

FACILITIES INFRASTRUCTURE STUDY

MECHANICAL SYSTEMS

For

**Milwaukee County Courthouse,
Milwaukee, WI**



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INTRODUCTION

The primary goal of this effort is to identify, rank and prioritize infrastructure projects at the Milwaukee County Courthouse. This ranking process can then be used as a basis for prioritizing and distributing capital for infrastructure upgrades.

The infrastructure identified in this report includes the air handling units and associated equipment, exhaust fans and the chilled water system(s). The work under this study did not include performing a detailed survey of all of the buildings MEP systems. However, based on cursory site surveys we were able to identify a few deficiencies, but by no means was this examination detailed or inclusive of all systems.

The expected service life information shown in the exhibit spreadsheet is based on data from the American Society of Heating, Refrigeration, and Air Conditioning Engineers Handbook (see page 13).

Each system was graded based on overall condition, using a set of consistent criteria. Letter grades of A, B, C, D and F were assigned to each system based upon the overall condition, and colors of green, yellow and red were assigned to A-B, C and D-F rated systems, respectively, to provide an easy snapshot of which systems are in good, fair or poor overall condition. A break-down by major type of system and the amount in each graded category is as follows:

<u>System Equipment</u>	<u>Total</u>	<u>Green/Good</u>	<u>Yellow/Fair</u>	<u>Red/Poor</u>
Air Handlers/HVU	7	0	4	3
CRAC's/Split	7	6	1	0
Exhaust Fans	38	9	5	24
Chillers	4	4	0	0
Cooling Towers	4	0	4	0
Pumps	21	10	11	0

Grumman/Butkus Associates (G/BA) is a professional engineering firm committed to using its best efforts in providing professional engineering services. However, due to the cursory nature of this assignment, we do not warrant that our services will disclose all defects that are within the scope of the assignment given to us. While our report is limited to the objectives and scope stated herein and inherently cannot be all-inclusive, it is intended to present fairly, in all material respects, the condition of the subject structure in conformity with generally accepted professional engineering practices. We will not be responsible for any incidental or consequential damage or loss to you arising out of our work product.

EXECUTIVE SUMMARY

Mechanical systems recommendations and suggested time frame for implementation are summarized below in the following table. Recommended time frames for correction are grouped into three categories – 0-1 year, 2-5 years and 6-10 years. Numerous other comments are incorporated throughout the report. Refer to the body and exhibits for more detailed descriptions of equipment and systems.

Mechanical Systems Deficiency & Recommended Time Frames for Correction:

Item	Budget and Time Frame (Years)			Comments
	0 – 1 (near term)	2 – 5 (mid-term)	6 -10 (long term)	
General				
Complete a training program for the BAS system use and troubleshooting	X			
Complete a building balancing and pressurization study	X			This will allow for a proper balance throughout.
Complete a retro-commissioning program for the BAS		X		This will reduce inefficiency in the operation of equipment & improve comfort.
Mechanical				
Main air handling units coiling coil replacement		X		Most frames are badly rusted out.
Replace exhaust fans that are not operating	X			
Repair/replace exhaust fans that are showing signs of deterioration		X		
Repair URN fans to operating condition	X			Reinstitute a return air path.
Replace URN fans with new.		X		
Review operation of the CRAC units in the server room.	X			Interlocks with the dry agent fire suppression system.
Insulate the chilled water pump casings.	X			
Consider installing VFD's on the chilled water pumps for balancing		X		
Cooling tower replacement		X		
Complete a steam trap survey		X		
Consider a compressed air survey		X		
Implement an equipment upgrade schedule			X	

G/BA recommends the following top five mechanical issues to be addressed:

Based on our site survey the following mechanical projects from those listed on the previous page are recommended to be undertaken in order of importance:

1. Repair cooling tower damage prior to the cooling season.
2. Replace non-functioning exhaust fans and repair others to avoid failures.
3. Re-institute the return air paths for the URN fans, start a design for replacements units.
4. Implement a schedule for the cooling coils replacement in the four (4) main air handling units.
5. Complete a building pressurization analysis, with a retro commissioning of the control systems to identify any airflow and control operation deficiencies.
 - a. Resolve key issues with repairs and replacements.

