

Field	Value
Indoor Design Temp Summer (F)	80
Indoor Design Temp Winter (F)	60
Outdoor Design Temp Summer (F)	92
Outdoor Design Temp Winter (F)	-4
Ventilation Standard	ASHRAE 62.1
Cooling Safety Factor	1.15
Heating Safety Factor	1.25
Elevation (ft)	3570
Location/City	Hamilton, MT
Electrical Service Spare Capacity (%)	
Electrical Feeder VD Limit (%)	
Roof Live Load (psf)	
Snow Exposure Factor Ce	

Zone ID	Name	Area (ft2)	Occupancy	Cooling Load (Btuh)
Z01	HALL	1800	98.9	42460
Z02	TR1	50	1	732
Z03	TR2	50	1	734
Z04	TR3	50	1	734
Z05	MECH-JAN	45	1	816
Z06	STAGING	255	6	20336

Heating Load (Btuh)	Supply CFM	OA CFM	System
92640	1325	850	IR-1/2
1631	46	0	EWB
1632	46	0	EWB
1633	46	0	EWB
1149	34	0	EWB
9337	808	91	EUH-1

System ID	Type (RTU/Split/AHU/VAV/Chiller/Boiler/IR)	Serves Zones	Total Cooling (MBH)
IR-1/2	Gas IR Tube Heater	HALL	42.5
EWB	Electric Wall Heater	TR1, TR2, TR3, MECH-JAN	3
EUH-1	Electric Unit Heater	STAGING	20.3

Total Heating (MBH) Total CFM	
92.6	1325
6	171
9.3	808

Tag	Type	Description	Capacity	CFM
EF-1	EF	Exhaust fan serving TR1 -- 0.5 in wg	70 CFM @ 0.5 in	70
EF-2	EF	Exhaust fan serving TR2 -- 0.5 in wg	70 CFM @ 0.5 in	70
EF-3	EF	Exhaust fan serving TR3 -- 0.5 in wg	70 CFM @ 0.5 in	70
EF-4	EF	Exhaust fan serving MECH-JAN -- 0.5 in	50 CFM @ 0.5 in	50
EF-5	EF	Wall propeller exhaust fan serving STAG	400 CFM @ 0.1 in	400
IR-1/2	Gas IR Tube Heat	Gas IR Tube Heater -- heat only, 92.6 M	2 x 57.9 MBH	
EWB	Electric Wall Heat	Electric Wall Heater -- heat only, 6.0 M	4 x 1.9 MBH	
EUH-1	Electric Unit Heat	Electric Unit Heater -- heat only, 9.3	11.7 MBH	
EC-1	Evaporative Cool	Evaporative cooler on a steel stand on t	12,000 CFM, 2 HF	12000

Electrical (V/Ph)	MCA	Basis of Design (Mfr/Model)	Weight (lb)
120/1	1		
120/1	1		
120/1	1		
120/1	1		
120/1	2		
120/1	5		
240/1	12		
240/1	18		
208-230/1	15		

Notes

Sizing basis: 70 cfm/WC x 1 WC per ASHRAE 62.1 / IMC 403 toilet-room exhaust rates; intermittent (occupancy/s)

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Sizing basis: 1.00 cfm/ft² x 45 ft² (janitor) per ASHRAE 62.1 / IMC 403 toilet-room exhaust rates; continuous oper

[manual] Not a code exhaust, so the pipeline does not size it. Engineering judgment for holding-cabinet heat, abc

(MCA est. per electrical_rules.yaml mca_estimate -- replace with vendor data)

(MCA est. per electrical_rules.yaml mca_estimate -- replace with vendor data)

(MCA est. per electrical_rules.yaml mca_estimate -- replace with vendor data)

[manual] One direct evaporative cooler on a steel stand on the flat service wing roof (top 11.2 ft), discharging we

Item	Qty	Description	Related Tag
Exhaust fan serving TR1 -- 0.5 in wg	1	Exhaust fan serving TR1 -- 0.5 in wg	EF-1
Backdraft damper	1	Accessory for EF-1	EF-1
Disconnect switch	1	Accessory for EF-1	EF-1
Speed controller	1	Accessory for EF-1	EF-1
Exhaust fan serving TR2 -- 0.5 in wg	1	Exhaust fan serving TR2 -- 0.5 in wg	EF-2
Backdraft damper	1	Accessory for EF-2	EF-2
Disconnect switch	1	Accessory for EF-2	EF-2
Speed controller	1	Accessory for EF-2	EF-2
Exhaust fan serving TR3 -- 0.5 in wg	1	Exhaust fan serving TR3 -- 0.5 in wg	EF-3
Backdraft damper	1	Accessory for EF-3	EF-3
Disconnect switch	1	Accessory for EF-3	EF-3
Speed controller	1	Accessory for EF-3	EF-3
Exhaust fan serving MECH-JAN -- 0.5	1	Exhaust fan serving MECH-JAN -- 0.5 in	EF-4
Backdraft damper	1	Accessory for EF-4	EF-4
Disconnect switch	1	Accessory for EF-4	EF-4
Speed controller	1	Accessory for EF-4	EF-4
Wall propeller exhaust fan serving ST	1	Wall propeller exhaust fan serving STAGEF-5	EF-5
Backdraft damper	1	Accessory for EF-5	EF-5
Disconnect switch	1	Accessory for EF-5	EF-5
Speed controller	1	Accessory for EF-5	EF-5
Gas IR Tube Heater -- heat only, 92.	1	Gas IR Tube Heater -- heat only, 92.6 M	IR-1/2
Chain hanger kit + reflector end caps	1	Accessory for IR-1/2	IR-1/2
Vent and combustion air kit	1	Accessory for IR-1/2	IR-1/2
Flexible gas connector + shutoff valve	1	Accessory for IR-1/2	IR-1/2
Thermostat (event-heat, manual/tim	1	Accessory for IR-1/2	IR-1/2
Electric Wall Heater -- heat only, 6.	1	Electric Wall Heater -- heat only, 6.0 M	EWH
Recessed wall can	1	Accessory for EWH	EWH
Integral thermostat	1	Accessory for EWH	EWH
Electric Unit Heater -- heat only, 9.	1	Electric Unit Heater -- heat only, 9.3	EUH-1
Wall/ceiling mounting bracket	1	Accessory for EUH-1	EUH-1
Disconnect switch	1	Accessory for EUH-1	EUH-1
Thermostat	1	Accessory for EUH-1	EUH-1

Category	Notes
Equipment	
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Category	Item	Serves
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Inputs	Rule / Table Cited
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Intermediates	Result
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Flag / Notes

Zone ID	Zone Name	Space Type	Occupancy Category	Area (ft2)
Z01	HALL	multiuse_assembly	Multiuse assembly	1800
Z02	TR1	toilet_room	Toilet rooms -- exhaust only, no 62.	50
Z03	TR2	toilet_room	Toilet rooms -- exhaust only, no 62.	50
Z04	TR3	toilet_room	Toilet rooms -- exhaust only, no 62.	50
Z05	MECH-JAN	janitor	Janitor closets -- exhaust only	45
Z06	STAGING	kitchen_commercia	Food and beverage service	255

EXHAUST FAN REQUIREMENTS

Space	Basis	EF Tag	CFM	Drive Note
TR1	70 cfm/WC x 1 WC	EF-1		70 Direct-drive, in
TR2	70 cfm/WC x 1 WC	EF-2		70 Direct-drive, in
TR3	70 cfm/WC x 1 WC	EF-3		70 Direct-drive, in
MECH-JAN	1.00 cfm/ft2 x 45 ft2	EF-4		50 Direct-drive, w

Occupants (Pz)	p (cfm/person)	Ra (cfm/ft2) - 62.1 Breathing Zone OA (urrent/Design OA (cfm		
98.9	7.5	0.06	850	850
1	0	0	0	0
1	0	0	0	0
1	0	0	0	0
1	0	0	0	0
6	7.5	0.18	91	91

Order-of-Magnitude Check Pressurization		Notes
OK (same order)	neutral	
n/a	negative	62.1/IMC exhaust-only space. IMC Table 403.3.1.1 (public toilet room)
n/a	negative	62.1/IMC exhaust-only space. IMC Table 403.3.1.1 (public toilet room)
n/a	negative	62.1/IMC exhaust-only space. IMC Table 403.3.1.1 (public toilet room)
n/a	negative	1.0 cfm/ft ² exhaust per 62.1 Table 6.2.2.1 (janitor closets, trash room)
OK (same order)	negative	FLAG: commercial kitchen hood/makeup-air exhaust system is a sep

ASSUMPTIONS & BASIS

Reference C:\Users\mikes\OneDrive\Documents\Cla Edit equipment_rules.yaml directly to change any

Load source eplusout.csv IdealLoads Supply Air Total This is the TOTAL (sensible + latent, including outc in a dry/high-OA climate (see build_model.py Out

W -> tons c 3.412142 Btu/hr per W (equipment_rules. tons = (peak_W * w_to_btuh) / btuh_per_ton = p

Cooling Sa 1.15 (Design Criteria tab) Design Criteria tab "Cooling Safety Factor" field, fa

Heating Sa 1.25 (Design Criteria tab) Design Criteria tab "Heating Safety Factor" field, fi (no gas-furnace-stage table in this codebase yet).

Refrigerati Design Criteria tab "Product Pulldown Allomodel. Added on top of the safety-factored coincident co

Nominal to [1.5, 2, 2.5, 3, 4, 5, 6, 7.5, 10, 12.5, 15, 20, equipment_rules.yaml standard_tons -- raw tons

Nominal to [20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120 equipment_rules.yaml plant_standard_tons -- use Site elevation 3570 ft (building.yaml location.elev: Volume Flow Rate' output (previously used here) (Site:Location line: Standard Pressure/RhoAir at E the 20C/68F reference) -- a smaller correction (ro safe to use directly for fan/duct velocity selection

CFM basis Peak of a CURRENT (site/local) density vol independent Total Cooling/Heating Rate (W) colu

Glycol GPM 2.59 (equipment_rules.yaml glycol_gpm_ 25%% PG, 10F design dT -- used only for a plant sy

Tag	Serves	Type	Inputs
IR-1/2	HALL	Gas IR Tube He	zone(s) HALL: eplusout.csv IdealLoads Total Heating Rate peak = 92.6 MBH
EWH	TR1, TR2, TR3, MECH-JAN	Electric Wall H	zone(s) TR1, TR2, TR3, MECH-JAN: eplusout.csv IdealLoads Total Heating Rate peak = 6.0 MBH
EUH-1	STAGING	Electric Unit H	zone(s) STAGING: eplusout.csv IdealLoads Total Heating Rate peak = 9.3 MBH

TRACE NOTES -- hand-verification walkthroughs

conversion/tonnage-ladder/CFM-rounding assumption -- loads_to_schedule.py reads it fresh on every run.

floor-air conditioning) load the equipment actually has to deliver -- NOT the .eio 'Zone Sizing Information' number (put:Variable comments).

peak_W / w_per_ton (both paths give the same number -- listed both ways since "W/ton" is the more common scaling factor). Applied to raw E+ coincident peak cooling load and applied back to equipment_rules.yaml cooling_safety_factor_default if blank. Applied to raw E+ coincident peak heating load and applied back to equipment_rules.yaml heating_safety_factor_default if blank. Reported alongside Capacity as MBH.

cooling load ONLY for systems carrying a `plant:` block in building.yaml (chiller-plant aggregation) -- covers field heating load (after Cooling SF) rounds UP to the smallest ladder entry >= the requirement. A requirement above the largest ladder entry is used only for systems carrying a `plant:` block (whole-building coincident load, too large for the single-unit ladder aggregation).

ation_ft), barometric pressure 88918 Pa (same standard-atmosphere formula as build_model.py's SizingPeriod:Correction is NOT a sea-level-uncorrected figure as once assumed in this codebase -- eplusout.eio confirms EnergyPlus computation is just at a fixed 20C reference temperature. So the only real gap between 'standard' and 'current' density is roughly 1.05-1.08x at this elevation) than the ~1.13-1.14x once assumed from the (incorrect) sea-level premise. The difference is with no further manual correction. (Switched from Standard Density column to this computed Current Density values.)

system's pump GPM estimate; see design-tools\rules\pipe_rules.yaml glycol: block for the pipe-sizing use of the system's

Rule / Basis Cited	Intermediates
building.yaml system heat_only: true, count 2; Heating SF 1.25 (Design Criteria tab)	92.6 MBH x 1.25 = 115.8 MBH / 2 = 57.9 MBH output each
building.yaml system heat_only: true, count 4; Heating SF 1.25 (Design Criteria tab)	6.0 MBH x 1.25 = 7.6 MBH / 4 = 1.9 MBH output each
building.yaml system heat_only: true, count 1; Heating SF 1.25 (Design Criteria tab)	9.3 MBH x 1.25 = 11.7 MBH / 1 = 11.7 MBH output each

er, which is the zone's own sensible load only and under-counts OA conditioning

northward in the field).

ns before nominal-size rounding.

4 -- not currently applied to a separate heating-equipment nominal-size ladder

at from incoming product / defrost, which EnergyPlus's IdealLoads does not

ntry is FLAGGED, not silently truncated.

bove).

DesignDay Barometric_Pressure field). NOTE: EnergyPlus's own 'Standard Density
putes 'StdRhoAir' from this SITE's actual elevation-adjusted pressure already
y here is TEMPERATURE (actual supply air T, ~55F cooling to ~105F+ heating, vs.
is computed current-density CFM is the true site-corrected actual airflow and is
value 2026-08-02; TONNAGE is unaffected since it derives from the density-

ame convention.

Capacity	CFM	Heating (MBH)	Notes
2 x 57.9 MBH		92.6	heat only -- cooling tonnage not scheduled (3.54 ton raw cooling peak is informational)
4 x 1.9 MBH		6	heat only -- cooling tonnage not scheduled (0.25 ton raw cooling peak is informational)
11.7 MBH		9.3	heat only -- cooling tonnage not scheduled (1.69 ton raw cooling peak is informational)

ASSUMPTIONS & BASIS

Reference data C:\Users\mikes\OneDrive\Documents\Claude\desig

Pipe Fitting Al 1.50x (Design Criteria tab override, else FITTING_ALL

Domestic waterpipe_rules.yaml wsfu:

Hunter fixture-pipe_rules.yaml hunter_curve:

Water velocity |pipe_rules.yaml water_velocity_max_fps: cold=8, hc

Sanitary fixturepipe_rules.yaml dfu:

Sanitary branchpipe_rules.yaml horizontal_branch_capacity_dfu: / l

Sanitary slope Design Criteria tab "Sanitary Slope (in/ft)", default 0.

