ESL-TR-06-06-02

Austin ISD
Campbell Elementary School
HVAC Renovations
Commissioning Report

Prepared for

Austin Independent School District (AISD)
Austin, Texas

Under Task Order #26

Submitted by

Marvin Zeig, Jr.
Gary Napper
Guanghua Wei, P.E.
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Energy Systems Laboratory
Texas Engineering Experiment Station
The Texas A&M University System
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Acknowledgements

The Energy Systems Laboratory greatly appreciates the assistance provided by the AISD operation and maintenance staff. Their assistance was vital to the successful completion of the commissioning report. Special thanks go to Farshad Shahsavary, Jim Dillard, Jess Williams and Darrel Smith of AISD for their help with this project.

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Executive Summary

The Energy Systems Laboratory (ESL) of Texas A&M University was contracted by AISD to perform commissioning on the HVAC renovations project at Campbell Elementary School. ESL engineers visited the school on May 8-10, 2006 to commission the new HVAC equipment. At the time of the visit, the equipment had been operating between 6 and 8 months. After investigating the facilities, the following observations and recommendations were made.

Field Observations:

- OAU-2 does not turn on correctly. The unit is energized by the time schedule but the outside air damper fails to open and the supply fan remains off. However, the compressors turn on to try to maintain a cooling discharge temperature. With the supply fan off, there should be no mechanical heating or cooling.
- AHUs 1 and 2 are not secured to their bases and mounts. The units are simply sitting on their base. AHU-2 is near falling off of its base which could damage the unit and its plumbing and ductwork.
- The heating enable switch for AHU-2 was in the off position.
- AHU 1 and 2 heating mode will automatically turn on when the space or return air temperature falls below 55°F. This temperature is low and should be increased to 65°F.
- AHUs 1 and 2 outside air dampers are closed while the units are on rather than in the minimum position of 20%.
- The outside air dampers do not open and modulate when forced to move via the TAC Vista workstation.
- The space CO_2 sensors for AHUs 1 and 2 do not read correctly. The sensor for AHU-1 read 32-33 ppm constantly and that for AHU-2 reads 100 ppm constantly.
- The cooling coil leaving temperature of the OAUs was set at 51°F, which is too low.
- OAU-2 cooling dead band was high at 11°F and OAU-1 and OAU-3 cooling dead band was 6°F
- The units operated correctly while running. The units reached design coil temperatures and had correct airflows.
- All sensors were verified and were within calibration limits. However, for RTU-2, the supply air and return air temperature sensors readings are backwards on TAC Vista and need to be reversed.
- Indoor air quality was within acceptable limits.

Recommendations for Austin ISD:

1) OAU-2 outside air damper and fan need to be checked for correct operation since they would not open and turn on when the unit is energized by the time schedule.
2) The fan proof flow switch needs to be checked for proper function. With the fan off, this switch should be open and there should be no mechanical cooling or heating.
3) AHUs 1 and 2 need to be securely mounted to their base with spring isolators between the equipment and base.
4) The heating switch for AHU-2 needs to be in the enable position. This was done by ESL.

5) For AHU 1 and 2, the low space/return temperature setpoint for automatic heat mode should be increased to 65°F.
6) For AHUs 1 and 2, the outside air damper operation needs to be at a minimum of 20% open when the units are running.
7) For AHUs 1 and 2, the outside air damper operation needs to be checked by TAC. These dampers should modulate via a signal from TAC Vista.
8) For AHUs 1 and 2, the space CO_2 sensors need to be checked/fixed/ replaced by TAC.
9) For the OAUs, the cooling coil leaving temperature setpoint should be increased to 55°F. This was done by ESL.
10) For OAU-2, the cooling dead band should be decreased to 6°F, this was done by ESL.
11) For RTU-2, the return air and supply air temperature sensor readings on TAC Vista are backwards and need to be corrected.
12) Heating setpoint of OAUs
13) AHU heating safety of 55 needs to be increased

Project Description

The project for HVAC renovations at Campbell Elementary School involved the addition of three new outside air units (OAUs), two new roof top units (RTUs) and two new air handling units (AHUs) with DX cooling and electric heating. All OAUs and RTUs are located on the roof of the building while the two AHUs are located in separate mechanical rooms in the building. With the installation of the three new OAUs, new ductwork to the spaces was installed as well as new registers. Upon installation of the units, monitoring points and start/stop control was put on the TAC Vista workstation. This project renovation was substantially completed by October 2005.

