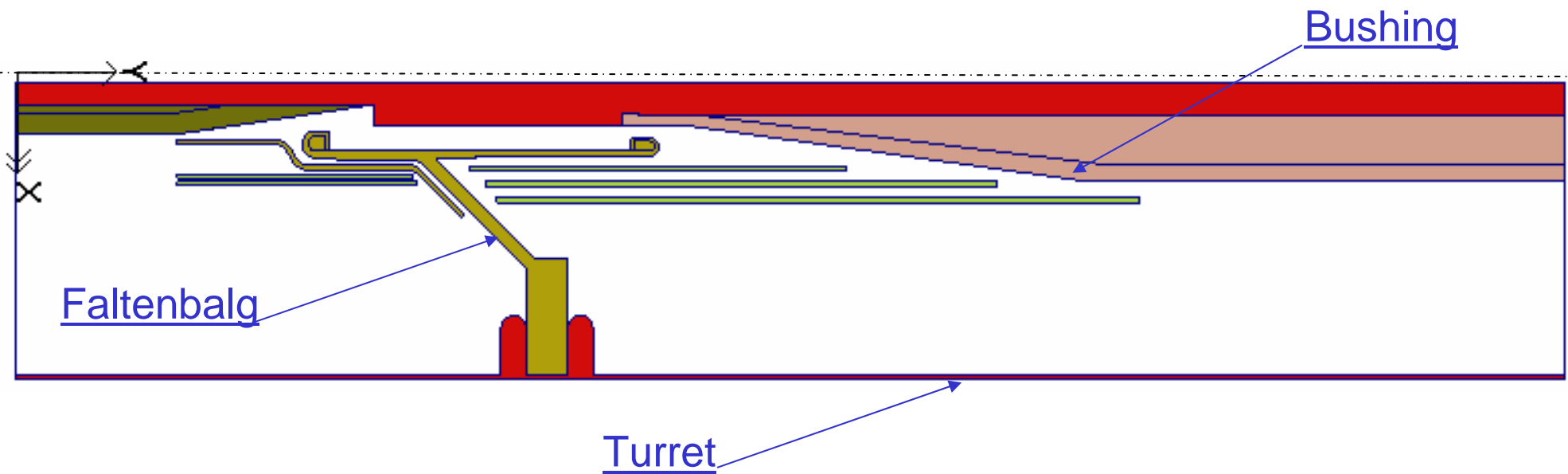


Effects of oil conductivity and time duration on polarity reversal (PR) test

Ugo Piovan

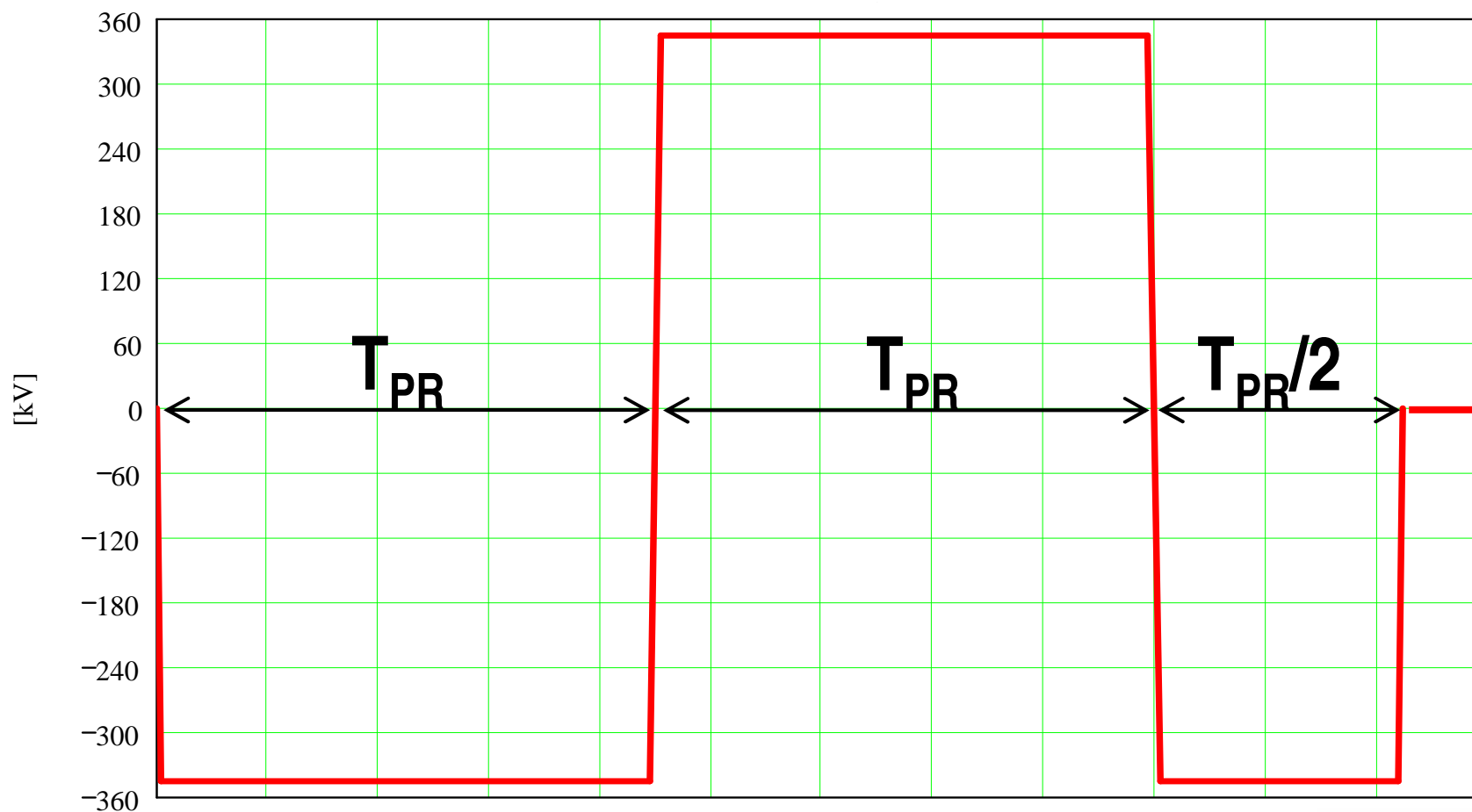
Bushing with Faltenbalg



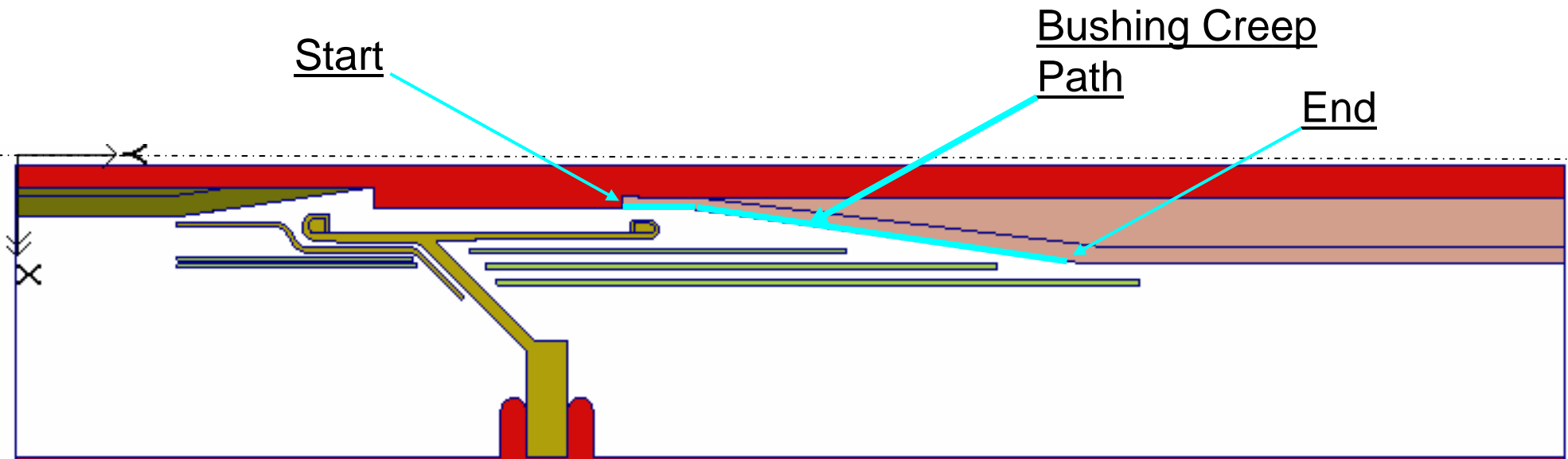