Gas AFUE (heatpipe_rules.yaml gas.default_afue = 0.80

Gas pipe sizing IFGC/NFPA 54 Spitzglass Eq. 402.4 (pipe_rules.yaml |

Compressed airpipe_rules.yaml compressed_air: demand_per_drop

Compressed airpipe_rules.yaml compressed_air.target_velocity_fps

Glycol GPM/tonDesign Criteria tab "Glycol GPM per Ton" override, e

Glycol velocity/pipe_rules.yaml glycol: velocity_min/max_fps, frictio

System	Segment	Serves
DOMESTIC_WATER		
domestic_water	DW-TR1	TR1
domestic_water	DW-TR2	TR2
domestic_water	DW-TR3	TR3
domestic_water	DW-STAGING	STAGING
domestic_water	DW-MECH	MECH
domestic_water	DW-MAIN	Building water service (all group
domestic_water	DW-HW	Hot water branch (WH-1 to fixtu
SANITARY		
sanitary	SS-TR1	TR1

sanitary	SS-TR2	TR2
sanitary	SS-TR3	TR3
sanitary	SS-STAGING	STAGING
sanitary	SS-MECH	MECH
sanitary	SS-MAIN	Building drain (all groups)
sanitary	SS-VENT	Building vent stack

GAS

gas	GAS-IR-1	IR-1
gas	GAS-IR-2	IR-2
gas	GAS-MAIN (7" wg)	All gas appliances (longest run)
gas	GAS-MAIN (2 psi)	All gas appliances (longest run)

TRACE NOTES -- hand-verification walkthroughs

DOMESTIC_WATER

DOMESTIC WATER -- example branch TR1: fixtures tally to 5.70 WSFU
 fps (water_velocity_max_fps.cold): $ID = \sqrt{5.02 / (2.448 \times 8)} = 0.50$

SANITARY

SANITARY -- example branch TR1: fixtures 1 WC@4, 1 LAV@1 tally to
against the total 27.5 DFU in building_drain_capacity_dfu at the 0.25C

GAS

GAS -- connected load: IR-1 75.0 MBH; IR-2 75.0 MBH = 150.0 MBH =
1.074 in -> rounds up to 1-1/4" Sch 40 (actual ID 1.380 in), capacity at

n-tools\rules\pipe_rules.yaml	Edit pipe_rules.yaml directly to change any rule for every run.
LOWANCE_DEFAULT in pipe_sizing.py)	Applied to any developed length computer routes). NOT applied to gas's longest_run_
	IPC Table E103.3(1)-style, public use. Edit p
hot_circulating=5	WSFU->GPM, flush-tank systems. Log-log i
	IPC 604.7-style branch/main velocity caps.
building_drain_capacity_dfu:	IPC Table 709.1-style.
.25	IPC Table 710.1(1)/(2)-style.
gas: block)	Governs which building_drain_capacity_dfu
hot_scfm/diversity_factor/safety_leakage_margin	Placeholder until basis-of-design equipment
; = 25 fps	Formula-based, not a transcribed table -- e
else pipe_rules.yaml glycol.gpm_per_ton_25pct_pg_10	Same assumptions as the superseded PLU
on_target_min/max_ft_per_100ft, hazen_williams_c, p	Typical compressed-air distribution main p
	25% PG, 10F design dT convention -- see L
	Sized at the upper velocity band edge (sm

Inputs	Rule / Table Cited
5.70 WSFU (1 WC@5, 1 LAV@0.7)	wsfu + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.cold=8 fps
5.70 WSFU (1 WC@5, 1 LAV@0.7)	wsfu + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.cold=8 fps
5.95 WSFU (1 WC@5, 1 LAV@0.7, 1 DF@0.25)	wsfu + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.cold=8 fps
6.60 WSFU (3 HS@0.7, 1 SINK3@4, 1 IM@0.5)	wsfu + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.cold=8 fps
8.00 WSFU (1 SVC_SINK@3, 2 HB@2.5)	wsfu + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.cold=8 fps
31.95 WSFU total (sum of branches)	wsfu + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.cold=8 fps
14.10 hot-side WSFU (sum of branches)	wsfu.hot + hunter_curve @ pipe_rules.yaml; water_velocity_max_fps.hot_circulating= 5 fps
5.0 DFU (1 WC@4, 1 LAV@1)	dfu + horizontal_branch_capacity_dfu @ pipe_rules.yaml; WC drain minimum 3 in (UPC Table 702.1 / IPC 710)

5.0 DFU (1 WC@4, 1 LAV@1)	dfu + horizontal_branch_capacity_dfu @ pipe_rules.yaml; WC drain minimum 3 in (UPC Table 702.1 / IPC 710)
5.5 DFU (1 WC@4, 1 LAV@1, 1 DF@0.5)	dfu + horizontal_branch_capacity_dfu @ pipe_rules.yaml; WC drain minimum 3 in (UPC Table 702.1 / IPC 710)
10.0 DFU (3 HS@1, 1 SINK3@3, 2 FS@2)	dfu + horizontal_branch_capacity_dfu @ pipe_rules.yaml
2.0 DFU (1 SVC_SINK@2)	dfu + horizontal_branch_capacity_dfu @ pipe_rules.yaml
27.5 DFU total (sum of branches)	dfu + building_drain_capacity_dfu @ pipe_rules.yaml, slope=0.250 in/ft (Design Criteria override or default 0.25); IPC 710.1 no-decrease-in-flow-direction floor vs. largest branch
27.5 DFU total	vent_sizing table @ pipe_rules.yaml (max length 200 ft)

IR-1: layout.gas.appliances fixed_mbh	layout.gas.appliances @ building.yaml; gas.default_afue @ pipe_rules.yaml
IR-2: layout.gas.appliances fixed_mbh	layout.gas.appliances @ building.yaml; gas.default_afue @ pipe_rules.yaml
150.0 MBH = 150 CFH total connected (IR-1 75.0 MBH; IR-2 75.0 MBH); longest run 80 ft	IFGC/NFPA 54 Spitzglass Eq. 402.4 (low pressure) @ pipe_rules.yaml gas.low_pressure/specific_gravity
150.0 MBH = 150 CFH total connected; longest run 80 ft	IFGC/NFPA 54 Spitzglass Eq. 402.4 (elevated pressure) @ pipe_rules.yaml gas.elevated_pressure/specific_gravity

(pipe_rules.yaml wsfu: table). Hunter curve interpolation (log-log between bracketing pipe_rules 5 in. Rounded up to the next copper_type_l_id in table entry >= that ID: 1/2" (actual ID 0.545 in).

5.0 DFU (pipe_rules.yaml dfu: table). Smallest horizontal_branch_capacity_dfu entry with capacity in/ft slope, giving 3".

150 CFH (@ ~1000 Btu/cf). Low-pressure option: $Cr = SG/0.60 = 0.50/0.60 = 0.833$. Required ID = (that size = $2313 * 1.380^{2.623} * (0.30/(0.833*80))^{0.541} = 289$ CFH $\geq$ 150 CFH required -- PASS

y WSFU/DFU/Hunter-curve/gas/compressed-air/glycol assumption -- pipe_sizing.py reads it fresh on

d by walking building.yaml layout coordinates (domestic water/sanitary/compressed-air/glycol
_ft, which is already a directly-stated design length.

per-fixture total/hot/cold there.

interpolated between points.

fu column is used.

nt submittal confirms actual efficiency.

every gas row is independently hand-verifiable.

MBING.xlsx Compressed Air tab, now computed rather than hand-typed.

ractice (20-30 fps band).

oad_Calc_Report.docx methodology.

allest adequate pipe), friction checked against the target band.

Intermediates	Size	Flag / Notes
5.70 WSFU -> 5.02 GPM (Hunter curve) -> req ID 0.506 in @ 8 fps	1/2"	6.9 fps actual
5.70 WSFU -> 5.02 GPM (Hunter curve) -> req ID 0.506 in @ 8 fps	1/2"	6.9 fps actual
5.95 WSFU -> 5.20 GPM (Hunter curve) -> req ID 0.515 in @ 8 fps	1/2"	7.2 fps actual
6.60 WSFU -> 5.67 GPM (Hunter curve) -> req ID 0.538 in @ 8 fps; PIPELINE SIZE 1/2"	3/4"	DRAWN 3/4", engineer override (pipeline 1/2"): 3-comp sink fill at 1/2 in runs over 7 fps. 3/4 in is 3.8 fps.
8.00 WSFU -> 6.65 GPM (Hunter curve) -> req ID 0.583 in @ 8 fps	3/4"	4.4 fps actual
31.95 WSFU -> 20.15 GPM (Hunter curve) -> req ID 1.014 in @ 8 fps	1"	7.8 fps actual
14.10 WSFU -> 10.56 GPM (Hunter curve) -> req ID 0.929 in @ 5 fps	1"	4.1 fps actual
5.0 DFU -> smallest branch size with capacity >= DFU = 2", raised to 3" for the WC	3"	cap 20 DFU

5.0 DFU -> smallest branch size with capacity >= DFU = 2", raised to 3" for the WC	3"	cap 20 DFU
5.5 DFU -> smallest branch size with capacity >= DFU = 2", raised to 3" for the WC	3"	cap 20 DFU
10.0 DFU -> smallest branch size with capacity >= DFU; PIPELINE SIZE 2-1/2"	3"	DRAWN 3", engineer override (pipeline 2-1/2"): 2-1/2 in is not a stock DWV size. Staging drains on its own through GI-1.
2.0 DFU -> smallest branch size with capacity >= DFU	1-1/2"	cap 3 DFU
27.5 DFU -> table size 3" (cap 50 DFU) -> governed by building_drain_capacity_dfu table; PIPELINE SIZE 3"	4"	DRAWN 4", engineer override (pipeline 3"): Toilet-side drain: 3 WCs at 25 DFU sits on the UPC 703.2 limit for 3 in. 4 in adds margin and matches the septic inlet.
table size 3.00 in vs. min_size_fraction_of_drain floor 1.50 in (50% x 3" main) -> governs at 3.00 in; PIPELINE SIZE 3"	2" + 3" VTR	DRAWN 2" + 3" VTR, engineer override (pipeline 3"): DFU per stack is small (V-1 to V-4). Increase to 3 in below the roof for frost closure.

input MBH = 75.0

input MBH = 75.0

Cr=SG/0.60=0.833; req ID = $(Q/(2313*(dH/(Cr*L))^{0.541}))^{1/2.623} = 1.074$ in @ dH=0.30 in wg, L=80 ft; PIPELINE SIZE 1-1/4"

P1=16.7 psia, P2=15.7 psia, $P1^2 - P2^2 = 32.4$; req ID = $(Q/(2313*((P1^2 - P2^2)/(Cr*L))^{0.541}))^{1/2.623} = 0.409$ in

DRAWN 3/4", engineer override (pipeline 1-1/4"): LP at 11 in wc, 0.5 in drop, 80 ft: 59.6 CFH, 0.74 in required. The tool sizes on natural gas at 7 in wc.
cap 451 CFH (200% spare) -- needs a line regulator at building entry

.yaml hunter_curve: points) gives 5.02 GPM. Required ID solved from $GPM = 2.448 \times V \times ID^2$ at $V = 8$
Actual velocity at that size = $GPM / (2.448 \times ID^2) = 5.02 / (2.448 \times 0.545^2) = 6.90$ fps.

$y \geq 5.0$ DFU is 3" (capacity 20 DFU) -- PASS since $20 \geq 5.0$. Building drain repeats the same lookup

$$\left(Q / (2313 * (dH / (Cr * L))^{0.541}) \right)^{1/2.623} = (150 / (2313 * (0.30 / (0.833 * 80))^{0.541}))^{1/2.623} =$$

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ASSUMPTIONS & BASIS

Reference data source: C:\Users\mikes\OneDrive\Documents\Claude\design-toc
Code edition: NEC 2020 (NFPA 70-2020)

PRELIMINARY DESIGN: Sizing aid, not a stamped electrical design

Service: 240/120, 1-phase 3-wire, 15 ft service run
Spare capacity: 25% (building.yaml electrical.service.spare_pct)

Lighting load basis: zones[].area_ft2 x zones[].lpd_w_ft2 (building.yaml)

Lighting demand: NEC Table 220.42, per occupancy bucket

Receptacle load basis: zones[].epd_w_ft2, else electrical_rules.yaml unit_loads_

Equipment MCA / Motor loads: Engineer's columns are authoritative; blanks backfilled from NEC 430.24 / 440.33 -- 125% of the largest motor + 100%

Conductor ampacity: NEC Table 310.16, copper, 75 C column (electrical_rules.y

Voltage drop: $Z_e = R \cos(\theta) + X \sin(\theta)$ at PF 0.85; limits feeder 2.

Panel circuiting + Equipment -> panel: electrical_rules.yaml branch_circuits: and phase_imbalan
serves:mechanical panel if voltage-compatible, else first c

Equipment -> panel

		toilet_room zone lighting
LIGHTING	TR2	toilet_room zone lighting
LIGHTING	TR3	janitor zone lighting
LIGHTING	MECH-JAN	HALL, TR1, TR2, TR3, MECH-JAN, STAGING
LIGHTING	220.42 demand (all_othe	All lighting
LIGHTING	Continuous adjustment	

RECEPTACLES (NEC 220.14 / 220.44)

		multiuse_assembly zone receptacle/plug load
RECEPTACLES	HALL	kitchen_commercial zone receptacle/plug load
RECEPTACLES	STAGING	janitor zone receptacle/plug load
RECEPTACLES	MECH-JAN	toilet_room zone receptacle/plug load
RECEPTACLES	TR1	toilet_room zone receptacle/plug load
RECEPTACLES	TR2	toilet_room zone receptacle/plug load
RECEPTACLES	TR3	All receptacle load
RECEPTACLES	220.44 demand	

MECHANICAL EQUIPMENT (MCA loop closure)

EF

MECH EQUIPMENT EF-1

EF

MECH EQUIPMENT EF-2

EF

MECH EQUIPMENT EF-3

EF

MECH EQUIPMENT EF-4

EF

MECH EQUIPMENT EF-5

Gas IR Tube Heater

MECH EQUIPMENT IR-1/2

Electric Wall Heater

MECH EQUIPMENT EWH

Electric Unit Heater

MECH EQUIPMENT EUH-1

Evaporative Cooler

MECH EQUIPMENT EC-1

All mechanical equipment

MECH EQUIPMENT 430.24 largest-motor ad

EQUIPMENT LOADS (NEC 220.56 / 220.14(A))

EQUIPMENT

OV-1

Ventless double-stack
convection oven (per deck)
[catering]

EQUIPMENT	HC-1	Heated holding cabinet [catering]
EQUIPMENT	CB-1	Coffee brewer [catering]
EQUIPMENT	RI-1	Reach-in refrigerator [catering]
EQUIPMENT	IM-1	Ice machine [catering]
EQUIPMENT	WH-1	50 gal electric water heater [plumbing]
EQUIPMENT	STG-1	Band / DJ stage power: PA, backline, stage lights (dedicated 20 A) [event] Projector, screen, presentation AV (dedicated 20 A) [event]
EQUIPMENT	AV-1	
EQUIPMENT	UPL-1	Uplighting and dance floor lighting (dedicated 20 A) [event]
EQUIPMENT	BUF-1	Buffet line: chafers, soup wells, warmers (dedicated 20 A) [event]
EQUIPMENT	BAR-1	Bar: glass chiller, blender, back- bar cooler (dedicated 20 A) [event]
EQUIPMENT	PB-1	Photo booth / guest table (dedicated 20 A) [event]
EQUIPMENT	OUT-1	Lawn ceremony power pedestal, WP GFCI (dedicated 20 A) [event]
EQUIPMENT	FT-1	Food truck / caterer trailer, 30 A 240 V receptacle [event]
EQUIPMENT	SL-1	String and accent lighting [event]
EQUIPMENT	XL-1	Exterior and path lighting [site]
EQUIPMENT	CF-1	Ceiling fans (hall) [hvac]
		OV-1, HC-1, CB-1
EQUIPMENT	220.56 kitchen demand	
EQUIPMENT	Equipment total	electrical.loads[]

SERVICE (NEC 220 Part III)

SERVICE	Lighting (demand)	All zones
SERVICE	Receptacles (demand)	All zones

Equipment Schedule

SERVICE	Mechanical equipment	
SERVICE	Equipment (electrical)	Kitchen, water heating, event, site
SERVICE	Total calculated load	Whole building
SERVICE	Spare allowance	Whole building
SERVICE	Service OCPD / MDP	Service disconnect
SERVICE	Service conductors	Utility -> MDP

EXISTING SERVICE CHECK (NEC 220.87)

EXISTING	Existing service capacity	Flower shop service
EXISTING	Existing load	Flower shop service
EXISTING	New load to add	This building
EXISTING	Decision	Flower shop service

PHOTOVOLTAIC SYSTEM (NEC 690 / 705)

PV	Roof plane	PV-1
PV	Fire pathways + layout	PV-1
PV	Specific yield	PV-1
PV	Annual use (estimate)	PV-1
PV	Target size	PV-1
PV	Cold Voc	

PV	Hot Vmp	PV-1
PV	Inverter	PV-1
PV	String design	PV-1
PV	DC source circuit	PV-1
PV	DC string fusing	PV-1
PV	Inverter output circuit	PV-1
PV	Interconnection (120% r	PV-1
PV	Rapid shutdown + discon	PV-1
PV	Annual production	PV-1
PV	Utility interconnection	PV-1
PV	Cost and payback (estim	

LIGHTING DESIGN (IES lumen method / IECC 2021 C405)

HALL (multiuse_assembly)

LIGHTING DESIGN HALL
Means of egress illumination
LIGHTING DESIGN HALL egress
IECC C405.2

LIGHTING DESIGN HALL controls
TR1 (toilet_room)

LIGHTING DESIGN TR1
IECC C405.2

LIGHTING DESIGN TR1 controls

		TR2 (toilet_room)
LIGHTING DESIGN	TR2	IECC C405.2
LIGHTING DESIGN	TR2 controls	TR3 (toilet_room)
LIGHTING DESIGN	TR3	IECC C405.2
LIGHTING DESIGN	TR3 controls	no zone (corridor)
LIGHTING DESIGN	CORR	Means of egress illumination
LIGHTING DESIGN	CORR egress	IECC C405.2
LIGHTING DESIGN	CORR controls	MECH-JAN (janitor)
LIGHTING DESIGN	MECH-JAN	IECC C405.2
LIGHTING DESIGN	MECH-JAN controls	STAGING (kitchen_commercial)
LIGHTING DESIGN	STAGING	Means of egress illumination
LIGHTING DESIGN	STAGING egress	