Equipment Designed Operation and Controls

Outside Air Units (OAUs)

The Campbell HVAC renovations included the replacement of three OAUs which treat outside air and supply it to the space. As designed, OAU-1 and OAU 2 supply 1440 cfm of outside air and OAU-3 supplies 1920 cfm of treated outside air. OAUs 2 and 3 supply the northwest wing of the building with treated outside air and OAU 3 supplies the northeast wing with treated outside air. This treated outside air is supplied directly to the space/rooms. All OAUs were manufactured by Engineered Air (EngA) and are of the model FWA. Integral, on board controllers are utilized to accomplish setpoints and stage equipment on and off. The units are on TAC Vista energy management system but the control capabilities through this are only limited to start/stop through a time schedule and are primarily used for monitoring purposes of temperatures, alarms, and status points. The time schedule for all OAUs is from 6:30am to 6:30pm from Monday through Friday. The units are off during the weekend. A schematic of the OAUs is detailed in Figure 1. The units are equipped with two-position outside air dampers. Each unit has two coils for cooling. The first coil for cooling has four parallel compressor circuits which stage on to maintain the cooling coil discharge air temperature setpoint off of both cooling coils. The second coil of cooling has a single compressor circuit which stages on first. This circuit is then used for the hot gas reheat coil, which serves as the condenser for this first stage of cooling. When the first stage of cooling is on, the condenser reheat is utilized.

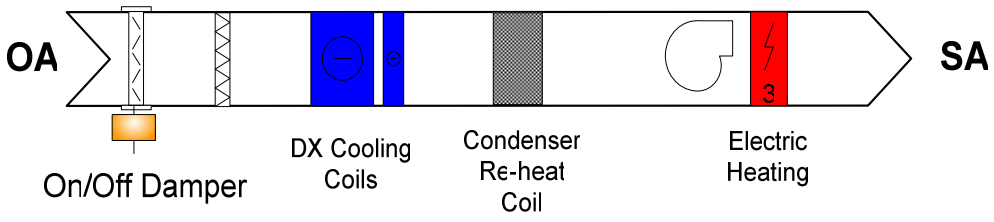

Figure 1: Outside Air Unit Schematic

When the OAU is on, the outside air damper opens; and when the OAU is off, the damper closes. An outside air temperature setpoint of 50°F, which is adjustable at the units, enables the heating

or cooling modes. The electric heating is locked out when the outside air temperature is above 50°F. Below this temperature, DX cooling is locked out. Thus mechanical cooling and electric heating do not run simultaneously. When in the heating mode, the electric heat is cycled on/off to maintain a supply air temperature between 70°F to 80°F. When in cooling mode, the temperature off of the cooling coil is maintained at 51°F and the condenser reheat will heat the supply air approximately to 65-68°F. As set in the onboard controller, OAUs 1 and 3 have a cooling dead band of 6°F and OAU-2 has a cooling dead band of 11°F. When the setpoint is reached and compressors stage off, the compressors will not stage on until the cooling coil temperature increases above the setpoint by the dead band amount. All compressors have an internally specified minimum runtime and off-time and stage on delay. The runtimes and delays are typically 4 to 6 minutes. Thus, when one compressor stages on after the dead band is surpassed, it will run for 4 to 6 minutes. If the setpoint is not reached in this time, another stage will turn on. This will continue until the setpoint is reached or all stages are on. As safety, hardwire measures, the OAUs are equipped with high and low discharge setpoints of 120°F and 40°F, respectively. If these temperature limits are surpassed, the unit will shut off. Also, the units are equipped with a fan proof, which is a differential static pressure switch (across the fan). If the fan is not proved "on", the unit will not cool or heat.

