A survey of your requirements should be taken to determine the amount of steam needed for humidification, the number, size and type of units required, and the location of both humidifier and humidity controllers.

**Sizing and Location with Natural Ventilation**

These are the average industrial humidification applications with:

- Room temperatures—65° to 80°F.
- Relative humidities—35% to 80%.
- Natural ventilation—i.e., infiltration around windows and doors.

**Selection Data Required**

Minimum Outdoor Temperature: For most jobs, figure 10°F above the lowest recorded temperature for your locality. The lowest temperatures are seldom encountered for more than a few hours.

- Indoor Temperature
- RH Desired
- Pressure of Steam Available for Humidification
- Number of Cubic Feet in Room
- Air Changes Per Hour: air changes taking place under average conditions exclusive of air provided for ventilation or regain of hygroscopic materials.

Rooms, 1 side exposed__________
Rooms, 2 sides exposed__________
Rooms, 3 or 4 sides exposed_____ 2
Rooms with no windows or outside doors__________

**Table 36-1. 70°F Humidification**

<table>
<thead>
<tr>
<th>Outdoor Temp.</th>
<th>25%</th>
<th>30%</th>
<th>35%</th>
<th>40%</th>
<th>45%</th>
<th>50%</th>
<th>55%</th>
<th>60%</th>
<th>65%</th>
<th>70%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°F—Relative Humidity Desired Indoors—70°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>0.164</td>
<td>.212</td>
<td>.269</td>
<td>.327</td>
<td>.385</td>
<td>.441</td>
<td>.499</td>
<td>.557</td>
<td>.615</td>
<td>.672</td>
<td>.730</td>
</tr>
<tr>
<td>-5</td>
<td>0.237</td>
<td>.294</td>
<td>.352</td>
<td>.409</td>
<td>.467</td>
<td>.524</td>
<td>.582</td>
<td>.639</td>
<td>.697</td>
<td>.754</td>
<td>.812</td>
</tr>
<tr>
<td>0</td>
<td>0.257</td>
<td>.314</td>
<td>.372</td>
<td>.430</td>
<td>.487</td>
<td>.545</td>
<td>.602</td>
<td>.660</td>
<td>.717</td>
<td>.775</td>
<td>.832</td>
</tr>
<tr>
<td>5</td>
<td>0.270</td>
<td>.327</td>
<td>.385</td>
<td>.442</td>
<td>.500</td>
<td>.557</td>
<td>.615</td>
<td>.672</td>
<td>.730</td>
<td>.787</td>
<td>.844</td>
</tr>
</tbody>
</table>

**Application of Unit Humidifiers for Direct Discharge**

Typical Problem:

- Design outdoor temperature 0°F
- Indoor temperature 70°F
- RH required 40%
- Air changes per hour 2
- Steam pressure available 5 psi

Room size 400' x 160' with 10' ceiling
Natural ventilation

Heated by: Unit heaters-fan on-off control

**Step I:** Steam required for humidification.

Our room contains (400' x 160' x 10') or 640,000 cu ft.

From the 70°F Table 36-1, read across from 0°F outside temperature to the 40% RH column where you find the figure .409 lbs of steam/hour per 1,000 cu ft of space for each air change. Then, 640 times .409 times 2 equals 524 lbs of steam/hour installed humidification capacity required.

**Step II:** Electric or air-controlled units.

The large floor area calls for multiple humidifiers. No explosion hazard has been specified so use of air-controlled units is not required. Electric units are recommended.

**Step III:** Number of humidifiers for job.

Divide steam required by capacity of humidifiers at steam pressure available.

**Step IV:** What size humidifier to use. For this example, a large number of smaller capacity units is recommended. Larger capacity units could cause condensation on the low ceiling. Also, because of the large floor area, the humidistats for fewer units would be widely spaced which could result in less accurate control than desirable.

**Step V:** What type humidifier to use.

In this example, integral fan units are preferable to steam jet units installed in conjunction with unit heaters. Since the unit heater fans are on or off to control temperature, it follows that the humidistat at may call for steam when the nearest unit heater is not running. With the low ceiling, the discharge from a steam jet humidifier might rise to the ceiling and produce condensation. Therefore, the integral fan type should be used.

