Feasibility Study

Illini Union – Exhaust Hood Conversion
University of Illinois at Urbana-Champaign
U12241

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Executive Summary

The University of Illinois Student Sustainability Committee has identified a potential opportunity to reduce energy consumption at the Illini Union by implementing demand control to reduce the exhaust airflow from some general exhaust and kitchen exhaust that serve the basement level when such exhaust is not needed. By reducing the exhausts in the basement, it is expected to not only save energy, but also to help with existing building pressure issues.

Hanson was hired to provide this study to identify and recommend the specific modifications to be implemented on each existing exhaust source, develop a phased plan to implement the recommendations, and prepare a simple payback calculation for the modifications.

We are recommending that an energy efficiency project be undertaken with the specific recommendations made in sections 3 and 4 of this report, of which the major items are summarized here:

- Permanently decommission fans EF-10 (bowling alley), and EF-12 (bakery hood).
- Replace EF-16, EF-17, and EF-18 with a chilled water fan coil system for conditioning Mechanical Room 88.
- Add DDC controls to enable EF-1 (Einstein Bros. Bagels) and EF-11(NE Locker Rooms) to run on a programmable schedule.
- Interlock EF-13 to the dishwasher to run only when the dishwasher runs, including a 30 minute delay off timer.
- Add variable speed demand controls to the kitchen hoods served by EF-3, 13A, 14, and 22 (Main kitchen and vendors) and provide a programmable schedule via a DDC controller. Upgrade the main kitchen makeup air handling unit (SF-14) controls to variable airflow. EF-14 needs to be replaced and the others will have the motor replaced.

A number of code deficiencies were identified within the kitchen exhaust systems, and these are summarized in Article 4.5. These deficiencies include inadequate hood airflows, improper duct type for grease exhaust, improper sloping of ducts for grease drainage, and a lack of the required fire rated enclosures or wraps on the existing grease ducts. We are not aware of any complaints about inadequate hood capture, so the recommendations in this study are directed toward maintaining or improving the exhaust rates with the existing equipment. EF-14 should be replaced by this project because it does not currently provide the code minimum duct velocity that is intended to minimize grease buildup. The other deficiencies identified relate to fire safety in the event that a grease fire that spreads in the exhaust ductwork. The correction of these deficiencies is not included in the recommended energy efficiency project; however we recommend that they be addressed under a separate project.

The Opinion of Probable Construction Cost (OPCC) plus the chilled water capacity charge for all of the changes listed in Sections 3 and 4 is three hundred fifty-eight thousand dollars ($358,000). The total energy cost savings resulting from the recommended revisions is anticipated to be approximately one hundred sixty-five thousand dollars ($165,000) per year. The resulting simple payback for all the recommended modifications is therefore calculated to be 2.2 years.

We are recommending that these changes be completed in a single project. Although we understand the potential funding may be released during two separate fiscal years, it is also our understanding that all of the funding will be available within the recommended construction schedule of the project which is April through August of 2014.

1. Introduction

The University of Illinois Student Sustainability Committee has identified a potential opportunity to reduce energy consumption at the Illini Union by implementing demand control to reduce the exhaust airflow from some general exhaust and kitchen exhaust that serve the basement level when such exhaust is not needed. The building, and especially the basement, is currently operating at a negative pressure. Although an ongoing project was adding makeup air for the food court in order to meet code ventilation requirements, it was not expected to fully rectify the building pressure problem. By reducing the exhausts in the basement, it is expected to not only save energy, but also to help with existing building pressure issues.

Prior to designing and implementing exhaust demand control, Hanson has been asked to provide a study to identify and recommend the specific modifications to be implemented on each existing exhaust source. One of the objectives of this study was to develop a phased plan to implement the recommendations as well as prepare simple payback calculation for the modifications.

The exhaust airstreams include a number of kitchen hoods in the main kitchen, a dishwasher exhaust in the main kitchen, and hoods in the vendor kitchens for the food court. Additionally, other general exhausts included in the study are those from the bowling lanes, the NE locker rooms, and basement mechanical Room 88. These sources are summarized in Table 1.1.

Table 1.1 Exhaust Sources Included in Study

Fan Tag	*Serves*	*Source Type*	*Hood Quantity*	*Airflow*
EF-1	Einstein Bros. Bagels	Type II Kitchen Hood General Exhaust Grille	1	1,350
EF-3	Main Kitchen Chick-Fil-A	Type I Kitchen Hoods Type I Kitchen Hoods	3 2	19,840[a]
EF-10	Bowling Alley	General Exhaust		7,892[b]
EF-11	NE Locker Rooms	General Exhaust		3,295[b]
EF-12	Bakery Hood Experimental Kitchen	Type I Kitchen Hood Type I Kitchen Hood	1 1	7,126[b]
EF-13	Main Kitchen Dishwasher	Type II Kitchen Exhaust	Direct Connection	1,133[b]
EF-13A	Rice Garden S'Barro's	Type I Kitchen Hood Type I Kitchen Hood	2 1	4,253[a]
EF-14	S'Barro's	Type I Kitchen Hood	1	1,478[a]
EF-16	Mechanical Room 88	General Exhaust		14,300
EF-17	Mechanical Room 88	General Exhaust		14,300
EF-18	Mechanical Room 88	General Exhaust		14,300
EF-22	Crepe Delicious Sushi San	Type I Kitchen Hood Type I Kitchen Hood	1 1	5,500[a]

Note: Superscript (a) indicates these are measured airflows as recorded by BPI Testing on 1/24/2013. Superscript (b) indicates these are measured airflows as recorded in the Illini Union Infrastructure Repairs Feasibility Study done by ESD. All other airflows are taken as design airflows from the drawings provided.

All of these exhausts currently run continuously, 24/7, with the exception of the basement Mechanical Room 88 which cycles to maintain the mechanical room temperature. The concept that was evaluated and described in this report is to shut off or reduce the airflow from as many of these sources in the basement as possible when they are not in use. Strategies considered include decommissioning unused exhausts, fan scheduling, adding variable frequency drives (VFDs) to the exhaust fans, hood modification or replacement, and/or reconfiguring exhaust ductwork to separate hoods and allow the unused hoods to shut off for longer periods.

The reference material available for this study included the existing building drawings provided by UIUC, the Illini Union Infrastructure Repairs Phase II, Feasibility Study performed by Environmental Systems Design Inc. (ESD) dated 2/7/2011, and airflow measurements performed by from a report dated 1/24/13 by BPI Testing, LLC. No drawings were provided for the current configuration of Chick-Fil-A, only the previous vendor’s exhaust configuration for this location was available.

It was not in the scope of the project to verify that the existing fire suppression systems operate per code to shut down the makeup air system and all the electric and gas to the appliances under all hoods connected to each fan in the event of a fire. The recommendations made in the report assume that the fire suppression systems are properly interlocked to the makeup air unit and kitchen equipment already and its function will not be altered by the new kitchen hood control system. The interlock of the exhaust fans to the fire suppression system was not verified during this study but should be verified during the design phase. In order to make sure the exhaust fan stays on in the event of a fire, the budget costs presented in this report include a cost allowance for wire to interlock the fire suppression systems to the fan starters if they are not already.

2. Methodology for Energy Calculations

The majority of the energy cost associated with exhausts is the conditioning of the makeup air that must be brought into the building to replace the exhausted air. When a makeup air handling unit conditions that makeup air, the heating, cooling, and/or dehumidification is handled directly by the air handling unit before the air is supplied to the room. When adequate makeup air is not brought into the building through an air handling unit, the building operates at a negative pressure and the makeup air infiltrates through the building envelope (walls, roof, windows, and doors). The energy needed to condition the air that finds its way in through the building envelope is still expended when the air handling unit attempts to maintain the desired space temperature and humidity. It is therefore reasonable to calculate the energy associated with the exhaust as the energy needed to conditions the makeup air.

Energy calculations were performed using the Outdoor Air Load Calculator provided by the Food Service Technology Center (http://fishnick.com/ventilation/oalc/oac.php).

The calculator uses the airflow rate, local weather data, hours of operation, fan power, part load factors, and indoor temperature and humidity to estimate the annual energy loads for exhausts. Utility rates are input to estimate annual energy costs.

The closest location available in the calculator for the local weather data is Springfield, IL. The indoor conditions assumed were 75°F and 50 percent relative humidity (RH) for cooling and 70°F for heating. Table 2.1 shows the utility rates used for this study.

Table 2.1 Utility Rates: UIUC FY 2013

Utility	*Rate*
Campus Steam	$17.59 per klbs
Campus Chilled Water	$16.71 per Million Btu
Electric Rate	$0.0746 per kWh

Because the energy cost of running an exhaust fan is predominantly for the energy required to condition makeup air (not the cost for running the fan), savings can be assessed using the general rule of thumb that was identified for current utility rates. Assuming the makeup air is not needed for economizer, the energy cost associated with exhaust and conditioning its makeup air is approximately five dollars ($5) per CFM per year. Therefore if a fan is shut off for 50 percent of the year, a rough rule of thumb is that a savings up to two dollars and fifty cents ($2.50) per CFM per year could be anticipated compared to running the fan continuously.

Table 2.2 shows the anticipated required operating hours of the areas served by each fan. These durations along with the specific conditions listed in the Articles under Sections 3 and 4 were used to calculate the energy savings that are summarized in Section 5.