IECC C405.2

LIGHTING DESIGN	STAGING controls	Whole building, space-by-space
LIGHTING DESIGN	IECC interior LPD	
LIGHTING DESIGN	Exit signs	IBC 1013
LIGHTING DESIGN	IECC exterior LPD	Lighting zone 1: Developed areas of national parks, state parks, forest land and rural areas IECC C405.2.7
LIGHTING DESIGN	Exterior controls	
LIGHTING DESIGN	HALL vs NEC basis	zones[].lpd_w_ft2
LIGHTING DESIGN	TR1 vs NEC basis	zones[].lpd_w_ft2
LIGHTING DESIGN	TR2 vs NEC basis	zones[].lpd_w_ft2
LIGHTING DESIGN	TR3 vs NEC basis	zones[].lpd_w_ft2
LIGHTING DESIGN	MECH-JAN vs NEC basis	zones[].lpd_w_ft2
LIGHTING DESIGN	STAGING vs NEC basis	zones[].lpd_w_ft2

PANELS

MDP

PANELS	MDP	lighting/receptacle/ mechanical/equipment
--------	-----	--

PANELS	LP-1
--------	------

FEEDERS & VOLTAGE DROP

MDP -> LP-1
(lighting/receptacle/mechanical/equipment)

FEEDERS LP-1 feeder

GROUNDING (NEC 250)

Utility -> MDP

GROUNDING Service EGC

Service grounding electrode
system

GROUNDING GEC

SHORT CIRCUIT + AIC (point-to-point, NEC 110.9 / 110.10 / 110.24)

Source

FAULT TX-2 secondary

Added at each bus

FAULT Motor + inverter contrib

240/120

FAULT MDP bus

240/120

FAULT LP-1 bus

Equipment terminals

FAULT LP-1 equipment SCCR scr

MDP

FAULT Utility pad sensitivity

Service equipment

FAULT NEC 110.24 field marking

FLAGS

FLAG #1

TRACE NOTES -- hand-verification walkthroughs
LIGHTING (NEC 220.42)

Zone HALL: 1800 ft² (building.yaml zones[].area_ft2) x 0.700 W/ft² (zones[].lighting_occupancy_by_space_type.multiuse_assembly. That bucket's zones is 1662 VA; x demand_factors.continuous_load_factor 1.25 (NEC 215.2(A)(1))

SERVICE (NEC 220 Part III)

Calculated load = lighting demand 2078 VA (220.42, continuous-adjusted) + r
73.2 kVA. Service current = 73248 / (1 x 240 V) = 305.2 A. Spare allowance 25
310.16, Cu, 75 C) with ampacity >= 400 A is 600 AWG/kcmil Cu at 420 A -- PA

FEEDER + VOLTAGE DROP (NEC 310.16 / Ch. 9 Table 9)

Panel MDP: demand 73248 VA at 240 V 1-phase -> I = 73248 / (1 x 240) = 305
0.0257 and X = 0.0390 ohm/kft, so at 0.85 power factor Ze = R x 0.85 + X x 0.5

ls\rules\electrical_rules.yaml

Edit electrical_rules.yaml directly to change any a run and hardcodes none of them. That file's head VERIFY against the edition adopted by the AHJ, in

This stage produces a defensible preliminary servi grounding electrode system detailing, conductor (building.yaml electrical.service. Line voltage 240 V Applied to the NEC 220 calculated service current position count.

The SAME lighting power density that drives the E Table 220.12's general-lighting VA/ft2 values are f allowance.

Zones are grouped by space_type into Table 220.4 remainder @ 50% row; everything else -> 'all othe NEC 220.14(I)/(K) unit-load approach. The zone's ESTIMATING table anchored on 220.14(K)(2)'s 1 V A POPULATED Electrical (V/Ph) or MCA cell is neve Notes cell is flagged "(MCA est. per electrical_rule the estimate is used for the load calculation only.

.va.by_space_type, else receptacle_va_per_ft2

om electrical_rules.yaml mca_estimate:

of the others

aml ampacity_cu_75c)

0% / branch 3.0% / total 5.0%

ice_flag_pct

:compatible panel (flagged)

Applied ONCE at the service (largest motor in the calculated load -- see the MDP row's basis text.

75 C terminations per 110.14(C)(1)(b). NO ambien add them by hand for a hot attic/roof run or a sha allowance is not relied on). 240.4(D) small-conduc R and X from NEC Chapter 9 Table 9 (uncoated co Note and 215.2(A)(1) Informational Note No. 2 re maximum of 5%. These are INFORMATIONAL NOT house design standard that keeps the combined t design current (the spare is future capacity, not pi 250.122(B) then requires a proportional EGC incre Circuits are derived from the calculated loads, not max_load_fraction. Phase assignment is determin schedule. Circuit numbers are sequential, not phy A unit is placed on a panel only if that panel's volt voltage_match_tolerance_pct). A 120/1 exhaust f rows.

Inputs	Rule / Table Cited
1800 ft2 x 0.700 W/ft2 (building.yaml zones[].area_ft2 / lpd_w_ft2)	NEC 220.42 occupancy bucket 'all_others' (electrical_rules.yaml lighting_occupancy_by_space_type.multiuse_ass embly)
255 ft2 x 1.000 W/ft2 (building.yaml zones[].area_ft2 / lpd_w_ft2)	NEC 220.42 occupancy bucket 'all_others' (electrical_rules.yaml lighting_occupancy_by_space_type.kitchen_com mercial)
50 ft2 x 0.800 W/ft2 (building.yaml zones[].area_ft2 / lpd_w_ft2)	NEC 220.42 occupancy bucket 'all_others' (electrical_rules.yaml lighting_occupancy_by_space_type.toilet_room)

50 ft2 x 0.800 W/ft2 (building.yaml zones[].area_ft2 / lpd_w_ft2)	NEC 220.42 occupancy bucket 'all_others' (electrical_rules.yaml lighting_occupancy_by_space_type.toilet_room)
50 ft2 x 0.800 W/ft2 (building.yaml zones[].area_ft2 / lpd_w_ft2)	NEC 220.42 occupancy bucket 'all_others' (electrical_rules.yaml lighting_occupancy_by_space_type.toilet_room)
45 ft2 x 0.600 W/ft2 (building.yaml zones[].area_ft2 / lpd_w_ft2)	NEC 220.42 occupancy bucket 'all_others' (electrical_rules.yaml lighting_occupancy_by_space_type.janitor)
1662 VA connected in the 'all_others' occupancy bucket	NEC Table 220.42 (electrical_rules.yaml demand_factors.lighting_220_42.all_others) -- All others -- NEC Table 220.42, no reduction
1662 VA total 220.42 demand	NEC 215.2(A)(1) / 230.42(A) / 210.20(A) -- 125% of a continuous load (electrical_rules.yaml demand_factors.continuous_load_factor = 1.25)

1800 ft2 x 2.000 VA/ft2 (building.yaml zones[].receptacle_outlets = 20 x 180 VA (NEC 220.14(I), electrical_rules.yaml unit_loads_va.receptacle_outlet_va); overrides epd_w_ft2 for the electrical calc only)	NEC 220.14(I)/(K) unit-load basis (electrical_rules.yaml unit_loads_va:); zone epd_w_ft2 preferred so the electrical and EnergyPlus plug loads agree by construction
255 ft2 x 4.235 VA/ft2 (building.yaml zones[].receptacle_outlets = 6 x 180 VA (NEC 220.14(I), electrical_rules.yaml unit_loads_va.receptacle_outlet_va); overrides epd_w_ft2 for the electrical calc only)	NEC 220.14(I)/(K) unit-load basis (electrical_rules.yaml unit_loads_va:); zone epd_w_ft2 preferred so the electrical and EnergyPlus plug loads agree by construction
45 ft2 x 8.000 VA/ft2 (building.yaml zones[].receptacle_outlets = 2 x 180 VA (NEC 220.14(I), electrical_rules.yaml unit_loads_va.receptacle_outlet_va); overrides epd_w_ft2 for the electrical calc only)	NEC 220.14(I)/(K) unit-load basis (electrical_rules.yaml unit_loads_va:); zone epd_w_ft2 preferred so the electrical and EnergyPlus plug loads agree by construction
50 ft2 x 3.600 VA/ft2 (building.yaml zones[].receptacle_outlets = 1 x 180 VA (NEC 220.14(I), electrical_rules.yaml unit_loads_va.receptacle_outlet_va); overrides epd_w_ft2 for the electrical calc only)	NEC 220.14(I)/(K) unit-load basis (electrical_rules.yaml unit_loads_va:); zone epd_w_ft2 preferred so the electrical and EnergyPlus plug loads agree by construction
50 ft2 x 3.600 VA/ft2 (building.yaml zones[].receptacle_outlets = 1 x 180 VA (NEC 220.14(I), electrical_rules.yaml unit_loads_va.receptacle_outlet_va); overrides epd_w_ft2 for the electrical calc only)	NEC 220.14(I)/(K) unit-load basis (electrical_rules.yaml unit_loads_va:); zone epd_w_ft2 preferred so the electrical and EnergyPlus plug loads agree by construction
50 ft2 x 3.600 VA/ft2 (building.yaml zones[].receptacle_outlets = 1 x 180 VA (NEC 220.14(I), electrical_rules.yaml unit_loads_va.receptacle_outlet_va); overrides epd_w_ft2 for the electrical calc only)	NEC 220.14(I)/(K) unit-load basis (electrical_rules.yaml unit_loads_va:); zone epd_w_ft2 preferred so the electrical and EnergyPlus plug loads agree by construction
5580 VA connected (sum of zones)	NEC Table 220.44 (electrical_rules.yaml demand_factors.receptacle_220_44) -- NEC Table 220.44 -- non-dwelling receptacle loads

Capacity 70 CFM @ 0.5 in wg; CFM 70	electrical_rules.yaml mca_estimate.by_type['EF'].bases[from=schedule_cfm]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 70 CFM @ 0.5 in wg; CFM 70	electrical_rules.yaml mca_estimate.by_type['EF'].bases[from=schedule_cfm]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 70 CFM @ 0.5 in wg; CFM 70	electrical_rules.yaml mca_estimate.by_type['EF'].bases[from=schedule_cfm]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 50 CFM @ 0.5 in wg; CFM 50	electrical_rules.yaml mca_estimate.by_type['EF'].bases[from=schedule_cfm]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 400 CFM @ 0.1 in wg; CFM 400	electrical_rules.yaml mca_estimate.by_type['EF'].bases[from=schedule_cfm]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 2 x 57.9 MBH; CFM -	electrical_rules.yaml mca_estimate.by_type['Gas IR Tube Heater'].bases[from=capacity_mbh]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 4 x 1.9 MBH; CFM -	electrical_rules.yaml mca_estimate.by_type['Electric Wall Heater'].bases[from=capacity_mbh]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 11.7 MBH; CFM -	electrical_rules.yaml mca_estimate.by_type['Electric Unit Heater'].bases[from=capacity_mbh]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
Capacity 12,000 CFM, 2 HP; CFM 12000	electrical_rules.yaml mca_estimate.by_type['Evaporative Cooler'].bases[from=capacity_hp]; mca_factor = 1.25 (NEC 440.33 / 430.24); default_power_factor = 0.85
9 equipment rows, 9576 VA connected total; largest motor load = EC-1 @ 2760 VA	NEC 430.24 / 440.33 (electrical_rules.yaml demand_factors.largest_motor_factor = 1.25)
2 x 5.6 kW / PF 1.00 = 5600 VA at 240/1	NEC 220.56 kitchen group

2 x 2 kW / PF 1.00 = 2000 VA at 120/1	NEC 220.56 kitchen group
1 x 3.6 kW / PF 1.00 = 3600 VA at 240/1	NEC 220.56 kitchen group
2 x 800 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
1 x 1200 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
1 x 4.5 kW / PF 1.00 = 4500 VA at 240/1; continuous	NEC 220.14(A) specific appliance, 100%; x1.25 continuous per 215.2(A)(1)/230.42(A)
4 x 1920 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
1 x 1000 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
2 x 1200 VA (building.yaml) at 120/1; continuous	NEC 220.14(A) specific appliance, 100%; x1.25 continuous per 215.2(A)(1)/230.42(A)
3 x 1800 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
2 x 1500 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
1 x 1200 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
2 x 1800 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
1 x 5760 VA (building.yaml) at 240/1	NEC 220.14(A) specific appliance, 100%
1 x 1500 VA (building.yaml) at 120/1; continuous	NEC 220.14(A) specific appliance, 100%; x1.25 continuous per 215.2(A)(1)/230.42(A)
1 x 500 VA (building.yaml) at 120/1; continuous	NEC 220.14(A) specific appliance, 100%; x1.25 continuous per 215.2(A)(1)/230.42(A)
4 x 150 VA (building.yaml) at 120/1	NEC 220.14(A) specific appliance, 100%
5 units, 18800 VA connected	NEC 220.56 / Table 220.56 (electrical_rules.yaml demand_factors.kitchen_220_56)
17 items, 58740 VA connected	Kitchen at Table 220.56, all other items at 100%, continuous items x1.25
1662 VA connected	NEC 220.42 + 215.2(A)(1)/230.42(A) continuous factor
5580 VA connected	NEC Table 220.44 (electrical_rules.yaml demand_factors.receptacle_220_44)

9 rows, 9576 VA connected	NEC 220.50 (motor loads per 430.24/440.33); no demand factor taken on HVAC
17 items, 58740 VA connected	NEC 220.56 (kitchen group) / 220.14(A) at 100%; continuous items x1.25
lighting 2078 + receptacle 5580 + mechanical 10266 + equipment 55325 VA	NEC 220.40 -- Part III feeder/service calculated load
305.2 A calculated	building.yaml electrical.service.spare_pct = 25% -- DESIGN ALLOWANCE for future load, not an NEC requirement
381.5 A design	NEC 240.6(A) breaker_ladder; electrical_rules.yaml panel_sizes for the switchboard/MDP bus
400 A OCPD, 15 ft run	NEC Table 310.16 copper 75 C (electrical_rules.yaml ampacity_cu_75c); 240.4(D) small-conductor caps; 310.10(G) 1/0 minimum for parallel sets
100 A at 240/120	service rating x V x (sqrt(3) if 3-phase)
220.87(1): 12-month max demand 6.75 kW x 1.25 = 8438 VA	NEC 220.87
NEC 220 Part III calculated load (SERVICE section, before spare allowance)	NEC 220.40
capacity vs existing + new	NEC 220.87
Orangery south roof slope: 76 ft x 15.0 ft run, 5:12 pitch, azimuth 180 deg	tilt = atan(pitch/12); slope length = run / cos(tilt)
eave 4.0 ft, gable ends 4.0 ft, ridge 0.0 ft; exclusions: Ridge lantern + sash swing (x 11-49, 7.0 ft from ridge)	IFC 2021 1205.3.1: 4 ft clear perimeter (building axis 76 ft <= 250 ft)
EPW USA_MT_Hamilton-Ravalli.County.AP.720759_TMYx.2011-2025.epw; horizon PVGIS DEM; losses 11.4% (soiling 2.0, mismatch 2.0, wiring 2.0, connections 0.5, lid 1.5, nameplate 1.0, availability 3.0); snow by month 20/15/5/0/0/0/0/0/0/0/5/15	hourly POA (isotropic sky) x IAM x Sandia cell temp x (1 + gamma (Tc - 25)) x losses x inverter 0.965
Event power (47 uses x 8 h x 8 kW avg, PLAN_2027 counts) 3000; Reach-ins + ice machine, May-Oct 2900; Wing freeze protection, electric heat 1500; Water heater standby + use 1200; Exterior and path lighting, 500 W x 2000 h 1000; Setup lighting, fans, misc 800	sum of the itemized annual use
10400 kWh/yr x 90% offset / (1464 kWh/kW x 0.430 kW/module)	Size below annual use: excess credit is forfeited at the annual true-up
Voc 38.90 V, TCvoc -0.260 %/C, low -20 F (-28.9 C)	NEC 690.7(A)(1) module Voc x (1 + TCvoc x (Tmin - 25 C))

