
PROCEDURES FOR MODELING BUILDINGS TO MNECB AND CBIP - PART 2

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1. PROBLEM DESCRIPTION

1.1 Introduction

The Breton Banville Associates head office is a 2-storey, 4850 m² office building located in St. Hilaire, Quebec. The building is primarily office space, but also contains a lobby, computer rooms, meeting rooms, a laboratory, storage spaces, a cafeteria, and mechanical/electrical rooms.

Architectural, mechanical, and electrical drawings for the BBA building are included in the appendix. To be considered for the Commercial Building Incentive Program, a full set of architectural, mechanical and electrical drawings must be included when the final application is submitted to Natural Resources Canada. As-built plans are the preferred drawing set, although construction/working plans may be submitted if as-built drawings are not available. Tendering drawings may be submitted if neither as-built drawings nor construction drawings are available. In addition to drawings, the following materials must also be submitted:

- Architectural, mechanical and electrical specifications
- Equipment manufacturer's specifications for any space heating / air conditioning equipment, water heating equipment, air handling units, heat recovery ventilators, pumps, fans, motors, automatic lighting controls, curtainwall or panelized wall systems, windows, specialized building materials and any other special energy conserving features
- Copies of utility rates and schedules
- A plan view of the drawing clearly indicating the zoning strategy
- Written explanation addressing any EE4 warnings encountered or modeling simplifications

1.2 Heating / Cooling System

The building is served by a hydronic heat pump system, with a gas-fired boiler, cooling tower, and distributed heat pump terminals. The boiler is intended to deliver water to a heat pump loop at 18.3 °C. In individual zones, distributed heat pumps extract or deliver heat from the hot water loop according to the heating or cooling needs of that zone.

If the return water temperature is greater than 20 °C, a cooling tower is used to reject heat from the heat pump loop.

1.2.1 Central Boiler

The heat pump loop is served by a central natural gas-fired boiler. It is indicated in the mechanical specification that the set point for this boiler shall be 18.3°C. The boiler manufacturer specification sheet lists the rated output at 469 kW and input of 521 kW.

Information about the circulation pumps was obtained from curves supplied by the pump manufacturer. At the specified operating conditions, the circulation pumps have an efficiency of 77%, and the motor efficiency is 85%.

1.2.2 Service Water Heater

Hot water is provided by a storage-type natural gas-fired water heater. From manufacturers specification it is known that the input rate is 200 kW and the tank storage capacity is 151.4 L. The thermal efficiency is 80%.

1.2.3 Cooling Tower

The cooling tower is a single-cell type with a 461 kW cooling capacity and single-speed fan. In the mechanical specification the following design conditions are indicated:

Design wet bulb temperature: 23.9°C

Design entering water temperature: 33.3°C

Design leaving water temperature: 27.8°C

Minimum leaving water set point: 20°C

The pump manufacturer's specifications indicate that the cooling tower circulation pump efficiency is 71% and motor efficiency is 85%. The pump pressure head is 150 kPa.

1.2.4 Central Make-Up Air Unit

The packaged central make-up air system provides ventilation air to the building. The unit consists of a heating coil, supply fan, exhaust fan, and air-to-air sensible heat exchanger. Total power for the fans and HRV is 3 HP (2237 watts).

At the desired flow rate, the HRV has an ARI-rated sensible effectiveness of 75%, as listed in the manufacturer's specifications.

1.2.5 Heat Pumps

The heat pump schedule found in the mechanical drawings appears below:

Table 1.1 – Heat Pump Schedule

Unit	Cooling Capacity @ 29°C (kW)	Cooling COP	Heating Capacity @ 16°C (kW)	Heating COP	Airflow (L/s)
101	8.5	3.4	10.2	4.3	455
102	10.3	3.3	11.7	4	568
103	10.3	3.3	11.7	4	568
104	6.9	3.4	8.0	4.3	364
105	18.2	3.2	19.3	3.8	909
106	10.3	3.3	11.7	4	568
107	27.8	3.2	29.2	3.8	1545
108	8.5	3.4	10.2	4.3	455
109	6.9	3.4	8.0	4.3	364
110	10.3	3.3	11.7	4	568
111	3.6	3.3	4.3	4.3	175
112	6.9	3.4	8.0	4.3	364
113	10.3	3.3	11.7	4	568
114	10.3	3.3	11.7	4	568
115	18.2	3.2	19.3	3.8	909
116	4.1	3.4	5.2	4.3	241
117	13.9	3.2	14.6	3.8	773
118	10.3	3.3	11.7	4	568
119	6.9	3.4	8.0	4.3	364
201	10.3	3.3	11.7	4	568
202	13.9	3.2	14.6	3.8	773
203	13.9	3.2	14.6	3.8	773
204	8.5	3.4	10.2	4.3	455
205	10.3	3.3	11.7	4	568
206	10.3	3.3	11.7	4	568
207	10.3	3.3	11.7	4	568
208	8.5	3.4	10.2	4.3	455
209	6.0	3.4	6.5	4.3	295
210	3.6	3.3	4.3	4.3	175
211	10.3	3.3	11.7	4	568
212	6.9	3.4	8.0	4.3	364
213	18.2	3.2	19.3	3.8	909
214	12.2	3.2	13.9	3.8	682
215	18.2	3.2	19.3	3.8	909
216	10.3	3.3	11.7	4	568
217	18.2	3.2	19.3	3.8	909
218	6.9	3.4	8.0	4.3	364
219	12.2	3.2	13.9	3.8	682
220	18.2	3.2	19.3	3.8	909
221	6.0	3.4	6.5	4.3	295

1.3 Building Envelope

1.3.1 Brick Walls and Floor Slab

The following diagrams are taken from the architectural drawings:

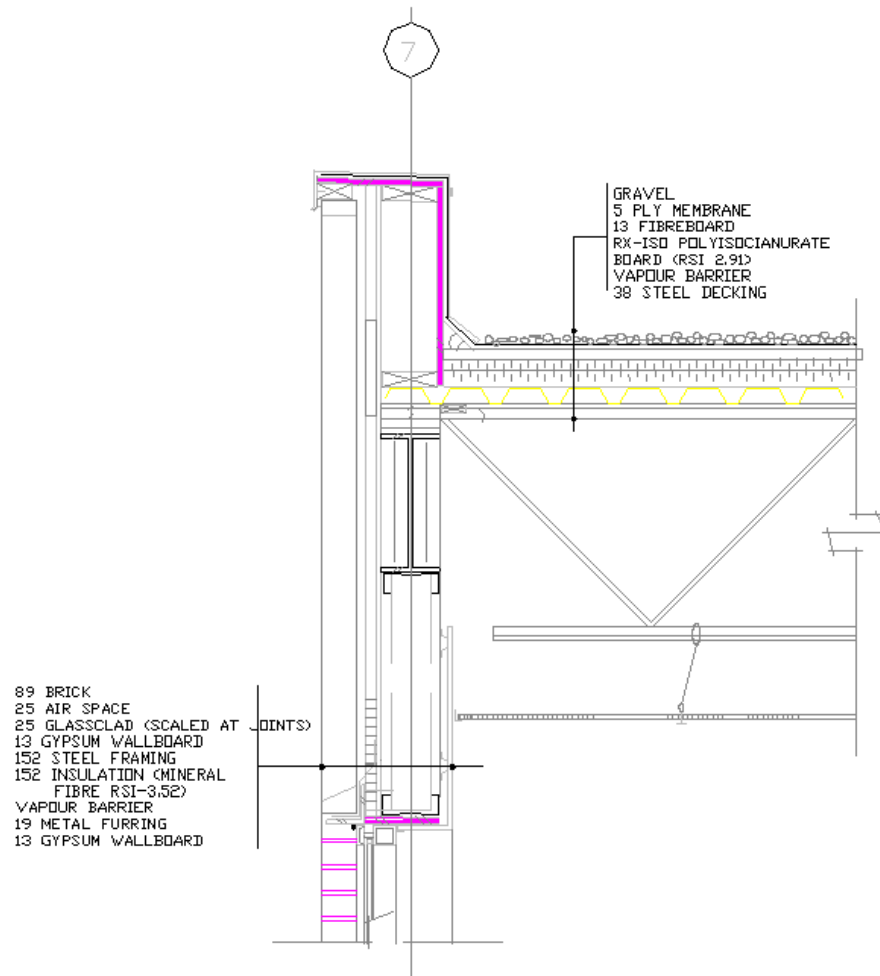


Figure 1.1 – Roof/Brick Wall Schematic

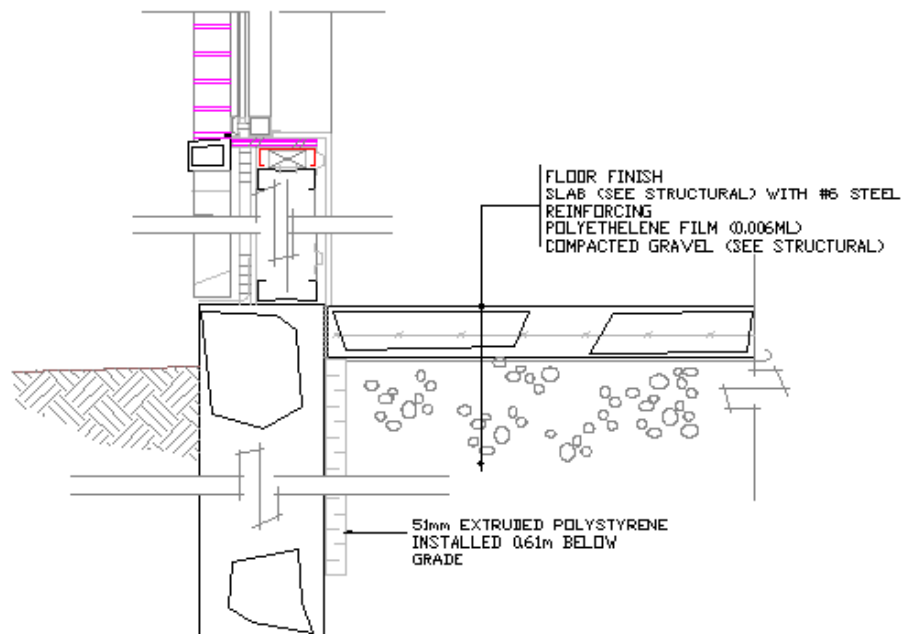


Figure 1.2 – Floor Schematic

1.3.2 Windows








Two types of glazing appear in the building:

- Fixed windows: double glazed, clear, thermally broken aluminum frames
- Curtainwall assembly: double glazed, thermally broken aluminum frames

1.4 Lighting

The lighting plan is indicated on the reflected ceiling drawings. The lighting legend is indicated in the table below:

Table 1.2 – Lighting Schedule

	“F” Fixture (32 Watts/Fixture)
	“K” Fixture (120 Watts/Fixture)
	3 X 4 ft. F32T8 (92 Watts/Fixture)
	2 X 4 ft. F32T8 (62 Watts/Fixture)
	“O” / “P” / “M” Fixture (150 Watts/Fixture)
	“N” Fixture (26 Watts / Fixture)
	“C” / “E” Fixture (100 Watts / Fixture)

According to the electrical specification, all lighting in the building is controlled by occupancy sensors. Lighting in the main lobby and in perimeter areas near windows are also controlled by daylight sensors.

1.5 Utility Rate Structures

Table 1.3 – Electricity Rate Structure

Electricity	Rate
Fixed charge	
• Monthly fixed charge	\$11.67
Price of energy (cents/kWh)	
• First 11,700 kWh	7.41 cents
• Remaining consumption	3.74 cents
Price of power (\$/kW)	
• Billing demand exceeding 40 kW	\$13.59

Table 1.4 – Natural Gas Rate Structure

December through March (inclusive)	
Customer charge per month	\$18.00
First 30 m ³ used per month	13.9425 cents per m ³
Next 55 m ³ used per month	13.4200 cents per m ³
Next 1315 m ³ used per month	12.8451 cents per m ³
Next 1400 m ³ used per month	12.2200 cents per m ³
Next 2800 m ³ used per month	11.5950 cents per m ³
All over 5600 m ³ used per month	10.6555 cents per m ³
Gas supply charge	15.2111 cents per m ³
April through November (inclusive)	
Customer charge per month	\$18.00
First 30 m ³ used per month	10.7791 cents per m ³
Next 55 m ³ used per month	10.2566 cents per m ³
Next 1315 m ³ used per month	9.6817 cents per m ³
Next 1400 m ³ used per month	9.0566 cents per m ³
Next 2800 m ³ used per month	8.4316 cents per m ³
All over 5600 m ³ used per month	7.4921 cents per m ³
Gas supply charge	15.2111 cents per m ³

2. SOLUTION

2.1 Step 1 – Collection of Data

The first step in the simulation process is to collect as much information as possible on building characteristics. This includes architectural, mechanical, and electrical drawings, equipment specifications and efficiency ratings, operating schedules, and applicable utility rate information.

EE4 allows data to be input in either SI (metric) or IP (Imperial) unit systems. A units system is selected by clicking on the “Tools” drop down menu and selecting “Options”. In the “Units” tab, either system can be selected. The units system can also be changed back and forth as data is entered into the program depending on which system is easier to work in. However, before running calculations, the user should switch to SI units. In addition, compliance reports (which must be printed out and submitted with the application) are only generated in SI units.

2.2 Step 2 – Input General Building Information

When selecting to start a new file in EE4, the first element to appear is the “building” element. Double-clicking the building icon introduces a dialog box where various general information about the building and project can be entered.

Figure 2.1 – Building Input Screen

2.2.1 Building Name

“BBA Head Office” is typed in the name space.

2.2.2 Documentation Author

This input is the name of the individual or company preparing the CBIP submission. This is left blank in this example.

2.2.3 Job Number

This is an optional input that allows a company job name or number to be associated with the project. This is left blank in this example.

2.2.4 Rotation

This input is optional and can be used to correlate a project direction to a real direction. For instance, if project north for a building was actually N7°W, all elements in the building could be entered with respect to project north. After the model is complete, entering 7° in this box would rotate all walls, windows, and roofs to the proper direction. (7° clockwise) In the Breton Banville example, the general orientation of the walls are exactly NW, NE, SW, and SE. As these directions are relatively easy to consider, this entry will be left as “0”.

2.2.5 Location

The building location must be selected from one of the cities on the list. If the city is not listed, the closest location which is in the same MNECB administrative region must be selected. St. Hilaire is located outside Montreal in MNECB region “Quebec A”, so Montreal (Dorval) is selected as the building location.

2.2.6 Basis of Space Use

Since the Breton Banville building contains detailed space use classifications, “space function” is the best method to describe space use.

2.2.7 Project Title

This field is optional and allows the project address to be entered. This address will be printed on the reports generated by EE4.

2.2.8 Designer

This is the name and address of the coordinating professional of the project. This individual may be a licensed architect or engineer and will affix a professional seal to the final EE4 report to certify that the building meets the requirements of the MNECB and CBIP.

2.2.9 Energy Cost

Energy costs are entered to estimate the annual utility cost for the building and to determine the amount of the CBIP incentive. Incentives are based on energy costs not including GST, so the costs entered should be the most current prices available excluding GST. Energy rate structures are obtained by contacting the utility or can often be found on the utility company's internet website.

Clicking on the field beside "Electricity" brings up a list of electricity rates. To add the Hydro-Quebec rate, "New" is clicked.

A utility rate dialogue box appears:

The screenshot shows a 'Utility Rate' dialog box with the following fields and values:

- Name:** Hydro-Quebec
- Fuel Type:** Electricity (selected), Fuel Oil, Propane, Natural Gas
- Date Entered:** Sep 2000
- Monthly Charges:**
 - Meter Charge (\$): 11.67
 - Demand Charge: 0.00
 - Min. Monthly Charge (\$): 0.00
 - Min. Demand Charge: 0.00
- Seasonal Charges:**

Seasonal Charges	Ending Month	Ending Day
Season 1	n/a	n/a
Season 2	n/a	n/a
Season 3	n/a	n/a

Buttons: OK, Cancel

Figure 2.2 – Electricity General Input Screen

The basic monthly cost for service of \$11.67 is entered in the "Meter Charge" box. There are no monthly demand charges, or minimum monthly charges. EE4 allows up to three seasonal rates to be entered. Since there are no seasonal variations in this rate structure "Season 1" is clicked and 12/31 is entered as the "end date" for this rate structure. This tells EE4 that the rate is applied from January 1 until December 31:

Ending Month	Period Charges	Ending Hour
12	Period 1	n/a
31	Period 2	n/a
	Period 3	n/a

Figure 2.3 – Utility Rate Season Definitions

Up to three time-of-day variations can also be entered into EE4. The Hydro-Quebec rate structure does not change throughout the day. To define the rate structure, “Period 1” is clicked.

The ending hour is set to 24, and the number of tiers is set at 2 as indicated in the diagram below:

Electricity [?] [X]

Energy Rate | Demand Rate | Energy/Demand Rate (kWh / kW)

Ending Hour:

Number of Blocks:

Charges are per kWh of energy

Block	Charge (\$)	kWh Limit
Block 1	<input type="text" value="0.07410"/>	<input type="text" value="11700"/>
Block 2	<input type="text" value="0.03740"/>	<input type="text" value="0"/>
Block 3	<input type="text" value="0.00000"/>	<input type="text" value="0"/>
Block 4	<input type="text" value="0.00000"/>	<input type="text" value="0"/>
Block 5	<input type="text" value="0.00000"/>	<input type="text" value="0"/>
Block 6	<input type="text" value="0.00000"/>	<input type="text" value="0"/>

OK Cancel

Figure 2.4 – Energy Rate Input Screen

The demand charge of \$13.59/kW must also be entered on the “Demand Rate” tab:

Electricity [?] [X]

Energy Rate | **Demand Rate** | Energy/Demand Rate (kWh / kW)

Number of Blocks: Charges are per kWh/kW of energy

Block	Charge (\$)	kW Limit
Block 1	<input type="text" value="0.00000"/>	<input type="text" value="40"/>
Block 2	<input type="text" value="13.59000"/>	<input type="text" value="0"/>
Block 3	<input type="text" value="0.00000"/>	<input type="text" value="0"/>
Block 4	<input type="text" value="0.00000"/>	<input type="text" value="0"/>
Block 5	<input type="text" value="0.00000"/>	<input type="text" value="0"/>
Block 6	<input type="text" value="0.00000"/>	<input type="text" value="0"/>

OK Cancel

Figure 2.5 – Demand Rate Input Screen

Since there are no seasonal variations in this rate structure, only one seasonal rate structure is entered, with ending month of “12” and ending day of “31”. This indicates the rate is the same from January 1 up until the end of December.

The natural gas rate structure, however, is more complicated. It is a 6-tier system with seasonal changes at the end of March and at the end of November.

