Attachment A

Emeryville Civic Center
HVAC Retrofit Options Analysis

April 10, 2024

Prepared by
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David Heinzerling, PE, Principal

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1 Executive Summary

Taylor Engineers has completed a concept design for HVAC upgrades at Emeryville Civic Center and has prepared this report to document our findings.

HVAC equipment and control systems at Emeryville Civic Center have reached the end of their useful life, so replacement is recommended. Operational costs, thermal comfort, operations, and maintenance will be improved by completing an HVAC retrofit.

Three HVAC options were considered as part of this concept design.

- Option 1: Like-for-like replacement with a high-efficiency natural gas boiler
- Option 2: All-electric heat pump with like-kind heating capacity
- Option 3: All-electric heat pump that is "right sized" per Taylor Engineer's load calculations. Option 3 is evaluated with two sub options (option 3A and option 3B).

Rough order of Magnitude (ROM) HVAC first costs for HVAC upgrade options have been prepared and summarized in paragraph 6, and annual operation costs for HVAC upgrade options have been prepared and summarized in paragraph 7.

Any of the above retrofit options will maintain improved comfort and significantly reduce greenhouse gas emissions at this site. The all-electric options will have the lowest annual greenhouse gas emissions, though they come at a first cost and operational cost premium.

Regardless of the option chosen, we recommend that the equipment be right-sized based on our load calculations and not simply matched to the existing capacities. Oversized equipment will cycle more frequently, which leads to decreased efficiency, decreased control (comfort), and increased wear on the equipment.

Key text is highlighted in yellow and key charts are outlined in yellow.

2 Introduction

The City is interested in retrofitting the HVAC equipment and controls system at the Civic Center building. The current HVAC system design is a VAV AC packaged unit serving VAV hot water reheat terminal boxes, with hot water supplied by a non-condensing natural gas boiler. The boiler and packaged unit are at the end of their lives and require replacement.

Additionally, the City is interested in pursuing a potential conversion to an all-electric building for multiple reasons:

- Reduce greenhouse gas emissions in order to meet state-mandated carbon reduction goals.
- Provide building system resiliency in the event of gas outages or future price increases.
- Become closer to net-zero site energy by expanding the existing site photovoltaic system.

- Become a shelter site in the event of natural disasters during the winter (summer cooling is already all-electric)

This report summarizes and expands upon the following linked reports from 2012, 2019, and 2023. Additionally, the following supplemental reports from the current analysis are included as appendices in this report.

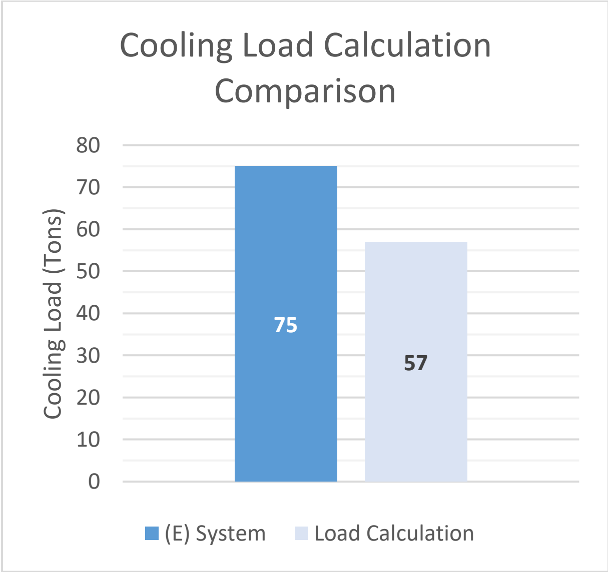
- **Appendix A:** 2024-03-05 - Emeryville HVAC Systems ROM Pricing Narrative
- **Appendix B:** Emeryville HVAC Systems ROM Price report
- **Appendix C:** 2024-03-05 - Emeryville City Hall - Pre-Design Test and Balance Summary

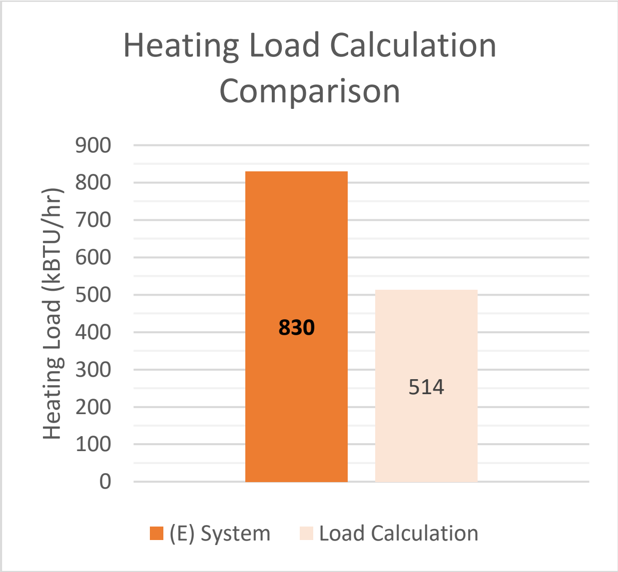
This report aims to develop Rough Order of Magnitude (ROM) pricing for first costs and operational costs to help the City make a decision regarding whether to provide an all-electric HVAC system. Structural and electrical considerations were evaluated in 2023 but were excluded in this report.

3 Existing Systems

The existing HVAC system is served by an existing packaged AC unit that supplies conditioned air to VAV reheat terminal units. Heating hot water is provided by an existing natural gas boiler. The AC unit and natural gas boiler have reached the end of their recommended useful life, so we recommend replacement. We also recommend replacing the existing control system with a modern HVAC controls and control sequences to provide energy savings and improved facility operations.

Taylor Engineers has refined load calculations prepared in 2023. Based on our calculations, the existing heating and cooling systems appear to be oversized. See below summary of existing capacities (dark bars) compared with our calculation results (light bars)





Cooling load calculations are based on a window solar heat gain coefficient of 0.75 (where 1.0 is clear glass, and 0 is an opaque wall) based on engineering experience. During our CD-level load calculations, we will further research performance data for the existing windows to refine our load calculations. Cooling loads are calculated at the Oakland Design 0.5% summer condition (84°F Dry Bulb / 64°F Coincident Wet Bulb) per Title 24 paragraph 140.4(b)3.

Heating load calculations are based on single-pane glass with a U factor of 1.0, an uninsulated concrete slab floor, and insulated walls and roof per code minimum insulation values at the time of construction. No credits are provided for heat gain from lights, plug loads, and occupants. Heating loads are calculated at the Oakland median of extremes condition (32°F Dry Bulb) per Title 24 paragraph 140.4(b)3. Taylor Engineers has reviewed existing terminal unit heating capacities and hot water flows through existing pipe. We have determined that flows can generally be increased by ~20% without exceeding our recommended pipe size criteria for acoustically sensitive spaces. For all-electric designs, our ROM cost narrative and concept design is based on increased flows and an upsized secondary pump to prevent the need to replace terminal units or piping.

Taylor Engineers engaged a Test and Balance (TAB) contractor to take readings of existing heating capacities to help resolve discrepancies between our load calculations and reports that heating issues exist with oversized equipment. TAB readings helped validate that heating issues are due to controls issues rather than insufficient capacity. The full TAB report is provided in Appendix C.

4 Base scope retrofit applicable regardless of heating system upgrade.

Our HVAC ROM cost narrative includes the following base scope. See the Appendix A for more information:

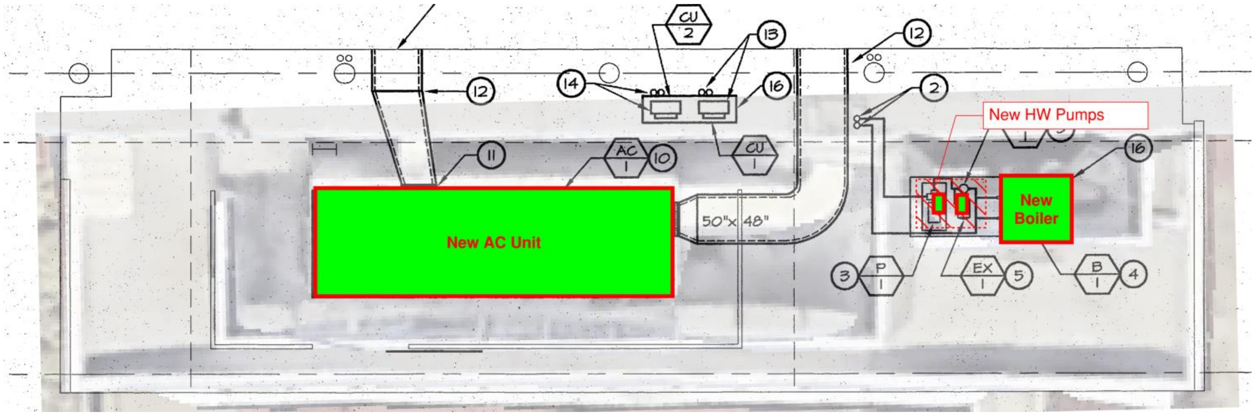
- Replace existing Packaged AC Unit
- Controls replacement for VAV boxes and new HVAC equipment
- The following add-alternates
    - Package unit supply fan array/wall upgrade.
    - VAV box hot water pipe trim upgrades
    - Add ceiling fans for comfort and destratification.
    - Additional supply grilles near the perimeter.

5 Heating retrofit options.

Three heating retrofit options are considered in this report.

5.1 Option 1: Like-for-like replacement

For Option 1, the existing boiler is replaced in-kind, with a high efficiency condensing furnace. This option will be low-cost and simple but does not provide all-electric heating and may not meet the city's sustainability and carbon emissions goals.



5.2 Option 2: All-electric 2-pipe heating-only heat pump with like-kind capacity and 160°F hot water supply temperature.

Based on Taylor Engineers review of terminal unit heating capacities and hot water flows, existing heating capacities can be maintained with 160°F hot water supply temperature. We have found an EcoGreen heat pump selection[1] that can provide 160°F hot water and like-kind heating capacity at 32°F outdoor air conditions, accounting for defrost derates. Air-to-water heat pump options are limited at this temperature resulting in significant additional costs.

Due to the recent refrigerant phaseouts, this equipment is very new/rare, and uses a reciprocating compressor unlike most conventional heat pumps. We haven't specified or commissioned this unit on any of our jobs, so this equipment is untested by us. This equipment is likely to run into more operational issues than a standard AC unit or heat pump and will likely be more difficult to hire qualified service technicians to work on it.

[1] See linked directory of Ecogreen 160°F heat pump selection
https://tayloreng.egnyte.com/fl/BvrM0aD8zh

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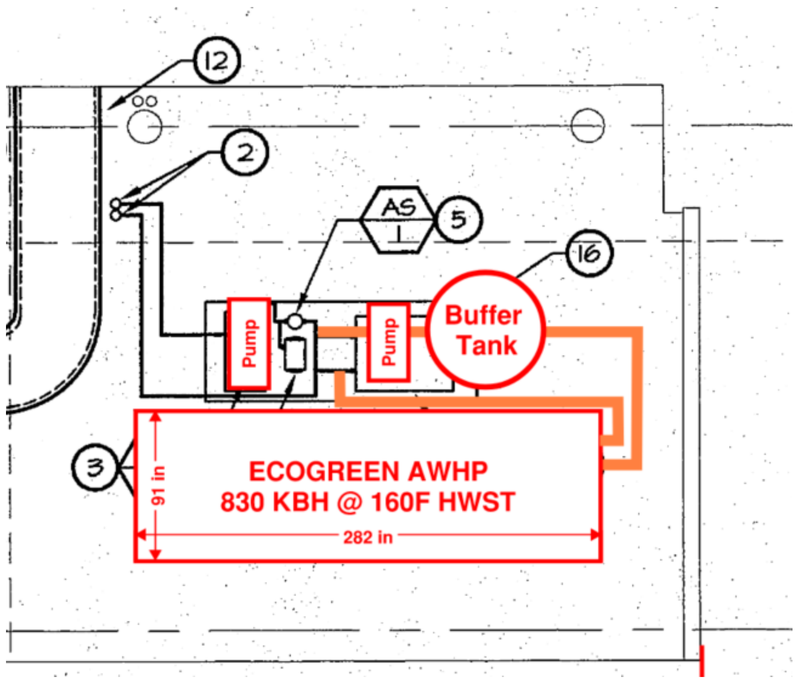
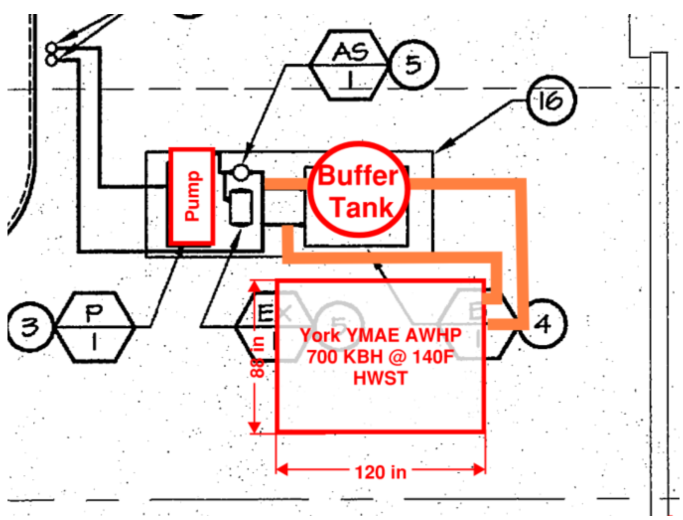


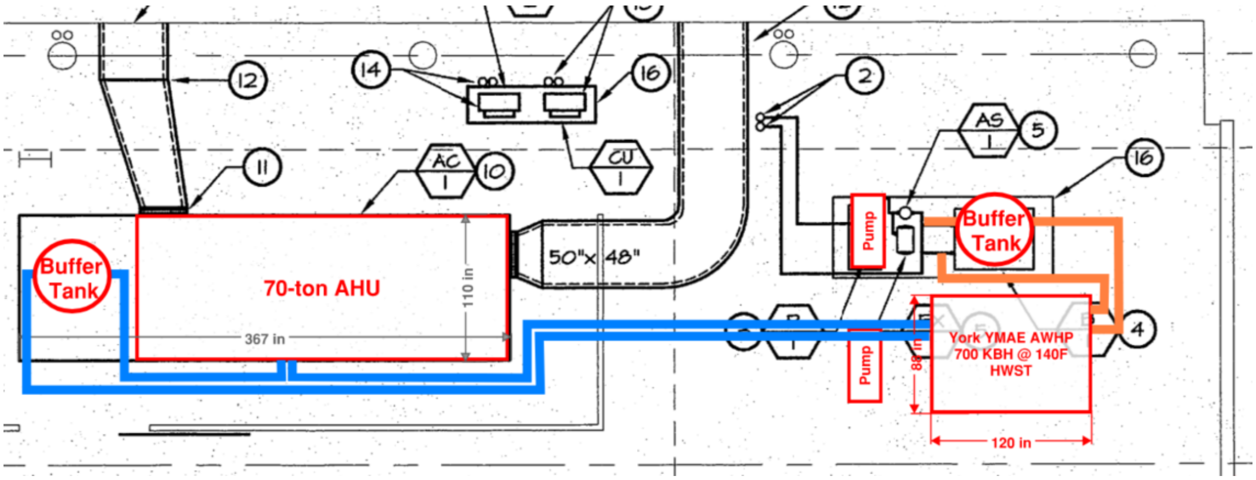
5.3 Option 3 – All-electric heat pump sized per Taylor Engineer's load calculations and 140°F hot water supply temperature.

Option 3 is the same as option 2, except sized per Taylor Engineers load calculations, which allow heat pumps to be selected to provide 140°F hot water supply temperature. 140°F HWST allows for more conventional air-to-water heat pumps to compete and results in a more affordable and efficient all-electric design. Below is product information for the York YMAE, which is the basis of our ROM cost narrative.



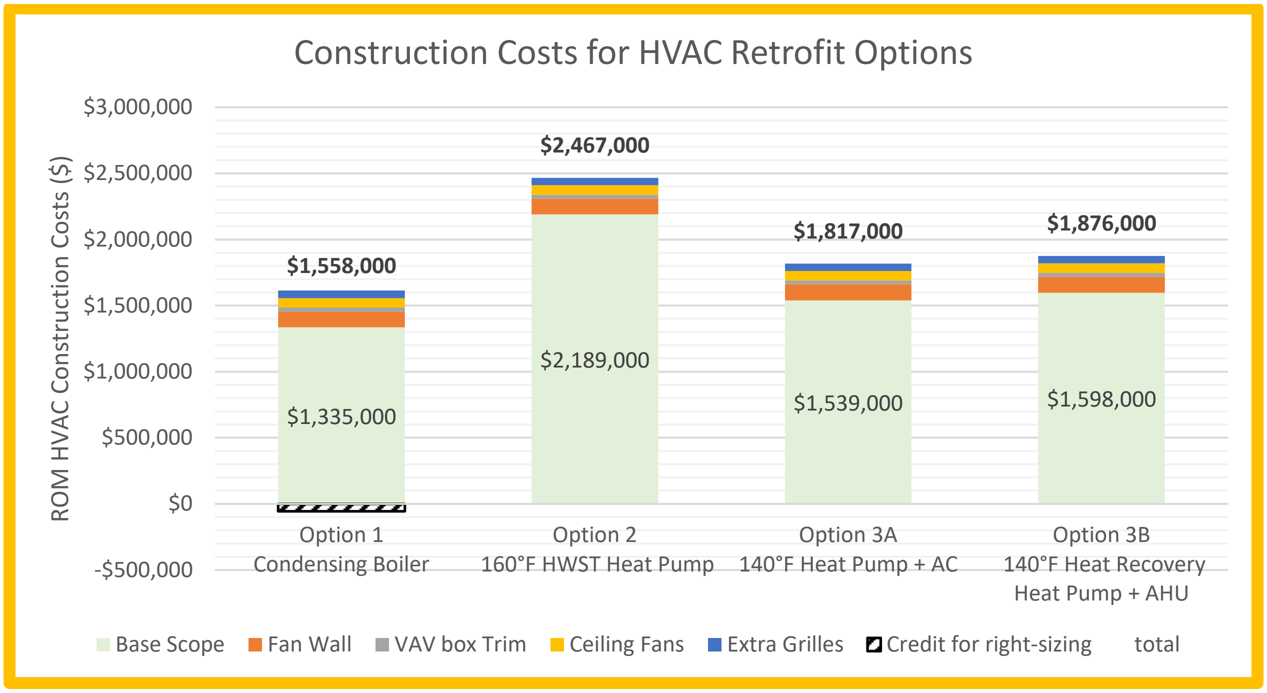
The YMAE has variable speed vapor-injected scroll compressors, which improves efficiency and part-load performance compared to most other conventional heat pumps.

As an add-alternate (called option 3B below), the York YMAE can provide simultaneous heating and cooling duty, with a custom AHU (rather than DX AC unit). This design results in some minor efficiency gains, due to the heat recovery and improved AHU controls, and lower equipment costs, since the AC unit compressors are not required. However, option 3B results in additional installation costs, controls complexity, buffer tank, and additional compressor run time (potentially shorter equipment lifespan) given the compressors are running year-round to provide both heating and cooling.