Other considerations for projects are as follows:

1. Label piping with flow direction arrows and service type.
2. Perform retro-commissioning to identify any control issues.
3. Continue a mechanical assessment of VAV boxes.
4. Consider a steam and condensate pipe study to implement control valves, rather than manual valves for comfort control.
 - a. There was indication of numerous leaks in system from facility personnel.
5. Implement a computer maintenance management system for equipment / system work order tracking.

EQUIPMENT CONDITON AND OBSERVATIONS

Main Air Handling Units (4):

There are four main custom built-up air handling units that are used to heat, cool and ventilate the courthouse. Each unit serves a quadrant through a dual duct system and VAV boxes. The main components of these units consist of a return fan, filters, supply fan, chilled water cooling coil and a steam heating coil. The distribution ductwork is routed thru the various light courts prior to entering the buildings on the respective floors.

SA-1 and SA-2 are located on the 8th floor of the building. The dampers are showing signs of age and do not close completely, thus allowing outside elements into the plenum and damage the floors. For the most part the components were in good shape, other than the cooling coils. The frames for the coils are rusted out with holes throughout. Only one (AC-1) steam coil appeared to have signs of a leak. SA-1 and SA-2 cooling coil drain lines appeared to be undersized or the traps are not sized properly, causing standing condensate inside the unit. SA-2 cooling coil has a couple of patches from a prior repair. Braces between SA-1 (discharge side of supply fan section) and the north wall were witnessed. Is there an issue with the air handling unit casing that requires bracing?

AC-3 and AC-4 are accessed from the ground floor and located in light courts. The outside air intake is located on the roof of the air handling units and the relief is ducted to above the roof line. This arrangement draws fresh air down the light court to the air handling unit. Access around the units outside is difficult due to the amount of debris and bird droppings, and should be cleaned. AC-3 and AC-4 have commercial ceiling fans installed in the plenum. These fans were installed to circulate the warm air in the plenum that results from the heating coil control valve going 100% open when the fans are off.

New VFD's were installed on the supply and return fans of air handling units, with only one motor being equipped with AEGIS rings to dissipate any stray current that may discharge through the bearings.

Recommendations:

1. These units are on a night set back schedule from 6 pm to 6am, an optimal start program may assist in the comfort of the building.
2. A program change to regulate the MAT to a set value, rather than have the heating valve go 100% open when off.
3. Replace the cooling coils in the units.
4. Increase the size of the condensate drain for cooling in SA-1 and SA-2.
5. Remove any vegetation from the insulation. Inspect surrounding insulation and repairs as needed.
6. Visually inspect duct work for any leaks and repair as found. (leaks were heard while the survey was conducted)
7. Investigate bracing of air handling unit casing to north wall.
8. Review the operation and maintenance manuals for preventative maintenance program.

Heating and Ventilation Units (3), Urn fans:

There are three smaller units that appear to be for ventilation and comfort conditioning of the main entrances. One serves the 10th street entrance (HVU-9) and two serve the east side entrances of MacArthur Square. One serves the north end (HVU-8) and one serves the south end (HVU-7). These are single skin units with steam coils with no fins and a face-bypass damper. Newer VFD's and motors are installed on the units. The filters are a 30% filter media with no great filtration properties.

HVU-7, located off the 9th street tunnel is currently turned off at the VFD due to comfort complaints of overheating. The steam is still on to the 4 coils. HVU-8 is identical to HVU-7 and located in the paint shop. The steam isolation valve is closed and the motor disconnect is off and does not appear to have been operational in awhile.

HVU-9 is located near the new substation in the basement. It has similar components to HVU-7 and 8.

While each unit has a return air path, HVU-7 and 8 have had their return ductwork cut off (see pictures). These units now return air from the location where they sit. The block wall opening where the return path was has been bricked over. The location of current pipe and duct suggests that these duct paths have been gone for awhile. Existing return grilles are seen in the entrance vestibules, however no air movement can be felt through them. The lack of a proper return air to these units will affect their operation.

HVU-9 draws return air from the electrical vault in the basement and transfer this air to the west entrance vestibule. A return duct is present on top of the unit, yet no path could be found from the ground level or any return grilles.

