The Effects of Deep Cycling of Humidity on Pianos

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Preface

In the thirty years that I have practiced the tuning profession I have not seen a published list of all the problems that a piano may suffer when exposed to humidity extremes. Many articles have been written addressing some of the problems.

I wrote this article from an institutional point of view such as a in a State university. The problems concerning piano maintenance at the institutional level are greatly magnified for many reasons. The most obvious reason is that of more frequent use. Restricted administrative budgets allow minor problems to be neglected until they become major, thus compounding the overall effect of deep cycling of humidity.

One of the problems which has been addressed in some recent journal articles is the increased airflow which has been mandated by the U.S. Government at the institutional level. Because of this increased airflow, uncontrolled, or insufficient humidity control will wreak havoc quickly and constantly on the pianos located in the facility. Without sufficient humidity control, what normally would take a complete season to affect a piano in the home can and will take place in days (indeed I have recorded hours) at the institutional level. I believe this is a major factor why most technicians I know don't enjoy working at the institutional level.

"I have observed over several years of taking measurements that for every change in humidity a change in pitch will take place in the piano equivalent to about a beat for every 10% change"

All the determining factors that apply in the need and use of home humidity control units apply at the institutional level but on a much more massive scale. Because of the massive airflow, my experience has been that even with two high -capacity home dehumidifier systems installed on a concert grand, the units could not keep up with the changes. The humidity control provided by a home unit is no match for the air exchange systems found in these buildings.

However, since this article was first written, Dampp-Chaser Electronics, who manufacturer the home units, has added a semi-porous back cloth (or undercloth in grand pianos) that sufficiently slows down the air flow and allows their units to control the humidity at the piano under these conditions.

There is a solution which I found described in an article in the *ASHRAE Online Journal (The American Society of Heating, Refrigerating, and Air conditioning Engineers). There is a humidity control unit called a desiccant wheel which can be added to whole building systems to effectively control the humidity. When this unit is added to an existing system, the overall operational cost is less than with just the air conditioning unit alone. 1

If this article can be a help to other technicians who work in an educational institutional to approach their administration with this information, than I have accomplished my purpose.

The Effects of High Humidity on a Piano

1. When wood swells against a metal part, the metal doesn't give and the cellular walls of the wood may be crushed. This can be very detrimental to a pinblock.
2. When felt takes on moisture it swells. In center pin bushings the felt swells against the center pin causing sluggishness. In Steinway pianos with Teflon *TM* bushings, high humidity causes center pins to become loose in the Teflon *TM* bushings resulting in annoying "clicks" in the action.
3. When hammers take on moisture it can alter the sound quality (usually a softer sound).
4. As the soundboard absorbs humidity it swells, pushing upward on the bridge thus tightening the strings and raising the pitch. If enough moisture is absorbed by the soundboard, the excessive crown across the board will inhibit the vibration of the soundboard, thus robbing the piano of power and sonority. Sometimes a soundboard ridge will be seen in the presence of high moisture. Since the expanding soundboard has nowhere to go when swollen with moisture a ridge will form where the slats are mated. This can be a likely place for a crack to form when the humidity drops to a low point.
5. The swelling of the felt parts in the action changes the regulation measurements and contributes to sluggishness and a loss of control by the pianist.
6. The swelling of felt and wood in the keys and keybed changes regulation measurements and contributes to sluggishness and loss of control by the pianist.
7. Excessive humidity contributes to rust on the strings.
8. If the bridge rises excessively because of a swelling soundboard, some strings may "buzz" against the sides of the notches in the bridge because allowable tolerances have been exceeded.

The Effects of Low Humidity on a Piano

1. Felt bushings shrink. In very low humidity, felt fibers become brittle and wear faster. A source of mysterious squeaks in the action and pedals. Because the felt shrinks, the pins in the flange bushings become loose. Teflon *TM* bushings, found on Steinway pianos, become tight and sluggish. This is because Teflon *TM* is very sensitive to the wood around it. As the wood shrinks the Teflon *TM* shrinks and the pins in the bushings become tight and sluggish.

2. Wood fibers shrink, contributing to loose glue joints which may appear in any part of the piano. This also includes case parts such as veneer as well as leg and pedal lyre integrity.

3. Wood fibers that have been crushed in high humidity begin to
collapse and loose their cellular resiliency in low humidity. This results in loose screws and tuning pins. Also flange bushing pins can work out of the birdseye, which should be a tight fit, and work out of the flange, thus causing serious problems in function.

4. Hammers that have taken on high humidity become harsh and "tinny" sounding in low humidity. When the moisture leaves the hammer the felt fibers, now void of moisture, will pack together much more quickly upon impact with the strings. The felt loses its resiliency. The added compression of the felt makes the surface of the hammers harder, creating a more harsh tone. This is similar to the principle of how a steam iron works.

5. When the soundboard gives up humidity, it results in the relaxing of the crown. This causes the pitch to fall. If the dry conditions continue long enough it could result in loose joints where the soundboard slats are mated (cracks in soundboard). Also soundboard ribs (which maintain the crown) can become loose, causing buzzes to be heard.

6. When enough moisture is given up in the keyboard it results in loss of regulation and weight distribution, and control in the action.