6 ROM first cost results

Western Allied Mechanical has prepared rough order of magnitude costs based on the cost narrative in Appendix A. Western Allied Mechanical's report is provided in Appendix B. Below are the results:



Base Scope	
Option 1 Condensing Boiler	$1,335,000
Option 2 160°F HWST Heat Pump	$2,189,000
Option 3A 140°F Heat Pump + AC	$1,539,000
Option 3B 140°F Heat Recovery Heat Pump + AHU	$1,598,000

Add Alternates	
Rooftop Unit Fan Wall Upgrade	$120,000
VAV box HW pipe trim replacement	$30,000
Ceiling Fans for comfort and destratification	$72,000
Extra sidewall grilles for additional perimeter airflow	$56,000
Deduct for right-sized boiler and AC unit	($55,000)

ROM costs are significantly higher than cost estimates gathered in prior feasibility studies. This is in part due to general post-pandemic inflation for most goods and services, but also due to the addition of a controls retrofit scope which was not included in prior cost estimates.

7 Rough order of magnitude (ROM) operational cost results

We re-evaluated ROM operational costs based on the following assumptions.

- Same load profile used in the 2019 report, which was based on 2017-2018 utility data. The pandemic has altered the occupancy and overall load profile of the building, so 2017-2018 pre-pandemic load profile is used.

- HVAC is 30% of electric consumption based on 2012 California Commercial End Use Survey (see appendix in 2012 report).
- 2024 utility rates shown below[2]
    - Gas Rate = $1.14 / therm
    - Winter 2024 Electricity rates as follows
        - $0.23 / kWH delivery charge plus the following generation charges
        - $0.17 / kWh winter 2024 off peak rate
        - $0.20 / kWh winter 2024 peak rate
    - Summer 2023 Electricity rates as follows
        - $0.16 / kWH delivery charge plus the following generation charges
        - $0.14 / kWh off peak rate
        - $0.17 / kWh part peak rate
        - $0.23 / kWh peak rate

          Although summer peak rates are typically higher, the recent PG&E rate hikes have resulted in increased winter rates. It is also possible that Emeryville could restructure their PG&E rate to a place with better winter electricity rates to make an all-electric system more cost-effective. PG&E offers different rate structures for electric-buildings.
- Equipment efficiency data shown below
    - Gas Unit average heating system efficiency as follows
        - Existing boiler 55%.[3]
        - New condensing boiler 85%
    - Heat Pump annual estimated system efficiency coefficient (kW/kW)[4]
        - EcoGreen heat pump = 2.50
        - York YMAE = 3.07
    - Packaged AC Unit annual estimated Energy Efficiency Ratio (Btu/w)
        - Existing = 12 Btu/w[5]
        - New AC Unit = 17.4 Btu/w
        - New AHU + Heat Recovery Chiller = 18.1 Btu/w
- HVAC controls energy savings
    - We estimate a 50% HVAC energy savings upon replacement of HVAC controls.

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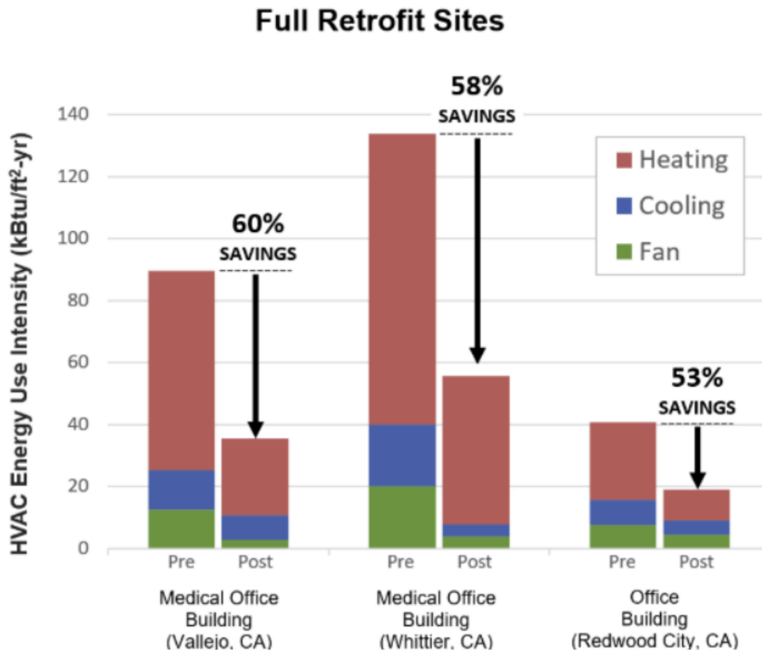
[2] Results are based on current rates, which are currently fluctuating. Future rates are unknown and may significantly change the cost effectiveness over the life of the HVAC equipment, especially as gas equipment is phased out, which may result in higher gas rates due to reduced supply or customers paying for gas infrastructure maintenance.

[3] Although the existing boiler nameplate AFUE is greater than 60%, we are selecting 60% as a realistic efficiency based on experience with oversized non-condensing boilers.

[4] Heat Pump COPs are based a weighted average of manufacturer performance data at the following conditions: 100% Load 32°F OAT for 10% of runtime, 100% Load 45°F OAT for 30% of runtime, and 50% Load 65°F OAT for 60% of runtime.

[5] Although nameplate efficiency might be greater than 12 BTU/w, we are selecting 12 as a realistic efficiency based on experience.

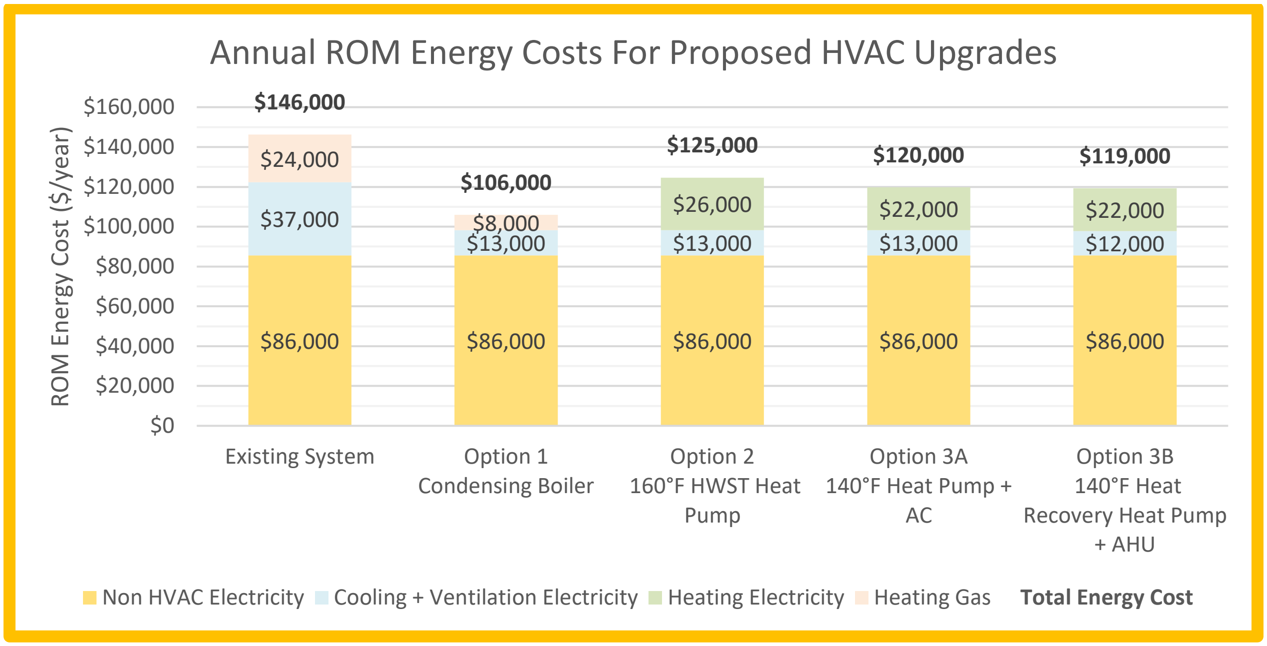
- See our California Energy Commission Best in Class study showing multiple example buildings where HVAC energy consumption has been reduced by 50-60% after upgrading terminal units to dual-maximum control with low minimum airflow rates, and incorporation demand based resets of rooftop equipment setpoints. See link to our project brief[6], and our BAS Best Practices Guide[7]



ROM Operational costs are summarized below:

- All retrofit options will reduce operational costs by 15-30% due to new efficient equipment and controls systems.
- All electric options show a ~15% increased operational cost compared to a gas boiler replacement, but still lower operational cost than the existing system. Operational costs may be able to be lowered by changing the City's utility rate structure to a plan with lower winter electric rates.

[6] See https://tayloreng.egnyte.com/dl/fzlRmpRUWI/CEC_Best_in_Class_-_Project_Brief.pdf_
[7] See https://tayloreng.egnyte.com/dl/phXTDfFQb8/2022-06-13_BAS_Best_Practices_Guide_v1.0.pdf_



8 Recommendations

Any of the above retrofit options will maintain improved comfort and significantly reduce greenhouse gas emissions at this site. The all-electric options will have the lowest annual greenhouse gas emissions, though they come at a first cost and operational cost premium.

For the all-electric options, we strongly recommend against option 2 and recommend either 3A or 3B. The determination of which one (3A or 3B) is optimal from a first cost, energy cost, and lifecycle cost is within the noise of this ROM level analysis. The decision mainly comes down to "soft" advantages and disadvantages described in section 5.3, and/or structural implications that are beyond this ROM study's scope. The choice of 3A vs 3B can be deferred to later stages of design and discussed with all parties to come to the best solution for all stakeholders.

Regardless of the option chosen, we recommend that the equipment be right-sized based on our load calculations and not simply matched to the existing capacities. Oversized equipment will cycle more frequently, which leads to decreased efficiency, decreased control (comfort), and increased wear on the equipment.

Appendix A: ROM Pricing Narrative

Appendix A: ROM Pricing Narrative

SECTION 230000 - HVAC SYSTEMS

PART 1 GENERAL

1.1 SYSTEM OPTION SUMMARY

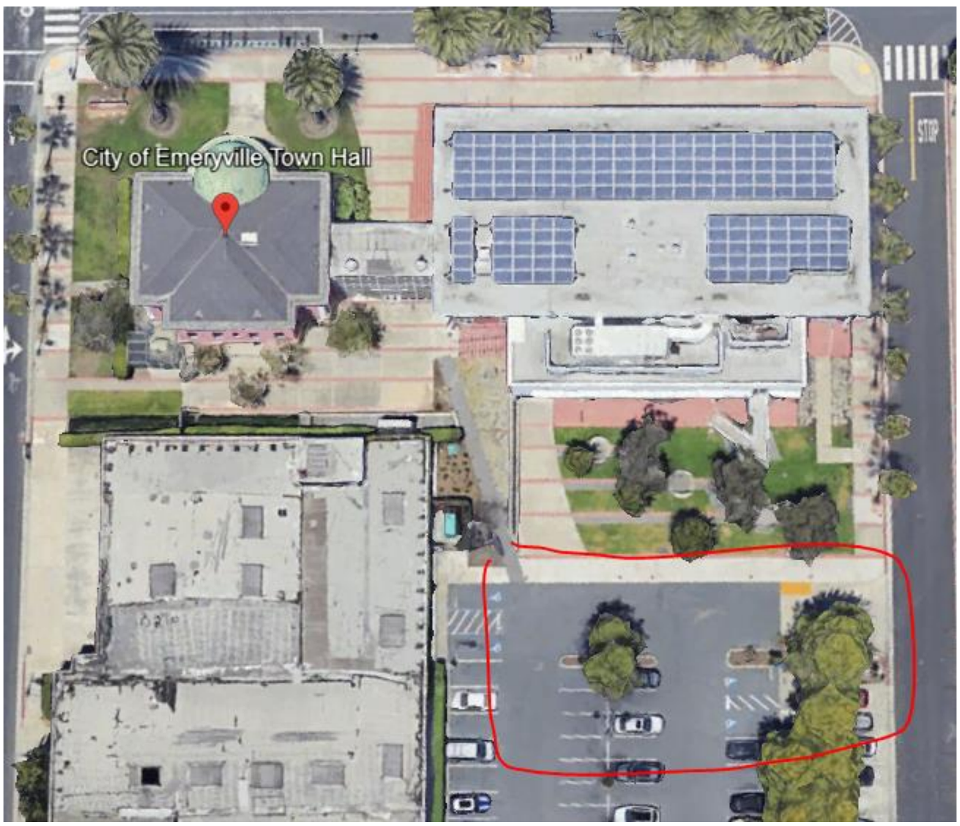
A. Existing HVAC Systems, including the packaged rooftop AC unit, heating plant, and control system, are due for replacement.

B. Three heating plant options are being evaluated for first cost as part of this exercise:

1. Like-for-like replacement with a gas boiler.
2. All-electric 2-pipe heating-only heat pump with like-kind capacity and 160°F hot water supply temperature.
3. All-electric 2-pipe heating-only heat pump sized per Taylor Engineer's load calculations and 140°F hot water supply temperature.

C. This document is intended to provide sufficient information for rough order of magnitude (ROM) HVAC pricing to develop a project budget, not for exact, definitive, pricing.

D. Interior scope will be completed during normal business hours. Rooftop scope will be completed during weekend(s) to minimize disruption to HVAC service during normal hours. A crane can be placed in the parking lot to avoid road closures.

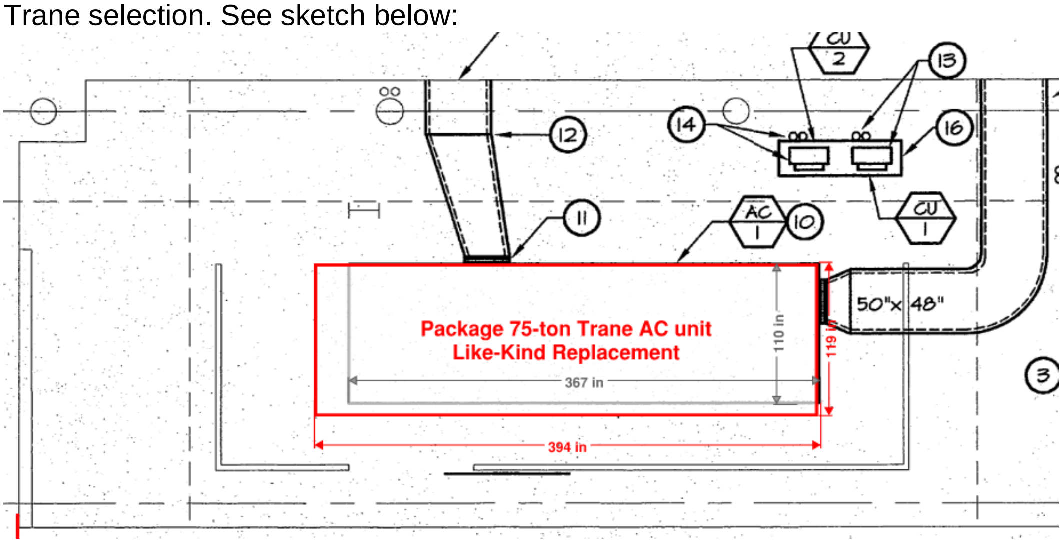


1.2 BASE SCOPE APPLICABLE TO ALL SYSTEMS

A. Replace the existing package AC unit with the following:

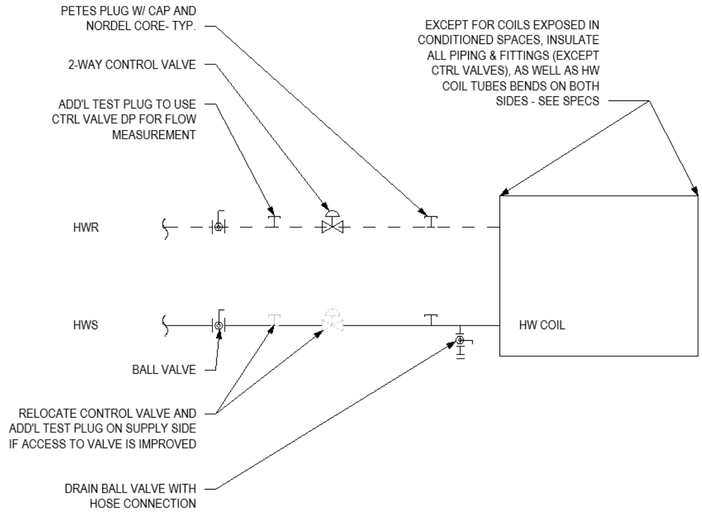
1. 75 tons, 2.5" ESP, 24,000 cfm, 460V
2. Economizer with relief fan (1.25" ESP, 21,000 cfm)
3. Epoxy coated evaporator and condenser coil fins
4. 316 SS low-leak dampers
5. Controls BACnet gateway
6. Outdoor air airflow measurement station
7. 5500-hour ASTM salt-spray coating
8. Base scope is 2 supply fans to provide partial redundancy.
9. Based around Trane (SXHMF7540*66DVLE8C01A0WU0VJ0A*0RW1M8G0).
10. **As an Add-Alternate:** upgrade to a fan array with 4 or more supply fans.

The existing package unit may be slightly larger than the existing unit. Trane offers an Intellipak Replacement Unit (IRU) selection that is designed to be cantilevered over an existing roof curb to reduce structural costs. Structural evaluation will be required since the replacement unit is ~1300 lbs heavier than the existing unit, but structural upgrades are unlikely. The existing mechanical screen should not require replacement with this Trane selection. See sketch below:



B. Provide the following scope for each of the (30) existing VAV reheat terminal units:

1. Replace the existing VAV box controller with a new controller.
2. Replace the existing hot water valve and valve actuator.
3. Include a new discharge air temperature sensor.
4. Replace the existing Delta thermostat with a new thermostat.
5. **As an Add-Alternate:** Replace the existing hot water coil trim with new trim per the below diagram.



C. **Add-Alternate:** Provide (2) new destratification fans Air Pear 25-EC-Standard with 0-10V DC control from the building automation system. Provide (6) new ceiling fans Big Ass Fan ES6 84 inch or equal in single-height areas with occupant adjustable wall switch for improved comfort. See linked floor plans with proposed ceiling fan locations.

D. **Add-Alternate:** Provide 16”x16” supply duct plenums with a manual volume damper and a new 14”x14” sidewall grill directed down and towards the windows on the North and East façade. Typical of 7 supply ducts on ground level and 7 supply ducts on level 2. See linked floor plans with proposed sidewall grille locations.

E. Replace the existing Delta Controls System with new DDC controls (Johnson Controls Facility Explorer, Alerton, or Distech) for the following equipment.

1. (30) existing VAV reheat terminal units with new controllers and new valve actuators
2. (6) existing constant speed rooftop exhaust fans
3. (1) new packaged AC unit.
4. (1) new heating plant, including DP sensors for variable primary flow control

Provide new sequences of operation following ASHRAE Guideline 36.

F. Include TAB services to rebalance all affected systems. Terminal unit balancing of variable flow hydronic systems is not required.

1.3 HEATING PLANT OPTIONS

A. Option 1 – Like-for-like replacement with a gas boiler.

1. One high efficiency condensing boiler, 830 MBH output capacity.
   a. AERCO Benchmark 1000
   b. Cleaver-Brooks ClearFire-CE 1000
   c. Lochinvar Crest 1000
   d. Or equal

2. One constant speed HW pump, 55 gpm, 45' head, 460V, 2 HP
3. Reuse existing expansion tank and air separator, but replace existing ancillary devices like the pot feeder and make-up water valve.
4. HW distribution shall be primary-only with a minimum flow bypass.

