Rating Under Special Installation Conditions and Uprating of Existing Cables

Workshop on Cable Ampacity at the IEEE ICC Spring Meeting Orlando, Florida

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Presented by

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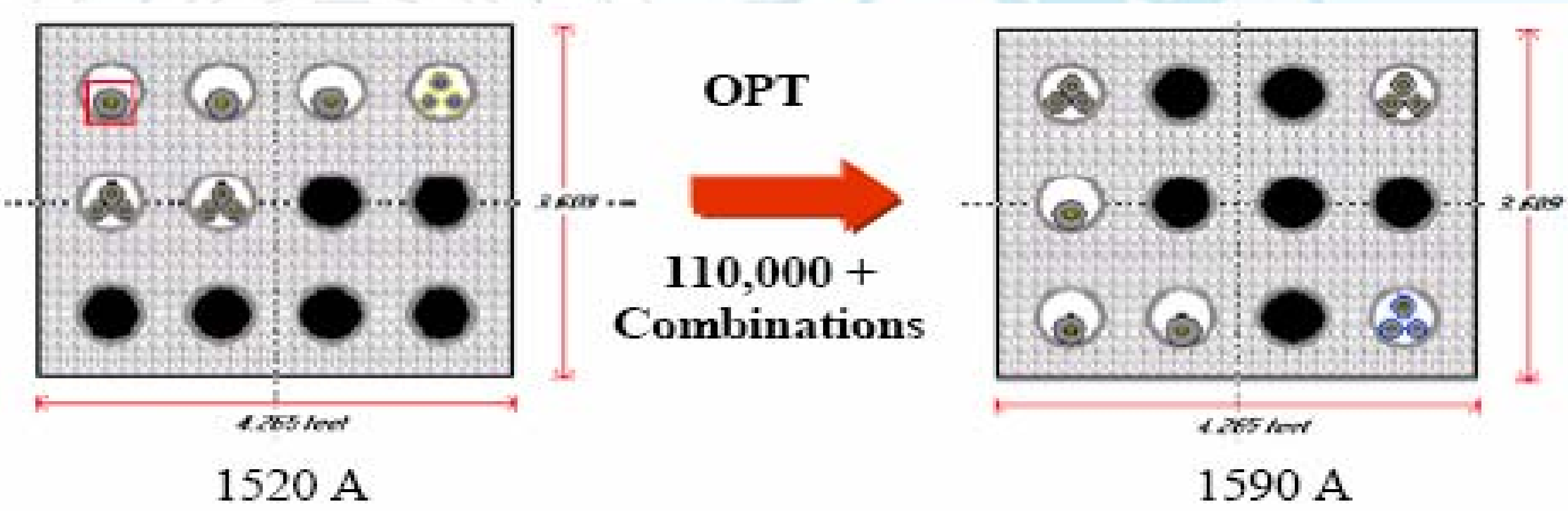
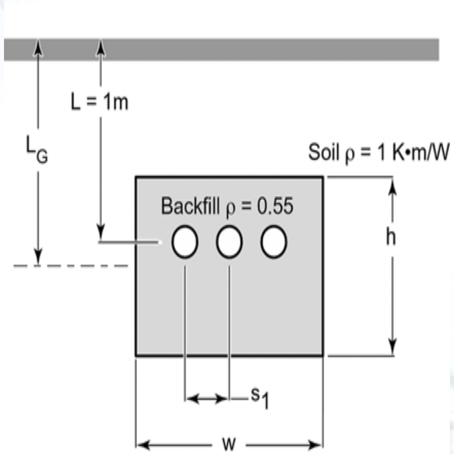
Cables in duct banks
What is the “best” circuit arrangement?

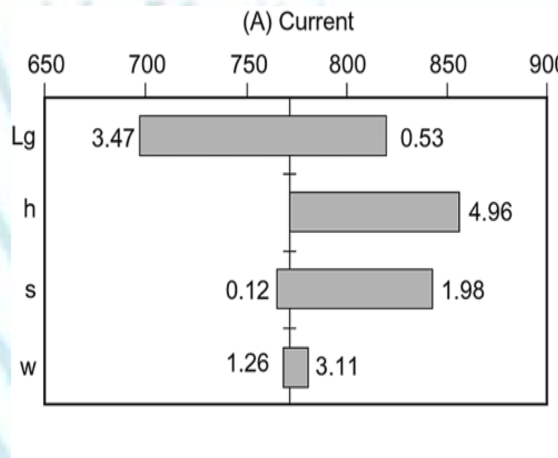
- The duct bank overall ampacity, i.e. the sum of the ampacities for all circuits, is maximized.
- The duct bank overall ampacity, i.e. the sum of the ampacities for all circuits, is minimized.
- The ampacity of any given circuit is maximized.
- The ampacity of any given circuit is minimized.

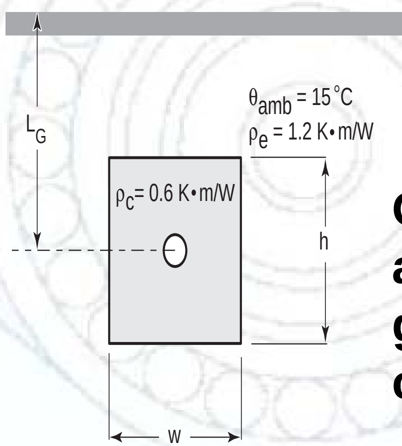


Cables in Backfills
What is the optimal backfill size?