Vmp 32.60 V, ambient 95 F + 35 C cell rise (roof_flush)	Vmp x (1 + TC x (Tcell - 25)); string must stay above the MPPT minimum
6.45 kW DC; catalog max DC/AC 1.30	smallest generic 240 V string inverter that keeps DC/AC at or below the max
4 to 13 modules per string (100 / 28.20 V and 600 / 44.35 V); 1 string(s) per MPPT by Isc	NEC 690.7 max system voltage <= inverter rating; hot Vmp >= MPPT minimum
Isc 14.00 A; conductor ambient 35.0 C (raceway >= 7/8 in above roof, no 310.15(B)(2) adder)	690.8(A)(1) Imax = 1.25 Isc; 690.8(B)(1) 1.25 Imax at the 75 C terminals; 690.8(B)(2) Imax at 90 C after correction
1 string(s) per MPPT	NEC 690.9(A)(1): no series fuse with 2 or fewer strings in parallel
21.0 A max continuous AC at 240 V, 40 ft to MDP	690.8(A)(1)(e) / 705.30: OCPD and conductor at 125% of max output current; 250.122 EGC
MDP: 400 A bus, 400 A main	NEC 705.12(B)(3)(2): 1.25 x inverter output + main OCPD <= 1.20 x busbar; PV breaker at the opposite end from the main
building-mounted array	NEC 690.12 (inside-boundary 80 V in 30 s), 690.13/690.15, 705.20
6.45 kW DC / 5.0 kW AC	hourly model above with inverter clipping
Ravalli Electric Co-op; 5.0 kW AC	REC net metering: up to 10 kW standard; larger needs REC engagement (406-961-3001)
\$2.50-3.25/W DC; ITC 30%; \$0.085/kWh on 9439 kWh credited	planning range, not a quote; 48E needs in-service by 2027-12-31

60.0 x 30.0 ft = 1800 ft2, type A 3500 lm / 28 W, mount 12.0 ft, workplane 2.5 ft, walls 10%, clean	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.direct_wide (GENERIC); LLF = LLD 0.85 x LDD 0.95; target lighting_rules.yaml target_fc.multiuse_assembly
type EM 500 lm on battery, mount 8.0 ft, floor workplane multiuse_assembly, open, 1800 ft2, daylight 100% (sidelit), 420 W general	IBC 2021 1008.3.5 (1 fc avg at floor, 0.1 fc min, 40:1 max:min), 1008.3.4 90 min IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft2), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
4.5 x 6.5 ft = 29 ft2, type C 1000 lm / 10 W, mount 9.0 ft, workplane 2.5 ft, walls 50%, clean	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.direct_wide (GENERIC); LLF = LLD 0.85 x LDD 0.95; target lighting_rules.yaml target_fc.toilet_room
toilet_room, enclosed, 29 ft2, daylight 0% (sidelit), 10 W general	IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft2), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)

4.5 x 6.5 ft = 29 ft ² , type C 1000 lm / 10 W, mount 9.0 ft, workplane 2.5 ft, walls 50%, clean	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.direct_wide (GENERIC); LLF = LLD 0.85 x LDD 0.95; target lighting_rules.yaml target_fc.toilet_room
toilet_room, enclosed, 29 ft ² , daylit 0% (sidelit), 10 W general	IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft ²), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
6.0 x 6.5 ft = 39 ft ² , type C 1000 lm / 10 W, mount 9.0 ft, workplane 2.5 ft, walls 50%, clean	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.direct_wide (GENERIC); LLF = LLD 0.85 x LDD 0.95; target lighting_rules.yaml target_fc.toilet_room
toilet_room, enclosed, 39 ft ² , daylit 0% (sidelit), 10 W general	IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft ²), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
8.0 x 7.0 ft = 56 ft ² , type C 1000 lm / 10 W, mount 9.0 ft, workplane 0.0 ft, walls 50%, clean	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.direct_wide (GENERIC); LLF = LLD 0.85 x LDD 0.95; target lighting_rules.yaml target_fc.corridor
type EM 500 lm on battery, mount 8.0 ft, floor workplane corridor, enclosed, 56 ft ² , daylit 0% (sidelit), 20 W general	IBC 2021 1008.3.5 (1 fc avg at floor, 0.1 fc min, 40:1 max:min), 1008.3.4 90 min IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft ²), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
7.0 x 7.0 ft = 49 ft ² , type D 3000 lm / 22 W, mount 9.0 ft, workplane 2.5 ft, walls 50%, medium	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.wraparound (GENERIC); LLF = LLD 0.85 x LDD 0.90; target lighting_rules.yaml target_fc.janitor
janitor, enclosed, 49 ft ² , daylit 0% (sidelit), 22 W general	IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft ²), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
15.0 x 16.0 ft = 240 ft ² , type B 4000 lm / 29 W, mount 9.0 ft, workplane 3.0 ft, walls 50%, medium	IES lumen method $N = E \times A / (lm \times CU \times LLF)$; RCR = 5 h (L+W) / (L W); CU lighting_rules.yaml cu_tables.wraparound (GENERIC); LLF = LLD 0.85 x LDD 0.90; target lighting_rules.yaml target_fc.kitchen_commercial
type EM 500 lm on battery, mount 8.0 ft, floor workplane	IBC 2021 1008.3.5 (1 fc avg at floor, 0.1 fc min, 40:1 max:min), 1008.3.4 90 min

kitchen_commercial, enclosed, 240 ft2, daylit 0% (sidelit), 174 W general	IECC 2021 C405.2.1 occupant sensors (listed spaces + enclosed <= 300 ft2), C405.2.4 daylight zones > 150 W; lighting_rules.yaml controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
HALL 420 W / 1584 W; TR1 10 W / 18 W; TR2 10 W / 18 W; TR3 10 W / 25 W; CORR 20 W / 23 W; MECH-JAN 22 W / 17 W; STAGING 174 W / 262 W	IECC 2021 C405.3.2(2) space-by-space; allowances trade between spaces (C405.3.2.2); emergency, exit and theatrical/event lighting exempt (C405.3.1). Values: UNVERIFIED: lower of recalled 90.1-2019 and up.codes IECC 2021 readings; check the ICC table
6 x EX at 2 W	IBC 2021 1013.1 (two exits or more), 1013.6.3 90 min battery; 5 W per face limit
5 x X1 Hall doors S/N/W, wing service door, bottle filler; 8 x X2 Path to the flower shop	IECC 2021 C405.4.2 Tables C405.4.2(1)/(2); SECONDARY (up.codes 2026-09-30, ICC page blocked); base site 350 W LZ1 matches recall
dusk to dawn, dark-sky full cutoff	IECC 2021 C405.2.7 exterior lighting controls (SECONDARY (up.codes 2026-09-30): occupant list, 20 min, 150 W daylight thresholds, 50% exterior reduction)
zone 1800 ft2 x 0.70 W/ft2 = 1260 W	electrical_sizing.py lighting load (NEC 220.12 via designed LPD); not changed by this stage
zone 50 ft2 x 0.80 W/ft2 = 40 W	electrical_sizing.py lighting load (NEC 220.12 via designed LPD); not changed by this stage
zone 50 ft2 x 0.80 W/ft2 = 40 W	electrical_sizing.py lighting load (NEC 220.12 via designed LPD); not changed by this stage
zone 50 ft2 x 0.80 W/ft2 = 40 W	electrical_sizing.py lighting load (NEC 220.12 via designed LPD); not changed by this stage
zone 45 ft2 x 0.60 W/ft2 = 27 W	electrical_sizing.py lighting load (NEC 220.12 via designed LPD); not changed by this stage
zone 255 ft2 x 1.00 W/ft2 = 255 W	electrical_sizing.py lighting load (NEC 220.12 via designed LPD); not changed by this stage
connected 75558 VA (L 1662 / R 5580 / M 9576 / E 58740)	building.yaml electrical.panels[] serves: assignment; electrical_rules.yaml branch_circuits:, panel_sizes:, panel_circuit_positions:, phase_imbalance_flag_pct
connected 75558 VA (L 1662 / R 5580 / M 9576 / E 58740)	building.yaml electrical.panels[] serves: assignment; electrical_rules.yaml branch_circuits:, panel_sizes:, panel_circuit_positions:, phase_imbalance_flag_pct

73248 VA demand, 10 ft, 240/120	NEC 240.6(A) ladder; Table 310.16 Cu 75 C; Table 250.122 EGC; Ch. 9 Table 9 R/X for VD (electrical_rules.yaml conductor_resistance/reactance_ohm_per_kft, voltage_drop_power_factor=0.85)
---------------------------------	--

400 A service OCPD	NEC Table 250.122 (electrical_rules.yaml egc:)
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largest ungrounded service conductor 600	NEC Table 250.66 (electrical_rules.yaml gec.rows)
--	--

100 kVA, 1.50%Z nameplate, 240/120, infinite-bus primary	Point-to-point method, Eaton Bussmann SPD; NEC 110.9, 110.10, 110.24, 240.86; %Z x 0.90 (ANSI C57.12.00 -7.5% tolerance, worst case)
7216 VA running motors; PV inverter 5.0 kW string, 21.0 A rated	motor 4.0 x FLA; inverter 2.0 x rated AC (electrical_rules.yaml fault_current)
from TX-2: 30864 A L-L, 46296 A L-N	Point-to-point; C from Ch. 9 Table 9 R (at 25 C) and X; governing = max(L-L, L-N) + contributions

from MDP: 26337 A L-L, 30544 A L-N	Point-to-point; C from Ch. 9 Table 9 R (at 25 C) and X; governing = max(L-L, L-N) + contributions
------------------------------------	---

worst circuit: FT-1 -- Food truck / caterer trailer, 30 A 240 V receptacle; #10 Cu, 25 ft assumed same 1.50%Z, pad ladder	NEC 110.10, 409.22, 440.4(B): equipment SCCR >= available fault at its terminals What-if: which utility transformer size breaks the selected MDP rating
---	--

Non-dwelling service equipment	NEC 110.24(A) mark; 110.24(B) re-mark on change; 110.16(A) arc-flash warning label
--------------------------------	--

$\text{load_w_ft2} = 1260 \text{ VA connected (1 W = 1 VA at the unity power factor assumed for LED driver load). The total 1662 VA connected; applying demand_factors.lighting_220_42.all_others (All others -- NEC Table 220.42(A), lighting is a continuous load) = 2078 VA carried into the service calculation. At 240 V 1-phase}$

receptacle demand 5580 VA (Table 220.44: 5580 VA @ 100%) + mechanical connected 9576 VA + largest-r
 % (building.yaml electrical.service.spare_pct): $305.2 \times 1.25 = 381.5 \text{ A design. Smallest NEC 240.6(A) stand}$
 SS since $420 \geq 400$. EGC from Table 250.122 at the 400 A row = #3. GEC from Table 250.66 for a 600 serv

.2 A. OCPD = smallest NEC 240.6(A) entry $\geq 305.2 \text{ A} = 400 \text{ A}$. Conductor = smallest ampacity_cu_75c ent
 $i_{27} = 0.04239 \text{ ohm/kft. } V_d = 2 \times I \times L \times Z_e / 1000 = 2 \times 305.2 \times 15 \times 0.04239 / 1000 = 0.39 \text{ V, i.e. } 0.16\% \text{ of } 2$

mpacity/breaker/demand-factor/MCA-estimate/conductor-R/EGC/GEC assumption -- e
er states the NEC edition and which blocks are code tables vs. in-house estimating table
cluding local amendments, before issuing for construction. Article/table numbers cited

ice size, panel schedule, and feeder list for budgeting and coordination. Short-circuit/ari
derating for ambient/fill, and the final circuit layout are NOT performed here.
/, line-to-neutral 120 V.

before the 240.6(A) ladder pick. A DESIGN ALLOWANCE for future load, not an NEC req

EnergyPlus model, so the electrical and thermal calcs cannot drift apart. 1 W is taken as
NOT used -- the project's actual designed LPD is a better number and is already required

42 buckets via electrical_rules.yaml lighting_occupancy_by_space_type (warehouse/stc
ers', no reduction). Continuous 125% is applied AFTER the demand factors.

own equipment power density wins so the electrical and EnergyPlus plug loads agree; tl
A/ft2 office figure, not a code table. NEC Table 220.44 demand then applies.

er overwritten (loads_to_schedule.py's engineer-owned-columns contract). A BLANK ce
s.yaml mca_estimate -- replace with vendor data)". A cell that is populated but non-nu
mca_estimate: is an IN-HOUSE CORRELATION, not vendor data -- replace with submitta

building) and ONCE per feeder (largest motor on that feeder). This is why the sum of th

it-temperature correction (310.15(B)(1)) and NO more-than-3-current-carrying-conduct
ired raceway. Conductors are sized so ampacity >= the OCPD rating (the conservative re
tor caps ARE enforced.

pper, PVC conduit). The limits themselves are RECOMMENDED PRACTICE, not enforceal
commend sizing branch-circuit and feeder conductors for a maximum 3% voltage drop
ES -- recommended practice, not enforceable code requirements. The 2% feeder target
otal under 5% when the branch circuit uses its full 3%. VD is evaluated at the calculated
resent flow). A feeder over the limit is automatically upsized one conductor size at a tir
ase, which this script does NOT auto-apply.

: from a fixture/device count: each zone's category load is divided into equal circuits cap
istic (VA descending, each circuit to the currently-lightest phase, ties A-B-C) so an unch
sical bus positions.

age system can actually supply the unit's voltage/phase (electrical_rules.yaml voltage_s
an therefore lands on the 208Y/120 panel even when the mechanical panel is 480Y/277

Intermediates	Result
1800 x 0.700 = 1260 VA connected (1 W = 1 VA at unity PF for LED driver/ballast load)	1260 VA
255 x 1.000 = 255 VA connected (1 W = 1 VA at unity PF for LED driver/ballast load)	255 VA
50 x 0.800 = 40 VA connected (1 W = 1 VA at unity PF for LED driver/ballast load)	40 VA

50 x 0.800 = 40 VA connected (1 W = 1 VA at unity PF for LED driver/ballast load)

40 VA

50 x 0.800 = 40 VA connected (1 W = 1 VA at unity PF for LED driver/ballast load)

40 VA

45 x 0.600 = 27 VA connected (1 W = 1 VA at unity PF for LED driver/ballast load)

27 VA

1662 VA @ 100% = 1662 VA demand

1662 VA

1662 x 1.25 = 2078 VA (applied AFTER the 220.42 demand factors: 220.42 reduces the CALCULATED load, the 125% multiplier then sizes conductors/OCPD for the continuous portion of that calculated load)

2078 VA

1800 x 2.000 = 3600 VA connected

3600 VA

255 x 4.235 = 1080 VA connected

1080 VA

45 x 8.000 = 360 VA connected

360 VA

50 x 3.600 = 180 VA connected

180 VA

50 x 3.600 = 180 VA connected

180 VA

50 x 3.600 = 180 VA connected

180 VA

5580 VA @ 100% = 5580 VA demand

5580 VA

Equipment Schedule 'Electrical (V/Ph)' = '120/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 1 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 96 \text{ VA}$

96 VA @ 120/1, MCA :

Equipment Schedule 'Electrical (V/Ph)' = '120/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 1 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 96 \text{ VA}$

96 VA @ 120/1, MCA :

Equipment Schedule 'Electrical (V/Ph)' = '120/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 1 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 96 \text{ VA}$

96 VA @ 120/1, MCA :

Equipment Schedule 'Electrical (V/Ph)' = '120/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 1 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 96 \text{ VA}$

96 VA @ 120/1, MCA :

Equipment Schedule 'Electrical (V/Ph)' = '120/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 2 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 192 \text{ VA}$

192 VA @ 120/1, MCA

Equipment Schedule 'Electrical (V/Ph)' = '120/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 5 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 480 \text{ VA}$

480 VA @ 120/1, MCA

Equipment Schedule 'Electrical (V/Ph)' = '240/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 12 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 2304 \text{ VA}$

2304 VA @ 240/1, MC

Equipment Schedule 'Electrical (V/Ph)' = '240/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 18 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 3456 \text{ VA}$

3456 VA @ 240/1, MC

Equipment Schedule 'Electrical (V/Ph)' = '208-230/1' (ENGINEER'S COLUMN -- authoritative). Equipment Schedule 'MCA' = 15 A (ENGINEER'S COLUMN -- authoritative). Connected VA back-calculated as $MCA / mca_factor \ 1.25 \times V \times 1 = 2760 \text{ VA}$