Roof Top Units (RTUs)

Located on the roof of the school are two new additional RTUs. RTU-1 serves the library and RTU-2 serves the computer room. As designed, RTU-1 supplies a total of 3200 cfm of which outside air comprises 540 cfm. As designed, RTU-2 supplies a total of 1200 cfm of which outside air comprises 330 cfm. The outside air damper for these two units is motorized and opens when the unit is energized. These units utilize two stages of DX cooling and two stages of electric heat which stage in sequence to maintain the zone space temperature setpoints as specified through TAC Vista workstation. The occupied cooling and heating setpoints are 74°F and 69°F, respectively. The unoccupied cooling and heating setpoints are 85°F and 60°F, respectively. During unoccupied periods, if the space temperature strays beyond the setpoint, the RTU will turn on to bring the space temperature back within the setpoints. The two RTUs are equipped with monitoring points (supply and return air temperature and cooling and heating status) tied to the TAC Vista workstation which allows the user to view the operation of the units. The units are turned on/off through a TAC Vista time schedule. This schedule is from 6:30am to 7:00pm on Mondays through Fridays. When the units are on, the fan runs continuously.

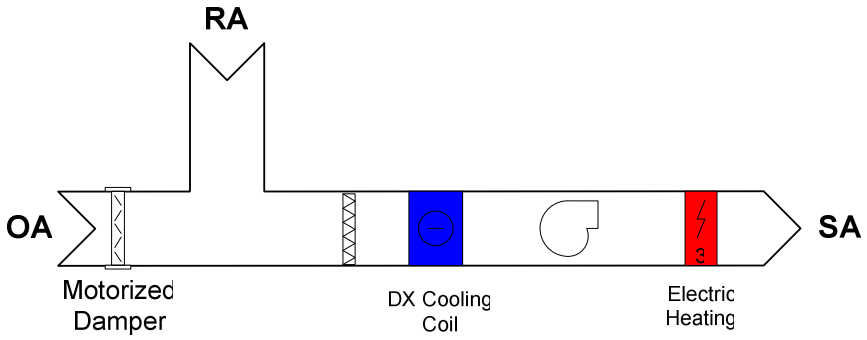

Figure 2: RTU schematic.

Air Handling Units (AHUs)

Located in two separate mechanical rooms are two new AHUs. AHU-1 and AHU-2 both serve the cafeteria and supply a total of 4600 cfm each, of which a maximum of 1125 cfm is untreated outside air (when the outside air damper is 100% open).

The AHUs operate to maintain the space temperature setpoint. A heating setpoint of 69°F and a cooling setpoint of 74°F with a 5°F dead band at all times is implemented through TAC Vista workstation. The space temperature sensor does allow a few degrees of adjustment. At anytime, if the return air temperature or space temperature falls below 55°F, the AHU will energize in the heating mode. If cooling is required and desired space temperature has not been achieved within 20 minutes of continuous operation, an alarm will be sent to the EMS workstation. If space CO_2 levels stray beyond setpoint levels of 1000 ppm (specified and adjustable in TAC Vista), the outside air damper will open from its minimum position of 20% and modulate, up to 100% open, to maintain the space CO_2 level setpoint. When the unit is de-energized, the outside air damper will close. These units are also equipped with local override push buttons which will energize the unit for a duration of 2 hours when the unit is in the unoccupied mode. Figure 3 shows a schematic of the AHUs.

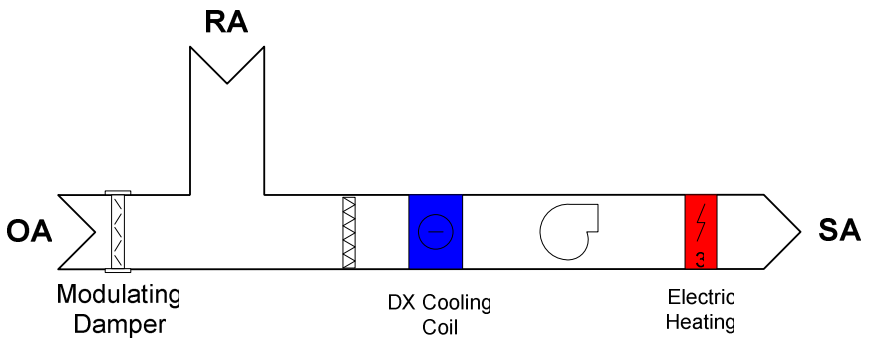

Figure 3: AHUs 1 and 2 Schematic.

Issues and Field Observations

1. **OAU-2 supply fan and outside air damper**
   When the unit is energized via a time schedule, the outside air damper fails to open and the supply air fan does not turn on. However, the unit tries to cool by turning on compressors. When this occurs, ice begins to form on the coils. By turning power off and on to the entire unit at the disconnect switch, the unit began to operate correctly. While the unit functioned correctly, measurements were taken on the unit and the control operation was verified. The unit was allowed to run after measurements were taken. However, upon checking the unit's operation the next morning, the unit was in the original state where the outside air damper was closed, fan off, and several compressors on. The start/stop operation of this OAU needs to be examined by an Engineered Air technician. The fan proof safety switch needs to be checked also. When the fan is off, there should be no mechanical heating or cooling.