Table 2.2 Occupancy Times Used for Areas Served by Each Fan

Fan Tag	*Serves*	*Required Operating Time*		*Periods Can be Shut Down*
		From	*Until*	
EF-1	Einstein Bros. Bagels	7:30 AM[(a)]	8:00 PM	Christmas to Jan 2-4
EF-3	Main Kitchen Chick-Fil-A	6:00 AM 7:30 AM	1:30 PM 10:00 PM	Dec 25 to Jan 2-4, Spring Break Dec 25 to Jan 2-4
EF-10	Bowling Alley	N/A	N/A	
EF-11	NE Locker Rooms	5:00 AM	1:00 AM	Dec 25 to Jan 2-4
EF-12	Bakery Hood Experimental Kitchen	N/A	N/A	
EF-13	Main Kitchen Dishwasher	6:00 AM	3:00 PM[(c)]	Dec 25 to Jan 2-4
EF-13A	Rice Garden S'Barro's	10:00 AM 10:00 AM[(a)]	6:00 PM[(b)] 7:00 PM[(b)]	Dec 25 to Jan 2-4 Dec 25 to Jan 2-4
EF-14	S'Barro's	10:00 AM[(a)]	7:00 PM[(b)]	Dec 25 to Jan 2-4
EF-16	Mechanical Room 88	N/A	N/A	
EF-17	Mechanical Room 88	N/A	N/A	
EF-18	Mechanical Room 88	N/A	N/A	
EF-22	Crepe Delicious Sushi San	8:00 AM	7:00 PM[(b)]	Dec 25 to Jan 2-4

Note: Where multiple times are indicated for different spaces on each fan, the longest duration indicated in the table is normally experienced and was used for the energy calculations. Where no time is indicated it was determined the fan is not required to be run. Refer to Sections 3 and 4 for additional information. Superscript (a) indicates that the start time varies and may be as early as 6:00 AM. Superscript (b) indicates that the closing time varies and may be as late as 8:00 PM. Superscript (c) indicates that the dishwasher was assumed to be interlocked to operate with a 30 minute delay off timer for the energy calculations.

3. General Exhausts

3.1 Bowling Lane Exhaust (EF-10)

The bowling lane has three existing exhaust fans (EF) behind the pin setters. EF-8 and EF-9 are ducted fans that exhausted the east and west sides of the area behind the pin setters and have previously been permanently shut off. EF-10 is a general exhaust propeller fan that exhausts air from the center of the south wall behind the pin setters. EF-10 runs continuously still, although the exhaust does not appear to be code required and they don’t appear to serve a distinct purpose that warrants exhaust. EF-8 and EF-9 should remain shut down. It appears that EF-10 fan can be shut down permanently also.

The energy savings in Section 5 are based on shutting EF-10 down permanently.

3.2 North East Locker Room Exhaust (EF-11)

The locker rooms and surrounding spaces in the northeast corner of the lower level are served by EF-11 for general exhaust. Although this fan currently runs continuously, it is only required by code to run when the spaces are occupied. Applying occupancy sensors does not appear to be practical , thought, due to the number of spaces the fan serves. If a new starter were added to the fan and connected to the building automation control system, it could be started and stopped via an adjustable time schedule.

The energy savings in section 5 are based on shutting EF-11 down on the schedule indicated in Table 2.2.

3.3 Mechanical Room 88 Exhaust (EF-16, EF-17, EF-18)

Mechanical Room 88 is in the lower level of the Union just west of the food court. This space serves as both an equipment room and a maintenance support area. There are three exhaust fans in the room that are used for space conditioning. Each of them is sized for 14,300 CFM. There is an outside air intake that opens directly to the room for makeup air. It appears that the design intent of the system is that the exhaust fans cycle on to temper the room when it gets warm and because they draw the room negative, outside air is pulled in through a gravity intake louver and damper.

Conceptually this would have provided limited tempering of the mechanical room to remove waste heat when it previously contained absorption chillers. The absorption chillers are now gone, and the space is now used as a maintenance area. The original system does not provide adequate comfort for its function during periods of high or low outdoor temperatures. As commonly happens when an HVAC system is not providing adequate comfort, the occupants have found ways to defeat or supplement the system to improve comfort. In this case, the outside air intake has been partially blocked with insulation, presumably to limit the spilling of cold air in the winter. It was noted during some of our site visits, that the door to the mechanical room was left propped open, reportedly to make the space more comfortable. It works quite well, however the result is that the makeup for the exhaust is conditioned air from the food court area rather than unconditioned air directly from outside.

It would be more energy efficient to condition the space with a chilled water fan coil system that can recirculate some of the air rather than temper the space with conditioned 100 percent outside air as it currently is operated. An energy recovery ventilator may be used to precondition the necessary ventilation air needed for the room. This could be accomplished relatively easily since no work is required in vendor areas or public spaces.

In the Illini Union Infrastructure Repairs Feasibility Study completed by ESD, they noted that when the door to Mechanical Room 61 (aka 88), 10,601 CFM was measured through the doorway in to the mechanical room through that single door. For the energy savings calculation it was assumed that this airflow only occurs eight hours a day, 250 days a year. The energy savings in Section 5 are based on reducing the infiltration by the amount and times shown above and replacing these exhaust fans with a cooling only fan coil(s).

The mechanical room also contains some large steam pipes that are not insulated. These steam pipes are contributing to the need for cooling in the space. The heat loss from the steam pipes and associated cooling in the space both are energy losses. These pipes should be insulated by this project. The opinion of cost and fan coil size both assume the pipes will be insulated by this project.

4. Kitchen Exhausts

4.1 Types of Exhaust Hoods

There are two types of hoods defined in the International Mechanical Code and ANSI/ASHRAE Standard 154-2011. Type I hoods are used for grease exhaust and Type II are used for exhausting heat and condensate. Although the wording of the International Mechanical Code has evolved over the past few code cycles, the general intent has remained the same and is relatively consistent with ANSI/ASHRAE 154.

Type I hoods shall be installed where cooking appliances produce grease or smoke. Type I hoods shall be installed over medium-duty, heavy-duty, and extra-heavy-duty cooking appliances and Type I hoods shall be installed over light duty cooking appliances that produce grease or smoke.

Type II hoods shall be installed above dishwashers and light-duty appliances that produce heat or moisture and do not produce grease or smoke, except where the heat and moisture loads from such appliances are incorporated into the HVAC system design or into the design of a separate removal system. Type II hoods shall be installed above all light-duty appliances that produce grease or smoke.

All of the kitchen hoods in the lower level are constructed as Type I hoods with the exception of the hood in Einstein Bros. Bagels which is a Type II hood and currently has no kitchen equipment installed under it.

4.2 Exhaust Hood Duty Ratings

Exhaust hoods are assigned a duty rating of Light Duty, Medium Duty, Heavy Duty, or Extra-Heavy Duty based on the kitchen equipment installed under them. The most stringent requirement for any one piece of equipment under the hood dictates the hood duty rating. The rating of each hood is indicated in Section 4.6 and the details of the type of equipment that is currently under them and the calculations for the required airflow are provided in Appendix B. The organization of this appendix is based on the categorization of equipment per the International Mechanical Code.

ANSI/ASHRAE 154-2011 provides a definitive table of what equipment fits in each category. The tables from this standard for both Type I and Type II hoods are included in Appendix A for reference. When other vendors are considered for new leases, these tables may be consulted along with the existing equipment list provided in Appendix B for comparison.

4.3 Required Exhaust Rates for Kitchen Hoods

Hoods are considered “listed” if they have been tested and by an organization such as Underwriters Laboratory (UL) and certified to perform based on a specific airflow for a given duty rating. Listed hoods have a required CFM/foot published by the manufacturer for that duty rating. Unlisted hoods must use the CFM/foot listed in the code which is generally higher than that of listed hoods.

The hood type (Backshelf/pass-over, Double island canopy, Eyebrow, Single island canopy, or Wall-mounted canopy), the duty rating, length of hood, and whether it is listed or not determine the required exhaust rate of each hood.

The only hoods that had tags that displayed a listing and the make and model number were the hoods in Chick-Fil-A, Einstein Bros. Bagles, and Rice Garden. The hoods in Rice Garden were made by a manufacturer that is no longer in business and the listed CFM for the current application could not be verified. Therefore, the calculated required airflows for all the hoods except Chick-Fil-A and Einstein Bros. Bagels were based on the unlisted hood value from the International Mechanical Code.

Table 4.1 shows the apparent duty rating needed for the currently installed equipment, the original design airflow, the calculated code required airflow, and the measured airflow for each Type I kitchen hood that is still in use. The details of the calculations are provided in Appendix B.

Table 4.1 Type I Kitchen Hood Airflows: Code Required and Measured for Hoods in Use

Fan Tag	*Serves*	*Hood #*	*Airflow (CFM)*		
			Design Drawings	Code Required	Measured
EF-3	Main Kitchen	1	12,760	12,000	6,055
	Main Kitchen	2	9,500	19,200	5,616
	Main Kitchen	3	6,900	9,600	6,063
	Chick-Fil-A	4	Not Available(a)	912	657
	Chick-Fil-A	5	Not Available(a)	1,824	1,449
EF-13A	Rice Garden	1	Not on Drawing(b)	3,200	1,902
	Rice Garden	2	Not on Drawing(b)	3,200	1,491
	S'Barro's	3	Not on Drawing(b)	3,200	859
EF-14	S'Barro's	1	Not on Drawing(b)	2,400	1,478
EF-22	Crepe Delicious	1	1,600	2,400	1,643
	Sushi San	2	3,200	3,200	1,796

Note: Because the kitchen hoods are not given distinct tags on the drawings, the hood numbering used was taken from the balancing report provided in Appendix E so that they would correspond. Superscript (a) indicates that no drawings were provided for the current configuration of this vendor. Superscript (b) indicates that no airflow information was on the design drawings for this hood.

Table 4.1 demonstrates that none of the existing grease exhaust hoods has enough airflow to comply with the code minimum exhaust requirements for the type of kitchen equipment currently being used.

