HIGH VOLTAGE INTERFERENCE CALCULATION

PIPELINE ROUTING

WHEN CHOOSING PIPELINE ROUTES
IMPORTANT POINTS MUST BE CONSIDERED
SUCH AS :

THE BEST POSSIBLE INTEGRATION IN THE ENVIRONMENT

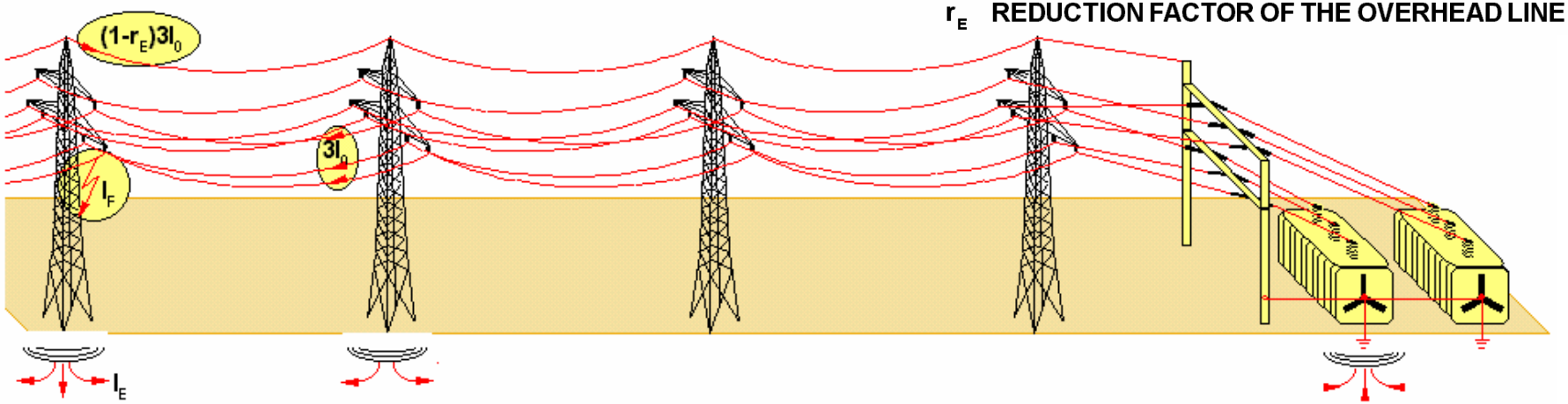
AUTHORITIES REQUIREMENTS FOR REASONS OF
LAND PLANNING AND RURAL PROTECTION

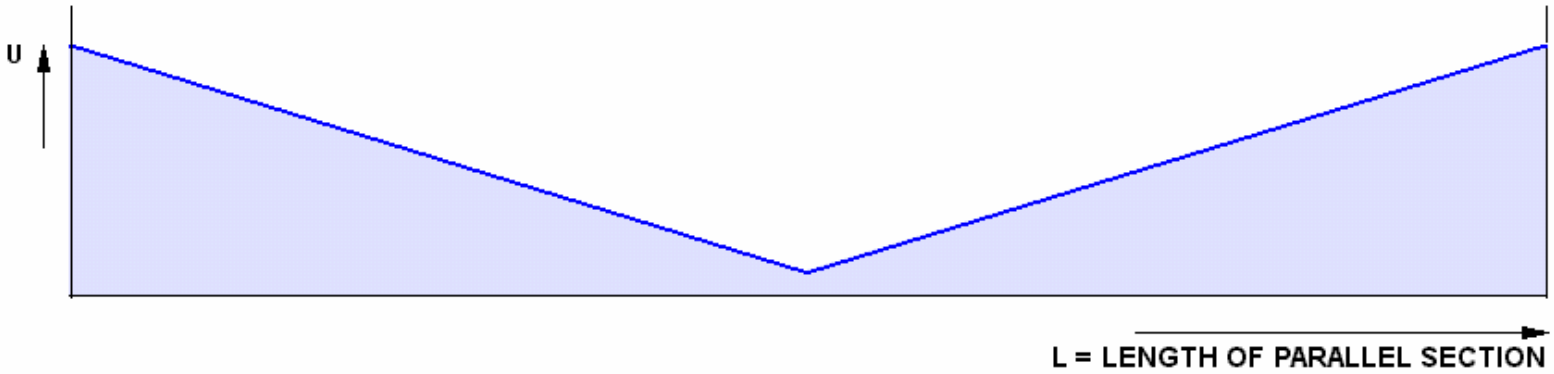
CONGESTED RESIDENTAL AND INDUSTRIAL CENTRES

WHICH RECENTLY LED TO THE NECESSITY OF USING ALREADY
EXISTING HIGH VOLTAGE TRANSMISSION ROUTES

HIGH VOLTAGE INTERFERENCE
INDUCED PIPE TO SOIL VOLTAGE

$3I_0$ TRIPLE ZERO SEQUENCE SYSTEM CURRENT
I_F EARTH FAULT CURRENT
I_E EARTHING CURRENT
r_E REDUCTION FACTOR OF THE OVERHEAD LINE



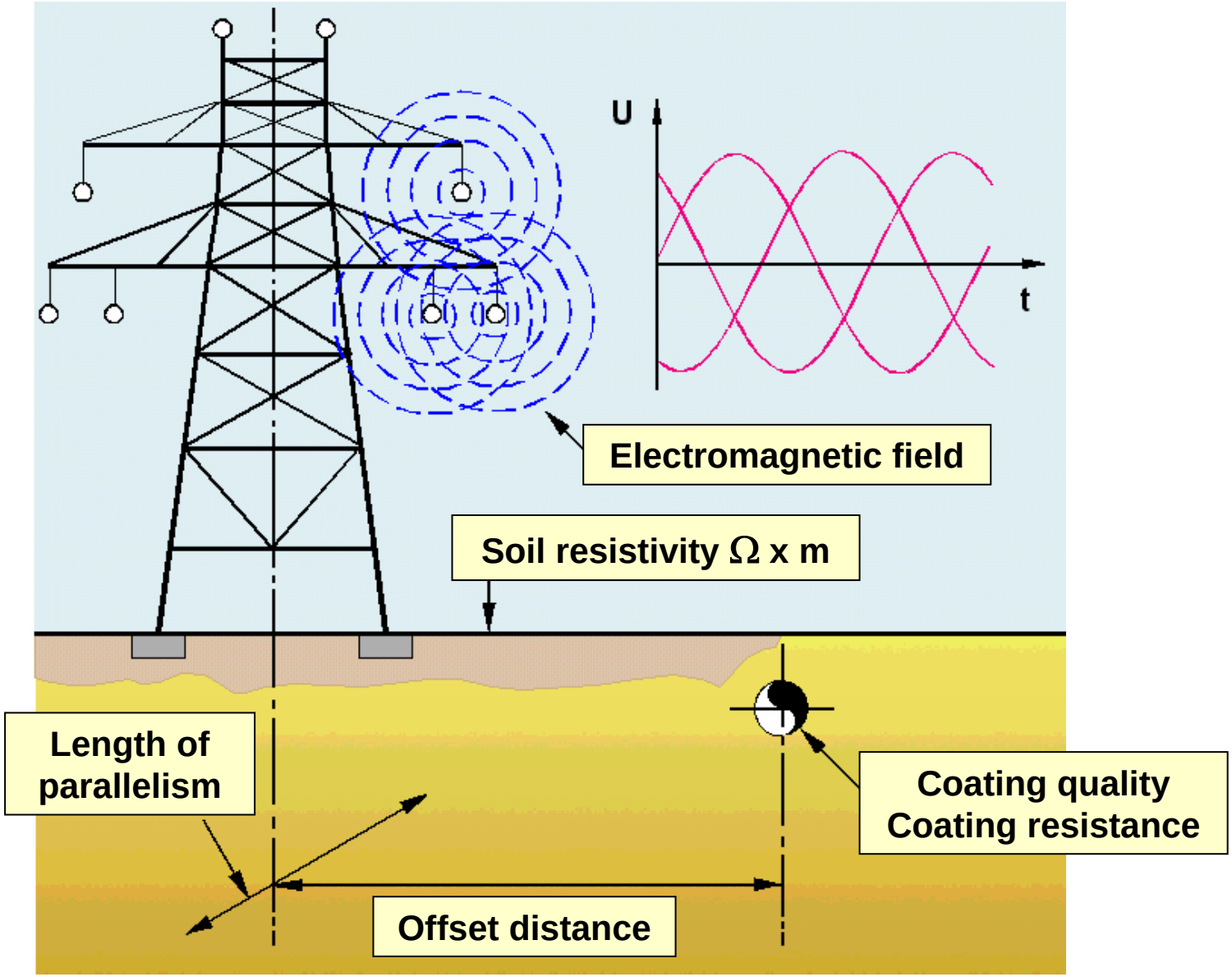


INDUCED PIPE - TO SOIL VOLTAGE IN CASE OF SHORT CIRCUIT (PHASE TO EARTH)

