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OVERCOMING THE NEW THREAT TO PIPELINE INTEGRITY

- AC Corrosion Assessment and its Mitigation -

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1. Background

1) Increase in the pipelines paralleling overhead HVAC power transmission lines and/or AC-powered rail transit systems
2) Increase in the high resistivity coatings such as extruded polyethylene

Increase in the AC corrosion risk on buried pipelines

AC corrosion case history

Author	Case	Coatings	CP level	Cause
W. Printz, 1992 (Germany)	A leak, 1986	PE (1980)	E_{OFF}: –1.0V	AC train
F. Stalder, 1997 (Switzerland)	100 metal losses, 1987	PE		AC train
I. Ragault, 1998 (France)	31 metal losses, 1993	PE	E_{ON} : –2 to –2.5V	HVAC power line
R. Wakelin, 1998 (North America)	A metal loss (0.29mm/y), 1995	CE (1972)		HVAC power line
	A leak (1.4mm/y), 1991	PE，5.6WT (1987)		HVAC power line
R. Wakelin, 2004 (US)	A leak (0.6mm/y), 2002	PE，6.4WT (1991)	E_{ON}: –1.35V	HVAC power line
R. Floyd, 2004 (US)	A leak (1.6mm/y), 2002	FBE, 4.7WT	E_{OFF}: –1.265 to –1.056V	HVAC power line
H. R. Hanson, 2004 (US)	4 leaks (Max 10mm/y), 2001	FBE, 5.6WT (2000)		HVAC power line
C. M. Movley, 2005 (UK)	93 metal losses (Max 1.3mm/y), 2002	FBE, 5.6WT (1999)		HVAC power line

Needs to establish new CP criteria

Pipe-to-soil potential CP criteria (ex. $-0.85V_{CSE}$) are not applicable for the assessment of AC corrosion risk.

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New CP criteria based on DC and AC current densities (AC = 50Hz)

2. Experimental and Results

2.1 Studies on new CP criteria

- Corrosion rate measurement in laboratory and field tests
- Establishment of new CP criteria based on I_{DC} and I_{AC}

2.2 Studies on AC mitigation methodology

- Earthing using Mg anodes and/or DC decoupling device
- Compatibility with CP system

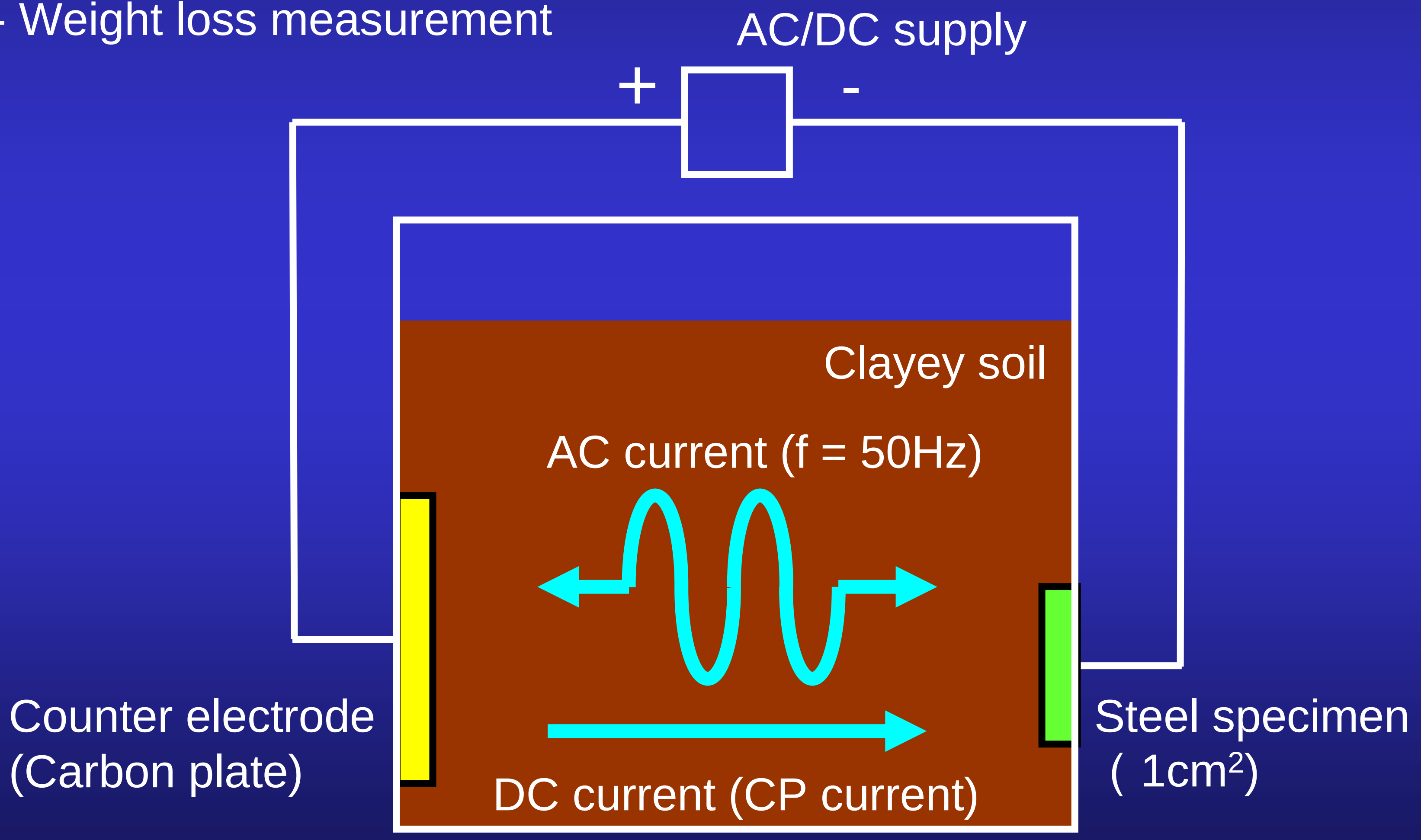
2.3 Studies on the effectiveness of the criteria & AC mitigation