Test Voltage Wave shapes

UPR = 345 kV

We considered $T_{PR} = 90, 180, 360, 720$ min



Bushing with Faltenbalg: creep path



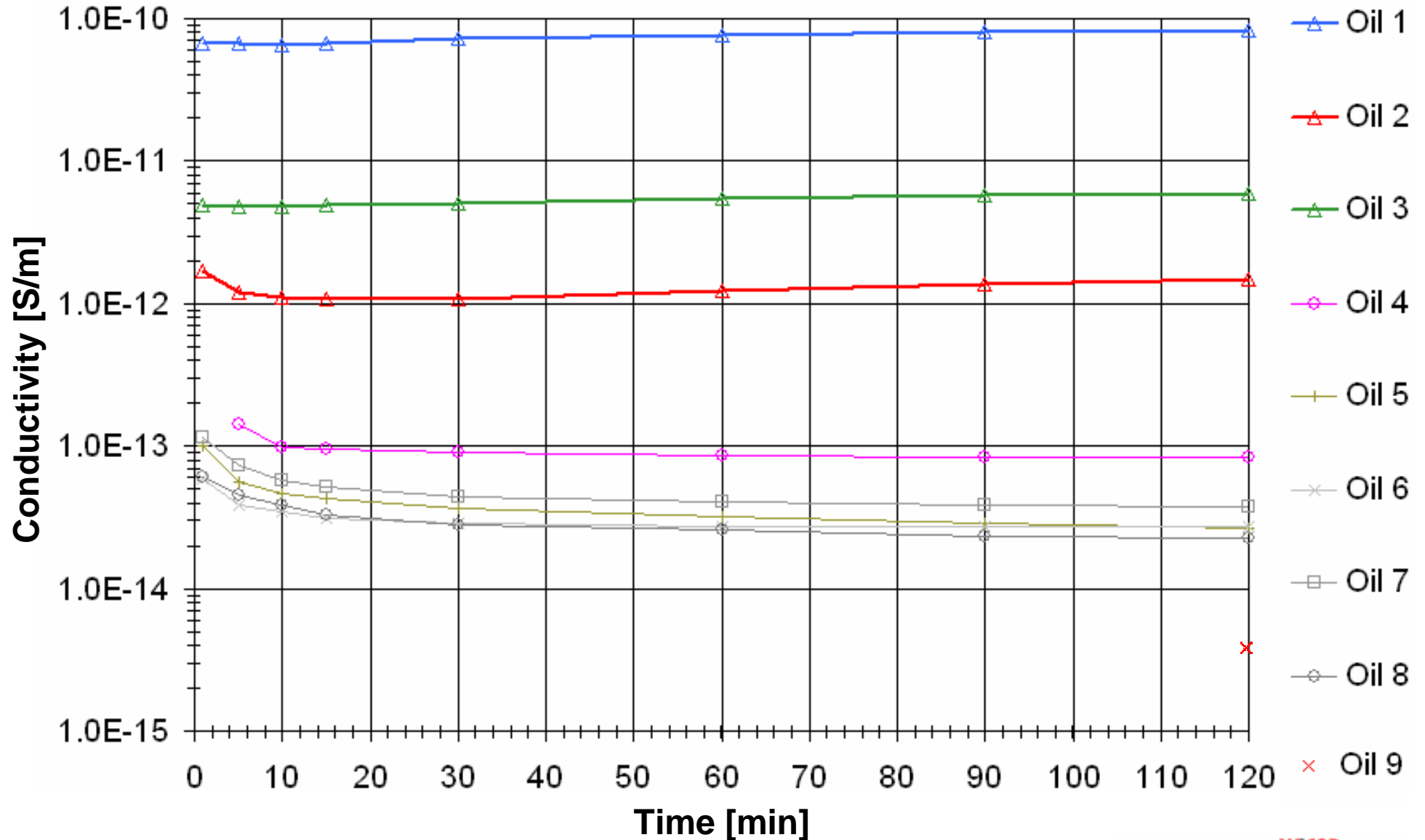
Oil conductivity

Weidmann carried out conductivity measurements on various types of transformer oil both new and aged.

We determined that oil conductivity can vary significantly (up to 4 orders of magnitude).

Oil conductivity depends on oil type and it increases with aging.