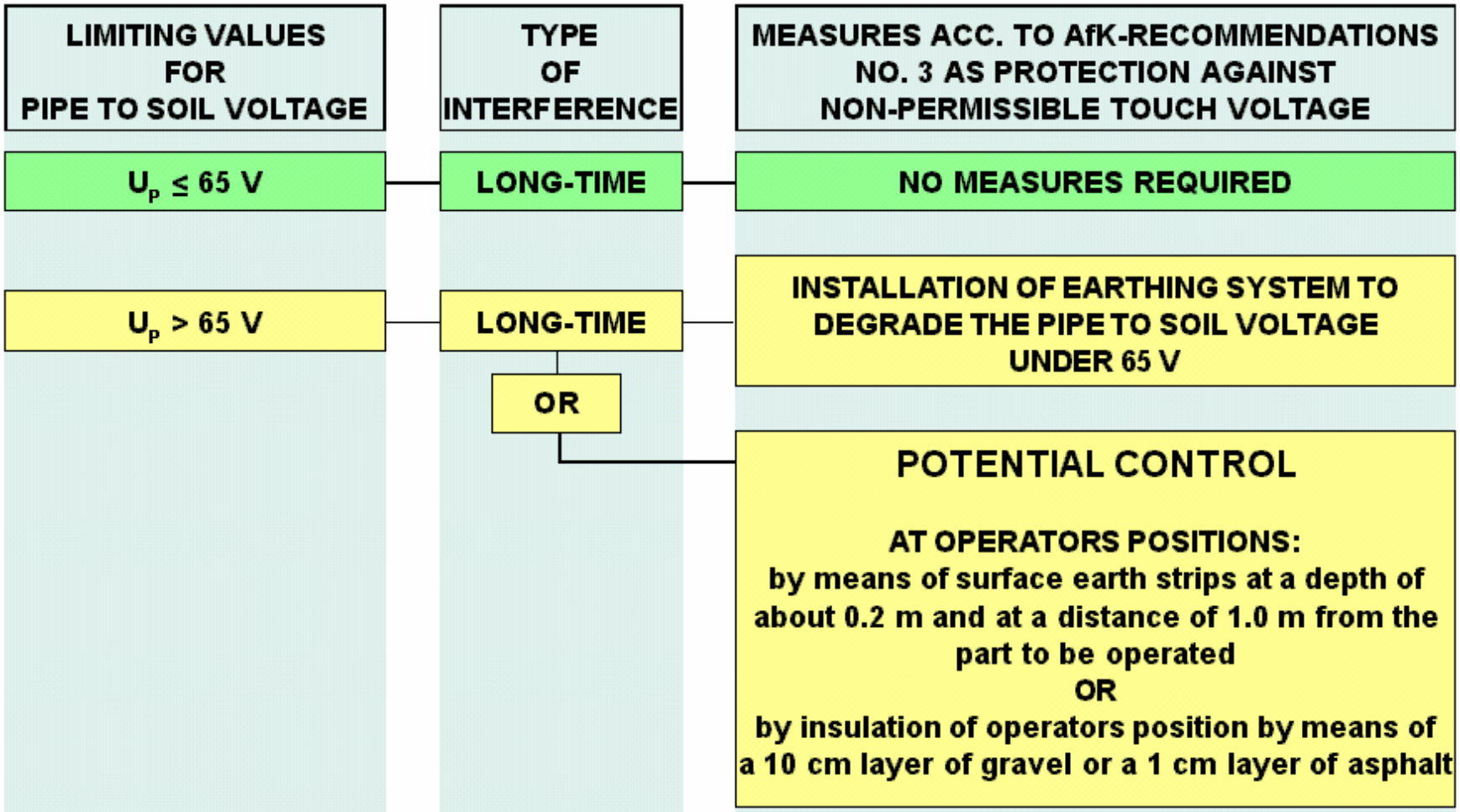
HIGH VOLTAGE INTERFERENCE
INDUCED PIPE TO SOIL VOLTAGE

GCP

SIGNIFICANT PARAMETERS IN ANALYSIS OF HVAC INTERFERENCE ON PIPELINES



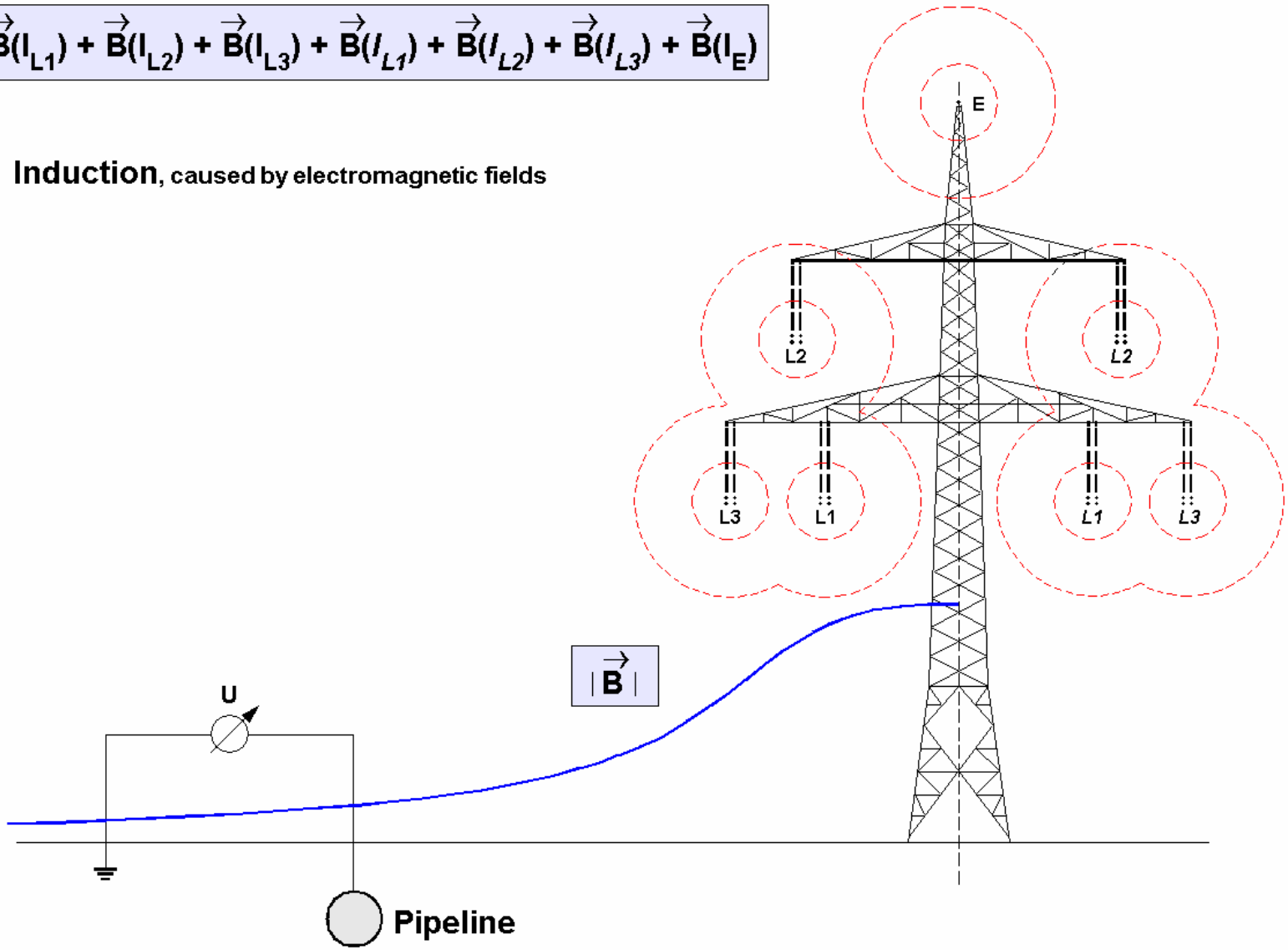
MEASURES AGAINST AC INDUCED VOLTAGES IN UNDERGROUND PIPELINES



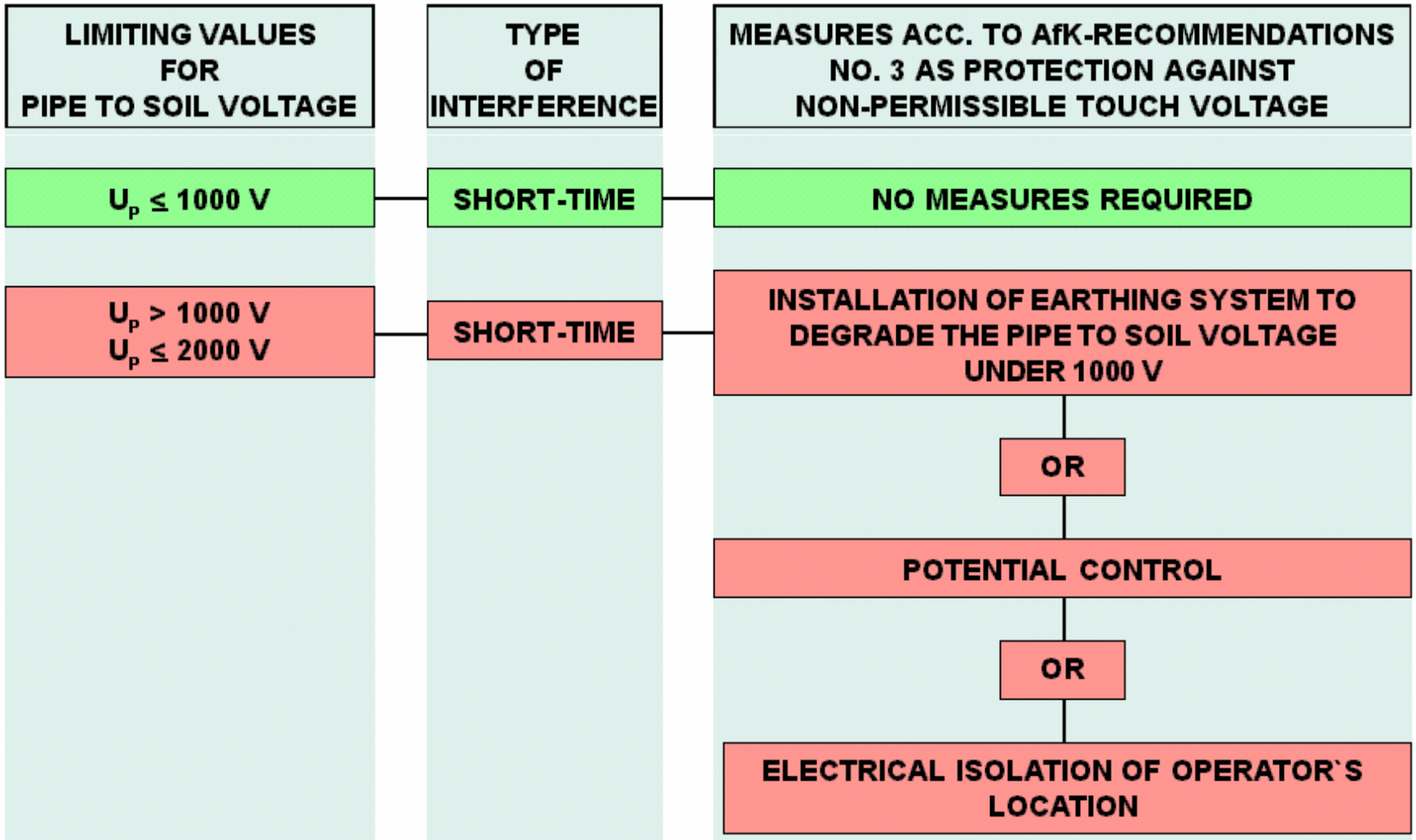