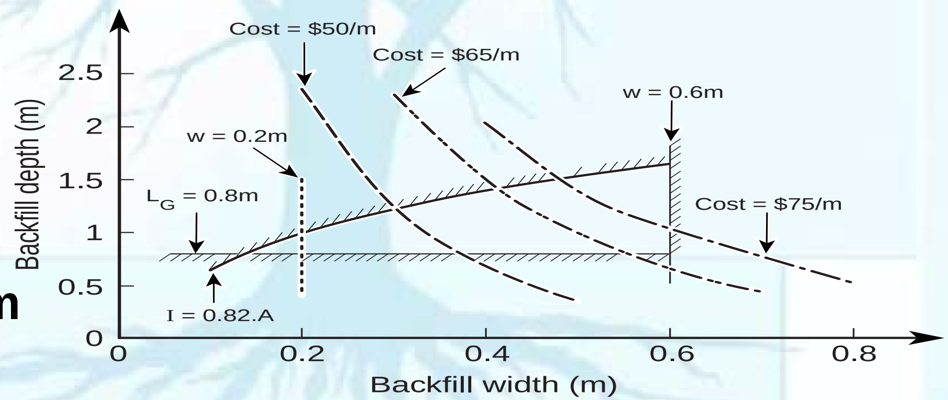


Which parameters are important?



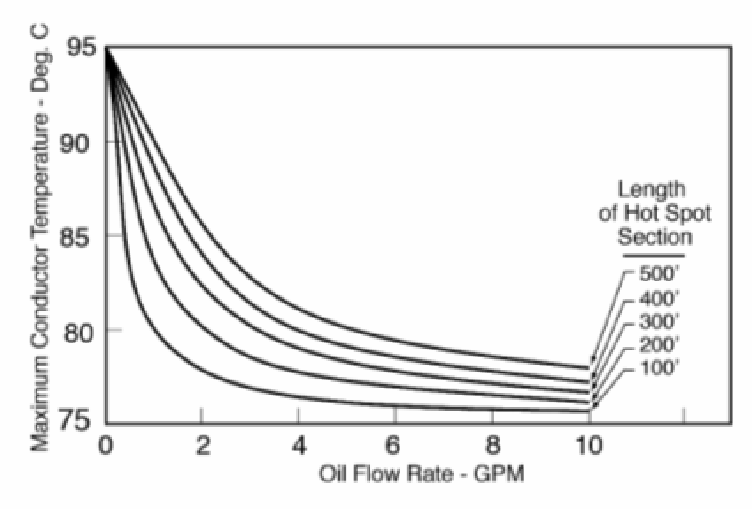


Optimal depth and width for given minimum current



Rating of Pipe Type Cables with Slow Circulation of Dielectric Fluid

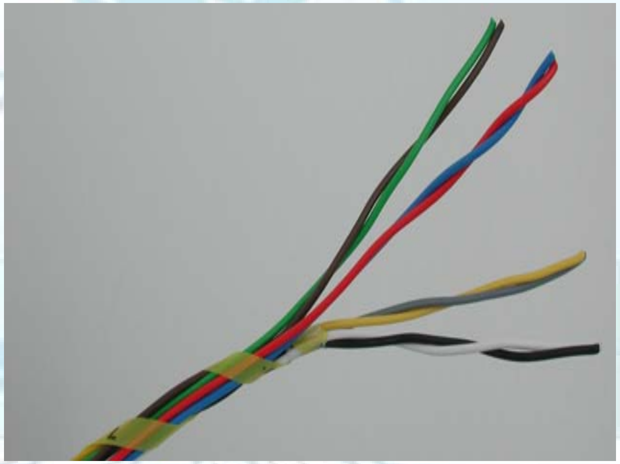
- Dielectric fluid flowing in the pipe with normal environment moves into a hot-spot section at an initial temperature θ_f^{in}.
- When passing through, the fluid temperature rises at an exponential rate to a maximum value θ_f^{out}
- As fluid moves again into a long section with normal environment, the temperature decreases at an exponential rate toward an asymptotic value of θ_f^{in}



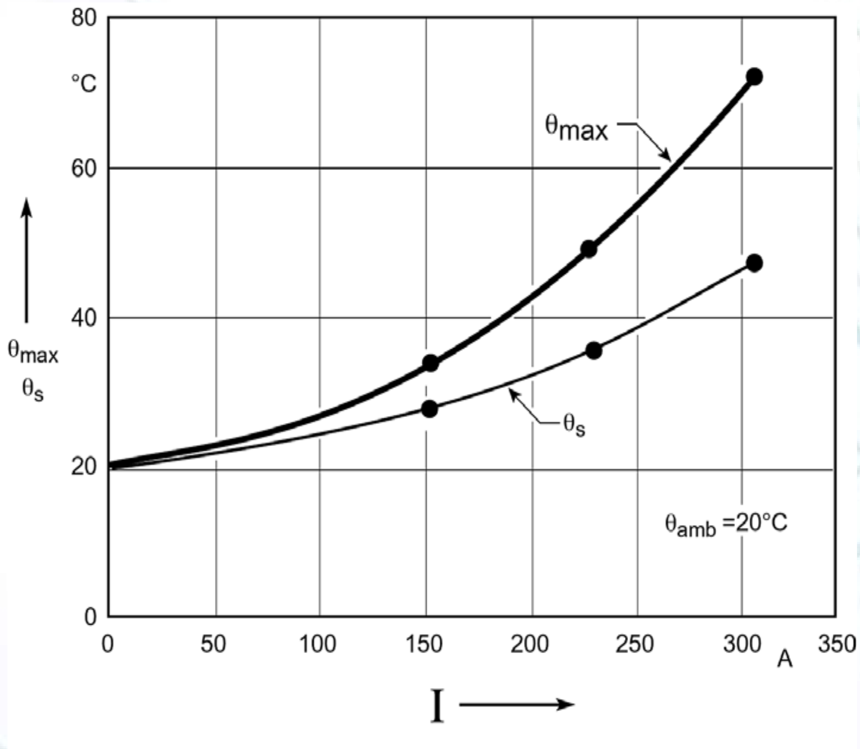
Effect of oil-flow rate on hot spot temperature reduction (Burrell 1965)

