Continuous Commissioning® Report

For the

Harrington Tower Building

Building #435

Submitted to:

Utilities Energy Office
Physical Plant Department
Texas A&M University

Prepared by:

Energy Systems Laboratory

August 31, 2006
Executive Summary

The building assessed in this report is the Harrington Tower. It is an 8-story building consisting of offices and classrooms located on the main campus at Texas A&M University. The HVAC system consists of one dual duct VAV air handler conditioning floors 2 through 8, the basement, and part of the first floor, 3 single zone air handling units with reheat conditioning the first floor, and 1 fan coil unit serving the fourth floor server room. The air handling units, relief fans, and water pumps are all DDC controlled.

Several measures are proposed to be implemented including:
- modifying control code to control chilled water differential pressure and the return valve from the server room fan coil unit discharge air temperature
- increasing chilled water flow to the 4th floor server room fan coil unit by increasing pipe size
- reducing the cold duct discharge temperature in order to reduce total humidity to spaces due to the dual duct operation of the building
- recalibrate existing static pressure transducers
- add a static pressure transducer to the main trunk so each cold duct can be read independently
- reset duct static set point based on outside air temperature.

Additionally, it is recommended that the following retrofit recommendations be considered for further building improvement; convert the remaining first floor T12 and incandescent lighting to T8 and compact fluorescent.

The baseline energy consumption for the building before Continuous Commissioning is shown in Figures 3, 4, and 5. Since none of the proposed CC measures in Table 5 have been implemented at this time, no analysis of any savings is available. After the selected measures are implemented we suggest requesting a follow-up analysis of the energy consumption.

However, based on some testing ESL conducted, implementing the improved piping to the fourth floor server room would allow the 25 hp building CHW pump to run at 30% of what is now required and greatly improve the building CHW temperature differential. Sealing the gaps at the second floor level will allow the 200 hp AHU-1 fan to maintain building static pressure at a lower operating cost. Insulating windows that extend above the drop ceiling area will reduce this unnecessary cooling load by an estimated 837 MMBtu per year.

The occupant comfort of the building as a whole can be rated as good for temperature and CO2 levels. Return air measurements have CO2 levels of 575-580 ppm taken independently at the sensor location, these readings correlate well to readings taken throughout the building on various days and times. Humidity complaints are common, especially for the second floor. Isolated hot complaints have been reported for rooms 718 and 717, which are an office and classroom, respectively. Room 802F has reported cold complaints at temperatures of 72.5°F.
Acknowledgements

The Continuous Commissioning® (CC®) process detailed in this report was a collaborative effort among the Energy Office, Area Maintenance, and the Energy Systems Laboratory at Texas A&M University. Many persons from each entity are responsible for the work done in the building, from the field and comfort measurements and CC® measures determination, to the maintenance and controls items implemented. This document is designed to serve as a deliverable from the Energy Systems Laboratory to the Energy Office, and primarily details the CC® activities and measures in which the Energy Systems Laboratory has been involved.

For information concerning the Office of Energy Management, please contact Homer L. Bruner, Jr. at (979) 862-2794. The lead CC® investigator for this building was Larry Thompson. For additional information regarding the information in this report or the overall Continuous Commissioning® program at the Energy Systems Laboratory, please contact Song Deng at (979) 862-1234.
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I. Introduction

Since 1997, more than 80 TAMU – College Station buildings have been commissioned, resulting in energy savings to the University of millions of dollars. This building was identified as a prime candidate for Continuous Commissioning due to operational problems, low chilled water temperature differential, high pumping rates and pressure differential, and humidity concern. Commissioning began June 2006 and was completed August 2006.

II. Facility Information

A. General Building Description

Figure 1. Harrington Tower Building.
The Harrington Tower building, pictured above in Figure 1, was constructed in 1973 and is located adjacent to Cushing Library and the Academic Building (see Figure 2 above). It is home to the College of Education and Human Development, and consists primarily of offices and classrooms. The building has eight floors for a total area of 130,844 square feet. It is generally occupied 8:00 a.m. to 5:00 p.m., Monday through Saturday. Harrington Tower was renovated in 1985 to enclose the area now used as first floor offices, which included the installation of the three first floor air handlers. In 1998, the building was converted to direct digital controls with the exception of reheat units on the first floor and added to Apogee.