Although the natural gas rate has only a 2-season structure, it must be entered as a 3-season system as EE4 requires that the first season begins in January. Thus, for EE4 purposes, the first season runs from January until the end of March, the second season runs from April 1 until November 30, and the third season includes only the month of December. The ending dates for each season are identified as follows:

Utility Rate [?] [X]

Name:

Fuel Type:

☐ Electricity
 ☐ Fuel Oil
 ☒ Natural Gas
 ☐ Propane

Date Entered:

Monthly Charges:

Meter Charge (\$):
 Demand Charge:

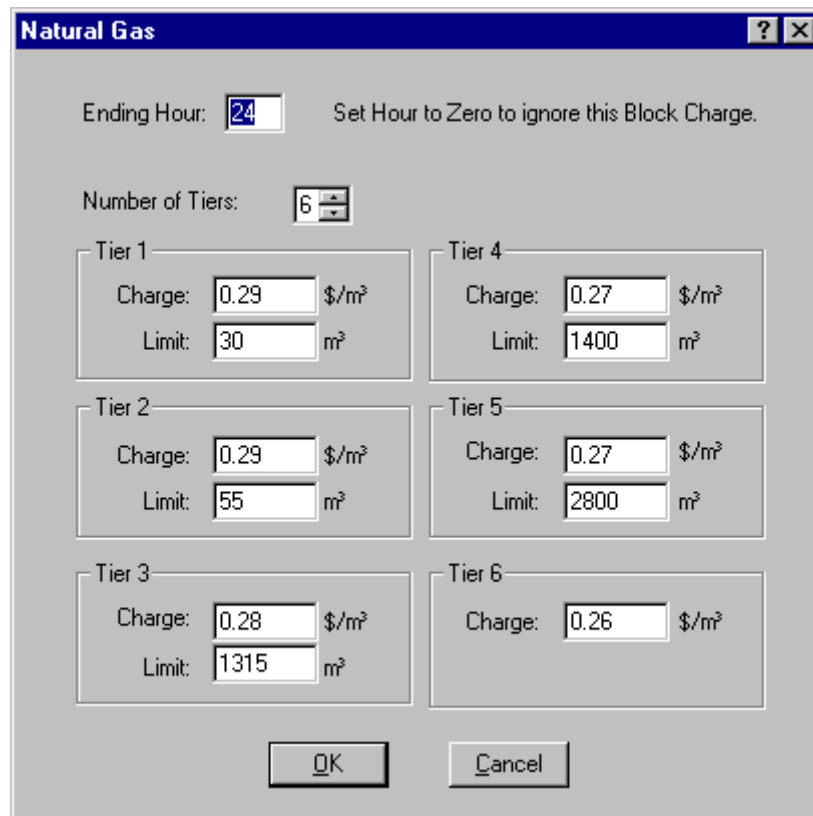
Min. Monthly Charge (\$):
 Min. Demand Charge:

Seasonal Charges	Ending Month	Ending Day
<input type="text" value="Season 1"/>	<input type="text" value="3"/>	<input type="text" value="31"/>
<input type="text" value="Season 2"/>	<input type="text" value="11"/>	<input type="text" value="30"/>
<input type="text" value="Season 3"/>	<input type="text" value="12"/>	<input type="text" value="31"/>

[OK] [Cancel]

Figure 2.6– Natural Gas General Input Screen

Both components of the price of gas, the delivery charge and supply (gas) charge, are added together and put into the 6-tier structure. The winter rate would be entered as indicated below:



Natural Gas [?] [X]

Ending Hour: Set Hour to Zero to ignore this Block Charge.

Number of Tiers:

Tier	Charge (\$/m³)	Limit (m³)
Tier 1	<input type="text" value="0.29"/>	<input type="text" value="30"/>
Tier 2	<input type="text" value="0.29"/>	<input type="text" value="55"/>
Tier 3	<input type="text" value="0.28"/>	<input type="text" value="1315"/>
Tier 4	<input type="text" value="0.27"/>	<input type="text" value="1400"/>
Tier 5	<input type="text" value="0.27"/>	<input type="text" value="2800"/>
Tier 6	<input type="text" value="0.26"/>	

[OK] [Cancel]

Figure 2.7 – Natural Gas Rate Input Screen

The summer rate would be entered in a similar manner. The third season (December) is identical to the winter rate structure.

For both gas and electricity rate structures, the ending hour is set to 24, indicating that there are no time-of-day variations in rate structure.

2.3 Step 3 – Defining The Central Plant

Right-clicking on the building element and choosing “insert” introduces a central plant element. This is where any central boiler, service water heater, chiller, heat pump, and cooling tower characteristics are defined.

2.3.1 Service Water

The service water tab is where the central plant is named and where the service water heater characteristics are defined. The plant will be called “SWH-Boiler” and the water heater size, fuel, input rate, and efficiency is entered. From the mechanical specifications, it is known that water heater is natural gas-fired, has tank size 151.4 L, and an input rate of 200 kW. For efficiency, the thermal efficiency of 80% is entered as 0.80. (note that this is thermal efficiency, not energy factor)

If the box “Service Water Heating Not Included in Analysis” is checked, EE4 will define an electric water heater that is identical in both proposed and reference cases. In this case no credit or penalty will be realized.

2.3.2 Central Heating

The building’s heating needs are served by a 469 kW natural gas boiler. Clicking the field next to “Heating Boiler” brings up a short list of pre-defined boiler types. Since none of these correspond to the boiler in the Breton Banville building, “new” is clicked to define a new type of boiler.

The boiler is named “469 kW Natural Gas Boiler”, the fuel type selected as natural gas, the output capacity of 469 kW is entered, and the thermal efficiency of 90% (output / input) is entered as 0.90.

Since only 1 boiler is installed, the boiler multiplier is set to 1, and the sequencing capacity is set at 0.

The circulation pump efficiencies and effective head are not defined on the “central heating” for heat pump systems. These items will be defined later under the “heat pump” tab.

2.3.3 Central Cooling

Since the building’s cooling needs are supplied by distributed heat pumps, no central chiller is installed. The chiller is left as “undefined or MNECB default”. Since the chiller is not defined, the remaining values on the central cooling tab are ignored by EE4, even though they appear on the compliance report.

Plant [?] [X]

Cooling Tower Heat Pump Spring Fall Changeover
Service Water Central Heating Central Cooling

Purchased Cooling ☐

Chiller: undefined or MNECB Default

Chiller Multiplier: 1

Sequencing Capacity: 0 kW

Cooling Circulation Pumps

Pump Type: Fixed-Speed ▼

Effective Head: 0 kPa

Design Temp. Drop: 5.6 °C

Pump Efficiency: 77.0 %

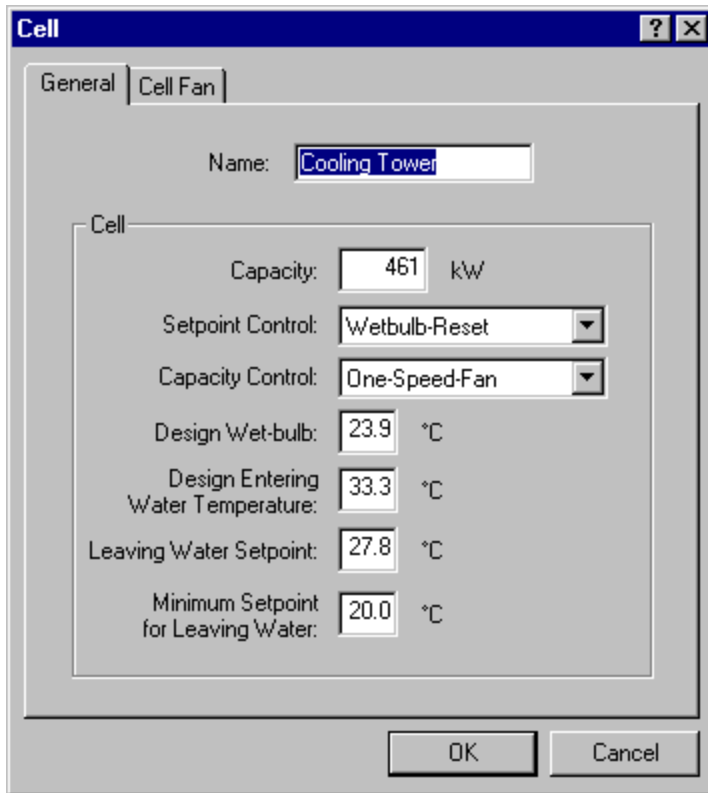
Motor Efficiency: 85.0 %

OK Cancel

Figure 2.8 – Central Cooling Inputs

2.3.4 Cooling Tower

The cooling tower is defined on the cooling tower tab, in the space marked “cell”. Clicking in the field reveals a list of pre-defined cooling towers. Since the cooling tower is not on the list, “new” is clicked to describe the characteristics. A dialogue box appears and the cooling tower parameters are entered as indicated in the manufacturer’s specification.



The image shows a software window titled "Cell" with two tabs: "General" and "Cell Fan". The "Cell Fan" tab is selected. Inside the tab, there is a "Name:" label followed by a text box containing "Cooling Tower". Below this is a "Cell" label followed by a large rectangular area containing several input fields and dropdown menus. The inputs are: "Capacity:" with a text box "461" and the unit "kW"; "Setpoint Control:" with a dropdown menu showing "Wetbulb-Reset"; "Capacity Control:" with a dropdown menu showing "One-Speed-Fan"; "Design Wet-bulb:" with a text box "23.9" and the unit "°C"; "Design Entering Water Temperature:" with a text box "33.3" and the unit "°C"; "Leaving Water Setpoint:" with a text box "27.8" and the unit "°C"; and "Minimum Setpoint for Leaving Water:" with a text box "20.0" and the unit "°C". At the bottom of the window are "OK" and "Cancel" buttons.

Parameter	Value	Unit
Capacity	461	kW
Setpoint Control	Wetbulb-Reset	
Capacity Control	One-Speed-Fan	
Design Wet-bulb	23.9	°C
Design Entering Water Temperature	33.3	°C
Leaving Water Setpoint	27.8	°C
Minimum Setpoint for Leaving Water	20.0	°C

Figure 2.9 – Cooling Tower Input Screen

In the “Cell Fan” tab, the characteristics of the cooling tower fan are described. Here the fan is identified as an axial fan.

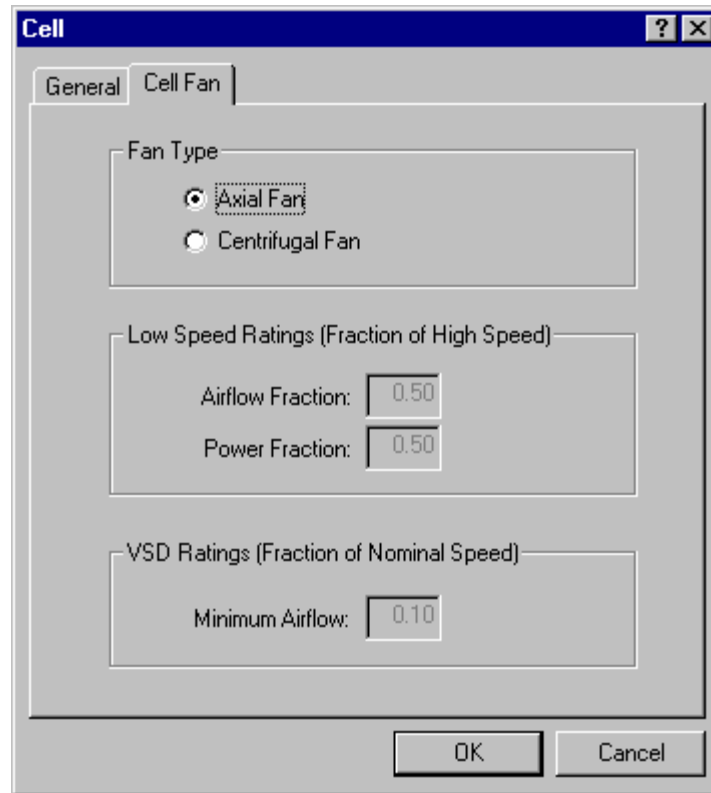


Figure 2.10 – Cooling Tower Fan

2.3.5 Heat Pump

Characteristics of the heat pump loop are described in the “Heat Pump” tab. The heat pump loop source is boiler/cooling tower, so the corresponding button is selected. The circulation pumps for the heat pump loop are also defined on this tab. From the manufacturer pump curve, the head rise at the flow rate specified in the mechanical specification is 65 ft (194 kPa). The pump efficiency of 77% and motor efficiency of 85% are also entered.

The 'Plant' dialog box has a title bar with a question mark and a close button. It contains three tabs: 'Service Water', 'Central Heating', and 'Central Cooling'. The 'Central Heating' tab is active, showing sub-tabs for 'Cooling Tower', 'Heat Pump', and 'Spring Fall Changeover'. The 'Heat Pump' sub-tab is selected.

Source for Heat Pump Loop

☒ Boiler / Cooling Tower ☐ Ground Loop

Heat Pump Circulation Pump

Pump Type: Fixed-Speed

Effective Head: 194 kPa Pump Efficiency: 77.0 %

Design Temp. Drop: 5.6 °C Motor Efficiency: 85.0 %

Boiler Set Point Temperature 18.3 °C

Ground Temperatures

January: 15.6 °C	May: 15.6 °C	September: 15.6 °C
February: 15.6 °C	June: 15.6 °C	October: 15.6 °C
March: 15.6 °C	July: 15.6 °C	November: 15.6 °C
April: 15.6 °C	August: 15.6 °C	December: 15.6 °C

OK Cancel

Figure 2.11 – Heat Pump Loop Characteristics

2.3.6 Spring/Fall Changeover

This tab applies only to two-pipe induction units and two-pipe fan-coil systems and does not apply to this building.

2.4 Step 4 – Defining Systems

To introduce the next building element, right-click on the plant element and choose “insert” from the pop-up menu, which introduces the “system” element. For a heat pump loop, this system element is used to describe the make-up air handling unit. Double-clicking on the system element brings up the System dialogue box. The name of the system is entered as “WLHP System”. To define more specific parameters, the field next to “HVAC” is clicked.

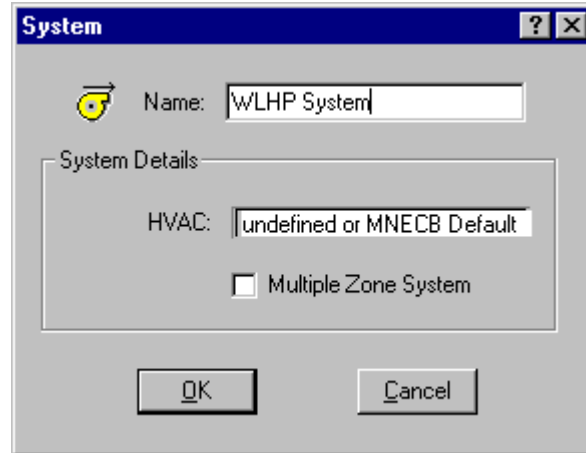


Figure 2.12 – System Input Screen

This brings up a list of pre-defined air handling systems. Since the specified make-up air unit does not appear on the list, “add” is chosen to enter the parameters of the system.

2.4.1 General

The general HVAC system type and heating characteristics of the make-up air unit are input on the general tab. Here the name is entered as “120 kW Make-up Air Handler” and the system type is defined as “Hydronic Heat Pump” from the drop-down list.

The Breton Banville make-up air unit tempers outdoor air with hot water delivered from the central plant. An assumption of the hydronic heat pump system type is that the boiler serving the heat pump loop also serves the heating coil in the make-up air unit. The total output capacity of the coil is 120.2 kW, and is intended to bring the outdoor air temperature up to 13.3°C. These specifications are entered in the “Heating Characteristics” box on the “General” tab:

System [?] [X]

Supply Fan | Return Fan | Preheat Coil | Zone

General | Cooling | Outdoor Air

Name: 120 kW Make-up Air Handler

System Type: Hydronic Heat Pump

Heating Characteristics:

Heating Type: Hot Water

Coil Control: Constant Temp

Output: 120.2 kW

Backup Heating: 0.0 kW

Supply Temperature: 13.3 °C

Heating Efficiency:

Efficiency Rating Type:

☒ EER / AFUE

☐ COP / Thermal Eff.

Efficiency: 0.800

OK Cancel

Figure 2.13 – System General Tab

2.4.2 Cooling

Since no cooling occurs at the system level (make-up air is not cooled until it reaches the zonal heat pump) the cooling capacity is set to 0 kW on the “Cooling” tab. The value beside “% Sensible” is not applicable in this case and is left at the default value of 0.75.

2.4.3 Outdoor Air

The “Outdoor Air” tab is used to describe an economizer or heat recovery ventilator. No economizer has been installed in this system. However, a heat recovery ventilator has been specified. The manufacturer specification lists the effectiveness as 75% at the specified operating conditions, so 0.75 is entered in the “sensible heat recovery effectiveness” field.

2.4.4 Supply Fan

The electrical consumption of the make-up air supply fan is accounted for in the “Supply Fan” tab. The power consumption can be specified in one of two ways: static pressure/efficiency or power. In this case, the power can be easily obtained from the fan information, so “power” is selected as the fan rating type, and the design fan power of 2237 W (3 hp) is entered. The total system heating capacity (120.2 kW, entered on the general tab) does not include heat gain due to the fan, so the box “Fan power included in ratings” is left unchecked.

System [?] [X]

General | Cooling | Outdoor Air | **Supply Fan** | Return Fan | Preheat Coil | Zone

Fan Operation:

- ☐ Operate Fans According to Schedule
- ☐ Fans are Always On
- ☐ Cycle Main Fans with Setback
- ☒ Cycle Zone Fans with Setback

Fan Control: FC w/Vanes

Fan Rating Type

- ☐ Static Pressure/Eff.
- ☒ Power

Fan Power

Airflow: 0 L/s

Design Fan Power: 2237 watts

Fan Placement: Blow-Through

Motor Outside Airstream ☐

Static Pressure: 0.00 Pa

Combined Efficiency: 55 %

Mechanical Efficiency: 55 %

Fan Power Included in Ratings ☐

OK Cancel

Figure 2.14 – Supply Fan Input Screen

2.4.5 Return Fan, Preheat Coil, Zone

Entries on these tabs have been automatically disabled because they are not applicable to a heat pump system. For VAV and CV systems, return fans, preheat coils and zone reheat systems (baseboards or reheat coils) may be defined using these tabs.

2.5 Step 5 – Zoning

Before entering more information into the EE4 program, the building must be subdivided into thermal zones. The Breton Banville office building was zoned according to the guidelines presented in part 1 of this manual.

Similar Operation and Building Function

Areas of the building with significantly different operation schedules and space use characteristics cannot be in the same zone. On the first floor of the BBA building, the laboratory, cafeteria, and main lobby have a significantly different function than the office areas which make up the majority of the building. On the second floor, only the upper lobby has a significantly different space use characteristic. The first step in zoning the building would be to single out these zones from the rest of the building.

Same HVAC System and Thermostat

In the BBA building, the entire building is served by the same central heat pump loop, so all zones are included in the same system.

Similar Heating and Cooling Loads

Finally, the building is divided into areas that would share the same heating cooling load. Zones must be small enough so that the entire area of the zone does not have a significantly different load, yet large enough to ensure that there is not an unreasonably large number of zones to put it into the EE4 program. Perimeter areas on different sides of the building should be separated from one another. For instance, on a cold, sunny, winter morning, the southeast side of the building will heat up due to solar gains, and will require much less heating than the northwest side of the building, which will be dark and very cold. Meanwhile, the core interior of the building will have a different heating load than either perimeter area so it should be separated as well.

Zone 1 – Laboratory

As mentioned above, the laboratory is distinguished from the rest of the building because it has significantly different space function. Since the laboratory is a relatively small area, is served by a single heat pump, and there will not be a large load difference from one end to the other, there is no need to subdivide into more zones.