2760 VA @ 230/1, MC

125% of the largest motor plus 100% of the others = $6816 + 1.25 \times 2760 = 10266 \text{ VA}$ (equivalently: connected total + 690 VA adder)

10266 VA

$2 \times 5600 = 11200 \text{ VA}$ connected; $\times 0.700$ demand = 7840 VA; circuit 25 A 2-pole (unit 23.3 A)

7840 VA

2 x 2000 = 4000 VA connected; x0.700 demand = 2800 VA; circuit 20 A 1-pole (unit 16.7 A)	2800 VA
1 x 3600 = 3600 VA connected; x0.700 demand = 2520 VA; circuit 15 A 2-pole (unit 15.0 A)	2520 VA
2 x 800 = 1600 VA connected; x1.000 demand = 1600 VA; circuit 15 A 1-pole (unit 6.7 A x 1.25)	1600 VA
1 x 1200 = 1200 VA connected; x1.000 demand = 1200 VA; circuit 15 A 1-pole (unit 10.0 A x 1.25)	1200 VA
1 x 4500 = 4500 VA connected; x1.000 demand x 1.25 continuous = 5625 VA; circuit 25 A 2-pole (unit 18.8 A x 1.25)	5625 VA
4 x 1920 = 7680 VA connected; x1.000 demand = 7680 VA; circuit 20 A 1-pole (unit 16.0 A)	7680 VA
1 x 1000 = 1000 VA connected; x1.000 demand = 1000 VA; circuit 15 A 1-pole (unit 8.3 A)	1000 VA
2 x 1200 = 2400 VA connected; x1.000 demand x 1.25 continuous = 3000 VA; circuit 15 A 1-pole (unit 10.0 A x 1.25)	3000 VA
3 x 1800 = 5400 VA connected; x1.000 demand = 5400 VA; circuit 15 A 1-pole (unit 15.0 A)	5400 VA
2 x 1500 = 3000 VA connected; x1.000 demand = 3000 VA; circuit 15 A 1-pole (unit 12.5 A)	3000 VA
1 x 1200 = 1200 VA connected; x1.000 demand = 1200 VA; circuit 15 A 1-pole (unit 10.0 A)	1200 VA
2 x 1800 = 3600 VA connected; x1.000 demand = 3600 VA; circuit 15 A 1-pole (unit 15.0 A)	3600 VA
1 x 5760 = 5760 VA connected; x1.000 demand = 5760 VA; circuit 25 A 2-pole (unit 24.0 A)	5760 VA
1 x 1500 = 1500 VA connected; x1.000 demand x 1.25 continuous = 1875 VA; circuit 20 A 1-pole (unit 12.5 A x 1.25)	1875 VA
1 x 500 = 500 VA connected; x1.000 demand x 1.25 continuous = 625 VA; circuit 15 A 1-pole (unit 4.2 A x 1.25)	625 VA
4 x 150 = 600 VA connected; x1.000 demand = 600 VA; circuit 15 A 1-pole (unit 1.2 A x 1.25)	600 VA
5 units -> factor 0.70: 18800 x 0.70 = 13160 VA; floor = two largest units 11200 VA; demand = 13160 VA	13160 VA
sum of item results	55325 VA

1662 VA connected -> 1662 VA after Table 220.42 -> x1.25 continuous = 2078 VA	2078 VA
5580 VA @ 100% = 5580 VA	5580 VA

9576 VA connected + 690 VA largest-motor adder (EC-1 @ 2760 VA x 25%) = 10266 VA

see the EQUIPMENT LOADS section	10266 VA
73248 VA = 73.2 kVA; $I = VA / (1 \times 240 \text{ V}) = 305.2 \text{ A}$	55325 VA
$305.2 \times (1 + 25/100) = 381.5 \text{ A design}$	73.2 kVA / 305.2 A
smallest 240.6(A) rating $\geq 381.5 \text{ A} = 400 \text{ A}$; smallest panel_sizes entry $\geq 381.5 \text{ A} = 400 \text{ A bus}$	381.5 A
smallest size with ampacity $\times$ sets $\geq 400 \text{ A}$: 600 AWG/kcmil Cu (420 A)	400 A
	(3) 600 Cu + 3 EGC

100 x 240 = 24000 VA	24.0 kVA
220.87(1): 12-month max demand 6.75 kW x 1.25 = 8438 VA	8.4 kVA
73248 VA = 305.2 A at 240/120	73.2 kVA
This building alone (73.2 kVA, 305 A) exceeds the whole 100 A Flower shop service rating (24.0 kVA) before any existing load is counted. No existing-load data is needed to decide this; size the new service from the SERVICE section.	NEW SERVICE REQUIR

tilt 22.6 deg, slope 16.25 ft	1235 ft ² plane
module 67.8 x 44.6 in; best orientation landscape	21 modules fit = 9.03
1 kW DC unclipped	
6 items	1464 kWh/kW-yr
15 modules wanted, 21 fit	10400 kWh/yr
$38.90 \times (1 + -0.00260 \times (-28.9 - 25))$	15 modules
	44.35 V per module

Tcell 70.0 C	28.20 V per module
5.0 kW string: 600 Vdc max, MPPT 100-480 V, 2 MPPT, 22.5 A max Isc per MPPT, 21.0 A AC strings 8+7; max Voc 355 V; min hot Vmp 197 V	5.0 kW string, DC/AC 1
	15 modules = 6.45 kW
Imax 17.5 A; need 21.9 A at 75 C (10 AWG = 35 A) and 17.5 A at 90 C x 0.96 (10 AWG = 38.4 A)	#10 Cu PV wire, OK
per MPPT parallel strings = 1	none required
1.25 x 21.0 = 26.2 A -> 30 A 2-pole; 10 AWG/kcmil Cu; VD 0.76% (limit 1.5%)	30 A 2P, 2 #10 + #10 E
1.25 x 21.0 + 400 = 426 A vs 1.20 x 400 = 480 A	
module-level rapid shutdown devices on every module; PV AC disconnect, lockable, visible blade, at the meter-main	LOAD-SIDE OK
monthly kWh 371 500 876 1031 1060 1085 1138 1026 921 663 452 315; clipped 7 kWh threshold 10 kW	MLPE RSD + PV AC dis
	9439 kWh/yr (1463 kW)
installed \$16k-21k, net of ITC \$11k-15k; saves \$801/yr	SIMPLE NET METERIN
	payback 14-18 yr

h_rc 9.5 ft, RCR 2.38, CU 0.893, LLF 0.807, N min 15 -> grid 5 x 3
at 12.0 x 10.0 ft, S/MH 1.26

RCR 2.00, CU 0.930, LLF 0.807	15 x A = 21 fc (target 2)
daylit general lighting 420 W vs 150 W threshold	5 x EM = 1.0 fc avg

h_rc 6.5 ft, RCR 12.22, CU 0.570, LLF 0.807, N min 1 -> grid 1 x 1 at 4.5 x 6.5 ft, S/MH 1.00	occupant sensor, auto
daylit general lighting 0 W vs 150 W threshold	1 x C = 16 fc (target 1)
	occupant sensor, auto

h_rc 6.5 ft, RCR 12.22, CU 0.570, LLF 0.807, N min 1 -> grid 1 x 1
at 4.5 x 6.5 ft, S/MH 1.00

daylit general lighting 0 W vs 150 W threshold

1 x C = 16 fc (target 1

h_rc 6.5 ft, RCR 10.42, CU 0.570, LLF 0.807, N min 1 -> grid 1 x 1
at 6.0 x 6.5 ft, S/MH 1.00

occupant sensor, auto

daylit general lighting 0 W vs 150 W threshold

1 x C = 12 fc (target 1

h_rc 9.0 ft, RCR 12.05, CU 0.570, LLF 0.807, N min 2 -> grid 2 x 1
at 4.0 x 7.0 ft, S/MH 0.78

occupant sensor, auto

RCR 10.71, CU 0.570, LLF 0.807

2 x C = 16 fc (target 1

daylit general lighting 0 W vs 150 W threshold

1 x EM = 4.1 fc avg

h_rc 6.5 ft, RCR 9.29, CU 0.449, LLF 0.765, N min 1 -> grid 1 x 1
at 7.0 x 7.0 ft, S/MH 1.08

occupant sensor, auto

daylit general lighting 0 W vs 150 W threshold

1 x D = 21 fc (target 20

h_rc 6.0 ft, RCR 3.88, CU 0.740, LLF 0.765, N min 6 -> grid 2 x 3
at 7.5 x 5.3 ft, S/MH 1.25

occupant sensor, auto

RCR 5.17, CU 0.800, LLF 0.765

6 x B = 57 fc (target 50

1 x EM = 1.3 fc avg

daylit general lighting 0 W vs 150 W threshold

designed 666 W vs allowance 1947 W (34% of allowance)

occupant sensor, auto

PASS

OK

base site 350 W, entries 12 ft x 14 = 168 W, walkway 100 lf x 0.5
= 50 W

170 W vs 568 W: PASS

designed 420 W over 1800 ft2 of lighting rooms

photocell or astronom

OK

designed 10 W over 29 ft2 of lighting rooms

OK

designed 10 W over 29 ft2 of lighting rooms

OK

designed 10 W over 39 ft2 of lighting rooms

OK

designed 22 W over 49 ft2 of lighting rooms

OK

designed 174 W over 240 ft2 of lighting rooms

OK

MDP is sized by the NEC 220 Part III SERVICE calculation (73248 VA demand, single NEC 430.24 largest-motor adder), NOT by summing the downstream feeder demands (73248 VA) -- each of those carries its own 430.24 adder for the largest motor on that feeder, so the sum double-counts by 0 VA. Service 400 A OCPD, 400 A bus at 240/120. Cross-check: sum of feeders is 100.0% of the service calculated load.

400 A main / 400 A bu

Connected 75558 VA (lighting 1662 / receptacle 5580 / mechanical 9576 / equipment 58740); demand 73248 VA [lighting x1.250 per NEC 220.42+continuous, receptacle x1.000 per NEC Table 220.44, mechanical at 100% + 690 VA largest-motor adder (EC-1)]; 305.2 A at 240 V 1ph -> 350 A main (NEC 240.6(A)), 400 A bus, 84 circuit positions (used 61 poles + 25% spare). Feeder 10 ft: (3) 500 Cu + 3 EGC, VD 0.12% (limit 2.0%, electrical_rules.yaml vd_limits.feeder_pct).

350 A main / 400 A bu

$I = 73248 / (1 \times 240) = 305.2 \text{ A} \rightarrow \text{OCPD } 350 \text{ A} \rightarrow 500 \text{ AWG/kcmil}$
Cu (ampacity 380 A); $Z_e = R \times 0.85 + X \times 0.527 = 0.04553$
ohm/kft; $V_d = 2 \times 305.2 \times 10 \times 0.04553 / 1000 = 0.28 \text{ V} = 0.12\%$

(3) 500 Cu + 3 EGC, 35

400 A falls in the '400 A' row $\rightarrow$ 3 AWG Cu

#3 Cu

600.0 kcmil $\rightarrow$ row 'Over 350 kcmil through 600 kcmil' $\rightarrow$ 1/0
AWG Cu

#1/0 Cu

$I_{FLA} = 100 \times 1000 / (240) = 416.7 \text{ A}$; $I_{sc} = 416.7 / (0.0135) =$
30864 A L-L; L-N = $1.50 \times \text{L-L} = 46296 \text{ A}$ (center-tapped
secondary)

46.3 kA

motor FLA 30.1 A $\times 4.0 = 120 \text{ A}$; inverter 42 A; added
undiminished at every bus

162 A

TX-2 $\rightarrow$ MDP, 600 AWG/kcmil Cu, 15 ft: C 22443, $f = 2 \times 15 \times$
 $30864 / (22443 \times 1 \times 240) = 0.172$, M 0.853 $\rightarrow 26337 \text{ A L-L}$; L-N: f
 $= 2 \times 15 \times 46296 / (C \times 1 \times 120) = 0.516$, M 0.660 $\rightarrow 30544 \text{ A}$; +
162 A contributions = 30707 A

30.7 kA $\rightarrow$ 35 kAIC

MDP $\rightarrow$ LP-1, 500 AWG/kcmil Cu, 10 ft: C 21674, $f = 2 \times 10 \times$
 $26337 / (21674 \times 1 \times 240) = 0.101$, M 0.908 $\rightarrow 23915 \text{ A L-L}$; L-N: f
 $= 2 \times 10 \times 30544 / (C \times 1 \times 120) = 0.235$, M 0.810 $\rightarrow 24735 \text{ A}$; +
162 A contributions = 24897 A

24.9 kA $\rightarrow$ 25 kAIC

bus 24897 A through 25 ft #10 $\rightarrow$ 3870 A

3.87 kA

25 kVA 10.4 kA, 37.5 kVA 14.7 kA, 50 kVA 18.6 kA, 75 kVA 25.2
kA, 100 kVA 30.7 kA, 167 kVA 41.7 kA

35 kAIC holds up to 10

AVAILABLE FAULT CURRENT 30.7 kA RMS SYM AT MDP,
CALCULATED 2026-10-01 (POINT-TO-POINT, TX-2 100 kVA
1.50%Z, ASSUMED)

label

Fault current: TX-2 data is ASSUMED: REC has not sized pad
TX-2; 100 kVA 1-ph, 1.5%Z, infinite-bus primary. Get kVA, %Z
and primary fault MVA from the utility, then rerun before
equipment release.

zone's space_type 'multiuse_assembly' maps to the NEC Table 220.42 occupancy bucket 20.42, no reduction) gives 1662 VA @ 100% = 1662 VA demand. Summed with every other that is 2078 / (1 x 240) = 8.7 A.

motor adder 690 VA (EC-1 at 2760 VA x 25%, electrical_rules.yaml demand_factors.large_lard rating >= 381.5 A (electrical_rules.yaml breaker_ladder) = 400 A. Conductor: smallest size conductor (Over 350 kcmil through 600 kcmil) = #1/0.

ry >= 400 A = 600 AWG/kcmil Cu (tabulated ampacity 420 A). Voltage drop, NEC Chapter 40 V -- within the 2.0% limit (electrical_rules.yaml vd_limits.feeder_pct).

lectrical_sizing.py reads it fresh on every
s.

in each row below are per that edition.

c-flash study, selective coordination,

uirement. Also drives each panel's circuit-

1 VA (unity PF) for LED driver load. NEC
l to be at or below the energy code's

orage -> the 12,500 VA @ 100% +

he by_space_type table is an in-house

ll is filled with an estimate and the row's
meric ("TBD", "-") is left untouched and
l nameplate values before issuing.

e feeder demands exceeds the service

or adjustment (310.15(C)(1)) is applied --
ading; 240.4(B)'s next-standard-size-up

ble code: NEC 210.19(A) Informational
with a combined feeder-plus-branch
t below the 3% note is the tighter in-
load current, not at the spare-inflated
ie and FLAGGED -- note that NEC

pped at breaker x volts x
anged input reproduces an identical

systems[].supplies, matched within
' -- that fallback is flagged on the affected

Flag / Notes

Commercial lighting treated as
continuous (3 h or more)





Applied ONCE at the service and ONCE
per feeder (to the largest motor on that
feeder)



ASSUMED -- confirm with Mike / vendor
data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

422.13 storage WH treated continuous (conservative for the service)

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data; 24 A load at 80% of 30 A; drop if caterers never bring a trailer

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data

ASSUMED -- confirm with Mike / vendor data



NEC 220.60 noncoincident-load reduction
NOT taken (electrical_rules.yaml
demand_factors.noncoincident_220_60_
applied = false)

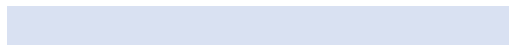
NEC 220.60 noncoincident reduction
(heat vs event loads) NOT taken

240/120, 400 A bus

VD 0.16% over 15 ft at the 305.2 A
calculated load (limit 2.0%)



REVIEW



Confirm pathway rules with the fire
marshal; IFC 1205.3 is the basis

Snow loss is an assumption; Bitterroot
valley floor, 5:12 metal roof sheds fast

ASSUMED: replace with the meter once a
season of events is on record

ASSUMED -20 F; verify ASHRAE extreme
annual mean minimum for Hamilton

Basis of design only: swap in the submittal datasheet

Co-op usually requires the visible lockable AC disconnect; confirm in the interconnection agreement

Excess credited at wholesale and forfeited each April (FWEC research 2026-08-12)

ESTIMATE: tax credit eligibility is for Mike's tax advisor

RCR 12.2 > 10: small/tall room, CU clamped at RCR 10

RCR 12.2 > 10: small/tall room, CU
clamped at RCR 10

RCR 10.4 > 10: small/tall room, CU
clamped at RCR 10

RCR 12.1 > 10: small/tall room, CU
clamped at RCR 10

lighting room area 29 ft2 vs zone 50 ft2

lighting room area 29 ft2 vs zone 50 ft2

lighting room area 39 ft2 vs zone 50 ft2

MDP feeders are 3-pole -- balanced by construction.

