Underground Raceways Systems

Theoretical concepts

While designing a power distribution system, cable ampacity is the main concern. The term ampacity is defined as the current in ampere a conductor can carry continuously under the conditions (of the surrounding medium in which the cables are being installed) of use without exceeding its temperature rating. Therefore, cable ampacity study is the calculation of temperature rise of conductors in a cable under steady state conditions. The term steady state is intended to mean a continuous constant current i.e. 100% load factor, just sufficient to produce the maximum conductor temperature, assuming the surrounding ambient conditions constant.

When an electrical current flows through a cable, heat is generated and number of heat generating sources depend on the type of cable, its connection, location and installation. The heat from the source flows to the surrounding medium through a series of thermal resistances. The operating temperature of the cable is directly related to the amount of heat generated and the effective thermal value of resistance through which it flows.

The temperature calculation is based on the following methods

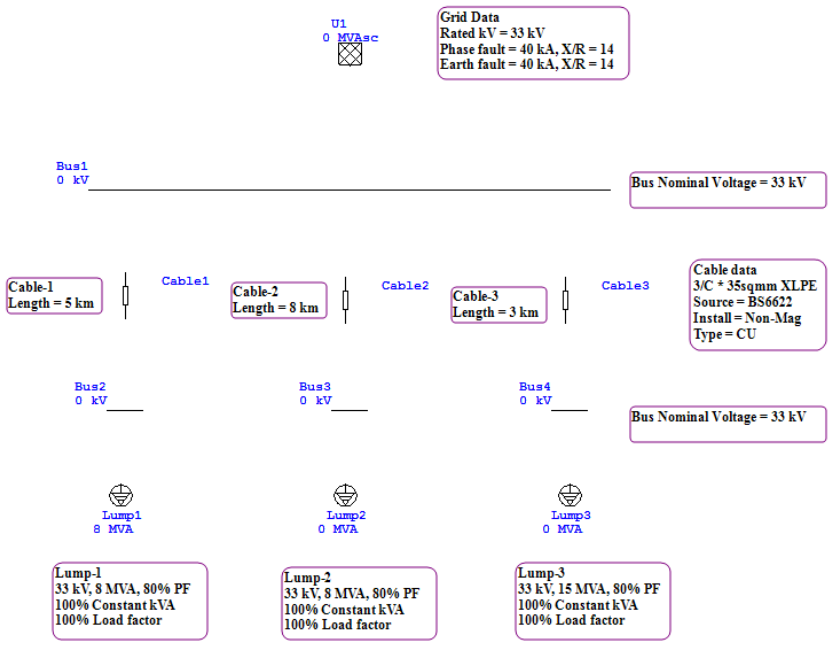
- IEC 60287 standard is used in calculating the steady state temperature rise in a cable.
- NEC accepted Neher McGrath method is used in calculating both steady state and transient temperature rise in a cable.

Purpose and Description

The purpose of this module is to understand the effect of temperature on ampacity of cable in underground raceways.

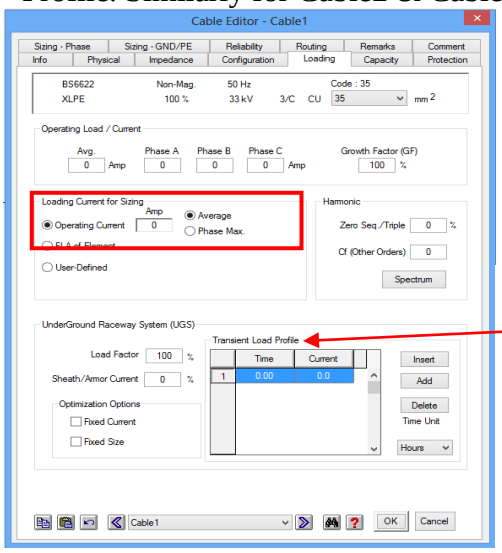
Procedure

1. Drag and drop Power Grid, Lump loads, Cables and Buses on the OLV. Enter data in element editors and connect them.



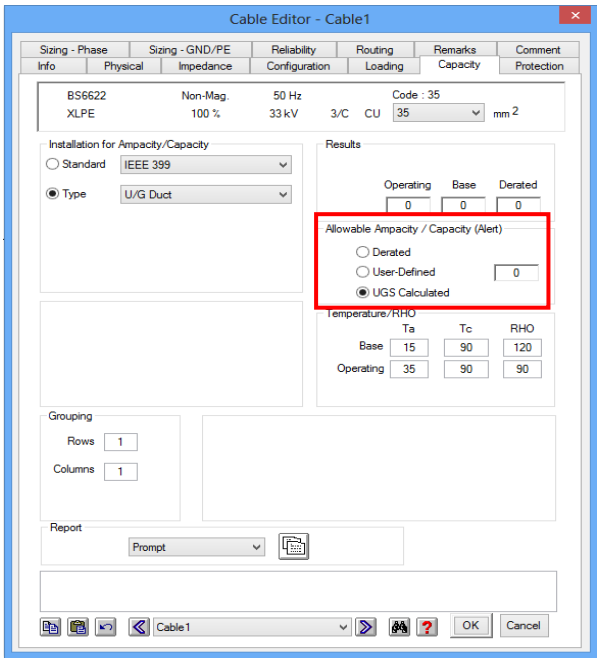
Underground Raceways Systems

2. Double click on Cable1, go to Loading page and select Operating Current option as shown & add the transient load data shown in the table below in Transient Load Profile. Similarly for Cable2 & Cable3 ad transient load profile data.



