE 1988; Hill 1988; Stum 1990) and from a frequency of activity survey (Aslam 1985; BPA 1989), Table 1, found in the appendix, was generated from which moisture generation values \( Q_g \) can be taken. A curve fit of the table is also provided. These curve fits (Equations 14, 15) on the bottom of the table do not account for moisture release from combustion of gas in ranges and gas dryers. Refer to the notes at the bottom of the table for values for those sources.

The equations do account for moisture transfer from an average-sized basement, well damp proofed in dry soil, with a vapor retarder on the inside of concrete walls and under concrete floors. Moisture diffusion through basement walls and slab floors and from crawl spaces is a function of soil type and water content, exterior damp proofing, interior vapor retarders, basement size, and interior relative humidity. All these factors have yet to be combined into a versatile, reliable model. Therefore, the soil diffusion value included in Table 1 and used in the nomographs is a minimum value. Variance from these "dry" soil interface conditions may require increasing the moisture generation rate by up to an additional 3 lb/h (Barringer and McGugan 1989a,b).

All the variables used in Equation 6 have now been defined and their value determination given. The site altitude, inside and outside average monthly temperatures, house volume, average air change rate, interior moisture generation rate, and the outside monthly mean dew-point
temperature are the input values, along with Equations 7 through 11, needed to solve Equation 6.

Humidifier Moisture Load Calculation

Equation 1 from ASHRAE (1988, Chapter 5) is used as the basis for determining the load on a residential humidifier $Q_m$ when a given interior relative humidity is desired. With the diffusion to the outside and the storage term equal to zero, and by using Equations 3, 4, and 5 herein, and by assuming a 70°F (21°C) inside temperature and a 2,000-ft (600-m) elevation, solving Equation 1 herein for $Q_m$ gives

$$Q_m = VAc((0.0156\phi_i/(13.7 - 0.3633\phi_i)) - \omega_e/(13.55) - Q_e. \tag{12}$$

Equation 12 is now in a convenient form. The source for the variable inputs was explained previously.

GRAPHIC SOLUTIONS

Nomographs were created for convenient solutions to relative humidity and moisture load predictions. In order to simplify Equation 6 sufficiently to make it convenient for nomographs, some of the variable terms had to be given constant values. For all the graphs (relative humidity and load prediction), an elevation of 2,000 ft (600 m), an outside temperature of 35°F (1.7°C), and an inside temperature of 70°F (21°C) were assumed. A sensitivity analysis was performed for setting these conditions. Elevation changes of 2,000 ft (600 m) either way from the base 2,000 ft (600 m) will only change the relative humidity about 1 relative humidity point (1%). An outside temperature of 0°F (−18°C) will alter the solution by about the same amount. Therefore, these assumptions will yield negligible errors for residential conditions throughout the U.S. and Canada. However, for predicting relative humidities with an inside temperature other than 70°F (21°C), a corrected RH value can be obtained by using the RH value at 70°F (21°C) with a psychrometric chart, keeping the absolute humidity constant.

Interior Relative Humidity Prediction Nomograph

The above assumptions applied to Equation 6 yield the simplified equation

$$\text{RH}_i = 3766.41\left(\frac{Q_d}{VAc}\right) + \frac{\omega_e}{(13.55)}/\left(\frac{Q_d}{VAc}\right) + (\omega_e/(13.55) + 0.0429). \tag{13}$$

Equation 13 requires the inputs of the moisture generation, volume, air change rate, and outside mean dew-point temperature.

To create the nomograph, four graphs (Figure 2) were fit to Equation 13 including a moisture generation vs. occupants graph generated from Table 1. The $\omega_e$ value in the equation was curve fit as a function of outside mean dew-point temperatures, which are found in Table 2 in the appendix. The dew-point temperature can also be found for any given condition using the standard psychrometric chart. Note the special directions and assumptions at the bottom of the figure and in Table 1. Graph 1 of the nomograph assumes that there is no humidifier operating and that the concrete and wood in the structure are past their initial drying (typically 12 to 18 months [Quirouette 1984]). If this is not the case, increase appropriately the moisture generation rate used in the nomograph. It is noted that by trying different air change rates, the nomograph can also be used to determine the air change rate required to maintain a desired interior relative humidity. This can be useful when trying to maintain a relative humidity by adjusting the mechanical ventilation rate.