Phase imbalance 0.0% (max phase vs. mean) -- within the 20% in-house flag threshold (electrical_rules.yaml phase_imbalance_flag_pct)

VD 0.12% <= 2.0% limit
(electrical_rules.yaml
vd_limits.feeder_pct)

250.122(B) EGC upsizing for VD-upsized
conductors NOT auto-applied -- apply by
hand where a feeder below is flagged
UPSIZED
Caps per 250.66(A)/(B)/(C): #6 to a
rod/pipe/plate, #4 to a concrete-encased
electrode, #3 to a ground ring

ASSUMED: REC has not sized pad TX-2;
100 kVA 1-ph, 1.5%Z, infinite-bus primary

no aic_ka in building.yaml: specify FULLY
RATED >= 35 kA (series ratings per 240.86
not relied on)

no aic_ka in building.yaml: specify FULLY
RATED >= 25 kA (series ratings per 240.86
not relied on)

within the 5 kA default SCCR

Ask the utility for the installed pad kVA
and %Z; a larger pad or lower %Z can
exceed this
Recalculate and re-mark if the utility
changes the pad

REVIEW

t 'all_others' via electrical_rules.yaml
er bucket, the building's lighting demand

est_motor_factor 1.25) = 73248 VA =
:st ampacity_cu_75c entry (NEC Table

:r 9 Table 9 uncoated copper in PVC: R =

PANEL SCHEDULES -- preliminary, from design-tools\electrical_sizing.py

Circuits are generated from the NEC 220 calculated loads, not from a fixture/device count. Phase assigned to each circuit is the lightest phase (ties A-B-C), so an unchanged input reproduces an identical schedule. Breaker sizes are based on the calculated load. Circuit numbers are bus positions on a two-column board (odd left, even right, rows alternate A-B-C); opposite the main.

Panel	Ckt	Load Description	Load Type	Connected VA
PANEL MDP		Fed from: SERVICE	240/120	75558
		MDP is sized by the NEC 220 Part III SERVICE calculation (73248 VA demand, plus 430.24 VA adder for the largest motor on the panel) -- each of those carries its own 430.24 adder for the largest motor on the panel; check: sum of feeders is 100.0% of the service calculated load.		
basis				
MDP	1,3	LP-1 feeder	feeder	75558
MDP	10,12	PV-1 PV inverter output (backfed, opposite end from main)	PV	0
		PHASE TOTALS (connected VA)	A=37779; B=3777	75558

PANEL LP-1		Fed from: MDP	240/120	75558
		Connected 75558 VA (lighting 1662 / receptacle 5580 / mechanical 9576 / equipment 5760) per NEC Table 220.44, mechanical at 100% + 690 VA largest-motor adder (EC-100% + 25% spare). Feeder 10 ft: (3) 500 Cu + 3 EGC, VD 0.12% (limit 2.0%, elc)		
basis				
		FT-1 -- Food truck / caterer trailer, 30 A 240 V receptacle		
LP-1	1,3		equipment	5760
		OV-1 -- Ventless double-stack convection oven (per deck) (1 of 2)		
LP-1	2,4		equipment	5600
		OV-1 -- Ventless double-stack convection oven (per deck) (2 of 2)		
LP-1	5,7		equipment	5600
		WH-1 -- 50 gal electric water heater		
LP-1	6,8		equipment	4500
		CB-1 -- Coffee brewer		
LP-1	9,11		equipment	3600
		EUH-1 -- Electric Unit Heater (240/1, MCA 18 A)		
LP-1	10,12		mechanical	3456

		EC-1 -- Evaporative Cooler (230/1, MCA 15 A)		
LP-1	13,15	EWB -- Electric Wall Heater (240/1, MCA 12 A)	mechanical	2760
LP-1	14,16	HC-1 -- Heated holding cabinet (1 of 2)	mechanical	2304
LP-1	17	STG-1 -- Band / DJ stage power: PA, backline, stage lights (dedicated 20 A) (1 of 4)	equipment	2000
LP-1	18	HC-1 -- Heated holding cabinet (2 of 2)	equipment	1920
LP-1	19	STG-1 -- Band / DJ stage power: PA, backline, stage lights (dedicated 20 A) (2 of 4)	equipment	2000
LP-1	20	STG-1 -- Band / DJ stage power: PA, backline, stage lights (dedicated 20 A) (3 of 4)	equipment	1920
LP-1	21	BUF-1 -- Buffet line: chafers, soup wells, warmers (dedicated 20 A) (1 of 3)	equipment	1920
LP-1	22	STG-1 -- Band / DJ stage power: PA, backline, stage lights (dedicated 20 A) (4 of 4)	equipment	1800
LP-1	23	BUF-1 -- Buffet line: chafers, soup wells, warmers (dedicated 20 A) (2 of 3)	equipment	1920
LP-1	24	BUF-1 -- Buffet line: chafers, soup wells, warmers (dedicated 20 A) (3 of 3)	equipment	1800
LP-1	25	OUT-1 -- Lawn ceremony power pedestal, WP GFCI (dedicated 20 A) (2 of 2)	equipment	1800
LP-1	26	OUT-1 -- Lawn ceremony power pedestal, WP GFCI (dedicated 20 A) (1 of 2)	equipment	1800
LP-1	27		equipment	1800

		RECEPTACLE -- HALL (1 of 2)		
LP-1	28		receptacle	1800
		RECEPTACLE -- HALL (2 of 2)		
LP-1	29		receptacle	1800
		SL-1 -- String and accent lighting		
LP-1	30		equipment	1500
		BAR-1 -- Bar: glass chiller, blender, back-bar cooler (dedicated 20 A) (1 of 2)		
LP-1	31		equipment	1500
		BAR-1 -- Bar: glass chiller, blender, back-bar cooler (dedicated 20 A) (2 of 2)		
LP-1	32		equipment	1500
		IM-1 -- Ice machine		
LP-1	33		equipment	1200
		UPL-1 -- Uplighting and dance floor lighting (dedicated 20 A) (1 of 2)		
LP-1	34		equipment	1200
		LIGHTING -- HALL		
LP-1	35		lighting	1260
		PB-1 -- Photo booth / guest table (dedicated 20 A)		
LP-1	36		equipment	1200
		RECEPTACLE -- STAGING		
LP-1	37		receptacle	1080
		RI-1 -- Reach-in refrigerator (1 of 2)		
LP-1	38		equipment	800
		UPL-1 -- Uplighting and dance floor lighting (dedicated 20 A) (2 of 2)		
LP-1	39		equipment	1200
		AV-1 -- Projector, screen, presentation AV (dedicated 20 A)		
LP-1	40		equipment	1000
		RI-1 -- Reach-in refrigerator (2 of 2)		
LP-1	41		equipment	800

		RECEPTACLE -- MECH-JAN		
LP-1	42	XL-1 -- Exterior and path lighting	receptacle	360
LP-1	43	IR-1/2 -- Gas IR Tube Heater (120/1, MCA 5 A)	equipment	500
LP-1	44	EF-5 -- EF (120/1, MCA 2 A)	mechanical	480
LP-1	45	RECEPTACLE -- TR2	mechanical	192
LP-1	46	LIGHTING -- STAGING	receptacle	180
LP-1	47	RECEPTACLE -- TR1	lighting	255
LP-1	48	CF-1 -- Ceiling fans (hall) (1 of 4)	receptacle	180
LP-1	49	CF-1 -- Ceiling fans (hall) (3 of 4)	equipment	150
LP-1	50	RECEPTACLE -- TR3	equipment	150
LP-1	51	CF-1 -- Ceiling fans (hall) (2 of 4)	receptacle	180
LP-1	52	EF-1 -- EF (120/1, MCA 1 A)	equipment	150
LP-1	53	EF-2 -- EF (120/1, MCA 1 A)	mechanical	96
LP-1	54		mechanical	96

		CF-1 -- Ceiling fans (hall) (4 of 4)		
LP-1	55	EF-3 -- EF (120/1, MCA 1 A)	equipment	150
LP-1	56	EF-4 -- EF (120/1, MCA 1 A)	mechanical	96
LP-1	57	LIGHTING -- TR3	mechanical	96
LP-1	58	LIGHTING -- TR1	lighting	40
LP-1	59	LIGHTING -- TR2	lighting	40
LP-1	60	LIGHTING -- MECH-JAN	lighting	40
LP-1	63		lighting	27
PHASE TOTALS (connected VA)			A=37770; B=3778	75558

placement is deterministic: circuits are sorted by VA descending and each is placed on the currently-
the NEC 240.6(A) ladder; per-circuit VA caps come from electrical_rules.yaml branch_circuits:.
a 2-pole breaker shows both positions (1,3). PV backfeed breakers sit at the end of the bus

Demand VA	Phase	Poles	Breaker (A)	Rule / Table Cited
73248 1 ph			400 Bus 400 A	(electrical_rules.yaml panel_sizes)

single NEC 430.24 largest-motor adder), NOT by summing the downstream feeder demands (73248
t feeder, so the sum double-counts by 0 VA. Service 400 A OCPD, 400 A bus at 240/120. Cross-

73248 A		2	Feeder OCPD from the LP-1 row in the FEEDERS 350 section
0 AB		2	NEC 705.12(B)(3)(2); 5.0 kW AC generation, not a 30 load
73248			MDP feeders are 3-pole -- balanced by construction.

73248 1 ph			350 Bus 400 A	(electrical_rules.yaml panel_sizes)
-------------------	--	--	----------------------	--

equipment 58740); demand 73248 VA [lighting x1.250 per NEC 220.42+continuous, receptacle x1.000
-1)]; 305.2 A at 240 V 1ph -> 350 A main (NEC 240.6(A)), 400 A bus, 84 circuit positions (used 61
electrical_rules.yaml vd_limits.feeder_pct).

5760 AB		2	25	electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
3920 AB		2	25	electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
3920 AB		2	25	electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
4500 AB		2	25	electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
2520 AB		2	15	electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
3456 AB		2	20	NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 18 A (nameplate MOCP governs when available)

			NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 15 A (nameplate MOCP governs when available)
2760 AB	2	15	
			NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 12 A (nameplate MOCP governs when available)
2304 AB	2	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1400 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1920 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1400 B	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1920 B	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1920 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1800 A	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1920 B	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1800 B	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1800 A	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1800 A	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1800 B	1	15	

			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
1800 B	1	20	
			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
1800 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1500 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1500 B	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1500 B	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1200 A	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1200 A	1	15	
			electrical_rules.yaml branch_circuits.lighting (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.20(A) / 210.23
1575 B	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1200 B	1	15	
			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
1080 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
800 A	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1200 B	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
1000 B	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
800 A	1	15	

			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
360 A	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
500 B	1	15	
			NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 5 A (nameplate MOCP governs when available)
480 B	1	15	
			NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 2 A (nameplate MOCP governs when available)
192 A	1	15	
			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
180 A	1	20	
			electrical_rules.yaml branch_circuits.lighting (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC
319 B	1	20	210.20(A) / 210.23
			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
180 B	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
150 A	1	15	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
150 A	1	15	
			electrical_rules.yaml branch_circuits.receptacle (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC 210.23(A) / 220.14(I)
180 B	1	20	
			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
150 B	1	15	
			NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 1 A (nameplate MOCP governs when available)
96 A	1	15	
			NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 1 A (nameplate MOCP governs when available)
96 A	1	15	

			electrical_rules.yaml branch_circuits.equipment -- NEC 210.19(A)(1) / 210.20(A) / 422.10 / 422.13 -- individual branch circuit per appliance
150 B	1	15	NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 1 A (nameplate MOCP governs when available)
96 B	1	15	NEC 440.32 / 430.22 -- individual branch circuit per unit, MCA governs; OCPD = smallest NEC 240.6(A) breaker_ladder entry >= MCA 1 A (nameplate MOCP governs when available)
96 A	1	15	electrical_rules.yaml branch_circuits.lighting (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC
50 A	1	20	210.20(A) / 210.23 electrical_rules.yaml branch_circuits.lighting (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC
50 B	1	20	210.20(A) / 210.23 electrical_rules.yaml branch_circuits.lighting (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC
50 B	1	20	210.20(A) / 210.23 electrical_rules.yaml branch_circuits.lighting (20 A x 120 V x 0.80 = 1920 VA max/ckt) -- NEC
34 B	1	20	210.20(A) / 210.23 Phase imbalance 0.0% (max phase vs. mean) -- within the 20% in-house flag threshold (electrical_rules.yaml phase_imbalance_flag_pct)
73248			

LIGHTING FIXTURE SCHEDULE -- preliminary, from design-tools\lighting_design.py
Quantities come from the lumen-method calc on the Electrical tab (LIGHTING DESIGN section). Basis of design is

Type	Description	Mounting	Source	Lumens
A	LED round pendant, direct, hall general lighting	Pendant 12 ft AFF	LED 3000K 90 CRI	3500
B	LED 4 ft vapor-tight linear, NSF splash zone, food prep	Surface ceiling 9 ft	LED 4000K 80 CRI	4000
C	LED 6 in downlight, damp location	Recessed ceiling 9 ft	LED 3000K 90 CRI	1000
D	LED 4 ft strip, wire guard	Surface ceiling 9 ft	LED 4000K 80 CRI	3000
EM	Emergency unit, 2 LED heads, 90 min battery, self-test	Wall 8 ft AFF	LED	500
EX	LED exit sign, red letters, battery, self-test	Wall or ceiling over exit door	LED	0
X1	Exterior LED wall sconce, full cutoff, dark-sky	Wall 8 ft by each door	LED 3000K 80 CRI	2000
X2	LED path bollard, 3.5 ft, full cutoff	Grade, path to the flower shop	LED 3000K 80 CRI	700

generic: lumens and watts are planning values to be replaced with the submitted fixture's data and I

Input W	Volts	Dimming / Driver	Qty	Total W	Locations
28	120-277	0-10 V to 1%	15	420	HALL
29	120-277	0-10 V	6	174	STAGING
10	120	0-10 V	5	50	TR1, TR2, TR3, CORR
22	120-277		1	22	MECH-JAN
3	120		7	21	HALL, CORR, STAGING
2	120		6	12	HALL, CORR, STAGING
18	120		5	90	Hall doors S/N/W, wing service door, bottle filler
10	120		8	80	Path to the flower shop

ES file. Emergency and exit fixtures are exempt from the IECC lighting power tot

Controls	Basis of Design
daylight-responsive dimming in the sidelit zone (C405.2.4); manual dimming (0-10 V); occupant sensor, auto-off 20 min, manual-on or auto-on to 50%	Generic 3,500 lm architectural pendant
manual dimming (0-10 V); occupant sensor, auto-off 20 min, manual-on or auto-on to 50%	Generic IP65 vapor-tight 4 ft
manual dimming (0-10 V); occupant sensor, auto-off 20 min, manual-on or auto-on to 50%	Generic 6 in wafer/can downlight
occupant sensor, auto-off 20 min, manual-on or auto-on to 50%	Generic 4 ft strip
unswitched, battery 90 min, self-test	Generic LED emergency unit
unswitched, battery 90 min, self-test	Generic LED exit sign
photocell + time switch, 50% after-hours reduction	Generic full-cutoff wall sconce
photocell + time switch, 50% after-hours reduction	Generic bollard

al.