- In proximity to an overhead HVAC power line
- In proximity to an AC-powered rail transit system

2.1 Studies on new CP criteria

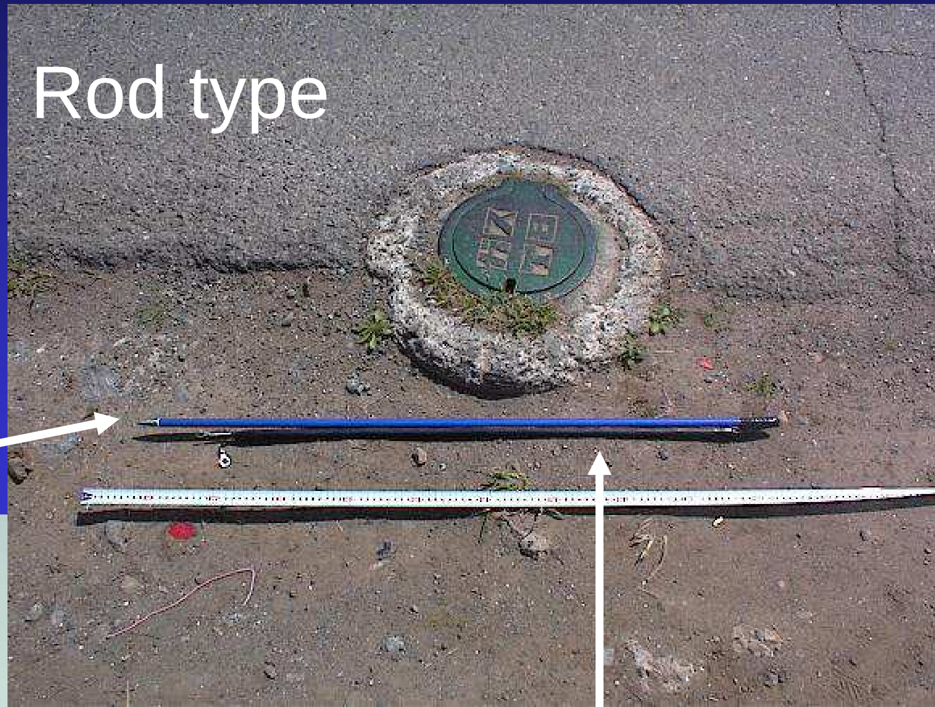
(1) Laboratory tests

- Various levels of I_{DC} and I_{AC}
- Weight loss measurement