Oil conductivities at 20 °C



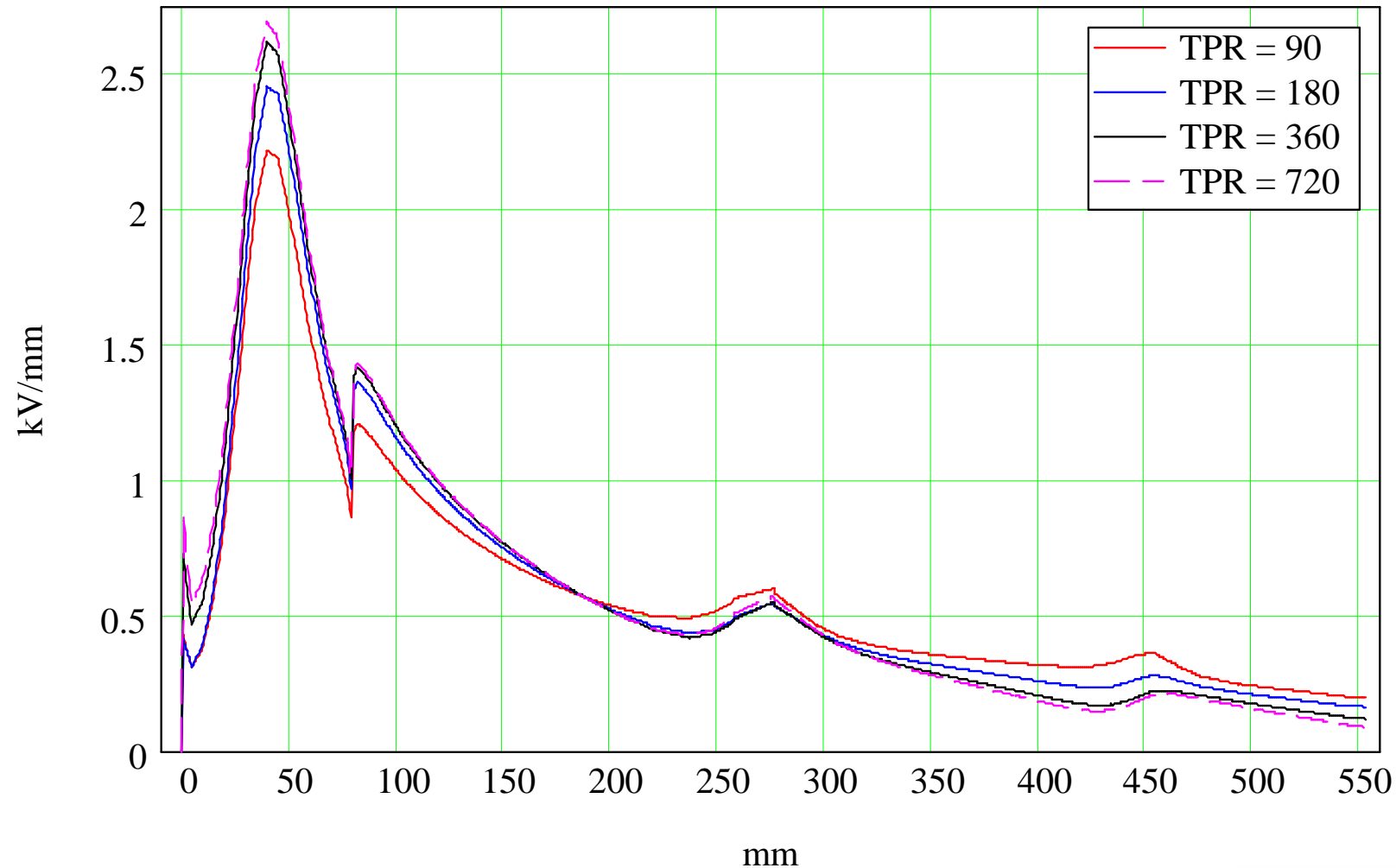
Material conductivities for simulations

For this study we identified 2 cases:

