# Paper Notes

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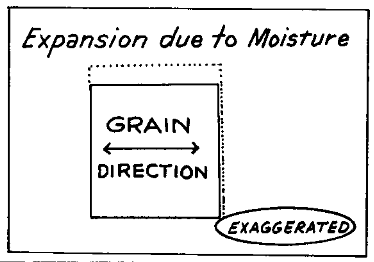
# Relative Humidity & Temperature

Understanding the significance of relative humidity is difficult because it is a moving target. The effect of relative humidity is directly related to temperature. Relative humidity is the amount of water in the air, in vapor form, relative to the amount of water that the air could hold at a given temperature . The effect of water vapor in the air has a definite effect on paper and how it processes and reacts to its environment.

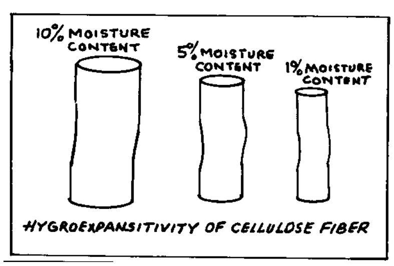
Paper, by nature, is hygroscopic. This means that it will pick up moisture from its environment and it will release moisture into the environment to try to reach equilibrium with the moisture in the air surrounding it. Paper is said to be in equilibrium when it neither takes on nor looses moisture to the environment. This physical characteristic is a property to which the paper user must adapt. It can be manipulated and somewhat controlled as discussed in this chapter, but the principles never change. It is essential for anyone who uses or stores paper to have an understanding of relative humidity and temperature conditioning and its effect on paper at every part if its life cycle. The lack of this knowledge can be very expensive and frustrating.

As the paper (actually it's the cellulose fiber) takes on moisture, the fibers increase in size; as a result the paper sheet size actually increases in size. The opposite holds true for paper that releases its moisture into the atmosphere. The overall dimension gets smaller.




When printing close register work, these dimensional changes in paper size become a very important consideration.

The expansion or contraction of the fiber, as it picks up or looses moisture, is not uniform. The each individual cellulose fiber will expand or contract, due to the moisture change, from two to five times greater across the width of the fiber than in length, or in short, the individual fiber gets fatter, not longer. (See illustration).

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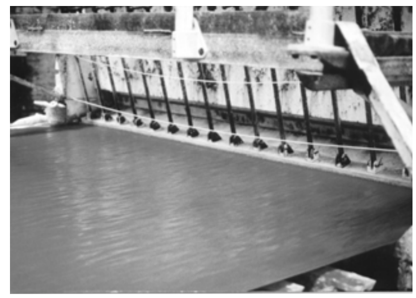
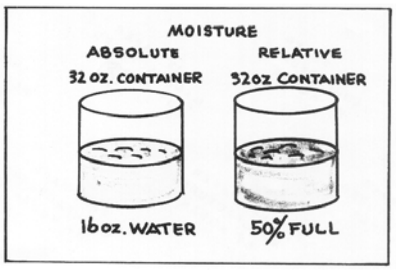
During the papermaking process, as the furnish (the fiber and water mixture) flows from the headbox onto the wire, most of the



individual fibers align in the machine direction. There is a higher concentration of fiber aligned parallel to the machine direction than across grain. An analogy might be a log floating down a river. Most logs will take the path of least resistance and they will float aligned with the current (machine direction), not sideways (cross direction). As a result, the sheet grows more across (CD) the grain than with (MD) the grain.

For this is the reason, paper mills recommend printing only long grain paper (grain running parallel with the impression cylinder) for the offset process. The offset printing process uses water or a wetting agent to repel ink in the non-image areas of the printing plate. As moisture is applied in each offset press unit, the sheet picks up some of the moisture and expands. With long grain paper, the pressman has the option to correct for this growth by packing the plate or blanket cylinder. This increases or decreases the circumference of the cylinder—thus increasing or decreasing the image length. The pressman has no recourse when the paper grows side-to-side as with short grain paper. Mills rarely honor register problem complaints when the paper has been printed short grain.

The moisture, or humidity, in the air can be measured in two ways--Absolute and relative.




Absolute humidity is measured as the number of grains of water per pound of dry air (7000 grains = 1 pound). Air holds a predictable amount of water at any given temperature. At 80 degrees air can hold 156 grains of moisture per pound. At 40 degrees it can hold 36 grains per pound. This bit of information is very important in understanding how relative humidity can be manipulated to control pressroom conditions. Relative humidity (RH) is a measure of the amount of water vapor in the air (at a given temperature) stated as a percentage of the maximum amount of water the air can hold at that specific temperature.