Zone 2 – Cafeteria

As with the laboratory, the cafeteria has a distinct space use classification. Looking at the mechanical drawings, it is seen that the entire cafeteria is served by a single heat

pump, and it is small enough that there would not be a significant load distribution throughout. Next to the cafeteria is a stairway which will have a similar operating schedule as the cafeteria, and similar heating and cooling loads. The stairway and cafeteria can be grouped into a single zone.

Zone 3 – First Floor Interior Core

Referring to the architectural floor plan, the interior of the first floor is generally offices, board rooms, and office equipment. These areas will all be occupied at the same time of day, and because the zone is interior and not subject to envelope gains or losses, the heating and cooling load throughout the interior will be relatively constant at any given time of day. The entire interior area on the first floor can then be considered to be a single zone. Because there is some variation in space use throughout the zone, including washrooms, equipment rooms, and board rooms, this zone will later be divided into several spaces.

Zone 4 – Northwest Office

The office area on the northwest side of the building has a different space use than the neighbouring cafeteria, but will have a different heating and cooling load than the interior core. It should then be included in a new zone. Since there is no definite wall separating this zone 4 from Zone 3, the decision of where to place the dividing line is somewhat arbitrary. Since the perimeter area is served by heat pump #104, and Zone 3 in this area is served by heat pump #105, the dividing line can be placed about halfway between the air diffusers from the two heat pumps.

Zone 5 – Southwest Office

This is a perimeter zone. The heating and cooling load along the entire wall will be the same, and the dividing line is placed about halfway between perimeter and interior diffusers.

Zone 6 – South Office

This small area is made its own zone because it has a different space use than the neighbouring main lobby, has different orientation than Zone 5, and is a perimeter area so should not be included in Zone 3.

Zone 7 – Main Entrance

The main entrance has a different space use classification than the rest of the building and is made a distinct zone. It need not be divided into more than one zone because it is relatively small and is served by only one heat pump.

Zone 8 – Southeast Office

Zone 8 includes the southeast perimeter area. Although it could be argued that the southwest wall could be a distinct zone, the area is small enough that it can be included in the southeast zone with little loss of accuracy.

Zone 9 – Northeast Wall

The perimeter area on the northwest wall contains a mechanical room, stairway, and a perimeter office space. This area is not conditioned by its own perimeter heat pump system. Instead, heat from neighbouring zones is used to condition this space.

Upper Level Zones

The second floor is zoned in a similar manner to the lower level. Perimeter zones are separated from interior zones, and the upper lobby is kept separated. Since the BBA building contains only two stories, no lower level zones can be grouped with upper level zones, because there are significantly different heating and cooling load characteristics between zones on grade and those under an exposed roof. However, for larger multi-story buildings, areas on several floors may be grouped into a single zone provided that the floors have similar operating characteristics and heating/cooling loads.

2.6 Step 6 – Entering Zone #1 Into EE4

A zone is entered by right-clicking on the system element and picking “insert”. A blue zone icon appears.

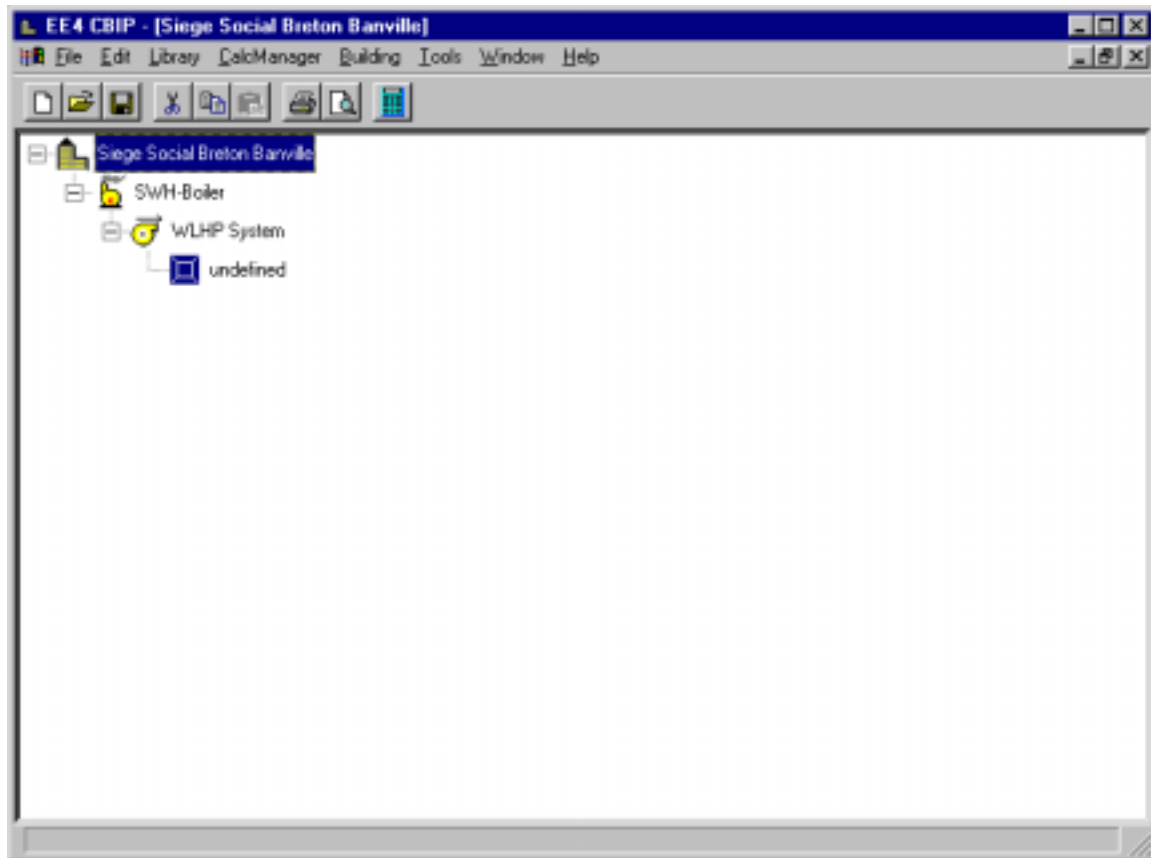


Figure 2.15 – CBIP Zone Screen

Double-clicking on the zone icon produces a dialogue box where various zone parameters can be inserted.

2.6.1 General Tab

Name

The zone is named “Zone #1” as shown on the drawings. The zone is located in the north corner of the first floor.

Zone Type

Because this zone is heated, “directly conditioned” is selected. All zones in this building are directly conditioned. Examples of indirectly conditioned zones are unheated attics, mechanical penthouses, and unheated parking garages.

Description

A description must be entered, that will explain to the user where this zone is. If no text is entered here, the simulation will not be performed. For Zone 1, the text entered is “Laboratory at north side of building served by heat pump #119.”

The screenshot shows a software window titled "Zone" with a standard Windows interface including a title bar with a question mark and close button, and a tabbed interface. The "General" tab is selected. The "Name" field contains "Zone 1". The "Zone Type" section has two radio buttons: "Directly Conditioned" (selected) and "Indirectly Conditioned". The "Description" field contains the text "Laboratory at north side of building served by heat pump #119.". The "Zone Details" section contains several fields: "Space Use" is a dropdown menu set to "Office"; "Floor Number" is a text box with "1"; "Rotation" is a text box with "0" followed by the unit "degrees"; "Principal Heating Source" is a dropdown menu set to "Natural Gas"; and "Floor Weight" is a dropdown menu set to "Medium". At the bottom right of the window are "OK" and "Cancel" buttons.

Figure 2.16– Zone General Input Screen

Floor Number

This zone is on the first floor – enter “1”.

Rotation

This zone is not turned at an oblique angle to the rest of the building, so “0” is entered.

Principal Heating Source

For Quebec Region “A”, natural gas has a higher energy source adjustment factor than heat pump, so it is selected from the dropdown list.

Floor Weight

The floor weight is left at the default value of “Medium”. (70 lb/sq.ft)

2.6.2 Lighting Tab

Lighting Area Factor

Clicking the lighting tab allows several of the characteristics of the lighting to be entered. The lighting area factor allows the allowable lighting power density for the reference building to be increased depending on space type, ceiling height and area.

The equation to determine the LAF is

$$\text{LAF} = 0.2 + 0.8(1/0.9^n)$$

$$\text{where } n = \frac{10.21(\text{CH} - 0.76)}{\sqrt{A}} - 1$$

CH = ceiling height in metres,

A = area of space (m²).

For the laboratory, the ceiling height is 3 m and the total area is 140 m². Plugging the numbers into the equation yields 1.08. (refer to the MNECB, 4.3.3.5 for exceptions and rules regarding lighting area factors)

Predominant Lighting Type

From the plan drawings it is known that this zone contains primarily fluorescent lamps, “non-incandescent” is selected.

Fixture Location

These fluorescent lights are recessed into the ceiling, which is chosen from the dropdown list.

Zone [?] [X]

General | **Lighting** | Mechanical | Schedules

Basis of Space Use:

Building Type: _____ Space Function: _____

☐ Lighting Not Specified ☒ Lighting Area Factor: 1.08

Connected and Adjusted Lighting

Installed LPD: 9.739 W/m²

Adjusted LPD: 6.817 W/m²

Predominant Lighting Type

☐ Incandescent

☒ Non-Incandescent

Fixture Location: Recessed in Ceiling

Heat to Space: 100 %

OK Cancel

Figure 2.17 – Lighting Tab

2.6.3 Mechanical Tab

Zone Heating Output / Cooling Output

The total heating capacity of all terminal heating units in this zone is included. From the mechanical drawings it can be seen that this zone is served by heat pump #119. From the heat pump schedule and manufacturers specifications, the following information is obtained.

Table 2.1 - Heating and Cooling Capacity

Unit #	Heating Capacity (kW)	Heating COP	Cooling Capacity (kW)	Cooling COP	Airflow (L/s)
119	8.0	4.3	6.9	3.4	364

These values are entered into the appropriate location on the mechanical tab.

Design Fan Power

Fan power is used to take into account electrical consumption of the heat pump fan. For this particular manufacturer, the published COP values already take fan power into account, so zero is entered into the fan power box.

The screenshot shows a software window titled "Zone" with a blue header bar containing a help icon and a close button. Below the header are four tabs: "General", "Lighting", "Mechanical", and "Schedules". The "Mechanical" tab is currently selected. The main content area is divided into three sections:

- Zone Level Mechanical System Data:**
 - Terminal Type: A dropdown menu showing "Baseboard".
 - Zone Heating Output: A text box containing "11.7" followed by "kW".
 - Zone Cooling Output: A text box containing "10.3" followed by "kW".
 - Maximum Airflow Rate: A text box containing "0" followed by "L/s".
 - Minimum Airflow Rate: A text box containing "0" followed by "L/s".
- Heat Pump Performance:**
 - Heating COP: A text box containing "4.0".
 - Cooling COP: A text box containing "3.3".
- Terminal Fan:**
 - Airflow Rate: A text box containing "568" followed by "L/s".
 - Design Fan Power: A text box containing "0" followed by "watts".

At the bottom right of the window are two buttons: "OK" and "Cancel".

Figure 2.18 – Zone Mechanical Input Screen

2.6.4 Schedules Tab

Schedules may be specified for lighting, occupancy, receptacle loads, process loads, service water heating, fan operation, and heating and cooling set points. If no schedules

are specified, MNECB defaults for the type of space use (which will be defined in the next step) are assumed. Since the operating schedule of this building is not expected to deviate significantly from a typical office building, no changes are made on the schedule tab.

2.7 Step 7 – Enter Remaining Zones into EE4

Step 6 is repeated for all zones in the building. Note that zones in the same building may have different heating and cooling capacities, principal heating sources, lighting characteristics, floor weights, schedules, etc.

2.8 Step 7 – Defining Spaces

Each zone must now be subdivided into one or more spaces. Spaces are used to describe one or more occupancy types within a zone. Most zones in the Breton Banville Office need not be separated into more than one space. For instance, the “storage” area in the Zone #1 is relatively small and can be included with the laboratory space. Zone #3, on the other hand, is split into 4 spaces: office space, office equipment, corridor, and washrooms.

EE4 uses the space use classification to determine the outdoor air flow rates, occupant densities, receptacle loads, operating schedules, and service water heating loads that will be used in both proposed and reference buildings. It also uses space use classification to determine the reference building lighting density. The default values used by EE4 appear in Table 4.3.2.B in the online help.

It is required that Zone 3 be divided into several spaces to accurately represent the energy use in that space. For example, even though the entire area is office-related space, the washrooms require less lighting according to the MNECB than the office area. If the washroom was not defined and assumed to be office space, lighting performance credits would have unfairly been obtained. Similarly, the corridor area has a lower lighting requirement under the MNECB than general office space. The office equipment area, on the other hand, has a higher allowable lighting power density than office space.

2.9 Step 8 – Entering Spaces into EE4

A space is entered by inserting it under the zone element. In this example, the space being entered is the laboratory space in Zone #1.

2.9.1 General Tab

Name

The space is named “Lab”.

Space Use

The space use is selected from the drop down list. Details on each type of space is available in the EE4 help file, in Table 4.3.2.B. There is a laboratory category, which is chosen from the drop down list.

Area

The floor area is measured, which will be used to determine outdoor air flow rates, interior heat gain due to occupants, reference building lighting density, etc. The floor area of the laboratory space in Zone 1 is This value is entered in metric units in the “Area” box.

Desired Temperature

The desired space temperature settings are left at the default values of 21.1°C (winter) and 23.3°C. (summer)

Figure 2.19 – Room General Input Screen

2.9.2 Infiltration Tab

For CBIP compliance purposes the infiltration rate is set to 0.25 L/s per m² of gross wall area. Higher infiltration rates may be modeled for non-compliance simulations. In this example the value is left at zero.

2.9.3 Occupant Tab

Occupant Density

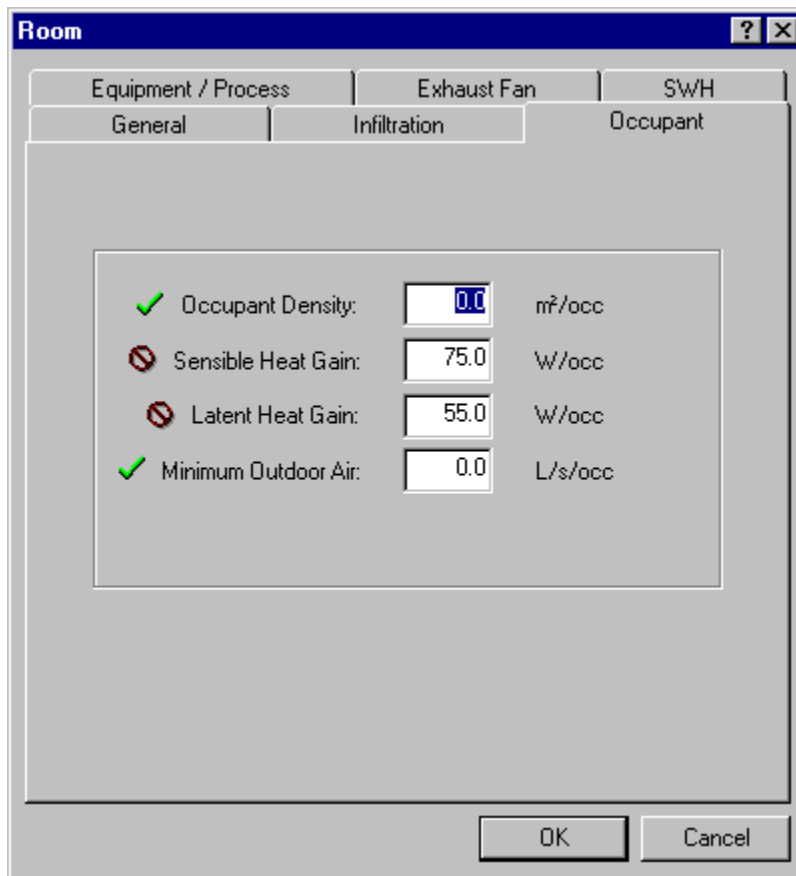
It is not expected that the occupant density will be significantly higher or lower than the standard default MNECB occupancy density. The occupant density is left at 0, which means EE4 will assume the MNECB default. The default values are listed in the help file, in Table 4.3.2 B.

Sensible and Latent Heat Gain

The heat gain from each occupant cannot be altered for CBIP compliance purposes so these inputs are left at their default values. These values can be changed for non-compliance purposes.

Minimum Outdoor Air

As with occupant density, the outdoor air ventilation rate will not vary significantly from the MNECB default value. Entering “0” ensures that EE4 will assume the MNECB default flow rate. If minimum outdoor is set to a value other than the MNECB default, the occupant density must also be defined. The same outdoor air flow rate will be used in both proposed and reference buildings.



The image shows a software window titled "Room" with a standard Windows-style title bar (minimize, maximize, close buttons). Inside the window, there are three tabs: "Equipment / Process", "Exhaust Fan", and "S/WH". Below these tabs are three sub-tabs: "General", "Infiltration", and "Occupant". The "Occupant" sub-tab is currently selected. The main area of the window contains a list of input fields for occupant-related parameters. Each field has a status icon to its left: a green checkmark for "Occupant Density" and "Minimum Outdoor Air", and a red circle with a diagonal slash for "Sensible Heat Gain" and "Latent Heat Gain". The input values are: Occupant Density: 0.0 m²/occ; Sensible Heat Gain: 75.0 W/occ; Latent Heat Gain: 55.0 W/occ; Minimum Outdoor Air: 0.0 L/s/occ. At the bottom right of the window are "OK" and "Cancel" buttons.

Parameter	Status	Value	Unit
Occupant Density	✓	0.0	m²/occ
Sensible Heat Gain	✗	75.0	W/occ
Latent Heat Gain	✗	55.0	W/occ
Minimum Outdoor Air	✓	0.0	L/s/occ

Figure 2.20 – Room Occupant Input Screen

2.9.4 Equipment / Process

Receptacle Loads

Receptacle loads are used by EE4 only in non-compliance calculations. For the purposes of CBIP compliance, the default values are used, according to the space type selected. In this example, these values are left at zero.

Process Loads

Since this is a standard office space, there will be no significant process heat loads. This field is left at the default value of 0. EE4 uses the same process in proposed and reference cases whether a process load is specified or not.

2.9.5 Exhaust Fan Tab

There is a single zone-level exhaust fan in the laboratory, with a rated flow rate of 100 L/s and power consumption of 100 watts. This fan will follow the same schedule as the HVAC fans described in the Schedules tab in the Zone element.

The screenshot shows a software window titled "Room" with a tabbed interface. The tabs are "General", "Infiltration", "Occupant", "Equipment / Process", "Exhaust Fan", and "S/W/H". The "Exhaust Fan" tab is currently selected. Inside this tab, there is a section titled "Fan Description" which contains three input fields: "Airflow:" with the value "100" and unit "L/s", "Design Fan Power:" with the value "100" and unit "watts", and "Multiplier:" with the value "1". At the bottom right of the window are "OK" and "Cancel" buttons.

2.9.6 SWH Tab

Space hot water use characteristics are defined in the “SWH” tab. This differs from the plant hot water capacity as SWH load is the amount of hot water demanded by occupants in a space, but plant capacity is the amount of hot water that the central water heater can deliver to the load.