Quartersawn Wood and Humidity Changes

Much of the wood used in pianos has to be cut in a manner that it must be sensitive enough to faithfully reproduce sound vibrations and it must also be able to hold and stabilize the tremendous forces of string tension exhibited on the piano. This special cut of the wood is known as a quartersawn cut. It is the strongest and most expensive way to cut a wood log. As you look down at a soundboard, for instance, you are looking at the end grain of the wood. Because the end grain is exposed, it is also very sensitive to humidity changes, since moisture can enter the wood most easily through the end grain. The parts of the piano that consists of this cut of wood are:

1. The keyboard (including the keys, keybed, & frame)
2. The Soundboard
3. The Pinblock
4. Many of the Action Parts

This differs from most furniture and paneling in that much of these items are constructed with boards cut along the side grain revealing more of the beauty of the wood, not its strength. This also is what you see in wood veneers. Much of the piano case is constructed this way. With current technology, many piano case parts are constructed with composite materials covered with a wood veneer. Some manufacturers are also using metal case parts in models with solid color finishes. These parts are not as sensitive to humidity as those referred to above.

The Effects of Deep Cycling of Humidity on Pianos

Note: A piano that goes through deep humidity cycles will need frequent tuning. Tuning the piano more frequently does not address any of these other problems.

When a piano is subjected to one humidity extreme or the other it is affected by that extreme as noted earlier. But when the piano cycles from one extreme to the other often enough, damage to the piano is accelerated. Indeed if a piano is serviced well at either extreme and stabilized at that extreme it will fare much better with fewer recurring problems than one that is subject to constant deep humidity changes.

Another factor that exacerbates instability is the flow of air across the piano. The greater the air flow, the faster changes take place in the piano. In recent years, Federal regulations have mandated a greater exchange of air in public buildings because of "sick building syndrome" that was discovered during the 1980's. This regulation was revised in 1997 because of over-reaction to the problem.

Problems from Deep Cycling

When a piano manufacturer has evidence of extreme humidity cycles he has a right to void the warranty because of environmental abuse.

**** Tuning Instability***

It has been recorded that a positive five percent change in humidity coupled with a high volume of air exchange will result in a 1/2 beat rise in pitch within 24 hrs. A performance piano will have to be retuned.

**** Loose Tuning Pins***

When a pinblock is subjected to high humidity the wood is crushed against the steel tuning pins. During dry periods the tuning pin hole may be weak because the integrity of the wood cells has been lost. As a result the tuning pin may not be able to hold the tension of the string. This is likely to happen on an older piano, but not necessarily. The pinblock may delaminate. That is, the multi-plies may separate.

"Without sufficient humidity control, what normally would take a complete season to affect a piano in the home can and will take place in days at the institutional level."

**** Constantly Changing Regulation Problems***

1. Loose Action Screws

The expansion and contraction of the wood against the screws will eventually result in them becoming loose. Some actions may have as many as 350 or more screws.

2. Constant Changes in Action Control

The expansion and contraction of the many fine adjustments in the action result in inconsistent control from one season to another. A piano finely regulated during high humidity may very likely perform very poorly during low humidity. A piano that is regulated during low humidity may be very sluggish during high humidity. (The opposite of this is true for most Steinways because actions with Teflon *TM* bushings react just the opposite of actions with felt bushings, i.e.; when felt swells- Teflon *TM* shrinks.)

3. Inconsistent Damper Control

Some parts twist and turn with humidity changes. This is true of damper mechanisms. Set screws may need to be tightened more frequently.

4. Rusty Strings

Rusty strings look bad. Especially on new pianos.

5. Dead Bass Strings
Dead bass strings can result from excessive moisture creeping between the core and the winding of the string causing oxidation of the core filling in the air space of the winding rendering the string forever dampened.

6. Broken Strings
Extreme humidity changes coupled with hard playing can contribute to accelerated wear on the hammers. The flattened surface of the hammers and oxidation of the strings contribute to early string breakage.

**** Soundboard Cracks***
Excessive moisture contributes to soundboard ridges which can, in time, result in a soundboard crack in a dry environment. Also the constant flexing from excessive crown to very little crown may result in rib separation leading to buzzes in the soundboard.

**** Bridge Problems***
Multi-ply bridges may delaminate or come loose where it is glued to the soundboard. Bridge pins may work loose because of constant swelling and shrinking.

**** Hairline Cracks in Keycovers (Ivories coming off in older pianos.)***
Hairline cracks in plastic keytops is always a sign of deep cycling. The wood does not expand at the same rate as the plastic keytop. If the glue joint is good the keytop will respond to the tension by forming hairline cracks in the surface. If the glue joint is marginal the keytop may pop off. This is true of Sharps as well as Naturals. Ivory usually cannot expand as well as plastic and will pop off much sooner.

**** Subtle Changes To Intended Piano Design***
A piano saturated with 70% humidity is so swollen with moisture that it will play and sound quite differently than at 20%. This is the result of hundreds of subtle dimensional differences. A piano is designed to perform best at 42%.

**** Problems and/or Failure in Case Parts***
Case parts are usually the last to respond to extreme humidity changes. This is because the wood grain is exposed differently to the environment than the inner components of the piano. In high humidity the surface will feel cold and “clammy”. Eventually some parts just won’t fit if they have to be removed for service. Some wood joints that go through deep cycling will eventually loosen and fail such as in the legs, pedal lyre, and where the soundboard attaches to the rim.

**** Veneer can come loose.***
Even the finest finish will be effected, resulting in a cracked, flaking or peeling surface.

**** Health Hazards***
Viruses and bacteria thrive best at humidity levels below 30% and above 60%. Mold and mildew thrive at levels above 60%.

1. Douglas R. Kosar, Michael J. Witte, Ph.D., Don B. Shirey, III, and Roger L. Hedrick, "Dehumidification Issues Of Standard 62-1989"
ASHRAE Online Journal March 1998 Access on the web:
http:\\www.ashrae.org
A more recent article dealing with heat recovery dehumidification systems is available at their online journal at the following url:
http://www.ashrae.org/JOURNAL/paarporn.pdf

By Samchai Paarporn, P.E., "Runaround Loop Heat Recovery With Humidification System"