PRINCIPLE OF THE INDUCTIVE INTERFERENCE OF PIPELINES BY OVERHEAD POWER LINES

$$\vec{B} = \vec{B}(I_{L1}) + \vec{B}(I_{L2}) + \vec{B}(I_{L3}) + \vec{B}(I_{L1}) + \vec{B}(I_{L2}) + \vec{B}(I_{L3}) + \vec{B}(I_E)$$

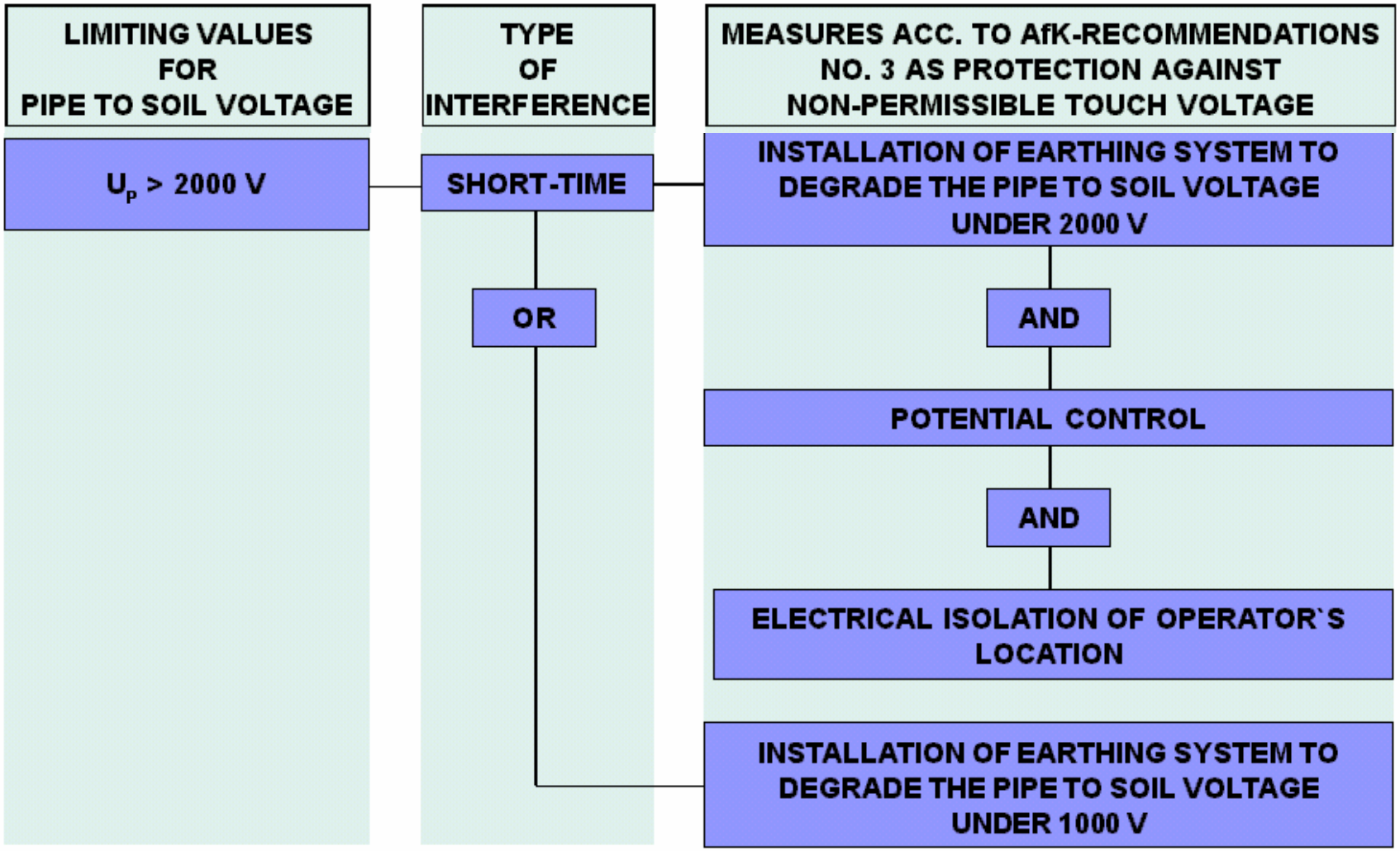
$|\vec{B}|$ **Induction**, caused by electromagnetic fields



