ENEL 674 Industrial and Commercial Power Systems

Group 7

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Project Milestone 2

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1. Connected Load vs Load Demand:

Total connected load (continuous and non-continuous loads) in the system is as follows,

Load type	Connected Load					Demand Factor	Total Load Demand	Remarks
	DISTRIBUTION BOARD - 1P	DISTRIBUTION BOARD - 2P	DISTRIBUTION BOARD - 3P	DISTRIBUTION BOARD - U	Total			
	KVA	KVA	KVA	KVA	KVA		KVA	
Lighting	2469.1			838.0	3307.1	0.8	15622.6	1. As per CEC for first 10KVA Diversity Factor is 1.0 & for rest 0.5. 2. However, for emergency lights which run contineously during the emergency, we have considered demand factor 1.
Receptacles	17100.0				17100.0			
Furnace			15113.3		15113.3	0.5	7556.6	1. Non continous load
Condensate Units			38862.7		38862.7	0.5	19431.4	1. As cooling and heating can not run simultaneously, hence we have considered the demand factor of 0.5
Baseboard heaters	4123.7	10320.0			14443.7	0.5	7221.9	
Exhaust Fan			1239.9	206.0	1445.9	1.0	1445.9	1. Continuous load
Spare	5760.0	960.0	5760.0	4320.0	16800.0	0.6	9480.0	1. Non continous load
Others I.e., dryer, CCTV, Projector, Fridge, Oven…etc	16150.9			60.6	16211.5	0.5	8136.1	1. Non continous load
Fire Pump				16531.9	16531.9	1.0	16531.9	1. Continuous load
Total					139816.1	0.6	85426.2	

Further calculation for the distribution panels is as below.

2. Distribution Board – 1P Incomer 3ϕ, 4W, 125A breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 1” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R	14423.59	1920
Phase Y	13376.90	1440
Phase B	12043.18	2400

Table 1

Load Summary (VA)		Diversity	Demand Load
Receptacle	17100	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5	14784.55
Lighting	2469.1		
Other	20274.57	0.5	10137.29
Spare	5760	0.5	2880

Table 2

Considering demand factor and total load, maximum current requirements at distribution board 1P breaker I/C is 77.17 Amps.

Total Demand (kVA)	27.8
Total Demand (Amps)	77.17
Spare Load (Included in Total Demand)	14%

Table 3

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 77.17 = 96.46\ A$

As per CEC, we decided to go with available breaker size of $125\ A$.

Conductor Sizing

We need $3\phi, 4W, 125A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $125A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
$3/0$	165

Table 4

We are considering 3ϕ, 4W cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with 3/0 conductor size that can carry $165\ A$ (which is greater than $125/0.8\ =\ 156.25\ A$) at 60 degree Celsius.

For 3/0 conductor with jacket, conduit size will be 63mm. In addition to that minimum radius to center of conduit is $267mm$. Final design for distribution board – 1P incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$165\ A$	$3/0$	$63\ mm$	$267\ mm$

Table 5

3. Distribution Board – 2P Incomer 3ϕ, 4W, 20A breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 2” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R-Y-B	10320	960

Table 6

Load Summary (VA)		Diversity	Demand Load
Receptacle	0	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5	0
Lighting	0		
Baseboard Heater	10320	0.5	5160
Spare	960	0.5	480

Table 7

Considering demand factor and total load, maximum current requirements at distribution board 2P breaker I/C is $13.79\ Amps$.

Total Demand (kVA)	5.64
Total Demand (Amps)	15.67
Spare Load (Included in Total Demand)	9%

Table 8

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 15.67 = 19.59\ A$

As per CEC, we decided to go with available breaker size of $20\ A$.

Conductor Sizing

We need $3\phi, 4W, 20A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $20A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
AWG#10	30

Table 9

We are considering 3ϕ, 4W cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with AWG#10 conductor size that can carry $30\ A$ at 60 degree Celsius.

For AWG#10 conductor with jacket, conduit size will be $21mm$. In addition to that minimum radius to center of conduit is $114mm$. Final design for distribution board – 2P incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$30\ A$	AWG#10	$21\ mm$	$114\ mm$

Table 10

4. Distribution Board – 3P Incomer 3ϕ, $4W$, $110A$ breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 3” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R-Y	55215.89	5760

Table 11

Load Summary (VA)		Diversity	Demand Load
Receptacle	0	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5	0
Lighting	0		
Condensing Unit	38862.72	0.5	19431.36
Exhaust Fan	1239.889	1	1239.89
Furnace	15113.28	0.5	7556.64
Spare	5760	0.5	2880

Table 12

Considering demand factor and total load, maximum current requirements at distribution board 3P breaker I/C is $86.41\ Amps$.