**B. HVAC & Lighting System Description**

**HVAC**

The chilled water system utilizes one 25 hp pump with VFD. The pump is designed and programmed to be controlled by secondary differential pressure. The building control valve is designed and programmed to be controlled by return temperature reset from outside air. The piping system is two-way variable speed flow without bypass.

A 1 hp in-line pump with 2½-inch piping connections was added to provide chilled water to the three first floor air handling units. At a later date, a run of 135 feet of 7/8 OD copper piping extended CHW to a fourth floor fan coil unit cooling a computer server room.

The heating water system utilizes one 10 hp pump with a VFD run by EMCS control. This pump is designed and programmed to be controlled by secondary differential pressure. The building control valve is designed and programmed to be controlled by return temperature reset from outside air. The piping system is two-way variable speed flow without bypass.
A 3/4 hp in-line pump was added to provide heating water to a first floor unit and re-heat coils on the other two units.

A summary of the building pumping information is shown below in Table 1.

At the present time the building chilled water differential pressure is controlled at 30 psi, and the building return valve is manually set wide open to attempt to provide adequate cooling to the server room on the fourth floor. Measures are proposed to reduce this excessive energy usage.

**Table 1. Building pumping information.**

<table>
<thead>
<tr>
<th></th>
<th>CW System</th>
<th>CW System In-Line</th>
<th>HW System</th>
<th>HW System In-Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pumps</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pump control source</td>
<td>APOGEE</td>
<td>Manual</td>
<td>APOGEE</td>
<td>Manual</td>
</tr>
<tr>
<td>Pump speed control</td>
<td>VFD</td>
<td>Constant</td>
<td>VFD</td>
<td>Constant</td>
</tr>
<tr>
<td>Pump speed control method</td>
<td>DP</td>
<td>N/A</td>
<td>DP</td>
<td>N/A</td>
</tr>
<tr>
<td>Bldg Valve control method</td>
<td>DT</td>
<td>N/A</td>
<td>DT</td>
<td>N/A</td>
</tr>
<tr>
<td>Piping system type</td>
<td>Two-way variable speed flow loop without bypass</td>
<td>Two-way constant speed</td>
<td>Two-way variable speed flow loop without bypass</td>
<td>Two-way constant speed</td>
</tr>
<tr>
<td>Control valve type</td>
<td>DDC</td>
<td>N/A</td>
<td>DDC</td>
<td>N/A</td>
</tr>
<tr>
<td>Nameplate GPM</td>
<td>890</td>
<td>60</td>
<td>280</td>
<td>45</td>
</tr>
<tr>
<td>Nameplate Head (ft)</td>
<td>90</td>
<td>40</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Nameplate HP</td>
<td>25</td>
<td>1</td>
<td>10</td>
<td>3/4</td>
</tr>
<tr>
<td>Nameplate RPM</td>
<td>1740</td>
<td>1750</td>
<td>1750</td>
<td>1750</td>
</tr>
</tbody>
</table>

The HVAC system in this 130,844 ft² building consists of four air handling units and one fan coil unit. The total design maximum supply flow in the building is 153,000 cfm, of
which 25,000 cfm is outside air. The total design maximum exhaust flow from the building is 112,175 cfm and is achieved with two exhaust fans and five relief fans. Table 2 below gives an overview of the units comprising the building HVAC system with their design information.

**Table 2. HVAC system airflow design information.**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Function</th>
<th>Service</th>
<th>Supply cfm</th>
<th>Outside Air cfm</th>
<th>Exhaust cfm</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU-1</td>
<td>Supply</td>
<td>Basement, Partial 1\textsuperscript{st} Floor, and floors 2-8</td>
<td>139,000</td>
<td>105,000 max design</td>
<td></td>
</tr>
<tr>
<td>AH-1</td>
<td>Supply</td>
<td>First Floor</td>
<td>3100</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>AH-2</td>
<td>Supply</td>
<td>First Floor</td>
<td>4200</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>AH-3</td>
<td>Supply</td>
<td>First Floor</td>
<td>6520</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>FC-1</td>
<td>Supply</td>
<td>4\textsuperscript{th} floor server room</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Exhaust Fan 5</td>
<td>Exhaust</td>
<td>Women’s Restrooms</td>
<td></td>
<td></td>
<td>4,275</td>
</tr>
<tr>
<td>Exhaust Fan 6</td>
<td>Exhaust</td>
<td>Men’s Restrooms</td>
<td></td>
<td></td>
<td>3,550</td>
</tr>
<tr>
<td>Relief Fan 2A-2E</td>
<td>Relief</td>
<td>Common Relief</td>
<td></td>
<td></td>
<td>20,670 ea.</td>
</tr>
</tbody>
</table>