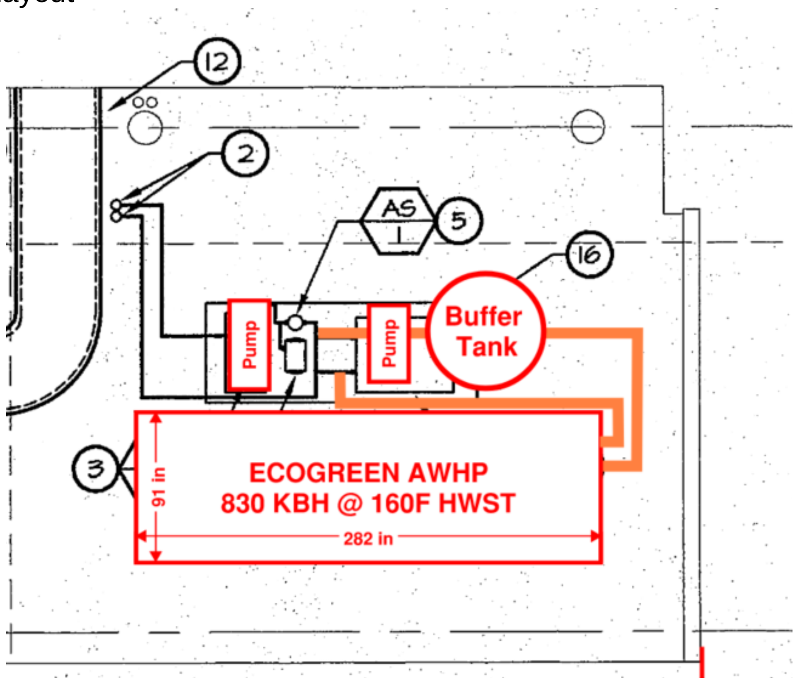
The option 1 hot water plant will fit in the existing footprint.

B. Option 2 – All-electric 2-pipe heat pump with like-kind capacity and 160°F hot water supply temperature.

1. Ecogreen Heat Pump model ECCLA-HPR150A or equal (no known equal at a competitive price point)
   a. 2-pipe, heating only
   b. 830 kBTU/hr, 160°F HWST at 32°F outdoor air temperature

2. Provide a 900 gallon HW buffer tank
3. One constant speed primary HW pump, 150 GPM, 10' head, 460V, 2 HP, either standalone or factory provided.
4. One variable speed secondary HW pump, 75 GPM, 80' head, 5 HP.

Option 2 will require a new structural platform and a new equipment screen, since the heat pump and pumps will exceed the footprint of the existing plant. See sketch below of proposed layout

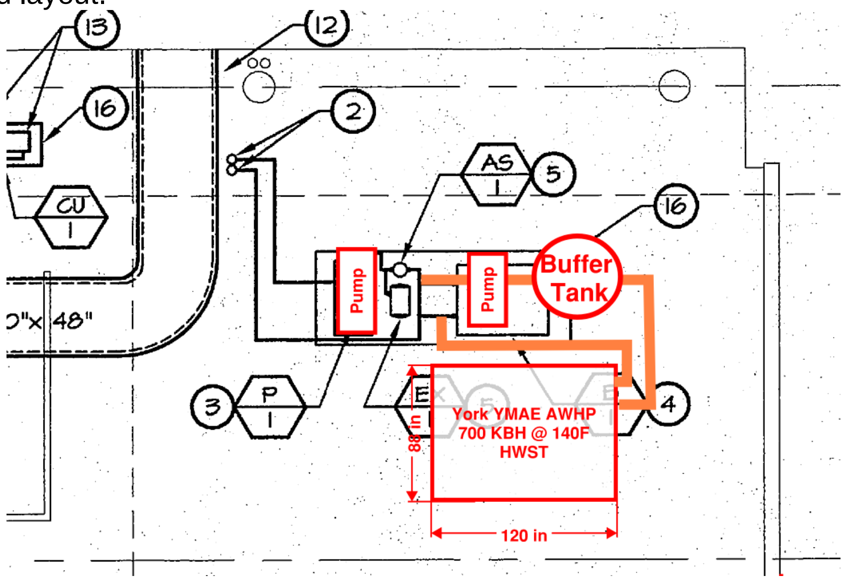


C. Option 3 – All-electric 2-pipe heat pump sized per Taylor Engineer's load calculations and 140°F hot water supply temperature.

1. York YMAE 0070 or equal
   a. 2-pipe, heating only
   b. 550 kBTU/hr, 140°F HWST at 32°F outdoor air temperature.

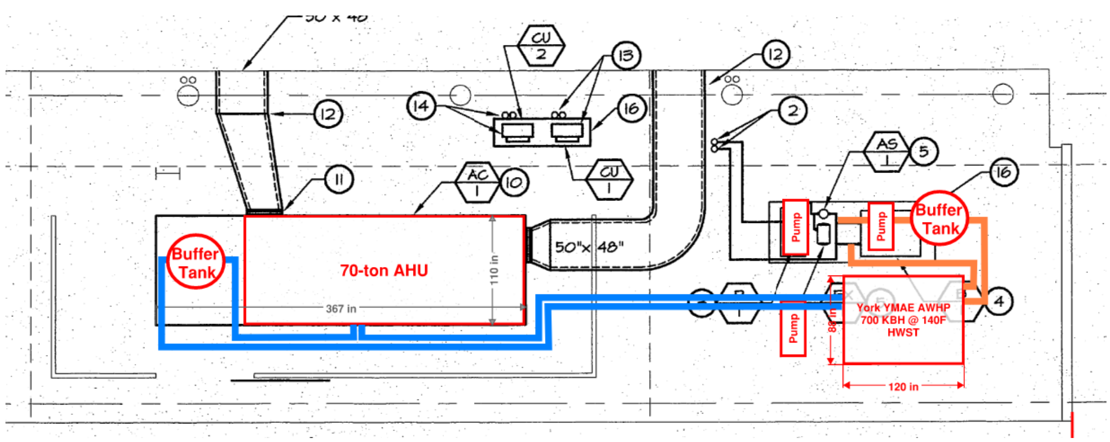
2. Provide a 450 gallon HW buffer tank
3. One variable speed HW pump, 75 GPM, 80' head, 5 HP.

Option 3 will require a new structural platform and a new equipment screen, since the heat pump and pumps will exceed the footprint of the existing plant. See sketch below of proposed layout.



Add-Alternate: Upgrade the York YMAE to provide both heating and cooling by including the following:

a. York YMAE - 4-pipe, heating and cooling heat recovery
b. 70-ton nominal cooling capacity at AHRI conditions.
c. Provide an air-handling unit instead of the base scope AC unit specified in 1.2A.
d. Add one 450 gallon CHW buffer tank.
e. Add one constant speed CHW pump, 85 GPM, 15' head, 460V, 2 HP, either standalone or factory provided. Capacity control will be handled via water temperature setpoint reset.
f. 2-1/2" chilled water pipe from the heat pump to the AHU as shown below.
g. Associated additional sequences of operation/controls



END OF SECTION

Appendix B: Emeryville HVAC Systems ROM Price report

Western Allied MECHANICAL

BUDGET PROPOSAL (rev1)

Date: April 3, 2024

To: Taylor Engineers
Attn: Adam Williams

Project: **Emeryville Civic Center - Electrification**

Dear Adam:

Western Allied Mechanical is pleased to provide a Budget proposal for the heating, ventilating, and air conditioning work at the Emeryville Civic Center. This proposal is based upon the Emeryville HVAC Systems ROM Pricing Narrative dated 3/5/2024 as prepared by Taylor Engineers.

PRICING BREAKDOWN:

Option 1a: AC Unit, VAV control valves, BMS, TAB, Gas Boiler		**$1,335,000**
• Equipment	$480,000	
• Labor, Materials, Misc.	$627,000	
• Controls	$228,000	
Option 1b: Smaller AC Unit, VAV control valves, BMS, TAB, Smaller Gas Boiler		**$1,280,000**
• Equipment	$425,000	
• Labor, Materials, Misc.	$627,000	
• Controls	$228,000	
Option 2: AC Unit, VAV control valves, BMS, TAB, EcoGreen 2-pipe ASHP		**$2,189,000**
• Equipment	$1,186,000	
• Labor, Materials, Misc.	$761,000	
• Controls	$242,000	
Option 3: AC Unit, VAV control valves, BMS, TAB, York 2-pipe ASHP		**$1,539,000**
• Equipment	$601,000	
• Labor, Materials, Misc.	$701,000	
• Controls	$237,000	
Option 4: AHU, VAV control valves, BMS, TAB, York 4-pipe ASHP		**$1,598,000**
• Equipment	$426,000	
• Labor, Materials, Misc.	$907,000	
• Controls	$265,000	
Alternate 1: AC Unit Fan Wall		**ADD $120,000**
Alternate 2: VAV Box Trim Replacement		**ADD $30,000**
Alternate 3: Air Pear & BAFs		**ADD $112,000**
Alternate 4: Duct Plenums & GRDs		**ADD $56,000**

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<u>OPTION 1a</u>:

Specific Inclusions:

1. *New Equipment (Furnished and Installed):*
   A. (1) 75-ton Trane cooling only rooftop AC Unit
   B. (1) 1000MBH Aerco condensing natural gas boiler
   C. (1) 55gpm constant speed HHW pump

2. *Demolition Services:*
   A. Existing rooftop package unit
   B. Existing boiler

3. *Piping Work:*
   A. Re-pipe HHW piping on roof to create primary only configuration and tie into existing distribution.
   B. Replace (30) existing VAV box control valves with new.

4. *Sheet Metal and Duct Work:*
   A. Disconnect and reconnect existing supply and return ductwork from rooftop AC Unit

5. *Crane and Rigging Services:*
   A. Receiving, storing, hauling, and lifting new equipment.
   B. Lifting, hauling, and disposal of old equipment.

6. *Insulation:*
   A. All new and disturbed ductwork and HHW piping shall be insulated per Title-24 requirements.

7. *Controls:*
   A. Tie in new controls into new Alerton Server
   B. Provide and configure new Alerton Global Controller
   C. Develop graphics, provide engineering, coordinate/participate in design/sequence review meetings, and provide start-up.
   D. Up to (8) hours of Training included
   E. Up to (8) hours of Vx assistance included
   F. Up to (8) hours of TAB assistance included
   G. DDC Control of the following equipment:
      i. (1) Trane Package Unit
         a. BACnet Integration
         b. AFMS
      ii. Central Heating Plant
         a. (1) Gas boiler
         b. (1) Constant Speed HHW Pump
      iii. (30) VAV with Reheat
         a. HW Valve
         b. Actuator
         c. SAT Sensor

Western Allied MECHANICAL

d. Thermostat

iv. (6) Exhaust Fans

a. Start/Stop

b. Status

8. *Commissioning Services:*
   A. Startup of new equipment.
   B. Testing, adjusting, and balancing.
   C. Labeling of new equipment.

9. *Miscellaneous:*
   A. State taxes.
   B. One year warranty on all new equipment, materials, and labor.
   C. OT as required for all roof work.

<u>OPTION 1b</u>:

Specific Inclusions:

1. *New Equipment (Furnished and Installed):*
   A. (1) 60-ton Trane cooling only rooftop AC Unit
   B. (1) 750MBH Aerco condensing natural gas boiler
   C. (1) 55gpm constant speed HHW pump

2. *Demolition Services:*
   A. Existing rooftop package unit
   B. Existing boiler

3. *Piping Work:*
   A. Re-pipe HHW piping on roof to create primary only configuration and tie into existing distribution.
   B. Replace (30) existing VAV box control valves with new.

4. *Sheet Metal and Duct Work:*
   A. Disconnect and reconnect existing supply and return ductwork from rooftop AC Unit

5. *Crane and Rigging Services:*
   A. Receiving, storing, hauling, and lifting new equipment.
   B. Lifting, hauling, and disposal of old equipment.

6. *Insulation:*
   A. All new and disturbed ductwork and HHW piping shall be insulated per Title-24 requirements.

7. *Controls:*
   A. Tie in new controls into new Alerton Server
   B. Provide and configure new Alerton Global Controller

C. Develop graphics, provide engineering, coordinate/participate in design/sequence review meetings, and provide start-up.
D. Up to (8) hours of Training included
E. Up to (8) hours of Vx assistance included
F. Up to (8) hours of TAB assistance included
G. DDC Control of the following equipment:
    i. (1) Trane Package Unit
        a. BACnet Integration
        b. AFMS
    ii. Central Heating Plant
        a. (1) Gas boiler
        b. (1) Constant Speed HHW Pump
    iii. (30) VAV with Reheat
        a. HW Valve
        b. Actuator
        c. SAT Sensor
        d. Thermostat
    iv. (6) Exhaust Fans
        a. Start/Stop
        b. Status

8. *Commissioning Services:*
    A. Startup of new equipment.
    B. Testing, adjusting, and balancing.
    C. Labeling of new equipment.

9. *Miscellaneous:*
    A. State taxes.
    B. One year warranty on all new equipment, materials, and labor.
    C. OT as required for all roof work.

<u>OPTION 2</u>:
Specific Inclusions:
1. *New Equipment (Furnished and Installed):*
    A. (1) 75-ton Trane cooling only rooftop AC Unit
    B. (1) EcoGreen ECCLA-HPR150A 2-pipe Air Source Heat Pump
    C. (2) HHW pumps
        i. (1) 150gpm constant speed primary
        ii. (1) 75gpm variable speed secondary
    D. (1) 5hp VFD for HHW pump
    E. (1) 900gallon Storage Tank

2. *Demolition Services:*
    A. Existing rooftop package unit
    B. Existing boiler

3. *Piping Work:*
    A. Re-pipe HHW piping on roof to create primary/secondary configuration and tie into existing distribution.
    B. Replace (30) existing VAV box control valves with new.

4. *Sheet Metal and Duct Work:*
    A. Disconnect and reconnect existing supply and return ductwork from rooftop AC Unit

5. *Crane and Rigging Services:*
    A. Receiving, storing, hauling, and lifting new equipment.
    B. Lifting, hauling, and disposal of old equipment.

6. *Insulation:*
    A. All new and disturbed ductwork and HHW piping shall be insulated per Title-24 requirements.

7. *Controls:*
    A. Tie in new controls into new Alerton Server
    B. Provide and configure new Alerton Global Controller
    C. Develop graphics, provide engineering, coordinate/participate in design/sequence review meetings, and provide start-up.
    D. Up to (8) hours of Training included
    E. Up to (8) hours of Vx assistance included
    F. Up to (8) hours of TAB assistance included
    G. DDC Control of the following equipment:
        i. (1) Trane Package Unit
            a. BACnet Integration
            b. AFMS
        ii. Central Heating Plant
            a. (1) Heat Pump Unit
            b. (1) Constant Speed HHW Pump
            c. (1) Variable Speed HHW Pump
        iii. (30) VAV with Reheat
            a. HW Valve
            b. Actuator
            c. SAT Sensor
            d. Thermostat
        iv. (6) Exhaust Fans
            a. Start/Stop
            b. Status

8. *Commissioning Services:*
    A. Startup of new equipment.
    B. Testing, adjusting, and balancing.
    C. Labeling of new equipment.

9. *Miscellaneous:*
    A. State taxes.
    B. One year warranty on all new equipment, materials, and labor.
    C. OT as required for all roof work.

<u>OPTION 3</u>:

Specific Inclusions:

1. *New Equipment (Furnished and Installed):*
    A. (1) 75-ton Trane cooling only rooftop AC Unit
    B. (1) York YMAE 0070 2-pipe Air Source Heat Pump
    C. (1) HHW pump
        i. (1) 75gpm variable speed primary
    D. (1) 5hp VFD for HHW pump
    E. (1) 450gallon Storage Tank

2. *Demolition Services:*
    A. Existing rooftop package unit
    B. Existing boiler

3. *Piping Work:*
    A. Re-pipe HHW piping on roof to create primary only configuration and tie into existing distribution.
    B. Replace (30) existing VAV box control valves with new.

4. *Sheet Metal and Duct Work:*
    A. Disconnect and reconnect existing supply and return ductwork from rooftop AC Unit

5. *Crane and Rigging Services:*
    A. Receiving, storing, hauling, and lifting new equipment.
    B. Lifting, hauling, and disposal of old equipment.

6. *Insulation:*
    A. All new and disturbed ductwork and HHW piping shall be insulated per Title-24 requirements.

7. *Controls:*
    A. Tie in new controls into new Alerton Server
    B. Provide and configure new Alerton Global Controller
    C. Develop graphics, provide engineering, coordinate/participate in design/sequence review meetings, and provide start-up.
    D. Up to (8) hours of Training included
    E. Up to (8) hours of Vx assistance included
    F. Up to (8) hours of TAB assistance included
    G. DDC Control of the following equipment:
        i. (1) Trane Package Unit

        a. BACnet Integration
        b. AFMS
    ii. Central Heating Plant
        a. (1) Heat Pump Unit
        b. (1) Variable Speed HHW Pump
    iii. (30) VAV with Reheat
        a. HW Valve
        b. Actuator
        c. SAT Sensor
        d. Thermostat
    iv. (6) Exhaust Fans
        a. Start/Stop
        b. Status

8. *Commissioning Services:*
    A. Startup of new equipment.
    B. Testing, adjusting, and balancing.
    C. Labeling of new equipment.

9. *Miscellaneous:*
    A. State taxes.
    B. One year warranty on all new equipment, materials, and labor.
    C. OT as required for all roof work.

<u>OPTION 4</u>:

Specific Inclusions:

1. *New Equipment (Furnished and Installed):*
    A. (1) 75-ton Petra Air Handling Unit
    B. (1) York YMAE 70-ton 4-pipe Air Source Heat Pump
    C. (1) HHW pump
        i. (1) 75gpm variable speed primary
    D. (1) CHW pump
        i. (1) 85gpm constant speed primary
    E. (1) 5hp VFD for HHW pump
    F. (2) 450gallon Storage Tanks

2. *Demolition Services:*
    A. Existing rooftop package unit
    B. Existing boiler

3. *Piping Work:*
    A. Re-pipe HHW piping on roof to create primary only configuration and tie into existing distribution.
    B. New CHW piping on roof to feed AHU
    C. Replace (30) existing VAV box control valves with new.

4. *Sheet Metal and Duct Work:*
    A. Disconnect and reconnect existing supply and return ductwork from rooftop AC Unit

5. *Crane and Rigging Services:*
    A. Receiving, storing, hauling, and lifting new equipment.
    B. Lifting, hauling, and disposal of old equipment.

6. *Insulation:*
    A. All new and disturbed ductwork and HHW piping shall be insulated per Title-24 requirements.

7. *Controls:*
    A. Tie in new controls into new Alerton Server
    B. Provide and configure new Alerton Global Controller
    C. Develop graphics, provide engineering, coordinate/participate in design/sequence review meetings, and provide start-up.
    D. Up to (8) hours of Training included
    E. Up to (8) hours of Vx assistance included
    F. Up to (8) hours of TAB assistance included
    G. DDC Control of the following equipment:
        i. (1) Trane Package Unit
            a. BACnet Integration
            b. AFMS
        ii. Central Heating/Cooling Plant
            a. (1) Heat Recovery 4-pipe Unit
            b. (1) Variable Speed HHW Pump
            c. (1) Constant Speed CHW Pump
        iii. (30) VAV with Reheat
            a. HW Valve
            b. Actuator
            c. SAT Sensor
            d. Thermostat
        iv. (6) Exhaust Fans
            a. Start/Stop
            b. Status

8. *Commissioning Services:*
    A. Startup of new equipment.
    B. Testing, adjusting, and balancing.
    C. Labeling of new equipment.

9. *Miscellaneous:*
    A. State taxes.
    B. One year warranty on all new equipment, materials, and labor.
    C. OT as required for all roof work.