Additionally we looked at the duct velocities for the duct system connected to each fan. For fire safety, the code requires that a minimum duct velocity of 500 fpm be maintained in grease ducts at all times when cooking is occurring. Grease exhaust ducts were historically and often still are sized to maintain 1,500 to 1,800 fpm velocity at the design exhaust rate, but since 2001 the 1,500 fpm velocity is no longer a code requirement. 500 fpm is the current code requirement. When exhaust airflow is reduced with demand control the code required duct velocity of 500 fpm must be maintained at all times when cooking operations occur. Table 4.2 shows the duct velocities calculated from the measured airflows based on the duct sizes reported on the available drawings.

Table 4.2 Calculated Velocity of Air in Grease Ducts using Measured Airflow Rates

Fan Tag	*Serves*	*Duct Velocity (fpm)*
EF-3	Main Kitchen Chick-Fil-A	538
EF-13A	Rice Garden S'Barro's	754
EF-14	S'Barro's	441
EF-22	Crepe Delicious Sushi San	641

Note: Velocity listed represents the lowest velocity through any segment of duct connected to the fan.

As can be seen from Table 4.2, all of the Type I grease exhaust fans in use have a very low duct velocity in at least one segment of duct. EF-14 is the only fan that would require additional exhaust to meet this code requirement.

4.4 Operation of Type I Exhaust Hoods

4.4.1 Minimum Operation Control for Type I Exhaust Hoods

Per Section 507.2.1.1 of the International Mechanical Code, Type I hood systems shall be designed and installed to automatically activate the exhaust fan whenever cooking operations occur. The activation of the exhaust fan shall occur through an interlock with the cooking appliances, by means of heat sensors or by means of other approved methods.

One option that had been used in the past was to simply provide manual switches on each hood for start and stop. Kitchen equipment was interlocked to prevent operation when the hood was off. This could not be used with standing pilots, but the code no longer allows this method at all. A manual switch is permissible, but there is no true off position, only on and auto. The auto function is controlled by heat sensors.

A heat sensor would need to be retrofitted into (or near) every duct connection on all hoods served by the fan. When any single heat sensor detects its temperature set point, the fan is started. They can also be wired in parallel with a manual switch or the building automation system to start the fans on an adjustable time schedule.

Manual switches can be difficult to retrofit onto the face of existing hoods. On past projects we have used wireless switches with an RF receiver to avoid running an exposed conduit in the kitchen or cutting a hole in an existing hood. This is what we would recommend if manual switches are desired.

The least complicated option for adding heat sensors is to use the 120-Volt version that have a default setting of 85°F. These sensors are wired in parallel to the fan starter so any one can close the circuit to start the fan.

Another option is to use the low voltage type sensors and connect them to a control panel associated with each fan. This control panel would provide additional options. It would allow the temperature setpoint of each sensor to be field adjustable and tuned to the specific application. It can also provide a reference temperature in the kitchen to use a temperature differential to start the fan. If a connection to the building automation system is desired, it could be tied to this control panel to start and stop the fans on an adjustable schedule.

4.4.2 Variable Speed Demand Control for Type I Exhaust Hoods

Although heat sensors can be used to sense cooking operations, when they are used to vary the fan speed in a demand control application, the temperature sensors alone may not respond fast enough to provide adequate capture and containment of the cooking effluents. Several products have been introduced to the market recently to provide better response in variable airflow demand control applications. There are at least two manufactures of such systems. Both use an optical sensor to help determine when cooking operations have started. One uses optical opacity sensors to detect the presence of cooking effluent in a hood cavity. Another uses infrared temperature sensors to monitor the surface temperature of the cooking appliances. Data from these sensors along with the space temperature and hood exhaust temperature sensors are analyzed to interpret the status of cooking appliances (idle, cooking, or off) and adjust hood exhaust airflow accordingly.

Melink is one manufacturer that offers the optical sensor system and it is branded Intelli-Hood. Their system consists of heat sensors in every duct connection to the hood and an optical opacity sensor. The optical sensor would be mounted in the hood cavity and will cover up to 40 ft length. Longer hoods like the 48 ft hood in the main kitchen will require two sensors. In application like Rice Garden, where two hoods are side by side, a hole may be cut between the hoods to allow a single sensor to cover both hoods. The double island canopy hoods like the ones in the main kitchen will require on sensor on each side of the hood. The heat sensors and optical sensors on all of the hoods connected to each fan are wired back to a controller single controller. That controller is connected to the fan VFD. The controller has an adjustable minimum speed which can be set in 10 percent increments and is most often set to 50 percent. The heat sensors are set to an adjustable range to ramp the fan between min and max airflow. That range of temps in each hood would be field tuned for the specific application (e.g., 75-90°F or 75-150°F) by the manufactures representative to ensure capture. The heat sensors are used to start the fans. They are also used to ramp the fan between min and max airflow based on that temperature range to capture the heat when the kitchen equipment is operating at idle. The optical sensor is used to sense the actual start of cooking operations, so when this sensor trips, the fan is forced to full speed to comply with Section 507.2.1.1of the international mechanical code.

Although the heat sensors can be used to start the exhaust fan, it is recommended that during periods that the space is normally occupied, the building DDC system should start the fan using that time schedule. When it is outside of that schedule the system should be left in auto.

Another consideration for demand control is that the kitchen area must remain negative with respect to the dining area. Using demand control on the exhaust means that the makeup air to the room must also be variable. Because the vendor areas are open to the food court and the rest of the first floor via the stairwell, both of which are currently very negative pressure, no changes are anticipated to makeup air AHU's for these hoods. The main kitchen however is a closed zone and would require changes to its makeup air handling unit to make it variable volume.

Our recommendation is that all the Type I exhausts currently in use should be connected to variable speed demand control system with heat and optical sensors which should also be connected to a DDC controller to schedule the exhaust fan to start and run during the normally hours of use. The basis of the energy savings is that the control system provided should have heat sensors to vary the fan speed during idle cooking operation and an optical sensor to drive the fan to full speed when the optical sensor identifies that cooking has started. Additional specifics for each fan are listed in Article 4.6.

4.5 Existing Deficiencies

Although identifying code deficiencies was not explicitly in the scope of the study, it is necessary for us to point out the following items that we uncovered during the course of the study that do not appear to comply with the International Mechanical Code or ANSI/ASHRAE Standard 154-2011:

1. Airflows of all Type I kitchen hoods in use are below the code required exhaust rate and the hoods that are known to be listed are below the airflow required by their listing.
2. Several exhaust ducts being used for grease exhaust (Type I hoods) are constructed of standard galvanized ductwork and are not constructed for service as grease ducts. Ducts serving Type I hoods should be constructed of carbon steel of a minimum 16 gauge thickness or stainless steel of a minimum 18 gauge thickness. All seams, joints and penetrations should have a liquid tight continuous external weld or the ductwork should be a factory-built product listed and labeled in accordance with UL 1978. Ducts that are improperly constructed include, but are not necessarily limited to, the duct main just outside (south) of and serving Chik-Fil-A and the ductwork for EF-22 which serves Crepe De Licious and Sushi San.
3. Grease exhaust ducts should be sloped at a minimum of 2 percent (1/4 in. per ft) back toward the hood or an approved grease reservoir. Horizontal runs over 75 ft should be sloped at 8.3 percent (1 in. per ft). Most of the horizontal grease exhaust ducts are not sloped at all. No grease traps or reservoirs were observed on the drawings or during the field survey.
4. Ducts connected to Type I hoods are required to have a clearance of not less than 18 in. to combustible construction and 3 in. to gypsum wallboard and noncombustible construction. There is an exception to this if it is wrapped in a listed and labeled grease duct enclosure. Additionally the International Mechanical Code states that "A grease duct serving a Type I hood that penetrates a ceiling, wall or floor shall be enclosed from point of penetration to the outlet

terminal. …. Ducts shall be enclosed in accordance with the International Building Code requirements for shaft construction." All the ducts penetrate floors or walls and should be wrapped with the appropriate insulation or enclosed in a fire rated assembly. There are a number of ducts not wrapped with insulation and it was not clear from the limited survey that all these ducts meet the clearance requirements.

4.6 Kitchen Exhaust Modifications

4.6.1 Einstein Bros. Bagels Exhaust (EF-1)

This exhaust fan serves only one vendor. It is a class II kitchen exhaust with one exhaust hood and one general exhaust grille. There is no kitchen equipment under the class II hood. We are recommending this fan be connected to a DDC controller with a programmable schedule that only runs the fan during occupied hours.

The energy savings in section 5 are based on shutting this fan down based on the schedule shown in Table 2.2.

4.6.2 Main Kitchen and Chick-Fil-A Kitchen Hoods (EF-3)

This exhaust fan serves three hoods in the main kitchen and the two hoods in Chick-Fil-A. The main kitchen and Chick-Fil-A operate on different schedules as shown in table 2.2. Ideally these two would have separate exhaust fans to allow them to shut down on separate schedules. The energy cost savings of separating these two exhausts could be on the order of twenty-five thousand dollars ($25,000) per year. As indicated in article 4.6.3 the bakery hood is no longer used. We evaluated several routing options to try to repurpose the duct riser for EF-12 to serve Chick-Fil-A, however none of them are considered viable.

The first option considered was to route the duct around the corridor to the south of the main kitchen and then north through the corridor that is to the east of the main kitchen. The duct would have to run all the way back to the duct riser next to the elevator on the north side of the old bakery. As you can see in the photos to the right, there is no space to route a new duct. The photo in the upper right shows the corridor to the south of the main kitchen. It was difficult to get the ceiling tiles out let alone add a new duct to this location. The corridor is entirely blocked with existing ductwork as can be seen in the second photo taken in the corridor to the east of the kitchen looking south. Complicating this routing is the fact that the corridor to the east of the kitchen has asbestos tile that would have to be abated if it is disturbed.

The second option we looked at was to route through the main kitchen. There is no available space in the ceiling of the main kitchen either. In addition, it appears the insulation on the existing grease duct here is asbestos.