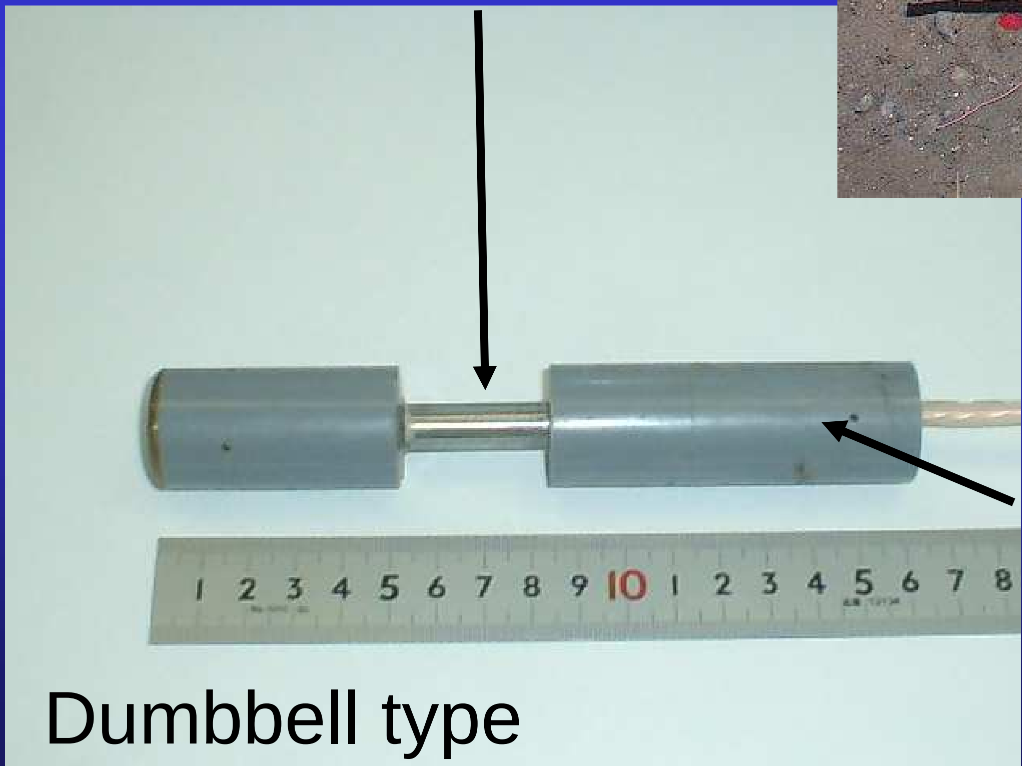


(2) Field tests

Tokyo Gas Coupon

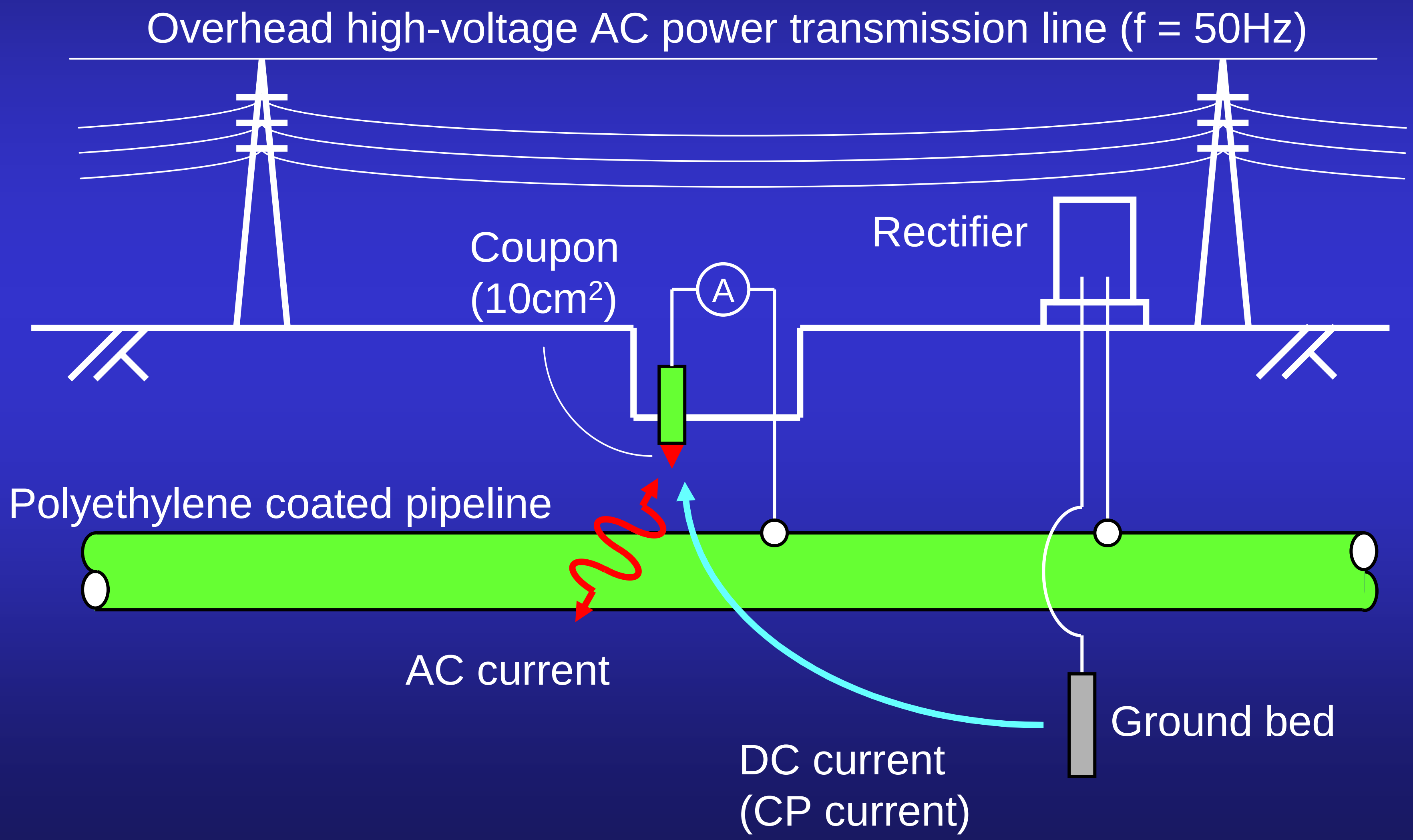


Exposed surface ($10 cm^2$)



High resistivity coating

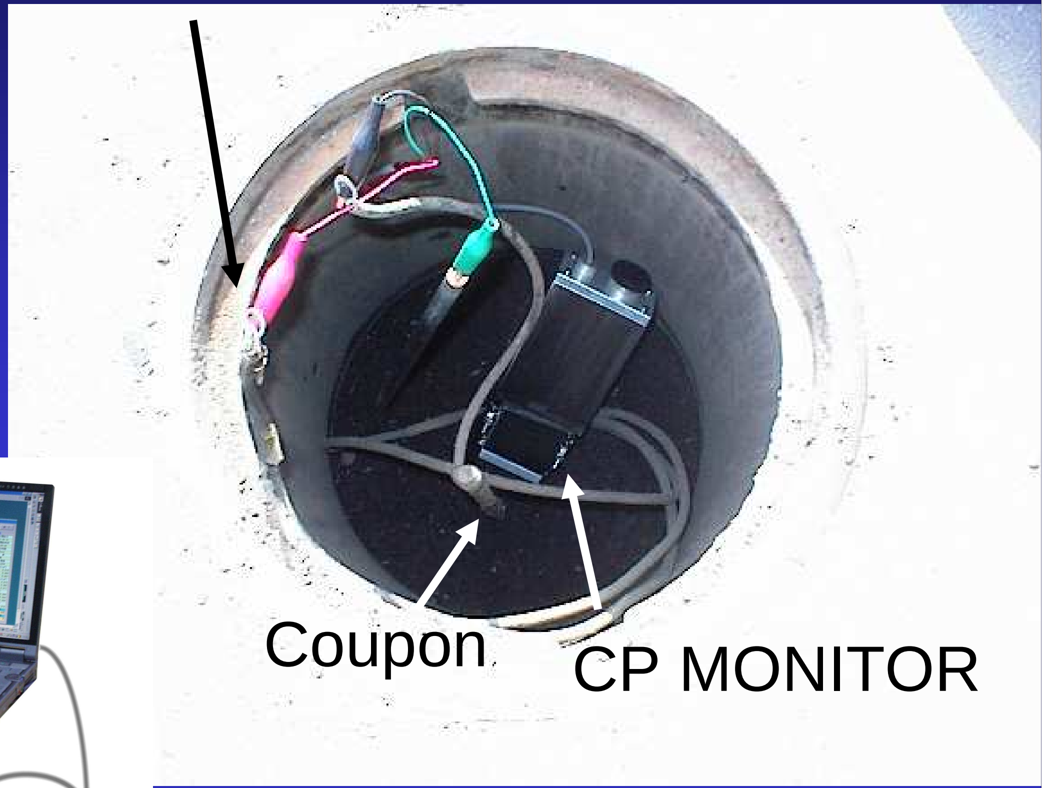
- Simultaneous measurement of I_{DC} and I_{AC}
- Weight loss measurement