Total SWH Load

The hot water load for this space is not expected to be significantly higher or lower than the MNECB hot water defaults. This value is left at 0 which will ensure EE4 will use the MNECB default. The default value appears in Table 4.3.2.B in the online help.

Peak Load Percentages / Max Flows

This entry is used to specify peak load percentages for showers and faucets. Energy consumption due to showers and faucets is not significant for this type of space, so the value is left at 0 which assumes the MNECB defaults.

2.10 Step 9 – Building Envelope Take-offs

Now that the building has been divided into distinct zones and spaces, wall, window, door, floor, and roof measurements for each space must be obtained. Measurements can be easily tracked using a spreadsheet or table.

It is easiest to name and label components on a plan diagram to keep track of which walls are in each space. In the BBA building, walls were numbered clockwise starting from the northeast wall in the laboratory space. Each wall in each space must be measured separately. Furthermore, if there are two or more types of walls in a building, the area of each construction type must be known. In the BBA building, there are two wall types – brick (as indicated on the architectural drawings) and an insulated curtainwall panel.

The take off sheets used by the simulator for wall, floor, roof, and windows areas appears in the appendix.

2.10.1 Walls

For the walls, the full gross interior wall area should be measured. This particular space is on the first floor with a conditioned space above it, so a roof does not need to be defined.

2.10.2 Doors

There is one insulated steel door in the laboratory zone. The measured area includes the door frame. Glass doors, such as those found in the front entrance of the building, should be included as window.

2.10.3 Floor

The floor is specified as “underground” at a depth of 0 because it is a concrete slab-on-grade. The perimeter value is the exposed perimeter (length of wall in contact with ground).

2.11 Step 10 – Entering Building Envelope Elements into EE4

2.11.1 Walls

In EE4, walls in each space of each construction type must be entered separately. To enter a wall, right-click on the space element and choose “insert”. A list of envelope components appears. “Exterior wall” is selected from the list. “Wall #1” has been defined as the northeast-facing wall in the laboratory zone. Inserting a wall element into the laboratory space brings up the following box:

Exterior Wall

Name: Wall #1

Area: 68.2 m²

Construction: BBA Brick Wall

Orientation: 45 degrees

Tilt: 90 degrees

☒ ☐ Exempt

OK Cancel

Area

The interior wall area of 68.2 m² as indicated on the take-off spreadsheet.

Orientation

The orientation is the outward facing direction of the wall, with 0° as north and 180° as south. Since this wall is facing NW, 45° as the orientation.

Tilt

The tilt is used to define the angle the wall makes to the horizontal. As this is a standard vertical wall, the tilt angle is 90°.

Construction

Clicking the space beside “Construction” brings up a pre-defined list of various wall, roof, and floor types. Since this wall type is not listed, “new” brings up the following table:

Construction Assembly [?] [X]

Component Description

Assembly Name:

MNECB Type:

☒ Absorptivity: ☒ ASHRAE Group:

☒ Roughness:

☐ Input Assembly U-Value U-Value: W/m²·°C

Framing

☐ No Framing ☐ Wood

Metal - Framing Spacing

☒ < 500 mm, w/o Insul. Sheathing

☐ < 500 mm, with Insul. Sheathing

☐ 500 mm and greater

Framing Percent: %

Construction Components

Material	Thickness	Framing	R-Value	
			Cavity	Framing
Outside Surface Air Film			0.030	0.030
Siding, Alum or Steel w/Sheathing	9.500		0.102	0.102
Insulation, Mineral Fibre, RSI-2.11	89.000	X	2.110	0.001
Gypsum Sheathing	13.000		0.081	0.081
Inside Surface Air Film			0.120	0.120
Subtotal			2.442	0.334
Weight: 30.9 kg/m ²				
Heat Capacity: 32.7 kJ/m ² ·°C				
Overall U-Value: 0.8773				
Overall R-Value: 1.1				

Figure 2.21 – Construction Assembly Input Screen

MNECB Type

“Wall” is selected from the drop-down list.

Absorptivity

Absorptivity is used to describe the fraction of radiation that is absorbed by the wall. A perfectly mirrored surface that reflects all incident solar radiation would have an absorptivity of 0; a black surface absorbing all incident radiation would have an absorptivity of 1.0. For unshaded surfaces, 0.7 is a recommended value, so that number is used in the BBA Building. The same number is used by EE4 in both reference and proposed buildings.

ASHRAE Group

The ASHRAE Group is used to determine the transfer function coefficients to take into account thermal mass effects of the wall. The value is used by EE4 for system sizing calculations in CBIP, but is not used in the actual compliance calculations. A list of Group definitions is included in ASHRAE Fundamentals p. 28.21 and 28.22, and in the online help.

The value is set to Group 2, “frame wall with 127 mm insulation”. This group best describes this wall of any on the list.

Roughness

Roughness is used to describe the texture of the exterior wall and is used by EE4 for system sizing calculations only. “Brick, Plaster” is selected from the drop-down list.

Input Assembly U-value

The EE4 program should be used to determine the total-wall U-value, so this box is left unchecked. Otherwise, hand calculations showing the MNECB procedure to calculate wall U-values (MNECB Appendix C) must be included with the application. It is not permissible to enter the nominal U-value in this box.

Construction Components

Each building layer is entered by clicking “add”. The following box appears:

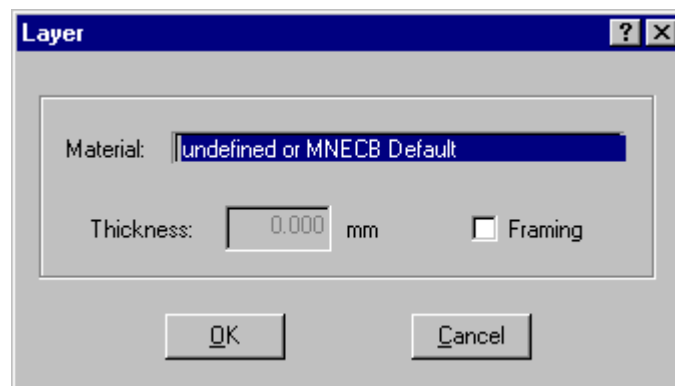
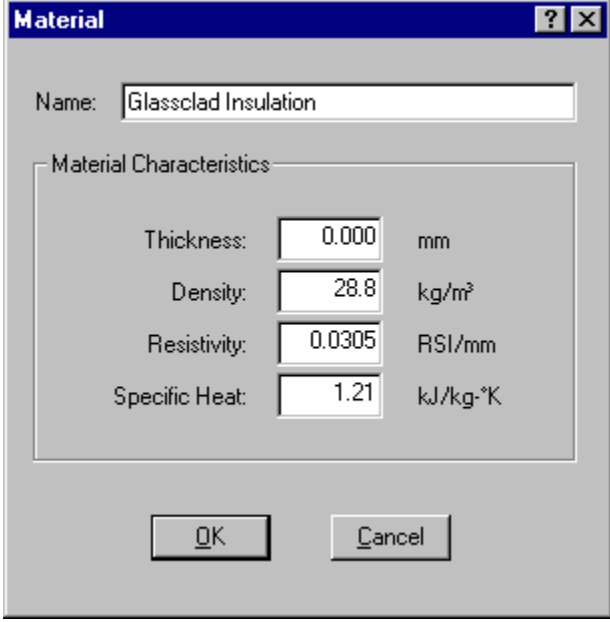
A screenshot of a software dialog box titled "Layer". The dialog has a blue title bar with a question mark icon and a close button (X). Inside the dialog, there is a "Material:" label followed by a text field containing "undefined or MNECB Default". Below this, there is a "Thickness:" label followed by a text field containing "0.000" and the unit "mm". To the right of the thickness field is a checkbox labeled "Framing", which is currently unchecked. At the bottom of the dialog are two buttons: "OK" and "Cancel".

Figure 2.22 – Construction Component Input Screen

Clicking the field beside “Material” brings up a list of pre-defined materials. The first layer, according to the architectural drawings, is 88.9 mm brick. It can be selected from the list, and the thickness is entered.

The remaining components are added in a similar manner. Since Glassclad is not listed in the default building material library, it must be added by clicking “add” on the material list, which introduces the screen shown below.



The image shows a Windows-style dialog box titled "Material". It has a "Name:" label followed by a text box containing "Glassclad Insulation". Below this is a section titled "Material Characteristics" which contains four rows of input fields: "Thickness:" with a value of "0.000" and unit "mm"; "Density:" with a value of "28.8" and unit "kg/m³"; "Resistivity:" with a value of "0.0305" and unit "RSI/mm"; and "Specific Heat:" with a value of "1.21" and unit "kJ/kg·K". At the bottom of the dialog are "OK" and "Cancel" buttons.

Property	Value	Unit
Thickness	0.000	mm
Density	28.8	kg/m³
Resistivity	0.0305	RSI/mm
Specific Heat	1.21	kJ/kg·K

Figure 2.23 – Material Input Screen

The relevant material properties are entered, including density, resistivity, and specific heat. If the material is of a fixed thickness, it also may be entered. For materials that can be purchased in various thicknesses, such as insulation or sheathing, the thickness should not be specified in the material properties box. Material properties should be obtained from the ASHRAE Fundamentals handbook. If listings are not available in ASHRAE, the Canadian Construction Materials Classification (CCMC) may be used.

Framing

The type of framing must also be specified. This building has 6” metal studs, 16 inches apart. Thus we select metal framing, <500 mm w/o insulating sheathing. Since it is not clear from the drawings what the actual framing percentage is, we use Table C-1 in the EE4 help file: “Framing Percentages for Typical Wood and Steel-Framed Assemblies”. This table lists an appropriate framing percent of 0.64%.

It is essential to identify which layer in the wall contains the framing. In this particular building, the framing is in the mineral wool insulation layer. In this case, the box beside “framing” is checked beside the mineral wool layer box.

Framing can only be specified in one layer, otherwise an EE4 error will result.

The final wall assembly and U-value appear as follows:

Construction Assembly

Component Description

Assembly Name: BBA Brick Wall

MNECB Type: Wall

Absorptivity: 0.70

ASHRAE Group: 2

Roughness: Brick, Plaster

☐ Input Assembly U-Value U-Value: 0.3540 W/m²·°C

Framing

☐ No Framing ☐ Wood

Metal - Framing Spacing

☒ < 500 mm, w/o Insul. Sheathing

☐ < 500 mm, with Insul. Sheathing

☐ 500 mm and greater

Framing Percent: 0.64 %

Construction Components

Material	Thickness	Framing	R-Value	
			Cavity	Framing
Outside Surface Air Film			0.030	0.030
Brick, Face	88.900		0.068	0.068
Air Space	25.400		0.148	0.148
Glasclad Insulation	25.400		0.774	0.774
Gypsum Sheathing	12.700		0.079	0.079
Insulation, Mineral Fibre, Loose Fill	152.400	X	3.516	0.002
Air Space	22.225		0.148	0.148
Gypsum Sheathing	12.700		0.079	0.079
Inside Surface Air Film			0.120	0.120
Weight:	215.2 kg/m ²	Subtotal	4.962	1.448
Heat Capacity:	175.2 kJ/m ² ·°C	Overall U-Value:	0.3540	
		Overall R-Value:	2.8	

Buttons: Insert, Add, Delete, OK, Cancel

Figure 2.24 – Construction Assembly Input Screen

2.11.2 Interior Partitions

Interior partitions are used to identify an interior wall between two areas of different space temperature. This can occur when the systems of two neighbouring zones operate according to different schedules, or have different heating or cooling setpoints. In the BBA building, Zone 1 operates according to the “laboratory” schedule and Zone 3 operates according to the “office” schedule. Since these zones are connected, the wall between them should be modeled.

Interior partitions are entered in similar to walls. Right-click on the space element, choose “insert” and highlight “interior partition”.

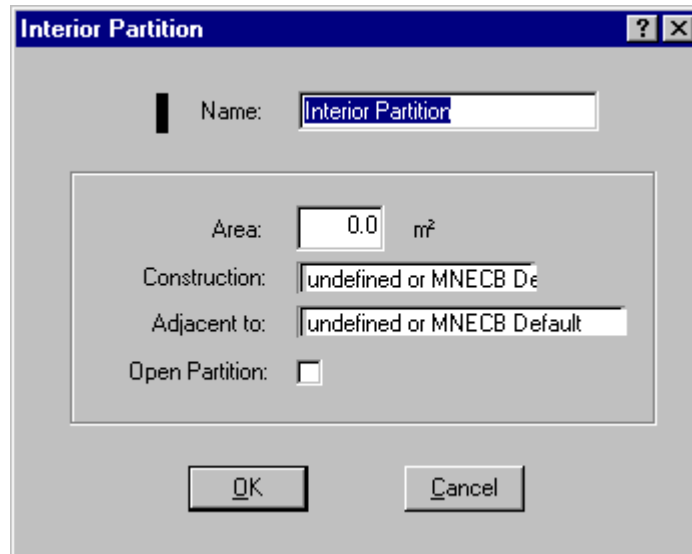


Figure 2.25 – Interior Partition

Clicking construction introduces the list of wall and roof assemblies. EE4 includes a predefined interior partition consisting of an air space with gypsum wall board on each side. This construction assembly is selected for the BBA building.

Clicking the field “Adjacent to” brings up a list of all spaces that have been defined in the building. It is only necessary to define the interior partition in one space. Since the partition between Zones 1 and 3 is being defined here in Zone 1, there is no need to put another interior partition in Zone 3.

2.11.3 Roofs

Roofs are entered into EE4 in a manner similar to that described for walls. The “MNECB Type” for the roof may be one of three types:

Type 1 – attic-type roofs

Type 2 – parallel-chord trusses and joist-type roof

Type 3 – all other roofs (e.g., concrete decks with rigid insulation)

The type will selected be used to determine the U-value of the roof in the reference building. (see MNECB, Appendix A, Table A-3.3.1.1)

2.11.4 Exposed Floors

As this building has no floors over unconditioned spaces (the floor is slab-on-grade), there are no exposed floors that need be defined. The floor of the upper level need not be defined because it is over a conditioned space.

2.11.5 Underground Floors

Underground floors are any sub-grade or slab on grade that is directly in contact with the ground. The floor in the BBA Building is slab-on-grade, so a floor must be defined for all spaces in the lower level of the building.

Area

Here the total floor area of 140 m² is entered.

Exposed Perimeter

This is the length of wall in contact with the ground, or perimeter of the space along and exterior wall. For the laboratory space, the exposed perimeter is 24.5 m.

Depth

Since this floor is a slab-on-grade, the depth is 0.

Insulation Configuration

The exact insulation configuration may not be included in the dropdown list. As indicated on the drawings, this floor has a 2" extruded polystyrene interior and no perimeter insulation, so "R10 Interior" is selected from the list because it most closely represents what is actually specified. New user-defined underground floor types cannot be defined in EE4.

Figure 2.26 – Floor In Contact With Ground Input Screen

2.11.6 Windows

Windows and doors are entered as elements within a wall. To define a window, the total-window U-value (including frame) and SHGC must be known. Since the window manufacturer could not provide an NFRC-rated total-window U-value, the table in the Fenestration chapter in ASHRAE Fundamentals 1997, (Chapter 29, Table 5) must be used. For the fixed windows, the ASHRAE published value is $U_i = 3.22$. For the curtainwall glazing, the published value is 3.51. The solar heat gain coefficient is also obtained from ASHRAE Fundamentals 1997 (Chapter 29 Table 12). For clear glass (no tint or low-e coating), the published value for double-glazed, 6.4 mm thick glass installed at 0° (vertical) is 0.70. This value is used for both fixed windows and the curtainwall system.

To enter the window into EE4, right-click on the wall element and choose “insert”.

Figure 2.27 – Window and Door Entry

“Window” is selected from the box. Double clicking on the window icon that appears results in the following dialogue box:

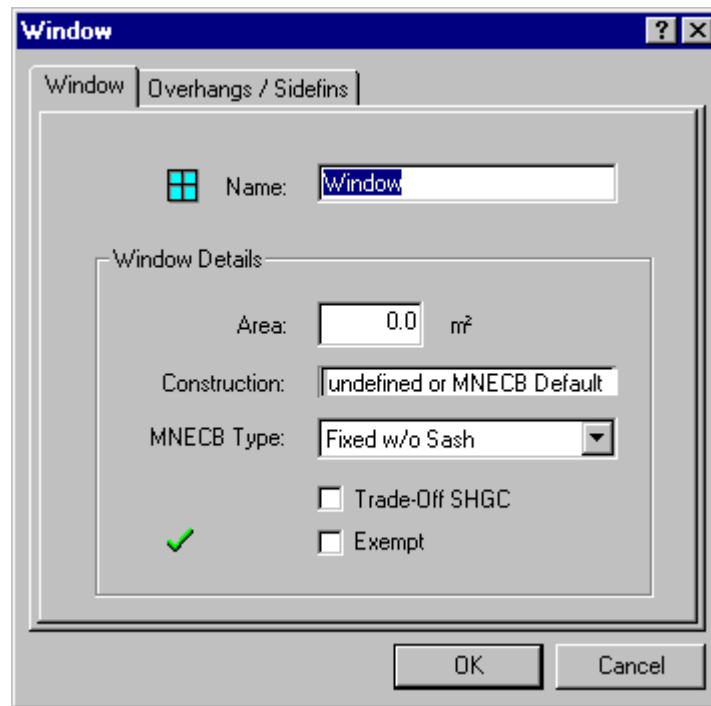


Figure 2.28 – Window Screen

Area

The full area, including frame, is entered.

Construction

Clicking on the field beside “Construction” introduces a list of pre-defined types.

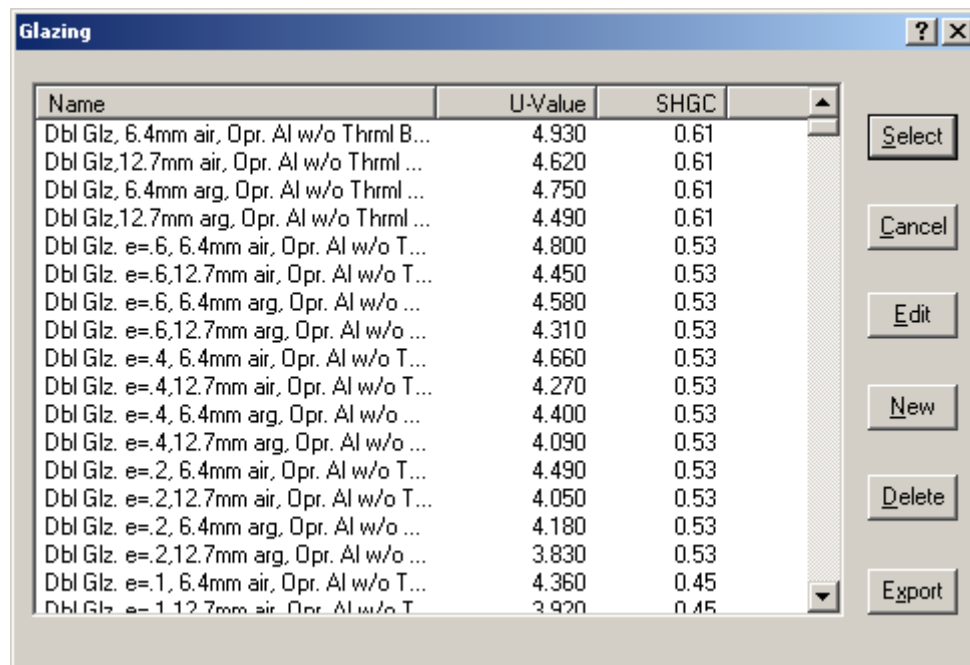


Figure 2.29 – Glazing Library

The default window U-values found in the EE4 table correspond to those found in ASHRAE Fundamentals, Chapter 29. According to the window specification, the window type is double-glazed, fixed, with thermally broken aluminum frames. The window type labeled “Dbl Glz, 12.7mm air, Fix. Al w/Therml Brk” is selected from the drop down list.