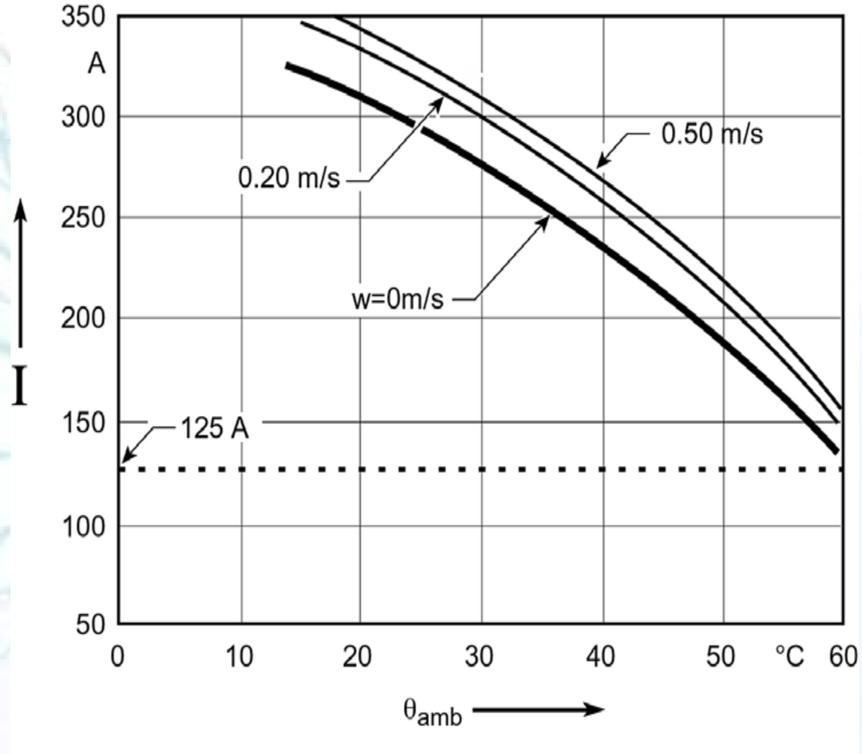
Current Rating of Multicore Cables

- ✓ The need for bundle rating arises from the fact that modern telecommunication cables or cables installed in aircraft are grouped together for a portion of the cable run. An example of such cable is shown here. In this figure, a bundle of N separate cores is held by means of an aluminum band (static shield) and enclosed by a PVC-sheath.



Calculated vs. experimental results

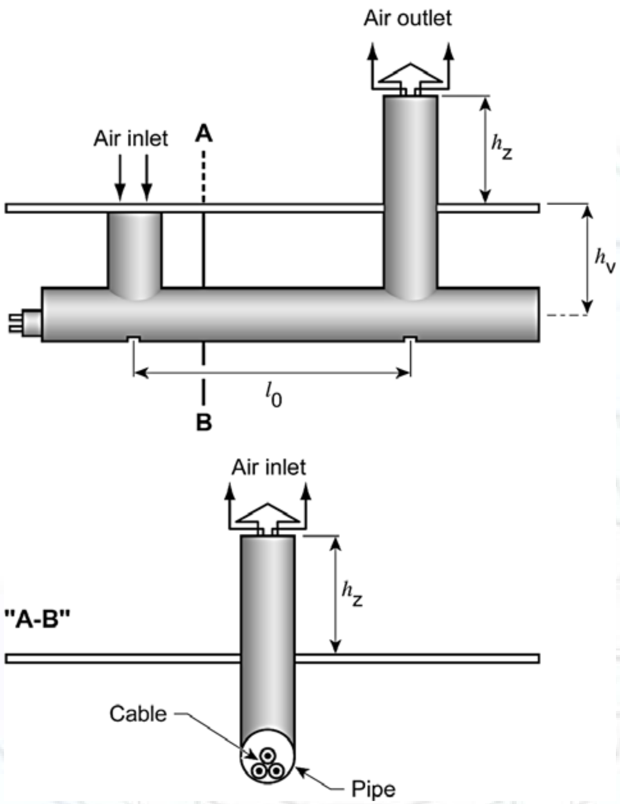


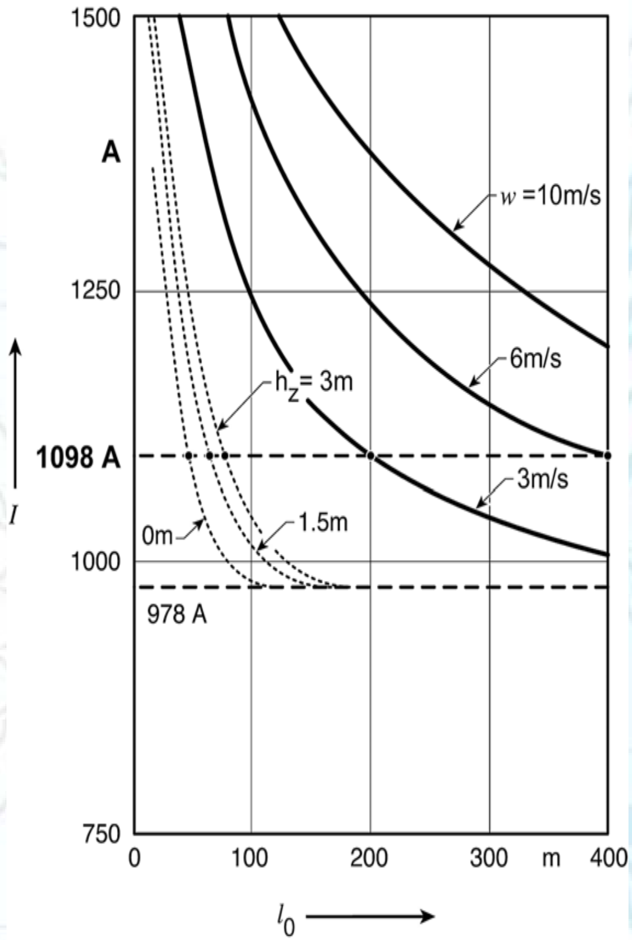


Dots represent measured values

Permissible total current as a function of ambient air temperature. The dot indicates the measured value