All of these units discharge their air through large Urns in the vestibules. It appears that there is a concern for the filtration, as the Urns have a 4" filter duct taped to the top of these urns.

Recommendations:

1. Establish a return path to the units to allow for proper operation.
2. Change out filter rack with a MERV 8 pleated filter.
3. Design and install new efficient units.
4. Review operation and maintenance manuals for preventative maintenance program.

Computer room air conditioning units (CRAC) and Mini-Split Units:

On the ground level in room G2A, there is one floor mount CRAC and four mini-split systems. Their respective condensing units are located in the light court to the south of the room on the same level. Access to the condensing units is through a window in the G1 maintenance offices. These condensing units need to be regularly cleaned due to the amount of feathers/dirt build up.

The floor mounted unit is manufactured by Liebert and is a typical stand up unit. It is in good condition and appears to be maintained. Control may be via a return air sensor inside the unit and thru the onboard controls. The BAS shows this unit interfaces thru the DDC control system for alarms and temperatures.

The four (4) Mitsubishi mini-split units are ceiling hung and controlled by their individual thermostats. These units do not appear on the BAS; therefore no alarms will be present if these fail. All these units appear to be newer and in good condition.

The room has a drop ceiling and has a supply grille and return diffuser from its corresponding quadrant SA-1 unit. This may be for pressurization and ventilation. However, there is also a clean agent fire suppression system in this room. It is unclear whether there are any dampers or control system functions to shut down units and stop air flow in the event of a release.

A newer UPS room is located in the basement and served by a newer Trane mini-split system. Its condensing unit is located in the light court above. The room has supply and return ducted to the mini-split. A large opening exists in the ceiling of the UPS room, allowing cool air to escape from the room.

A small room is located on the 9th floor (roof) containing communication equipment. A small mini-split system serves this room and is in fair condition. The room is heated in the cold months via a steam radiator.

Recommendations:

1. Incorporate an alarm point to the BAS system for the four mini-split systems to indicate a failure.
2. Investigate the controls in place in the event of a dry agent fire suppression system release. Verify that the room is isolated to contain the suppression gas when it is released.
3. Seal up the hole in the UPS room ceiling to aid in maintaining a clean cool environment for the UPS system.
4. Review operation and maintenance manuals for preventative maintenance program.

Exhaust Fans:

Areas served by exhaust fans were not verified using existing drawings or visually, however some appear to be serving bathroom exhaust risers. Most fans had a local disconnect or motor switch at the fan. Any remote breakers were not traced, therefore we were not able to determine whether these had tripped on overload if the fans were found not running. The majority of fans were not marked with any sort of identifying marks, therefore we were unable to correlate these back to the BAS system. Those that had labels are assumed to be correct.

As noted in the exhaust fan condition letter dated March 12th, 2015. (exhibit 1) ten (10) fans were running, seven (7) had their motors running with the belts broken, eight (8) were not running at all and three (3) were running, but the belts were poorly fitting/stretched and barely turning the fan. The next site visit ten more fans were found. Of these, six (6) were running and four (4) were not running.

The fans were found to be either in fair condition given their age, or poorly neglected, rusted and seized. Of the fans not running, their conditions varied from rusted out motors, seized fan shafts to broken backdraft dampers.

The kitchen has four (4) exhaust fans on the roof in the light court; two appeared to serve a hood of some sort. These two fans were extremely greasy, posing the question of when they were professionally cleaned to prevent the buildup of grease. One fan was found off due to a seized motor. It was unclear as to the use of area it serves.

A single exhaust fan was found outside a 3rd floor window and served a single grille in a room on the 2nd floor. This room is now office/file storage. Occupants indicated that at times a noise comes from the grille and occasionally water is observed dripping from the grille.

The BAS has twenty-two (22) exhaust fans listed on a screen. All showed their start/stop command as on, yet nine (9) showed status as off.

Recommendations:

1. Repair / replace any non-running units.
2. Overhaul existing running fans.
3. Label all exhaust fans, and create a floor plan or location chart of units as well as investigate the current use of all fans.
4. Consolidate fan belt sizes to reduce inventory.
5. Contract a company that is dedicated to inspection and cleaning the kitchen exhaust fans (and duct work) as dictated by Section 609 of the international Fire Code and NFPA 96.
6. Review operation and maintenance manuals for preventative maintenance program.