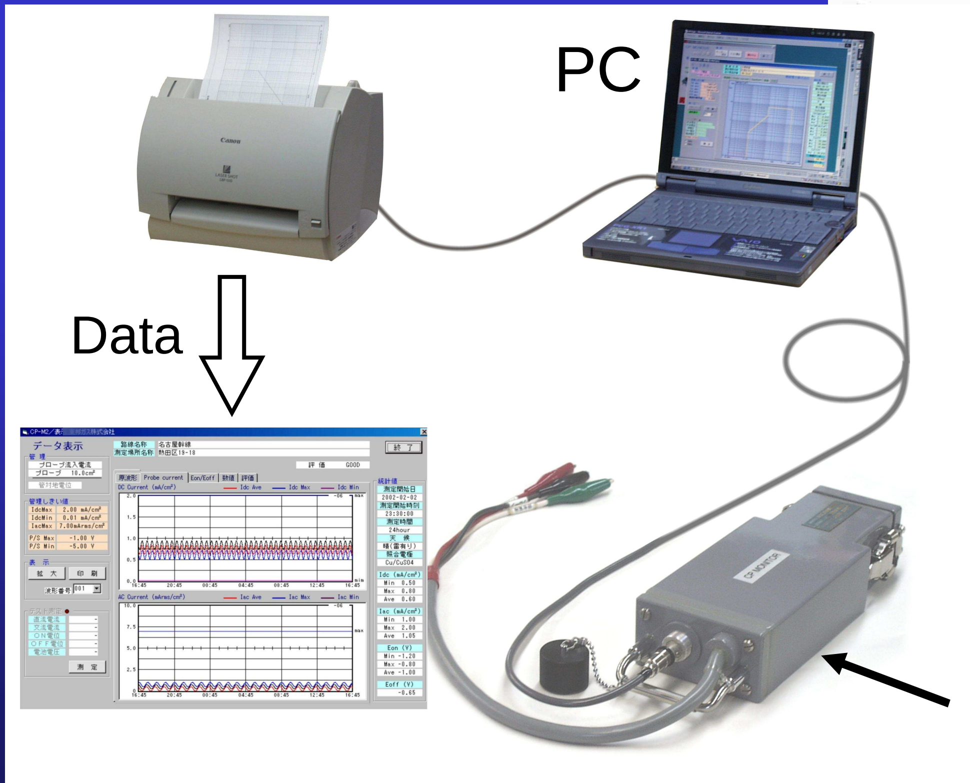
New instrument
"CP MONITOR"

Pipe cable

In a test station



Measurement system



CP MONITOR

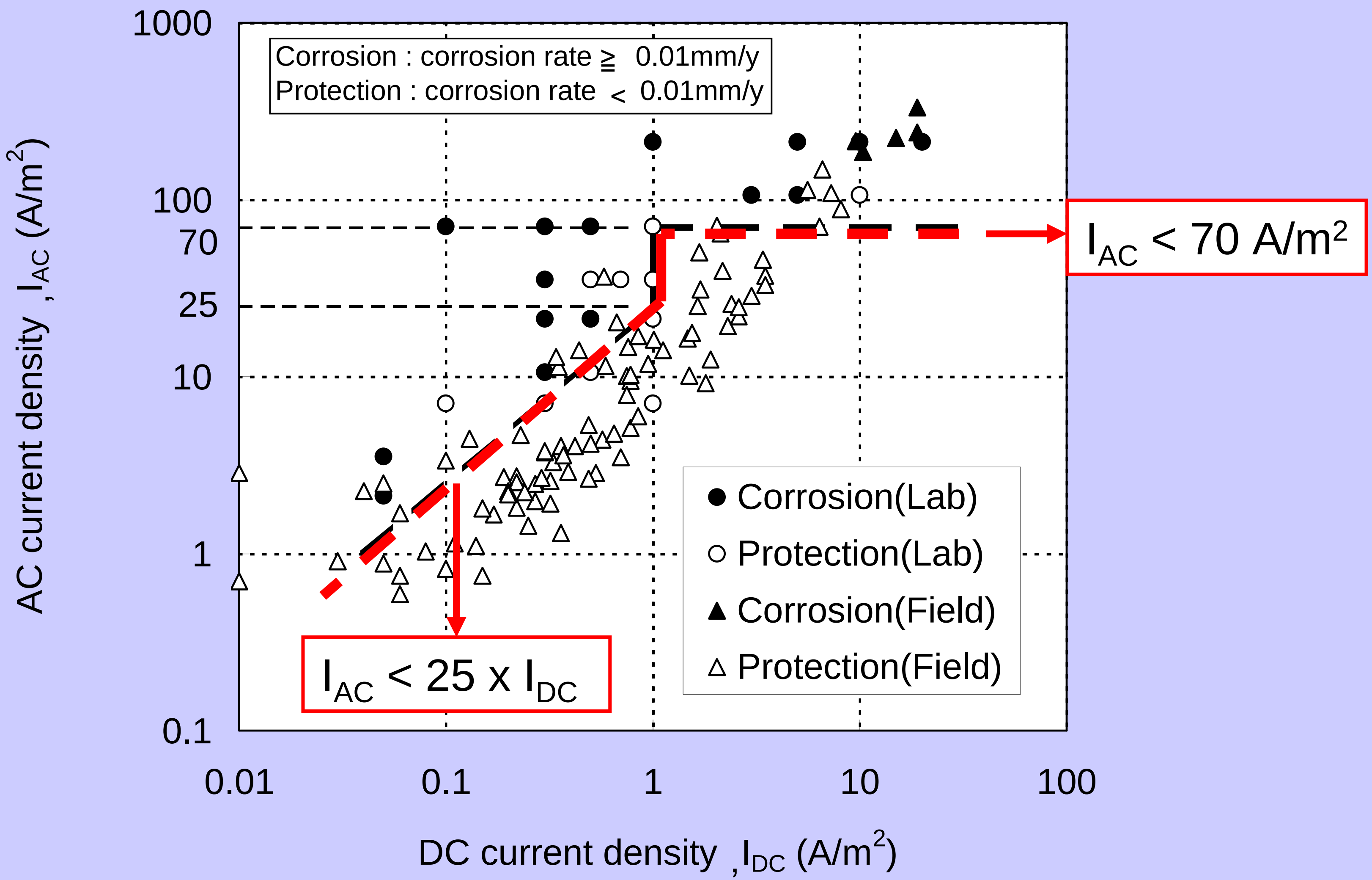


Fig.1 Effect of I_{DC} and I_{AC} on corrosion rate.
(AC frequency 50Hz)