2. **AHU 1 and 2 mounting**
   As detailed in the mechanical drawings, the two AHUs are to be mounted on a 4 inch housekeeping pad with spring isolators. As existing, the AHUs are sitting on framed I-beams with a rubber pad between the AHU mounting feet and the framed I-beams. AHU-2's mounting feet are nearly off of the I-beams as shown in the right image of Figure 4. If these feet fall off of the base, the AHU will fall several inches to the floor level. This could cause damage to the AHU and its associated duct work and plumbing. The two AHUs need to be securely fastened to their base/pad as detailed in the mechanical drawings with spring isolators between the AHU mounting feet and the pad.

Figure 4: AHU mounting feet not anchored to floor mounts.

3. **AHU-1 and 2 automatic heating mode**
   At anytime, if the return air temperature or space temperature falls below 55°F, the AHU will energize in the heating mode. This temperature is too low, even when the space is unoccupied. This temperature setpoint needs to be changed to 65°F.

4. **AHU-2 heating switch**
   The electric heating for AHU-2 was in the off position when the AHU was examined by ESL engineers. Upon verification that there was no problem with the electric heating, the switch was put in the on position by ESL engineers, enabling the heating elements. This did not physically turn the heating elements on but rather enabled them and a signal from the EMS will turn the electric heat on when needed in the heating mode.

5. **AHUs 1 and 2 outside air damper control**
   As designed, the outside air damper for each AHU is to be at a minimum position of 20% while the AHU is running or should modulate to maintain the space CO_2 levels. During the visit by ESL engineers, these outside air dampers remained closed when the AHUs were on. Also, the dampers would not move when forced to move through TAC Vista. The CO_2 level setpoint was then adjusted below the actual CO_2 sensors' outputs to allow the outside air damper PID to move the dampers. During this test, the PID sent a modulating signal to the damper but the damper did not move. The control of these outside air dampers need to be check by TAC. Furthermore, to aid in monitoring, the outside air damper positions should be displayed on the AHU graphic pages as well.

6. **AHUs 1 and 2 CO_2 sensors and control**
   Located in the cafeteria which the AHUs serve are two CO_2 sensors, one for each AHU. When these sensors read higher than the CO_2 setpoint, the outside air damper for each AHU will modulate to maintain the CO_2 level at the setpoint. However, the CO_2 sensor for AHU-1 reads 32-33ppm all of the time and that for AHU-2 reads 100ppm constantly. Thus, the outside air dampers will not modulate open if the actual space CO_2 levels increase above the setpoint of 1000ppm because both sensors are reading incorrectly. These sensors need to be checked/repaired/replaced. Also, to aid in monitoring, the CO_2 readings should be displayed on the AHU graphic pages.

7. **OAU cooling coil setpoints**
   All three of the outside air units operated with the same control sequence and setpoints. The discharge air temperature setpoint off of the cooling coil was 51°F. It is recommended to increase this setpoint to 55°F which will still provide the required dehumidification yet improve the efficiency of the unit which was designed to have a cooling discharge air temperature of 57°F. This setpoint has been adjusted by ESL.

8. **OAU-2 cooling dead band**
   The cooling dead band for OAU 1 and 3 were set at 6°F. For OAU-2, the cooling dead band was set at 11°F. This is too large of a dead band and can result in high humidity since this treated outside air is supplied directly to the space and not to another air handling unit. By decreasing the dead band the OAU will operate more efficiently also.

It is recommended that the cooling dead band for OAU-2 be decreased to 6°F. This has been done by ESL.

9. OAU, RTU, and AHU measurements

Field measurements taken on these units were compared to the units' design schedules. The table below details the measured values versus the design values. These values are within acceptable limits of the design/setpoint values. Heating controls were not tested during the visit since heating was locked out and not needed since the outside air temperature was above 90°F.