ALTERNATE 1 Scope of Work:

- Add pricing to furnish and install rooftop AC unit with Fan Wall type configuration in lieu of standard fan configuration.

ALTERNATE 2 Scope of Work:

- Replace (30) VAV box coil trims, in addition to the included control valve replacement.

ALTERNATE 3 Scope of Work:

- Furnish and install (2) Air Pear Destratification Fans and (6) Big Ass Fan ceiling fans, including DDC controls

ALTERNATE 4 Scope of Work:

- Furnish and install (14) 16”x16” supply duct plenums with manual dampers and 14”x14” sidewall grilles.

Specific Exclusions:

A. All structural **upgrade** engineering and/or support work as required to accommodate mechanical equipment including all steel or wood air conditioning supports.
B. Survey, repairs, and/or modifications of existing HVAC system other than those specifically included.
C. All work associated with hazardous materials (lead, asbestos, etc.).
D. All electrical upgrade work including power and 120 volt wiring, conduit, disconnect switches, motor starters, interlock wiring of smoke/fire dampers, smoke detectors and smoke detector wiring.
E. All plumbing upgrade work including gas, make-up water, rooftop sanitary connection and condensate piping.
F. Excluded are cash discounts in exchange for quick payment, regardless of pre bid documents, unless specifically agreed to in writing by Western Allied.
G. Furnishing or installing of FLS devices.

Western Allied Mechanical appreciates the opportunity to present this proposal and looks forward to working with you on this project.

Should you have any questions, or if I can be of further assistance, please feel free to call.

Sincerely,

Eddie Patterson, LEED AP
Estimating Manager

Note: This price is valid for 30 days from date of issuance. Should this proposal expire, a revised proposal can be provided upon request.

taylor | engineers

Appendix C: Pre-Design Test and Balance Summary

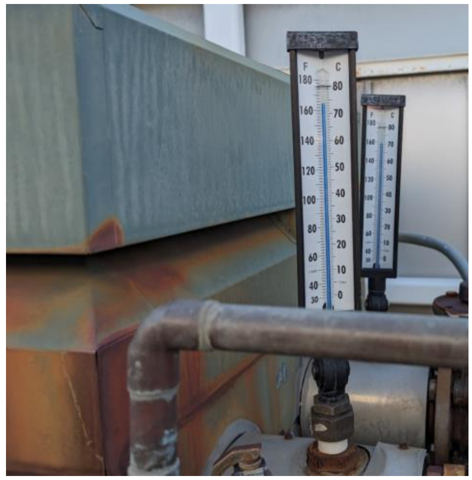
To:	Ali Ahmadzadeh
From:	Adam Williams
Subject:	Emeryville City Hall - Pre-Design Test and Balance Summary
Date:	March 5 2024

Taylor Engineering has completed pre-deign measurements with a Test and Balance (TAB) contractor to help understand the existing system and current operating conditions as part of our all-electric concept design scope. Below is an executive summary of key takeaways from the TAB work. An executive summary of findings is provided below:

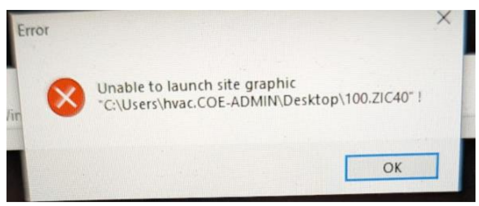
- Although the existing boiler was set to provide 180°F hot water supply temperature, only 160°F hot water supply temperature is being provided, most likely due to boiler control issues.
- We suspect that all terminal units on the second floor have controls issues which significantly reduce their design heating capacity.
- The terminal units operate with high minimum airflow setpoints which increase the likelihood of overcooling if zone heating is disabled or fails.
- At least 1 terminal unit's heating is disabled due to existing hot water pipe leakage, which contributes to heating complaints in that space.
- The building can typically warm up in 40 minutes when the systems are functioning normally, which indicates that the heating system may be oversized.
- Comfort complaints reported to the chief facility engineer have been caused by failed equipment, rather than insufficient heating capacity.
- We did not measure significant amounts of air temperature stratification, but the supply air temperature coming off of the coils greatly exceeds recommended temperatures to prevent stratification.
- The single pane glass makes a measurable temperature difference between perimeter and interior spaces, which may still result in some comfort issues now and after the HVAC upgrades.

Below is a detailed description of the measurement activities and findings, with key points highlighted in yellow. The preliminary TAB report prepared by RSA is also included.

1) Although the existing boiler was set to provide 180°F hot water supply temperature, only 155°F to 165°F hot water is being supplied to the building. Primary supply temperature was verified with existing temperature gauges, and secondary hot water supply temperature was verified by the TAB contractor using a test port. The discrepancy between the setpoint and output temperature is most likely due to calibration issues with the existing boiler controls. Presumably, ~160°F hot water has been provided to this building all winter without issue. This evidence likely means that 160°F hot water can meet system loads without any piping modifications, which aligns with our load calculations and engineering experience.



2) TAB work was very difficult due to issues with the existing building automation system (BAS). For example, all of the terminal units on level 2 were unable to be monitored or adjusted by the BAS, and the level 2 terminal unit that was measured (TUR30) did not function properly. TUR30's hot water valve opened, then shut regardless of zone temperature and setpoint adjustment, resulting in ineffective heating. We presume this situation is happening on all level 2 terminal units, and this operation contributes to heating difficulties in this building. The terminal units on level 1 did appear to function properly, but the BAS was not able to control these units or provide much monitoring. Our recommendation is to replace the BAS entirely due to age.



3) The terminal units are operating with single-max airflow setpoints (high minimum airflow), where the airflow never falls below the airflow required to meet the heating load. These airflow setpoints are very inefficient, and not compliant with current code. These setpoints also significantly increase the likelihood of overcooling spaces if the zone heating fails or is disabled such as in item 4) below. New airflow setpoints will be determined as part of the design work and will help reduce the likelihood of heating issues.

4) Two of the terminal units have leaking hot water pipe at the bottom of the heating coil. One does not leak significantly enough to require being disabled. The other terminal units has its hot water valve disabled to prevent water leakage, which disables heating. The lack of heat is exasperated by issue 3) above. As a temporary measure, consider lowering the minimum airflow setpoint to

5) Based on the TAB work that could be completed, we believe the terminal units tend to provide design heating capacity, although some coils may be receiving excessive hot water flow and high leaving air temperatures. The high water flows may be false readings because the existing calibrated balance valves, may be out of calibration due to sediment buildup in the valve.

6) Per discussion with the facility engineer, Kevin Meixner, below are takeaways based on his experience in the last 3-4 months of operation:
   a. The HVAC system runs Monday-Friday from 6AM to 6PM, with a goal of maintaining setpoints by 7:30, so a 1.5 hour warmup period. Per accounts form Kevin, the building typically warms up in ~40 minutes on most mild-winter mornings. Warmup can take longer on very cold winter mornings. Typical warmup times on design heating are 2-3 hours on modern systems, and modern systems automatically adjust the warmup duration based on each evening's outdoor air conditions using a machine-leaning approach.
   b. Comfort complaints received by Kevin have always been due to failed equipment, typically the AC unit supply fan, which has tripped due to ground faults at the VFD on multiple occasions and stopped providing air to the space. It is possible that less minor comfort complaints may existing but have not been communicated to Kevin since the building has had comfort problems for several years and occupants may be "given up" on relaying these
   c. Comfort complaints aren't focused on a specific location, unless there's a zone terminal unit failure. Temperature complaints are typically building-wide due to AHU or boiler issues.

   d. The boiler was set to 140°F HWST setpoint, and probably supplying even colder water as noted in issue 1), when Kevin joined. The setting was changed to 180°F HWST setpoint and actually provides 160°F hot water per issue 1).

7) Room air stratification was measured around 11:00AM when outdoor air temperature was ~54°F. During that testing, stratification was only ~2°F from the ground on level 1 to the ceiling of level 2. This stratification was less than expected, possibly due to a number of factors
   a. Outdoor air was more mild at the time of testing
   b. Heating on level 2 was reduced/ineffective due to controls issues.

   We still recommend considering adding ceiling fans for destratification and comfort reasons. Ceiling fans also provide an extra level of resiliency by reducing warmup times, as well as making spaces more comfortable on hot days or if mechanical cooling is unavailable.

8) Along with that testing, there was an ~2°F temperature differential between perimeter and interior zones at 54°F outdoor air temperature. We estimate at winter design outdoor air conditions (~32°F outdoor air temperature), the temperature differential could be as high as 5°F resulting in comfort complaints for occupants sitting next to the single-pane glass. Comfort issues like this cannot be remedied by simply a like-kind unit replacement. Recommendations could be as follows:
   - Re-organize office layouts so circulation areas and/or communal areas are along the windows.
   - Provide or allow personal comfort enhancements (personal fans or heaters)
   - Replace or retrofit the existing single-pane glass.
   - Add sidewall diffusers to the end of zone round branch ductwork that faces the glazing. This would require rebalancing all diffusers in each zone this solution is applied to.

9) The building also contains operable windows, which increase heating loads if the windows are not shut on cold days. Building operations and/or janitorial services should ensure that windows are closed at the end of each day..

RSA
RSAnalysis
Environmental System Performance Specialists

Preliminary Report

EMERYVILLE CITY HALL

PRE-DESIGN SURVEY

DATE: 2/27/2024

TECHNICIAN: MICHAEL SANDEN

TBE: JOEL JOHNSON

1035 Suncast Lane, Suite 130, El Dorado Hills, CA 95762
Phone: 916.358.5672 | Fax: 916.358.5673 | rsanalysis.com

Las Vegas, NV 702.740.5537
Reno, NV 775.323.8866
South San Francisco, CA 650.583.9400
Salt Lake City, UT 801.255.5015

Project Summary

Date:	2/27/2024
Project:	Emeryville City Hall Pre-Design Survey
Job Number:	TBD
Technician:	Mike Sanden

Scope of Work

Pre-design survey the existing HVAC system as requested and directed by client.

Observations & Outcomes

- All systems tested at the direction and witnessed by mechanical engineer of record (Taylor Engineering).
- All HVAC VAV's are a Delta DDC type with single inlet and reheat coils at terminal units. All systems tested in "AS FOUND" mode with systems in heating mode of operation. VAVs put into heating mode by others.
- 2nd floor VAVs not communicating with the BMS system at time of testing. When RSA attempted to test the 2nd floor VAV the reheat actuator would open and then close again with t-stat set above or below the room zone temperature seen on the t-stat. RSA recommends controls system be inspected and re-established to control VAVs.
- RSA found clogged test ports and were informed of multiple leaks in HHW piping requiring zones to be shut off.
- Stratification location #1 on 1st Floor at 6' = 70.5 degrees, 10.5' = 70.6 degrees, 16'= 71.3 degrees.
- Stratification location #2 on 2nd Floor at 6' = 71.2 degrees, 10.5' = 71.2 degrees, 16'=72.3 degrees.
- Stratification location #3 on 2nd Floor at 6' = 71.4 degrees, 10.5' = 71.4 degrees, 16'= 71.8 degrees.

In our efforts to constantly improve in all aspects of our performance, we would appreciate any feedback, positive or negative, regarding your experience with the RSA team.
Please click the link below to be directed to our Quality Assurance Survey. Thank you!
RSA Quality Assurance

BOILER TEST SHEET

Date	27-Feb-24	Area Served	HHW	Location	Roof

Boiler Data		Design Data	
Equipment I.D.	DNL	Input MBH	DNL
Manufacture	DNL	Output MBH	DNL
Model	DNL	Entering Water Temp	DNL
Service	HHW	Leaving Water Temp	DNL
		GPM	DNL

Test Data			
Entering Water Temp	DNA (1)	Outside Air Temp D.B.	50.0
Leaving Water Temp	DNA (1)	Entering Water Pressure	DNA (1)
High Fire	180	Leaving Water Pressure	DNA (1)
Low Fire	165	Safety Relief Valve	60 psi
GPM	DNA (1)	MBH Output	DNA

Remarks

Secondary discharge temperature 160.5 degrees

(1) No test ports installed.

BOILER TEST SHEET

Date		Area Served		Location	

Boiler Data		Design Data	
Equipment I.D.		Input MBH	
Manufacture		Output MBH	
Model		Entering Water Temp	
Service		Leaving Water Temp	
		GPM	

Test Data			
Entering Water Temp		Outside Air Temp D.B.	
Leaving Water Temp		Entering Water Pressure	
High Fire		Leaving Water Pressure	
Low Fire		Safety Relief Valve	
GPM		MBH Output	

Remarks

FLOW MEASURING STATION CONSTANT VOLUME

Date	27-Feb-24	Pump Identification	Secondary Pump	System Type	HHW

Unit	Size	Setting	Design		Tested		Pressure	
			P.D.	GPM	P.D.	GPM	In	Out
Main	MPV-025-1	100% (1)	DNL	DNL	3.21'	135	-	-
TUR1	AP-100	100% (2)	36"	5.2	133"	10	-	-
TUR4	AP-075L	75% (2)	20"	1.3	404"	5.8	-	-
TUR30	AP-075L	50% (2)	DNL	DNL	DNA (4)	DNA (3)	-	-

Remarks

(1) Taco circuit setter.

(2) FDI circuit setter. (3) Test ports clogged with debris, unable to determine flow.

(4) Control actuator opens and closes when t-stat set to extreme temperature.

HEATING COIL DATA

Date	27-Feb-24

System	TUR1		TUR4		TUR30			
Location	1st Floor				2nd Floor			
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM	1,570	1,344	390	248	350	519		
Entering Air Temp D.B.	55.0	67.2	55.0	61.4	55.0	69.2		
Leaving Air Temp D.B.	100.0	106.0	100.0	128.2	98.0	81.3		
Delta-T	45.0	38.8	45.0	66.8	43.0	12.1		
Sensible Air MBH	77	57	19	18	16	7		
GPM	5.2	10.0	1.3	5.8	1.1	DNA (1)		
Coil Pressure Drop Ft.	DNL	DNT	DNL	DNT	DNT	DNT		
Entering Water Temp	180.0	169.3	180.0	169.5	180.0	156.6		
Leaving Water Temp	150.0	144.5	150.0	159.9	150.0	69.0		
Delta-T	30.0	24.8	30.0	9.6	30.0	87.6		
Water MBH	78	124	20	28	17			

System								
Location								
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM								
Entering Air Temp D.B.								
Leaving Air Temp D.B.								
Delta-T								
Sensible Air MBH								
GPM								
Coil Pressure Drop Ft.								
Entering Water Temp								
Leaving Water Temp								
Delta-T								
Water MBH								

Remarks
(1) Test ports clogged with debris, unable to determine flow.

RSA RSAnalysis

AABC

COOLING COIL DATA

Date	27-Feb-24	Altitude	Sea Level

System	AC-1							
Location	Roof							
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM	DNL	DNT						
Entering Air Temp D.B.	DNL	73.5						
Leaving Air Temp D.B.	DNL	67.8						
Delta-T D.B.	DNL	5.7						
Sensible MBH	DNL							
Entering Air Temp W.B.	DNL	DNT						
Leaving Air Temp W.B.	DNL	DNT						
Delta-T W.B.	DNL							
Total Air MBH								
GPM	DNL	DNT						
Coil Pressure Drop	DNL	DNT						
Entering Water Temp	DNL	DNT						
Leaving Water Temp	DNL	DNT						
Delta-T	DNL							
Water MBH								

System								
Location								
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM								
Entering Air Temp D.B.								
Leaving Air Temp D.B.								
Delta-T D.B.								
Sensible MBH								
Entering Air Temp W.B.								
Leaving Air Temp W.B.								
Delta-T W.B.								
Total Air MBH								
GPM								
Coil Pressure Drop								
Entering Water Temp								
Leaving Water Temp								
Delta-T								
Water MBH								

Remarks
OSA @ 57.0 degrees.
OSA damper broken off from the return air damper blades, OSA dampers look to be rusted in place at approx 30%.
RA damper looks to be approx 95% open.

TAB FORM

Background

Emeryville civic center is a 18,000 SQFT existing office building. The existing system is a multiple-zone VAV reheat system with a packaged DX unit and a natural gas boiler.
The building currently experiences heating and cooling comfort issues.
Load calculations indicate that the existing systems are oversized.
The city wants to replace with an all-electric air-to-water heat pump.
The city is hesitant to adopt an all-electric design or a design with less system capacity than existing, unless they understand why comfort issues exist with the existing system.

	Date	2/27/2024			
	Name	Mike S.			

	Parameter	**Unit**	**Design**	**Measured**	**Notes**
	Boiler Testing				
Boiler	Boiler Secondary HWST	°F	180	160.5	
	Boiler Secondary HWRT	°F	150	140	Surface temp only.
	Boiler Secondary HW Flow	GPM	55	130	We will consider removing if this is a signficant add cost for the TAB contractor to determine.
	AC Unit Measurement				
AC-1	Outdoor Air Temperature	°F		57	
	Return Air Temperature	°F		73.5	Mixing Temp=71.9 Degrees
	AC-1 SAT	°F		67.8	
	AC-1 OA Damper Position	%		30%	
	AC-1 RA Damper Position	%		95%	
	Terminal Unit Measurement				
TUR1	Zone Temperature	°F	70	70.2	
	Zone Temperature Setpoint	°F		74	
	Heating Airflow	CFM	1570	1344	
	Entering Air Temp	°F	55	67.2	
	Leaving Air Temp	°F	100	106	
	Entering Water Temp	°F	180	169.3	
	Leaving Water Temp	°F	150	144.5	
	Water Flow	GPM	5.2	10	
	Calibrated Balance Valve setting			100%	
	Hw Control Valve Position			DNA	
TUR4	Zone Temperature	°F	70	70	
	Zone Temperature Setpoint	°F		74	
	Heating Airflow	CFM	390	248	
	Entering Air Temp	°F	55	61.4	
	Leaving Air Temp	°F	100	128.2	
	Entering Water Temp	°F	180	169.5	
	Leaving Water Temp	°F	150	159.9	
	Water Flow	GPM	1.3	5.8	