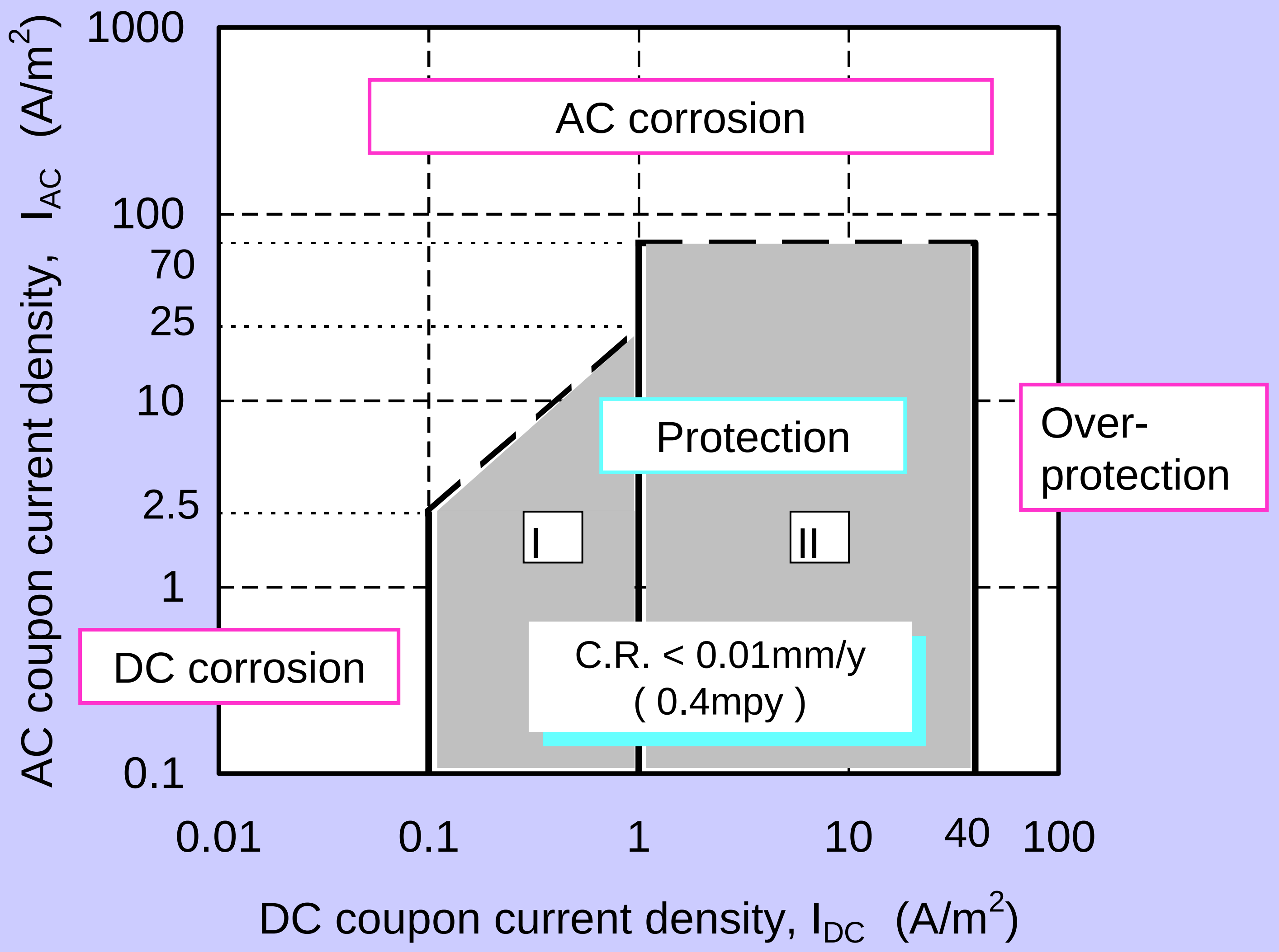


Fig.2 Current density CP criteria (AC 50Hz)