	DX Cooing (°F)		Heating (°F)		Supply air flow (cfm)		Outside air flow (cfm)	
	Meas.	Setpt	Meas.	Stpt/design	Meas.	Design	Meas.	Design
OAU-1	51.8	51	N/A	70-80	1590	1440	1590	1440
OAU-2	51.3	51	N/A	70-80	1610	1440	1610	1440
OAU-3	49.2	51	N/A	70-80	2320	1920	2320	1920
RTU-1	56.6	55	N/A	85	3200	3340	410	470
RTU-2	57.2	55	N/A	85	1460	1200	280	330
AHU-1	55.9	55	N/A	87	4280	4600	0	1125
AHU-2	55.3	55	N/A	87	4420	4600	0	1125

Note: RTU and AHU cooling and heating design temperatures are given. OAU setpoints are given.

10. Sensors labeled backwards

All sensors were verified by taking field measurements and comparing them with the readings provided on the TAC Vista workstation. All sensors readings were within ±1°F of the measured values. For RTU-1, the return air and supply air temperature points are labeled backwards on TAC Vista. Upon sensor verification, the measured return air temperature matched that of the supply air temperature sensor reading and vice versa for the measured supply air temperature measurement and return air sensor reading. These points need to be labeled correctly in TAC Vista as well as on the graphic page.

11. Indoor air quality

Indoor air quality measurements were taken in the areas the new HVAC equipment served. These measurements included space temperatures, relative humidity levels, and CO_2 levels. The school had acceptable indoor air quality. Space temperatures ranged between 73-75°F with humidity levels between 52-58%. CO_2 levels fluctuated between 500-950 ppm.

Summary and Recommendations

Field Observations:

- OAU-2 does not turn on correctly. The unit is energized by the time schedule but the outside air damper fails to open and the supply fan remains off. However, the compressors turn on to try to maintain a cooling discharge temperature. With the supply fan off, there should be no mechanical heating or cooling.
- AHUs 1 and 2 are not secured to their bases and mounts. The units are simply sitting on their base. AHU-2 is near falling off of its base which could damage the unit and its plumbing and ductwork.
- The heating enable switch for AHU-2 was in the off position.
- AHU 1 and 2 heating mode will automatically turn on when the space or return air temperature falls below 55°F. This temperature is low and should be increased to 65°F.
- AHUs 1 and 2 outside air dampers are closed while the units are on rather than in the minimum position of 20%.
- The outside air dampers do not open and modulate when forced to move via the TAC Vista workstation.
- The space CO_2 sensors for AHUs 1 and 2 do not read correctly. The sensor for AHU-1 read 32-33 ppm constantly and that for AHU-2 reads 100 ppm constantly.
- The cooling coil leaving temperature of the OAUs was set at 51°F, which is too low.
- OAU-2 cooling dead band was high at 11°F and OAU-1 and OAU-3 cooling dead band was 6°F
- The units operated correctly while running. The units reached design coil temperatures and had correct airflows.
- All sensors were verified and were within calibration limits. However, for RTU-2, the supply air and return air temperature sensors readings are backwards on TAC Vista and need to be reversed.
- Indoor air quality was within acceptable limits.

Recommendations for Austin ISD:

1) OAU-2 outside air damper and fan need to be checked for correct operation since they would not open and turn on when the unit is energized by the time schedule.
2) The fan proof flow switch needs to be checked for proper function. With the fan off, this switch should be open and there should be no mechanical cooling or heating.
3) AHUs 1 and 2 need to be securely mounted to their base with spring isolators between the equipment and base.
4) The heating switch for AHU-2 needs to be in the enable position. This was done by ESL.
5) For AHU 1 and 2, the low space/return temperature setpoint for automatic heat mode should be increased to 65°F.
6) For AHUs 1 and 2, the outside air damper operation needs to be at a minimum of 20% open when the units are running.
7) For AHUs 1 and 2, the outside air damper operation needs to be checked by TAC. These dampers should modulate via a signal from TAC Vista.
8) For AHUs 1 and 2, the space CO_2 sensors need to be checked/fixed/ replaced by TAC.

9) For the OAUs, the cooling coil leaving temperature setpoint should be increased to 55°F. This was done by ESL.
10) For OAU-2, the cooling dead band should be decreased to 6°F, this was done by ESL.
11) For RTU-2, the return air and supply air temperature sensor readings on TAC Vista are backwards and need to be corrected.
12) Heating setpoint of OAUs
13) AHU heating safety of 55 needs to be increased