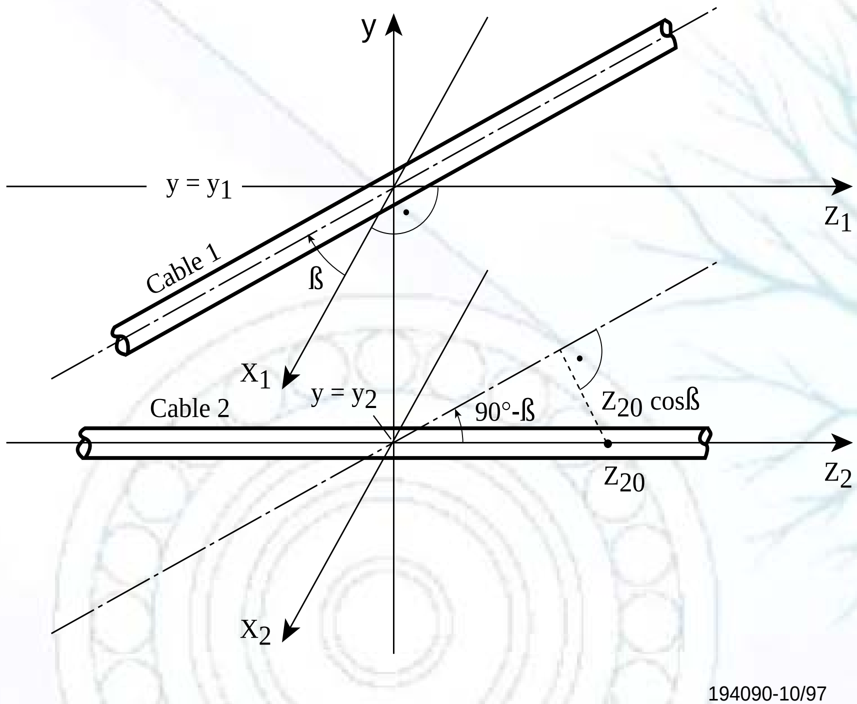
Increasing Ampacity of Cables by Application of Ventilated Pipes

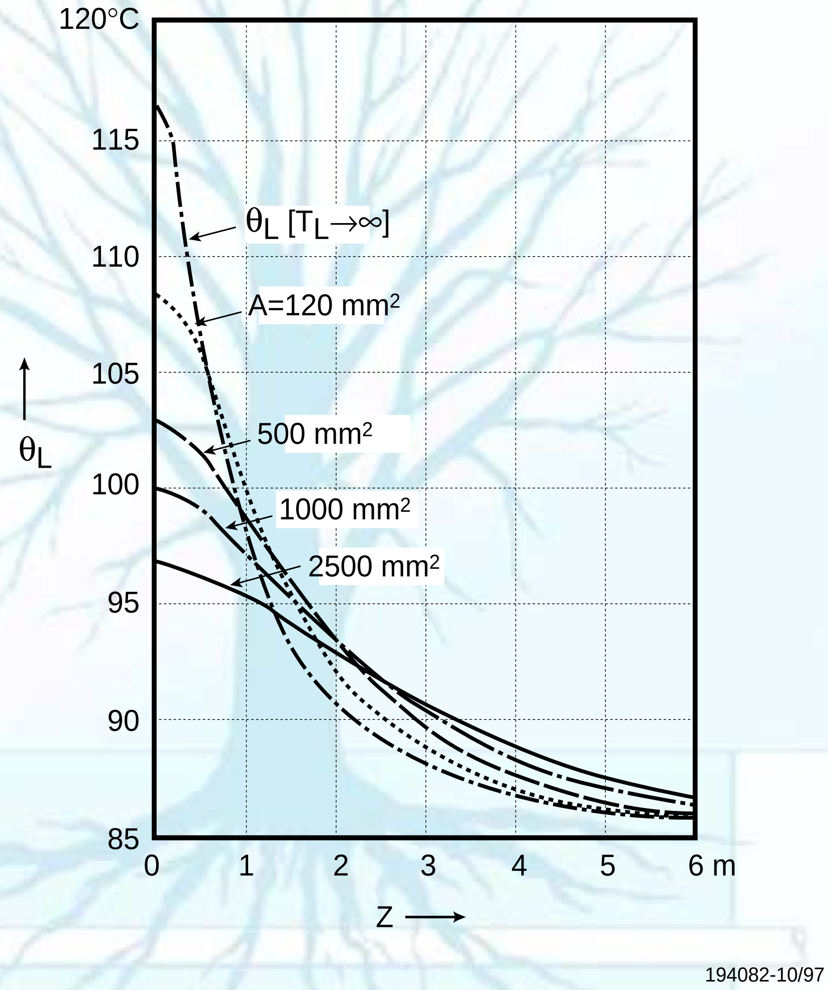




- Continuous current rating as function of the cooling section length l0 for a non-metallic pipe with inner diameter of 300 mm
- Dotted lines denote natural air convection with the outlet-height as a parameter
- Solid lines denote forced air convection with the flow velocity as a parameter.