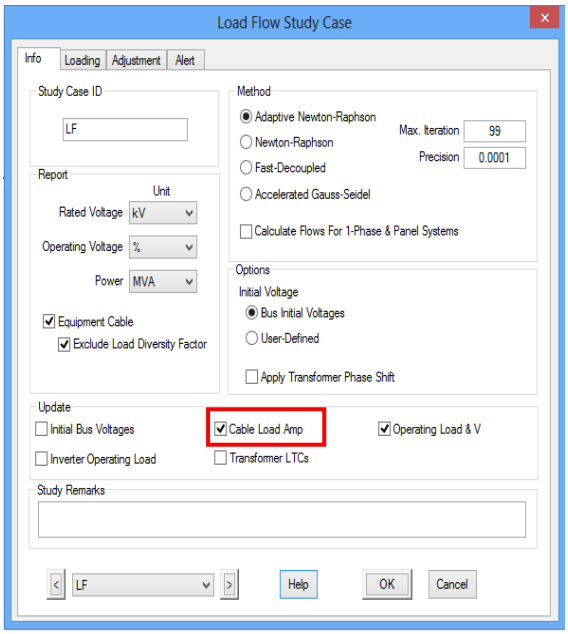
Time in hours	Current in amperes		
	Cable 1	Cable 2	Cable 3
0	181	150	270
3	200	75	300
6	181	75	200
9	300	50	150
15	300	50	150
21	150	300	150
24	140	150	400