Notes

ASSUMPTIONS & BASIS

Reference data source: C:\Users\mikes\OneDrive\Documents\Claude\design-tools\

Estimate basis date: 2026-08-10

AACE Class: Class 3 -- accuracy range -20% / +30%

Location factor: 0.92 (MT, from register Project Info State)

General condition: 8%

Overhead & profit: 15%

Contingency: 15% (Class 3)

Escalation: 4.0%/yr (0 yr applied -- no future bid date given)

Equipment access: 12% of parent equipment cost

Piping fittings/hour: 25% (folded into every \$/ft figure)

Ductwork gauge/cost_rules.yaml: ductwork.gauge_bands / gauge_weight_lb

Piping route length: recomputed from building.yaml layout coordinates (see model)

Building area: 2250 ft2 (sum of building.yaml zones[].area_ft2)

Benchmark build: assembly_heat_only (matched 'orangery'/'event'/'assembly')

Division 26 electrical: INCLUDED -- 04-Calcs\electrical_sizes.yaml present

Group	Item	Qty	Unit
HVAC EQUIPMENT			
HVAC Equipment	EF-1 -- Exhaust fan	1	ea
	EF-1 -- Accessories (EF kit, 3 items)		
HVAC Equipment		0.12	pct
HVAC Equipment	EF-2 -- Exhaust fan	1	ea
	EF-2 -- Accessories (EF kit, 3 items)		
HVAC Equipment		0.12	pct
HVAC Equipment	EF-3 -- Exhaust fan	1	ea
	EF-3 -- Accessories (EF kit, 3 items)		
HVAC Equipment		0.12	pct
HVAC Equipment	EF-4 -- Exhaust fan	1	ea
	EF-4 -- Accessories (EF kit, 3 items)		
HVAC Equipment		0.12	pct
HVAC Equipment	EF-5 -- Exhaust fan	1	ea
	EF-5 -- Accessories (EF kit, 3 items)		
HVAC Equipment		0.12	pct
	IR-1/2 -- Gas IR tube heater group (2 units)		
HVAC Equipment		2	ea

HVAC Equipment	IR-1/2 -- Accessories (Gas IR Tube Heater kit, 4 items)	0.12 pct
HVAC Equipment	EWB -- Electric wall heater group (4 units)	4 ea
HVAC Equipment	EWB -- Accessories (Electric Wall Heater kit, 2 items)	0.12 pct
HVAC Equipment	EUH-1 -- Electric unit heater	1 ea
HVAC Equipment	EUH-1 -- Accessories (Electric Unit Heater kit, 3 items)	0.12 pct
HVAC Equipment	EC-1 -- Fixed evaporative cooler	1 ea
HVAC Equipment	EC-1 -- Accessories (Evaporative Cooler kit, 3 items)	0.12 pct
HVAC EQUIPMENT SUBTOTAL		

DUCTWORK

Ductwork	SD-1a (36 in round, spiral, collar to 40 ft)	265 lb
Ductwork	SD-1b (30 in round, spiral, with reducer)	181.6 lb
Ductwork	SD-1c (24 in round, spiral, reducer and end cap)	116.2 lb
Ductwork	SR-1..12 -- Side registers 24 x 10 in, double deflection, OBD	12 ea
DUCTWORK SUBTOTAL		

PLUMBING

Plumbing	DW-MAIN (domestic water service/main)	57.8 ft
Plumbing	DW-TR1 branch	22.5 ft
Plumbing	DW-TR2 branch	22.5 ft

	DW-TR3 branch	
Plumbing		22.5 ft
	DW-STAGING branch	
Plumbing		22.5 ft
	DW-MECH branch	
Plumbing		22.5 ft
	DW-HW (hot water branch to WH)	
Plumbing		7.1 ft
	SS-MAIN (building drain)	
Plumbing		56.4 ft
Plumbing	SS-VENT (building vent stack)	24 ft
	SS-TR1 branch	
Plumbing		22.5 ft
	SS-TR2 branch	
Plumbing		22.5 ft
	SS-TR3 branch	
Plumbing		22.5 ft
	SS-STAGING branch	
Plumbing		22.5 ft
	SS-MECH branch	
Plumbing		22.5 ft
	GAS-MAIN (elevated pressure)	
Plumbing		80 ft
	Fixture -- WC (installed, incl. rough-in)	
Plumbing		3 ea
	Fixture -- LAV (installed, incl. rough-in)	
Plumbing		3 ea
	Fixture -- DF (installed, incl. rough-in)	
Plumbing		1 ea

Plumbing	Fixture -- HS (installed, incl. rough-in)	3 ea
	Fixture -- SINK3 (installed, incl. rough-in)	
Plumbing	Fixture -- FS (installed, incl. rough-in)	1 ea
Plumbing	Fixture -- IM (installed, incl. rough-in)	2 ea
Plumbing	Fixture -- SVC_SINK (installed, incl. rough-in)	1 ea
Plumbing	Fixture -- HB (installed, incl. rough-in)	1 ea
Plumbing		2 ea
	PLUMBING SUBTOTAL	

ELECTRICAL

	SERVICE ENTRANCE -- 240/120, 400 A	
Electrical	MDP -- MDP, 240/120, 400 A bus / 400 A main	1 ea
Electrical	LP-1 -- Panelboard, 240/120, 400 A bus / 350 A main	1 ea
Electrical	SERVICE UTILITY->MDP ((3) 600 Cu + 3 EGC)	1 ea
Electrical	FEEDER MDP->LP-1 ((3) 500 Cu + 3 EGC)	15 ft
Electrical	LIGHTING -- HALL luminaires (LED interior)	10 ft
Electrical	BRANCH WIRING -- HALL lighting circuits	1800 ft2
Electrical		1800 ft2

	BRANCH WIRING -- HALL receptacle circuits	
Electrical		1800 ft2
	WIRING DEVICES -- HALL receptacles	
Electrical		20 ea
	WIRING DEVICES -- HALL switches/sensors	
Electrical		4 ea
	LIGHTING -- TR1 luminaires (LED interior)	
Electrical		50 ft2
	BRANCH WIRING -- TR1 lighting circuits	
Electrical		50 ft2
	BRANCH WIRING -- TR1 receptacle circuits	
Electrical		50 ft2
	WIRING DEVICES -- TR1 receptacles	
Electrical		1 ea
	WIRING DEVICES -- TR1 switches/sensors	
Electrical		1 ea
	LIGHTING -- TR2 luminaires (LED interior)	
Electrical		50 ft2
	BRANCH WIRING -- TR2 lighting circuits	
Electrical		50 ft2
	BRANCH WIRING -- TR2 receptacle circuits	
Electrical		50 ft2
	WIRING DEVICES -- TR2 receptacles	
Electrical		1 ea
	WIRING DEVICES -- TR2 switches/sensors	
Electrical		1 ea

	LIGHTING -- TR3 luminaires (LED interior)	
Electrical		50 ft2
	BRANCH WIRING -- TR3 lighting circuits	
Electrical		50 ft2
	BRANCH WIRING -- TR3 receptacle circuits	
Electrical		50 ft2
	WIRING DEVICES -- TR3 receptacles	
Electrical		1 ea
	WIRING DEVICES -- TR3 switches/sensors	
Electrical		1 ea
	LIGHTING -- MECH-JAN luminaires (LED interior)	
Electrical		45 ft2
	BRANCH WIRING -- MECH-JAN lighting circuits	
Electrical		45 ft2
	BRANCH WIRING -- MECH-JAN receptacle circuits	
Electrical		45 ft2
	WIRING DEVICES -- MECH-JAN receptacles	
Electrical		1 ea
	WIRING DEVICES -- MECH-JAN switches/sensors	
Electrical		1 ea
	LIGHTING -- STAGING luminaires (LED interior)	
Electrical		255 ft2
	BRANCH WIRING -- STAGING lighting circuits	
Electrical		255 ft2
	BRANCH WIRING -- STAGING receptacle circuits	
Electrical		255 ft2

WIRING DEVICES -- STAGING
receptacles

Electrical 3 ea

WIRING DEVICES -- STAGING
switches/sensors

Electrical 1 ea

ELECTRICAL SUBTOTAL

FACTOR STACK

Direct cost buildup (sum of all group subtotals)

x Location Factor (MT) 0.92 -> factors.location_factors

x (1 + General Conditions 8%) -> factors.general_conditions_pct

x (1 + Overhead & Profit 15%) -> factors.overhead_profit_pct

x (1 + Contingency 15%, AACE Class 3) -> factors.contingency_by_class.3

x (1 + Escalation 0.0% = 0 yr x 4.0%/yr) -> factors.escalation_pct_per_yr

TOTAL (Class 3) 156787.55 Accuracy range -20%/-

CLASS-5 BENCHMARK CHECK

Buildup: \$156,788 / 2250 ft2 = \$69.68/ft2 -- ABOVE band --
benchmarks.mech_not by itself a defect)

TRACE NOTES -- hand-verification walkthrough

EQUIPMENT EXAMPLE -- EF-1 -- Exhaust fan: qty 1.00 ea (Equipment Schedule (location factor 0.92 = \$109,772.14; x (1+GC 8%) = \$118,553.91; x (1+O&P 15%) : \$203,824.

REFERENCE UNIT COSTS FOR PRELIMINARY ESTIMATING -- NOT BID DATA -- CALIBRATE FROM ACTUAL R unit cost/factor; cost_estimate.py reads it fresh on every run.
cost_rules.yaml factors.estimate_date -- unit costs are as of this date; escalate via factors.escalation_pct --aace-class CLI flag (default 3). Class 5 = concept screening (-30%/+50%); Class 3 = budget authorization
cost_rules.yaml factors.location_factors -- RSMeans-style cost index keyed by register State.
cost_rules.yaml factors.general_conditions_pct.
cost_rules.yaml factors.overhead_profit_pct.
cost_rules.yaml factors.contingency_by_class.
cost_rules.yaml factors.escalation_pct_per_yr.
cost_rules.yaml equipment.accessory_pct_of_equipment -- prices bom_kits.yaml kit items (curb, discont itemizing each.
cost_rules.yaml piping.fittings_hangers_valves_pct_included.
Sheet weight computed from actual sized dimensions, not a frozen \$/ft figure.
pipe_sizing.py's sidecar does not persist length for every system -- same coordinate source re-walked he explicit coordinate use piping.typical_branch_length_ft, flagged ESTIMATED.
Used for the \$/ft2 benchmark row below.
cost_rules.yaml benchmarks.mech_cost_per_ft2 -- override by editing infer_building_type() or passing --
Electrical group quantities come from electrical_sizing.py's sidecar (service OCPD, panels[], transformers, lighting/branch/device areas) priced against cost_rules.yaml electrical:. Those unit costs are the WEAKES been checked against them (see cost_rules.yaml calibration: seed-data marker). Equipment disconnects mechanical accessory adder (bom_kits.yaml). The benchmark \$/ft2 band below is a MECHANICAL band a buildup to read high against it.

Qty Source	Unit Cost	Rule/Key Cited
Equipment Schedule (1 unit) bom_kits.yaml kits.EF (3 items, not itemized)	950	cost_rules.yaml equipment.ef_each cost_rules.yaml equipment.accessory_pct_of_equipment = 12% of EF-1 installed cost
Equipment Schedule (1 unit) bom_kits.yaml kits.EF (3 items, not itemized)	950	cost_rules.yaml equipment.ef_each cost_rules.yaml equipment.accessory_pct_of_equipment = 12% of EF-2 installed cost
Equipment Schedule (1 unit) bom_kits.yaml kits.EF (3 items, not itemized)	950	cost_rules.yaml equipment.ef_each cost_rules.yaml equipment.accessory_pct_of_equipment = 12% of EF-3 installed cost
Equipment Schedule (1 unit) bom_kits.yaml kits.EF (3 items, not itemized)	950	cost_rules.yaml equipment.ef_each cost_rules.yaml equipment.accessory_pct_of_equipment = 12% of EF-4 installed cost
Equipment Schedule (1 unit) bom_kits.yaml kits.EF (3 items, not itemized)	950	cost_rules.yaml equipment.ef_each cost_rules.yaml equipment.accessory_pct_of_equipment = 12% of EF-5 installed cost
Equipment Schedule IR-1/2 Capacity '2 x 57.9 MBH' ('N x' count prefix, 1 if absent)	4500	cost_rules.yaml equipment.ir_tube_heater_each (flat per unit)

bom_kits.yaml kits.Gas IR Tube Heater (4 items, not itemized)

Equipment Schedule EWH Capacity '4 x 1.9 MBH' ('N x' count prefix, 1 if absent)

bom_kits.yaml kits.Electric Wall Heater (2 items, not itemized)

Equipment Schedule EUH-1 Capacity '11.7 MBH' ('N x' count prefix, 1 if absent)

bom_kits.yaml kits.Electric Unit Heater (3 items, not itemized)

Equipment Schedule EC-1 Capacity '12,000 CFM, 2 HP' ('N x' count prefix, 1 if absent)

bom_kits.yaml kits.Evaporative Cooler (3 items, not itemized)

cost_rules.yaml

equipment.accessory_pct_of_equipment = 12% of IR-1/2 installed cost

cost_rules.yaml

equipment.electric_wall_heater_each (flat per 700 unit)

cost_rules.yaml

equipment.accessory_pct_of_equipment = 12% of EWH installed cost

cost_rules.yaml

equipment.electric_unit_heater_each (flat per 1500 unit)

cost_rules.yaml

equipment.accessory_pct_of_equipment = 12% of EUH-1 installed cost

cost_rules.yaml

equipment.evap_cooler_fixed_each (flat per 9000 unit)

cost_rules.yaml

equipment.accessory_pct_of_equipment = 12% of EC-1 installed cost

building.yaml layout.hand_ducts SD-1a:
pi x 36 in x 20.0 ft -> 22 ga (max_in 54) -> 1.406 lb/ft2

cost_rules.yaml

ductwork.dollar_per_lb_installed + gauge_bands + gauge_weight_lb_per_ft2[22]

6.5

building.yaml layout.hand_ducts SD-1b:
pi x 30 in x 20.0 ft -> 24 ga (max_in 30) -> 1.156 lb/ft2

cost_rules.yaml

ductwork.dollar_per_lb_installed + gauge_bands + gauge_weight_lb_per_ft2[24]

6.5

building.yaml layout.hand_ducts SD-1c:
pi x 24 in x 16.0 ft -> 24 ga (max_in 30) -> 1.156 lb/ft2

cost_rules.yaml

ductwork.dollar_per_lb_installed + gauge_bands + gauge_weight_lb_per_ft2[24]

6.5

building.yaml
layout.hand_ducts.registers.count

cost_rules.yaml ductwork.register_each

220

building.yaml layout.domestic_water
entry+riser+main_run coordinates x Pipe
Fitting Allowance Factor 1.50x

cost_rules.yaml piping.copper_l[1.0"] (incl. 25% fittings/hangers/valves allowance)

29

cost_rules.yaml
piping.typical_branch_length_ft (no
explicit routed coordinate for this
branch) x fitting allowance

cost_rules.yaml piping.copper_l[0.5"] (incl. 25% fittings/hangers/valves allowance)

18

cost_rules.yaml
piping.typical_branch_length_ft (no
explicit routed coordinate for this
branch) x fitting allowance

cost_rules.yaml piping.copper_l[0.5"] (incl. 25% fittings/hangers/valves allowance)