**Step VI:** Location of humidifiers. Several patterns are possible, and actual location can usually conform with the existing steam supply and return lines to make an economical installation with a minimum of new piping.
In our problem of a 400' x 160' x 10' room, there would likely be steam lines along both sides of the room, and humidifiers can be located as shown in black in Fig. 37-1. If the supply lines run down the center of the room the colored line pattern would be practical. Runouts to integral fan units in a 160' wide room would be about 20' long. If the room were only 60 or 80 feet wide, runouts need be no longer than required for actual hookup.

Step VII: Location of humidistat. This should be from 20 to 30 feet away from the humidifier and slightly to one side of the air stream from the unit. The humidistat should “see” its humidifier and be in “active” air. Do not hide it behind a post or in the channel of an H-beam. It must get a good sample of the air to control the humidity.

Sizing and Location with Forced Ventilation

Typical Jobs: Mill and sanding rooms in furniture factories. Here, the problem of selecting and installing humidifiers is much the same as previously described except for:

1. Determining the number of air changes.
2. Location of humidifiers and humidistats.

Air Changes: These can be determined from the exhaust fans’ capacities. The cubic feet per hour capacity of the fans, divided by the cubic feet of space to be humidified, will give the number of air changes.

Where the capacity of fan or fans is not known, air changes can be measured with velometer readings at all open doors, elevator shafts, etc. leading to the room and with fans operating at full capacity. Your Armstrong Representative can determine air changes for you.

Humidifier Location: Bear in mind that humidifiers will have to control the humidity 24 hours a day, seven days a week during the heating season. Exhaust fans may operate only 40 hours or 80 hours per week. Thus the humidifiers and humidistats must be located for good distribution of humidity during fan-off periods as well as when the fans are operating.
Sizing for High or Low Temperature Humidification

Where air temperatures are well above 75°F or below 70°F, it is impractical to use Tables 36-1 or 37-1. Humidification requirements must be figured from Table 5-1, page 5, showing grains of water per cu ft of saturated air at various temperatures. Typical problem: How much steam per hour is required to humidify 60,000 cu ft of space with four air changes per hour to 40% RH when the air temperature is 90°F? Assume that any makeup air will come from outdoors at 0°F, 75% saturated.

90°F saturated air = 14.9 gr/cu ft saturated = 5.976 gr/cu ft at 40% RH
Outdoor air 0°F saturated = .475 gr/cu ft
75% saturated = .356 gr/cu ft
5.976 minus .356 = 5.620 grains to be added per cu ft

\[
\frac{5.620 \times 1,000}{7,000} = .803 \text{ lb per M cu ft per air change}
\]

NOTE: 7,000 gr = 1 lb

With four air changes in a 60,000 cu ft room, then .803 x 60 x 4, or 193 lbs steam would be required per hour. Humidifier capacity required for temperatures below 70°F is determined in exactly the same manner.

NOTE: For high temperature air in particular, air volume changes dramatically with RH. Armstrong Software Program 2 will provide greater accuracy in humidifier sizing for these applications.

Explosion Hazard Humidification

Sizing air-operated humidifiers for areas when explosion hazard exists is done exactly as for other requirements except that they should be sized for the most severe conditions of makeup air, RH required and minimum steam pressure. Humidifiers should be located to get the best possible dispersal and distribution of vapor in the area.

Special Purpose Industrial Applications

In some industrial operations, a stratum of high relative humidity is required in close proximity to a fast moving sheet or film of paper, thin gauge plastic, fabric, cellophane, etc. The objective may be to prevent accumulation of static electricity charges, or to prevent loss of moisture from the material. If the sheet or film is hot, as it very well might be, it tends to give up its moisture very quickly. By using steam shower humidifiers expressly adapted for this application to create a laminar zone of high humidity adjacent to the sheet, moisture loss is prevented and moisture content of the material is properly maintained.

For this application, the humidifier must be interlocked with the drive of the machine, and it is essential that the steam be discharged in a dry state, with no water droplets or liquid spray.

Application of Unit Humidifiers for Direct Discharge, Continued...