**Lighting**

The majority of the lighting in the building has been upgraded to T8 fluorescents. However, some T12 and incandescent lighting remains on the first floor.
III. Continuous Commissioning® Activities

A. Existing Building Conditions (Pre-CC)

The baseline energy use of the building before commissioning began is shown in the following graphs.

Figure 3. Electricity usage vs. outside air dry bulb temperature on weekdays.
Figure 4. Chilled water usage vs. outside air dry bulb temperature.

Figure 5. Hot water usage vs. outside air dry bulb temperature.
1. Existing HVAC Conditions

Measurements were taken on AHU-1, which serves 157 dual-duct VAV boxes. The results were not definitive because of the VAV configuration. Furthermore, sound attenuators on the first and third floors prevented measurements at those points. Measurements on the other floors were consistent from floor to floor and with the heat load conditions at the time of measurement. Data is presented in Appendix A.

Before the CC process started, the building chilled water pump was set to maintain a 30 psi differential pressure. This was done in an effort to provide the required flow to the fourth floor server room fan coil unit. The temperature of the fourth floor server room was normally 75°F, and occupants have added 2 small fans to the room to help keep the equipment cool. Inspection of the chilled water system revealed an in-line 1 hp pump on the piping supplying the fan coil unit and three small air handlers on the first floor. When the pump was energized, the fourth floor server room temperature was lowered to 72°F.

Even with the temperature improvement from the in-line pump, there is concern that the existing operation is marginal for the existing equipment/heat load. During one investigation, an additional 3,500 Btuh heat load raised the space temperature by 1.5°F (from 72.0 to 73.5) in 15 minutes.

The control program was originally designed with an occupied/unoccupied point. When this point is switched to unoccupied, the two restroom exhaust fans are to shut down. Currently, the fans are commanded to run continuously and exhaust 7,825 cfm even when the DDVAV boxes reduce air flow in the unoccupied mode.

The original design included Outside Air Damper, Return Air Damper, and Relief Fan (with damper) control. In the normal mode, a minimum amount of Outside Air is drawn in and mixed with the Return Air. When more Outside Air is required, additional Outside Air Dampers are opened, the Return Air Dampers partially close, and up to five Relief Fans are started (and their respective dampers open). At the present time the controls are manually set to allow only the Minimum Outside Air Damper to be open, the Return Air Dampers are 10% closed, and no Relief Fans are operating.

During investigation of the building, technicians noted that windows extended above the dropped ceiling through the plenum return area and up to the concrete flooring above on floors 3 through 6. The window is not visible from inside, but some light is let into the plenum space. The total window area exposed to the return air plenum is over 2,780 ft².

This window area allows both a solar heat gain and a conductive heat transfer directly to the return air. A simple cooling load calculation for the windows shows that the max cooling load occurs in August at a value of over 97,000 Btu/hr.
2. Existing Comfort/Indoor Air Quality Conditions

The occupant comfort of the building as a whole can be rated good for temperature and CO₂ levels. Return air measurements have CO₂ levels of 575-580 ppm taken independently at the sensor location. These readings correlate well to readings taken throughout the building which ranged from 600 to 638 on various days and times. Outside air CO₂ readings during these times ranged from 370 to 463.

Isolated hot complaints have been reported for rooms 718 and 717, which are an office and classroom, respectively. Room 802F has reported cold complaints at temperatures of 72.5°F even during the summer.

Table 3 below is a summary of the comfort measurements performed in the building during commissioning.