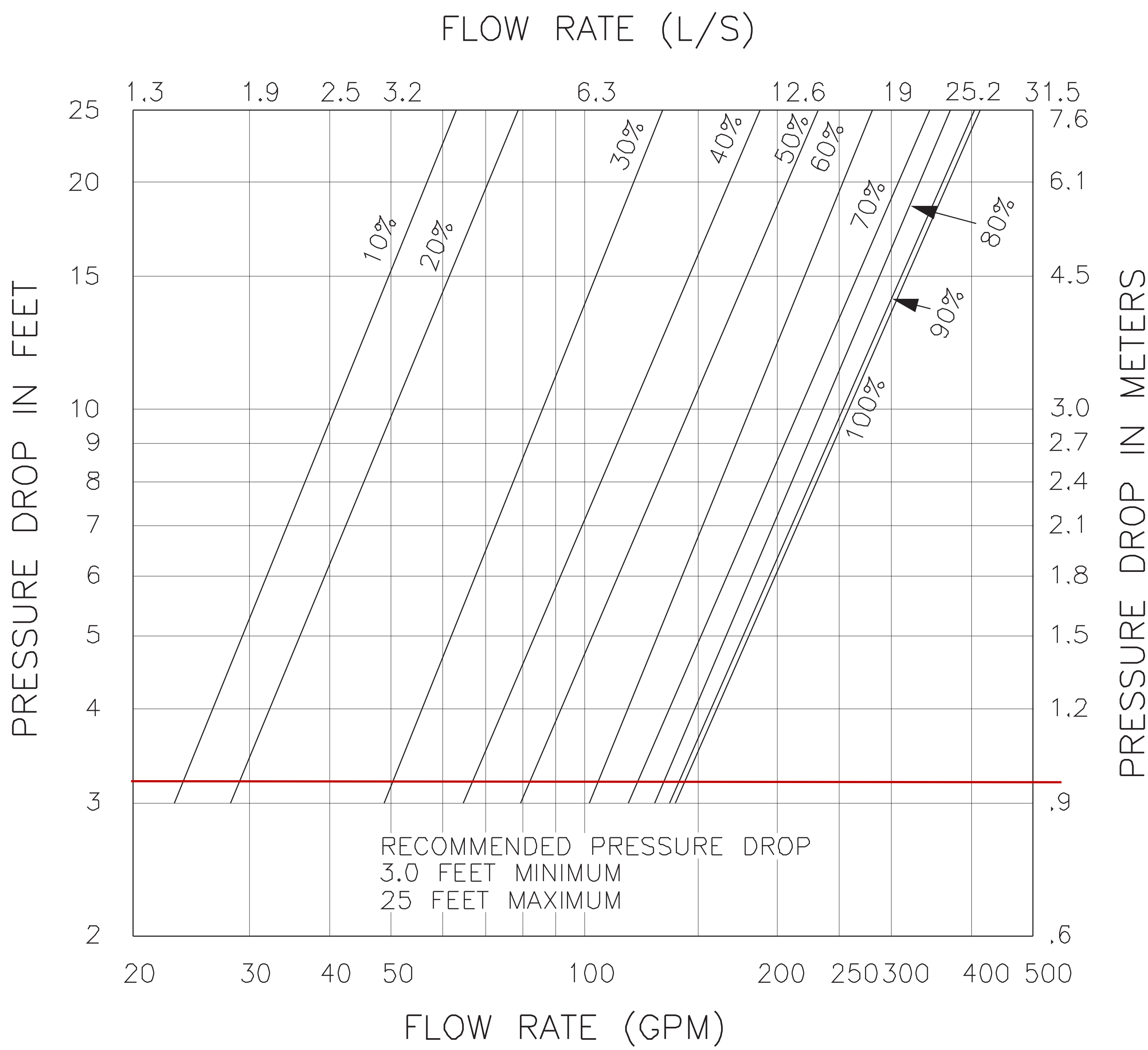
TAB FORM

	Calibrated Balance Valve setting			75%	
	Hw Control Valve Position			DNA	
TUR30	Zone Temperature	°F	70		
	Zone Temperature Setpoint	°F			
	Heating Airflow	CFM	350	519	
	Entering Air Temp	°F	55	69.2	`
	Leaving Air Temp	°F	98	81.3	
	Entering Water Temp	°F	180	156.6	
	Leaving Water Temp	°F	150	69	
	Water Flow	GPM	1.1	DNA	Test ports clogged, unable to attain flow.
	Calibrated Balance Valve setting			50%	
	Hw Control Valve Position			DNA	

Stratification Measurement

Stratificati	Zone Temp at	°F	
on	6ft above floor	°F	70.5
Location 1	10.5ft above floor	°F	70.6
(Mark on	16 ft below ceiling	°F	71.3
Stratificati	Zone Temp at	°F	
on	2ft above floor	°F	71.2
Location 2	6ft above floor	°F	71.2
(Mark on	1 ft below ceiling	°F	72.3
Stratificati	Zone Temp at	°F	
on	2ft above floor	°F	71.4
Location 3	6ft above floor	°F	71.4
(Mark on	1 ft below ceiling	°F	71.8

2.5 INCH MPV STRAIGHT & RIGHT ANGLE
INDICATED DATA FOR SYSTEM BALANCING



FlowSet
FLOW DESIGN INC.

Models F, AS, AP, VT

Venturi GPM Flow versus Inches W.C. Differential

Differential Pressure: Inches W.C.

Flow GPM	Models					
	050UL	050L	050H 075L	075H	100	125
.1	3					
.2	**10**					
.3	**22**					
.4	**40**	12				
.5	**62**	**19**				
.6	**89**	**27**				
.7	**121**	**37**				
.8	**158**	**48**				
.9	**200**	**61**				
1.0	**247**	**74**	12			
1.1	299	**91**	15			
1.2	356	**108**	17			
1.3	418	**127**	20			
1.4	484	**147**	**24**			
1.5		**169**	**27**			
1.6		**192**	**31**			
1.7		**217**	**35**			
1.8		**242**	**38**			
1.9		271	**43**			
2.0		299	**48**	12		
2.2		362	**58**	14		
2.4		431	**69**	17		
2.6			**81**	20		
2.8			**94**	**23**		
3.0			**108**	**27**	12	
3.2			**123**	**31**	14	
3.4			**139**	**35**	15	
3.5			**147**	**37**	16	
3.6			**156**	**39**	17	
3.8			**173**	**43**	19	
4.0			**192**	**48**	21	
4.2			**212**	**53**	**24**	
4.4			**232**	**58**	**26**	
4.5			**242**	**61**	**27**	
4.6			254	**63**	**28**	
4.8			276	**69**	**31**	
5.0			299	**75**	**33**	
5.2			324	**81**	**36**	
5.4			350	**87**	**39**	
5.5			362	**91**	**40**	12
5.6			176	**94**	**42**	13
5.8			404	**101**	**45**	14
6.0			431	**108**	**48**	15
6.2			461	**115**	**51**	16
6.4			491	**123**	**55**	17
6.5				**126**	**56**	17
6.6				**131**	**58**	18
6.8				**139**	**62**	19
7.0				**147**	**65**	20

Using the Differential Pressure (D.P.) Tables

1. ***The recommended ranges are shown in bold.*** All differentials have been rounded to the nearest inch W.C.

2. Generally, the recommended low ΔP signal is 24" so it can be read on most HVAC instuments. Also, signals below 12" are not accurate on some sizes.

3. The upper limit is an effort to minimize the permanent pressure drop which is 10 percent of the D.P. However, any Accusetter can be operated above the limit if the permanent drop is acceptable.

4. The D.P.'s in the table were calculated using the following formula:

$$D.P. = \left(\frac{GPM \cdot 17.3}{FF}\right)^2$$

Flow factors (FF) for all models are listed below.

Model	FF
0500L	1.1
050L	2
075L/050H	5
075H	10
100	15
125	27
150	42
200	80
250	135
300	225
400	480

Note: Permanent pressure loss equals 10 percent of differential pressure.

FlowSet
FLOW DESIGN INC.

Models F, AS, AP, VT

Venturi GPM Flow versus Inches W.C. Differential

Differential Pressure: Inches W.C.

Flow GPM	Models							
	075H	100	125	150	200	250	300	400
7.5	**168**	**75**	**23**					
8.0	**192**	**85**	**26**					
8.5	**217**	**96**	**30**					
9.0	**242**	**108**	**33**	14				
9.5	271	**120**	**37**	15				
10	299	**133**	**41**	17				
11	362	**161**	**50**	21				
12	431	**192**	**59**	**24**				
13		**225**	**69**	**29**				
14		261	**80**	**33**				
15		299	**92**	**38**				
16		340	**105**	**43**	12			
17		384	**119**	**49**	14			
18		431	**133**	**55**	15			
19		480	**148**	**61**	17			
20			**164**	**68**	19			
22			**199**	**82**	**23**			
24			**236**	**98**	**27**			
26			278	**115**	**32**			
28			322	**133**	**37**	13		
30			369	**153**	**42**	15		
32			420	**174**	**48**	17		
34			474	**196**	**54**	19		
36				**220**	**61**	21		
38				**245**	**68**	**24**		
40				271	**75**	**26**		
42				299	**82**	**29**		
44				328	**91**	**32**		
46				359	**99**	**35**	13	
48				390	**108**	**38**	14	
50				424	**117**	**41**	15	
52				458	**126**	**44**	16	
54				494	**136**	**48**	17	
56					**147**	**51**	19	
58					**157**	**55**	20	
60					**168**	**59**	21	
64					**192**	**67**	**24**	
68					**216**	**76**	**27**	
70					**229**	**80**	**29**	
75					263	**92**	**33**	
80					299	**108**	**38**	
85					338	**119**	**43**	
90					379	**133**	**48**	
95					422	**148**	**53**	12
100					467	**164**	**59**	13
105						**181**	**65**	14
110						**199**	**72**	16
115						**217**	**78**	17

Flow GPM	Models		
	250	300	400
120	**236**	**85**	19
125	257	**92**	20
130	278	**100**	22
135	299	**108**	**24**
140	322	**116**	**25**
145	345	**124**	**27**
150	369	**133**	**29**
155	395	**142**	**31**
160	420	**151**	**33**
165	447	**161**	**35**
170	474	**171**	**38**
175		**181**	**40**
180		**192**	**42**
185		**202**	**44**
190		**213**	**47**
200		**236**	**52**
210		261	**57**
220		286	**63**
230		313	**69**
240		341	**75**
250		369	**81**
260		399	**88**
270		430	**95**
280		463	**102**
290		497	**109**
300			**117**
310			**125**
320			**133**
330			**141**
340			**150**
350			**159**
360			**168**
370			**178**
380			**188**
390			**198**
400			**208**
410			**218**
420			**229**
430			**240**
440			251
450			263
460			276
475			293
500			324
525			358
550			392
575			429
600			467

Note: Permanent pressure loss equals 10 percent of inches W.C. differential.

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Brass Model UA

Venturi Balancing Data: Flow (gpm) versus Differential Pressure (in W. C.)

Form No.: F234.1
Date: 8.06
Supersedes: F234.0 12.02

Using the Differential Pressure (D.P.) Tables

1. ***The recommended ranges are shown in bold.***
2. Generally, the recommended low ΔP signal is 24" so it can be read on most instuments.
3. The upper limit is an effort to minimize the permanent pressure drop. However, any model can be operated above the limit if the permanent drop is acceptable.
4. The following equation has been approximated from the differential pressure table: $INWC = (B \bullet gpm)^2$
5. The permanent pressure loss can be calculated in the standard way from the valve's CV and flow rate: $PSID=(gpm/C_v)^2$

Venturi No.	B	C_v
1	24.4	0.283
2	11.1	0.771
3	4.86	2.15
4	2.21	4.79
5	1.78	5.95
6	0.819	17.5
7	0.467	18.4
8	0.217	68.5

Differential Pressure: Inches W.C.

Flow Rate (gpm)	1	2	3	4	5	6	7	8
0.1	7.3							
0.2	**27.1**	5.5						
0.3	**58.6**	12.1						
0.4	**101.2**	**21.2**						
0.5	**154.7**	**32.7**	6.7					
0.6	**218.8**	**46.7**	**9.5**					
0.65	**254.7**	**54.6**	**11.1**					
0.7	**293.3**	**63.1**	**12.8**					
0.8	378.0	**81.9**	16.6					
0.9	472.8	**103.1**	20.9					
0.95	524.0	**114.6**	**23.2**					
1.0		**126.7**	**25.6**					
1.1		**152.6**	**30.8**	5.4				
1.2		**180.9**	**36.5**	6.5	5.1			
1.3		**211.5**	**42.6**	7.6	6.0			
1.4		**244.4**	**49.1**	8.9	6.9			
1.5		279.6	**56.2**	10.2	7.9			
1.6		317.2	**63.6**	11.6	9.0			
1.7		357.1	**71.6**	13.2	10.1			
1.8		399.2	**79.9**	14.8	11.3			
1.9		443.7	**88.7**	16.5	12.6			
2.0		490.4	**98.0**	18.4	13.9			
2.2			**117.9**	**22.3**	16.7			
2.4			**139.5**	**26.7**	19.8			
2.6			**162.8**	**31.4**	**23.2**	5.0		
2.8			**188.0**	**36.6**	**26.8**	5.8		
3.0			**214.8**	**42.1**	**30.7**	6.7		
3.2			**243.4**	**48.0**	**34.8**	7.6		
3.4			273.7	**54.4**	**39.2**	8.5		
3.6			305.7	**61.1**	**43.9**	9.5		
3.8			339.4	**68.2**	**48.7**	10.6		
4.0			374.8	**75.8**	**53.9**	11.7		
4.2			412.0	**83.7**	**59.3**	12.8	5.3	
4.4			450.8	**92.1**	**64.9**	14.1	5.7	
4.6			491.3	**100.9**	**70.8**	15.3	6.2	
4.8			533.5	**110.0**	**77.0**	16.7	6.7	
5.0				**119.6**	**83.4**	18.0	7.3	
5.2				**129.6**	**90.1**	19.5	7.8	
5.4				**140.0**	**97.0**	21.0	8.4	
5.6				**150.8**	**104.1**	22.5	9.0	
5.8				**162.0**	**111.5**	24.1	9.6	
6.0				**173.6**	**119.2**	25.7	10.2	
6.2				**185.7**	**127.1**	27.4	10.8	
6.4				**198.1**	**135.2**	29.2	11.5	
6.6				**211.0**	**143.6**	31.0	12.2	
6.8				**224.2**	**152.2**	32.9	12.9	
7.0				**237.9**	**161.1**	34.8	13.6	
7.5				274.0	**184.4**	39.8	15.4	

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Brass Model UA

Venturi Balancing Data: Flow (gpm) versus Differential Pressure (in W. C.)

Differential Pressure: Inches W.C. (cont.)

Flow Rate (gpm)	1	2	3	4	5	6	7	8
8.0				312.6	**209.2**	**45.1**	17.4	
8.5				353.8	**235.6**	**50.8**	19.5	
9.0				397.7	263.5	**56.8**	21.6	
9.5				444.2	292.9	**63.1**	**23.9**	
10.0				493.3	323.8	**69.7**	**26.3**	5.1
11.0					390.2	**83.9**	**31.4**	6.2
12.0					462.7	**99.4**	**36.9**	7.3
13.0					541.1	**116.2**	**42.8**	8.6
14.0						**134.3**	**49.2**	9.9
15.0						**153.6**	**55.9**	11.4
16.0						**174.2**	**63.0**	12.9
17.0						**196.0**	**70.5**	14.5
18.0						**219.2**	**78.4**	16.2
19.0						**243.5**	**86.7**	18.0
20.0						269.1	**95.3**	20.0
21.0						296.0	**104.4**	22.0
22.0						324.1	**113.8**	**24.1**
23.0						353.4	**123.6**	**26.3**
24.0						384.0	**133.7**	**28.5**
25.0						415.8	**144.3**	**30.9**
26.0						448.8	**155.2**	**33.4**
27.0						483.1	**166.4**	**36.0**
28.0						518.5	**178.1**	**38.6**
29.0							**190.1**	**41.4**
30.0							**202.4**	**44.2**
31.0							**215.1**	**47.1**
32.0							**228.2**	**50.2**
33.0							**241.6**	**53.3**
34.0							255.3	**56.5**
35.0							269.5	**59.8**
36.0							283.9	**63.2**
37.0							298.7	**66.7**
38.0							313.9	**70.3**
39.0							329.4	**74.0**
40.0							345.3	**77.7**
41.0							361.5	**81.6**
42.0							378.0	**85.5**
43.0							394.9	**89.6**
44.0							412.1	**93.7**
45.0							429.7	**97.9**
46.0							447.6	**102.3**
47.0							465.8	**106.7**
48.0							484.4	**111.2**
49.0							503.3	**115.7**
50.0								**120.4**
52.0								**130.0**
54.0								**140.0**
56.0								**150.4**
58.0								**161.1**
60.0								**172.2**
62.0								**183.6**
64.0								**195.4**
66.0								**207.6**
68.0								**220.1**
70.0								**233.0**
72.0								**246.2**
74.0								**259.8**
76.0								**273.8**
78.0								**288.1**
80.0								**302.7**
82.0								**317.8**
84.0								**333.1**
86.0								**348.9**
88.0								**365.0**
90.0								**381.4**
92.0								**398.2**
94.0								**415.4**
96.0								432.9
98.0								450.8
100.0								469.0
102.0								487.6
104.0								506.5

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Steel Models: VW, VG, VF, AW, AG, AF, EG, EF, ER

Venturi GPM Flow versus Differential Pressure
16 to 775 GPM

Form No.: F193.3
Date: 8.06
Supersedes: F193.2 8.02

Differential Pressure: Inches W.C.

Flow GPM	Models												
	200L	200H	250L	250H	300L	300H	400L	400H	500L	500H	600L	600H	800L
16	10												
18	13												
20	16												
22	19												
24	23												
26	**27**	10	11										
28	**31**	11	12										
30	**36**	13	14										
32	**41**	15	16										
34	**46**	17	18										
36	**52**	19	20										
38	**58**	21	23										
40	**64**	23	**25**										
42	**71**	**26**	**28**										
44	**77**	**28**	**30**										
46	**85**	**31**	**33**										
48	**92**	**33**	**36**										
50	**100**	**36**	**39**										
55	121	**44**	**47**		11								
60	144	**52**	**56**	11	14								
65	169	**61**	**66**	13	16								
70	196	**71**	**77**	15	18								
75	225	**82**	**88**	17	21								
80	256	**93**	**100**	20	**24**								
85	289	**105**	**113**	22	**27**								
90	324	118	127	**25**	**30**								
95	361	131	141	**28**	**34**		10						
100	400	145	156	**31**	**38**		11						
110	484	176	189	**37**	**46**	11	13						
120		209	225	**44**	**54**	13	16						
130		245	264	**52**	**64**	15	19	10	11				
140		285	306	**60**	**74**	17	**22**	12	12				
150		327	352	**69**	**85**	20	**25**	13	14				
160		372	400	**79**	**96**	23	**28**	15	16				
170		420	452	**89**	**109**	**26**	**32**	17	18				
180		470		**100**	122	**29**	**36**	19	20				
190				111	136	**32**	**40**	21	23				
200				123	151	**36**	**44**	**24**	**25**				
220				149	182	**43**	**54**	**29**	**30**				
240				178	217	**51**	**64**	**34**	**36**		10		
260				209	254	**60**	**75**	**40**	**42**	10	12		
280				242	295	**70**	**87**	**47**	**49**	12	14		
300				278	339	**80**	**100**	**54**	**56**	13	16		
325				326	396	**94**	117	**63**	**66**	16	19		
350				378	461	**109**	136	**73**	**77**	18	22		
375				434		125	156	**84**	**88**	21	**25**		
400				494		143	178	**95**	**100**	**24**	**28**		
425						161	201	107	113	**27**	**32**		11
450						180	225	120	127	**30**	**36**		12
475						201	251	134	141	**33**	**40**	10	13
500						223	278	149	156	**37**	**44**	11	15
525						246	306	164	172	**40**	**48**	13	16
550						270	336	180	189	**44**	**53**	14	18
575						295	367	197	207	**49**	**58**	15	19
600						321	400	214	225	**53**	**63**	16	21
625						348	434	232	244	**57**	**69**	18	**23**
650						376	469	251	264	**62**	**74**	19	**25**
675						406		271	285	**67**	**80**	21	**27**
700						437		291	306	**72**	**86**	22	**29**
725						468		313	329	**77**	**92**	**24**	**31**
750								335	352	**83**	**99**	**26**	**33**
775								357	375	**88**	**106**	**27**	**35**

Notes:
1. Permanent pressure loss equals 10 percent of differential pressure.
2. The recommended ranges are shown in bold. All differentials have been rounded to the nearest inch.
3. Generally, the recommended low ΔP signal is 24" so it can be read on most HVAC instruments. D.P.'s below 12" are not accurate on some sizes.
4. The upper D.P. limit is an effort to minimize the permanent pressure loss which is 10 percent of the D.P. signal. Any venturi can be operated above the recommended range if the permanent pressure drop is acceptable.
5. The D.P.'s in the table were calculated using the following formula: $D.P. = \left(\frac{GPM \cdot 17.3}{FF}\right)^2$

For FF flow factors, see reverse

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Steel Models: VW, VG, VF, AW, AG, AF, EG, EF, ER

Venturi GPM Flow versus Differential Pressure 16 to 775 GPM

Differential Pressure: Inches W.C. (cont.)