2.2 Studies on AC mitigation methodology

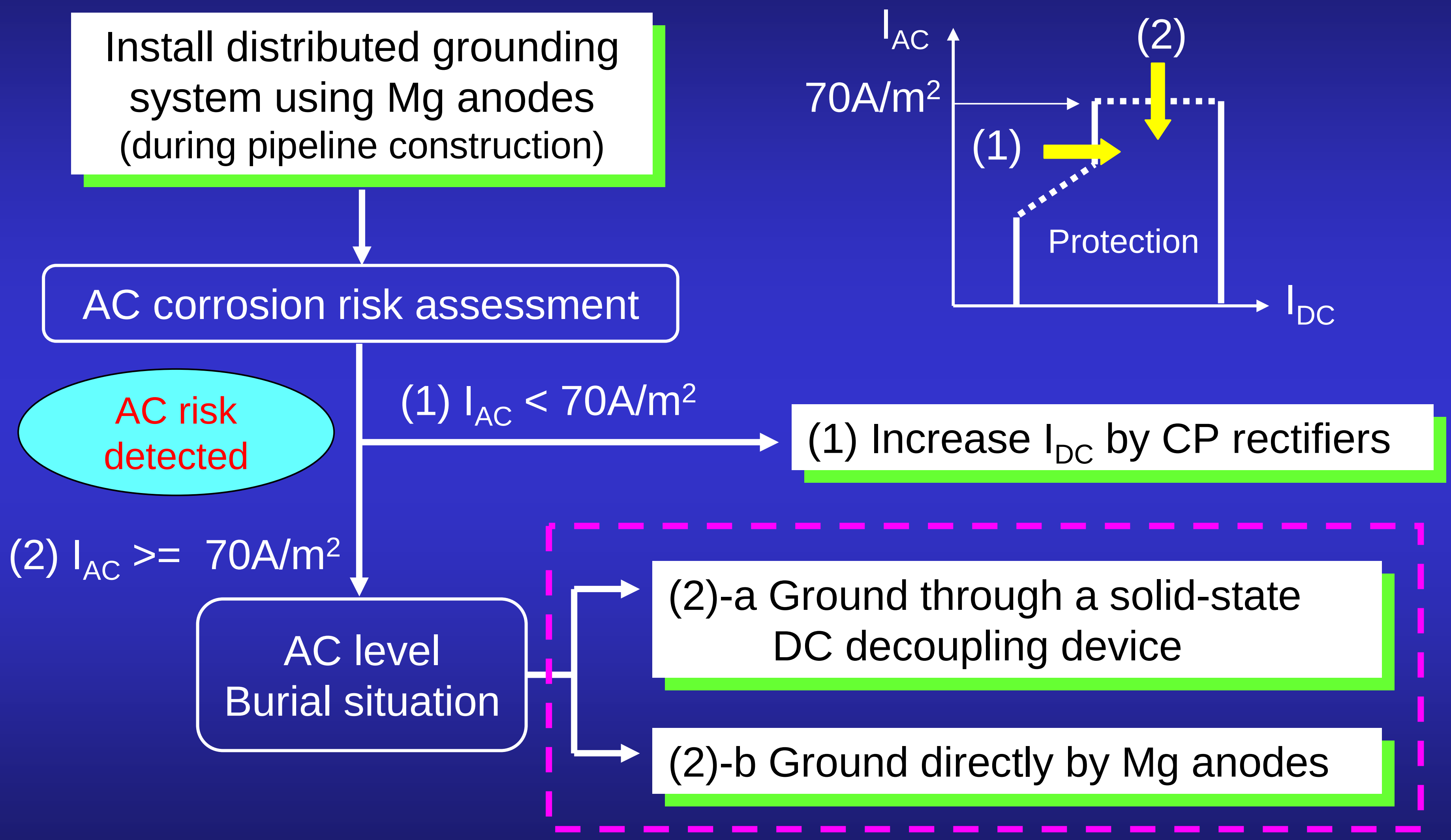