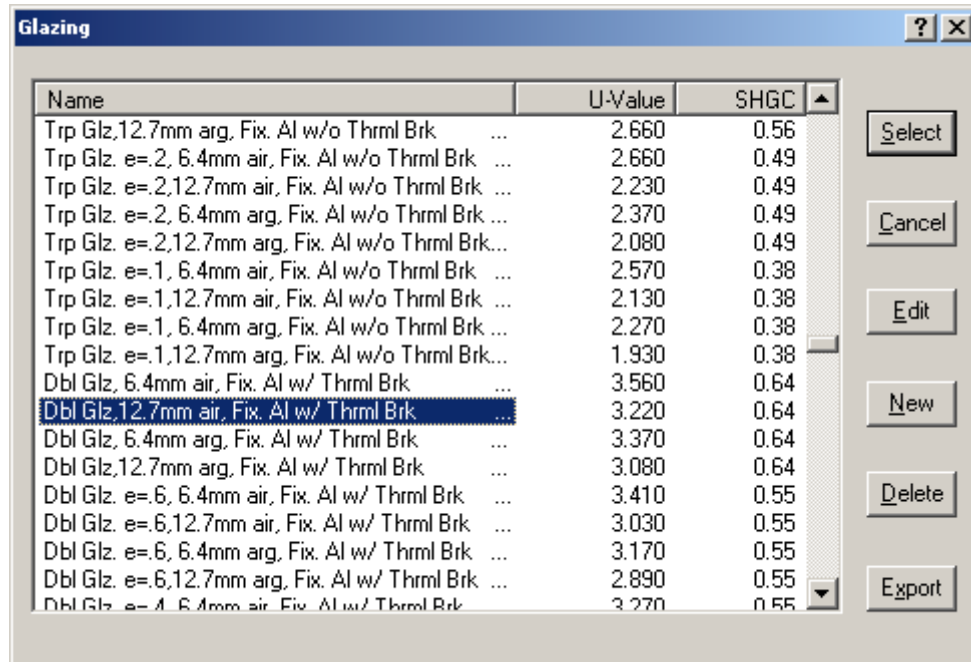


Figure 2.30 – Glazing Selection

MNECB Type

From the drop-down list, one of three MNECB types may be selected – fixed without sash, operable or fixed with sash, or glass block.

Although there are no windows in Zone 1 of the BBA building, most of the other zones do have windows. The windows within the brick wall have sashes, so “operable or fixed with sash” is selected from the drop down list. For the glazing units in the curtainwall, “fixed without sash” is selected.

Trade off SHGC

In the MNECB, performance credits are not permitted for an improved solar heat gain coefficient (SHGC). In the CODE version of EE4, SHGC in the proposed and reference buildings are modeled equally.

However, in the CBIP program, performance credits are permitted for SHGC where it is advantageous to the applicant.

If this box is left unchecked, windows in both proposed and reference buildings are set equal to the entered SHGC. If this box is checked, the reference building uses a SHGC of 0.64, and the proposed building uses the entered value.

It is not obvious whether a lower SHGC will improve the building’s energy performance. Lower solar heat gain coefficients reduce solar gains and therefore lower cooling

equipment energy consumption, however, heat energy required during the heating season may increase. Whether a low SHGC actually decreases total energy use will depend on several factors, including the quantity and orientation of the glazing. The best approach may be a “trial and error” method, where compliance calculations are performed with this box checked and again with it unchecked.

In the BBA building, this box is left unchecked.

Overhangs/Sidefins

If the window contains overhangs or sidefins, they should be modeled in the “Overhangs/Sidefins” tab.

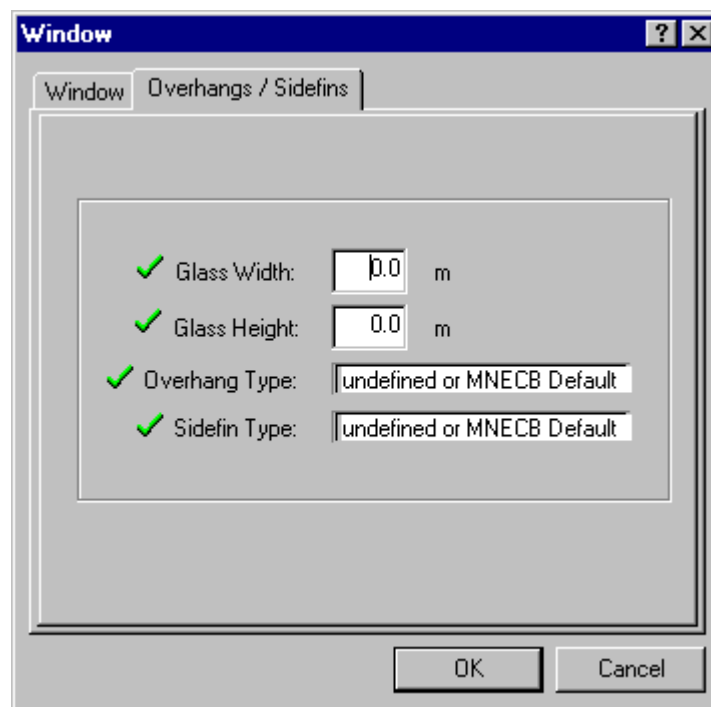


Figure 2.31 – Overhangs/ Sidefins Screen

Glass width and height only need to be specified if an overhang or sidefin is to be defined, so that EE4 can determine the fraction of window that is shaded from solar radiation. Clicking the field beside “Overhang Type” introduces a list of pre-defined overhangs. If the particular overhang is not in the list, one may be added.

Sidefins are defined in a similar manner.

2.11.7 Doors

Doors are entered similar to windows, except that only the total-door U-value is entered. (not solar heat gain coefficient is entered) The insulated door U-value could not be found in the specification, so the ASHRAE value is used. Table 7 in Chapter 29 of ASHRAE fundamentals lists U-values for various doors. The table lists insulated steel swinging doors at U-value = 2.10. EE4 will use the same value in the proposed and reference cases.

2.12 Step 11 – Lighting Elements

Lighting is entered as an element within a space. In Zone 1, the lighting plan indicates there are 22 2-lamp 4-ft T8 fixtures with electronic ballasts. All lights in the zone are controlled by occupancy sensors.

After inserting a lighting element, “(2) 4 ft Fluorescent T8 Elec” is chosen from the list of fixtures. The (2) in brackets indicates 2 lamps to a fixture, “Elec” refers to electronic ballasts.

The fixture multiplier is set to 22 because there are 22 identical fixtures. In the laboratory zone, the lights are automatically controlled by occupancy sensors. Since the sensors apply to all fixtures in the space, the control fraction is set to 1.0.

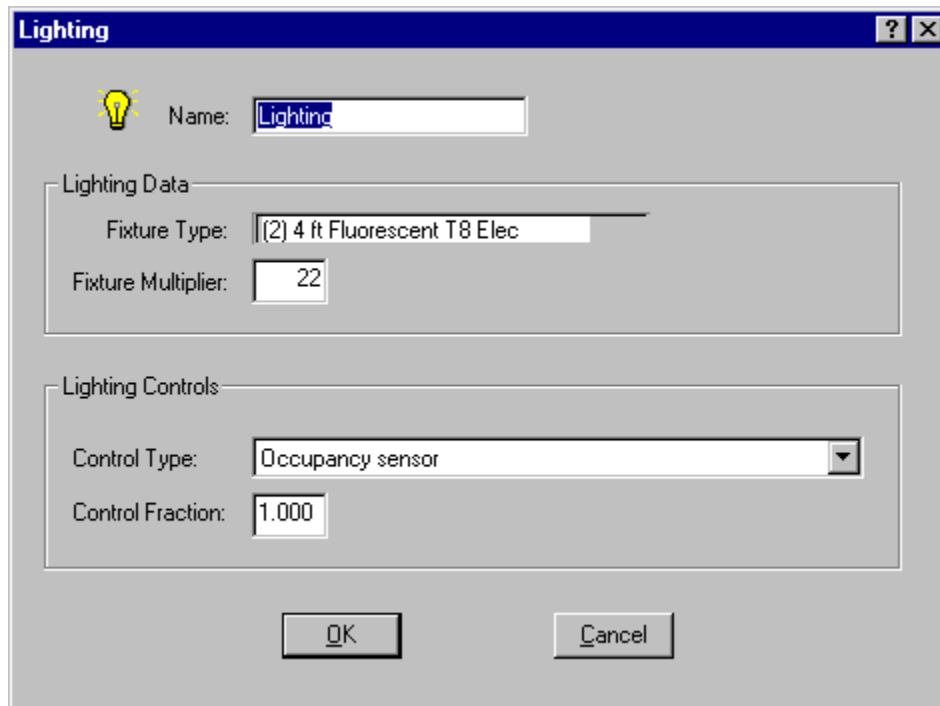
The image shows a software dialog box titled "Lighting". It has a lightbulb icon and a "Name:" label with a text field containing "Lighting". Below this is a section titled "Lighting Data" containing a "Fixture Type:" label with a dropdown menu showing "(2) 4 ft Fluorescent T8 Elec" and a "Fixture Multiplier:" label with a text field containing "22". Another section titled "Lighting Controls" contains a "Control Type:" label with a dropdown menu showing "Occupancy sensor" and a "Control Fraction:" label with a text field containing "1.000". At the bottom are "OK" and "Cancel" buttons.

Figure 2.32 – Lighting Input Screen

Although the list of light fixture is exhaustive, some fixtures may need to be added. Lights can be added by clicking “New” in the lighting library screen, and defining a name and total lamp wattage.

2.13 Step 13 – Simulation Results

2.13.1 System Sizing

EE4 uses a system sizing calculator to calculate zone heating and cooling loads and to determine the size of HVAC equipment that will be used in the reference building. To run the system sizing calculator, “Sizing” is selected from the “CalcManager” drop-down list.

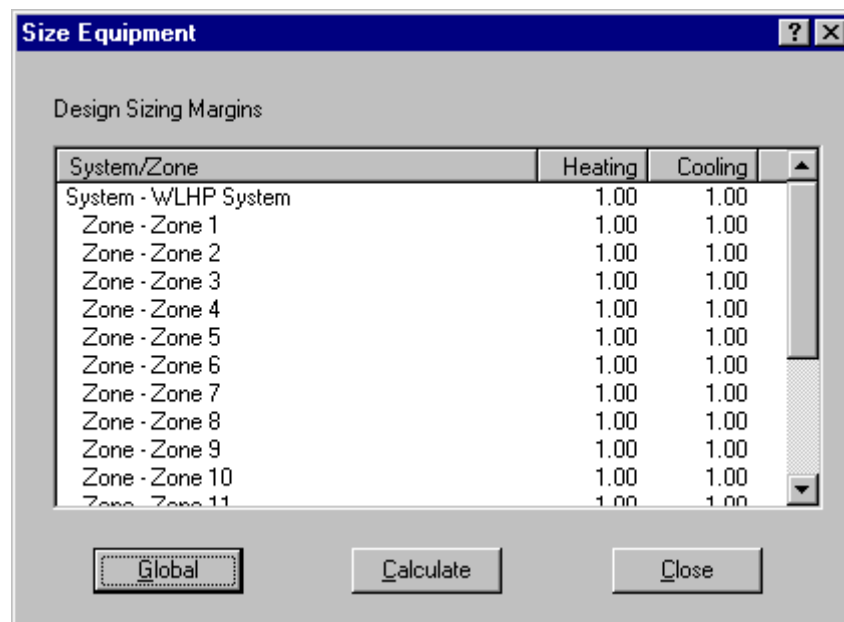


Figure 2.33 – Size Equipment Dialogue Box

The “Size Equipment” dialogue box appears and lists all zones in the building. Design sizing margins can be set for any or all zones. For instance, if 10% oversizing was desired for all heating and cooling equipment, “Global” would be selected.

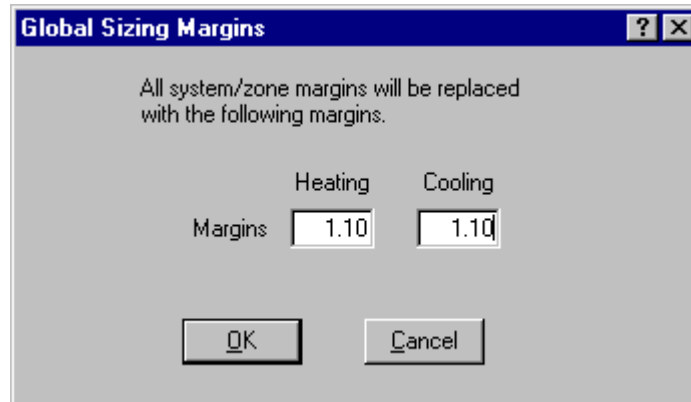


Figure 2.34 – Global Sizing Margins

To specify 10% oversizing, “1.10” is entered both heating and cooling margin fields. Selecting “OK” and clicking “Calculate” on the “Size Equipment” dialogue box displays results.

BBA Building - Loads				
System/Zone	Heating	Sensible	Latent	Airflow
System - WLHP System	95.9	0.0	4.3	2175
Zone - Zone 1	4.6	4.5	0.7	284
Zone - Zone 2	10.7	12.4	1.6	465
Zone - Zone 3	6.1	32.9	2.9	2253
Zone - Zone 4	6.4	7.5	0.4	87
Zone - Zone 5	14.3	23.6	0.6	163
Zone - Zone 6	5.2	6.1	0.3	65
Zone - Zone 7	11.8	19.4	1.5	429
Zone - Zone 8	17.9	22.1	1.0	321
Zone - Zone 9	4.6	2.2	0.4	154
Zone - Zone 10	17.2	18.2	1.0	295
Zone - Zone 11	12.4	18.5	0.6	163
Zone - Zone 12	4.9	5.1	0.2	57
Zone - Zone 13	10.8	16.7	1.5	429
Zone - Zone 14	8.7	10.7	0.5	138
Zone - Zone 15	8.6	9.2	0.4	124
Zone - Zone 16	12.4	9.1	0.8	224

* Heating and Cooling values are in kW * Airflows are in L/s

Figure 2.35 – Sizing Calculations

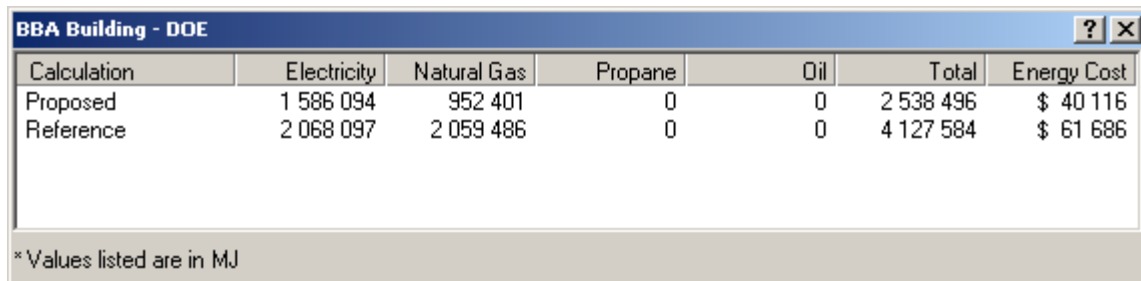
The results included both system and zone loads. The results indicate the heating capacity, sensible cooling capacity, latent cooling capacity and airflow needed to meet 110% of the load. The “System” loads refer to the make-up air unit.

In the BBA building, a 120 kW coil has been specified for the make-up air unit. Referring to the System heating load, a 96 kW would have been sufficient to achieve 10% oversizing.

2.13.2 CBIP Compliance Calculation

To determine if the building meets CBIP, “Calculate” in the Calcmanager drop-down menu is selected.

EE4 will run the DOE2 calculation if no errors or warnings are encountered. The calculation may take several seconds, depending on the speed of the computer and complexity of the building. The BBA calculation takes about 30 seconds on a 300 mHz computer. After running the simulation, the results appear as follows:



Calculation	Electricity	Natural Gas	Propane	Oil	Total	Energy Cost
Proposed	1 586 094	952 401	0	0	2 538 496	\$ 40 116
Reference	2 068 097	2 059 486	0	0	4 127 584	\$ 61 686

* Values listed are in MJ

Figure 2.36 – Results Screen

These results indicate that the proposed building energy use is 38% less than the reference building. This indicates that the building has met the 25% energy target and is eligible for CBIP application. The financial incentive is determined by the difference in energy costs, multiplied by 2, up to a maximum of \$60,000. In this case, the annual cost savings over the reference building are \$21,570. The BBA building would be eligible for an incentive of \$43,140.

2.13.3 Detailed and Summary Compliance Reports

EE4 prepares detailed Summary and Compliance Reports that must be submitted with the CBIP application package. To print the reports, select “Print” from the File drop-down menu after running the simulation. Select “Summary Compliance Report” and “Detailed Compliance Report” and choose “OK”. Both forms must be submitted to NRCan.

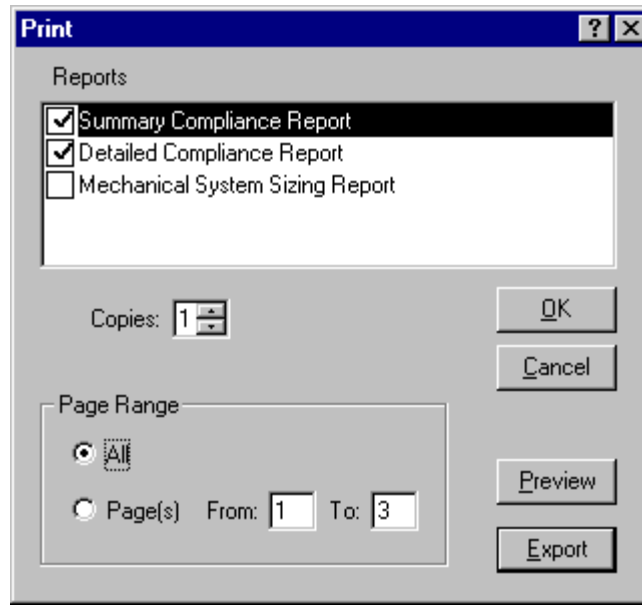


Figure 2.37 – Compliance Report Generation

2.13.4 System Sizing Reports

A mechanical system sizing report may also be prepared and printed. This is optional and need not be submitted with the CBIP application.

2.13.5 DOE2 Detailed Simulation Results

More detailed simulation results are obtained by analyzing the DOE2 reports with a text file. There are several reports that can be viewed, these are listed in the “DOE2 Reports” topic in the EE4 help file. To generate the reports, the “Delete DOE files after run” box in the Calcmanager/Options dialogue box must be unchecked. The simulation report will be saved in the “doe” subdirectory within the CBIP directory. The simulation results are in the text file with the “.SIM” extension.