The third option considered was a route in front of the vendor area. This route does not appear to be feasible due to the limited interstitial space, the coffered ceilings, existing ductwork, conduit, lighting and other existing obstructions.

Looking East in the ceiling above corridor just south of the main kitchen.

Looking South in the ceiling above corridor just East of the main kitchen.

Asbestos insulated grease duct above main kitchen.

Even if there were room, all of these routes would require well over 200 ft of horizontal grease duct which must be sloped at 1 in. per ft back to the hood or an approved grease reservoir.

None of the routes considered appears to be feasible without an abatement project and major revisions to existing ductwork and systems for the kitchen. We do not believe it is economically justifiable to do this as an energy savings project. If in the future, major kitchen renovations are considered, the issue should be revisited.

Our recommendation for this exhaust fan is to add a variable speed demand control system with heat sensors and optical sensors as described in section 4.4.2. The new control system should also be connected to a DDC controller to schedule the exhaust fan to start and run during the normally hours of use of the main kitchen. The system should be left in auto for the remainder of the time so that whenever the vendor in the Chick-Fil-A has their kitchen equipment on, it will trigger the system to start.

Air cannot be recirculated from a kitchen to the HVAC system, so any supply air needed for space conditioning must be exhausted. The kitchen must remain negative relative to the dining area at all times. This would necessitate that the makeup air AHU for the space be variable speed and interlocked to the exhaust operation. The supply to the main kitchen is from supply fan SF-14 which is not currently capable of variable speed operation.

We recommend SF-14 be upgraded to variable speed capability by adding a VFD and replacing the controls with new electronic DDC controls. SF-14 should have an air flow measuring station added the inlet of the supply fan. The airflow set point of SF-14 should be reset based on a new differential pressure sensor that is installed between the main kitchen and the food court to attempt to maintain an adjustable -0.02 in. WC differential. Additionally feedback from the kitchen hood exhaust controllers should be an input to this controller to allow it to respond more quickly when the exhaust varies or stages on/off. The return and outside air to this unit will need to have controls added to allow them to be variable to maintain economizer function and also not freeze the cooling coil in the unit.

The energy savings in Section 5 are based on shutting this fan down according to the hours of operation in Table 2.2 and an assumed demand control turndown to an average operating speed of 80 percent when in operation.

4.6.3 Bakery and Experimental Kitchen Hood Exhaust (EF-12)

This fan serves two hoods. Neither hood is currently in use. We recommend decommissioning this fan.

The energy savings in Section 5 are based on shutting the fan down permanently.

4.6.4 Main Kitchen Dishwasher Exhaust (EF-13)

The dishwasher exhaust currently runs continuously. The exhaust fan may be interlocked to run when the dishwasher runs and shut off on a 30-minute delay.

The energy savings in Section 5 are based on shutting the fan down when the dishwasher is not in operation as scheduled in Table 2.2 and assuming it will only run 80 percent of the time during occupied hours.

4.6.5 Rice Garden and S'Barro's Kitchen Hoods (EF-13A)

This fan serves two hoods in Rice Garden and one in S'Barro's. The two hoods in Rice garden are listed hoods made by Aerolator model number A81. That hood appears to be no longer made and we were unable to locate a listing airflow for that model. There was no tag on the hood in S'Barro's. There was no airflow data on the drawings for these hoods. None of these three hoods meets the airflow required for an unlisted hood given the duty rating for which they are being used. The two Aerolator hoods don't even meet the airflow on their equipment tag (2,625 CFM) which should have been based on duty rating of their original application. Additionally, the measured total fan airflow of 4,253 CFM is well short of the design fan airflow of 6,200 CFM. No fan static pressures were reported for this fan on the measurements done by BPI. The current airflow does meet the 500 fpm minimum velocity rule, and we are unaware of any hood capture complaints, so we are recommending keeping the existing fan and attempting to speed it up to improve the situation as much a possible with the existing fan. Assuming the ductwork was constructed of the gauge sheet metal required for grease ducts, there should be no problem with increasing the static pressure on the fan. The BPI measurement of motor shows it is only loaded to 5.4 Amps and it is rated for 6.7 Amps. If the fan was reshived to speed it up, you could expect to get up to 5,200 CFM using the existing motor size.

Our recommendation for this fan is to reshive the fan if possible to get as much airflow out of it as possible without overloading the motor. Our recommendation for the controls is to add a variable speed demand control system with heat sensors and optical sensors as described in section 4.4.. The new control system should also be connected to a DDC controller to schedule the exhaust fan to start and run during the normal hours of use. The system should be left in auto for the remainder of the time so that if kitchen equipment is started, it will trigger the exhaust system to start.

The energy savings in Section 5 are based on shutting this fan down according to the hours of operation in Table 2.2 and an assuming the average demand control turndown will approximately offset the increased peak airflow.

4.6.6 S'Barro's Kitchen Hood (EF-14)

This fan serves only one hood which has no tag and was assumed to be unlisted. When BPI did their airflow testing for this project they found EF-14 was running backwards. BPI corrected the rotation and nearly doubled the airflow to 1,478 CFM. This is still well short of the 2,400 CFM required for the duty rating of the hood or 2,870 CFM design airflow of the fan. Additionally the duct velocity of 441 fpm as indicated in table 4.2 is lower than the code minimum of 500 fpm. The airflow to this hood should be increased to meet the code duct velocity requirements. The measurements done by BPI indicate that the existing motor is insufficient to provide the required airflow. Although we are unaware of any hood capture complaints, because a new fan must be installed anyway, the new fan should be capable of the code required hood exhaust rate. We recommend the fan be replaced with one capable of 2,400 CFM at 2.8 in. of static.

Our recommendation for the controls is to add a variable speed demand control system with heat sensors and optical sensors as described in section 4.4.2. The new control system should also be connected to a DDC controller to schedule the exhaust fan to start and run during the normal hours of use. The system should be left in auto for the remainder of the time so that if kitchen equipment is started, it will trigger the exhaust system to start.

The energy savings in Section 5 are based on shutting this fan down according to the hours of operation in Table 2.2 and an assuming the average demand control turndown will approximately offset the increased peak airflow.

4.6.7 Crepe Delicious and Sushi San Kitchen Hoods (EF-22)

This fan serves two hoods (one in each vendor). Neither hood has a tag so both were assumed to be unlisted. The hood in Crepe Delicious meets the design airflow listed on the drawings which would be acceptable if it had light duty appliances under it (1,600 CFM), however the 1,643 CFM measured airflow is well short of the 2,400 CFM required for the medium duty appliances being used under it. The hood in Sushi San was the one hood with the proper design airflow shown on the drawing, however at a measured airflow of 1,796 CFM it is well short of the required 3,200 CFM. Neither hood meets the airflow required for an unlisted hood given the duty rating for which it is being used. The total fan airflow of 3,438 CFM is well below the design of 4,900 CFM. In order to meet the code required hood airflows, Crepe Delicious and Sushi San hoods would need to be increased by a factor of 1.46 and 1.78 respectively. The higher of the two ratios should be used to meet code for both hoods which would mean 6,120 CFM at 5.5 in. of static. The current airflow does meet the 500 fpm minimum velocity rule, and we are unaware of any hood capture complaints, so we are recommending keeping the existing fan and attempting to speed it up to improve the situation as much a possible with the existing fan. Assuming the ductwork was constructed of the gauge sheet metal required for grease ducts, there should be no problem with increasing the static pressure on the fan. The BPI measurement of motor shows it is only loaded to 4.2 Amps and it is rated for 5.4 Amps. If the fan was reshived to speed it up, you could expect to get up to 4,500 CFM using the existing motor size.

Our recommendation for this fan is to reshive the fan if possible to get as much airflow out of it as possible without overloading the motor. Our recommendation for the controls is to add a variable speed demand control system with heat sensors and optical sensors as described in section 4.4.2. The new control system should also be connected to a DDC controller to schedule the exhaust fan to start and run during the normal hours of use. The system should be left in auto for the remainder of the time so that if kitchen equipment is started, it will trigger the exhaust system to start.

The energy savings in Section 5 are based on shutting this fan down according to the hours of operation in Table 2.2 and an assuming the average demand control turndown will approximately offset the increased peak airflow.

5. Potential Energy Savings and Simple Payback

The energy savings and energy cost savings for all the modifications recommended in Sections 3 and 4 are summarized in Tables 5.1 and 5.2 respectively. In order to provide a more conservative result that can be related to current utility bills, where available, the existing measured airflows were used as the baseline. For the variable speed demand control exhaust hoods, it was assumed that the fans that were recommended to be increased in airflow, the demand control would allow it to turn down to the approximately the current exhaust rate during occupied hours. For the main kitchen fan EF-3 we assumed an average turndown to 80 percent fan speed during occupied hours.