<table>
<thead>
<tr>
<th>Room</th>
<th>Temperature</th>
<th>Relative Humidity</th>
<th>CO2 Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st floor hall</td>
<td>76.2</td>
<td>49.5</td>
<td>638</td>
</tr>
<tr>
<td>3rd floor hall</td>
<td>74.4</td>
<td>43.7</td>
<td>600</td>
</tr>
<tr>
<td>5th floor hall</td>
<td>74.3</td>
<td>39.6</td>
<td>617</td>
</tr>
<tr>
<td>Suite 801</td>
<td>72.6</td>
<td>45.5</td>
<td>606</td>
</tr>
</tbody>
</table>

The original HVAC design included a 25,000 cfm outside air tempering unit. It did not include a pre-heat coil. In about 1989-1990 the cooling coil froze and the unit was removed. There have been high humidity complaints from occupants throughout the building. The most obvious evidence of high humidity problems is found on the second floor. There are drooping ceiling tiles, stained ceiling tiles, and condensation on the surface of the DDVAV boxes. HOBO loggers were deployed in four locations on the second floor. The loggers
were placed above the ceiling space on the east and west side of the building and in the east and west return air ducts at the junction with the main building return. An additional logger was placed outside.

While placing the loggers, it was observed that around each exterior column there is a gap of approximately \( \frac{1}{2} \) inch allowing outside air into the building in the second floor return plenum. The total gap area is approximately 10.9 \( ft^2 \). This allows significant unconditioned outside air to infiltrate the building.

Absolute Humidity vs. Time results from the HOBO loggers are plotted in Figure 6 below. The DDVAV boxes are put into Day Mode at 6:00 AM and into Night Mode typically at 6:00 PM. In the Night Mode both the cold duct and the hot duct box dampers close so there is no supply air to the space even though AHU-1 is running. At the present time, the Toilet Exhaust Fans operate 24 hours a day. The Ceiling and Return readings below provide strong evidence of outside air being drawn in at night and being replaced by space return air during the day. (For reference - at 74°F, 68 grains of water per pound of dry air is 55% relative humidity.)

![Figure 6. Absolute humidity vs. time for second floor areas.](image)

Calculations based on the discharge air temperature, the second floor return air temperature, and the outside air indicate the average fraction of outside air coming from the second floor openings is 45% of the second floor return, or 6,000 cfm. Figure 7 below shows the outside air fractions for the east and west second floor returns.
Figure 7. Outside air fractions for second floor return area.
### B. Continuous Commissioning® Measures

#### 1. Implemented Measures

Table 4. Continuous Commissioning Implemented Measures.

<table>
<thead>
<tr>
<th>Category</th>
<th>CC Measure</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td>Energized the in-line CHW pump</td>
<td>To attempt to provide adequate cooling to the fourth floor server room.</td>
</tr>
<tr>
<td>Comfort</td>
<td>Corrected numerous small problems on several DDVAV boxes</td>
<td>Made the boxes functional again to improve space comfort conditions.</td>
</tr>
<tr>
<td>Comfort/Energy</td>
<td>Corrected operational error which allowed numerous DDVAV boxes to operate continuously in the Day Mode</td>
<td>With all boxes in the Night Mode AHU-1 operates at a much lower setting and fewer btu’s are consumed.</td>
</tr>
<tr>
<td>Comfort/Energy</td>
<td>Got all the Outside Air and Return Air dampers operational</td>
<td>Improved the control capability to provide outside air to properly pressurize the building.</td>
</tr>
</tbody>
</table>

A comment early in the CC effort indicated a concern about the Fan Coil Unit cooling the server room on the fourth floor. Investigation determined there was a 1 horsepower, in-line pump on the chilled water line to the FCU and three AHU’s on the first floor. Further investigation determined the pump was turned off and bypassed. Opening the valves to the pump, starting it, and closing the bypass improved the flow to the FCU and reduced the server room temperature by 2.5°F. However, the system is still marginal as stated earlier in this report.

The next implemented measure is the correction of numerous small problems on several of the DDVAV boxes. All of the boxes were checked from Apogee. Over 20 boxes had apparent operational problems. The “problems” included closed dampers (both on the box and the luminaires), disconnected sensors, disconnected power, and TEC’s simply out of
calibration. These were fixed by opening dampers, reconnecting sensors, reconnecting power, and recalibrating the TEC’s.