CHILLED WATER AND STEAM PLANT

Chillers and Cooling Towers:

The courthouse penthouse (8th floor) has four (4) Trane centrifugal chillers each served with an individual cooling tower. These chillers serve a primary/secondary chilled water system that supplies chilled water to each of the four (4) large air handling unit pumps within the penthouse.

Each of the chillers is in good condition and facility staff indicates that their condensers tubes are cleaned out on a regular basis. Some of the armaflex insulation on the chillers appears to be deteriorating and should be monitored to avoid any uninsulated rusting. All four chillers had their electrical panel unlocked and open; this should be avoided to prevent any electrical shock to personnel not trained. Chiller #1 had some discrepancies in labeling of flow through the pipes and should be relabeled.

As mentioned in an email sent March 10, 2015 (exhibit 2) to Milwaukee County.

Cooling towers 1 and 2 have the following conditions:

Interior coating has lost adhesion to the tower surface and is bubbling away from the tower. Penetration of water could result in rusting of the walls/floors. Coils and fan blades are dirty as there is also debris and scale build up on the bottom of the towers. The frames of the towers have rust showing through the paint.

Cooling towers 3 and 4 have the following conditions:

Damaged pneumatic sensors for level control, dirty coils and fan blades, debris and scale build up inside the towers. Tower #3 has some interior coating missing is badly rusting in these areas.

Recommendations:

1. Clean any debris and wash the fan blades.
2. Repair the level transmitters on CT-3 and 4.
3. Replace the belts on all fans, remove excessive grease from motors.
4. Repair CT-3 coating.
5. Repair CT-1 and 2 bubbling on coating.
6. Scrape and paint the frame work of the cooling towers.
7. Review operation and maintenance manuals for preventative maintenance program.

Pumps – Chilled and Condenser Water Pumps:

Each of the chillers has primary chilled water and a condenser water pump. The secondary system consists of three (3) chilled water pumps. Pumps 1 and 3 are sized equally and pump 2 is half the size of the others. All these pumps are constant volume that operated based on how many chillers are online. One point to note is that doesn't appear to be a balance valve on the pumps.

The general condition of these units is good. There appears to be over greasing of bearings as evidenced by the visual globs of grease below each bearing cap on the base. The motor vents are blocked with dirt and grease, thus inhibiting the flow of air through the motor. The piping is well insulated throughout the system up to the first flange of the pump. Because the pumps themselves are not insulated, rust has started to appear on the casings due to sweating in the summer months while the system is on. A couple of the pumps appear to have a pressure switch that is not piped into the system. Is this a safety switch or is it a differential pressure switch used for status?

Each of the four main air handling units have a dedicated pump with a set of chilled water control valves located in the penthouse. The insulation around the valves indicate that at some time these valves had packing leaks, with one control valve for SA-4 having a funnel in place to collect water.

Recommendations:

1. Insulate the chilled water casings to prevent further sweating and rusting.
2. Clean out vents on the motors and inspect to ensure no damage.
3. Scrape and paint the drain pans and frames that are showing signs or rust.
4. Consider retrofitting the pump motors with a VFD to aid in balancing the system.
 - a. Incorporate programming in the BAS for this as well.
5. Review operation and maintenance manuals for preventative maintenance program.

Pumps – Condensate Pumps:

SA-1 and SA-2 have new steam condensate pumps (circa 2014) in their respective penthouse. Each of these units pumps condensate to a Trane unit heater (UH) located along the outer wall. When the Aquastat sensor (set at 160°F) in the discharge pipe of the UH is tripped, the fan turns on to cool the condensate. The condensate then sits in an overflow tank until more is added and overflows to a floor drain nearby. A strap on Aquastat set at 110°F is located on the overflow pipe of the storage tank and is connected to the BAS to issue an alarm. If too hot, a manual hose bib is opened to cool the condensate as it goes down the drain. This hose is typically regulated by hand and left on at all times, whether the condensate is flowing or not.

AC-3 and AC-4 condensate drains to the basement duplex receiver and pump. At the time of survey, this unit was tripped out and overflowing to the floor and local floor drain. The discharge of this pump is to the main condensate vacuum system located in room B27.