Flow GPM	Models											
	500H	600L	600H	800L	800H	1000L	1000H	1200L	1200H	1400L	1400H	1600L
775	88	106	27	35		16						
800	94	113	29	38		17						
825	100	120	31	40		18						
850	106	127	33	42		20						
875	112	135	35	45	10	21						
900	119	143	37	47	11	22						
925	126	151	39	50	11	23						
950	133	159	41	53	12	24						
975	140	167	43	56	13	26						
1000	147	176	46	59	13	27						
1100	178	213	55	71	16	33		11				
1200	212	253	66	84	19	39		13				
1300	248	297	77	99	22	46	11	16				
1400	288	345	89	115	26	53	12	18		10		
1500	331	396	103	132	30	61	14	21		11		
1600	376	450	117	150	34	69	16	24	11	13		
1700	425		132	169	38	78	18	27	12	14		10
1800	476		148	190	43	88	20	30	14	16	10	12
1900			165	212	48	98	23	33	15	18	11	13
2000			183	235	53	109	25	37	17	20	12	14
2200			221	284	64	131	30	44	20	24	15	17
2400			263	338	76	156	36	53	24	29	17	21
2600			309	396	89	183	42	62	28	34	21	24
2800			358	460	104	213	49	72	33	39	24	28
3000			411		119	244	56	83	38	45	27	32
3200			467		135	278	64	94	43	51	31	37
3400					153	314	72	106	48	58	35	42
3600					171	352	81	119	54	65	39	47
3800					191	392	90	133	60	72	44	52
4000					212	434	100	147	67	80	49	58
4200					233	479	110	162	74	88	54	64
4400					256		121	178	81	97	59	70
4600					280		132	194	88	106	64	76
4800					305		144	212	96	115	70	83
5000					331		156	230	105	125	76	90
5500					400		189	278	127	151	92	109
6000					476		225	331	151	180	109	130
6500							264	388	177	211	128	152
7000							306	450	205	245	149	176
7500							352		235	282	171	203
8000							400		268	320	194	230
8500							452		302	362	219	260
9000									339	405	246	292
9500									377	452	274	325
10000									418	500	304	360
10500									461		335	397
11000											367	436
11500											401	476
12000											437	
12500											474	

Model	200L	200H	250L	250H	300L	300H	400L	400H	500L	500H	600L
FF	86.5	143.6	138.4	311.4	282	580	519	709	692	1427	1304

Model	600H	800L	800H	1000L	1000H	1200L	1200H	1400L	1400H	1600L
FF	2560	2259	4758	3322	6920	5709	8460	7733	9930	9117

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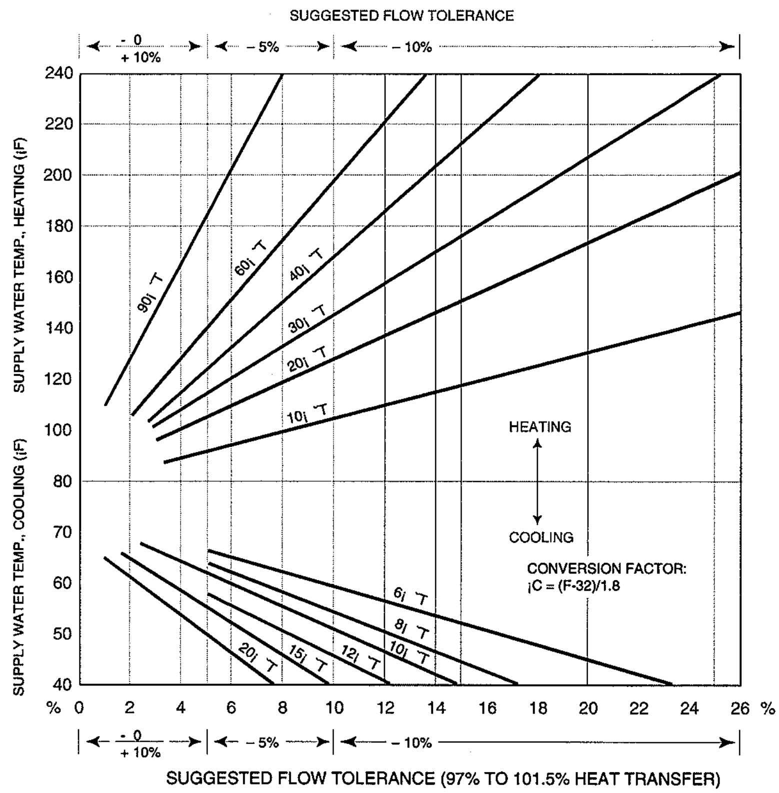
FlowSet Balancing Procedure

Form No.: F025.4
Date: 8.06
Supersedes: F025.3 1.99

SELECT THE FLOW TOLERANCE REQUIRED

As per the attached chart (ASHRAESystems Guide, 1984), ± 10% is generally accepted as a reasonably cost effective flow tolerance, but special systems may require more accurate balance. System tolerance is composed of three parts: the flow element (in our case ± 2%), the flow reading device (in our case ± 1/2% giving Flowset an installed and readable field accuracy of better than ± 3%). The third part, the field reading and adjusting, must be of a high degree of accuracy to produce overall results in the ± 10% range or better. It is important to specify both the accuracy and the reporting method to obtain best field results.



FLOW TOLERANCE PLOT

PRE-BALANCING PROCEDURE

1. Analyze the job drawings and develop a flow diagram listing design GPM at each designated location. Be sure all flow paths have at least flow readout and temperature readout capability.
2. System must be flushed, strainers cleaned and re-installed. All manual valves are to be in open position, all automatic temperature control valves in open position, expansion tank charged to at least 15 PSI and all air eliminated from the system.
3. With three way valve systems, the bypass valve should be closed at this point and reset later while reading the terminal units to provide the same pressure drop as the terminal. In primary/secondary systems, secondary pumps must be running and balancing valves open.
4. Equipment required: One (preferably two) flow meter kits. pressure gauge, temperature measurement equipment, radio communications systems for balancing team, and balancing forms (see installation/balancing tab for sample) for recording all data.

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Typical System Layout

STEP 1 — Read Pumps

STEP 2 — Read Risers

STEP 3 — Read Branches on Selected Riser

STEP 4 — Read Units on Selected Branch

STEP 5 — Adjust Units to Proportion of Lowest

STEP 6 — Adjust Units on All Branches Lowest to Highest

STEP 7 — Adjust Branches to Proportion of Lowest Riser Now Proportionally Balanced Repeat 4 thru 7 For All Risers

STEP 8 — Adjust Risers to Proportion of Lowest

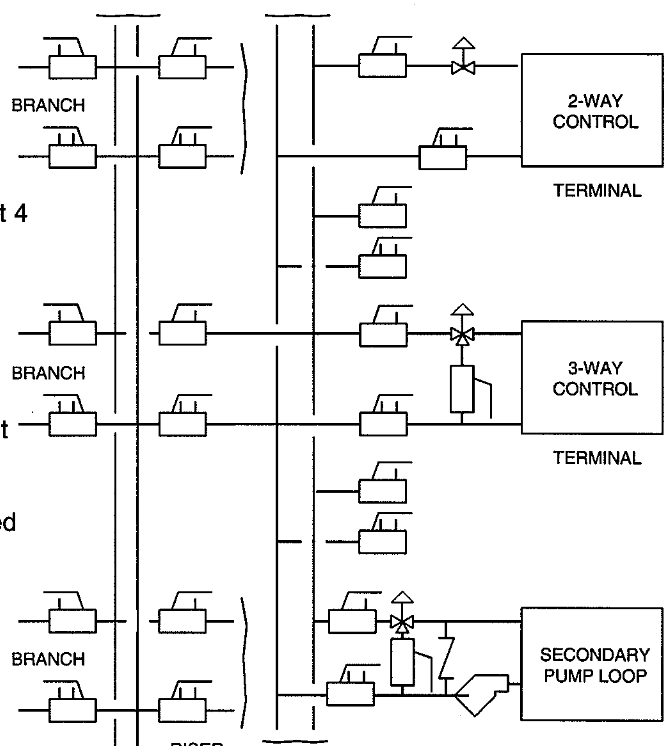
STEP 9 — Adjust Headers to Proportion of Lowest

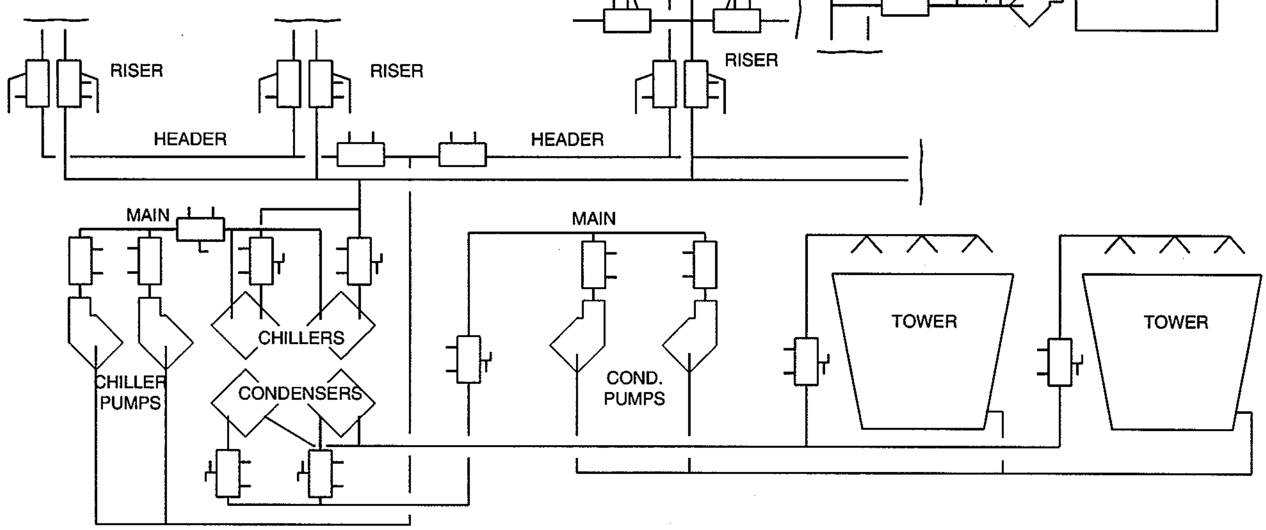
STEP 10 — Adjust Chillers yo Proportion of Lowest

STEP 11 — Adjust Condensers to Proportion of Lowest

STEP 12 — Adjust Towers to Proportion of Lowest

STEP 13 — Adjust Flow at Pumps — Method Described in “Energy Efficiency in Balancing”





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FlowSet Balancing Procedure

Balancing The System

The most efficient and lowest pressure drop balancing method is known as proportional balancing. This procedure develops one complete flow path with no balancing valves throttled. Rather than attempting to set design flows one at a time, the entire system is balanced to the same proportion or ratio of actual flow to design flow. The final adjustment of flow is accomplished at the pump and all previously proportionally balanced devices are brought to design flow simultaneously.

Step One
With all valves open, read system flow at pump(s) and compare to the total design flow of all connected devices. If the flow is less, verify that it is within the range of the intended diversity. If flow is more than 20% above design, adjust discharge of pump to + 20% maximum.

Step Two
Read the flows of all risers and/or secondary pump loops to identify the riser/loop having the highest proportion of actual to design flow. This is the riser with the lowest installed pressure drop and will be the first balanced. Any risers or secondary pump loops that are more than 20% above design flow should be adjusted to + 20% maximum.

Step Three
Read the flows of all branches on the selected riser to identify the branch having the highest proportion of flow. This is the branch with the lowest installed pressure drop and will be the first balanced. Any branches that are more than 20% above design flow should be adjusted to + 20% maximum.

Step Four
Read the flow of all the units on the selected branch and select the unit having the lowest proportion of actual to design. This is the unit with the highest installed pressure drop and will remain open.

Step Five
Adjust the unit with the next lowest proportion of actual to design to match the proportion of the lowest unit. You should check back on the lowest unit (which becomes the reference unit) as it will increase when the next unit is adjusted. Adjust all other units on this branch to the same proportion as the reference unit with appropriate check-backs as required. Balance from the lowest proportion to highest proportion until all units on branch are proportionally balanced. Readout all units to verify they are set at the same proportion.

Step Six
The next set of units balanced will be on the branch with the next lowest proportion of flow. Continue from lowest to highest, balancing all units on each of selected riser using procedure in STEP FIVE.

Step Seven
Find the branch with the lowest proportion (this branch will remain open), and then balance all other branches to the reference branch. The riser is now proportionally balanced. Repeat STEPS FOUR thru SEVEN for all risers until the units and branches on each are proportionally balanced.

Step Eight
Select the riser with the lowest proportion (this riser will remain open). Set the next lowest riser to the same proportion as the reference riser and proceed until all risers are proportionally balanced.

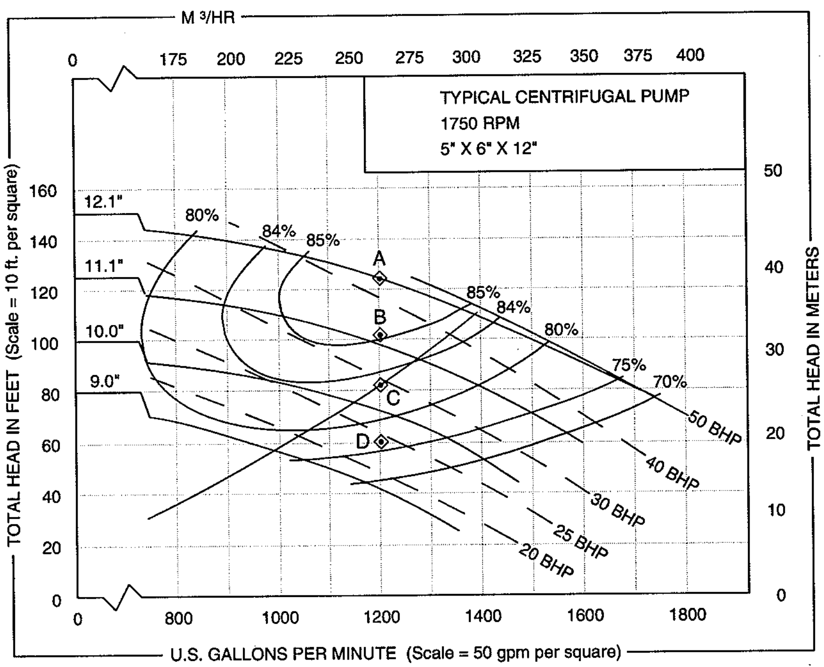
Step Nine
If system has multiple headers, identify the one having the lowest proportion (leave open) and set the next lowest proportional header to match. Adjust each header accordingly. System is now proportionally balanced and contains one open flow path from headers to risers to branches to terminals having the lowest pressure drop possible. Readout all terminals and fine tune any out of range devices, set memory stops, and record final readings. The final flow adjustment takes place at the pump and the method of achieving design flow is the subject of the section titled “Energy Efficiency in Balancing.”

FLOW DESIGN INC

FlowSet Balancing Procedure

Balancing The System

Using the following actual pump curve as an example, it is easy to tabulate the effects of various methods of obtaining design flow at the pump. Point E represents the proportionally balanced system before any adjustment at the pump to achieve design flow condition. The design flow may be obtained by throttling the pump, trimming the impeller, changing the pump or reducing the pump speed. The simplest and least costly of these options is to throttle the pump, (system goes to Point A) producing balanced design condition and saving three horsepower in our example. It is also possible to operate the system at Point C (design flow rate with actual system pressure drop). Operation at Point C can be obtained by trimming the pump impeller to approximately 10.5" or reducing the pump speed using a variable speed device. Trimming the pump impeller is the lowest cost method of obtaining this operating point but, once trimmed, the impeller offers no capability of producing additional flow should conditions warrant. A variable speed pump can match future load conditions, but imposes an additional penalty of the inefficiency of the drive on the system, thus making it a poor choice if this is all the drive is designed to accomplish. Systems having variable flow characteristics (modulating valves) can utilize variable speed drives to a substantial cost advantage taking into account the building's diversity, etc. The pump/system curve analysis also shows the effect of using the **FlowSet** low-loss design and **FlowSet Venturi/Pitot** design for all flow measuring and setting stations (System B). A system designed (per the attached schematic) using conventional flow measurement and setting devices on the pump discharge, chillers, headers, risers, branches, and units and selected per the manufacturers recommendations contrasted to **FlowSet** devices picked for the same line diameters and flow conditions would result in a net pressure drop approximately 21 feet higher than the **FlowSet** system. The effect of this 21 feet pressure drop savings produces a substantial reduction in pump horsepower. **FlowSet** valves, when matched with impeller trimming, produces a system offering the most efficient and cost effective design possible (System D).



Typical System Analysis

SYSTEM*	DESCRIPTION	GPM	HEAD	PUMP BHP	SYSTEM COMPARISON	$ SAVED** PER YEAR	$SAVED** PER 25 YEARS
A	Designed w/ conventional variable orifice balancing valves at pumps, chillers, headers, risers, branches, and terminals	1200	125'	44	A vs. E	1844	247,000
B	Same system w/ **FlowSet** devices in same position, same line size	1200	104'	36.3	B vs. E	4124	553,000
C	Trim Impeller/Variable Speed Pump - System A (Conventional)	1200	83'	30.2	C vs. E	6494	870,000
D	Trim Impeller/Variable Speed Pump - System B (**FlowSet**)	1200	60'	24.2	D vs. E	8788	1,179,000
E	Unbalanced System	1400	112'	47			

** Data based on design of 1200 GPM @ 125' total head, with 50 HP motor.*

** * Savings based on .05/kw, 24 hr./day, 365 days/yr. operation. Motor efficiency 85%. Electrical costs + 5%/yr. Average int, rate 10%.*

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FLOW DESIGN INC

Steel Venturi Selection Procedure

Models VW, VG and VF - Sizes 2" to 14"

Form No.: F199.4
Date: 12.07
Supersedes: F199.23 8.06

General Specifications

Selecting the Pipe Size

Determine pipe size based on the maximum GPM. Table 1 shows the ASHRAE recommendations. ASHRAE's criterion is, "a maximum friction loss of 4 feet head per 100 feet of pipe". Some designers prefer to use 80% of the ASHRAE maximum.

Table 1: Maximum GPM (Schedule 40 Pipe)

PIPE SIZE	GPM	PIPE SIZE	GPM	PIPE SIZE	GPM
2"	42	5"	475	12"	4600
21/2"	72	6"	775	14"	6000
3"	130	8"	1550	16"	8500
4"	275	10"	2900		

Selecting the Venturi Model

Using Table 2, select the size and venturi model where the design GPM falls between the low and high ΔP limits. The Selection Chart, shows the GPM ranges for all models. When this chart is used the maximum permanent head loss will usually be less than .9 feet and the minimum reading on the gauge will be 24" or 2 feet. If the design GPM falls within the recommended range of both the (L) and the (H) models, the (H) model is generally preferred because it will have the lowest permanent head loss.