Three boxes had either a bad TEC or a bad damper motor and these were reported to Siemens. One of these boxes served a conference room with a conference in session. A “patch” was put on the box with a cooperative effort between Siemens and ESL to get cooling to the room so that the conference attendees could be comfortable that day and the next.

In the Night Mode the DDVAV boxes shut both cold duct and hot duct dampers unless required because conditions are outside the set back set points. With all the box dampers closed AHU-1 operates at a much lower RPM. A survey of all the DDVAV boxes found that many of the boxes were not going into the Night Mode when the building was unoccupied. This allowed a lot of air circulation which required AHU-1 to operate at a higher RPM to maintain the night static pressure setting. It also consumed btu’s not required for night setback conditions. ESL identified the specific boxes and Siemens deleted and re-entered the boxes to get proper operation. AHU-1 now operates as intended at a much lower setting in the Night Mode.

Early in the CC effort ESL found the AHU-1 Outside Air and Return Air dampers did not all operate and the stroke on those that did needed adjustment. This was reported and AM7 later loosened and lubricated them. AM7 also adjusted the damper linkage and the operator stroke.

2. Proposed Measures

Table 5. Summary of proposed CC measures not implemented and their estimated potential savings.

<table>
<thead>
<tr>
<th>Category</th>
<th>CC Measure</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Conservation</td>
<td>Modify code to control CHW DP and building CHW return valve from server FCU discharge air temperature</td>
<td>Reduce excessive pump speed</td>
</tr>
<tr>
<td>Energy Conservation</td>
<td>Improve CHW flow to the server room FCU</td>
<td>Decrease speed of main CHW pump</td>
</tr>
<tr>
<td>Energy Conservation/Comfort</td>
<td>Raise cold duct discharge temp</td>
<td>Save chilled water usage and decrease building humidity</td>
</tr>
<tr>
<td>Comfort</td>
<td>Calibrate trunk static pressure transducers</td>
<td>Improve controls accuracy</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Comfort</td>
<td>Add a second cold duct static pressure transducer to main trunk</td>
<td>Read each trunk independently to read actual lowest trunk</td>
</tr>
<tr>
<td>Energy Conservation/Comfort</td>
<td>Seal gap around exterior columns</td>
<td>Decrease infiltration, thereby reducing humidity, increase building pressure, and decrease chilled water usage</td>
</tr>
<tr>
<td>Energy Conservation/Comfort</td>
<td>Install a good, moderating outside air pressure sensor diffuser</td>
<td>To obtain a useable building static pressure signal</td>
</tr>
</tbody>
</table>

Table 5 above is a summary of the Continuous Commissioning measures that have not been implemented in this building. Their implementation will complete this phase of Continuous Commissioning for this building and will correct the remaining problems with building performance.

At present, the main chilled water pump is operated to maintain 30 psig differential as controlled by the valve position on the server room FCU. Since the space temperature set point is several degrees below the coolest room temperature reachable, the valve stays 100% open and the main pump set point stays at 30 psig. The first proposed measure is to revise the existing code to control the chilled water differential pressure from the server room fan coil unit discharge air temperature. The present minimum space needs are met with 58°F discharge air. Changing the code will allow the main CHW pump to operate at a lower output and still meet the server room requirements. This proposal is offered as a temporary measure to reduce main chilled water pump energy consumption until proposal two can be implemented.

The second proposed measure is to increase chilled water flow to the fourth floor server room fan coil unit by increasing the pipe size. The present operation requires the main building chilled water pump to maintain a 30 psi differential pressure, which uses excessive pump energy and produces a building chilled water delta temperature of approximately 5°F.

Numerous options were investigated and considered. This proposal recommends replacing the current 7/8-inch OD copper pipe with 1.25-inch steel pipe. Calculations indicate this pipe change will reduce pipe losses enough to improve the availability of chilled water at the fourth floor server room fan coil unit. With that flow improved the main CHW pump can be operated at more normal pressures.

Implementation of this measure will allow the main CHW pump to operate at less than 15
psi differential and at about 30% of the current speed requirement. An additional benefit will be to allow control of AHU-1 off coil temperature with the building valve. This additional option should improve building chilled water differential temperature to a range of 12-16°F.