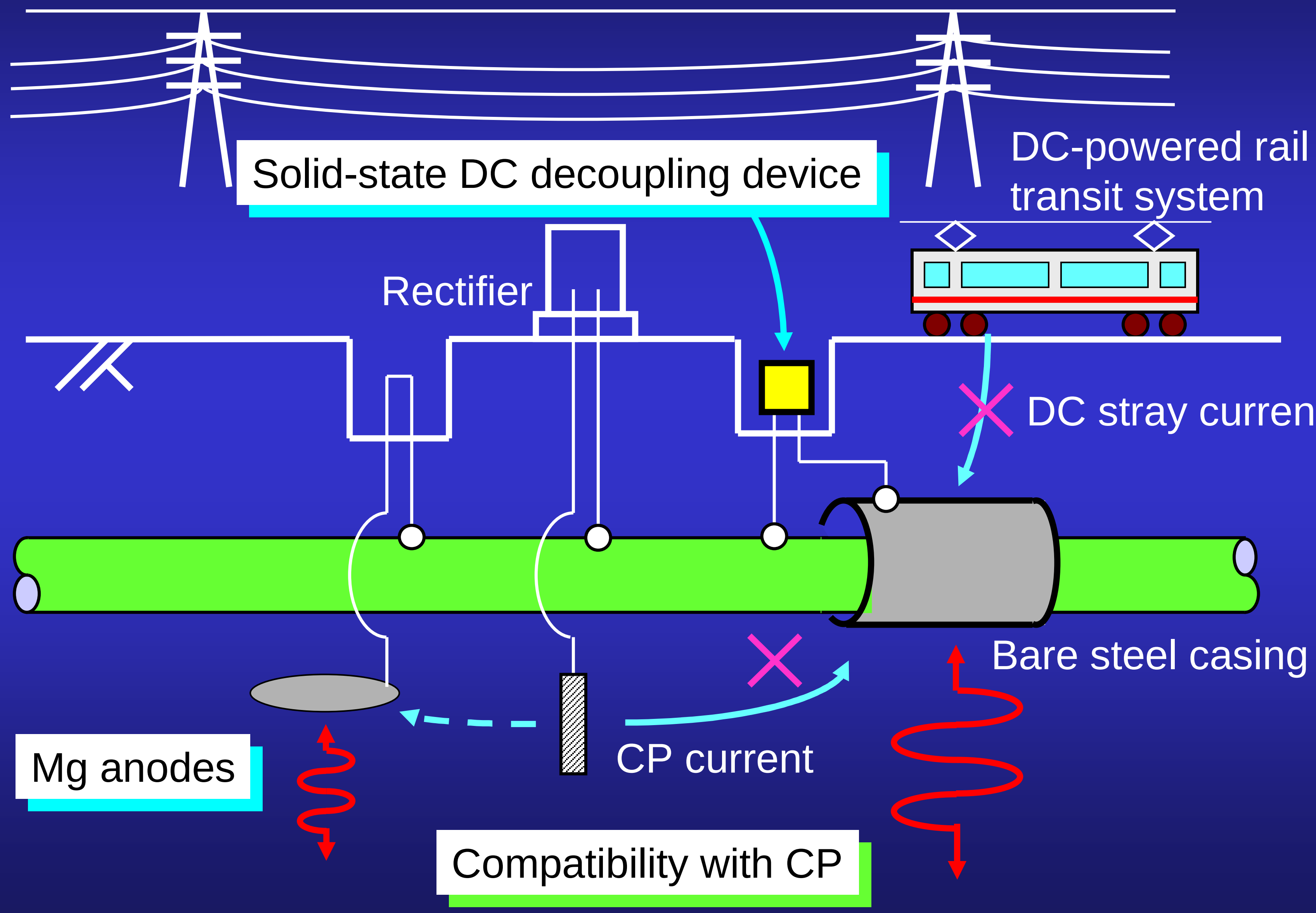
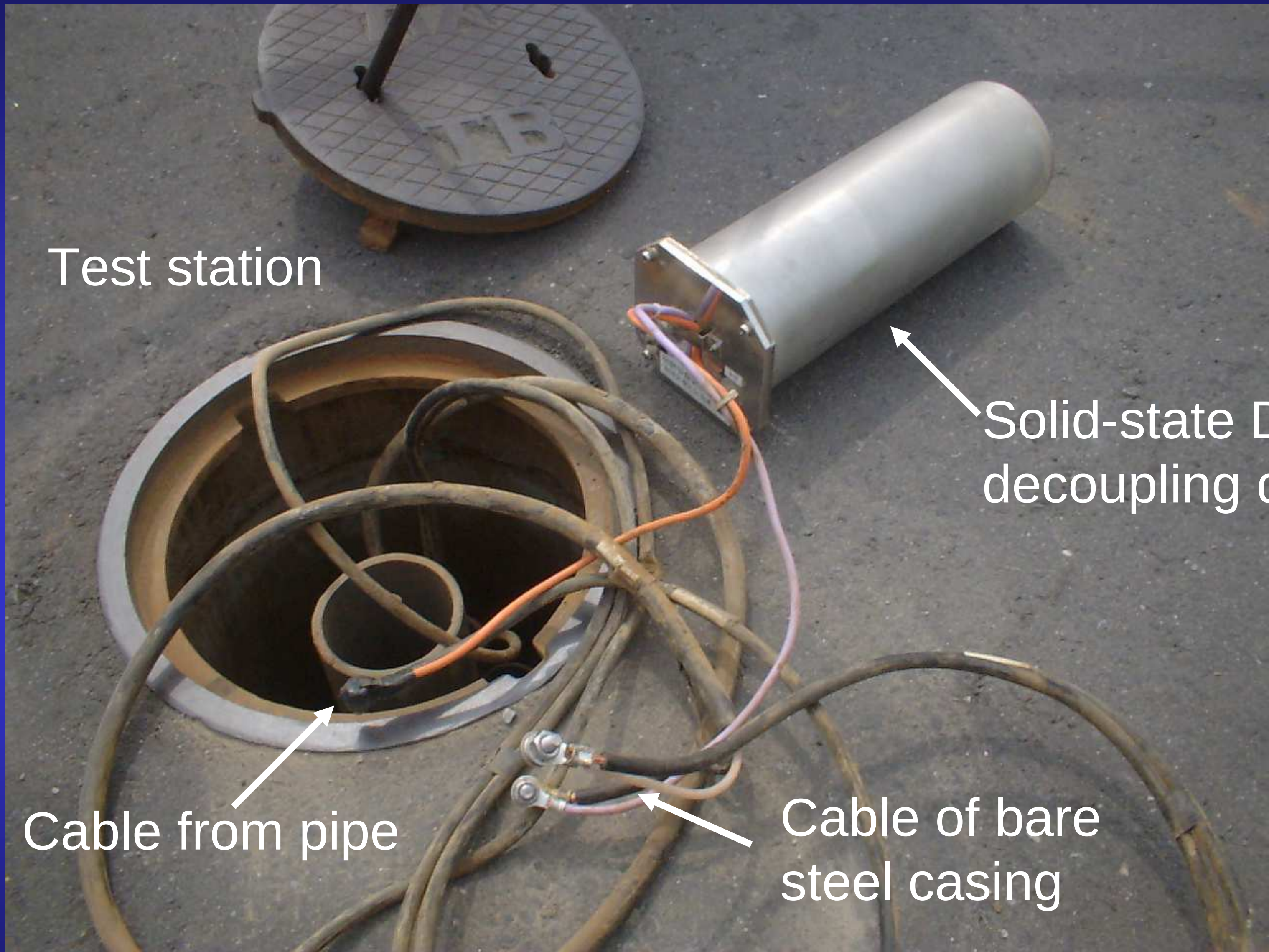