Humidifier Load Calculation Nomograph

Four graphs (Figure 3) were fit to Equation 12 for calculating the moisture load required from a humidifier. From Table 2 in the appendix, the lowest monthly dew-point temperature for the site should be used. A coincidence used to simplify Graph 4 is that the moisture generation difference between the dryer vented out and vented in is very close to the moisture generation difference when the number of occupants is doubled. Graph 4, as is, is for the clothes dryer-vented-out case. To evaluate a dryer-vented-in case, simply double the number of occupants. The nomograph in Figure 3 can actually be run backward to predict the interior relative humidity, if the humidifier moisture is at zero. However, it does not give the flexibility for being able to see what the actual occupant moisture generation rate is, as do the graphs in Figure 2.

MODEL APPLICATIONS AND LIMITATIONS

As detailed in the introduction, the model will be useful to HVAC engineers and contractors for predicting what the average relative humidity or humidifier load will be in dwellings. The nomographs will be especially convenient for rapid analysis.

The model is based on simple, accepted mass balance relationships. However, the interior moisture generation rate (especially the basement soil diffusion component) and the air exchange rate are two input variables that can be difficult to predict accurately.

The model will give the total dwelling monthly average relative humidity. The actual dwelling will have hourly and daily fluctuations in relative humidity, from the monthly average, on the order of ±7% RH (e.g., 30% to 37% [Tenwolde 1987; Barringer and McGugan 1989a]), due primarily to the fluctuations in interior moisture generation. In addition, the actual realized relative humidity variation from room to room during a given day may be even greater. This is especially true for basement areas that may have significantly higher humid-
DIRECTIONS: Choose the number of occupants on vertical axis of Graph 1, with a straight edge go right to Dryer line, up to Graph 2 and the House Volume, right to Graph 3 and the Air Change Rate, down to Graph 4 to the Outside Dew-Point Temperature (from Table 2), and left to the Relative Humidity.

Notes:
1. Graph 1, Moisture Generation Rate, is based on Table 1 and assumes dry soil conditions and a vapor retarder under the basement floor and on the inside of the basement foundation walls. Refer to Table 1, and if necessary adjust the moisture generation value and use with the nomograph by disregarding the number of occupants and going up on Graph 1 from the appropriate moisture generation rate.
2. If the house has a heat recovery ventilator that recovers moisture, the total air exchange rate used on Graph 3 should be lowered by the air change rate contribution of the ventilator multiplied by the fraction of moisture recovered from the outgoing airstream (typically about 50% to 70%). See Equation 12.

Figure 2 Residential steady-state relative humidity prediction.
DIRECTIONS: Choose desired Relative Humidity on Graph 1, bottom side. With a straight edge, go up to the Outside Dew-Point Temperature, right to Graph 2 and the Air Exchange Rate, down to Volume on Graph 3, left to Number of Occupants on Graph 4, and down to Humidifier Load. If the house volume is larger than 20,000 ft³ (566 m³), divide the actual Volume in half, find the Humidifier Load, then multiply it by 2. For a dryer-vented-in case, just double the actual number of occupants. Refer to the notes on the Relative Humidity Prediction nomograph.

Figure 3 Residential steady-state humidifier load.
ties than the balance of the house if the soil is damp or if the exterior damp proofing is poor or if there is no vapor retarder under the concrete slab floor and inside the concrete walls. For moisture or condensation risk assessment, these factors should be considered as well as using good judgment as to where the largest moisture contributions are coming from and where the most likely condensing surfaces are located.

The model assumes a home that is at least 18 months old. For average-sized dwellings less than 18 months old, up to 9 lb of moisture per day can be released from curing concrete foundations and floors and from drying lumber (Quirouette 1984). This is not accounted for directly in this model but could be by changing the moisture generation value accordingly. Wet-spray cellulose insulation can also contribute moisture during its approximately one-year drying time.

Due to moisture storage phenomena in the building materials not being taken into account, in cold dry climates with hot summers the model will give slight underpredictions of interior humidity for the early winter months and slight overpredictions for the late winter months (Tenwolde 1990). This occurs because the structure is somewhat "dry" coming into the winter (Sherwood 1983)—summer heat usually dries the structure—and thus it absorbs airborne moisture that would otherwise contribute to the relative humidity. The situation reverses when coming out of the winter, with the structure now holding more moisture and releasing it to the air inside the dwelling, thus increasing the relative humidity above that predicted by the model. These fall and spring prediction errors are expected to be less than 5% RH. For areas that have humid, mild summers with less drying potential, the previous scenario may be reversed. The model will give summer interior relative humidity predictions if the moisture added or removed due to any air conditioning is accounted for in the $Q_g$ term.