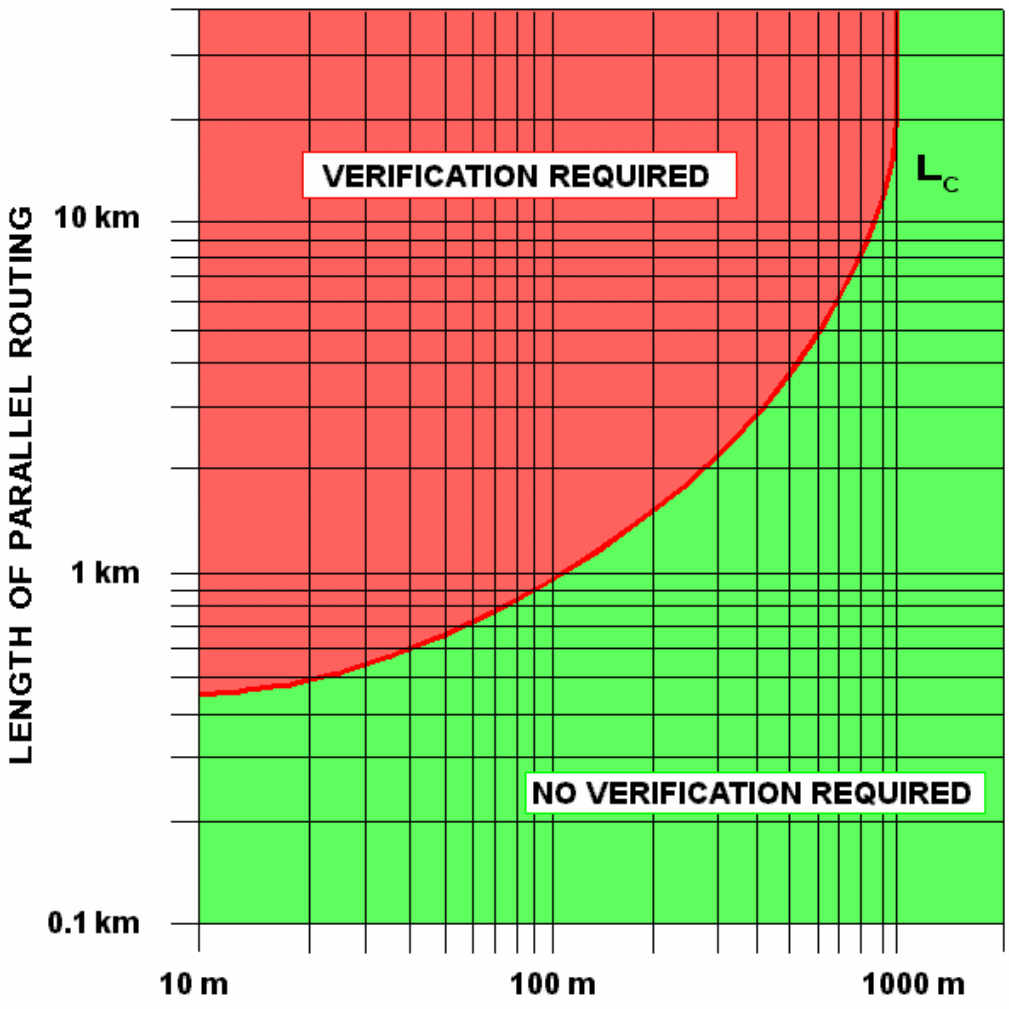
MEASURES AGAINST AC INDUCED VOLTAGES IN UNDERGROUND PIPELINES



MEASURES AGAINST AC INDUCED VOLTAGES IN UNDERGROUND PIPELINES



CALCULATION REQUIREMENTS



CRITICAL LENGTH [L_C] AS A FUNCTION OF DISTANCE BETWEEN PIPELINE AND H.V. - OVERHEADLINE (50 Hz) AND LENGTH OF PARALLEL ROUTING

REQUIRED INPUT DATA FOR CALCULATION

PIPELINE DATA

- Outside diameter of pipeline
- Thickness of pipeline coating
- Distance of pipeline axis to ground level
- Pipeline coating resistance
- Specific soil resistivity

INFLUENCED SECTION DATA

- Start point of section
- End point of section
- Offset distance pipeline – overhead line

OPERATING DATA OF OVERHEAD LINE

- Type of conductor
- Maximum operating current
- Operating frequency
- Neutral point of system
- Short circuit earth fault current
- Diameter and resistance of earth wire

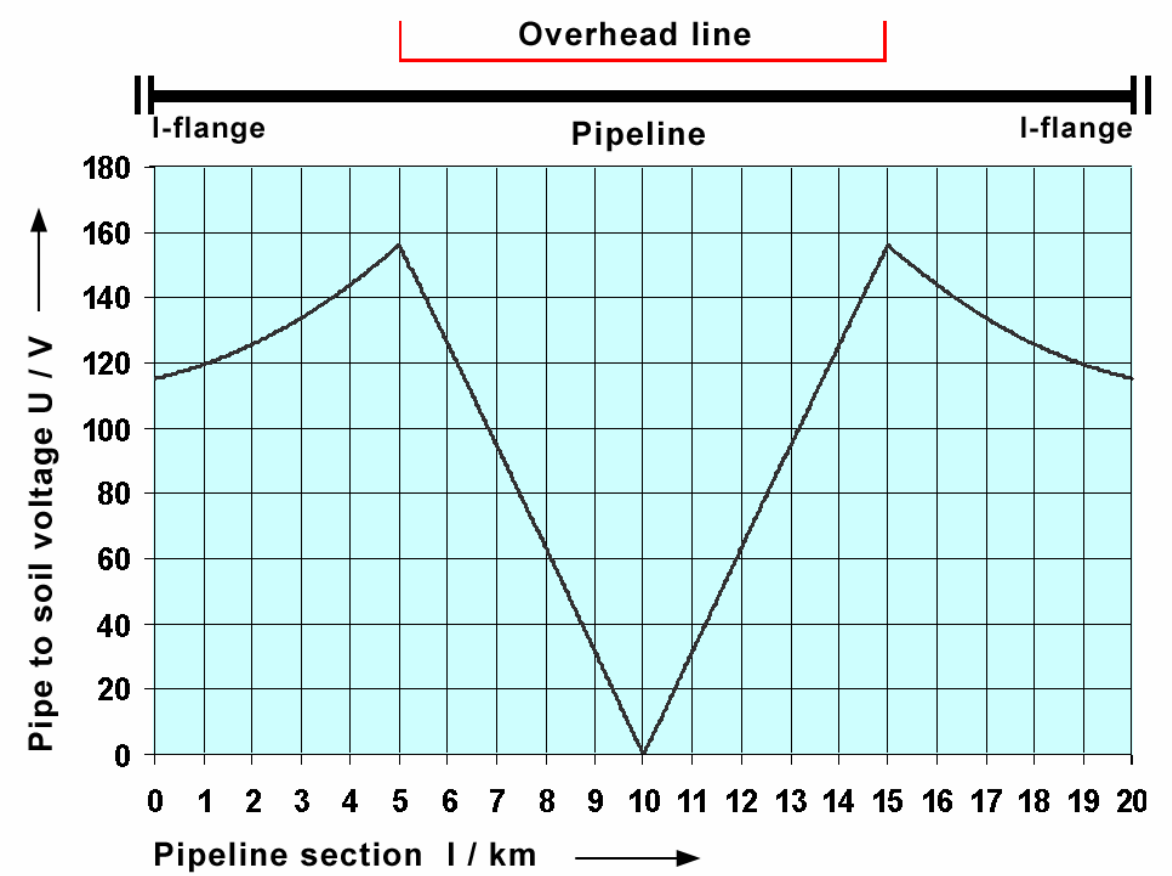
OVERHEAD LINE TOWER DATA

- X – Y coordinates of conductors and earthwire
- Maximum conductor sag

CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

GCP

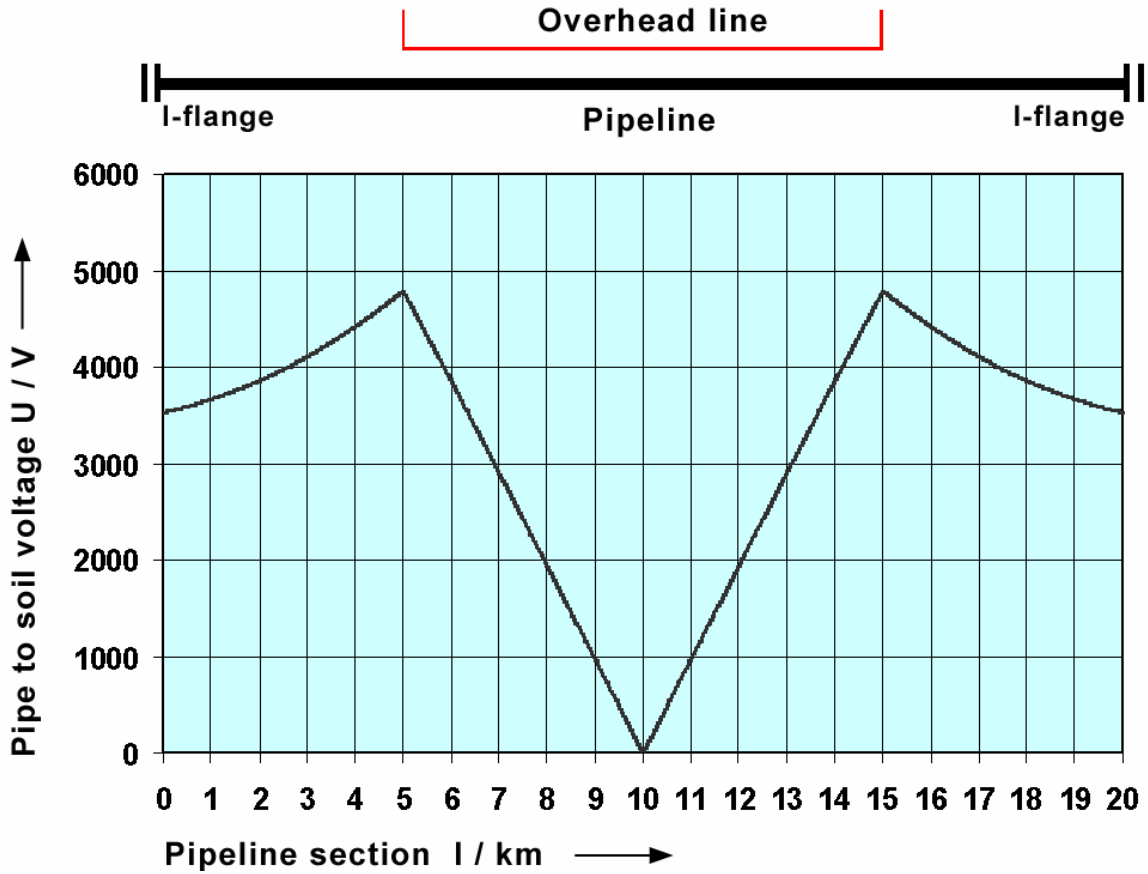
Induced pipe to soil voltage caused by operating currents