Total Demand (kVA)	31.11
Total Demand (Amps)	86.41
Spare Load (Included in Total Demand)	10%

Table 13

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 86.41 = 108.01\ A$

As per CEC, we decided to go with available breaker size of $110\ A$.

Conductor Sizing

We need $3\phi, 4W, 110A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $110A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
2/0	145

Table 14

We are considering $3\phi, 4W$ cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with $2/0$ conductor size that can carry $145\ A$ (which is greater than $110/0.8\ =\ 137.5\ A$) at 60 degree Celsius.

For $2/0$ conductor with jacket, conduit size will be $53mm$. In addition to that minimum radius to center of conduit is $241mm$. Final design for distribution board – 3P incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$145\ A$	$2/0$	$53\ mm$	$241\ mm$

Table 15

5. Distribution Board – UPS Incomer 3ϕ, $4W$, $110A$ breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 4” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R-Y-B	17870.50	4320

Table 16

Load Summary (VA)		Diversity	Demand Load
Receptacle	0	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5 (As this is emergency panel, it might required to turn on simultaneously in case of emergency. Thus demand factor is considered 1.0)	1072.01
Lighting	1072.01		
Fire Pump	16531.86	In case of emergency, it must be turn on regardless of other loading on the panel. Thus, diversity factor is considered 1.0	16531.86
Others	266.64	1	266.64
Spare	4320	Future load that will connect to emergency bus must remain turn on during the emergency. Thus, demand factor considered on higher side compared to other. (0.75)	3240

Table 17

Considering demand factor and total load, maximum current requirements at distribution board 3P breaker I/C is 58.6 $Amps$.

Total Demand (kVA)	21.1
Total Demand (Amps)	58.6
Spare Load (Included in Total Demand)	24%

Table 18

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 58.6 = 69.8\ A$

As per CEC, we decided to go with available breaker size of $70\ A$.

However, one of the circuit from the bus-bar fed to 20 hp fire pump, thus the breaker requirement for that load is $110\ \mathrm{A}$. Thus, income breaker of the busbar should be kept as same rating or higher than that.

Final breaker selection for the I/C breaker is $110\ \mathrm{A}$.

Conductor Sizing

We need $3\phi, 4W, 70A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $70A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
AWG#2	95

Table 19

We are considering $3\phi, 4W$ cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with $\mathrm{AWG\#2}$ conductor size that can carry $95\ A$ (which is greater than $70/0.8\ =\ 87.5\ A$) at 60 degree Celsius.

For $\mathrm{AWG\#2}$ conductor with jacket, conduit size will be $41mm$. In addition to that minimum radius to center of conduit is $210mm$. Final design for distribution board – UPS incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$95\ A$	$\mathrm{AWG\#2}$	$41\ mm$	$210\ mm$

Table 20

6. TR outgoing L.T. bkr to BUS-BAR Chamber 3ϕ, $4W, 300\ A$ breaker size calculation

As per our calculation mentioned above in section 1. To 4. The total demand in Amps is as follows,

Distribution board - 1P load demand in Amps	Distribution board - 2P load demand in Amps	Distribution board - 3P load demand in Amps	Distribution board - UPS load demand in Amps	Total load demand in Amps
77.17	15.67	86.45	58.6	237.19

Table 21

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 237.19 = \ 296.49\ A$

As per CEC, we decided to go with available breaker size of $300\ A$.

Conductor Sizing

We need $3\phi, 4W, 300A$ bus bar at BUS-BAR Chamber with $3\phi, 4W$ I/C cable that can handle $300A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
700 kcmil	385

Table 22

We are considering $3\phi, 4W$ cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with 700 kcmil conductor size that can carry $385\ A$ (which is greater than $300/0.8\ = \ 375\ A$) at 60 degree Celsius.

For 700 kcmil conductor with jacket, conduit size will be $116mm$. Final design for distribution board – UPS incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size
$385\ A$	700 kcmil	$116\ mm$

Table 23

7. 24.9kV/208V (delta/star) transformer sizing for given building

As per our calculations in section 5., we have considered transformer outgoing L.T. breaker size 300A, 208V.

For above mentioned load requirement, transformer loading can be calculated as follows,

$$\begin{aligned}\text{Tranformer rating} &= \sqrt{3} * line\ voltage * line\ current \\ &= \sqrt{3} * 208 * 300 \\ &= 107.952\ \text{kVA}\end{aligned}$$

Considering the nearby value, given transformer by utility having $112.5\ \text{kVA}$ rating is ideal.