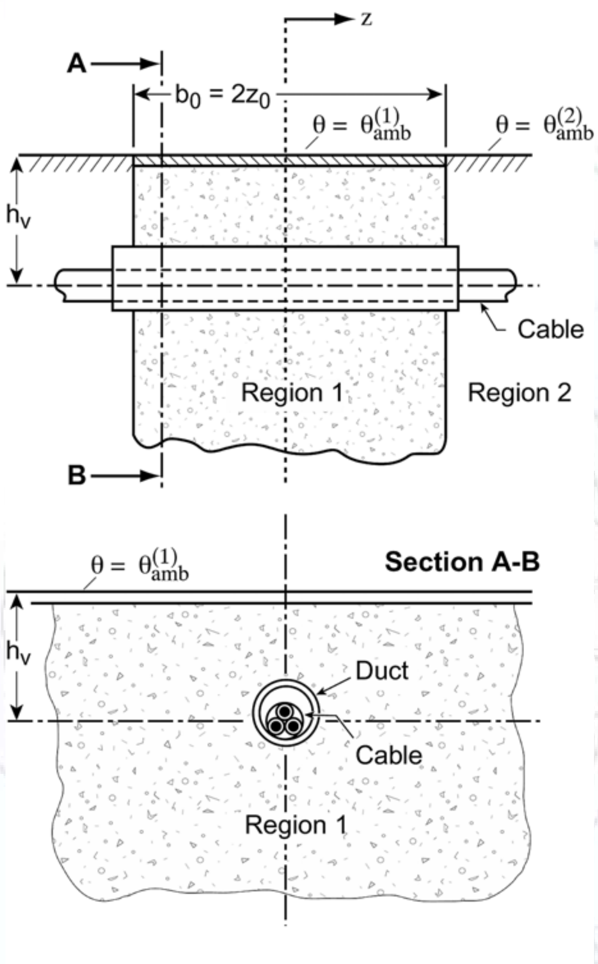
Cable Crossings

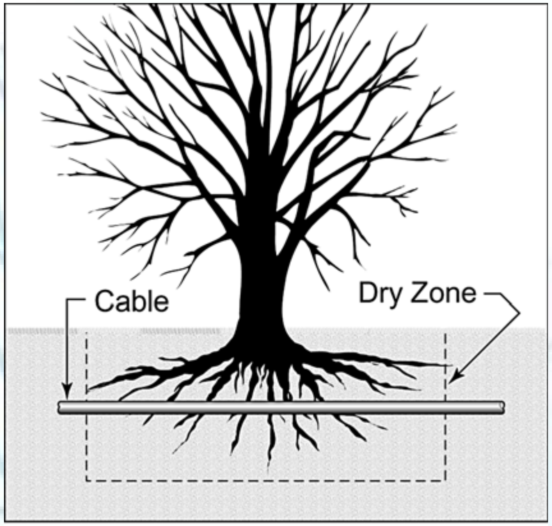


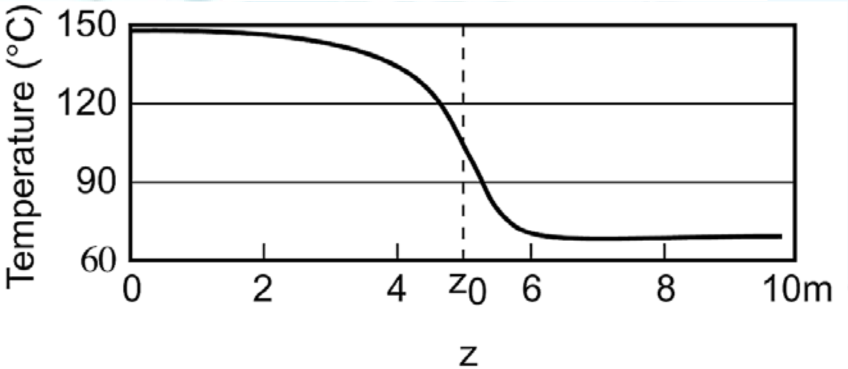


110 kV LPOF cable fully loaded and heated by an external perpendicular heat source 30 W/m, 30 cm above the cable