A useful report for comparing energy consumption is the “BEPS” report in the DOE output file. To view the report, the “BBA Building - Proposed.SIM” file is opened with a text viewer. Scrolling down to the “BEPS – Building Energy Performance Summary”, the total annual energy consumption by end-use is available:

IDA Building Proposed.1170 - Notepad
 In 5/6 Pgms 15p
 REPORT- BEPS BUILDING ENERGY PERFORMANCE SUMMARY WEATHER FILE- NOTTEST QUR CWC

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL GAS
CATEGORY OF USE		
AREA LIGHTS	354.9	0.0
MISC EQUIPMT	324.0	0.0
SPACE HEAT	203.4	580.4
SPACE COOL	233.8	0.0
PUMPS & MISC	325.6	0.0
VENT FANS	53.7	0.0
DHW HOT WATER	0.0	322.4
TOTAL	1503.4	902.8

Figure 2.38 – Total Annual Energy Consumption by End-Use

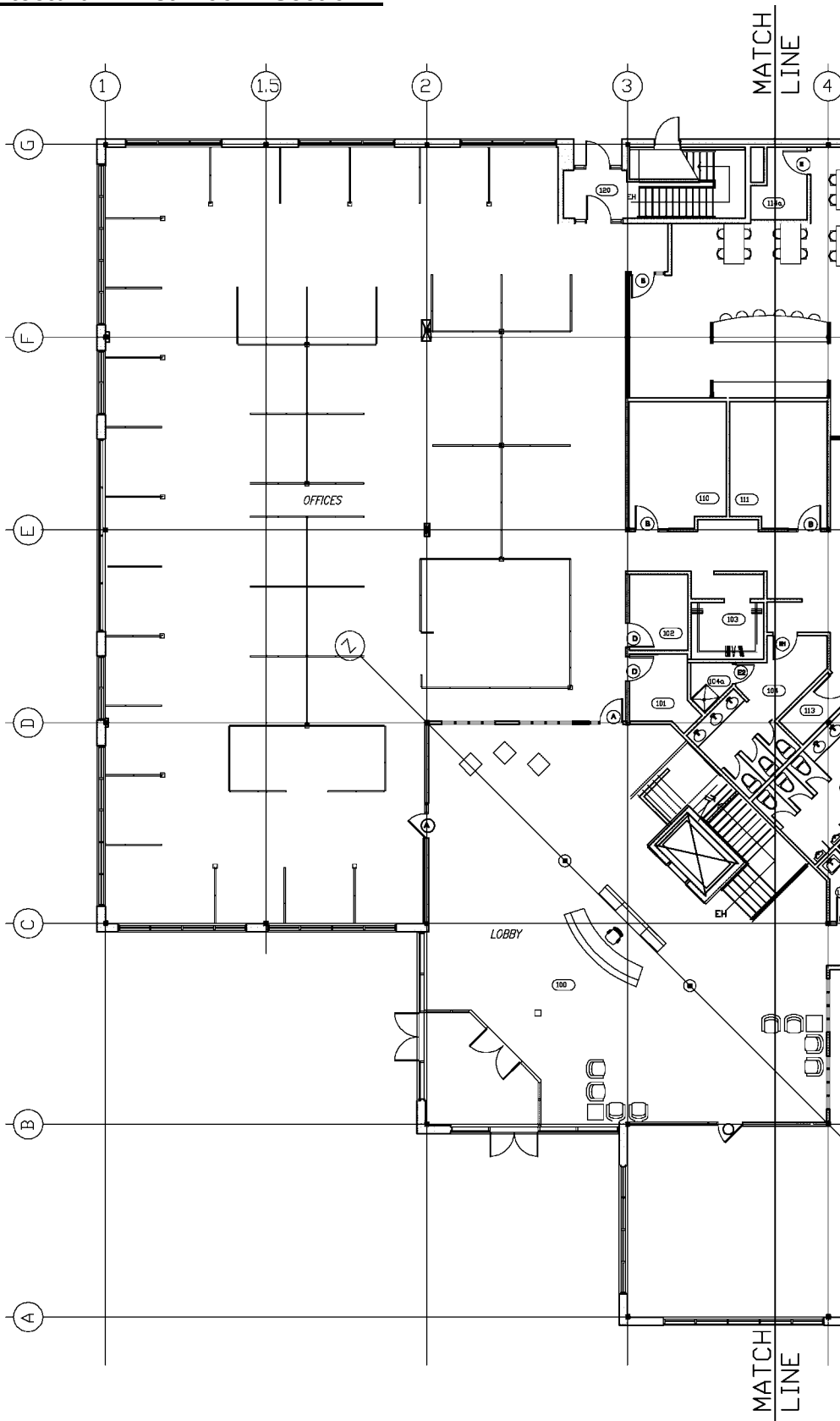
By comparing the BEPS report in the proposed building to that in the reference buildings, possible areas for improvement can be identified.

The total numbers in the last line are the numbers reported by the EE4 program. (DOE2 energy units are in MBTU)

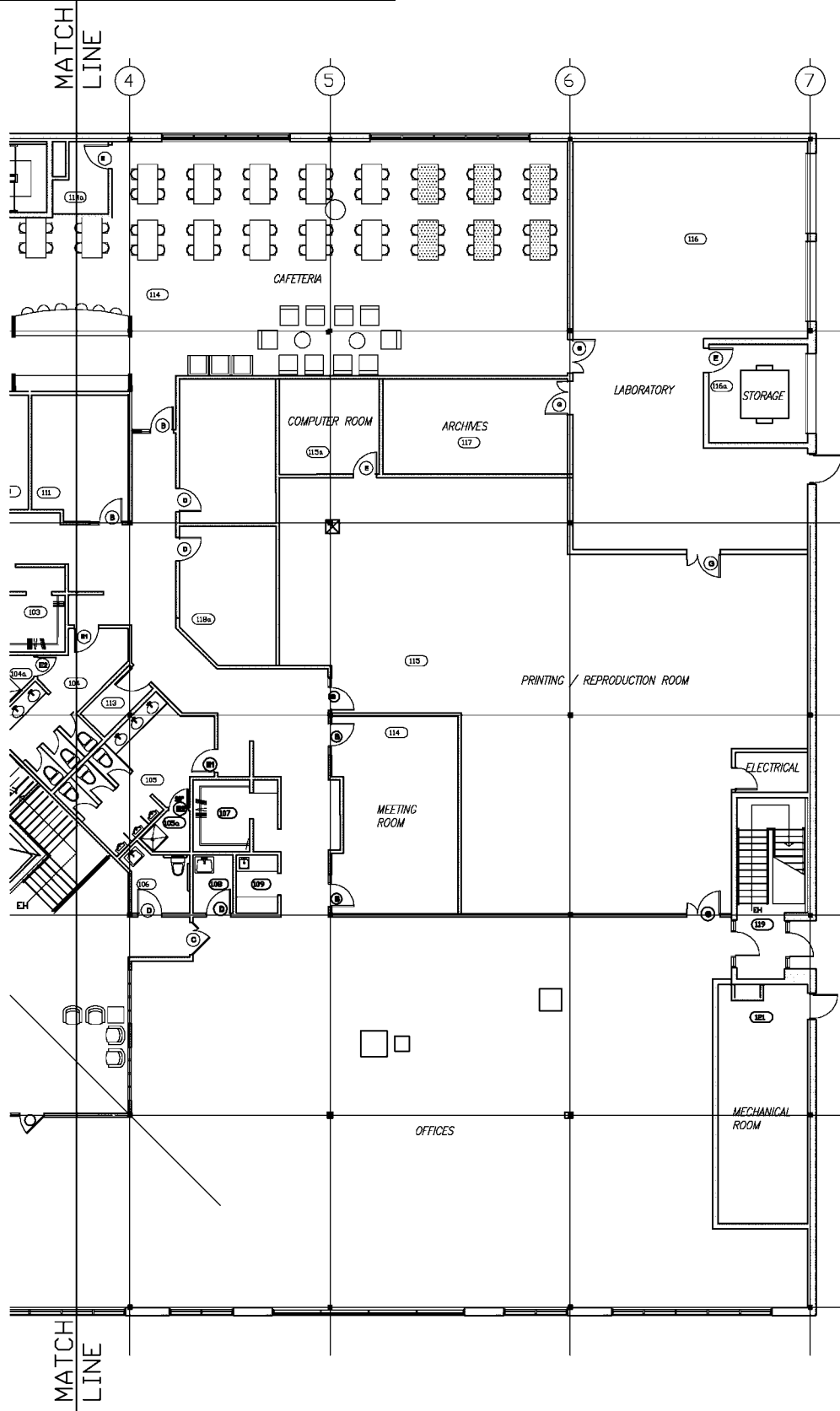
Many other useful reports are generated in the DOE output file; these are listed in the EE4 online help.

Appendix A.

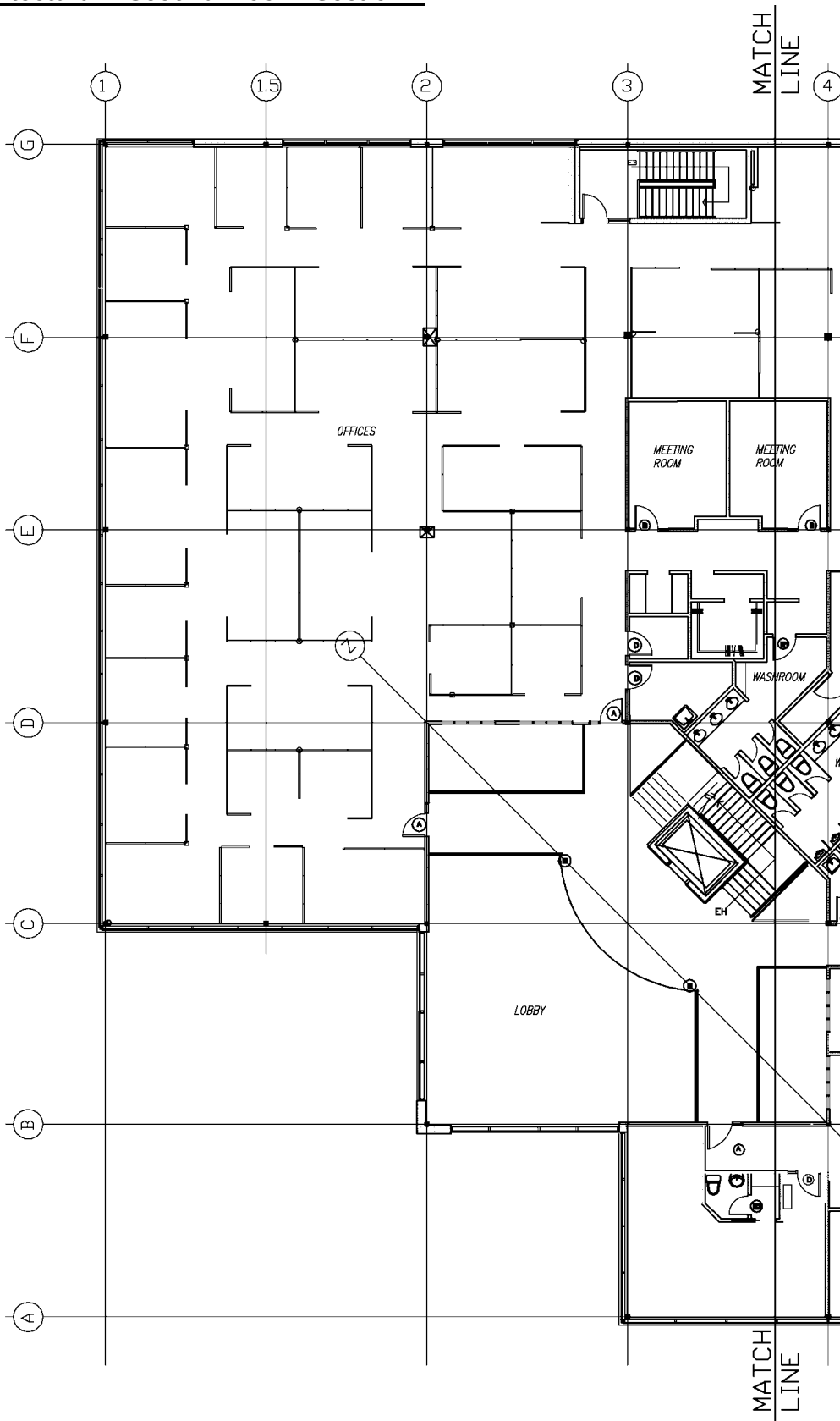
Architectural - First Floor – Section 1



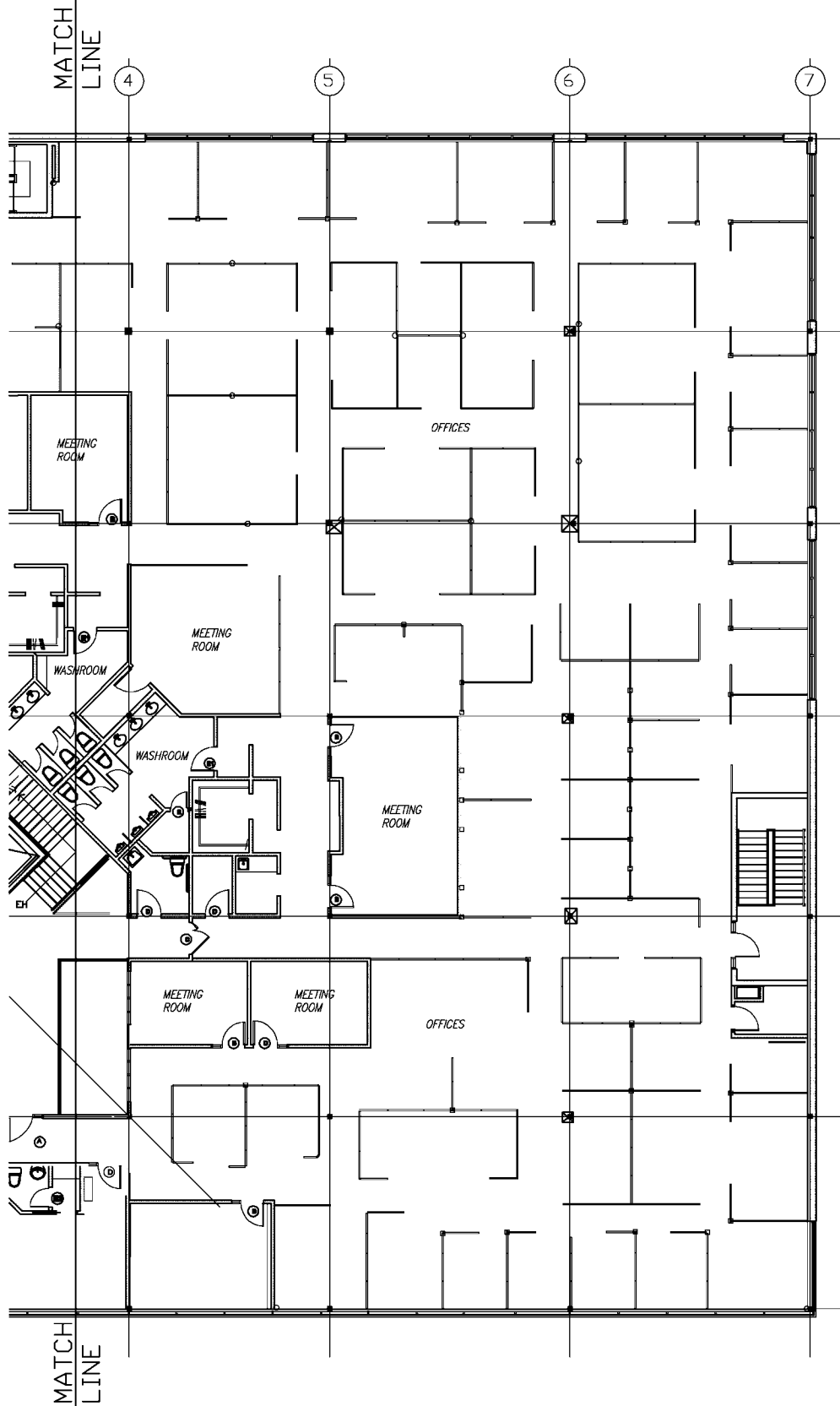
Architectural – First Floor – Section 2



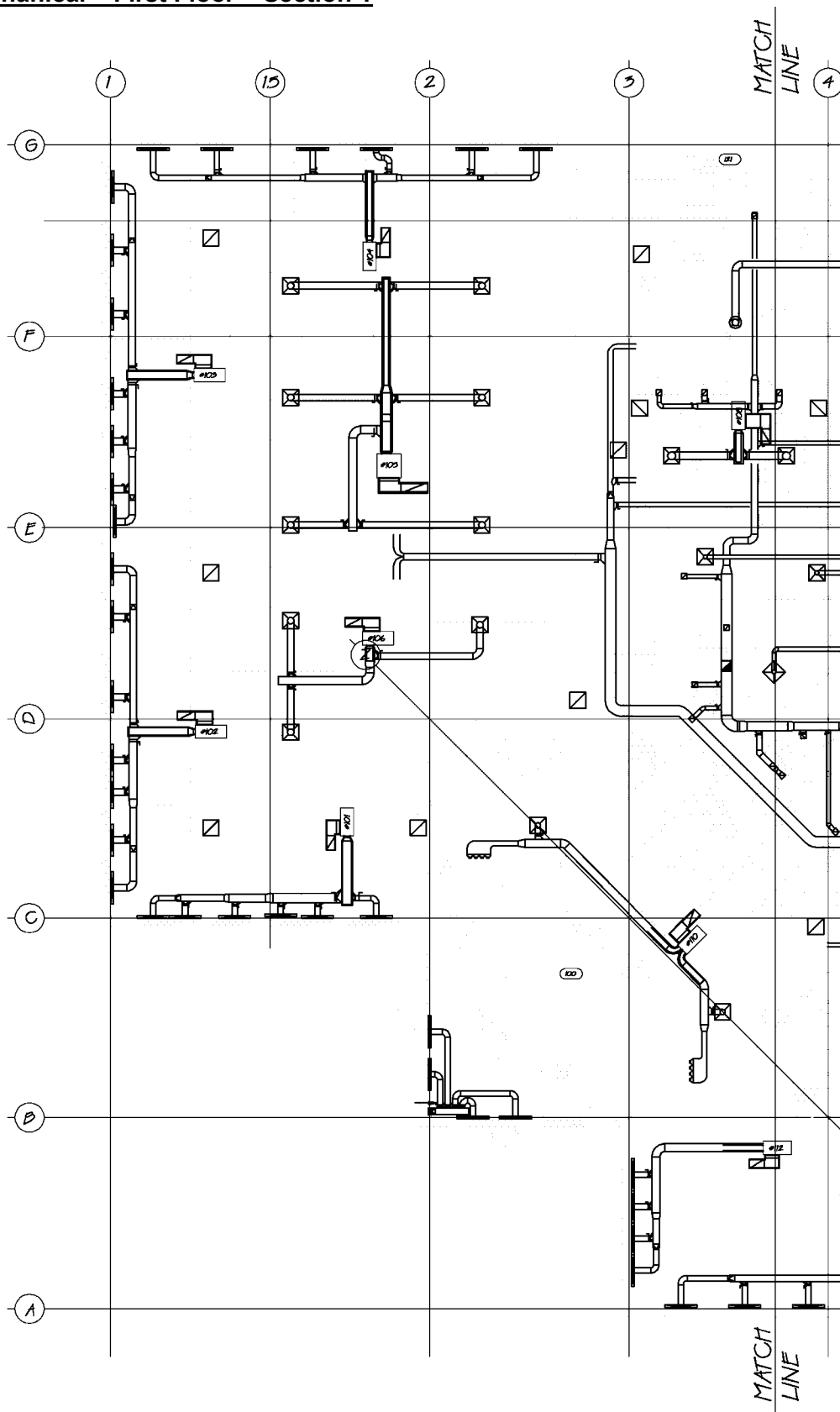
Architectural – Second Floor – Section 1