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The higher the air temperature, the more water vapor it can hold before reaching the saturation point or 100% relative humidity. As the temperature of air is lowered, so is its ability to hold water. Take, for example, air at a temperature of 50 degrees with a relative humidity of 50%--if the temperature were raised to 60 degrees, the relative humidity (RH) would drop to approximately 35%.

Since relative humidity is a function of moisture in the air and temperature, pressroom RH can vary drastically throughout the United States. In fact, there is normally a range of 10% to 90% within the United States of America during the year. While paper manufacturers are technically able to make paper at a specified RH for a specific area, it would be impractical, however, to do so on a regular basis. Not only would they need to make a different product for each geographical area, but a different one each month. Research has found that paper works in most environments if manufactured in the range of 40% to 50% RH at 72° .

Paper is manufactured on the paper machine to a specific moisture content that tends to be more accurate, reliable, and convenient to the paper maker than relative humidity measurements as a means of production control. The number normally used by paper mills is a percentage of total weight (Absolute Humidity) rather than relative humidity. It's simply easier as this does not vary with temperature. The numbers convert to the 40% to 50% range previously mentioned. Paper does, however, have an RH factor and must be brought into equilibrium with the environment of the pressroom or trouble will occur.

Above 35% relative humidity, static electricity that is generated by moving a non-conductor against a non-conductor is dissipated into the air; however, below 35% RH, static electricity builds up causing feeding, jamming, and other problems. When the relative humidity exceeds 65%, another set of problems begins to occur, the sheet becomes limp. Therefore, papermakers tend to make printing paper between 40% to 50%. This is the range that works best in all conditions throughout the various geographical areas. Paper functions best on the press when the RH of the pressroom is slightly above the RH of the paper.

As air gets colder, it looses its ability to hold moisture. An example would be as illustrated below. Outside air which has 75% relative humidity at 30°F has 18 grains of moisture per pound of dry air. When this air is heated the absolute moisture stays the same (18 grains/lb.), but because the warmer air can hold more moisture, the relative humidity is lower.

**The Effects of Heating Outside Air**

30° air @ 75% RH contains 18 grains/lb. of dry air.

| If heated to: | The RH becomes: |
|---|---|
| 60° | 23% |
| 70° | 16% |
| 80° | 12% |

Remember, the reason its called relative humidity is because the amount of moisture is relative to the temperature of the air. For example, our 30° F, 75% RH air becomes 16% RH at 70°F.

The effects of exposing paper to a very low humidity pressroom can be disastrous. Paper will try to reach equilibrium With its environment and will release its moisture to the surrounding air.

Summer time conditions:

Air conditioning can be used as a tool to reduce the moisture content of indoor air. To understand this concept, one must have and understanding of the relationship between moisture and air. Warm air can hold more moisture than cold air. Absolute moisture content is measured in grains of water per pound of dry air. Air at 70°F can hold 110 grains/lb., while air at 40° F can hold only 36 grains/lb. When warm, moist air is cooled beyond its capability to hold water, the excess condenses and becomes liquid. When this air is reheated, the lower absolute humidity translates to a lower relative humidity. This is illustrated in the above example. One pound of air at 85° and 85% relative humidity contains 157 grains of moisture. If that air is cooled to 50°F., its ability to hold moisture is reduced to 54 Grains, thus the excess 103 grains is condensed and turns to liquid. When the conditioned air is reintroduced to the inside environment and reheated to 70°F., the relative humidity becomes 54%.

**The Effects of Air Conditioning**

85° Air @ 85% RH contains 157 grains/lb. of moisture

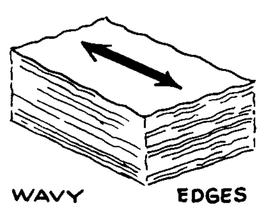
| Air cooled to: | Grains/lb. @ 100 % RH | Grains $H_2O$ Reduced | % Moisture Removed | RH @ 70°F. |
|---|---|---|---|---|
| 40° | 36 | 121 | 81% | 33% |
| 50° | 54 | 103 | 66% | 54% |
| 60° | 78 | 79 | 50% | 71% |