3. Go to Capacity page and check the UGS Calculated option for each cable as shown below.

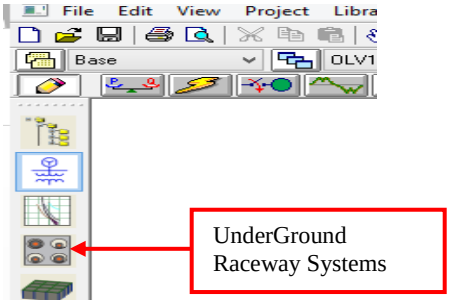


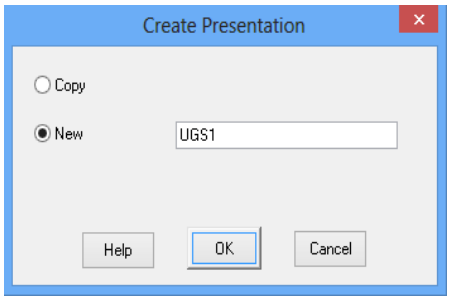
Underground Raceways Systems

4. Go to Load Flow Analysis module, click on Edit Study Case and check Cable Load Amp option as shown below.

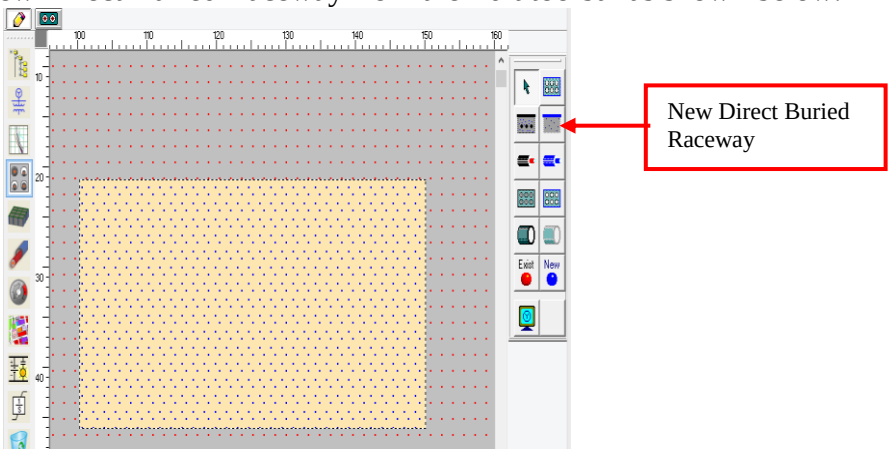


5. Click on UnderGround Raceway Systems on system toolbar and create a new presentation named UGS1 as shown below.



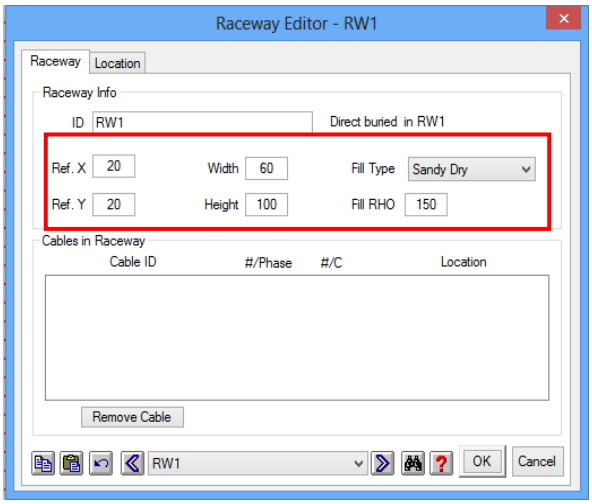


6. Drag and drop New Direct Buried Raceway from the Edit toolbar as shown below.

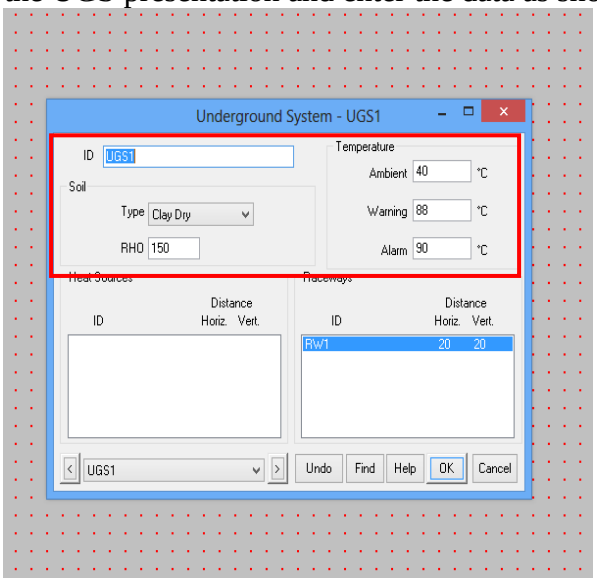


Underground Raceways Systems

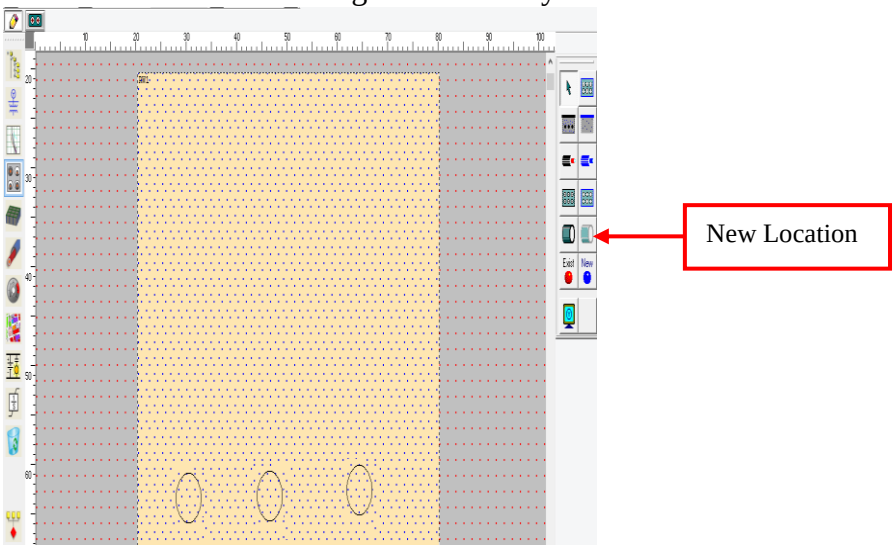
7. Double click on the Underground raceway and enter the data in Raceway page as shown below.



8. Double click on the UGS presentation and enter the data as shown below.

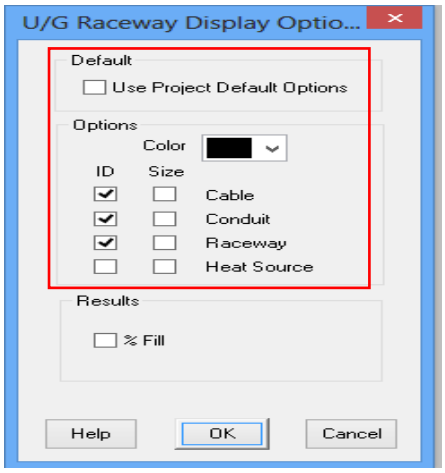


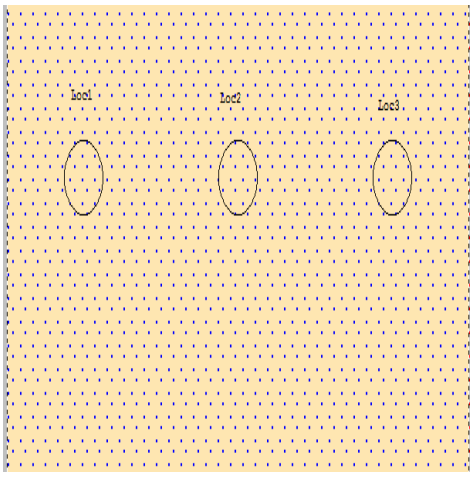
9. Drag and place three locations on the underground raceway as shown below.