The third proposed measure is to raise the cold duct temperature to reduce the total humidity provided to building spaces. The current discharge temperature is 55-60°F reset from outside air temperature. The DDVAV boxes are operating under Control Application 2065. Under certain conditions, this application uses hot duct air to maintain minimum flow. With the present system, the hot duct air is mixed air which includes a component of unconditioned outside air. This introduction of untreated, high dew point outside air contributes to increased space humidity. Raising the cold duct discharge temperature range to 57-62°F, will require more cold duct volume which will reduce the amount of untreated hot air, thereby reducing the amount of high humidity air entering the spaces.

The fourth proposed measure is to recalibrate the existing static pressure transducers to provide accurate control of the main trunk static pressure to the building. During the investigation, it was found that cold duct and hot duct static pressures are significantly below the reported values. The test readings were 0.22 to 0.28 inches H₂O below the reported respective readings. Thus, the box and building air flows are below what would be expected with the given Day Mode and Night Mode differential pressure set points.

The fifth proposed measure is to add a static pressure transducer to the main trunk so each cold duct can be read independently and the main trunk static can be truly controlled from the duct with the lowest pressure. The system is designed to operate from the lower duct static pressure, heating or cooling. The ductwork consists of one hot duct and two cold ducts. Currently, the two cold ducts have pressure taps that come to a common tee before going to the transducer. Thus, the system is reading an average cold duct pressure, rather than the lower cold duct pressure.

The averaging of the two cold ducts means approximately half of the DDVAV boxes are getting less static pressure than they need for proper operation and approximately half are getting more static than they need for proper operation. The additional transducer (along with revisions in the programming) will correct this measurement error, will assure maintaining adequate flow to the area(s) with greatest demand, and will alleviate the discrepancies between boxes getting too little air and boxes getting too much air.

The sixth proposed measure is to seal the ½ inch gap around the 22 exterior columns. The gap totals about 10.9 ft² and allows about 6,000 cfm of unconditioned air to infiltrate above the ceiling tiles on the second floor. During times of high outside air dew point conditions this air causes the second floor ceiling tiles to sag, moisture condenses on cold ducts and runs off, and the high negatively affects the entire building as it enters the return air stream. This gap also negatively affects building pressurization.
The seventh proposed measure is to install a good, moderating outside pressure sensor diffuser. Maintaining proper building pressure depends upon getting a good signal. The present outside signal is highly susceptible to wind gusts which cause significant variation in the differential pressure signal. Installing a good diffuser to moderate the fluctuations will provide a more stable, useable signal.

IV. Requested Action

In order to maximize the performance of the building and its potential energy savings, it is requested that a number of maintenance and controls issues be addressed in the building as soon as possible. These issues affect the results of some the proposed Continuous Commissioning measures and some general maintenance issues.

There are windows extending up the side of the building including the above-ceiling return plenum of floors 3-7. A CLTD calculation was performed and determined the average daily heat load is 2.295 MMBtu (or 837.7 MMBtu per year). Installing material such as a one inch thick Styrofoam with an R-Value of 5 can reduce the yearly load to 110.2 MMBtu.

As noted in the Proposed Measures section the duct static pressure transducers need to be calibrated. When measured, both the Hot Duct and Cold Duct transducers read high by about 0.30 inches H₂O on reported values of 1.8 and 1.2 inches H₂O respectively.

Another Proposed Measure is to install a cold duct static pressure transducer so each duct can be measured separately. Field measurements of the cold ducts were 1.03 and 0.75 inches H₂O with a transducer input of 0.92 H₂O and a reported value of 1.2 H₂O. The boxes on the low duct were transmitting far less air to their space than the boxes on the high duct. Programming will need to be revised to include this additional point in the fan control calculations.

Also, during the investigation it was noted that the two Toilet Exhaust Fans were running at night. They draw in unconditioned air as noted above. These fans are supposed to turn off when the Minimum Outside Air Damper closes which should happen in the unoccupied hours. However, this damper is in OPER because neither the CO₂ sensor nor the dew point sensor is working. Control of these fans could be put under the “Occupied” point HARRTWT.OCCP which is the one that controls the static pressure set point for AHU-1.