Crossing Unfavorable Regions

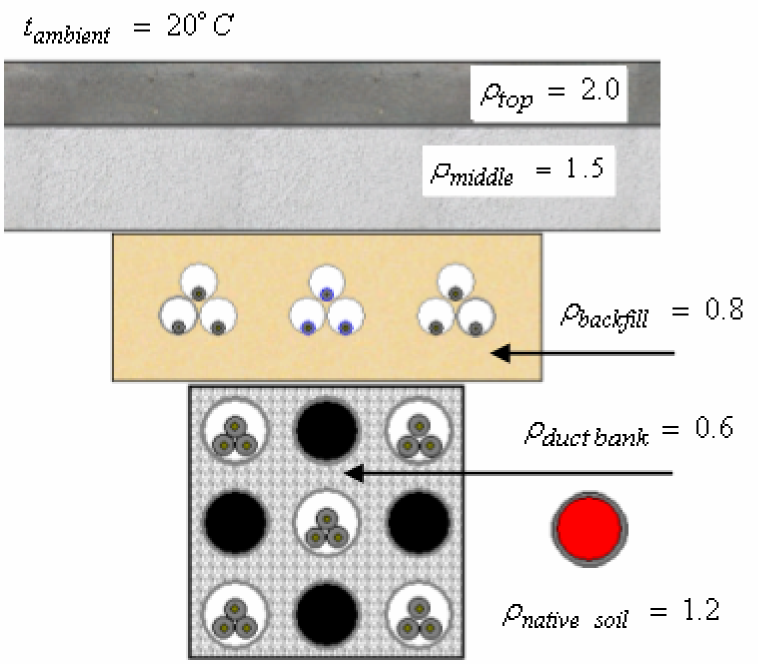


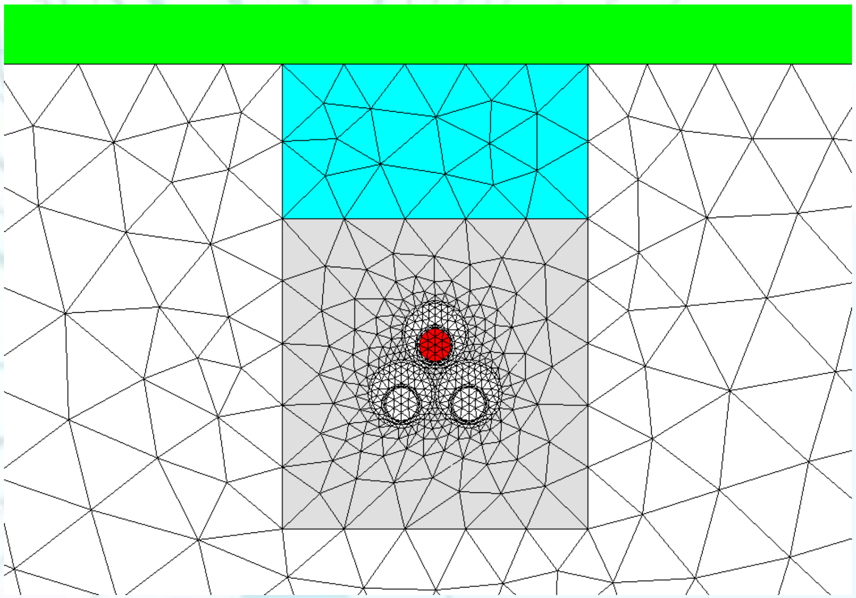




Example of the temperature distribution from the center of street crossing

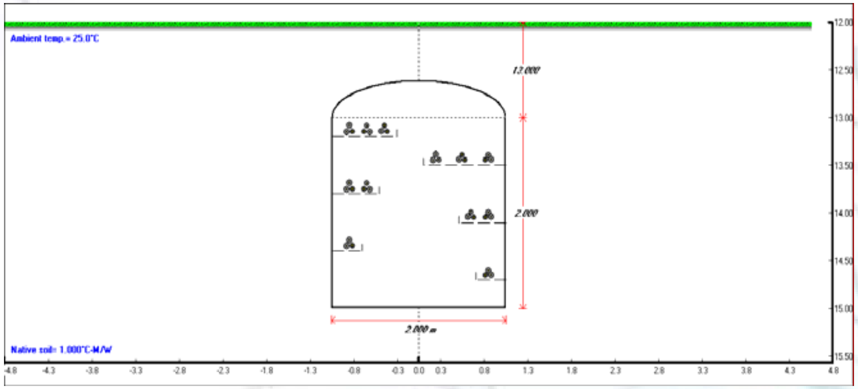
Complex Cable Arrangements

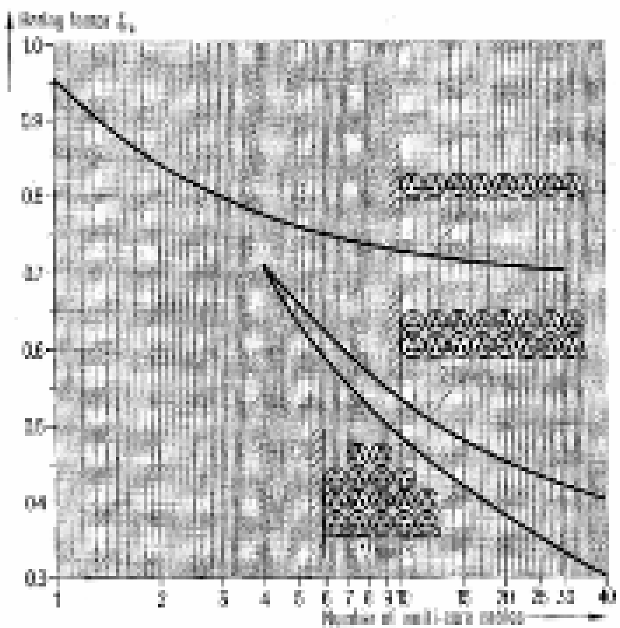




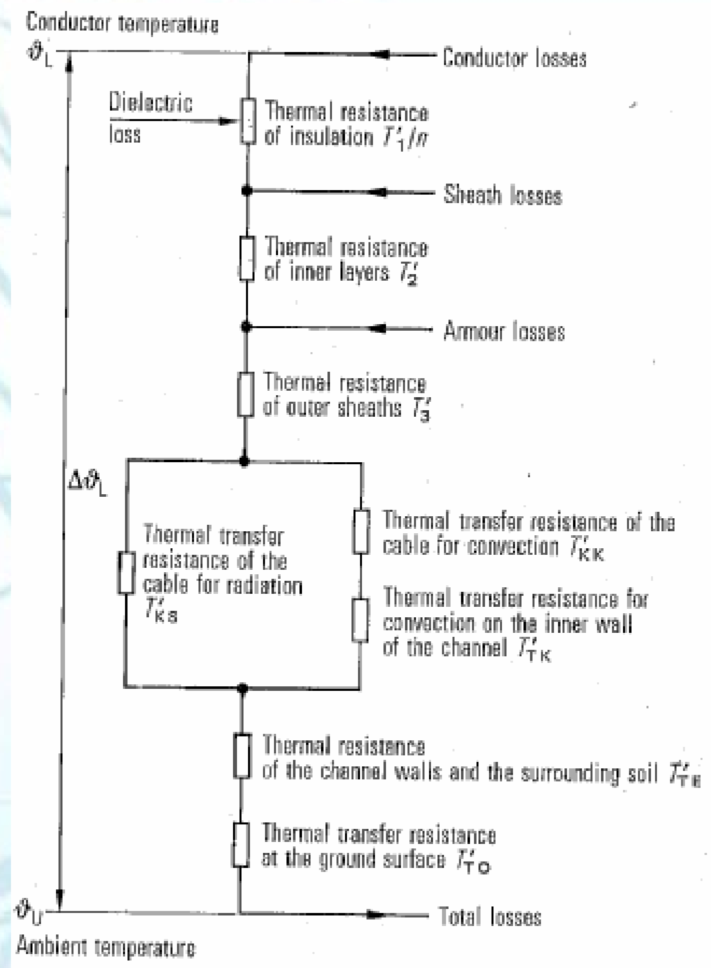
Solved by a combination of a Finite Element method and the Standard approach.