Table 5.1 Energy Calculation Results Summary

Fan Tag	*Serves*	*Annual Heating Savings (lbs. steam)*	*Annual Cooling Savings (kBtu Chilled Water)*	*Annual Electric Savings (kWh)*
EF-1	Einstein Bros. Bagels	140,830	35,399	1,165
EF-3	Main Kitchen Chick-Fil-A	2,008,839	633,114	1,674
EF-10	Bowling Alley	1,574,016	689,696	2,542
EF-11	NE Locker Rooms	129,430	26,260	424
EF-12	Bakery Hood Experimental Kitchen	1,421,242	622,754	2,542
EF-13	Main Kitchen Dishwasher	67,791	29,705	763
EF-13A	Rice Garden S'Barro's	581,017	180,974	1,589
EF-14	S'Barro's	201,915	62,892	1,589
EF-16 EF-17 EF-18	Mechanical Room 88	482,720	31,516	1,417
EF-22	Crepe Delicious Sushi San	417,862	113,568	1,377
Total		**7,025,662**	**2,425,878**	**15,082**

Table 5.2 Energy Cost Calculation Results Summary

Fan Tag	*Serves*	*Annual Heating Savings*	*Annual Cooling Savings*	*Annual Electric Savings*	*Annual Total Savings*
EF-1	Einstein Bros. Bagels	$2,477	$592	$87	$3,156
EF-3	Main Kitchen Chick-Fil-A	$35,335	$10,579	$125	$46,040
EF-10	Bowling Alley	$27,687	$11,525	$190	$39,401
EF-11	NE Locker Rooms	$2,277	$439	$32	$2,747
EF-12	Bakery Hood Experimental Kitchen	$25,000	$10,406	$190	$35,595
EF-13	Main Kitchen Dishwasher	$1,192	$496	$57	$1,746
EF-13A	Rice Garden S'Barro's	$10,220	$3,024	$119	$13,363
EF-14	S'Barro's	$3,552	$1,051	$119	$4,721
EF-16 EF-17 EF-18	Mechanical Room 88	$8,491	$527	$106	$9,123
EF-22	Crepe Delicious Sushi San	$7,350	$1,898	$103	$9,351
Total		**$123,581**	**$40,536**	**$1,125**	**$165,243**

The OPCC plus the chilled water capacity charge for all of the changes listed in Sections 3 and 4 is approximately three hundred fifty-eight thousand dollars ($358,000). A breakdown of the OPCC is provided in Appendix C.

With the anticipated total energy cost savings of approximately one hundred sixty-five thousand dollars ($165,000) per year, the resulting simple payback for all the recommended modifications is calculated to be 2.2 years.

6. Recommendations

We are recommending that an energy efficiency project be undertaken with the specific recommendations made in Sections 3 and 4 of this report, of which the major items are summarized here:

- Permanently decommission fans EF-10 (bowling alley), and EF-12 (bakery hood).
- Replace EF-16, EF-17, and EF-18 with a chilled water fan coil system for conditioning Mechanical Room 88.
- Add DDC controls to enable EF-1 (Einstein Bros. Bagels) and EF-11(NE Locker Rooms) to run on a programmable schedule.
- Interlock EF-13 to the dishwasher to run only when the dishwasher runs, including a 30 minute delay off timer.

- Add variable speed demand controls to the kitchen hoods served by EF-3, 13A, 14, and 22 (Main kitchen and vendors) and provide a programmable schedule via a DDC controller. Upgrade the main kitchen makeup air handling unit (SF-14) controls to variable airflow. EF-14 needs to be replaced and the others will have the motor replaced.

The recommended construction schedule is April 2014 to August 2013, which is shown in Appendix D. We are recommending the scope be completed in a single project. Although we understand the potential funding may be released during two separate fiscal years, it is also our understanding that all of the funding will be available within the recommended schedule of the project.

A number of code deficiencies were identified within the kitchen exhaust systems, and these are summarized in Section 4.5. These deficiencies include inadequate hood airflows, improper duct type for grease exhaust, improper sloping of ducts for grease drainage, and a lack of the required fire rated enclosures or wraps on the existing grease ducts. We are not aware of any complaints about inadequate hood capture, so the recommendations in this study have aimed to maintain or improve the exhaust rates with the existing equipment. EF-14 should be replaced by this project because it does not currently provide the code minimum duct velocity that is intended to minimize grease buildup. The other deficiencies identified relate to fire safety in the event that a grease fire that spreads in the exhaust ductwork. The correction of these deficiencies is not included in the recommended energy efficiency project; however we recommend that they be addressed under a separate project.

7. References

ANSI/ASHRAE Standard 154-2011. Ventilation for Commercial Cooking Operations.

International Code Council. (2006). 2006 International Mechanical Code.

Appendix A

Kitchen Equipment Duty Ratings from ANSI/ASHRAE 154-2011

TABLE 1 Type II Hood Requirements by Appliance Description

Appliance Description	Size	Hood Not Required[a,b]	Type II Hoods[a]	
			Light Duty	Medium Duty
Cabinet, holding, electric	All	•		
Cabinet, proofing, electric	All	•		
Cheese-melter, electric	All	•		
Coffee maker, electric	All	•		
Cooktop, induction, electric	All	•		
Dishwasher, under-counter, electric	All	•		
Dishwasher, powered sink, electric	All	•		
Drawer warmer, 2 drawer, electric	All	•		
Egg cooker, electric	All	•		
Espresso machine, electric	All	•		
Grill, panini, electric	All	•		
Hot dog cooker, electric	All	•		
Hot plate, countertop, electric	All	•		
Ovens, conveyor, electric	< 6 kW	•		
Ovens, microwave, electric	All	•		
Ovens, warming, electric (add temperature)	All	•		
Popcorn machine, electric	All	•		
Rethermalizer, electric	All	•		
Rice cooker, electric	All	•		
Steam table, electric	All	•		
Steamers, bun, electric	All	•		
Steamer, compartment atmospheric, countertop, electric	All	•		
Steamer, compartment pressurized, countertop, electric	All	•		
Table, hot food, electric	All	•		
Toaster, electric	All	•		
Waffle iron, electric	All	•		
Cheese-melter, gas	All		•	
Dishwasher, conveyor rack, chemical sanitizing	All		•	
Dishwasher, conveyor rack, hot water sanitizing	All		•	
Dishwasher, door-type rack, chemical sanitizing	All		•	
Dishwasher, door-type rack, hot water sanitizing	All		•	
Kettle, steam jacketed, tabletop, electric, gas and direct steam	< 20 gallons		•	
Oven, convection, half-size, electric and gas (non-protein cooking)	All		•	
Pasta cooker, electric	All		•	
Rethermalizer, gas	All		•	
Rice cooker, gas	All		•	
Steamer, atmospheric, gas	All		•	
Steamer, pressurized, gas	All		•	
Steamer, atmospheric, floor-mounted, electric	All		•	
Steamer, pressurized, floor-mounted, electric	All		•	
Kettle, steam-jacketed floor mounted, electric, gas, and direct steam	< 20 gallons		•	
Pasta cooker, gas	All			•
Smoker, electric and gas, pressurized	All			•
Steam-jacketed kettle, floor mounted, electric and gas	≥ 20 gallons			•

[a] A hood shall be provided for an electric appliance if it produces 3.1 × 10^{-7} lb/ft^3 (5 mg/m^3) of grease or more when measured at 500 cfm (236 L/s). See Section 4.2.1.

[b] Where hoods are not required, the additional heat and moisture loads generated by such appliances shall be accounted for in the sensible and latent loads for the HVAC system.

TABLE 2 Type I Hood Requirements by Appliance Type

Appliance Description	Size	Type I Hoods			
		Light Duty	Medium Duty	Heavy Duty	Extra-Heavy Duty
Braising pan/tilting skillet, electric	All	•			
Oven, rotisserie, electric and gas	All	•			
Oven, combination, electric and gas	All	•			
Oven, convection, full-size, electric and gas	All	•			
Oven, convection, half-size, electric and gas (protein cooking)	All	•			
Oven, deck, electric and gas	All	•			
Oven, mini-revolving rack, electric and gas	All	•			
Oven, rapid cook, electric	All	•			
Oven, rotisserie, electric and gas	All	•			
Range, discrete element, electric (with or without oven)	All	•			
Salamander, electric and gas	All	•			
Braising pan/tilting skillet, gas	All		•		
Broiler, chain conveyor, electric	All		•		
Broiler, electric, under-fired	All		•		
Conveyor oven, electric	≥ 6 kW		•		
Conveyor oven, gas	All		•		
Fryer, doughnut, electric and gas	All		•		
Fryer, kettle, electric and gas	All		•		
Fryer, open deep-fat, electric and gas	All		•		
Fryer, pressure, electric and gas	All		•		
Griddle, double-sided, electric and gas	All		•		
Griddle, flat, electric and gas	All		•		
Range, cook-top, induction	All		•		
Range, open-burner, gas (with or without oven)	All		•		
Range, hot top, electric and gas	All		•		
Broiler, chain conveyor, gas	All			•	
Broiler, electric and gas, over-fired (upright)	All			•	
Broiler, gas, under-fired	All			•	
Range, wok, gas and electric	All			•	
Appliances using solid fuel (wood, charcoal, briquettes, or mesquite) to provide all or part of the heat source for cooking	All				•

TABLE 3 Minimum Overhang Requirements for Type II Hoods

Type of Hood	End Overhang	Front Overhang	Rear Overhang
Wall-mounted canopy	6 in. (152 mm)	12 in. (305 mm)	N/A
Single-island canopy	12 in. (305 mm)	12 in. (305 mm)	12 in. (154 mm)
Double-island canopy	12 in. (305 mm)	12 in. (305mm)	N/A
Eyebrow	N/A	12 in. (305 mm)	N/A
Backshelf/proximity/pass-over	6 in. (152 mm)	10 in. (254 mm) (setback)	N/A