These and other maintenance issues that were noticed in the building are summarized in Appendix B.
V. Building Comfort Improvements

One of the primary objectives of Continuous Commissioning is to improve occupant comfort levels in buildings. As noted, occupants of the building have experienced some comfort issues before commissioning started. These included a cold complaint on the eighth floor, hot complaints on the seventh floor, and excess humidity on the second floor. The cold complaint was addressed by adjusting dampers to correct air flow problems. The hot complaints on the seventh floor have been direct to the Energy Management Office.

The second floor humidity issue has not been addressed. The problem may be temporarily helped by providing proper pressurization of the building control of the outside air dampers, the return air dampers, and the speed of AHU-1. It is dependent on a good, stable outside air pressure signal.

The permanent fix for the second floor humidity issue is to seal the gaps around the columns. Sealing the gaps will prevent the infiltration of unconditioned air. This will also reduce the air flow necessary to provide positive pressure in the ceiling plenum.

VI. Retrofit Recommendations

While working through the building there were several items that could improve the efficiency if implemented.

As mentioned above changing the first floor lighting to T8 and compact fluorescent lights will provide savings over the present lighting. The rest of the building was changed at an earlier date and this would complete the lighting retrofit.

The Fan Coil Unit (FCU) for the fourth floor server room is providing barely adequate cooling for the present equipment load. While starting the in-line pump and closing the bypass improved the situation, there is still a need for further improvement. ESL looked at several different ways of providing better flow to the unit and suggests a change in piping.

The present pipe is 7/8 inch OD copper. ESL calculations indicate 1¼ inch steel pipe from the take-off in the chase at the first floor level to the FCU on the fourth floor. The calculations indicate the present pump arrangement will be sufficient. In fact, this change should allow a significant reduction in the main building differential pressure.

The original building design included operating Relief Fans in conjunction with the outside air and return air dampers to promote adequate air flow through the building. The Relief Fans and their associated dampers were checked as part of the CC investigation. The fans and dampers now operate as designed. However, a relatively fine mesh screening is installed between the fans and the dampers. This fine mesh severely limits the amount of air...
that can get to the damper. Most of the air circulates in the penthouse where the fans are installed. The fine mesh screening needs to be removed. If screening is required, it should be more on the order of hardware cloth which will allow air to pass through.

A 15 hp outside air tempering unit was part of the original HVAC configuration. It brought 25,000 cfm of outside air into the building, at a positive pressure, for ventilation and pressurization requirements. It did not have a pre-heat coil and it is believed the cooling coil froze one winter. The unit was removed in about 1989-1990 and has not been replaced. Outside air is now brought into the mixed air at a negative pressure by the 200 hp AHU-1 fan. Before reinstallation of the unit, which could benefit both pressurization and energy consumption, a careful design review should be undertaken.

VII. Conclusions

The Harrington Tower has been part of the A&M system since 1973. The energy consumption, chilled water differential pressure requirements, and comfort issues in the building made it a good candidate for Continuous Commissioning. The process was performed in June, July, and August 2006. It is believed the implemented measures will save energy and improve comfort in the building. If the proposed measures are implemented significant, additional energy savings should occur and comfort conditions should improve, especially on the second floor. Additionally, if the fourth floor server room FCU can get adequate cooling without running the building pump at 30 psig DP, more energy will be saved, AHU-1 will operate with more normal cold duct temperatures, and the DDVAV boxes operation should improve.

A few items have been identified that need to be addressed in order that affected proposed Continuous Commissioning measures can be implemented. These include calibrating the CO₂ sensor and the duct static pressure sensors. Other items need to be resolved to improve comfort conditions. These are listed in Appendix B.