MODEL VALIDATION

Ten dwellings in Utah have been spot checked with a sling psychrometer for interior relative humidities during the winter. The houses had "known" air exchange rates from pressurization tests and covered a wide range of sizes and occupancy numbers. The measured values were compared with the model and found to agree quite well. However, the low frequency of spot checking along with other varying conditions needing to be more closely monitored require a more thorough and complete sampling for actual model validation.

CONCLUSION

A model for predicting the average steady-state winter interior relative humidity in dwellings has been developed. All required input variables have been defined and methods for their quantification outlined. A model for occupant moisture generation other than the "family of four" has been created as part of the model. Also, the ASHRAE equation for calculating humidifier moisture load in dwellings has been enhanced by providing a table and a curve-fit equation for finding the outside absolute humidity for more than 300 sites in the United States. In addition to these "equation form" models, nomographs have been created for relative humidity prediction and load calculation that provide a very convenient, yet accurate, method of solution. Results from the model have been compared to measured humidities from a small sample of dwellings in Utah and found to agree quite well. However, a more thorough validation with a larger data set is needed.

NOMENCLATURE

\[ \begin{align*}
Ac &= \text{total air change rate between inside and outside (h}^{-1}\text{)} \\
Ac_{net} &= \text{air change rate between inside and outside after being reduced to account for moisture reclamation of a heat recovery ventilator (h}^{-1}\text{)} \\
Ac_{HRV} &= \text{air change rate between inside and outside of a heat recovery ventilator (h}^{-1}\text{)} \\
Alt &= \text{altitude above sea level (ft)} \\
D &= \text{diffusion of moisture through solid building components from inside the structure to the outside (lb/h)} \\
f &= \text{fraction of moisture recovered from the outgoing airstream in a heat recovery ventilator} \\
P &= \text{total atmospheric pressure (psi)} \\
P_w &= \text{partial pressure of the water vapor in the air (psi)} \\
P_{ws} &= \text{pressure of saturated pure water (psi)} \\
P_{wak} &= \text{pressure of saturated pure water at inside air temperature, } ^{\circ}\text{F (psi)} \\
\phi &= \text{relative humidity ratio} \\
Q_m &= \text{moisture load on the humidifier (lb/h)} \\
Q_g &= \text{moisture generation from sources other than the humidifier, e.g., occupants, etc. (lb/h)} \\
R &= \text{universal gas constant for dry air (53.35 ft}\cdot\text{lbf/lnm}^{-1}\text{R)} \\
RH_i &= \text{relative humidity of inside air (}) \%\text{)} \\
t &= \text{temperature (}^{\circ}\text{F)} \\
t_d &= \text{dew-point temperature (}^{\circ}\text{F)} \\
T &= \text{absolute temperature in Rankine} \\
V &= \text{specific volume of air (ft}^3/\text{lb dry air)} \\
\omega &= \text{absolute humidity (lb moisture/lb dry air)} \\
\omega_i &= \text{absolute humidity inside the dwelling} \\
\omega_o &= \text{absolute humidity of the outside air} \\
\omega &= \text{power operator}
\end{align*} \]
REFERENCES