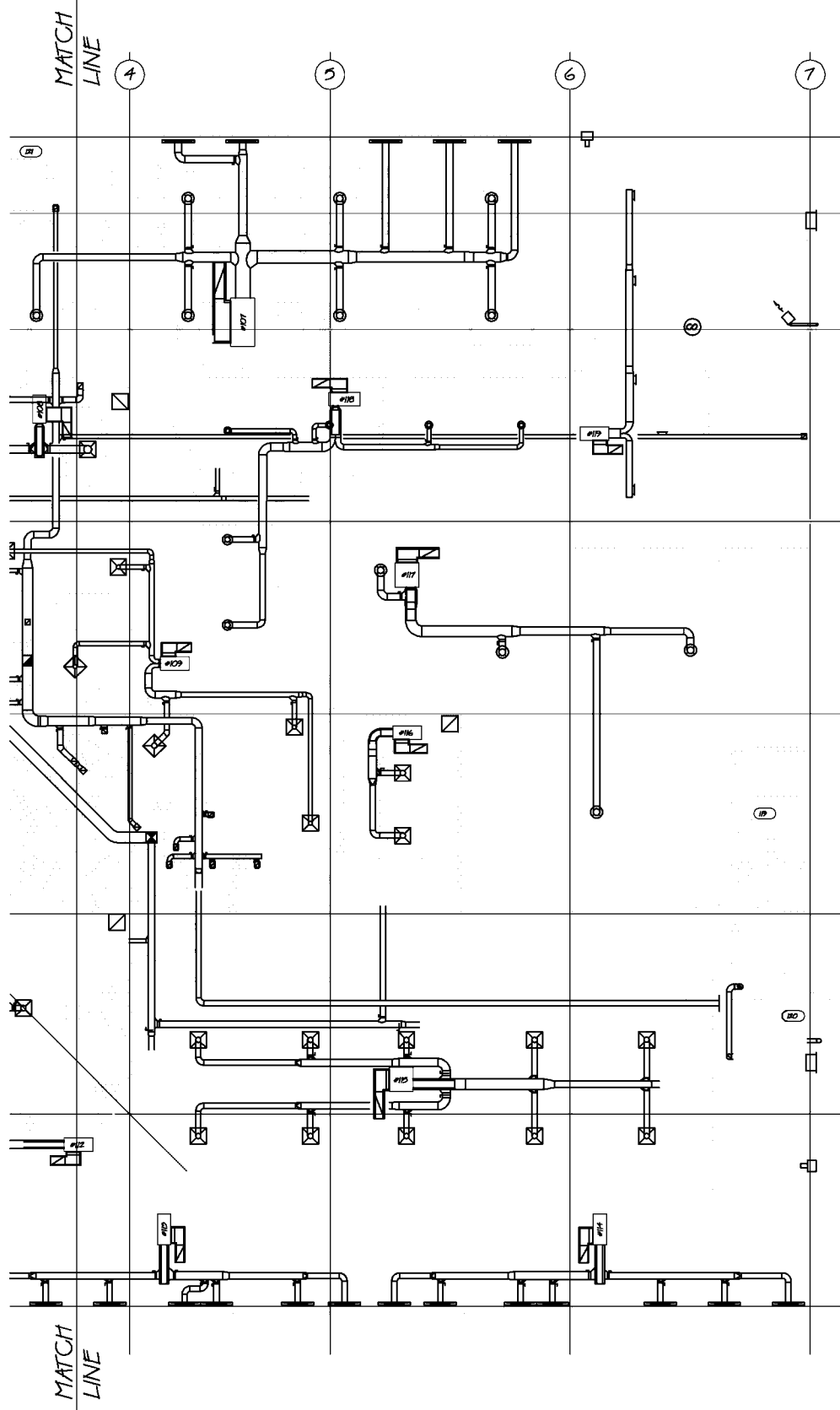
Architectural – Second Floor – Section 2