Schematic of Effect of air conditioning

# Temperature

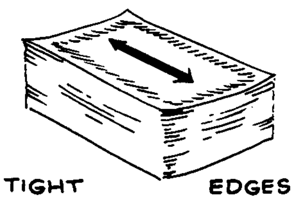
The temperature of paper can play and will play an important role in the temperature/relative humidity equation as explained in the previous text. Therefore, the environment in which paper is stored and used should be a major consideration for anyone utilizing paper. This one factor can significantly effect ones ability to efficiently use paper in the printing or converting process. In fact, careless exposure to the wrong environment can render it unusable. Paper mills will not normally honor claims for climatic/moisture related problems if the product was made to the correct moisture specification.

The actual temperature of paper when it is introduced to the ambient environment is a very important factor in the practical use of printing paper.




When cold paper is exposed to air at normal Relative Humidity (40-50%), the air around the paper is cooled past its dew point, or its ability to hold moisture. Like a frosty beer mug, the air condenses its moisture and it is absorbed into the edges of the stock creating the condition known as wavy edges. .

When wet paper is exposed to dry air the edges of the paper will loose its moisture to the ambient conditions. When this occurs, the paper will develop tight edges. In the printing process, this




usually manifests itself in a wrinkle beginning in the center of the sheet. This is the result of a baggy condition.

Paper is sealed in a moisture barrier to contain its own environment. The temperature of paper within the controlled environment and the relative humidity will remain constant because it cannot react to the ambient conditions outside of the barrier. Therefore, the paper can be exposed to extreme hot or cold conditions and, as long as the stock is brought to the same temperature as the pressroom when used, there should not be a equilibrium problem.

# Moisture Content of Air (Grains/lb.)

RH →

| °F ↓ | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -20 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| -15 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| -10 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| -5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| 5 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 |
| 10 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 9 |
| 15 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 11 | 11 | 12 |
| 20 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 12 | 13 | 14 | 14 | 15 |
| 25 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 30 | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 20 | 20 | 22 | 23 | 24 |
| 35 | 2 | 3 | 4 | 6 | 8 | 9 | 11 | 12 | 14 | 15 | 17 | 18 | 20 | 21 | 23 | 24 | 26 | 27 | 29 | 30 |
| 40 | 2 | 4 | 5 | 7 | 9 | 11 | 13 | 14 | 16 | 18 | 20 | 22 | 23 | 25 | 27 | 29 | 31 | 32 | 34 | 36 |
| 45 | 2 | 4 | 6 | 9 | 11 | 13 | 15 | 18 | 20 | 22 | 24 | 26 | 29 | 31 | 33 | 35 | 37 | 40 | 42 | 44 |
| 50 | 3 | 5 | 8 | 10 | 14 | 16 | 19 | 22 | 24 | 27 | 30 | 32 | 35 | 38 | 41 | 43 | 46 | 49 | 51 | 54 |
| 55 | 3 | 7 | 10 | 13 | 17 | 20 | 23 | 26 | 29 | 33 | 35 | 39 | 42 | 46 | 49 | 52 | 55 | 59 | 62 | 65 |
| 60 | 4 | 8 | 12 | 16 | 20 | 23 | 27 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 59 | 62 | 66 | 70 | 74 | 78 |
| 65 | 5 | 9 | 14 | 18 | 23 | 28 | 33 | 37 | 42 | 46 | 51 | 56 | 60 | 65 | 70 | 74 | 79 | 84 | 88 | 93 |
| 70 | 6 | 11 | 17 | 22 | 28 | 33 | 39 | 44 | 50 | 55 | 61 | 66 | 72 | 77 | 83 | 88 | 94 | 99 | 105 | 110 |
| 75 | 7 | 13 | 20 | 26 | 33 | 40 | 46 | 53 | 59 | 66 | 73 | 79 | 86 | 92 | 99 | 106 | 112 | 120 | 126 | 132 |
| 80 | 8 | 16 | 24 | 31 | 39 | 47 | 55 | 62 | 70 | 78 | 86 | 94 | 101 | 109 | 117 | 125 | 133 | 140 | 148 | 156 |
| 85 | 9 | 19 | 28 | 37 | 47 | 56 | 65 | 74 | 83 | 93 | 102 | 111 | 120 | 130 | 139 | 148 | 157 | 167 | 175 | 185 |

**Moisture Content of Air in Grains Per Pound of Dry Air**

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