It is highly recommended that the proposed issues be resolved and the proposed measures be implemented as quickly and as completely as possible to maximize the value of the Continuous Commissioning of this building, and most importantly, to maximize energy savings and comfort levels in the building. In this way, the Texas A&M University campus can move forward in its quest for energy efficiency, and the Continuous Commissioning process will have been beneficial in aiding in this endeavor.
Appendices
### Appendix A:

**Table 6. Main trunk field measurements.**

**Main trunk measurements**

<table>
<thead>
<tr>
<th>Floor</th>
<th>Date reading was taken</th>
<th>Cold duct flow CFM</th>
<th>Hot duct flow CFM</th>
<th>Cold duct SP (inch of water)</th>
<th>Hot duct SP (inches of water)</th>
<th>Cold duct temperature º F</th>
<th>Hot duct temperature º F</th>
</tr>
</thead>
<tbody>
<tr>
<td>8th</td>
<td>6/23/2006</td>
<td>4030-3930</td>
<td>2250-2200</td>
<td>860-840</td>
<td>0.74</td>
<td>0.97</td>
<td>1.37</td>
</tr>
<tr>
<td>7th</td>
<td>6/23/2006</td>
<td>6040-6000</td>
<td>4220-4090</td>
<td>2450-2250</td>
<td>0.96</td>
<td>0.89</td>
<td>1.36</td>
</tr>
<tr>
<td>6th</td>
<td>6/23/2006</td>
<td>7400-7150</td>
<td>7400-6950</td>
<td>3920-3800</td>
<td>0.97</td>
<td>0.95</td>
<td>1.38</td>
</tr>
<tr>
<td>5th</td>
<td>6/26/2006</td>
<td>18900-18700</td>
<td>19500-18000</td>
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<td>0.92</td>
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</tr>
<tr>
<td>4th</td>
<td>6/26/2006</td>
<td>25500-23400</td>
<td>28500-25000</td>
<td>4150-3170</td>
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<td>0.82</td>
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<tr>
<td>2nd</td>
<td>6/26/2006</td>
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<td>15000.00</td>
<td>4000.00</td>
<td>1.00</td>
<td>1.10</td>
<td>2.15</td>
</tr>
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</table>

**Notes:**
Readings could not be taken on the first and third floors due to sound attenuators and traps in the ductwork. Readings shown with an asterisk *** were taken when the chilled water pump was down for maintenance.
Appendix B:

Harrington Tower
Sensor and Mechanical Maintenance Issues
As of July 17, 2006

I. Sensor and Siemens Items

A. The Heating Hot Water Secondary return temperature sensor reads over 2 degrees F lower than the measured temperature.
B. The Chilled Water Primary Return pressure sensor reads about 1.5 psig higher than the secondary pressure sensor.
C. The following TEC controllers for dual duct boxes have the problems as listed by Box number, Room, and problem:
   1. - #713, Room 734, shows all points are deleted
   2. - #717, Room 713, air volume sensor shows 4 cfm; Heating damper is at 0% OVRD, and the Cooling damper is at 46% at set point of 76.
D. Cold duct and Hot duct static pressure transducers read higher than the measured static pressures. Both transducers read about 0.23 inches high.
E. The AHU-1 cold deck sensor, A1CDT, reads about 1.3 degrees F lower than the measured temperature.
F. The building CO₂ sensor in the Return Air duct appears to be inoperative. (It read 304 ppm when the actual value was about 575 ppm.

II. Mechanical Items

A. The following TEC controllers for dual duct boxes have the problems as listed by Box number, Room and problem:
   1. - #712, 704K cold deck damper is at 100% and at set point of 76.00.
   2. - #730, 701C air volume shows 4 cfm, Heating damper is at 100%, Cooling damper is at 23%, and the set point is 76.00.
B. The present screening on the Relief fans is such a fine mesh that it blocks most of the fan discharge. The air then circulates in the Penthouse rather than going outside.
C. The two Return Air damper sections closest to the outside wall do not close fully when the command signal goes to maximum. The two sections farthest from the outside wall do not full open when the command signal goes to minimum.
D. The Minimum Outside Air damper section needs to be loosened up and relinked to go fully open when the signal goes to maximum and fully closed when it goes to minimum.
E. All of the Outside Air damper sections need to be relinked to go fully open at maximum signal and fully closed at minimum signal.
F. Outside Air damper sections 1 and 4 (counting from the left) do not work.
G. Outside Air damper section 5 (counting from the left only opens part way. It needs to be loosened up.
H. The CHW coils for the three AHU on the first floor are piped wrong. The supply water is piped to the top and the return to the bottom. In addition, AH-1 has the supply piped to the leading (rather than trailing) side.
I. The Outside Air Damper for AH-3 is not connected.

Note: Items II-C, D, E, F, and G. have been addressed.