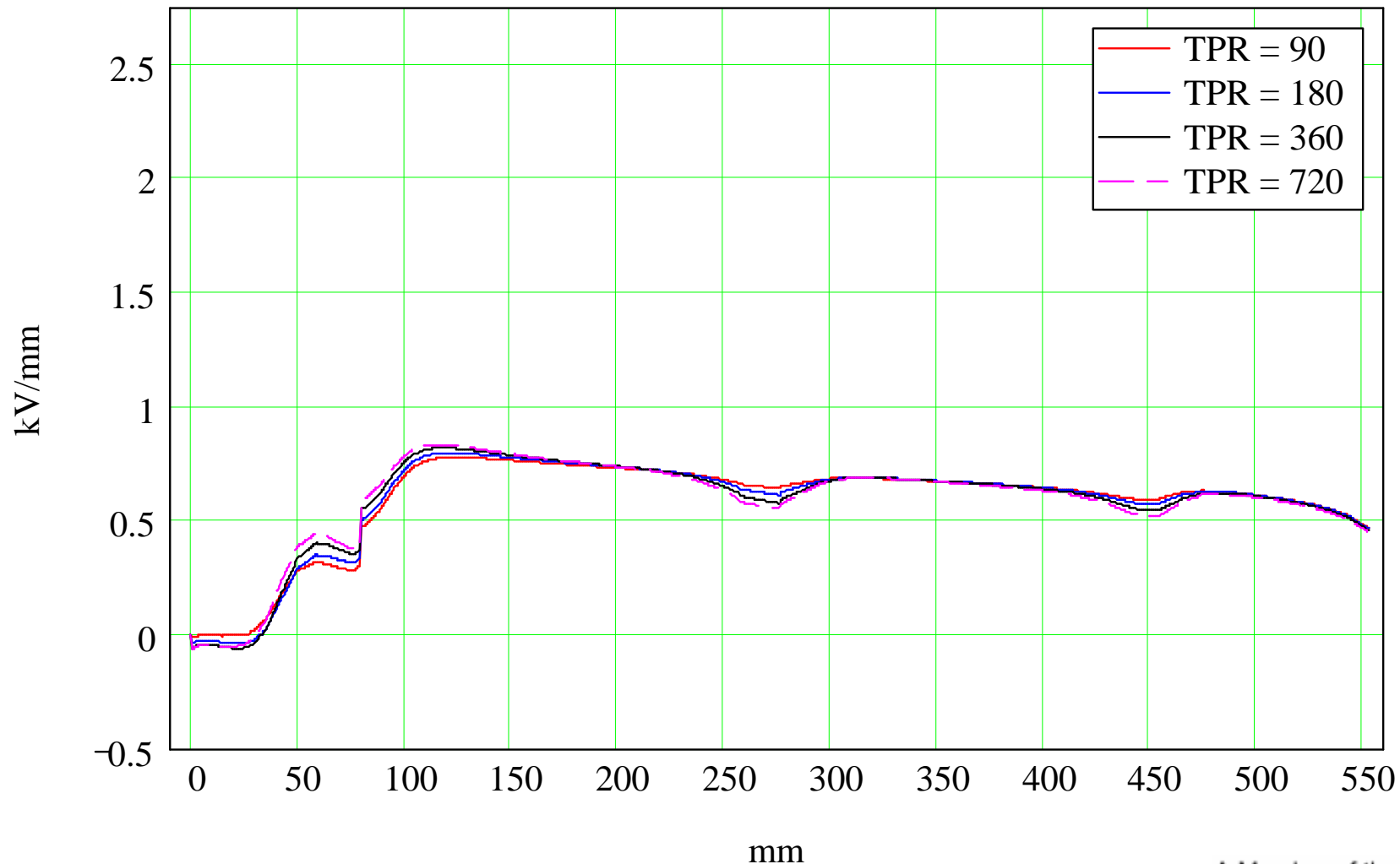
- Oil1 $\sigma = 10^{-13}$ S/m (Case 1)
- Oil2 $\sigma = 10^{-14}$ S/m (Case 2)