Each of the Urn fans (HVVU-7, 8 & 9) have dedicated duplex receivers and pumps and appear to be in fair condition.

The main vacuum-condensate pump system draws back condensate from the perimeter heating system. A second vacuum-pump appears to be isolated and abandoned in place. The discharge of this system is to a large receiver in the same room. This receiver has two inline pumps which then discharge the condensate to a storm drain conductor. A third small inline pump located on the side of the receiver circulates hot condensate through a small plate and frame heat exchanger meant to transfer heat to the domestic hot water system. This pump is off and the lines are isolated.

The domestic hot water side of the heat exchanger circulates domestic hot water with a small inline pump through the plate and frame heat exchanger. This is off and isolated as well. The domestic hot water tank is supplemented with a steam tube bundle inside the tank.

Recommendations:

1. Reestablish the condensate to domestic hot water heat recovery system to recover heat from the condensate.
2. Consider adding a solenoid valve connected to the strap on Aquastat on the discharge line of the condensate overflow tank to open only when the temperature is too hot for condensate to go down the drain.
3. Consider rebuilding the secondary vacuum-condensate pump system as a backup.
4. Review operation and maintenance manuals for preventative maintenance program.

EXPECTED SERVICE LIVES

The presented expected service life of most equipment is based on data from the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Handbook. An excerpt of this data follows:

Estimates of Service Lives of Various System Components

Equipment Item	Median Years	Equipment Item	Median Years	Equipment Item	Median Years
Air conditioners		Air terminals		Air-cooled condensers	20
Window unit	10	Diffusers, grilles, and registers	27	Evaporative condensers	20
Residential single or split package	15	Induction and fan-coil units	20	Insulation	
Commercial through-the-wall	15	VAV and double-duct boxes	20	Molded	20
Water-cooled package	15	Air washers	17	Blanket	24
Heat pumps		Ductwork	30	Pumps	
Residential air-to-air	15 ^b	Dampers	20	Base-mounted	20
Commercial air-to-air	15	Fans		Pipe-mounted	10
Commercial water-to-air	19	Centrifugal	25	Sump and well	10
Roof-top air conditioners		Axial	20	Condensate	15
Single-zone	15	Propeller	15	Reciprocating engines	20
Multizone	15	Ventilating roof-mounted	20	Steam turbines	30
Boilers, hot water (steam)		Coils		Electric motors	18
Steel water-tube	24 (30)	DX, water, or steam	20	Motor starters	17
Steel fire-tube	25 (25)	Electric	15	Electric transformers	30
Cast iron	35 (30)	Heat exchangers		Controls	
Electric	15	Shell-and-tube	24	Pneumatic	20
Burners	21	Reciprocating compressors	20	Electric	16
Furnaces		Package chillers		Electronic	15
Gas- or oil-fired	18	Reciprocating	20	Valve actuators	
Unit heaters		Centrifugal	23	Hydraulic	15
Gas or electric	13	Absorption	23	Pneumatic	20
Hot water or steam	20	Cooling towers		Self-contained	10
Radiant heaters		Galvanized metal	20		
Electric	10	Wood	20		
Hot water or steam	25	Ceramic	34		

- Notes:*
1. ASHRAE makes no claims as to the statistical validity of any of the data presented in this table.
 2. Table lists base values that should be adjusted for local conditions (see the section on Service Life).
 3. For updated information on heat pump life, see Lovvorn and Hiller (2002).

Source: Data obtained from a survey of the United States by ASHRAE Technical Committee TC 1.8 (Akalin 1978).

^a See Lovvorn and Hiller (1985) and Easton Consultants (1986) for further information.

^b Data updated by TC 1.8 in 1986.

EXHIBITS

The following exhibits are:

1. Exhibit 1 – Exhaust fan condition letter.
2. Exhibit 2 – Cooling tower condition letter.
3. Exhibit 3 - Facility Assessment Data – AHU / HVU / CRAC's
4. Exhibit 4 – Facility Assessment Data – Exhaust Fans
5. Exhibit 5 – Facility Assessment Data – Chilled Water and Steam Plant
6. Exhibit 6 – Building Description

See CD for individual assessment checklists and supporting pictures.