Pipeline	**Outside diameter**	**800 mm**
	Coating resistance	**100 kΩ/m²**
	Length of parallism	**10 km**
	Offset distance pipeline-overhead line	**40 m**
Overhead line	**2 three-phase-systems**	**380 kV**
	System operating currents	**1.6 kA**

CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

Induced pipe to soil voltage caused by short circuit current

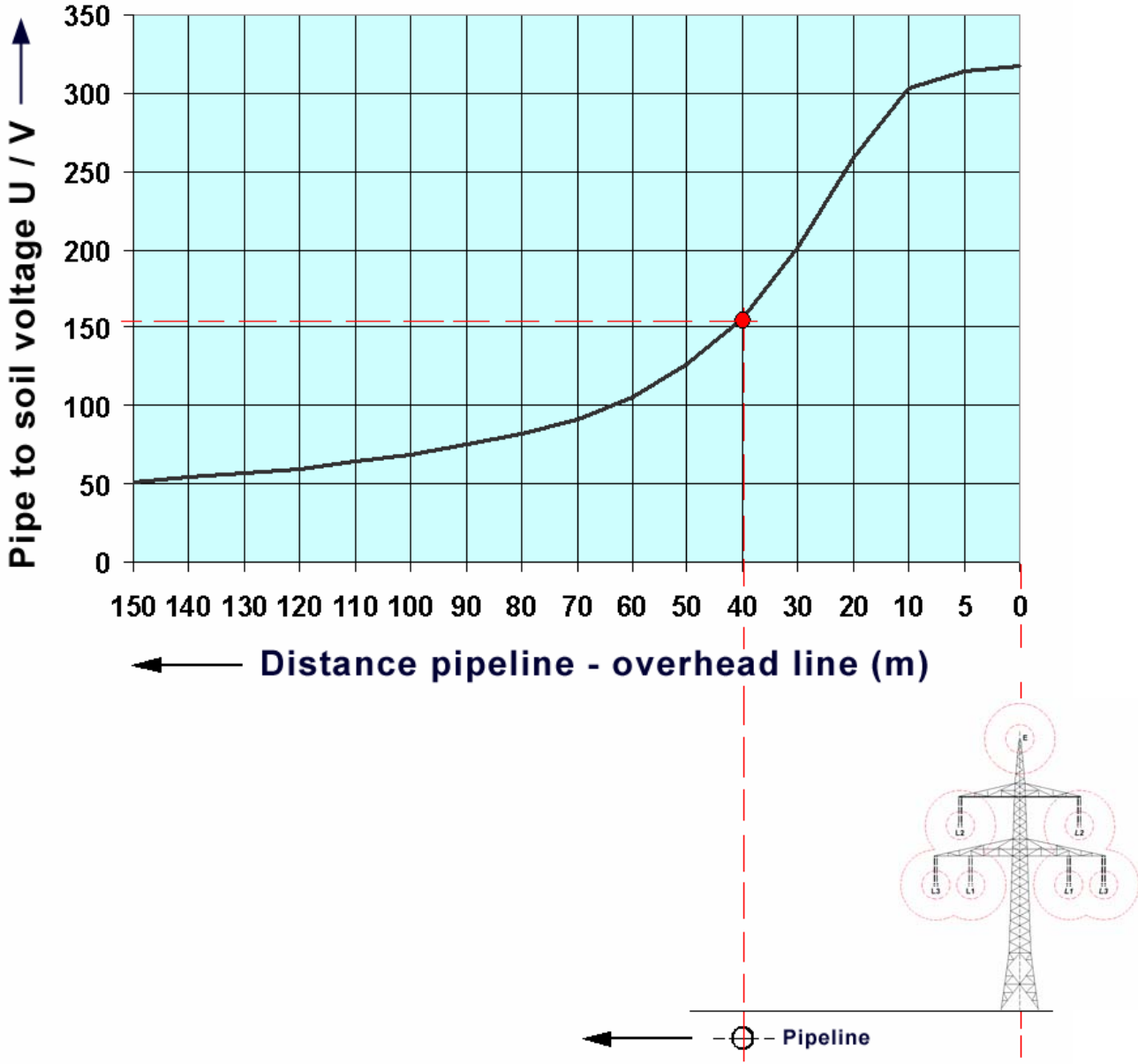


Pipeline	**Outside diameter**	**800 mm**
	Coating resistance	**100 kΩ/m²**
	Length of parallism	**10 km**
	Offset distance pipeline-overhead line	**40 m**
Overhead line	**2 three-phase-systems**	**380 kV**
	Short circuit current	**9.0 kA**

CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

GCP

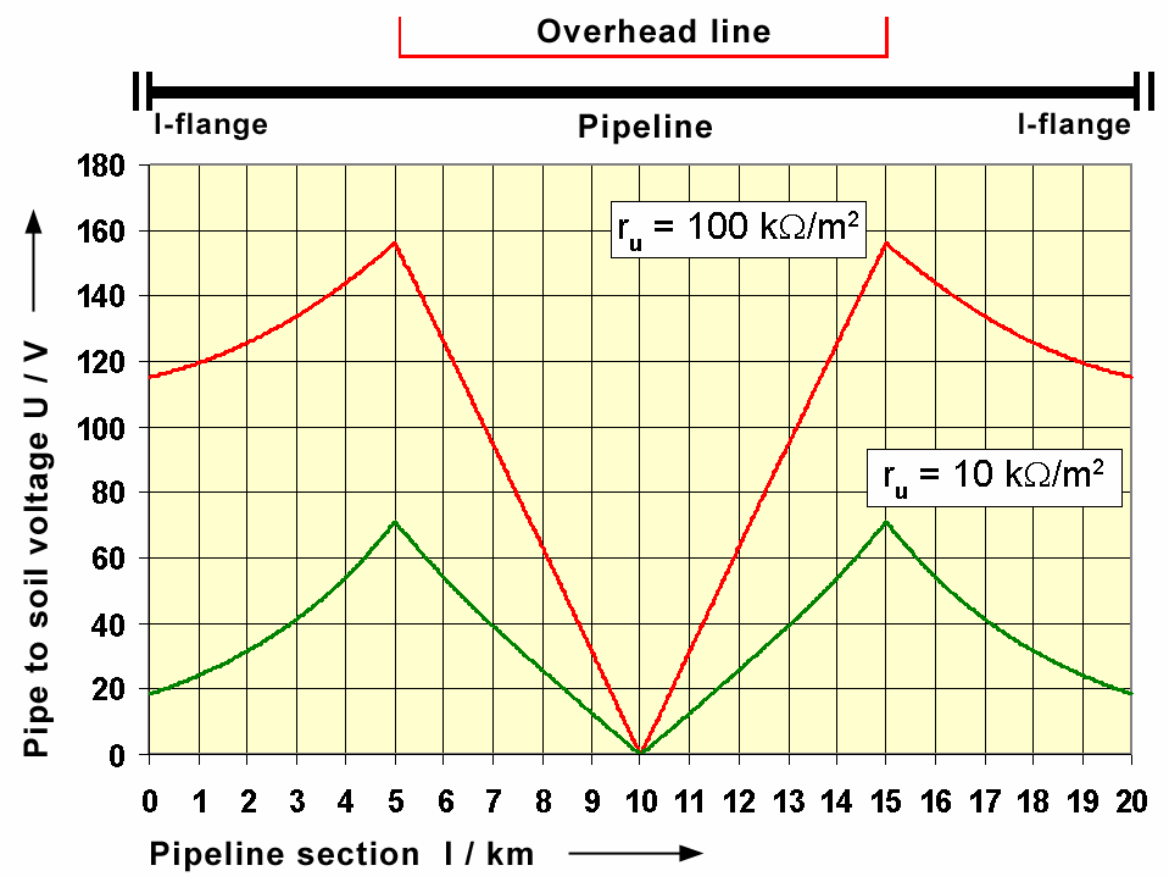
Influence of the distance between pipeline and overhead line



CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

GCP

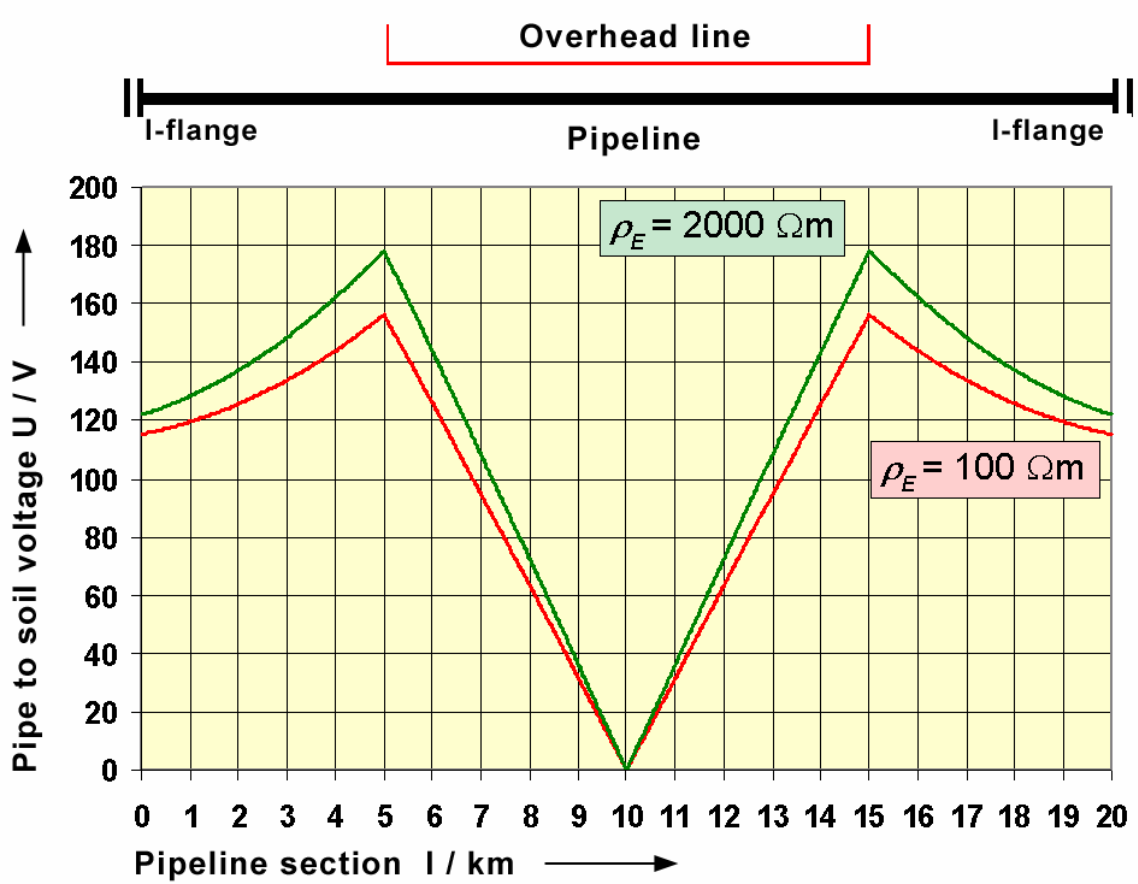
Influence of pipeline coating resistance [r_u]



Pipeline	**Outside diameter**	**800 mm**
	Coating resistance	**100 / 10 kΩ/m²**
	Length of parallism	**10 km**
	Offset distance pipeline-overhead line	**40 m**
Overhead line	**2 three-phase-systems**	**380 kV**
	System operating currents	**1.6 kA**

CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

Influence of specific soil resistance

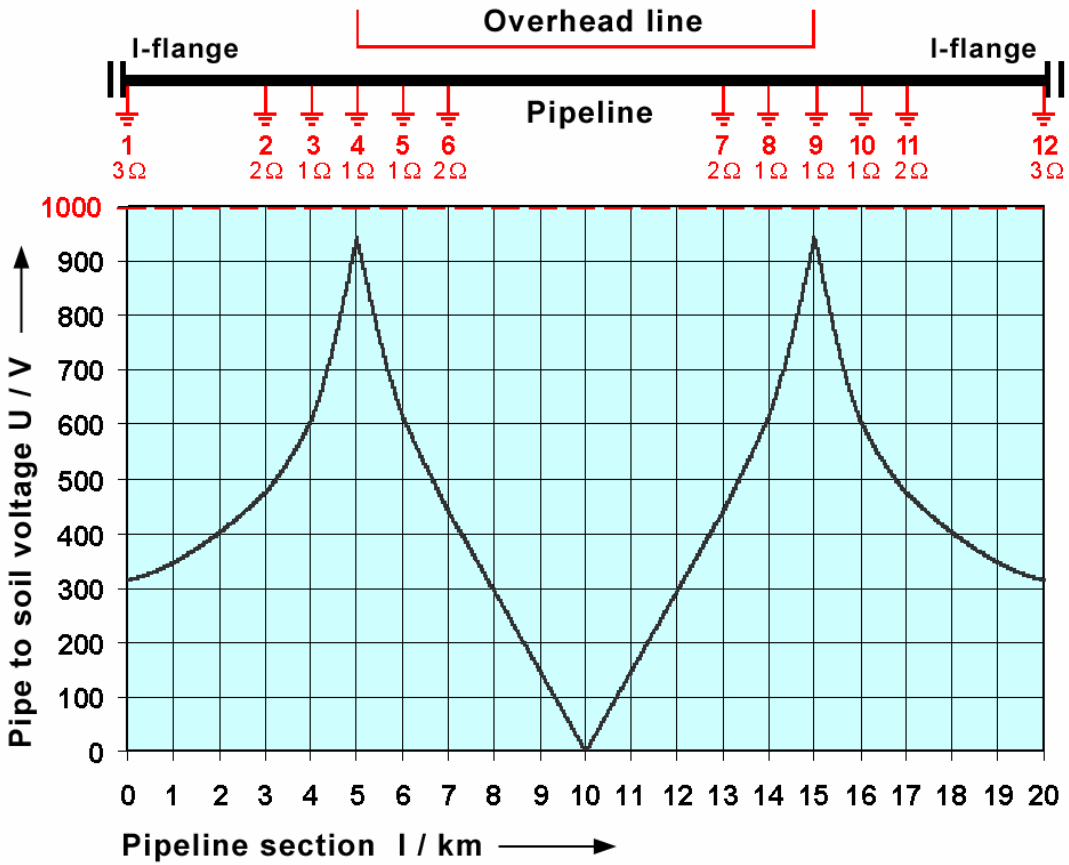


Pipeline	**Outside diameter**	**800 mm**
	Coating resistance	**100 kΩ/m²**
	Length of parallism	**10 km**
	Offset distance pipeline-overhead line	**40 m**
Overhead line	**2 three-phase-systems**	**380 kV**
	System operating currents	**1.6 kA**

CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

GCP

Earthing measures to degrade the pipe to soil potential under 1000 V caused by short circuit current

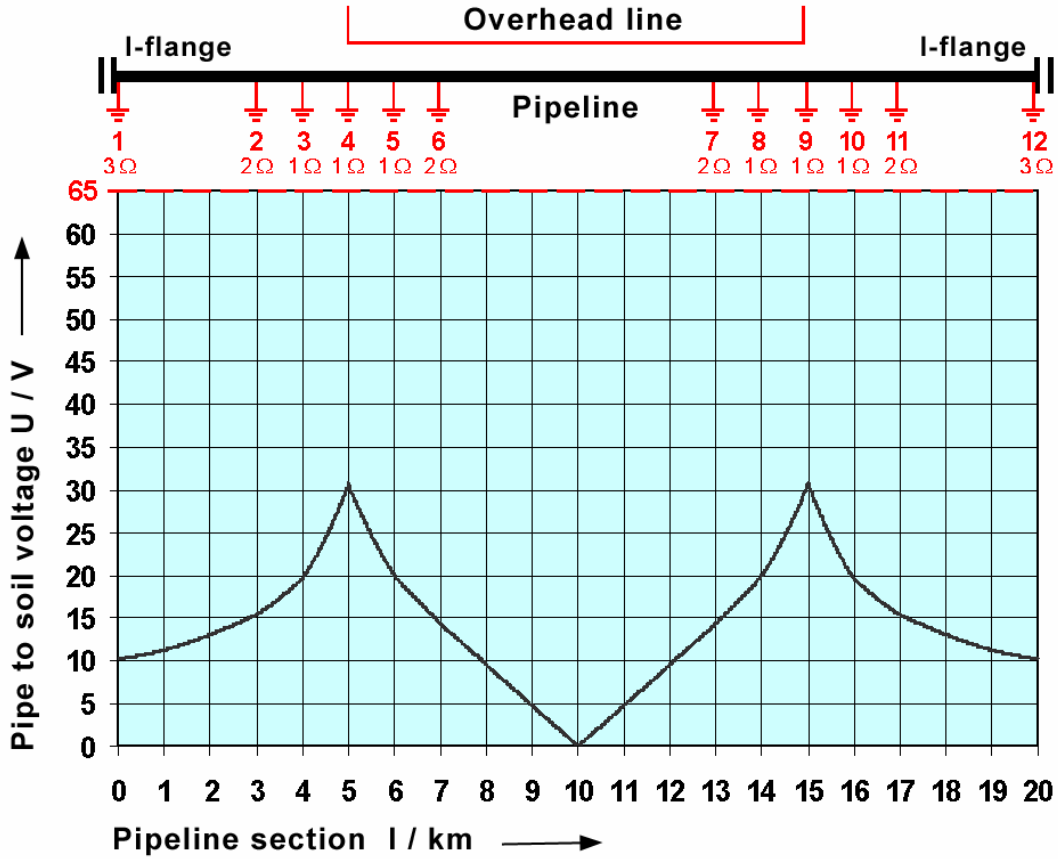


Pipeline	**Outside diameter**	**800 mm**
	Coating resistance	**100 kΩ/m²**
	Length of parallism	**10 km**
	Offset distance pipeline-overhead line	**40 m**
Overhead line	**2 three-phase-systems**	**380 kV**
	Short circuit current	**9.0 kA**