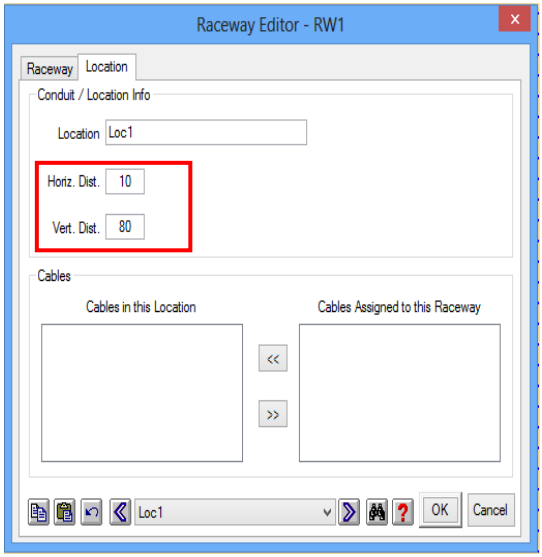
Underground Raceways Systems

10. Go to U/G Raceway display options, uncheck Use Project Default Options & check Conduit ID as shown below.

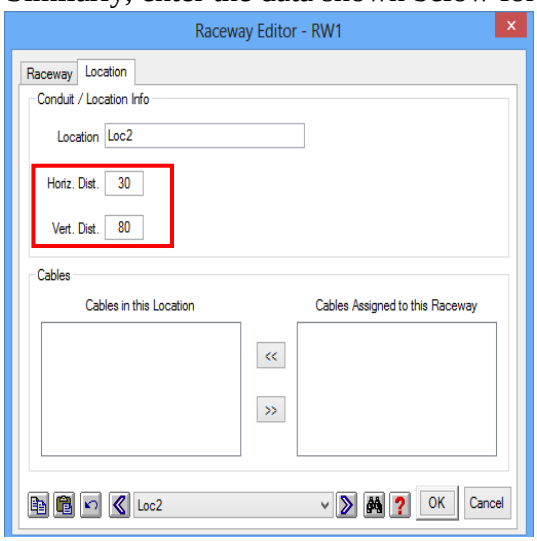


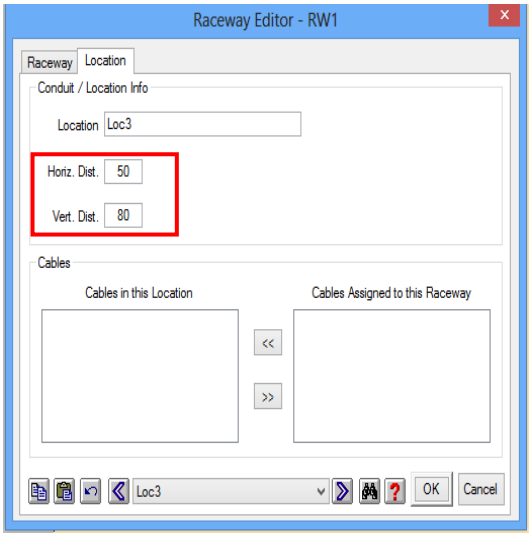


11. Double click on Loc1 and enter the data as shown below.



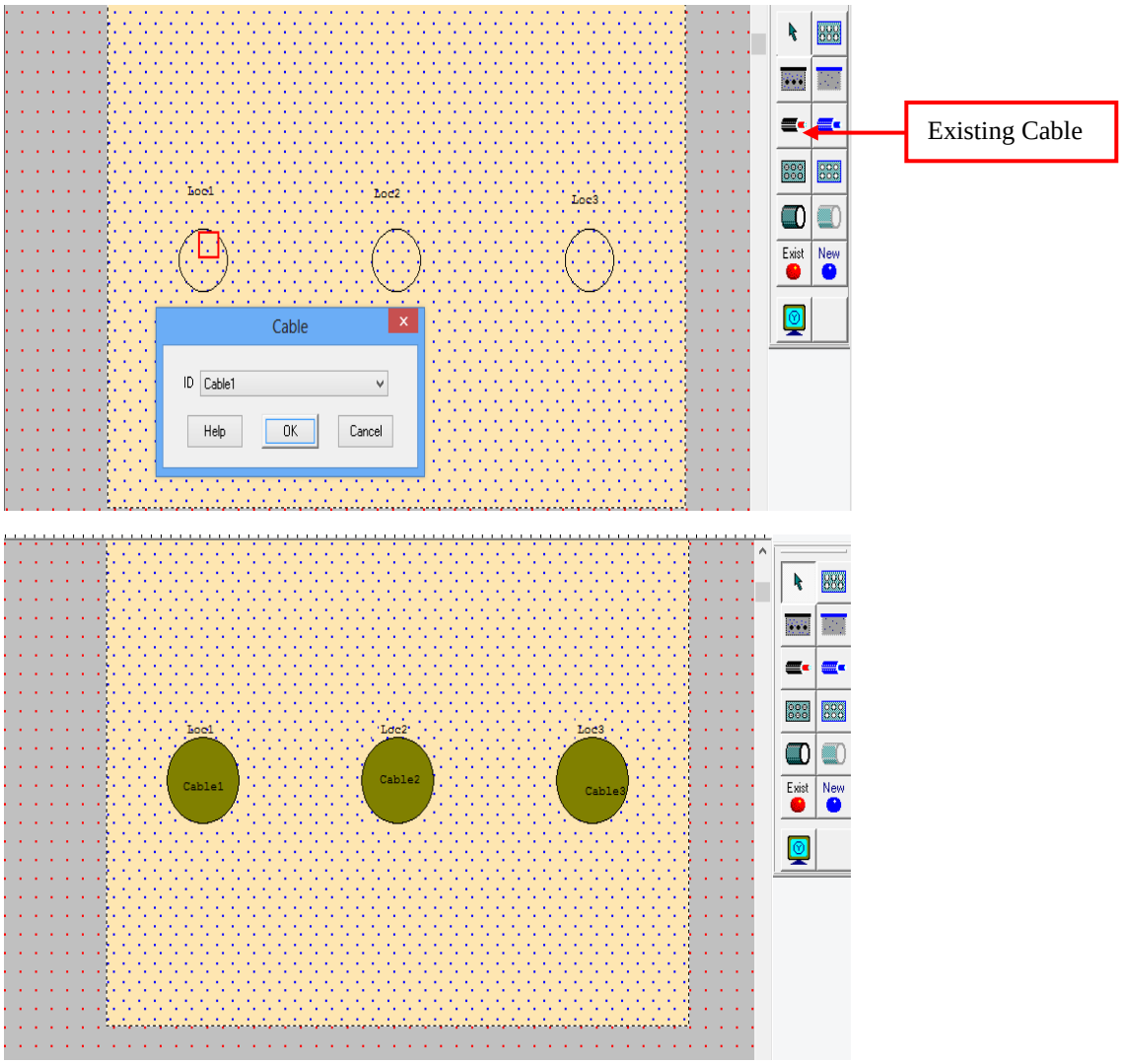
12. Similarly, enter the data shown below for Loc2 and Loc3.