N/A = not applicable

Appendix B

Existing Kitchen Equipment, Duty Ratings, and Required Exhaust Rates

			EF-3					EF-12		EF-13A			EF-14	EF-22		EF-1
			Hood 1	Hood 2	Hood 3	Hood 4	Hood 5	Hood 1	Hood 2	Hood 1	Hood 2	Hood 3	Hood 1	Hood 1	Hood 2	Hood 1
			Main Kitchen	Main Kitchen	Main Kitchen	Chick-Fil-A	Chick-Fil-A	Bakery Hood	Exp. Kitchen	Rice Garden	Rice Garden	Sborro	Sborro	Crepe de licious	Sushi San	Einstein Bros. Bagels
		Notes		Hood is 5' longer than design plan calls for.	Hood is 5' longer than design plan calls for.	**Ductwork outside of vendor area not constructed as grease duct. Should not be used as Type I hood.**		Not in Use	Not in Use	Tag Lists 2625 CFM				**Ductwork not constructed as grease duct. Should not be used as Type I hood.**		**Type II Hood Ductwork not constructed as grease duct.**
Appliance Types by Duty Category																
Light Duty (400°F)	Electric or Gas	Ovens (including standard, bake, roasting, revolving, retherm, convection/steamer, conveyor, deck, or deck-style pizza, Pastary)	X				X			X		X				
		Steam-jacket kettles			X											
		Compartment steamers (both pressure and atmospheric)	X		X								X			
		Cheesemelters														
		Rethermalizers														
Medium Duty (400°F)	Electric	Discrete element ranges (with or without oven)														
	Electric or gas	Hot-top ranges					X						X			
		Griddles		X			X							X		
		Double sided griddles					X									
		Fryers (including open deep-fat fryers, donut fryers, kettle fryers, pressure fryers)		X		X	X			X				X	X	
		Pasta cookers														
		Conveyor (pizza) ovens														
		Tilting skillets/braising pans														
		Rotisseries														
Heavy Duty (600°F)	Gas	Open-burner ranges (with or without oven)		X								X			X	
	Electric or Gas	Gas underfired broilers														
		Chain (conveyor) broilers														
		Wok ranges								X	X					
		Overfired (upright)salamander broilers														
Extra-heavy duty (700°F)		Appliances using solid fuel such as wood charcoal, briquettes, and mesquite to provide all or part of the heat source for cooking														
Hood Type and Airflow Requirements																
Hood Manufactuer, Model #						Captive Air SND-2	Captive Air SND-2			Aerolator A81	Aerolator A81				-	Captive Aire 4824 VH1
		Style (wall-mounted canopy, single-island, double -island, eyebrow, back shelf/proximity/pass-over	Double Island Canopy	Double Island Canopy	Wall Canopy	Wall Canopy	Wall Canopy			Wall Canopy	Wall Canopy	Wall Canopy	Wall Canopy	Wall Canopy	Wall Canopy	Wall Canopy
Type of Hod																Type II
		Listed or Unlisted	Unlisted	Unlisted	Unlisted	Listed	Listed			Listing Data Unavailable	Listing Data Unavailable	Unlisted	Unlisted	Unlisted	Unlisted	Listed
Cooking Equipment Category per Currently Installed Equipment			Light Duty	Heavy Duty	Light Duty	Medium Duty	Medium Duty	N/A	N/A	Heavy Duty	Heavy Duty	Heavy Duty	Medium Duty	Medium Duty	Heavy Duty	Light Duty Type II Hood
Hood Width (FT)			24	24	48	4	8			8	8	8	8	8	8	4
Minimum Exhaust Flow rate, cfm per linear floot of hood (per International Mechanical Code if unlisted, or per the listing)			500	800	200	228	228			400	400	400	300	300	400	100
Code Required Airflow (CFM) for current installed equipment			**12000**	**19200**	**9600**	**912**	**1824**	**Not in Use**	**Not in Use**	**3200**	**3200**	**3200**	**2400**	**2400**	**3200**	**400**
Measured Airflow (CFM) per testing done by BPI Testing LLC report dated 1/24/2013			**6055**	**5616**	**6063**	**657**	**1449**	**6584**	**Not Measured**	**1902**	**1491**	**859**	**1478**	**1643**	**1796**	**Not Measured**
Origonal Design (CFM) listed on the drawings whre available			**12760**	**9500**	**6900**	**No Drawings**	**No Drawings**	**8550**	**750**	**Not on Drawng**	**Not on Drawng**	**Not on Drawng**	**Not on Drawng**	**1600**	**3200**	
Exhsut defficiency (code required CFM - measured CFM)			5945	13584	3537	255	375			1298	1709	2341	922	757	1404	
% of code required exhaust (Measured CFM/code required CFM)			50%	29%	63%	72%	79%			59%	47%	27%	62%	68%	56%	

Appendix C

Opinion of Probable Construction Cost (OPCC)

Conceptual Level Opinion of Probable Construction Cost (OPCC)

General Exhaust Work (EF-10, 11, 16, 17, 18):	
Shut down fans, tag appropriately (EF-8, 9, 10)	$300
DDC scheduling control and new starter for EF-11	$3,000
Demolish fans EF-16, 17, 18	$2,000
Chilled Water FCU system for Mechanical Room 88	$40,000
Insulate Steam Pipe in Mechanical Room 88	$3,000
Kitchen Exhausts Work (EF-1, 3, 12, 13, 13A, 14, 22):	
Controllers (4 x $2,085)	$8,340
Control Pads (4 x $393)	$1,572
Optic Sensors (13 x $1,280)	$16,640
Heat Sensors (30 x $109)	$3,270
Cabling Allowance	$2,000
VFD's for 4 fans	$10,500
Labor and Install for Hood Controls (material x 1.5 for difficulty and overtime)	$63,483
DDC controls for scheduling of 4 fans+ VFD points+ Integration or Custom Programing	$29,000
VFD and DDC controls for SF-14	$56,000
New exhaust fan for EF-14	$4,000
Premium Efficient Inverter Duty Motors for EF-3, EF-14, EF-22 and reshiving	$4,500
DDC scheduling control and new starter for EF-1	$3,000
Shut down fan, tag appropriately (EF-12)	$100
Interlock dishwasher exhaust fan EF-13 to dishwasher with 30 min delay off	$4,000
General Work	$10,000
Asbestos Abatement Allowance	$10,000
Sub Total:	**$274,705**
Design Contingency (10%)	$27,471
General Conditions and OH&P (12%)	$32,965
Total Opinion of Probable Construction Cost:	***$335,141***
Recommended Allowance for Chilled Water Capacity Charge (10 tons):	***$22,800***
Total OPCC and Chilled Water Charge:	***$357,941***

The Conceptual Level OPCC was developed for the recommended alterations to the building HVAC systems. The OPCC is intended only as a conceptual level order of magnitude cost and should only be used for budgetary purposes. Many factors will influence the overall project cost, including, but not limited to, the economic climate within the construction industry, unforeseen conditions, and the final extent and limit of the required alterations revealed during construction.

Appendix D

Recommended Construction Schedule

Recommended Project Schedule

	Start	Finish
PSC Contract – Design & CA	6/10/13	7/8/13
Schematic Design / Design Development	7/8/13	8/30/13
50% Construction Documents	9/2/13	10/16/13
95% Construction Documents	10/17/13	12/2/13
100% Construction Documents	12/3/13	12/9/13
Bidding and Negotiating Phase	12/10/13	03/20/14
Construction Phase	3/21/14	8/15/14

Appendix E

Pre-Test Measurement Report
Done by BPI Testing, LLC 1/24/13

BPI TESTING, LLC

Ph: 309-663-1500 (800) 347-6315
Fax: 309-663-8075
email: bpi@bpi1llc.com
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Cover Page

FIRM: **BPI Testing, LLC**
2911 Gill St.
Suite 1A
Bloomington, IL 61704
PHONE: 309-663-1500
FAX: 309-663-8075

PROJECT: **Illini Union Exhaust Hood Pre-test**

,

DATE: 1/24/2013 **PROJECT #:** 2986
CONTACT: Chad Eichelberger

NOTES:

BPI Testing, LLC
NEBB
JOHN A. BRUE, P.E.
CERTIFICATION
2850
Exp. 3/31/13
Air and Hydronic Systems

ILLINOIS STATE SMACNA
SMARTA CERTIFIED
Contractor# SM101
Tech# 752
EXPIRES 7-30-2013

Air Contractor University of Illinois

REVIEWED
By Chad at 2:43 pm, 1/24/13

INSTRUMENT LIST

	Function	Range	Accuracy	Resolution	Manufacturer	Model#	Serial#	Calibration Date
A	Humidity Measurement	0 to 100% RH	+/-2% of RH	0.1%RH	Extech	RH390	11115138	3/6/2012
A	Air Volume Measurement	25 to 2500cfm	+/-3% of reading	1 cfm	Shortridge	ADM-860C	M12467	7/31/2012
A	Pitot Tubes				Dwyer	Series 160	18" & 24"	
H	Hydronic Pressure Measurement	0 to 250psi	+/-2% of reading	0.1psi	Shortridge	HDM250	W10103	7/26/2012
H	Hydronic Differential Pressure Measurement	0 to 250psi	+/-2% of reading	0.1psi	Shortridge	HDM250	W10103	7/26/2012
A,H	Rotation Measurement	0.5 to 19999rpm	+/-0.05%	0.01rpm	Extech	461995	Q675292	10/8/2012
	Temperature Measurement							
A	Air	-67 to 250degF	+/- 0.5degF	0.1degF	Shortridge	ADT-442	M12467 ki	7/31/2012
H	Immersion	-67 to 250degF	+/- 0.5degF	0.1degF	Shortridge	ADT-442	M12467 ki	7/31/2012
A,H	Electrical Measurement	0 to 600.0V; 0 to 600A	+/-2% of reading	0.1V&0.1A	Fluke	902	18940299	3/5/2012
A	Air Pressure Measurement	0.0001 to 60 in wc	+/-2% of reading	0.0001 in wc	Shortridge	ADM-860C	M12467	7/31/2012
A	Air Velocity Measurement	25 to 29000fpm	+/-3% of reading	7 fpm	Shortridge	ADM-860C	M12467	7/31/2012

TABLE OF CONTENTS

Fan Unit

PROJECT: Illini Union Exhaust Hood Pre-test
LOCATION: ,
PROJECT #: 2986

DATE: 1/24/2013
CONTACT: Chad Eichelberger

SYSTEM/UNIT: 13A

AREA: Rice Garden

Unit Data

Fan Manufacturer	Greenheck
Fan Model Number	Cube-300-20-G
Fan Serial Number	97K08565

Test Data

Actual Fan RPM	649 RPM
Actual Motor RPM	1745 RPM
Motor Volts T1-T2	207 Volts
Motor Volts T2-T3	207 Volts
Motor Volts T1-T3	207 Volts
Motor Amps T1	5.40 Amps
Motor Amps T2	5.30 Amps
Motor Amps T3	5.40 Amps

Motor Data

Motor Manufacturer	Marathon
Motor HP	2 est. HP
Motor RPM	1725 RPM
Motor Rated Volts	230 Volts
Motor Phase	3
Motor Hertz	60 Hz
Motor FL Amps	6.70 Amps
Motor Service Factor	1.15

Sheave Data

Motor Sheave Model	AK44
Motor Sheave Diam.	4.0 in.
Motor Sheave Bore	3/4 in.
Fan Sheave MFG	AK104
Fan Sheave Diam.	10.0 in.
Fan Sheave Bore	1 in.
Number of Belts	1
Belt Size	??
Sheave Center Line	9.5 in.