CALCULATION OF INDUCTIVE INFLUENCE ON A PIPELINE ON THE BASIS OF A MODEL SIMULATION

GCP

Earthing measures to degrade the pipe to soil potential under 65 V caused by operating currents



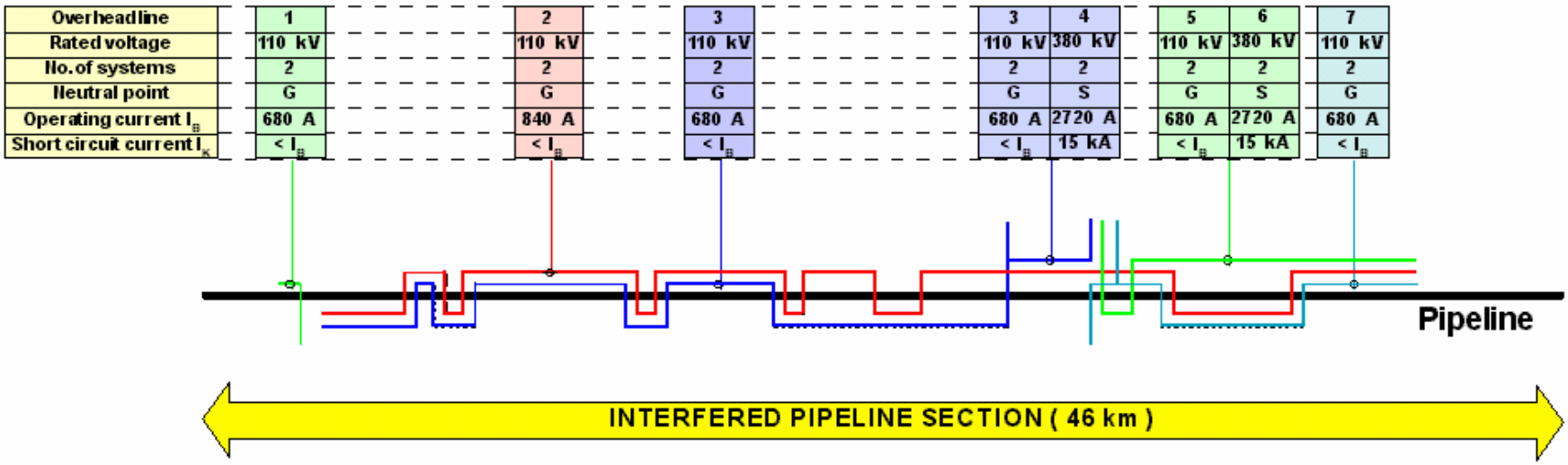
Pipeline	**Outside diameter**	**800 mm**
	Coating resistance	**100 kΩ/m²**
	Length of parallism	**10 km**
	Offset distance pipeline-overhead line	**40 m**
Overhead line	**2 three-phase-systems**	**380 kV**
	System operating currents	**1.6 kA**

SAMPLE CALCULATION – COMPUTER BASED

CALCULATION OF INTERFERENCE

The following is the MIDAL-interference section between km 389 and km 435, consisting of total 39 combined sections is presented as result of calculations.

The figure shows the schematic (without oblique approach) of area plan layout of the pipeline with 7 high voltage overhead lines consisting of 14 individual systems.
The high voltage overhead lines 1, 3, 4, 5, 6 and 7 each with 2 three -phase 50 Hz systems and the high voltage overhead line 2 (Federal German Railways) with 2 two-phase 16 2/3 Hz systems.



G = System neutral (resonant-earthed)
S = Netzsternpunkt (solidly earthed)

Interference by 7 Overhead-lines with a total of 14 systems
Pipeline section km 389 - 435 (Schematic arrangement)

SAMPLE CALCULATION – COMPUTER BASED

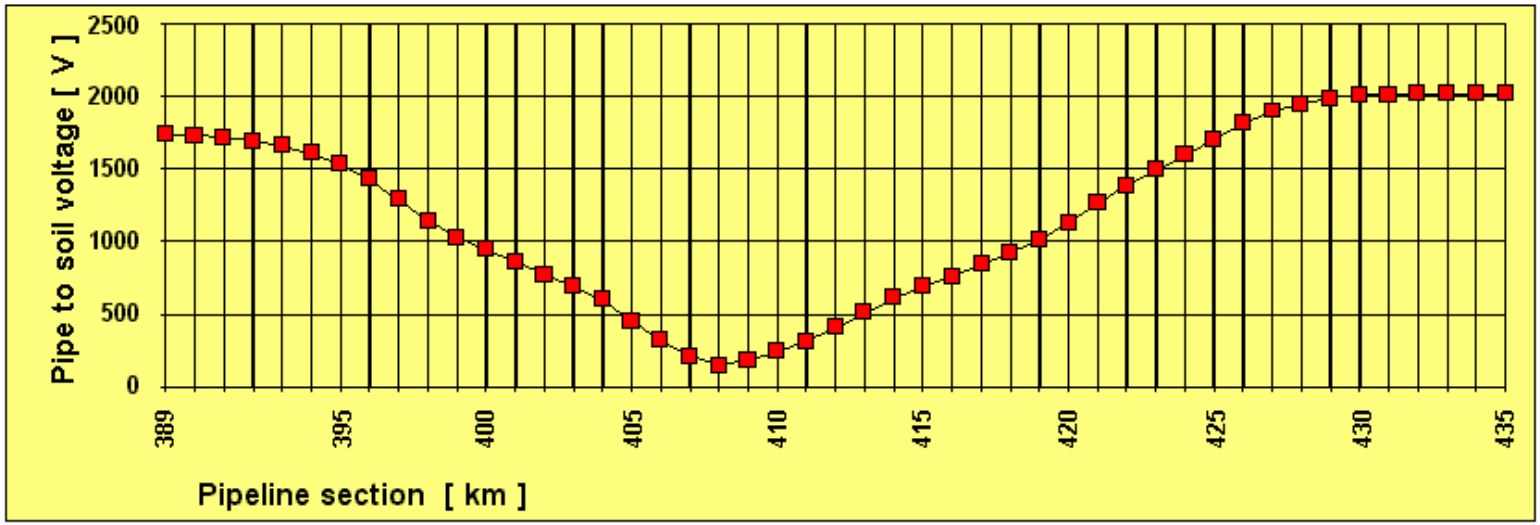


Fig. 4 : Pipe to soil voltage induced by operating currents
Long-time interference without earthing measures

The results of the calculations of the long time interference namely the continuously unchanged pipe to soil voltage along the pipeline route which are effected by the operating currents of the overhead lines are presented in Fig. 4

CALCULATION AND MEASURES AGAINST INTERFERENCE

The limiting value of the pipe to soil voltage as well as of the touch voltage in accordance with AfK-recommendations No. 3 without additional protection measures, is fixed with 65 V for long time interference. By over limitation, protective measures shall be met so that the isolation position is mostly separated, additional grounding measures shall be met to build-down the high pipe to soil voltage in order to avoid dangers.