To calculate an exact ΔP or GPM, use the Venturi Flow Factor from Table 2 in the following equations.

$$\Delta P \text{ (inches)} = \left[\frac{\text{GPM} \times 17.3}{\text{FF}}\right]^2$$

$$\text{GPM} = \frac{\text{FF}}{17.3} \times \sqrt{\Delta P} \text{ (inches W.C.)}$$

Table 2: Steel Venturi Selection Chart

Pipe Size	Venturi Model	GPM Range Low 24" ΔP		GPM Range High 100" ΔP	Venturi Flow Factor
2"	200L	25	–	50	86.5
	200H	42	–	85	143.6
2 1/2"	250L	39	–	85*	138.4
	250H	85	–	180	311.4
3"	300L	80	–	165	282.0
	300H	165	–	335	580.0
4"	400L	145	–	300	519.0
	400H	200	–	410	709.0
5"	500L	200	–	400	692.0
	500H	400	–	825	1427.0
6"	600L	375	–	750	1304.0
	600H	725	–	1500	2560.0
8"	800L	625	–	1300	2259.0
	800H	1300	–	2800	4758.0
10"	1000L	950	–	1900	3322.0
	1000H	1900	–	4000	6920.0
12"	1200L	1600	–	3100	5709.0
	1200H	2400	–	5000	8460.0
14"	1400L	2200	–	4400	7733.0
	1400H	2800	–	6000**	9930.
16"	1600L	2600	–	8500***	9117.0

Notes:
- ΔP = Flow Signal = Gauge Reading
- Permanent Loss = 10% x ΔP
- If the required flow is lower than that shown for a model (L) venturi, the low limit ΔP can be reduced from 24" to 12". The low GPM limit will go down by 29% (multiply the flow at 24" by .71). If the flow is lower than this, select the next smaller size venturi.

* Model 250L based on 117" ΔP
Model 500L based on 147" ΔP
Model 600L based on 194" ΔP
Model 1400L based on 224" ΔP

Selection Examples

1. **Select a venturi for a 4" line with a design flow of 225 GPM.**
In the Selection Chart, 225 GPM falls in the recommended range for both the 400L and 400H models. Choose the 400H because it will have the lowest permanent pressure loss. The following example shows how to calculate the ΔP and permanent pressure loss.

2. **What are the exact ΔP and permanent loss at 225 GPM for Models 400H and 400L?**

Model 400H

$$\Delta P \text{ (inches)} = \left[\frac{225 \times 17.3}{709}\right]^2 = (5.49)^2 = 30\text{" W.C.}$$

Permanent Loss = 10% ΔP = 3" W.C. or .25 feet

Model 400L

$$\Delta P \text{ (inches)} = \left[\frac{225 \times 17.3}{519}\right]^2 = (7.50)^2 = 56\text{" W.C.}$$

Permanent Loss = 10% ΔP = 6.9" W.C. or .6 feet

3. **What are the exact ΔP and permanent pressure loss for Model 1400L at 6000 GPM?**
This flow is above the normal recommended range of 100" W. C., but will work fine as long as the permanent pressure loss is not too high for designed pump head.

$$\Delta P \text{ (inches)} = \left[\frac{8500 \times 17.3}{9117}\right]^2 = (16.13)^2 = 260\text{"}$$

Permanent Loss = 10% ΔP = 22.4" W.C. or 1.9 feet

FDI
FLOW DESIGN INC

Steel Venturi Selection Procedure

Models VW, VG and VF - Sizes 2" to 14"

Common Questions and Answers

Q How is the venturi installed if three inlet and two outlet straight pipe runs are not available?

A There would be additional error in the readings. The standard accuracy of ±1% could become ±15% without the proper straight run. If the venturi must be installed anyway, the available straight run should be used on the inlet (upstream) side. The amount of error without proper straight run cannot be predicted.

Q Can a venturi be mounted vertically?

A Yes, and the flow can be either up or down.

Q What benefit do flanges provide on venturis?

A Flanges allow for easy removal for servicing, but since there is nothing to service on venturis the preferred connection is weld ends.

Q Can any D.P. meter be used to read FDI venturis?

A Yes, as long as it has the proper full scale calibration. 0 to 300" (0-20') is the most popular combination instrument for measurement and balancing.

Q Does the precision of the gauge kit affect the overall metering accuracy?

A Yes. One-half or more of the overall accuracy depends on the readout kit. Whatever meter error is present, adds algebraically to the 1% venturi error. The FDI Meter Kit 300.4 has a full scale accuracy of ±1.75%. In normal use, the error increases to 4% or 6% when metering at ^{3}P's below full scale.

Q Are flow curves available?

A Yes, individual venturi curves are shipped with each unit.

Q Can we get better than ±1% F.S. venturi accuracy.

A Yes, individual venturis can be flow tested by the FDI engineering department at a specified flow and certified to ±1/2% accuracy. The cost for this testing ranges between $300 and $600 per venturi.

Q Can venturis measure fluids other than water?

A Yes, FDI's engineering department can give formulae for converting other liquids and gases to standard GPM of water so the flow equations for water can be used.

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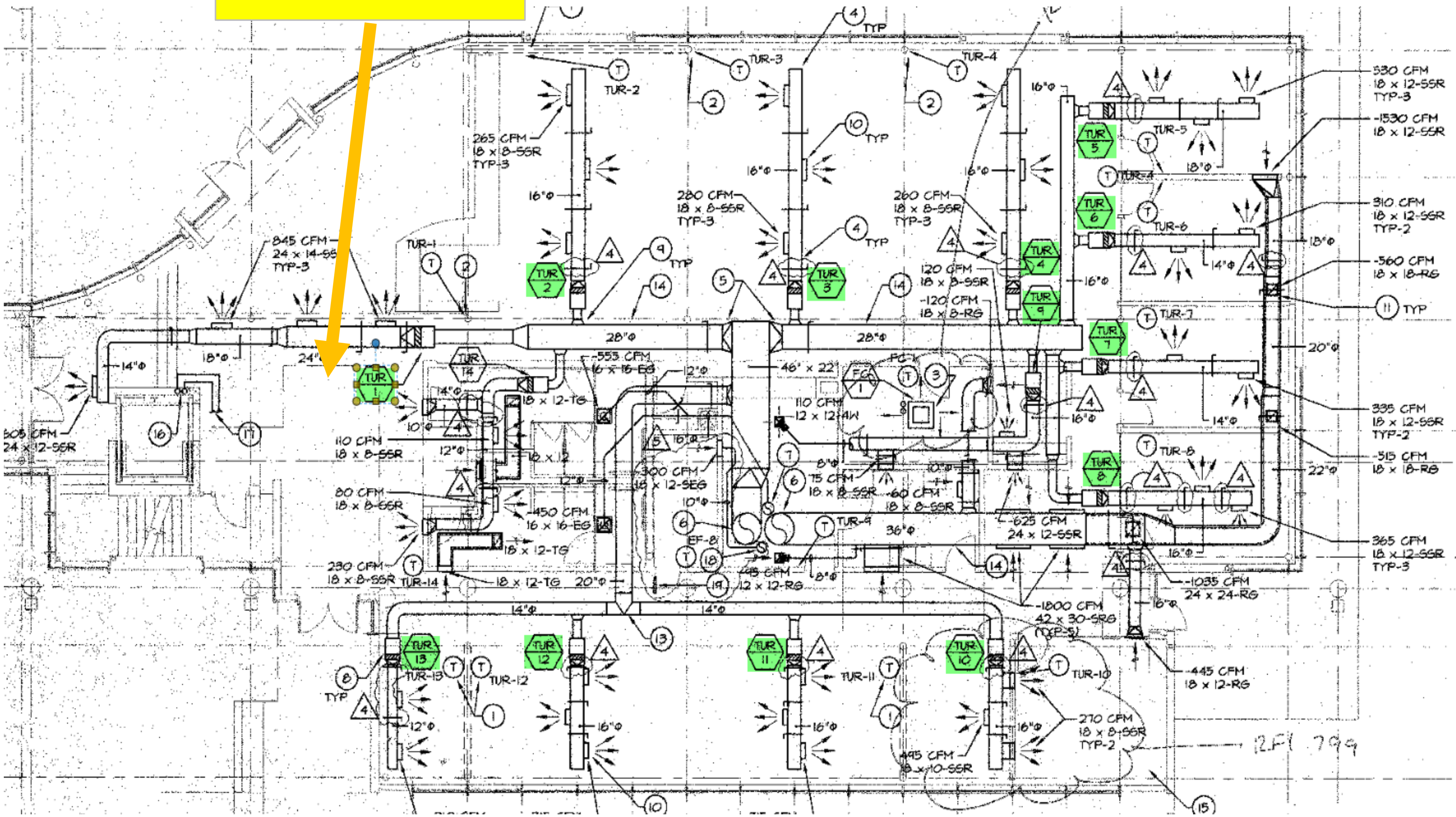
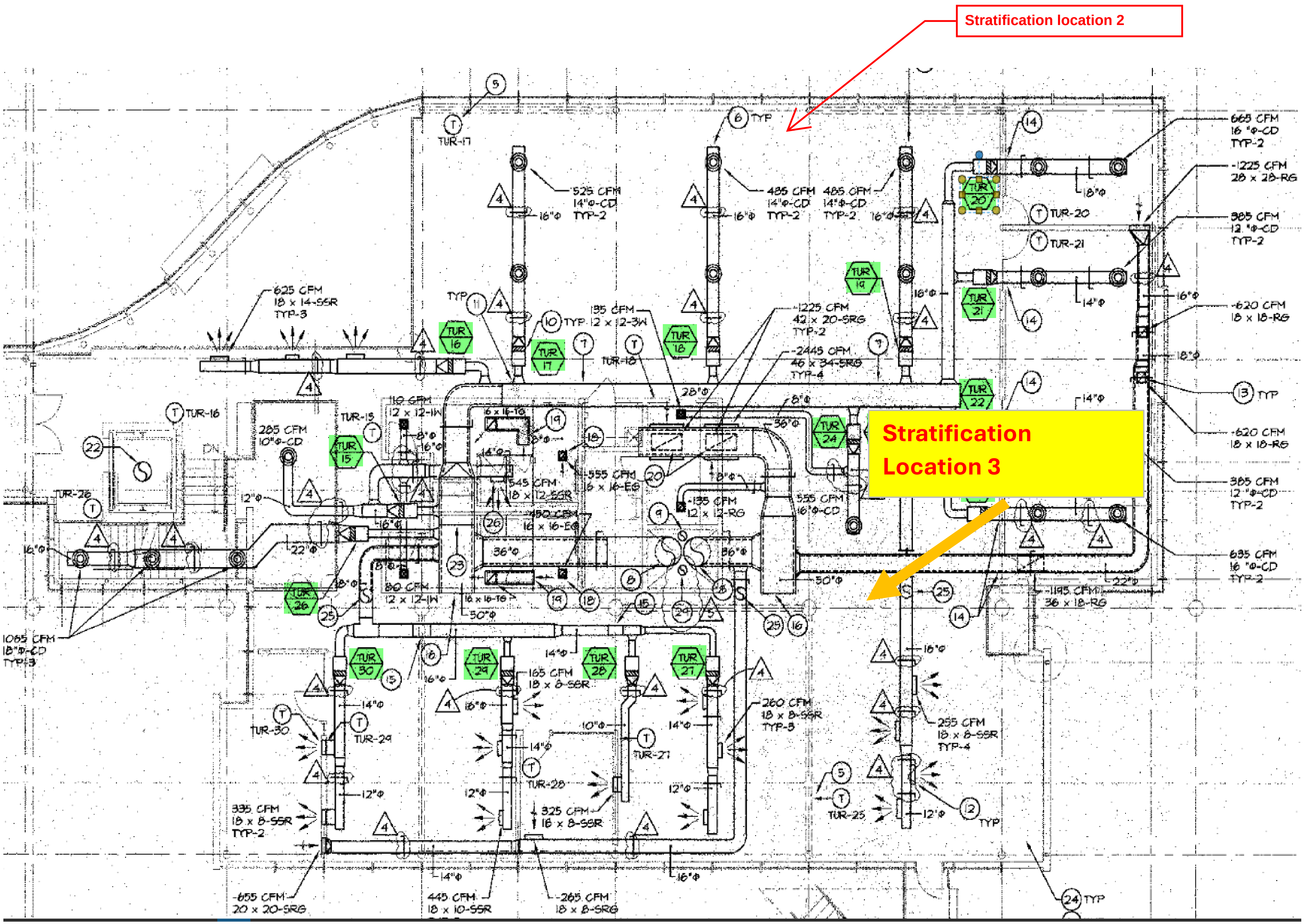
Stratification Location 1





Stratification location 2
Stratification Location 3

RSA RSAnalysis

Environmental System Performance Specialists

1035 Suncast Lane, Suite 130
El Dorado Hills, CA 95762

Phone: 916.358.5672 | Fax: 916.358.5673 | rsanalysis.com

TEST & BALANCE REPORT

EMERYVILLE CITY HALL
1333 PARK AVENUE
EMERYVILLE, CALIFORNIA
PRE-DESIGN SURVEY

CLIENT: **TAYLOR ENGINEERING**

PROJECT NUMBER: 32099-S

DATE: 2/27/2024

TECHNICIAN: MIKE SANDEN

TBE: JOEL JOHNSON

THIS IS TO CERTIFY THAT RSANALYSIS, LLC HAS BALANCED THE SYSTEM DESCRIBED HEREIN TO THEIR OPTIMUM PERFORMANCE CAPABILITIES, UNLESS OTHERWISE NOTED IN THE PROJECT SUMMARY. THE TESTING AND BALANCING HAS BEEN PERFORMED IN ACCORDANCE WITH THE STANDARD REQUIREMENTS AND PROCEDURES OF THE ASSOCIATED AIR BALANCE COUNCIL AND THE RESULTS OF THESE TESTS ARE HEREIN RECORDED.

Table of Contents

DESCRIPTION **PAGE**

GENERAL INFORMATION

TAB REPORT

AABC National Performance Guaranty

Pursuant to the agreement between

RSANALYSIS, LLC

AABC Certified Testing & Balancing Agency

and TAYLOR ENGINEERING

Client

All systems shall be tested and balanced in accordance with the project plans and specifications and to the optimum performance capabilities of the equipment. Testing and balancing shall be done in accordance with the standards published by the Associated Air Balance Council.

If the Agency listed above fails to comply with the specifications for any reason other than termination of business by the AABC agency or equipment malfunction or inadequacy which prevents proper balancing of the systems, AABC will investigate and, if warranted, will provide supervisory personnel to assist the member Agency to perform work in accordance with AABC Standards. This supervision will be provided at no additional cost to the building owner.

This Guaranty is valid for one year from the date of submission of a test and balance report, provided the Agency is a current member of AABC, and may only be invoked in writing by the building owner, architect, or engineer of record. The Guaranty is limited to the terms and conditions as stated herein.

Project Name EMERYVILLE CITY HALL PRE-DESIGN SURVEY

Address 1333 PARK AVENUE

EMERYVILLE, CALIFORNIA

Name of Engineer N/A

Engineering Firm TAYLOR ENGINEERING

Email Address N/A

Address N/A

Date 02/27/2024

TBE # 24-01-131

By [signature]

AABC Certified TBE

AABC
Associated Air Balance Council
1518 K Street, N.W.
Washington, D.C. 20005
202-737-0202 • Fax 202-638-4833
info@aabc.com • www.aabc.com

PERFORMANCE GUARANTY

Pursuant to the agreement between Integra Testing Services, LLC and/or its subsidiaries ("Integra Testing") and Client, all systems shall be tested, adjusted, and balanced in accordance with the project plans and specifications and to the optimum performance capabilities of the equipment. Testing and balancing shall be done in accordance with the standards published by the Associated Air Balance Council (AABC) and/or the National Environmental Balancing Bureau (NEBB).

If Integra Testing fails to comply with the specifications or pre-determined scope for any reason other than equipment malfunction or inadequacy which prevents proper balancing of the systems, Integra Testing's Quality Control Team will investigate and, if warranted, will provide supervisory personnel to assist in the rebalancing of the air or hydronic system(s). The rebalancing of any of the air or hydronic systems will be provided at no additional cost to the building owner. Reported items documented outside of design tolerances with reason are not included in this warranty. If a complaint issue is due to a mechanical equipment failure, control or maintenance related issue, the return trip may be subject to a service charge which is not covered under this warranty. Third party adjustments made to the system prior to invocation of warranty also voids this warranty.

This Guaranty is valid for one year from the date of submission of a test and balance report and may only be invoked in writing by the building owner, architect, or engineer of record. The Guaranty is limited to the terms and conditions as stated herein. Response to complaints will be provided within 10 business days of initial complaint.

Associated Air Balance Council
Annual Certificate

Awarded to

Joel M. Johnson, TBE

RSAnalysis, LLC - South San Francisco

In recognition of their qualification as a

Certified Test and Balance Engineer

under the rules, regulations, and requirements of the Association Air Balance Council. The above named is fully authorized to perform total system balance in accordance with the standards as established by the AABC and as a member of the Associated Air Balance Council for the year

2024

This registration number **24-01-131** *is fully recognized by the bylaws and charter of this professional association. Certification is renewable on an annual basis after examination of the agency's record for the preceding year. This certificate expires December 31, 2024.*

Gaylon Richardson, *President*

Raymond R. Bert, *Executive Director*

AABC

Associated Air Balance Council

hereby certifies that

Michael Sanden

has met all requirements and passed the necessary examination

to perform testing and balancing as an AABC

Certified Test & Balance Technician

under the supervision of a certified test and balance engineer for

RSAnalysis, LLC

This registration number **167-01-06** *is only recognized under the auspices of the above named AABC member agency. This certificate expires December 31, 2024 and is renewable on an annual basis.*

Gaylon Richardson, *President*

Raymond R. Bert, *Executive Director*

GENERAL NOTES

Date	27-Feb-24	RSA Job #	32099

1	Correction for temperature and altitude have been made on all test results shown in this report.
2	All corrections for instruments used for testing and balancing are traceable back to the national bureau of standards and are tested in our own labs.