*** Notes**

13A	24-Jan-13	Chad Eichelberger	Was asked not to turn fan off. Motor ID is hard to read estimated HP.

SYSTEM/UNIT: EF-03

AREA: Main Kitchen/Chik Fill-a

Unit Data

Fan Manufacturer	American Standard
Fan Model Number	Size 542
Fan Serial Number	542-11

Test Data

Actual Fan RPM	609 RPM
Actual Motor RPM	1770 RPM
Motor Volts T1-T2	484 Volts
Motor Volts T2-T3	484 Volts
Motor Volts T1-T3	484 Volts
Motor Amps T1	22.50 Amps
Motor Amps T2	22.80 Amps
Motor Amps T3	23.20 Amps
Suction SP	-2.10 in. wc
Discharge SP	0.34 in. wc
Actual ESP	2.44 in. wc

Motor Data

Motor Manufacturer	US Electric
Motor Frame	284T
Motor HP	25 HP
Motor RPM	1765 RPM
Motor Rated Volts	460 Volts
Motor Phase	3
Motor Hertz	60 Hz
Motor FL Amps	31.50 Amps
Motor Service Factor	1.25

Sheave Data

Motor Sheave Model	2BK90
Motor Sheave Diam.	8.4 in.
Fan Sheave MFG	STA 245
Fan Sheave Diam.	25 in.
Number of Belts	2
Belt Size	B175
Sheave Center Line	59.75 in.

*** Notes**

EF-03	24-Jan-13	Chad Eichelberger	Was asked not to turn fan off. Sheave sizes and RPMs estimated.

Fan Unit

PROJECT: Illini Union Exhaust Hood Pre-test
LOCATION: ,
PROJECT #: 2986

DATE: 1/24/2013
CONTACT: Chad Eichelberger

SYSTEM/UNIT: EF-12

AREA: Bakery Hood

Unit Data

Fan Manufacturer	American Standard

Test Data

Actual Fan RPM	882 RPM
Actual Motor RPM	1765 RPM
Motor Volts T1-T2	234 Volts
Motor Volts T2-T3	233 Volts
Motor Volts T1-T3	234 Volts
Motor Amps T1	6.40 Amps
Motor Amps T2	6.60 Amps
Motor Amps T3	6.60 Amps
Suction SP	-0.81 in. wc
Discharge SP	0.30 in. wc
Actual ESP	1.11 in. wc

Motor Data

Motor Manufacturer	Toshiba
Motor Frame	182T
Motor HP	3 HP
Motor RPM	1755 RPM
Motor Rated Volts	230 Volts
Motor Phase	3
Motor Hertz	60 Hz
Motor FL Amps	7.60 Amps
Motor Service Factor	1.15

Sheave Data

Motor Sheave Model	AK54H
Motor Sheave Diam.	5.0 in.
Motor Sheave Bore	H 1 1/8 in.
Fan Sheave MFG	AK104
Fan Sheave Diam.	10.0 in.
Number of Belts	1
Belt Size	A62
Sheave Center Line	19.75 in.

*** Notes**

EF-12	24-Jan-13	Chad Eichelberger	Filters are dusty.

SYSTEM/UNIT: EF-14

AREA: Sborro

Unit Data

Fan Manufacturer	American Standard

Test Data

Actual Fan RPM	1033 RPM
Actual Motor RPM	1765 RPM
Motor Volts T1-T2	234 Volts
Motor Volts T2-T3	233 Volts
Motor Volts T1-T3	234 Volts
Motor Amps T1	2.20 Amps
Motor Amps T2	2.30 Amps
Motor Amps T3	2.20 Amps
Suction SP	-0.78 in. wc
Discharge SP	0.27 in. wc
Actual ESP	1.05 in. wc

Motor Data

Motor Manufacturer	Century
Motor Frame	HA56
Motor HP	3/4 HP
Motor RPM	1765 RPM
Motor Phase	3
Motor Hertz	60 Hz
Motor FL Amps	2.60 Amps
Motor Service Factor	1.15

Sheave Data

Motor Sheave Model	1VP44
Motor Sheave Diam.	2.8 to 3.8 (2.9) in.
Fan Sheave MFG	AK49H
Fan Sheave Diam.	4.5 in.
Fan Sheave Bore	H 1 5/16 in.
Number of Belts	1
Belt Size	2420
Sheave Center Line	15.5 in.

*** Notes**

EF-14	24-Jan-13	Chad Eichelberger	Found fan running backwards. BPI corrected.

Fan Unit

PROJECT: Illini Union Exhaust Hood Pre-test
LOCATION: ,
PROJECT #: 2986

DATE: 1/24/2013
CONTACT: Chad Eichelberger

SYSTEM/UNIT: EF-22
AREA: Crepe de licious/ Sushi San

Unit Data

Fan Manufacturer	American Standard

Test Data

Actual Fan RPM	995 RPM
Actual Motor RPM	1750 RPM
Motor Volts T1-T2	239 Volts
Motor Volts T2-T3	236 Volts
Motor Volts T1-T3	236 Volts
Motor Amps T1	3.90 Amps
Motor Amps T2	3.90 Amps
Motor Amps T3	4.20 Amps
Suction SP	-1.33 in. wc
Discharge SP	0.40 in. wc
Actual ESP	1.73 in. wc

Motor Data

Motor Manufacturer	Baldor
Motor Frame	145T
Motor HP	2 HP
Motor RPM	1740 RPM
Motor Rated Volts	230 Volts
Motor Phase	3
Motor Hertz	60 Hz
Motor FL Amps	5.60 Amps
Motor Service Factor	1.15

Sheave Data

Motor Sheave Model	BK45H
Motor Sheave Diam.	3.5 in.
Motor Sheave Bore	H 7/8 in.
Fan Sheave MFG	AK64H
Fan Sheave Diam.	6 in.
Fan Sheave Bore	H 1 7/16 in.
Number of Belts	1
Belt Size	6844
Sheave Center Line	15 in.

*** Notes**

BPI Job# 2986 **Illini Union Pre-test** **By CJ Muir** **12/12/2012 & 12/13/12**

		Traverse	Traverse	Actual	Actual	Actual	
Full Path Name	Area	Size	Area	FPM	CFM	Motor Hz	REMARK
EF-3 Hood 1	Main Kitchen	16-19.5X13.5	29.25	207	6055	60	Traverse at hood filters
EF-3 Hood 2	Main Kitchen	16-19.5X13.5	29.25	192	5616	60	Traverse at hood filters
EF-3 Hood 3	Main Kitchen	26-19.5X14	49.29	123	6063	60	Traverse at hood filters
EF-3 Hood 4	Chick-Fil-A	42x14	4.08	161	657	60	Traverse at hood filters
EF-3 Hood 5	Chick-Fil-A	100X14	9.72	149	1449	60	Traverse at hood filters
				Fan Total	19840		
EF-12	Bakery Hood	16-13.75X19.5	29.79	221	6584	60	Traverse at hood filters
				Fan Total	6584		
EF-13A Hood 1	Rice Garden	89x19	11.74	162	1902	60	Traverse at hood filters
EF-13A Hood 2	Rice Garden	89x19	11.74	127	1491	60	Traverse at hood filters
EF-13A Hood 3	Sborro	76X17.5	9.24	93	859	60	Traverse at hood filters
				Fan Total	4253		
EF-14 Hood 1 Initial	Sborro	76X17.5	9.24	54	499	60	Traverse at hood filters
				Fan Total	499		Running backwards.
EF-14 Hood 1 Final	Sborro	76X17.5	9.24	160	1478	60	Traverse at hood filters
				Fan Total	1478		BPI Corrected rotation.
EF-22 Hood 1	Crepe de licious	72.5X18.75	9.44	174	1643	60	Traverse at hood filters
EF-22 Hood 2	Sushi San	76x14	7.39	243	1796	60	Traverse at hood filters
				Fan Total	3438		

BPI Job# 2986 **Illini Union Pre-test** **By CJ Muir** **12/12/2012**

EF-3 Hood-1	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
SW	1	19.5X13.5	1.83	211	386
	2	19.5X13.5	1.83	200	366
Oven	3	19.5X13.5	1.83	206	377
	4	19.5X13.5	1.83	194	355
	5	19.5X13.5	1.83	222	406
Oven	6	19.5X13.5	1.83	235	430
	7	19.5X13.5	1.83	235	430
SE	8	19.5X13.5	1.83	235	430
NE	9	19.5X13.5	1.83	207	378
	10	19.5X13.5	1.83	280	512
Oven	11	19.5X13.5	1.83	184	336
	12	19.5X13.5	1.83	142	260
	13	19.5X13.5	1.83	210	384
Oven	14	19.5X13.5	1.83	147	269
	15	19.5X13.5	1.83	209	382
NW	16	19.5X13.5	1.83	201	367
			Average	207	379