Cables in Tunnels



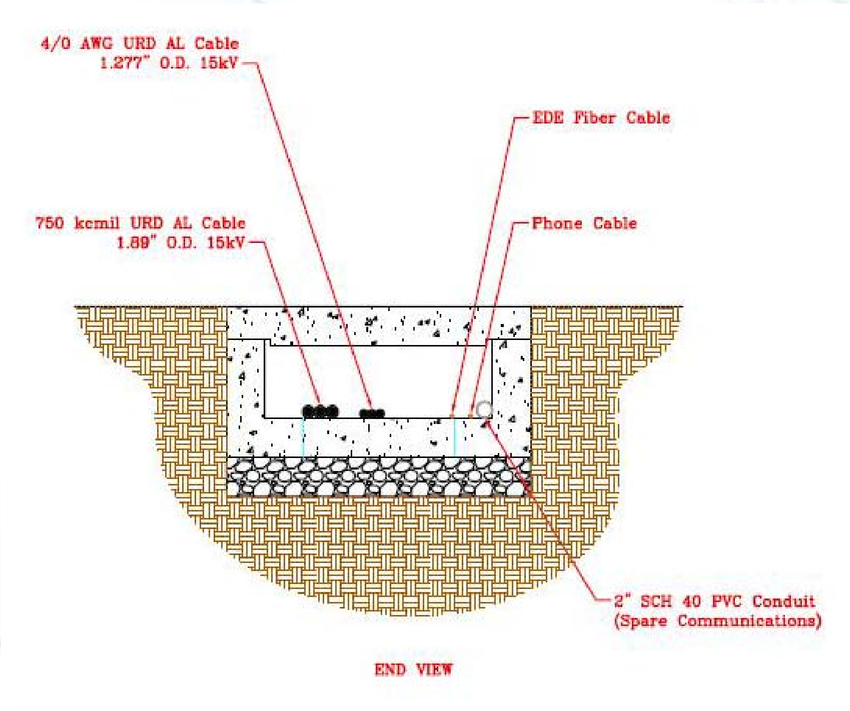


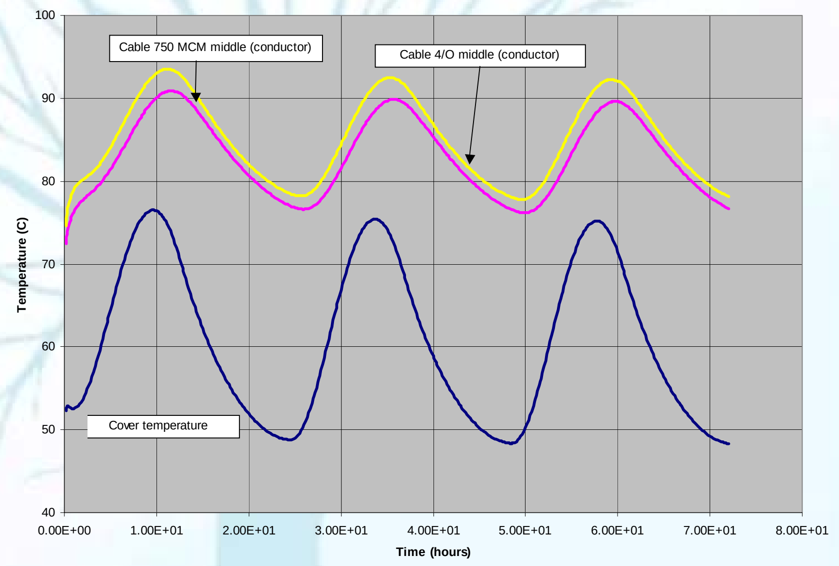
Example of derating factors depending on the arrangement and the number of cables in a tray