BIBLIOGRAPHY


# APPENDIX

## TABLE 1

**Interior Moisture Vapor Generation in Residences**

<table>
<thead>
<tr>
<th>Moisture Sources</th>
<th>Moisture Generation (lbs of vapor/day per household)</th>
<th>Number of Occupants per Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Sources</td>
<td>(lbs of vapor/day)</td>
<td>1  2  3  4  5  6  7  8  9  10</td>
</tr>
<tr>
<td>1. Human Metabolism</td>
<td>3.2  6.4  9.6  12.8  16.0  19.2  22.4  25.6  28.8  32.0</td>
<td></td>
</tr>
<tr>
<td>2. Bathing (shower)</td>
<td>.5  1.0  1.2  1.6  2.0  2.4  2.8  3.1  3.5  3.9</td>
<td></td>
</tr>
<tr>
<td>3. Cooking (elec.)</td>
<td>2.0  2.5  3.0  3.2  3.5  3.7  4.0  4.3  4.5  5.0</td>
<td></td>
</tr>
<tr>
<td>4. Dishwashing</td>
<td>.6  .7  .8  .9  .9  1.0  1.2  1.4  1.6  1.8</td>
<td></td>
</tr>
<tr>
<td>5. Floor Mopping</td>
<td>.3  .3  .3  .3  .3  .4  .4  .4  .4  .5</td>
<td></td>
</tr>
<tr>
<td>6. Clothes Washing</td>
<td>.4  .8  1.1  1.4  1.8  2.1  2.5  2.9  3.2  3.6</td>
<td></td>
</tr>
<tr>
<td>7. Clothes Drying</td>
<td>.6  10.7  16.1  21.4  26.8  32.1  37.5  42.9  48.2  53.6</td>
<td></td>
</tr>
<tr>
<td>elec., vented in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vented out</td>
<td>.3  .5  .8  1.1  1.3  1.6  1.9  2.1  2.4  2.7</td>
<td></td>
</tr>
<tr>
<td>8. Plants (8 x .15)</td>
<td>1.2  1.2  1.2  1.2  1.2  1.2  1.2  1.2  1.2  1.2</td>
<td></td>
</tr>
<tr>
<td>9. Soil Under House</td>
<td>2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5  2.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day Totals (lbs/day per household)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dryer Vented in</td>
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<tr>
<td>Dryer Vented Out</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Hourly Averages (lbs/hr per household)</th>
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</thead>
<tbody>
<tr>
<td>Dryer Vented in</td>
</tr>
<tr>
<td>Dryer Vented Out</td>
</tr>
</tbody>
</table>

Dryer vented in: lbs/hr = 0.293 + 0.401 x occupant number (Eq. 14)
Dryer vented out: lbs/hr = 0.257 + 0.193 x occupant number (Eq. 15)

Table 1 is based on surveys of occupant routines from Ref. 14 and from moisture generation data interpolated and extrapolated from Ref.'s 5, 6, 7, 12; 13.

**OTHER SOURCES OF INTERIOR MOISTURE:**

1. **BASEMENTS:** Number 9 above assumes an average size house (~1500 ft², 140 m²), good dampproofing dry soil and a vapor retarder on the inside of walls and under concrete floors. Changing these conditions can allow moisture diffusion from the soil of up to 3 lb/hr (Ref. 4;17).
2. **COMBUSTION OF NATURAL GAS IN COOKING STOVES** will give off a 24 hr. average of .05 to .1 lb of moisture into the air depending on the number of occupants and use (Ref. 5, 7; 16).
3. **COMBUSTION IN GAS DRYERS** will give off a 24 hr. average of .02 to .12 lb/hr depending on use.
| STATE AND STATION | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | YEAR |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| ALA. BIRMINGHAM  | 36  | 37  | 41  | 49  | 58  | 66  | 69  | 68  | 62  | 52  | 41  | 36  | 31  | 31  |
| MOBILE           | 36  | 37  | 41  | 49  | 58  | 66  | 69  | 68  | 62  | 52  | 41  | 36  | 31  | 31  |
| HUNTSVILLE       | 20  | 37  | 41  | 49  | 58  | 66  | 69  | 68  | 62  | 52  | 41  | 36  | 31  | 31  |
| ALASKA ANCHORAGE | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ANCHORAGE        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ERIE             | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| PENSACOLA        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| BOSTON           | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| BURLINGTON      | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ROCHESTER        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| SALT LAKE CITY   | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ST. LOUIS        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ST. PETERSBURG   | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ST. PAUL         | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| TALLAHASSEE      | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| TAMPA            | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| WEST PALM BEACH  | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| GAITHERSBURG     | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ATLANTA          | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| AUGUSTA          | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| SAVANNAH         | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| HAVANA           | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| MIAMI            | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| KEY WEST         | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| FT. MYERS        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| JACKSONVILLE     | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| KEY WEST         | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| NASHVILLE        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| KNOXVILLE        | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| ST. PETERSBURG   | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| TALLAHASSEE      | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| PALM BEACH       | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |
| WEST PALM BEACH  | 10  | 8   | 11  | 12  | 14  | 33  | 48  | 43  | 48  | 43  | 25  | 14  | 7   | 7   |

**TABLE 2**

Mean Dew Point Temperature (°F)

<table>
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<th>STATE AND STATION</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
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<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>YEAR</th>
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</thead>
</table>

**APPENDIX**

**TABLE 2**

Mean Dew Point Temperature (°F)
<table>
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<th>Mean Dew Point Temperature (°F)</th>
</tr>
</thead>
<tbody>
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<td><strong>FEB</strong></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td><strong>STATE AND STATION</strong></td>
<td><strong>FEB</strong></td>
</tr>
</tbody>
</table>

Based on years of data indicated in table during 1946-65