Transformerboard TIV $\sigma = 10^{-15}$ S/m

Creep stress on bushing at instant of max peak stress during PR with oil $\sigma = 10^{-13}$ S/m



Creep stress on bushing at instant of max peak stress during PR with oil $\sigma = 10^{-14}$ S/m



Comparison table of bushing max peak creep stresses during PRs

Simulations results are summarized in the table below:

		T_{PR} [min]				
		90	180	360	720	∞
σ Oil [S/m]	10^{-13}	0.819	0.905	0.968	0.994	1.000
	10^{-14}	0.288	0.294	0.302	0.308	0.310

1 pu = max peak creep stress on bushing with a PR from DC steady state and oil conductivity = 10^{-13} S/m

Effects of polarization time

- The peak stress with the current 90-90-45 min PR test achieves just 82% of the stress resulting from a PR from DC steady state.
- A 360-360-180 min PR test is recommended.

		T_{PR} [min]				
		90	180	360	720	∞
σ Oil [S/m]	10^{-13}	0.819	0.905	0.968	0.994	1.000
	10^{-14}	0.288	0.294	0.302	0.308	0.310

1 pu = max peak creep stress on bushing with a PR from DC steady state and oil conductivity = 10^{-13} S/m

Effects of oil conductivity

- Oil conductivity affects greatly the severity of the test.
- The effectiveness of PR and DC tests is doubtful if a low conductivity oil is used for tests and an oil with higher conductivity is used in service.

		T_{PR} [min]				
		90	180	360	720	∞
σ Oil [S/m]	10^{-13}	0.819	0.905	0.968	0.994	1.000
	10^{-14}	0.288	0.294	0.302	0.308	0.310

1 pu = max peak creep stress on bushing with a PR from DC steady state and oil conductivity = 10^{-13} S/m

Conclusions

- **360-360-180 min PR test allows for proper DC polarization before reversal.**
- **Severity and therefore effectiveness of PR and DC test depends on oil conductivity during test and in service.**
- **In order to assure effectiveness of DC and PR tests, the issue of oil resistivity during test and in service needs to be addressed.**