Hood 1 Total CFM	6061

BPI Job# 2986   Illini Union Pre-test   By CJ Muir   12/12/2012

EF-3 Hood-2	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
SW	1	19.5X13.5	1.83	182	333
	2	19.5X13.5	1.83	211	386
Flat Grill	3	19.5X13.5	1.83	237	433
	4	19.5X13.5	1.83	205	375
	5	19.5X13.5	1.83	207	378
Flat Grill	6	19.5X13.5	1.83	225	411
	7	19.5X13.5	1.83	204	373
SE	8	19.5X13.5	1.83	192	351
NE	9	19.5X13.5	1.83	138	252
Gas Stove	10	19.5X13.5	1.83	145	265
	11	19.5X13.5	1.83	171	313
Tilt Grill	12	19.5X13.5	1.83	224	410
Char Grill	13	19.5X13.5	1.83	182	333
	14	19.5X13.5	1.83	195	356
Deep Fryer	15	19.5X13.5	1.83	184	336
NW	16	19.5X13.5	1.83	175	320
			Average	192	352
				Hood 2 Total CFM	5622

EF-3 Hood-3	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
West	1	19.5X14	2.03	186	378
Steam Cooke	2	19.5X14	2.03	172	349
	3	19.5X14	2.03	192	390
Steam Cooke	4	19.5X14	2.03	204	414
	5	19.5X14	2.03	239	485
Steam Cooke	6	19.5X14	2.03	236	479
	7	19.5X14	2.03	199	404
Steam Cooke	8	19.5X14	2.03	198	402
	9	19.5X14	2.03	179	364
Steam Cooke	10	19.5X14	2.03	155	315
	11	19.5X14	2.03	124	252
Steam Cooke	12	19.5X14	2.03	126	256
	13	19.5X14	2.03	113	230
Steam Cooke	14	19.5X14	2.03	125	254
	15	19.5X14	2.03	132	268
Steam Cooke	16	19.5X14	2.03	119	242
	17	19.5X14	2.03	99	201
Steam Cooke	18	19.5X14	2.03	129	262
	19	19.5X14	2.03	123	250
Steam Cooke	20	19.5X14	2.03	130	264
	21	19.5X14	2.03	117	238
Steam Cooke	22	19.5X14	2.03	148	301
East	23	19.5X14	2.03	149	303
	24	19.5X14	2.03	131	266
Oven	25	19.5X14	2.03	105	213
NE	26	19.5X14	2.03	99	201
			Average	123	250
				Hood 3 Total CFM	6492

BPI Job# 2986 **Illini Union Pre-test** **By CJ Muir** **12/13/2012**

EF-3 Hood-4	Chick-Fil-A	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	14x14	1.36	180	245
	Fryer	2	14x14	1.36	158	215
		3	14x14	1.36	145	197
				Average	161	219
					Hood 4 Total CFM	657

EF-3 Hood-5	Chick-Fil-A	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	14x16.7	1.63	109	178
	Grill	2	14x16.7	1.63	108	176
		3	14x16.7	1.63	123	201
		4	14x16.7	1.63	140	229
	Grill	5	14x16.7	1.63	198	323
		6	14x16.7	1.63	214	350
				Average	149	243
					Hood 5 Total CFM	1457
					EF-3 Total CFM	20339

EF-12 Hood		Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
	North	1	13.75X19.5	1.86	196	365
		2	13.75X19.5	1.86	151	281
		3	13.75X19.5	1.86	172	320
		4	13.75X19.5	1.86	304	566
		5	13.75X19.5	1.86	256	477
		6	13.75X19.5	1.86	233	434
	Not In Use	7	13.75X19.5	1.86	211	393
		8	13.75X19.5	1.86	194	361
		9	13.75X19.5	1.86	263	490
		10	13.75X19.5	1.86	242	451
		11	13.75X19.5	1.86	245	456
		12	13.75X19.5	1.86	224	417
		13	13.75X19.5	1.86	251	467
		14	13.75X19.5	1.86	203	378
		15	13.75X19.5	1.86	231	430
	South	16	13.75X19.5	1.86	158	294
				Average	221	411
					EF-12 Total CFM	6577

BPI Job# 2986 Illini Union Pre-test By CJ Muir 12/13/2012

EF-13A Rice Garden Hood-1		Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	22.25X19	2.94	135	396
	Stir Fry	2	22.25X19	2.94	175	514
		3	22.25X19	2.94	181	531
	Oven	4	22.25X19	2.94	155	455
				Average	162	474
					Total CFM	1905

EF-13A Hood-2	Rice Garden	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	22.25X19	2.94	110	323
	Stir Fry	2	22.25X19	2.94	120	352
		3	22.25X19	2.94	155	455
	Stir Fry	4	22.25X19	2.94	123	361
				Average	127	373
					Total CFM	1494

EF-13A Hood-3	Sborro	Filter number	Filter Size	Filter area	Actual Final FPM	Actual Final CFM
		1	19X17.5	2.31	87	201
	Gas stove	2	19X17.5	2.31	93	215
		3	19X17.5	2.31	80	185
	Oven	4	19X17.5	2.31	113	261
				Average	93	215
					Total CFM	859
					EF-13A Total CFM	4258

EF-14 Hood-1	Sborro	Filter number	Filter Size	Filter area	Actual Initial FPM	Actual Initial CFM
		1	19X17.5	2.31	42	97
	Pizza Oven	2	19X17.5	2.31	40	92
	Pizza Oven	3	19X17.5	2.31	65	150
		4	19X17.5	2.31	70	162
				Average	54	125
					Total CFM	499

Running backwards.

EF-14 Hood-1	Sborro	Filter number	Filter Size	Filter area	Actual Final FPM	Actual Final CFM
		1	19X17.5	2.31	125	289
	Pizza Oven	2	19X17.5	2.31	180	416
	Pizza Oven	3	19X17.5	2.31	170	393
		4	19X17.5	2.31	165	381
				Average	160	369

EF-14 Total CFM	1478

BPI Corrected rotation.

Fan does not have grease duct. Heat removale only.

EF-22 Hood-1	epe de licio	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	24.17X18.75	3.15	166	523
		2	24.17X18.75	3.15	191	601
		3	24.17X18.75	3.15	165	520
				Average	174	548

Total CFM	1644

EF-22 Hood-2	Sushi San	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	15.2X14	1.48	193	285
	Deep Fry	2	15.2X14	1.48	243	359
		3	15.2X14	1.48	263	389
	Stir Fry	4	15.2X14	1.48	257	380
		5	15.2X14	1.48	259	383
				Average	243	359

Total CFM	1798
EF-22 Total CFM	3442

EF-12 Hood		Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
	North	1	13.75X19.5	1.86	196	365
		2	13.75X19.5	1.86	151	281
		3	13.75X19.5	1.86	172	320
		4	13.75X19.5	1.86	304	566
		5	13.75X19.5	1.86	256	477
		6	13.75X19.5	1.86	233	434
	Not In Use	7	13.75X19.5	1.86	211	393
		8	13.75X19.5	1.86	194	361
		9	13.75X19.5	1.86	263	490
		10	13.75X19.5	1.86	242	451
		11	13.75X19.5	1.86	245	456
		12	13.75X19.5	1.86	224	417
		13	13.75X19.5	1.86	251	467
		14	13.75X19.5	1.86	203	378
		15	13.75X19.5	1.86	231	430
	South	16	13.75X19.5	1.86	158	294
				Average	221	411

EF-12 Total CFM	6577

BPI Job# 2986 Illini Union Pre-test By CJ Muir 12/13/2012

EF-13A Rice Garden Hood-1	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
	1	22.25X19	2.94	135	396
Stir Fry	2	22.25X19	2.94	175	514
	3	22.25X19	2.94	181	531
Oven	4	22.25X19	2.94	155	455
			Average	162	474
				Total CFM	1905

EF-13A Rice Garden Hood-2	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
	1	22.25X19	2.94	110	323
Stir Fry	2	22.25X19	2.94	120	352
	3	22.25X19	2.94	155	455
Stir Fry	4	22.25X19	2.94	123	361
			Average	127	373
				Total CFM	1494

EF-13A Sborro Hood-3	Filter number	Filter Size	Filter area	Actual Final FPM	Actual Final CFM
	1	19X17.5	2.31	87	201
Gas stove	2	19X17.5	2.31	93	215
	3	19X17.5	2.31	80	185
Oven	4	19X17.5	2.31	113	261
			Average	93	215
				Total CFM	859

EF-14 Hood-1	Sborro	Filter number	Filter Size	Filter area	Actual Initial FPM	Actual Initial CFM
		1	19X17.5	2.31	42	97
	Pizza Oven	2	19X17.5	2.31	40	92
	Pizza Oven	3	19X17.5	2.31	65	150
		4	19X17.5	2.31	70	162
				Average	54	125
					Total CFM	499

Running backwards.

EF-14 Hood-1	Sborro	Filter number	Filter Size	Filter area	Actual Final FPM	Actual Final CFM
		1	19X17.5	2.31	125	289
	Pizza Oven	2	19X17.5	2.31	180	416
	Pizza Oven	3	19X17.5	2.31	170	393
		4	19X17.5	2.31	165	381
				Average	160	369
					EF-14 Total CFM	1478

BPI Corrected rotation.

Fan does not have grease duct. Heat removale only.

EF-22 Hood-1	Crepe de licious	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	24.17X18.75	3.15	166	523
		2	24.17X18.75	3.15	191	601
		3	24.17X18.75	3.15	165	520
				Average	174	548
					Total CFM	1644

EF-22 Hood-2	Sushi San	Filter number	Filter Size	Filter area	Actual FPM	Actual CFM
		1	15.2X14	1.48	193	285
	Deep Fry	2	15.2X14	1.48	243	359
		3	15.2X14	1.48	263	389
	Stir Fry	4	15.2X14	1.48	257	380
		5	15.2X14	1.48	259	383
				Average	243	359
					Total CFM	1798
					EF-22 Total CFM	3442