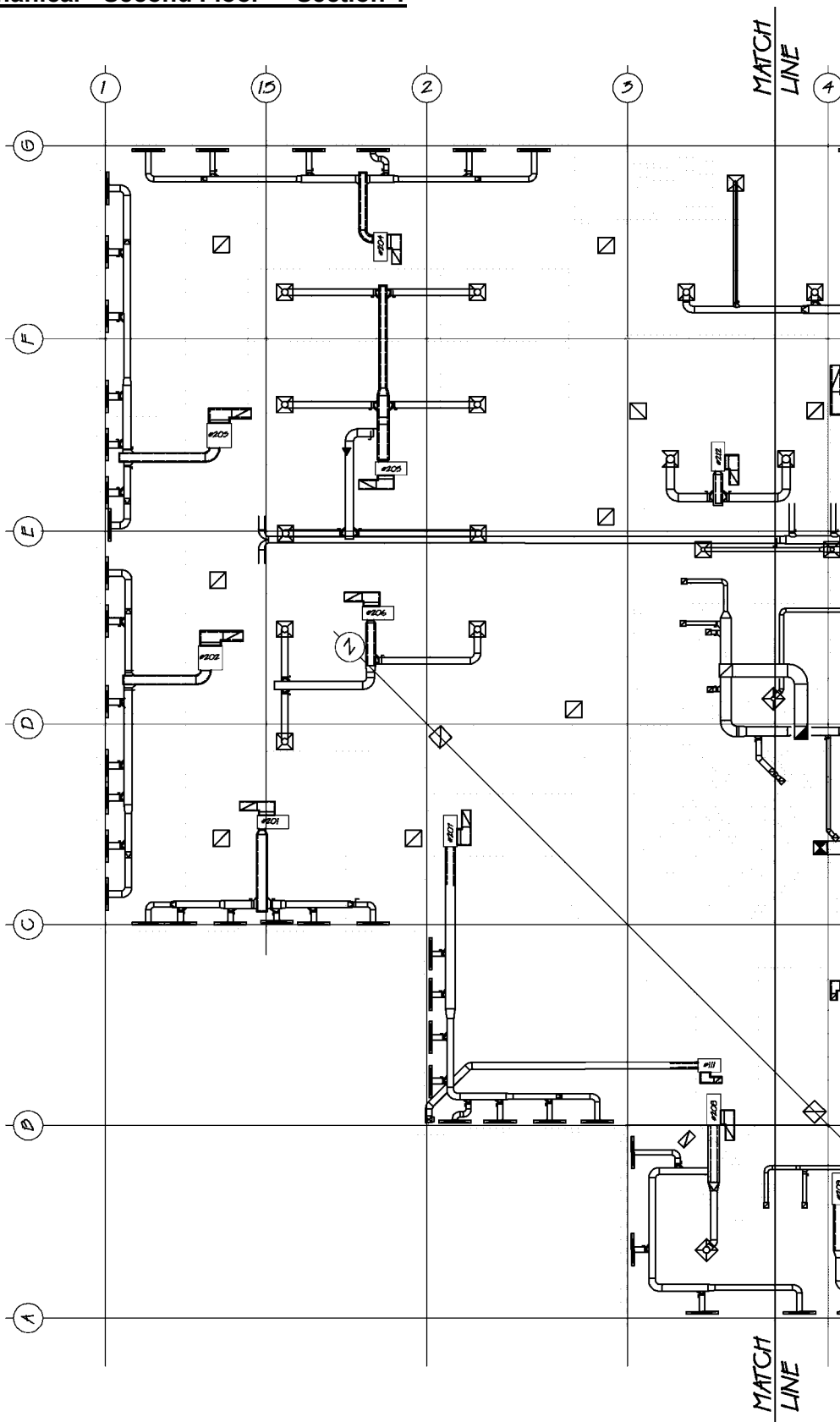
Mechanical – First Floor – Section 1



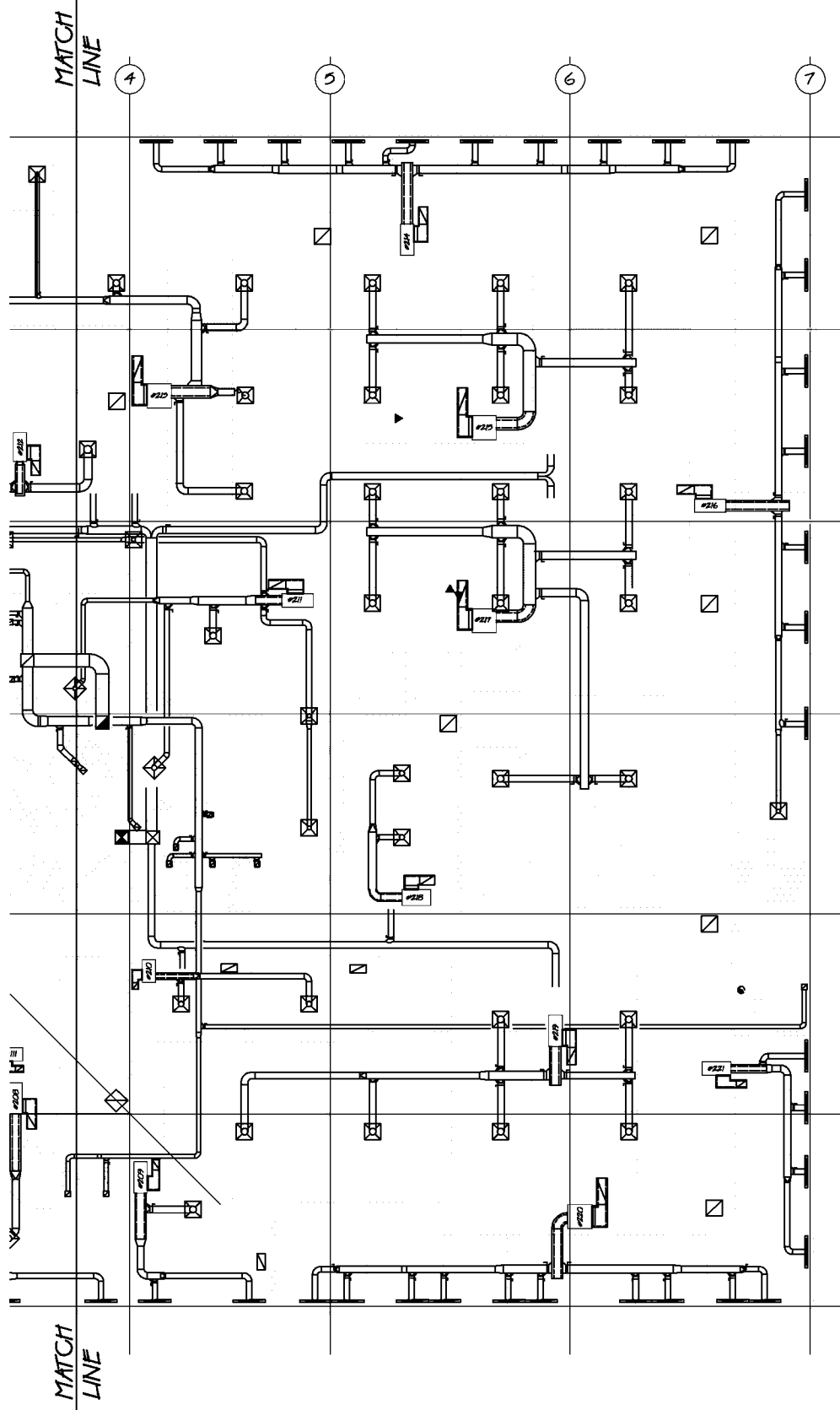
Mechanical – First Floor – Section 2



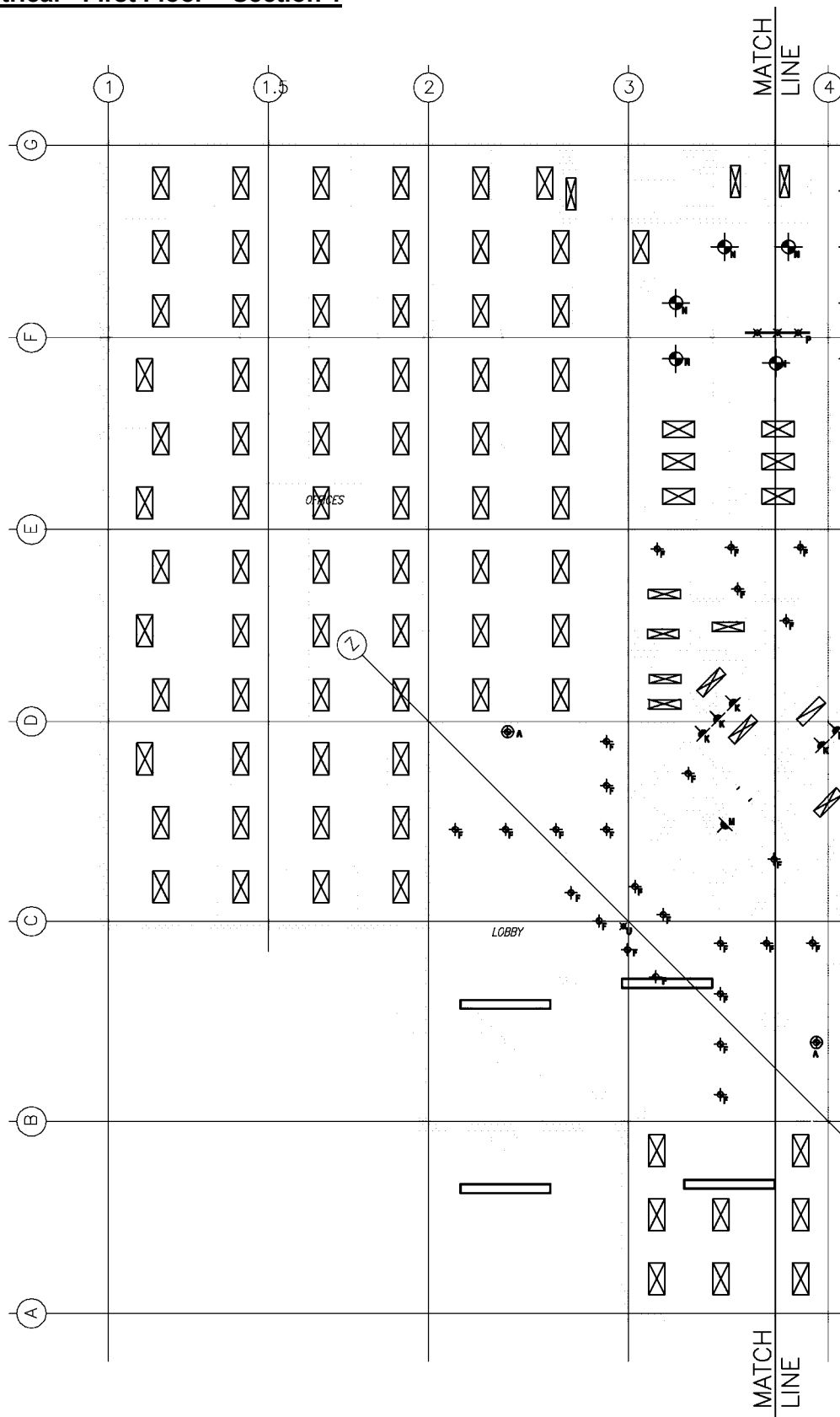
Mechanical - Second Floor – Section 1



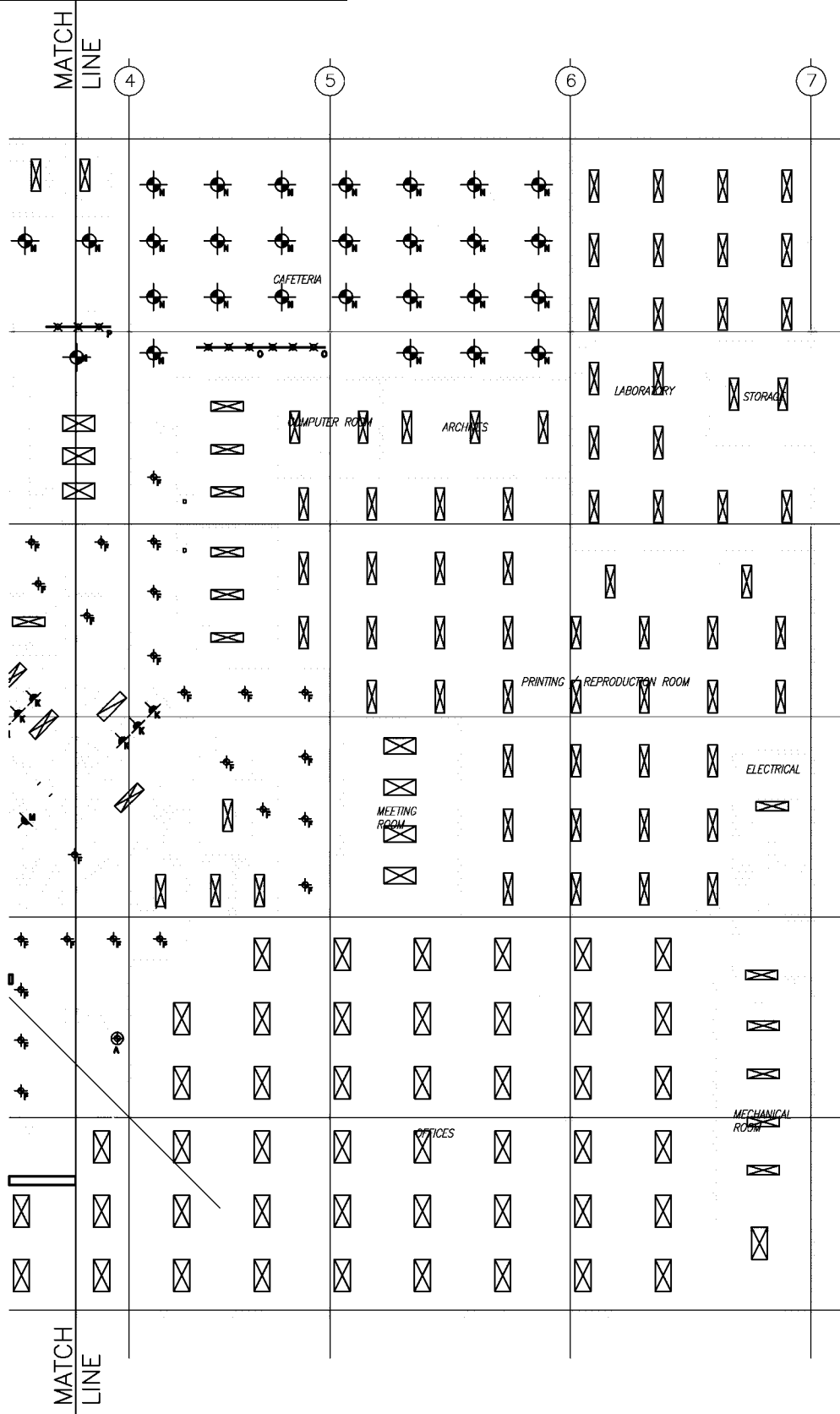
Mechanical - Second Floor – Section 2



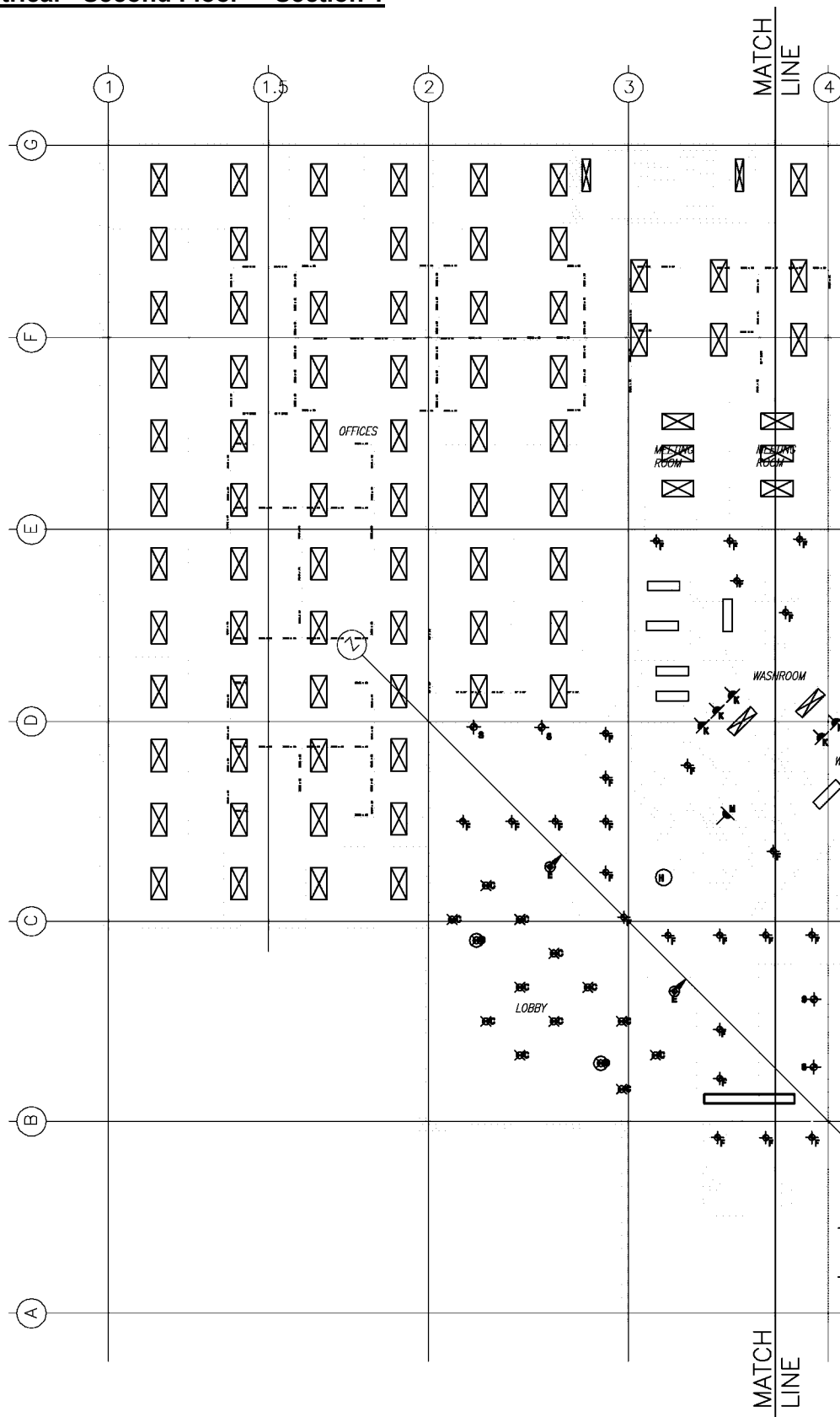
Electrical - First Floor – Section 1



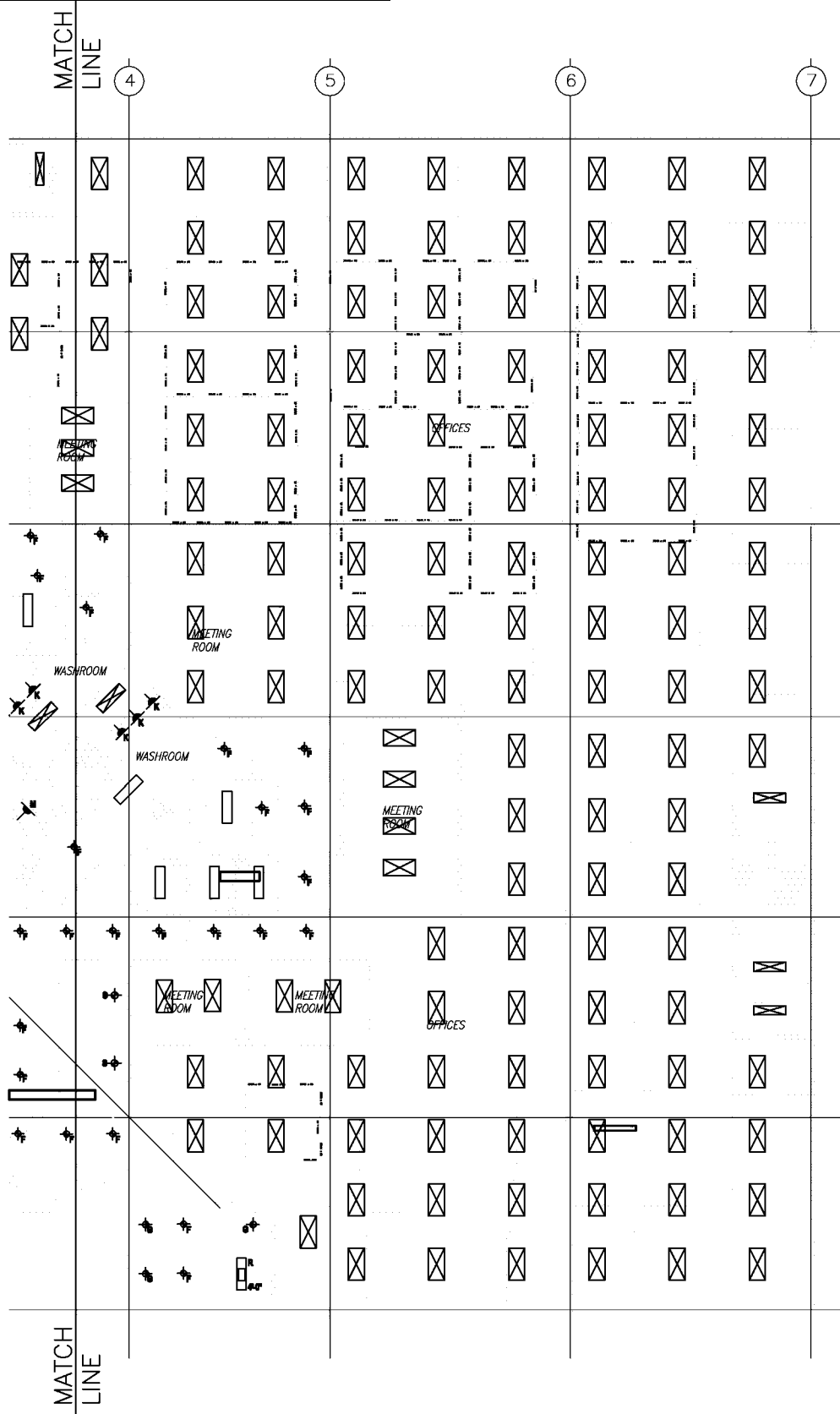
Electrical - First Floor – Section 2



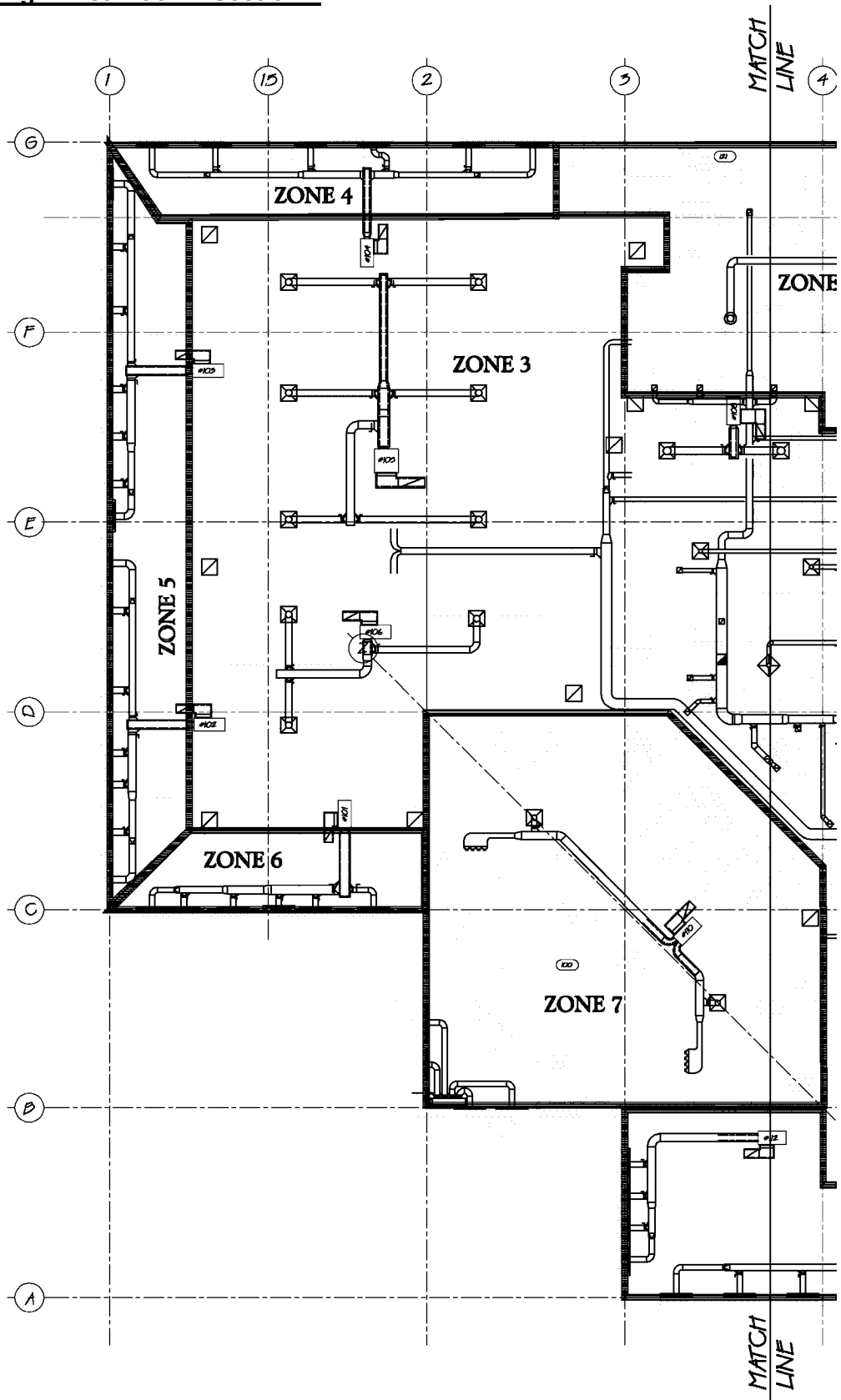
Electrical - Second Floor – Section 1



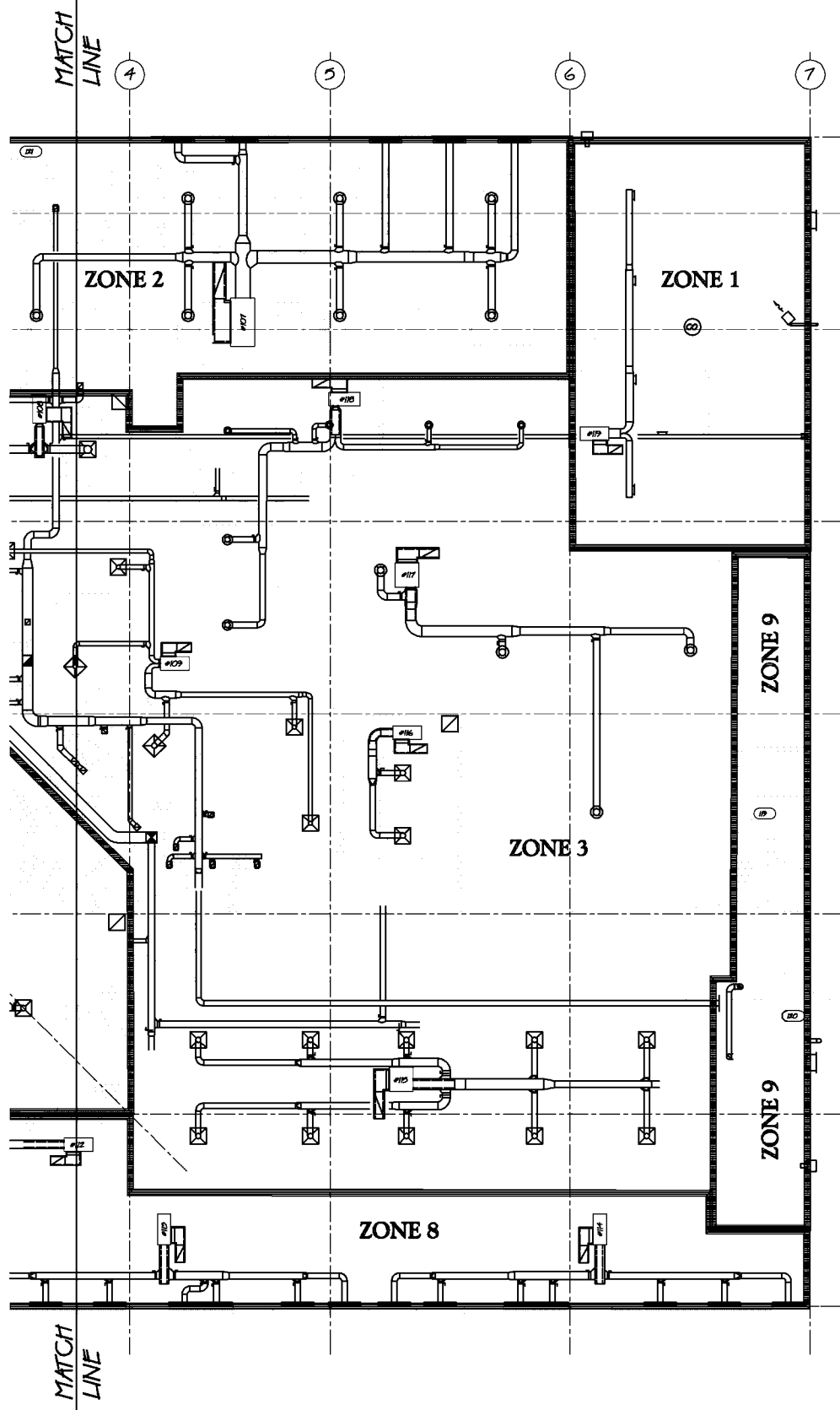
Electrical - Second Floor – Section 2



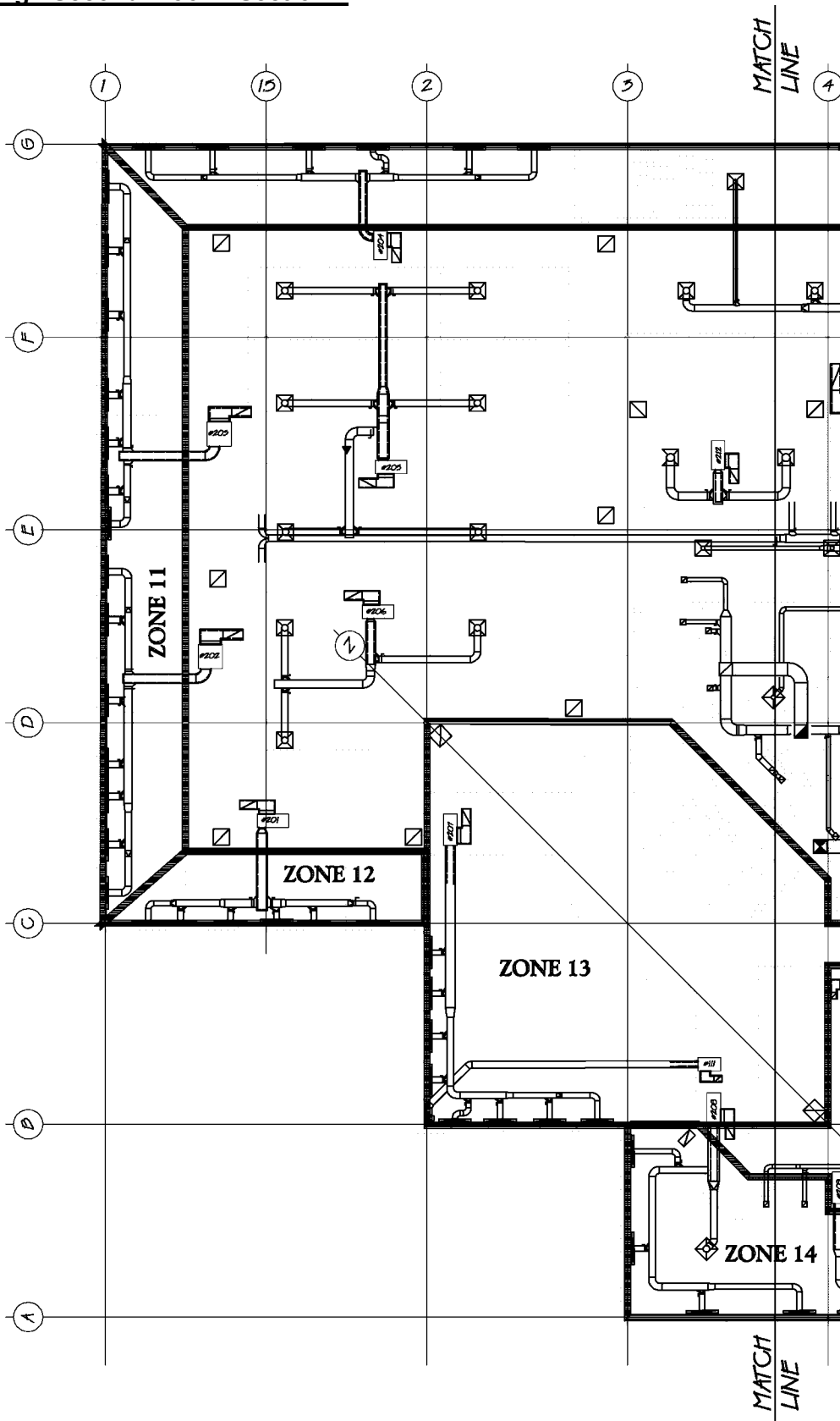
Zoning - First Floor – Section 1



Zoning - First Floor – Section 2



Zoning - Second Floor – Section 1



Zoning - Second Floor – Section 2