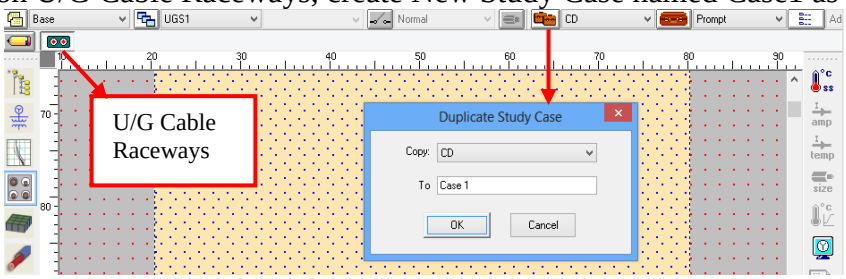


Underground Raceways Systems

13. Drag and place Cable1, Cable2 & Cable3 at Loc1, Loc2 & Loc3 respectively as shown below.

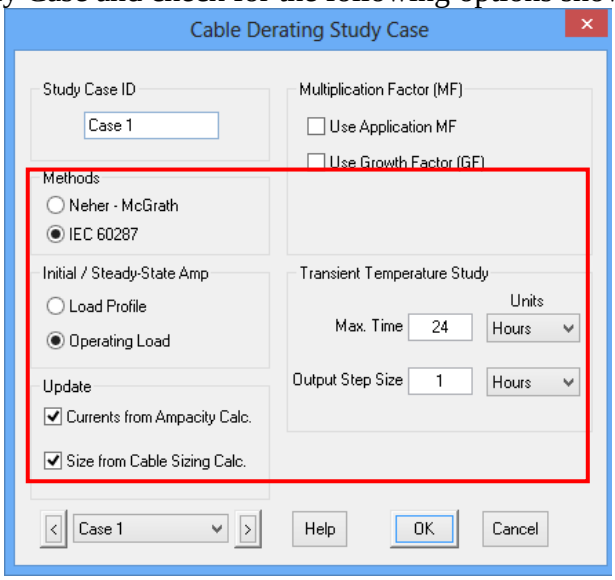


14. Click on U/G Cable Raceways, create New Study Case named Case1 as shown below.

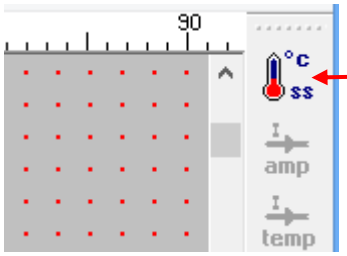


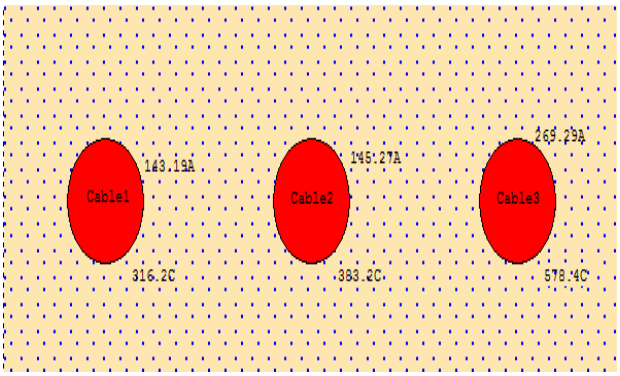
Underground Raceways Systems

15. Go to Edit Study Case and check for the following options shown below.



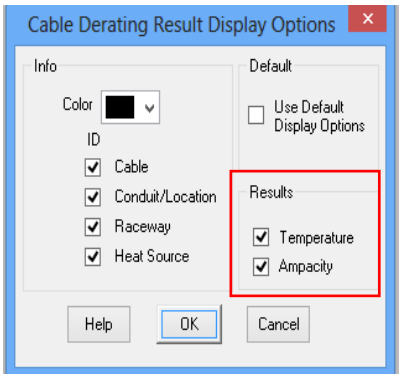
16. Run Steady-State Temperature calculation as shown and check for the results.



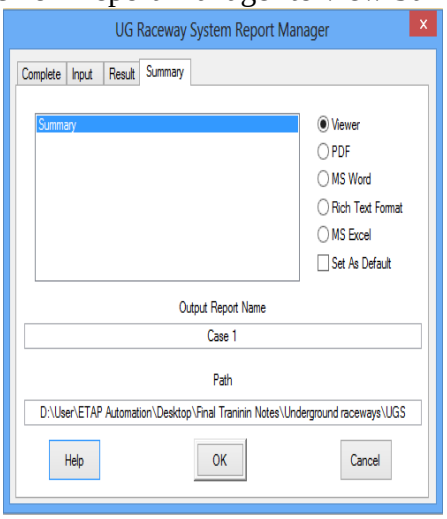


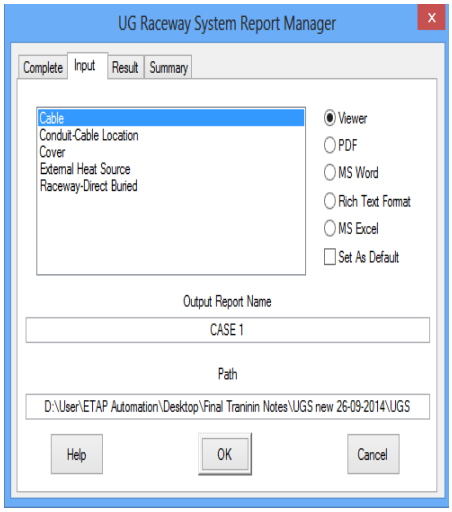
Underground Raceways Systems

17. Go to Display Options, uncheck use default display options & check the following options as shown below.



18. Click on Report Manager to view Summary and Cable data as shown below.





Underground Cable Raceway Systems (RW1)

Cable Data:

ID	Size	Rated kV	Current Amp	Individual Growth Factor %	Load Factor %	Conductor No.	Conductor Type	Conductor Per Phase	Conductor Construction	Insulation Type	Insulation Thickness mm	Insulation Thermal R Ohm-m
Cable1	35	33.000	143.19	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.764
Cable2	35	33.000	145.27	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.764
Cable3	35	33.000	269.29	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.764

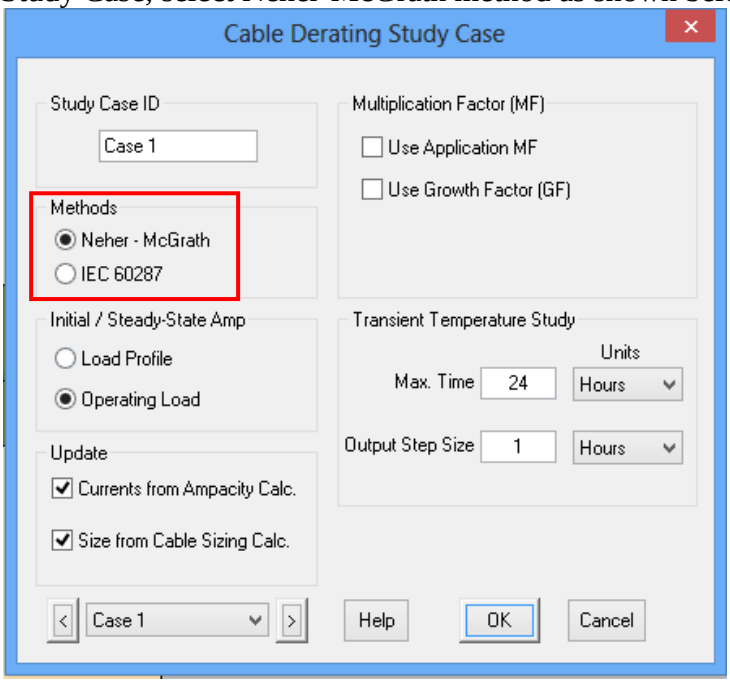
Summary (RW1)