Thermal model

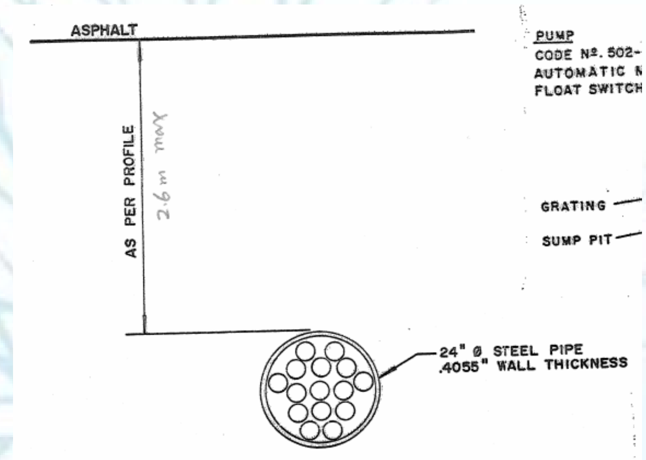
Cables in Covered Troughs



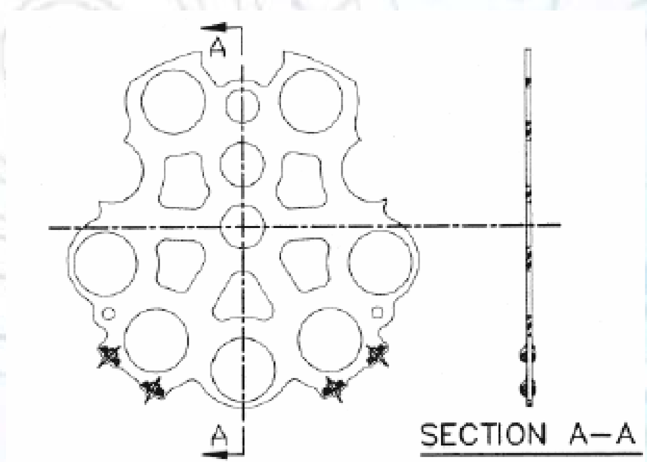


Installations To Be Studied

Utility sidewalk



Cables in plastic ducts placed in a steel pipe

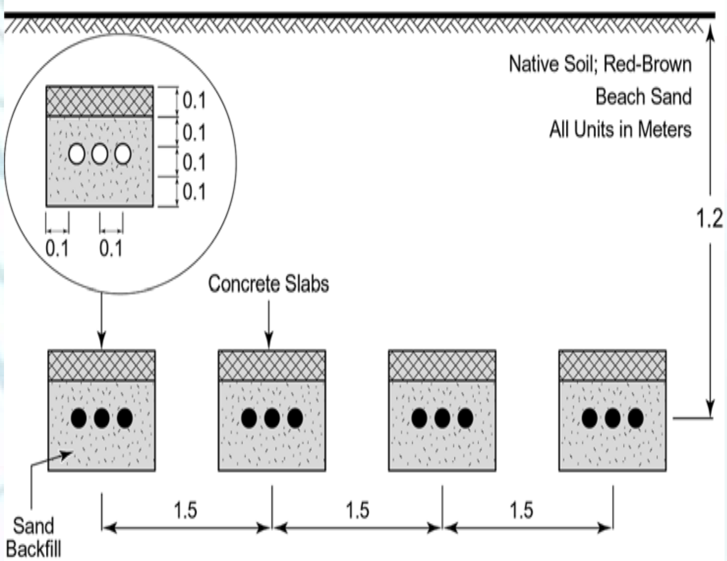


Borings with unusual shapes

Cable Uprating

- Sample problem

Typical environmental parameters assumed: the ambient soil temperature of 20ºC, native soil thermal resistivity of 1.2 K·m/W and backfill thermal resistivity, in this case, of 2.0 K·m/W. Under the above conditions each cable can carry a maximum steady state current of 800 A



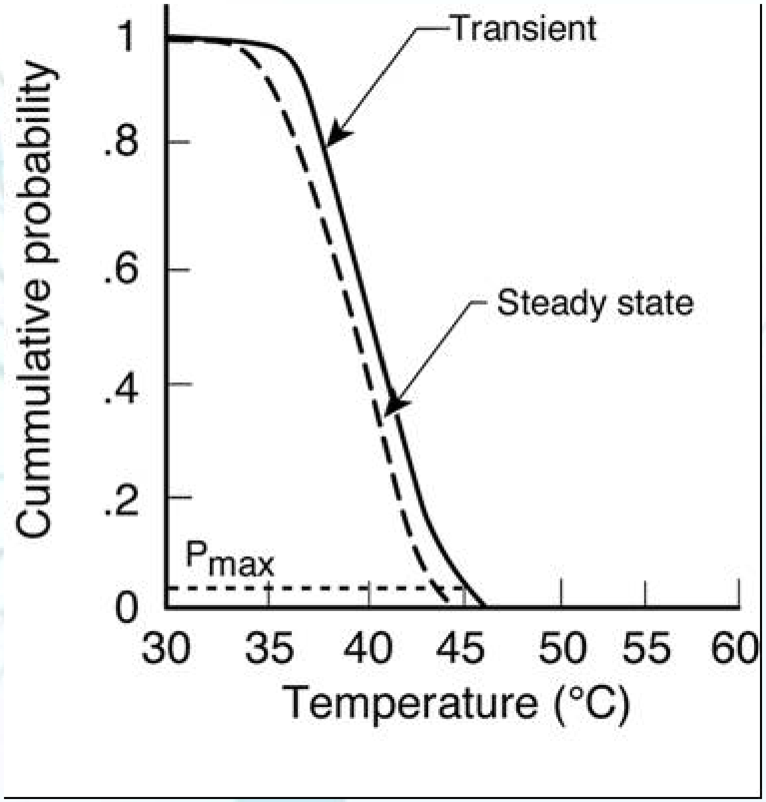
Predicted load growth

Year	1	2	4	7	9
Current (A)	787	818	892	980	1053

Cable Uprating

- Solution to a sample problem-year 2

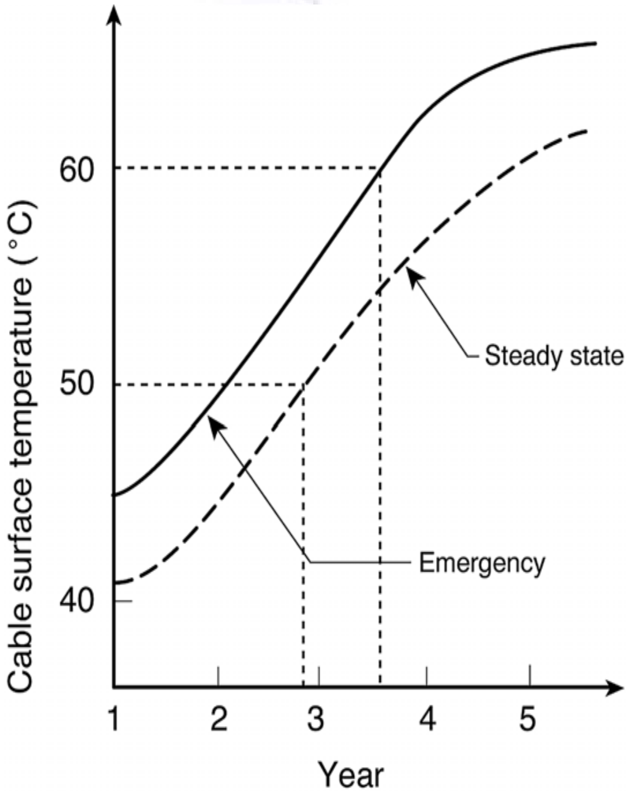
The critical cable surface temperature is usually in the range of 50 - 60ºC. Assuming the critical value in this study is 50ºC for steady state and 60ºC for transient conditions, respectively, it can be observed that these temperatures are not expected to be reached in that year.



Probability distribution of steady state and emergency hottest cable surface temperatures computed taking into account statistical variations of several parameters

Cable Uprating

- Which year to select?



Yearly cable surface temperature

Based on standard deterministic criterion, as discussed, the new cable would have to be installed in the second year.

Suppose that an acceptable risk ($p_{max} = 0.05$ **exceeding cable design temperatures is selected. From this figure, a critical year is selected in which either the steady state or emergency cable operating temperature is exceeded. In our case, a new cable has to be installed in year No. 3.**

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