18

cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	18	cost_rules.yaml piping.copper_l[0.5"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	23	cost_rules.yaml piping.copper_l[0.75"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	23	cost_rules.yaml piping.copper_l[0.75"] (incl. 25% fittings/hangers/valves allowance)
building.yaml layout.domestic_water_main_x/wh_connector_x0/wh1_drop_coordinates x fitting allowance	29	cost_rules.yaml piping.copper_l[1.0"] (incl. 25% fittings/hangers/valves allowance)
building.yaml layout.sanitary_rm1->rm2->bend->mid->low->exit + step drops x fitting allowance	50	cost_rules.yaml piping.pvc_dwv[4.0"] (incl. 25% fittings/hangers/valves allowance)
building.yaml layout.sanitary_vent_top_z - main_z x fitting allowance	38	cost_rules.yaml piping.pvc_dwv[3.0"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	38	cost_rules.yaml piping.pvc_dwv[3.0"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	38	cost_rules.yaml piping.pvc_dwv[3.0"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	38	cost_rules.yaml piping.pvc_dwv[3.0"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	38	cost_rules.yaml piping.pvc_dwv[3.0"] (incl. 25% fittings/hangers/valves allowance)
cost_rules.yaml piping.typical_branch_length_ft (no explicit routed coordinate for this branch) x fitting allowance	21	cost_rules.yaml piping.pvc_dwv[1.5"] (incl. 25% fittings/hangers/valves allowance)
building.yaml layout.gas.longest_run_ft (directly-stated design length, not coordinate-walked -- no fitting allowance per pipe_sizing.py convention)	17	cost_rules.yaml piping.steel_sch40[0.5"] (incl. 25% fittings/hangers/valves allowance)
building.yaml layout.shell.restrooms[]/mech_room fixtures.wc (summed across all groups)	1250	cost_rules.yaml fixtures.wc_each
building.yaml layout.shell.restrooms[]/mech_room fixtures.lav (summed across all groups)	950	cost_rules.yaml fixtures.lav_each
building.yaml layout.shell.restrooms[]/mech_room fixtures.df (summed across all groups)	1600	cost_rules.yaml fixtures.df_each

building.yaml
 layout.shell.restrooms[]/mech_room
 fixtures.hs (summed across all groups)
 building.yaml
 layout.shell.restrooms[]/mech_room
 fixtures.sink3 (summed across all groups)

cost_rules.yaml fixtures.hs_each
 900
 cost_rules.yaml fixtures.sink3_each

3800

building.yaml
 layout.shell.restrooms[]/mech_room
 fixtures.fs (summed across all groups)
 building.yaml
 layout.shell.restrooms[]/mech_room
 fixtures.im (summed across all groups)
 building.yaml
 layout.shell.restrooms[]/mech_room
 fixtures.svc_sink (summed across all groups)
 building.yaml
 layout.shell.restrooms[]/mech_room
 fixtures.hb (summed across all groups)

cost_rules.yaml fixtures.fs_each
 650
 cost_rules.yaml fixtures.im_each
 450
 cost_rules.yaml fixtures.svc_sink_each
 1150
 cost_rules.yaml fixtures.hb_each
 380

electrical_sizes.yaml service.ocpd_amps
 = 400 A (NEC 240.6 breaker ladder off
 demand_amps 305.2 A, NEC 220
 calculated load 73.2 kVA)

cost_rules.yaml
 electrical.service_entrance_by_amps (band
 <=400 A -> \$12500 ea)
 12500

electrical_sizes.yaml panels[MDP]:
 bus_rating_amps 400 A, 12 circuit
 positions, 4 poles used, demand 305.2 A

cost_rules.yaml
 electrical.panelboard_each_by_bus_amps
 (band <=400 A bus -> \$8200 ea)

8200

electrical_sizes.yaml panels[LP-1]:
 bus_rating_amps 400 A, 84 circuit
 positions, 61 poles used, demand 305.2 A

cost_rules.yaml
 electrical.panelboard_each_by_bus_amps
 (band <=400 A bus -> \$8200 ea)

8200

electrical_sizes.yaml topology[UTILITY-
 >MDP]: 15 ft route x 1 parallel set(s) [size
 '600' not tabulated -- priced at 500]

cost_rules.yaml
 electrical.feeder_per_ft["500"] (raceway +
 phase/neutral/EGC conductors + terminations,
 145 per ft of route)

electrical_sizes.yaml topology[MDP-
 >LP-1]: 10 ft route x 1 parallel set(s)

cost_rules.yaml
 electrical.feeder_per_ft["500"] (raceway +
 phase/neutral/EGC conductors + terminations,
 145 per ft of route)

electrical_sizes.yaml
 loads.lighting.by_zone.HALL: 1800 ft2 @
 0.70 W/ft2 LPD (from building.yaml
 zones[].area_ft2 / lpd_w_ft2) = 1260 VA
 connected

cost_rules.yaml
 electrical.lighting_fixtures_per_ft2_by_lpd
 (band <=0.7 W/ft2 -> \$2.40/ft2)

2.4

electrical_sizes.yaml
 loads.lighting.by_zone.HALL.area_ft2 =
 1800 ft2 (building.yaml zones[].area_ft2)

cost_rules.yaml
 electrical.branch_wiring_per_ft2.lighting

1.85

electrical_sizes.yaml
loads.lighting.by_zone.HALL.area_ft2 =
1800 ft2 (building.yaml zones[].area_ft2)

1800 ft2 / 1000 x 11.0 per 1000 ft2 (NEC
220.42 occupancy bucket 'all_others'
from electrical_sizes.yaml
loads.lighting.by_occupancy_bucket) =
20 devices, rounded
1800 ft2 / 1000 x 2.5 per 1000 ft2
(occupancy bucket 'all_others') = 4
devices, rounded

electrical_sizes.yaml
loads.lighting.by_zone.TR1: 50 ft2 @ 0.80
W/ft2 LPD (from building.yaml
zones[].area_ft2 / lpd_w_ft2) = 40 VA
connected

electrical_sizes.yaml
loads.lighting.by_zone.TR1.area_ft2 = 50
ft2 (building.yaml zones[].area_ft2)

electrical_sizes.yaml
loads.lighting.by_zone.TR1.area_ft2 = 50
ft2 (building.yaml zones[].area_ft2)
50 ft2 / 1000 x 11.0 per 1000 ft2 (NEC
220.42 occupancy bucket 'all_others'
from electrical_sizes.yaml
loads.lighting.by_occupancy_bucket) = 1
devices, rounded
50 ft2 / 1000 x 2.5 per 1000 ft2
(occupancy bucket 'all_others') = 1
devices, rounded

electrical_sizes.yaml
loads.lighting.by_zone.TR2: 50 ft2 @ 0.80
W/ft2 LPD (from building.yaml
zones[].area_ft2 / lpd_w_ft2) = 40 VA
connected

electrical_sizes.yaml
loads.lighting.by_zone.TR2.area_ft2 = 50
ft2 (building.yaml zones[].area_ft2)

electrical_sizes.yaml
loads.lighting.by_zone.TR2.area_ft2 = 50
ft2 (building.yaml zones[].area_ft2)
50 ft2 / 1000 x 11.0 per 1000 ft2 (NEC
220.42 occupancy bucket 'all_others'
from electrical_sizes.yaml
loads.lighting.by_occupancy_bucket) = 1
devices, rounded
50 ft2 / 1000 x 2.5 per 1000 ft2
(occupancy bucket 'all_others') = 1
devices, rounded

cost_rules.yaml
electrical.branch_wiring_per_ft2.receptacle

1.35

cost_rules.yaml
electrical.devices.receptacle_each x
electrical.devices.receptacles_per_1000_ft2.al
l_others

165

cost_rules.yaml electrical.devices.switch_each
x
electrical.devices.switches_per_1000_ft2.all_o
thers

145

cost_rules.yaml
electrical.lighting_fixtures_per_ft2_by_lpd
(band <=1.0 W/ft2 -> \$3.30/ft2)

3.3

cost_rules.yaml
electrical.branch_wiring_per_ft2.lighting

1.85

cost_rules.yaml
electrical.branch_wiring_per_ft2.receptacle

1.35

cost_rules.yaml
electrical.devices.receptacle_each x
electrical.devices.receptacles_per_1000_ft2.al
l_others

165

cost_rules.yaml electrical.devices.switch_each
x
electrical.devices.switches_per_1000_ft2.all_o
thers

145

cost_rules.yaml
electrical.lighting_fixtures_per_ft2_by_lpd
(band <=1.0 W/ft2 -> \$3.30/ft2)

3.3

cost_rules.yaml
electrical.branch_wiring_per_ft2.lighting

1.85

cost_rules.yaml
electrical.branch_wiring_per_ft2.receptacle

1.35

cost_rules.yaml
electrical.devices.receptacle_each x
electrical.devices.receptacles_per_1000_ft2.al
l_others

165

cost_rules.yaml electrical.devices.switch_each
x
electrical.devices.switches_per_1000_ft2.all_o
thers

145

electrical_sizes.yaml
loads.lighting.by_zone.TR3: 50 ft2 @ 0.80
W/ft2 LPD (from building.yaml
zones[].area_ft2 / lpd_w_ft2) = 40 VA
connected

electrical_sizes.yaml
loads.lighting.by_zone.TR3.area_ft2 = 50
ft2 (building.yaml zones[].area_ft2)

electrical_sizes.yaml
loads.lighting.by_zone.TR3.area_ft2 = 50
ft2 (building.yaml zones[].area_ft2)
50 ft2 / 1000 x 11.0 per 1000 ft2 (NEC
220.42 occupancy bucket 'all_others'
from electrical_sizes.yaml
loads.lighting.by_occupancy_bucket) = 1
devices, rounded
50 ft2 / 1000 x 2.5 per 1000 ft2
(occupancy bucket 'all_others') = 1
devices, rounded

electrical_sizes.yaml
loads.lighting.by_zone.MECH-JAN: 45 ft2
@ 0.60 W/ft2 LPD (from building.yaml
zones[].area_ft2 / lpd_w_ft2) = 27 VA
connected

electrical_sizes.yaml
loads.lighting.by_zone.MECH-
JAN.area_ft2 = 45 ft2 (building.yaml
zones[].area_ft2)

electrical_sizes.yaml
loads.lighting.by_zone.MECH-
JAN.area_ft2 = 45 ft2 (building.yaml
zones[].area_ft2)
45 ft2 / 1000 x 11.0 per 1000 ft2 (NEC
220.42 occupancy bucket 'all_others'
from electrical_sizes.yaml
loads.lighting.by_occupancy_bucket) = 1
devices, rounded
45 ft2 / 1000 x 2.5 per 1000 ft2
(occupancy bucket 'all_others') = 1
devices, rounded

electrical_sizes.yaml
loads.lighting.by_zone.STAGING: 255 ft2
@ 1.00 W/ft2 LPD (from building.yaml
zones[].area_ft2 / lpd_w_ft2) = 255 VA
connected

electrical_sizes.yaml
loads.lighting.by_zone.STAGING.area_ft2
= 255 ft2 (building.yaml zones[].area_ft2)

electrical_sizes.yaml
loads.lighting.by_zone.STAGING.area_ft2
= 255 ft2 (building.yaml zones[].area_ft2)

cost_rules.yaml
electrical.lighting_fixtures_per_ft2_by_lpd
(band <=1.0 W/ft2 -> \$3.30/ft2)

3.3

cost_rules.yaml
electrical.branch_wiring_per_ft2.lighting

1.85

cost_rules.yaml
electrical.branch_wiring_per_ft2.receptacle

1.35

cost_rules.yaml
electrical.devices.receptacle_each x
electrical.devices.receptacles_per_1000_ft2.al
l_others

165

cost_rules.yaml electrical.devices.switch_each
x

electrical.devices.switches_per_1000_ft2.all_o
thers

145

cost_rules.yaml
electrical.lighting_fixtures_per_ft2_by_lpd
(band <=0.7 W/ft2 -> \$2.40/ft2)

2.4

cost_rules.yaml
electrical.branch_wiring_per_ft2.lighting

1.85

cost_rules.yaml
electrical.branch_wiring_per_ft2.receptacle

1.35

cost_rules.yaml
electrical.devices.receptacle_each x
electrical.devices.receptacles_per_1000_ft2.al
l_others

165

cost_rules.yaml electrical.devices.switch_each
x

electrical.devices.switches_per_1000_ft2.all_o
thers

145

cost_rules.yaml
electrical.lighting_fixtures_per_ft2_by_lpd
(band <=1.0 W/ft2 -> \$3.30/ft2)

3.3

cost_rules.yaml
electrical.branch_wiring_per_ft2.lighting

1.85

cost_rules.yaml
electrical.branch_wiring_per_ft2.receptacle

1.35

255 ft2 / 1000 x 11.0 per 1000 ft2 (NEC
 220.42 occupancy bucket 'all_others'
 from electrical_sizes.yaml
 loads.lighting.by_occupancy_bucket) = 3
 devices, rounded
 255 ft2 / 1000 x 2.5 per 1000 ft2
 (occupancy bucket 'all_others') = 1
 devices, rounded

cost_rules.yaml
 electrical.devices.receptacle_each x
 electrical.devices.receptacles_per_1000_ft2.all_others
 165
 cost_rules.yaml electrical.devices.switch_each
 x
 electrical.devices.switches_per_1000_ft2.all_others
 145

+30%: \$125,430 to \$203,824

investigate (NOTE: the band is MECHANICAL \$/ft2 only; this buildup also carries the Division 26 Electrical

1 unit)) x unit cost \$950.00/ea (cost_rules.yaml equipment.ef_each) = \$950.00. FACTOR STACK -- direct b
 = \$136,337.00; x (1+contingency 15%, Class 3) = \$156,787.55; x (1+escalation 0.0%) = TOTAL \$156,787.55

(-20%/+30%).

rect, valve package, etc.) as one adder instead of

re, not re-derived independently. Rows with no

·building-type.

, topology[] feeder routes, per-zone

IT seed data in the file -- no Div 26 quote has ever

are NOT in this group: they are already inside the

and does not cover the electrical scope -- expect the

Extension (\$)	Notes
950	
114 950	
114 950	
114 950	
114 950	
114 950	
114	
9000	

1080

2800

336

1500

180

9000

1080

30296

Not insulated

1722.66

Not insulated

1180.3

Not insulated

755.39

2640

6298.35

1674.75

ESTIMATED length -- no explicit
layout coordinate for this branch

405

ESTIMATED length -- no explicit
layout coordinate for this branch

405

ESTIMATED length -- no explicit
layout coordinate for this branch

405

ESTIMATED length -- no explicit
layout coordinate for this branch

517.5

ESTIMATED length -- no explicit
layout coordinate for this branch

517.5

204.45

2820

912

ESTIMATED length -- no explicit
layout coordinate for this branch

855

ESTIMATED length -- no explicit
layout coordinate for this branch

855

ESTIMATED length -- no explicit
layout coordinate for this branch

855

ESTIMATED length -- no explicit
layout coordinate for this branch

855

ESTIMATED length -- no explicit
layout coordinate for this branch

472.5

1360

3750

2850

1600

2700

3800

1300

450

1150

760

31473.7

Meter/CT, service disconnect,
grounding electrode system (GEC
#1/0 Cu), utility coordination.

Service conductors and the MDP
12500 enclosure are separate rows.

Enclosure, copper bus, main device,
branch breakers, ground bus, typed
directory (branch breakers not
itemized -- folded into the each
8200 cost).

Enclosure, copper bus, main device,
branch breakers, ground bus, typed
directory (branch breakers not
itemized -- folded into the each
8200 cost).

400 A OCPD, VD 0.16%

2175

350 A OCPD, VD 0.12%

1450

LPD used as the luminaire-density
proxy -- no photometric layout stage
exists.

4320

Homerun + branch raceway,
conductors, boxes; luminaires priced
separately.

3330

Homerun + branch raceway,
conductors, boxes; devices priced
separately.

2430

ESTIMATED count -- no device
layout exists in the pipeline.

3300

ESTIMATED count -- no device
layout exists in the pipeline.

580

LPD used as the luminaire-density
proxy -- no photometric layout stage
exists.

165

Homerun + branch raceway,
conductors, boxes; luminaires priced
92.5 separately.

Homerun + branch raceway,
conductors, boxes; devices priced
67.5 separately.

ESTIMATED count -- no device
layout exists in the pipeline.

165

ESTIMATED count -- no device
layout exists in the pipeline.

145

LPD used as the luminaire-density
proxy -- no photometric layout stage
exists.

165

Homerun + branch raceway,
conductors, boxes; luminaires priced
92.5 separately.

Homerun + branch raceway,
conductors, boxes; devices priced
67.5 separately.

ESTIMATED count -- no device
layout exists in the pipeline.

165

ESTIMATED count -- no device
layout exists in the pipeline.

145

LPD used as the luminaire-density proxy -- no photometric layout stage exists.

165

Homerun + branch raceway, conductors, boxes; luminaires priced separately.

Homerun + branch raceway, conductors, boxes; devices priced separately.

ESTIMATED count -- no device layout exists in the pipeline.

165

ESTIMATED count -- no device layout exists in the pipeline.

145

LPD used as the luminaire-density proxy -- no photometric layout stage exists.

108

Homerun + branch raceway, conductors, boxes; luminaires priced separately.

Homerun + branch raceway, conductors, boxes; devices priced separately.

ESTIMATED count -- no device layout exists in the pipeline.

165

ESTIMATED count -- no device layout exists in the pipeline.

145

LPD used as the luminaire-density proxy -- no photometric layout stage exists.

841.5

Homerun + branch raceway, conductors, boxes; luminaires priced separately.

Homerun + branch raceway, conductors, boxes; devices priced separately.

344.25

ESTIMATED count -- no device
layout exists in the pipeline.

495

ESTIMATED count -- no device
layout exists in the pipeline.

145

51249.5

119317.55

109772.14

118553.91

136337

156787.55

156787.55

group, so a reading above the band is expected and is

uildup \$119,317.55 (sum of all group subtotals) x
. Accuracy range at Class 3 (-20%/+30%): \$125,430 to