No.	Cable ID	Conduit/Location ID	Size	Current Amp	Temp. °C
1	Cable1	Loc1	35	143.19	316.23 *
2	Cable2	Loc2	35	145.27	383.22 *
3	Cable3	Loc3	35	269.29	578.36 *

F Indicates fixed cable size in cable sizing calculations or fixed cable ampacity in uniform ampacity calculation
* Indicates a cable temperature exceeding its limit
\# Indicates a cable temperature exceeding its marginal limit

Underground Raceways Systems

19. Go to Edit Study Case, select Neher-McGrath method as shown below.



20. Run Steady-State Temperature, click on Report Manager to view Cable data and summary as shown below.

Underground Cable Raceway Systems (RW1)

Cable Data:

ID	Size	Rated kV	Current Amp	Individual Growth Factor %	Load Factor %	Conductor No.	Conductor Type	Conductor Per Phase	Conductor Construction	Insulation Type	Insulation Thickness mm	Insulation Thermal R Ohm-m
Cable1	35	33.000	143.19	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.808
Cable2	35	33.000	145.27	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.808
Cable3	35	33.000	269.29	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.808

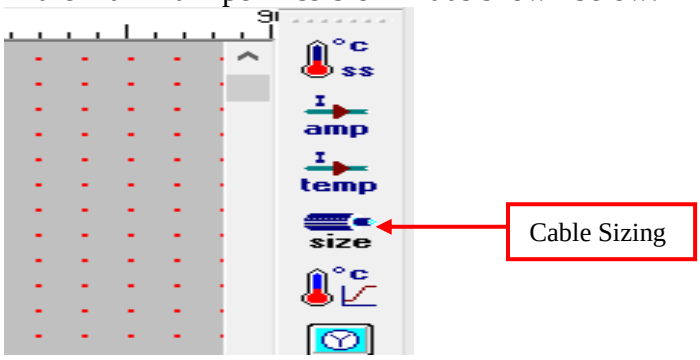
Summary (RW1)

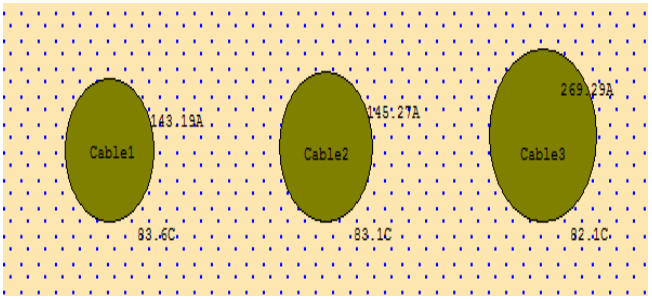
No.	Cable ID	Conduit/Location ID	Size	Current Amp	Temp. °C
1	Cable1	Loc1	35	143.19	324.07 *
2	Cable2	Loc2	35	145.27	393.32 *
3	Cable3	Loc3	35	269.29	603.79 *

F Indicates fixed cable size in cable sizing calculations or fixed cable ampacity in uniform ampacity calculation
* Indicates a cable temperature exceeding its limit
\# Indicates a cable temperature exceeding its marginal limit

Underground Raceways Systems

21. Click on Cable Sizing to automatically size the cables such that steady state temperature rise is within the maximum permissible limit as shown below.





22. Click on Report Manager to view cable data and summary as shown below.

Underground Cable Raceway Systems (RW1)

Cable Data:

ID	Size	Rated kV	Current Amp	Individual Growth Factor %	Load Factor %	Conductor No.	Conductor Type	Conductor Per Phase	Conductor Construction	Insulation Type	Insulation Thickness mm	Insulation Thermal R Ohm-m
Cable1	70	33.000	143.19	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.696
Cable2	95	33.000	145.27	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.648
Cable3	240	33.000	269.29	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.519

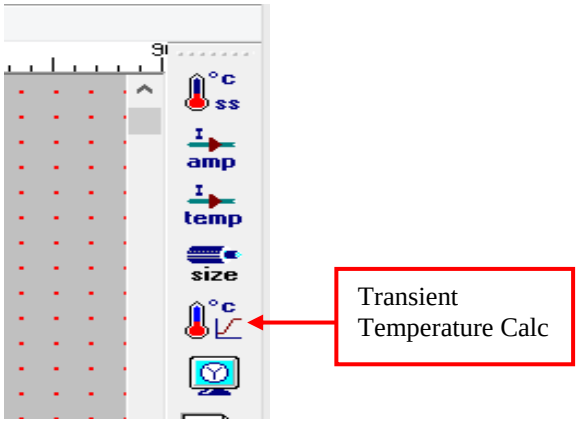
Summary (RW1)

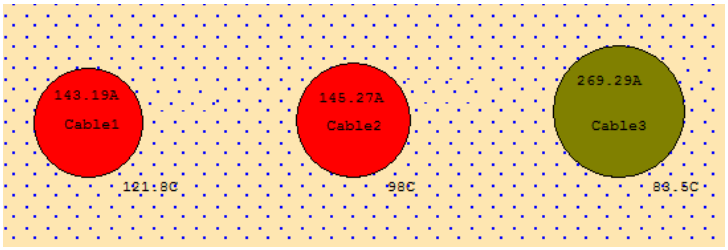
No.	Cable ID	Conduit/Location ID	Size	Current Amp	Temp. °C
1	Cable1	Loc1	70	143.19	83.61
2	Cable2	Loc2	95	145.27	83.13
3	Cable3	Loc3	240	269.29	82.09