SYMBOL SHEET

A	F.S.R. - Floor Supply Register	OPEN - No Terminal Device Installed
AHU - Air Handling Unit	FT. HD. - Feet of Head	OSA Min. - Outside Air Minimum
AC or ACU - Air Conditioning Unit	FTU - Fan Terminal Unit	OAT - Outside Air Temperature
ACCU - Air Cooled Condensing Unit	**G**	**P**
ADJ P.D. - Adjusted Pitch Diameter	GPM - Gallons Per Minute	PF - Power Factor
AMP - Amperage	GFH - Gas Fired Heater	PHC - Preheat Coil
AVG. - Average	GFHC - Gas Fired Heating Coil	PH - Phase (s)
B	**H**	PMP - Circulating Pump
B.H.P - Brake Horsepower	HC - Heating Coil	P.P. - Perforated Plate
C	Heater O.L. - Thermal Overload Protection For Motors	PSI - Pounds Per Square Inch
C.D. - Ceiling Diffuser		P.T. - Pitot Traverse
CFM - Cubic Feet Per Minute	HEPA - High Efficiency Particulate Arrestance	**R**
C.E. - Ceiling Exhaust		RA - Return Air
CEF - Ceiling Exhaust Fan	H.F. - Hepa Filter	RF - Return Air Fan
CH - Chiller	HOA - Hand/Off/Auto Switch	R.G. - Return Grille
CHWR - Chilled Water Return	H.P. - Horsepower	RHC - Reheat Coil
CHW or CHWS - Chilled Water Supply	HPS - High Pressure Steam	RPM - Revolutions Per Minute
C.R. - Ceiling Return	HRC - Heat Recovery Coil or Heat Reclaim Coil	**S**
CT - Cooling Tower		SA - Supply Air
CWR - Condenser Water Return	HVAC - Heating, Ventilation & Air Conditioning	SAT - Supply Air Temperature
CW or CWS - Condenser Water Supply		S.D. - Supply Diffuser
	HWR - Hot Water Return or Heating Water Return	SEF - Smoke Exhaust Fan
D		SF (Air) - Supply Fan
DB - Dry Bulb	HWS - Hot Water Supply or Heating Water Supply	S.F. (Electric) - Service Factor
D.D. - Direct Drive		SHC - Steam Heating Coil
D.P. - Difference, Net Increase or Decrease	HX - Heat Exchanger	SP "WC" - Static Pressure, Measured in Inches of Water Column
	I	
DIA - Diameter	I.D. - Inside Diameter	S.W.E - Sidewall Exhaust
D.N.A. - Data Not Available	**L**	S.W.R. - Sidewall Return
D.N.L. - Data Not Listed	LAT - Leaving Air Temperature	S.W.S. Sidewall Supply
E	L.D. - Linear Supply Diffuser	**T**
EAT - Entering Air Temperature	LPS - Low Pressure Steam	TAB - Test, Adjust, & Balance
EDC - Electric Duct Coil	L.R.D. - Linear Return Diffuser	TSP - Total Static Pressure
EDH - Eclectic Duct Heater	L.T. - Light Troffer	**U**
EF - Exhaust Fan	LWG - Low Wall Griller	UH - Unit Heater
EMCS - Energy Management Control System (s)	LWR - Low Wall Return	**V**
	LWT - Leaving Water Temperature	V - Volts
EWT - Entering Water Temperature	**M**	VAV - Variable Air Volume
F	MAU/MUA - Make Up Air Unit	VD - Volume Damper
FCU - Fan Coil Unit	MBH - 1000 Btu's Per Hour	VFD - Variable Frequency Drive
F.D. - Floor Diffuser	**N**	VP - Velocity Pressure
FH - Fume Hood	N.A. - Not Accessible	**W**
FG - Floor Grille	N.I. - Not Installed	W - Watts
F.E. - Floor Exhaust or Return	N.T. - Not Taken	WB - Wet Bulb
F.L.A. - Full Load Amperage	N.V.L - No Valid Location	W.G. - Water Gauge
FPB - Fan Powered Box	N.Z. - Nozzle	**Misc.**
FPM - Feet Per Minute	**O**	ΔP - Differential (Delta) Pressure
F.S. - Floor Supply	O.D. - Outside Diameter	ΔT - Differential (Delta) Temperature

TEST & BALANCE INSTRUMENTATION

Date	27-Feb-24	RSA Job #	32099	Technician	Mike Sanden

THE FOLLOWING INSTRUMENTS WERE USED TO SUCCESSFULLY MEASURE AND SET EACH DEVICE ON THIS PROJECT.

INSTRUMENT	MANUFACTURER	MODEL	SERIAL NO.	CALIBRATION DUE DATE
Air Data Multimeter	Evergreen	S-PVF-1	2100225C	11/2/2025
Hydronic Manometer	Shortridge	HDM-250	W17039	6/18/2024

Project Summary

Date:	3/14/2024
Project:	Emeryville City Hall Pre-Design Survey
Job Number:	32099
Technician:	Mike Sanden

Scope of Work

Pre-design survey the existing HVAC system as requested and directed by client.

Observations & Outcomes

- All systems tested at the direction and witnessed by mechanical engineer of record (Taylor Engineering) & GSH (Kevin Meixner).
- AC-1 fan performance removed from scope while onsite by mechanical engineer.
- All HVAC VAV's are a Delta DDC type with single inlet and reheat coils at terminal units. All systems tested in "AS FOUND" mode with systems in heating mode of operation. VAVs put into heating mode by others.
- 2nd floor VAVs not communicating with the BMS system at time of testing. When RSA attempted to test the 2nd floor VAV the reheat actuator would open and then close again with t-stat set above or below the room zone temperature seen on the t-stat. RSA recommends controls system be inspected and re-established to control VAVs.
- RSA found clogged test ports and were informed of multiple leaks in HHW piping requiring zones to be shut off.
- Stratification location #1 on 1st Floor at 6' = 70.5 degrees, 10.5' = 70.6 degrees, 16'= 71.3 degrees.
- Stratification location #2 on 2nd Floor at 6' = 71.2 degrees, 10.5' = 71.2 degrees, 16'=72.3 degrees.
- Stratification location #3 on 2nd Floor at 6' = 71.4 degrees, 10.5' = 71.4 degrees, 16'= 71.8 degrees.

In our efforts to constantly improve in all aspects of our performance, we would appreciate any feedback, positive or negative, regarding your experience with the RSA team.
Please click the link below to be directed to our Quality Assurance Survey. Thank you!
RSA Quality Assurance

BOILER TEST SHEET

Date	27-Feb-24	Area Served	HHW	Location	Roof

Boiler Data		Design Data	
Equipment I.D.	DNL	Input MBH	DNL
Manufacture	DNL	Output MBH	DNL
Model	DNL	Entering Water Temp	DNL
Service	HHW	Leaving Water Temp	DNL
		GPM	DNL

Test Data			
Entering Water Temp	DNA (1)	Outside Air Temp D.B.	50.0
Leaving Water Temp	DNA (1)	Entering Water Pressure	DNA (1)
High Fire	180	Leaving Water Pressure	DNA (1)
Low Fire	165	Safety Relief Valve	60 psi
GPM	DNA (1)	MBH Output	DNA

Remarks

Secondary discharge temperature 160.5 degrees

(1) No test ports installed.

BOILER TEST SHEET

Date		Area Served		Location	

Boiler Data		Design Data	
Equipment I.D.		Input MBH	
Manufacture		Output MBH	
Model		Entering Water Temp	
Service		Leaving Water Temp	
		GPM	

Test Data			
Entering Water Temp		Outside Air Temp D.B.	
Leaving Water Temp		Entering Water Pressure	
High Fire		Leaving Water Pressure	
Low Fire		Safety Relief Valve	
GPM		MBH Output	

Remarks

PUMP DATA SHEET

Date	3/14/2024	Location	Roof

Pump Data		Pump Data	
Pump Number	P-1	Pump Number	
Manufacture	Taco	Manufacture	
Model / Series	DNL (1)	Model / Series	
Size	DNL (1)	Size	
Impeller	DNL (1)	Impeller	
Service	Secondary HHW	Service	

Test Data											
	GPM	FT. HD.	BHP				GPM	FT. HD.	BHP		
Design	DNL	DNL	DNL			Design					
Actual		-				Actual		0.00			
Discharge	29.1					Discharge					
Suction	DNT (3)					Suction					
Delta	-	X 2.31 =	-	FT. HD.		Delta	0.0	X 2.31 =	0.00	FT. HD.	

Block Off					Block Off				
Discharge	31				Discharge				
Suction	DNT (3)				Suction				
Delta	-	X 2.31 =	-	FT. HD.	Delta	0.0	X 2.31 =	0.00	FT. HD.

Motor Data						Motor Data					
Manufacture	Baldor					Manufacture					
Frame	145T					Frame					
H.P.	DNL (2)					H.P.					
RPM	1750					RPM					
Nameplate		Actual				Nameplate		Actual			
Volts	460	Volts	486	480	488	Volts		Volts			
Amps	2.1	Amps	1.5	1.8	1.5	Amps		Amps			
VFD	☐	Hz	-			VFD	☐	Hz	-		

Remarks		Remarks	
Secondary VAV controls not fully operational.			
(1) No data tag installed.			
(2) Motor data tag worn.			
(3) No test port installed at time of testing.			

FLOW MEASURING STATION CONSTANT VOLUME

Date	27-Feb-24	Pump Identification	Secondary Pump	System Type	HHW

Unit	Size	Setting	Design		Tested		Pressure	
			P.D.	GPM	P.D.	GPM	In	Out
Main	MPV-025-1	100% (1)	DNL	DNL	3.21'	135	-	-
TUR1	AP-100	100% (2)	36"	5.2	133"	10	-	-
TUR4	AP-075L	75% (2)	20"	1.3	404"	5.8	-	-
TUR30	AP-075L	50% (2)	DNL	DNL	DNA (4)	DNA (3)	-	-

Remarks

(1) Taco circuit setter.

(2) FDI circuit setter. (3) Test ports clogged with debris, unable to determine flow.

(4) Control actuator opens and closes when t-stat set to extreme temperature.

HEATING COIL DATA

Date	27-Feb-24

System	TUR1		TUR4		TUR30			
Location	1st Floor				2nd Floor			
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM	1,570	1,344	390	248	350	519		
Entering Air Temp D.B.	55.0	67.2	55.0	61.4	55.0	69.2		
Leaving Air Temp D.B.	100.0	106.0	100.0	128.2	98.0	81.3		
Delta-T	45.0	38.8	45.0	66.8	43.0	12.1		
Sensible Air MBH	77	57	19	18	16	7		
GPM	5.2	10.0	1.3	5.8	1.1	DNA (1)		
Coil Pressure Drop Ft.	DNL	DNT	DNL	DNT	DNT	DNT		
Entering Water Temp	180.0	169.3	180.0	169.5	180.0	156.6		
Leaving Water Temp	150.0	144.5	150.0	159.9	150.0	69.0		
Delta-T	30.0	24.8	30.0	9.6	30.0	87.6		
Water MBH	78	124	20	28	17			

System								
Location								
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM								
Entering Air Temp D.B.								
Leaving Air Temp D.B.								
Delta-T								
Sensible Air MBH								
GPM								
Coil Pressure Drop Ft.								
Entering Water Temp								
Leaving Water Temp								
Delta-T								
Water MBH								

Remarks

(1) Test ports clogged with debris, unable to determine flow.

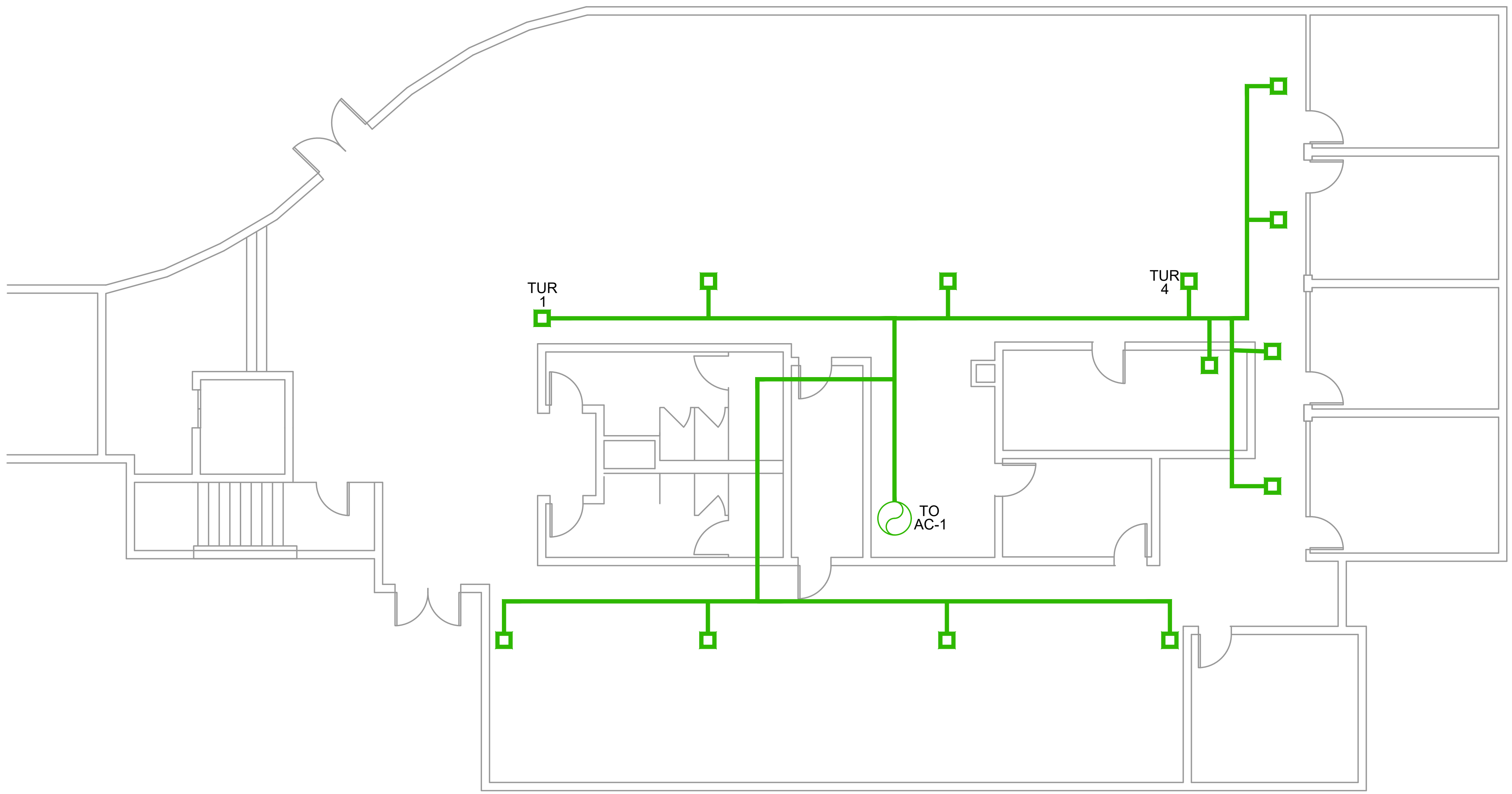
COOLING COIL DATA

Date	27-Feb-24	Altitude	Sea Level

System	AC-1							
Location	Roof							
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM	-	DNT						
Entering Air Temp D.B.	-	73.5						
Leaving Air Temp D.B.	-	67.8						
Delta-T D.B.		5.7						
Sensible MBH								
Entering Air Temp W.B.	-	DNT						
Leaving Air Temp W.B.	-	DNT						
Delta-T W.B.								
Total Air MBH								
GPM	-	DNT						
Coil Pressure Drop	-	DNT						
Entering Water Temp	-	DNT						
Leaving Water Temp	-	DNT						
Delta-T								
Water MBH								

System								
Location								
	Design	Actual	Design	Actual	Design	Actual	Design	Actual
CFM								
Entering Air Temp D.B.								
Leaving Air Temp D.B.								
Delta-T D.B.								
Sensible MBH								
Entering Air Temp W.B.								
Leaving Air Temp W.B.								
Delta-T W.B.								
Total Air MBH								
GPM								
Coil Pressure Drop								
Entering Water Temp								
Leaving Water Temp								
Delta-T								
Water MBH								

Remarks
OSA @ 57.0 degrees.
OSA damper broken off from the return air damper blades, OSA dampers look to be rusted in place at approx 30%.
RA damper looks to be approx 95% open.



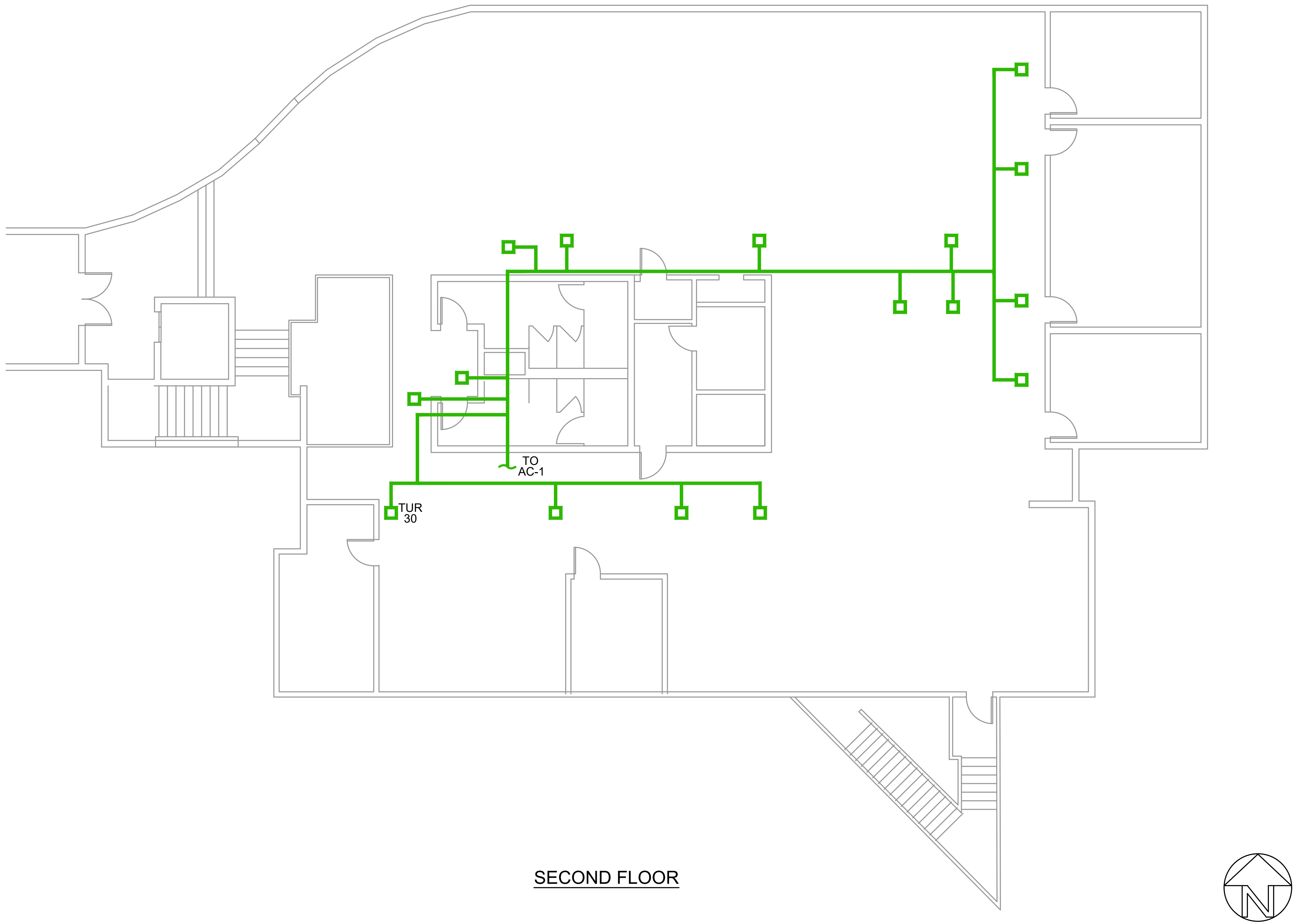
FIRST FLOOR

RSA
RSAnalysis
ENVIRONMENTAL SYSTEM TEST & BALANCE
1035 SUNCAST LN. STE. 130
EL DORADO HILLS, CA., 95762
PH: 888-330-1935
FAX: 916-358-5673

JOB#: 32099-S
DATE: 03-22-24
DRAWN BY: R.HURLEY
CHECKED BY: R.HURLEY
SCALE: NTS
REVISION:

PROJECT NAME:
EMERYVILLE CITY HALL
1333 PARK AVE., EMERYVILLE, CA
PRE-DESIGN SURVEY

M2.2



SECOND FLOOR

RSA
RSAnalysis
ENVIRONMENTAL SYSTEM TEST & BALANCE
1035 SUNCAST LN. STE. 130
EL DORADO HILLS, CA., 95762
PH: 888-330-1935
FAX: 916-358-5673

JOB#: 32099-S

DATE: 03-22-24

DRAWN BY: R.HURLEY

CHECKED BY: R.HURLEY

SCALE: NTS

REVISION:

PROJECT NAME:

EMERYVILLE CITY HALL
1333 PARK AVE., EMERYVILLE, CA
PRE-DESIGN SURVEY

M2.3