SAMPLE CALCULATION – COMPUTER BASED

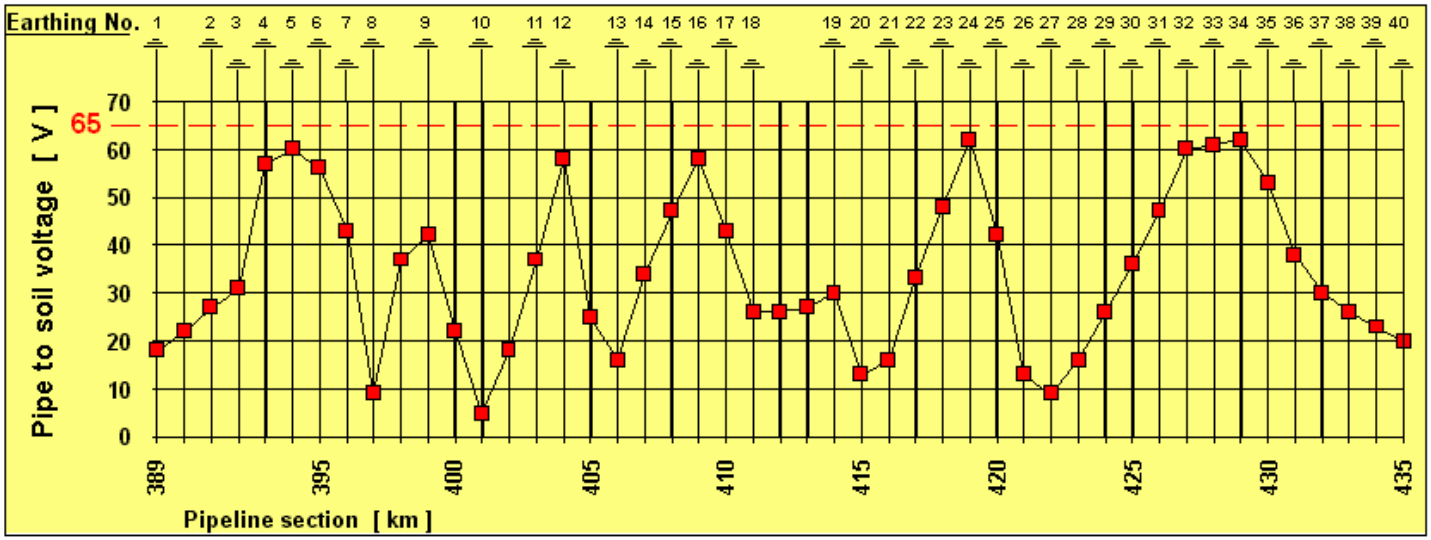


Fig. 5 : Pipe to soil voltage induced by operating currents - Earthing measures effective

In the given example necessary grounding measures on the pipeline are calculated, optimized and documented by the Computer program.

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Under consideration of the investigated specific soil resistivities in the interference sections, the following required data are made available for the practical applications :

- **40 single-grounding measures each with the required prepared resistances**
- **Geometrical arrangements of the connection points on the pipeline**
- **Pipe to soil voltage curve with effective grounding measure.**

SAMPLE CALCULATION – COMPUTER BASED

As the earthing measures was calculated first for the long-time interference only a second calculation for short-time interference with effective earthing measures had to be examined.

Short-time interference appears through short-circuit currents in solidly earthed overhead line systems. It is a relatively rare interference case by very short duration, since short-circuits in solidly earthed systems are switched off within 0.5 seconds.

According to AfK-recommendation no. 3 the pipe to soil voltage / touch voltage may not overstep 1000 V in this case.

Figure 6 shows the voltage profile at a short-circuit of overhead line no. 6. As the pipe to soil voltage as shown in figure 6 is much below the allowable level (1000 V) the layout of the earthing system had not to be modified.

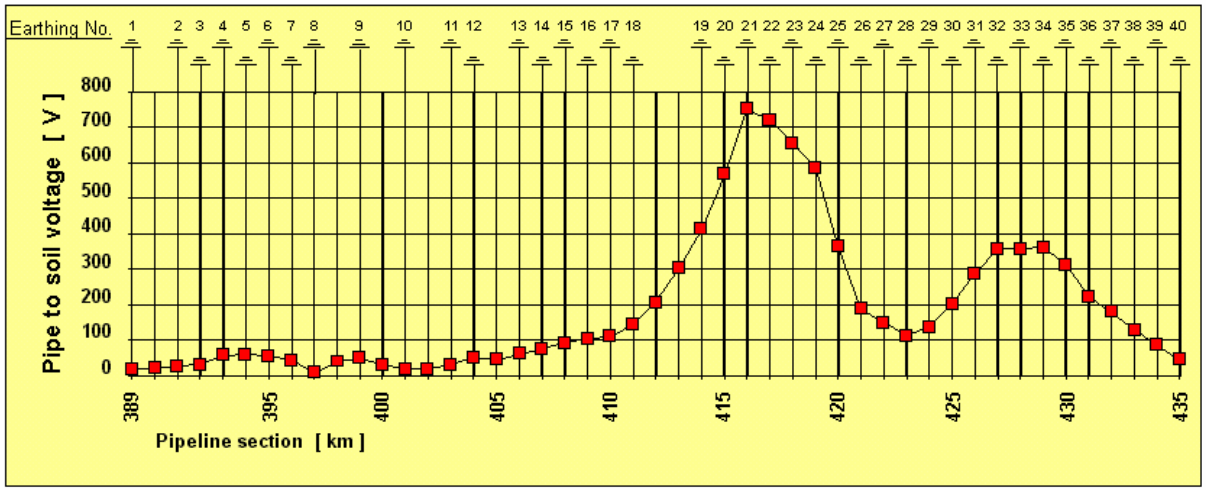
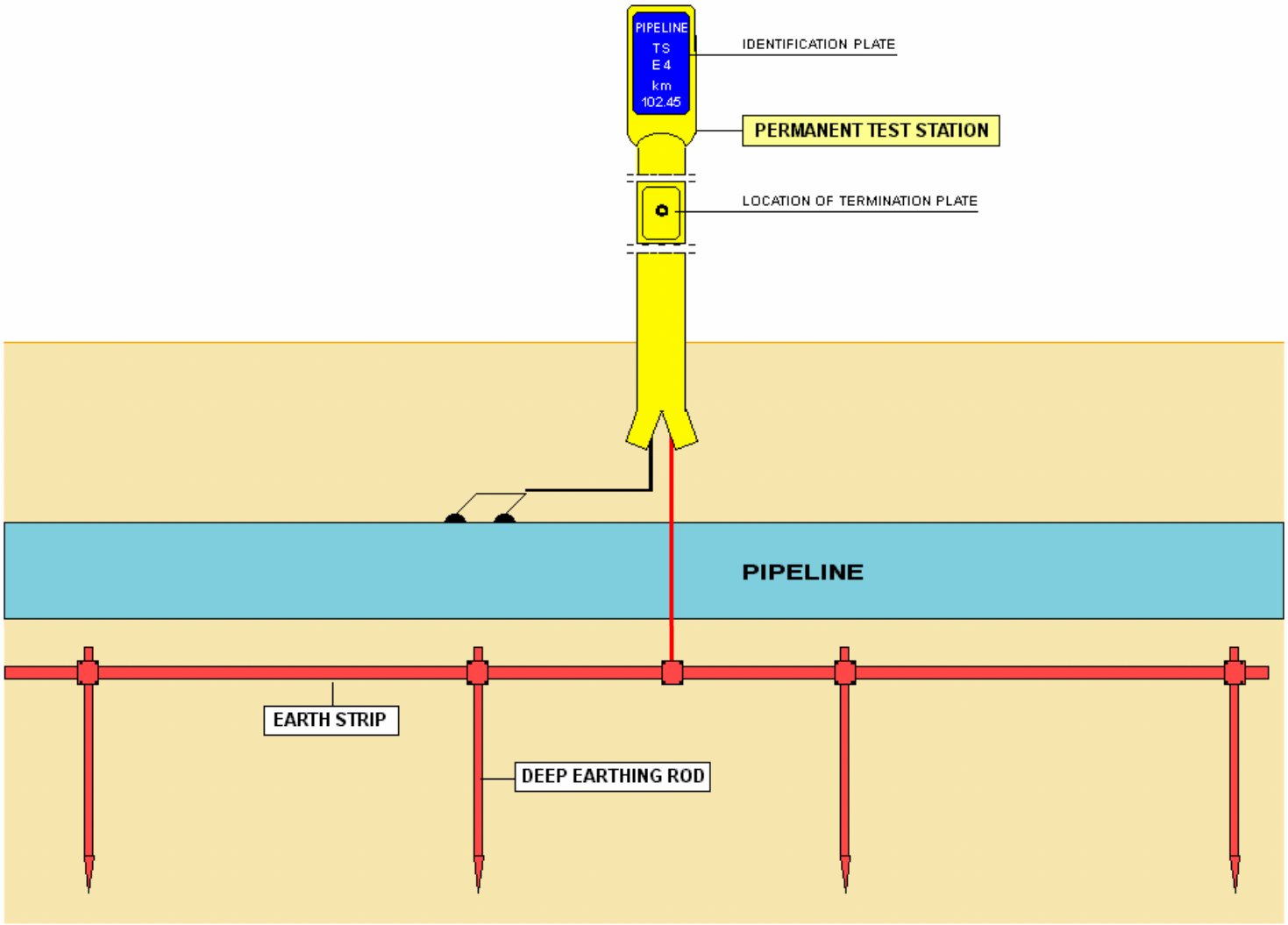


Fig. 6 : Pipe to soil voltage induced by short-circuit currents
Earthing measures effective

TYPICAL EARTHING MEASURE ON HIGH VOLTAGE INTERFERED PIPELINE



AC-VOLTAGE LIMITATION DEVICE

TO AVOID

CIRCULATION OF D.C. - CURRENTS

ESSENTIALLY HIGHER PROTECTIVE CURRENT REQUIREMENT

INADMISSIBLE DANGEROUS CONTACT VOLTAGE FOR OPERATING PERSONNEL

TO GUARANTEE

IR - FREE POTENTIAL MEASUREMENT

OPTIMUM PROTECTION RANGE