F Indicates fixed cable size in cable sizing calculations or fixed cable ampacity in uniform ampacity calculation
* Indicates a cable temperature exceeding its limit
# Indicates a cable temperature exceeding its marginal limit

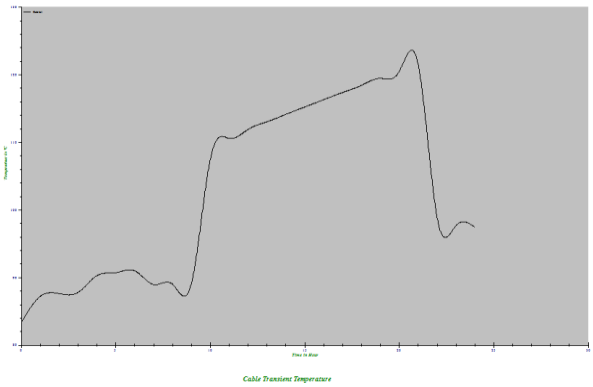
Underground Raceways Systems

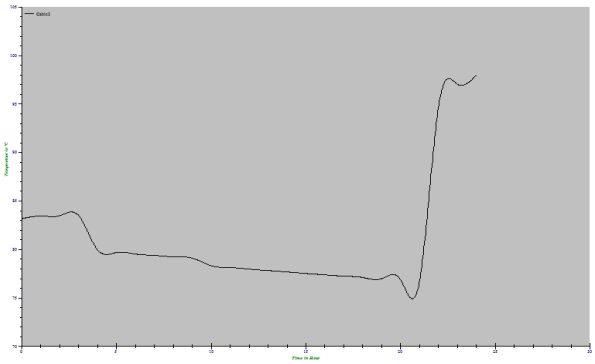
23. Run Transient Temperature Calc as shown and check for the results.



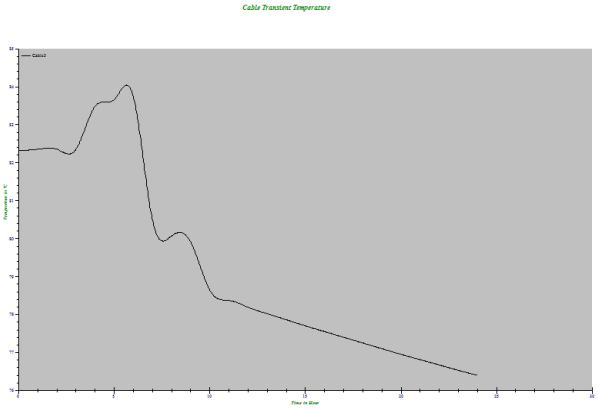


24. Click on View Plots, to view Cable Transient Temperature plot.





Underground Raceways Systems



25. Increase size of cable to bring its transient temperature profile below 90° C.
26. Change Cable1 size from 70 to 150 sq mm & Cable2 size from 95 to 120 sq mm.
27. Run Transient Temperature Calc, click on Report Manager to view Cable data and Summary as shown below.

Underground Cable Raceway Systems (RW1)

Cable Data:

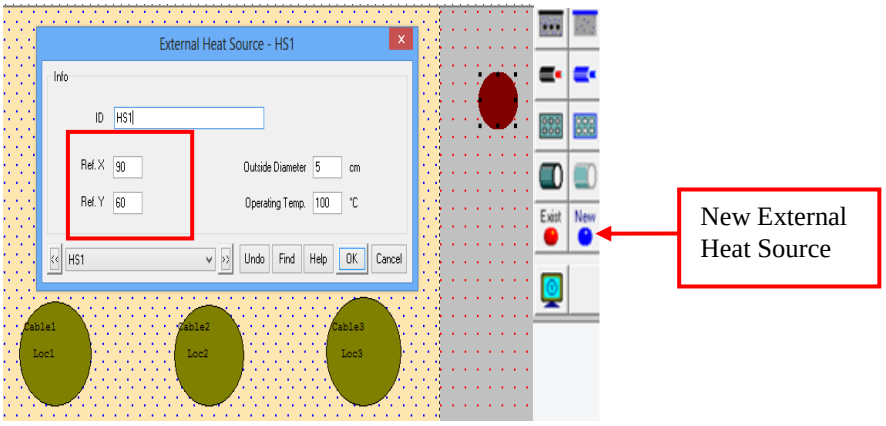
ID	Size	Rated kV	Current Amp	Individual Growth Factor %	Load Factor %	Conductor No.	Conductor Type	Conductor Per Phase	Conductor Construction	Insulation Type	Insulation Thickness mm	Insulation Thermal R Ohm-m
Cable1	150	33.000	143.19	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.579
Cable2	120	33.000	145.27	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.612
Cable3	240	33.000	269.29	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.519

Summary (RW1)

No.	Cable ID	Conduit/Location ID	Size	Current Amp	Temp. °C
1	Cable1	Loc1	150	150.00	80.35
2	Cable2	Loc2	120	300.00	82.58
3	Cable3	Loc3	240	150.00	76.59

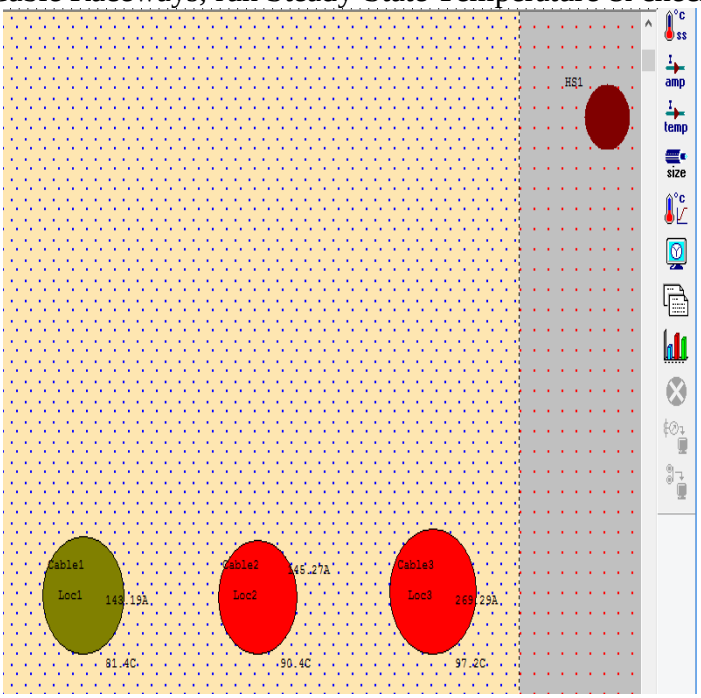
F Indicates fixed cable size in cable sizing calculations or fixed cable ampacity in uniform ampacity calculation
* Indicates a cable temperature exceeding its limit
\# Indicates a cable temperature exceeding its marginal limit

28. Go to Edit mode, drag and place New External Heat Source & enter the data as shown.



Underground Raceways Systems

29. Go to U/G Cable Raceways, run Steady-State Temperature & check for results.



30. Click on Report Manager to view Cable data and summary as shown below.

Underground Cable Raceway Systems (RW1)

Cable Data:

ID	Size	Rated kV	Current Amp	Individual Growth Factor %	Load Factor %	Conductor No.	Conductor Type	Conductor Per Phase	Conductor Construction	Insulation Type	Insulation Thickness mm	Insulation Thermal R Ohm-m
Cable1	150	33.000	143.19	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.579
Cable2	120	33.000	145.27	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.612
Cable3	240	33.000	269.29	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.519

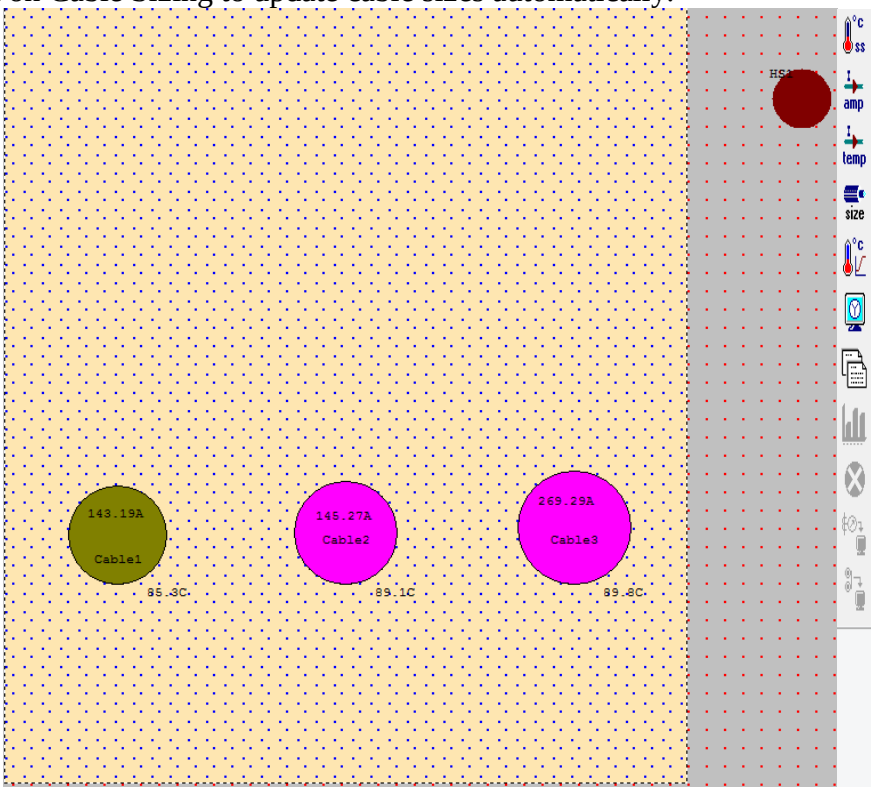
Summary (RW1)

No.	Cable ID	Conduit/Location ID	Size	Current Amp	Temp. °C
1	Cable1	Loc1	150	143.19	81.28
2	Cable2	Loc2	120	145.27	90.87 *
3	Cable3	Loc3	240	269.29	97.40 *

F Indicates fixed cable size in cable sizing calculations or fixed cable ampacity in uniform ampacity calculation
* Indicates a cable temperature exceeding its limit
# Indicates a cable temperature exceeding its marginal limit

Underground Raceways Systems

31. Click on Cable Sizing to update cable sizes automatically.



32. Click on Report Manager to view Cable data and summary as shown below.

Underground Cable Raceway Systems (RW1)

Cable Data:

ID	Size	Rated kV	Current Amp	Individual Growth Factor %	Load Factor %	Conductor No.	Conductor Type	Conductor Per Phase	Conductor Construction	Insulation Type	Insulation Thickness mm	Insulation Thermal R Ohm-m
Cable1	95	33.000	143.19	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.648
Cable2	120	33.000	145.27	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.612
Cable3	400	33.000	269.29	100	100	3/C	CU	1	ConRnd-NT	XLPE	8.0	0.463

Summary (RW1)

No.	Cable ID	Conduit/Location ID	Size	Current Amp	Temp. °C
1	Cable1	Loc1	95	143.19	85.28
2	Cable2	Loc2	120	145.27	89.05#
3	Cable3	Loc3	400	269.29	89.82#

F Indicates fixed cable size in cable sizing calculations or fixed cable ampacity in uniform ampacity calculation
* Indicates a cable temperature exceeding its limit
# Indicates a cable temperature exceeding its marginal limit