Fig.3 AC mitigation methodology

Grounding for AC mitigation

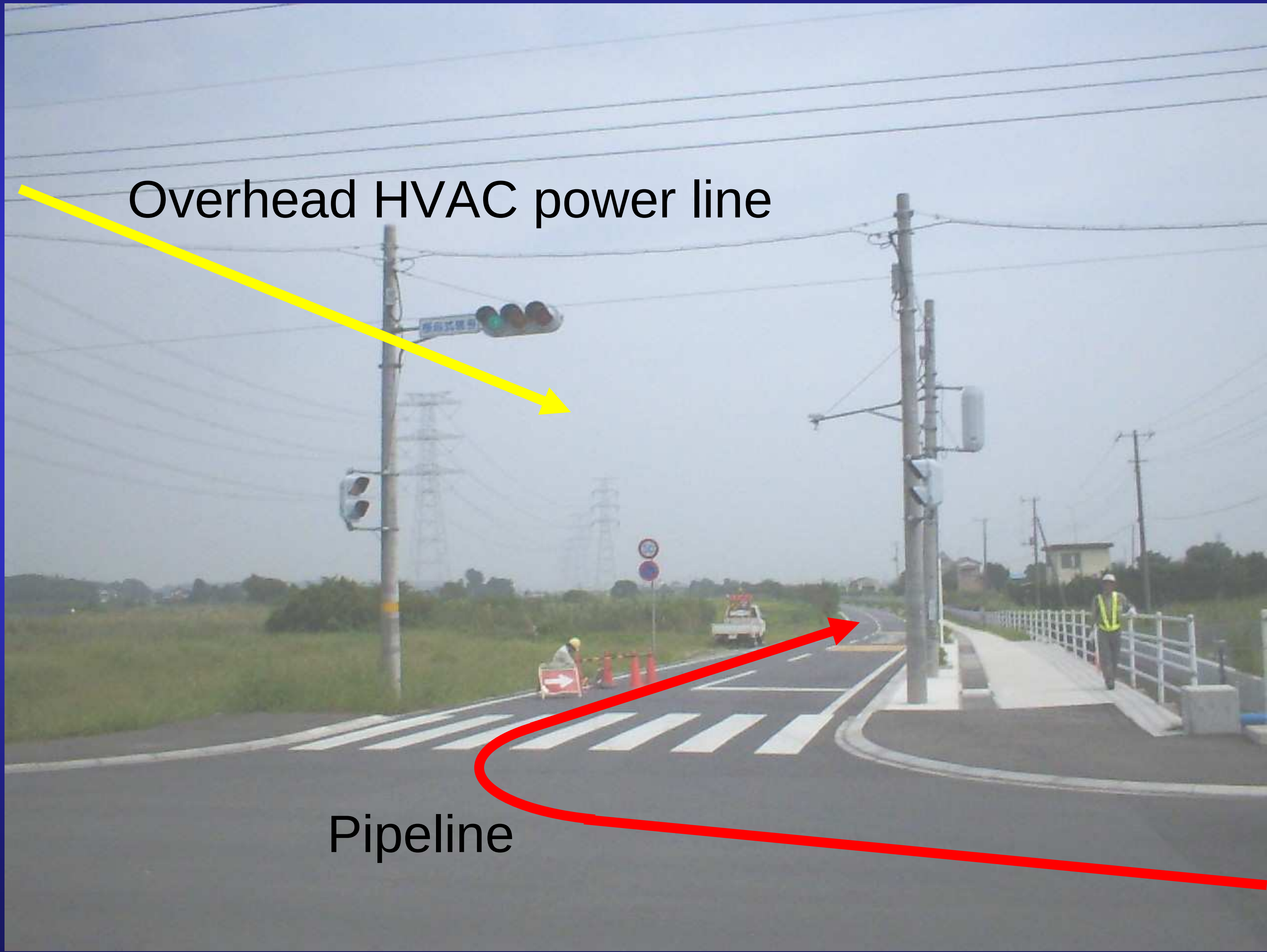




Tokyo Gas solid-state DC decoupling device

2.3 Studies on the effectiveness of the criteria & AC mitigation

Case 1 : In proximity to an overhead HVAC power line



a : Solid-state DC decoupling device + bare steel piles
b : Additional Mg anodes

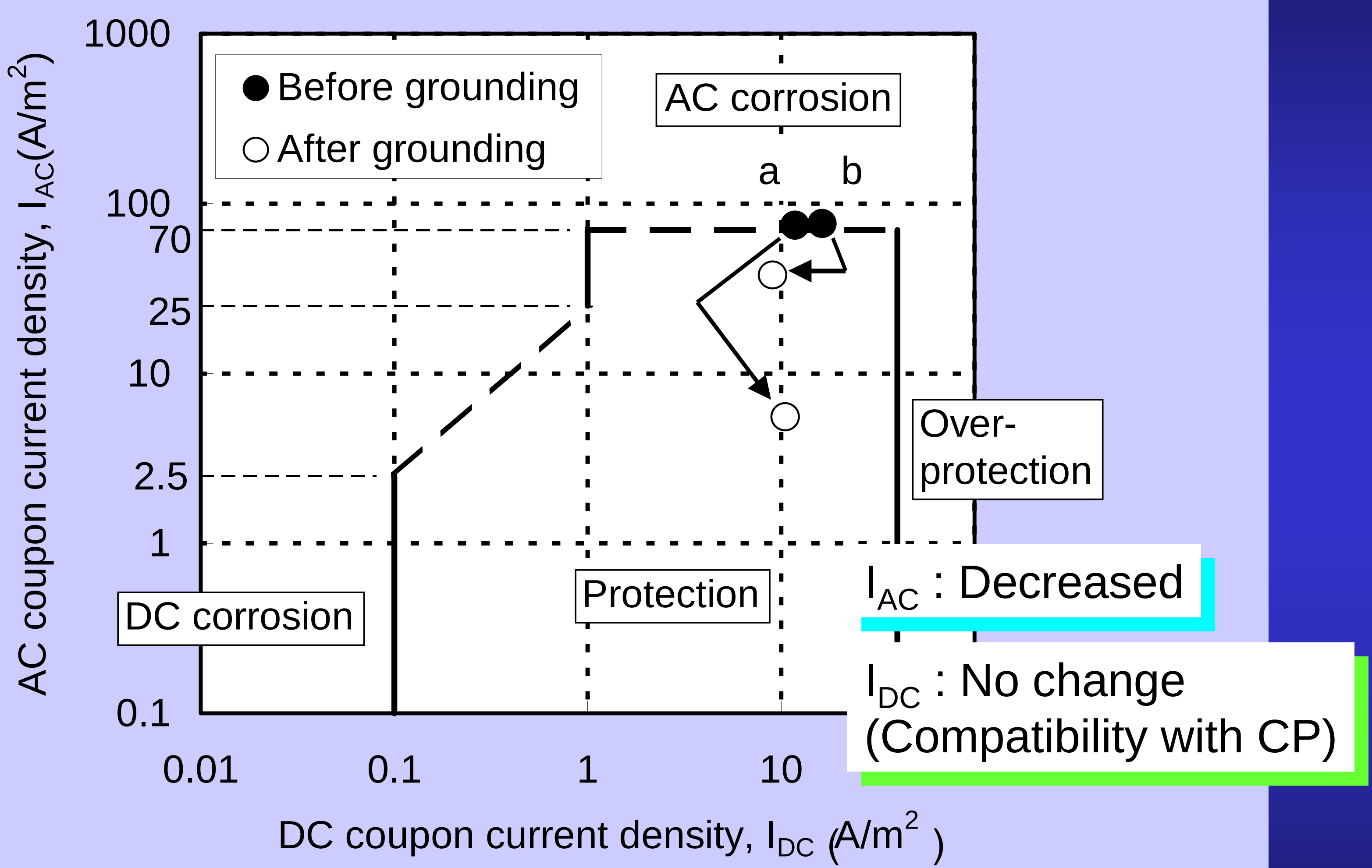
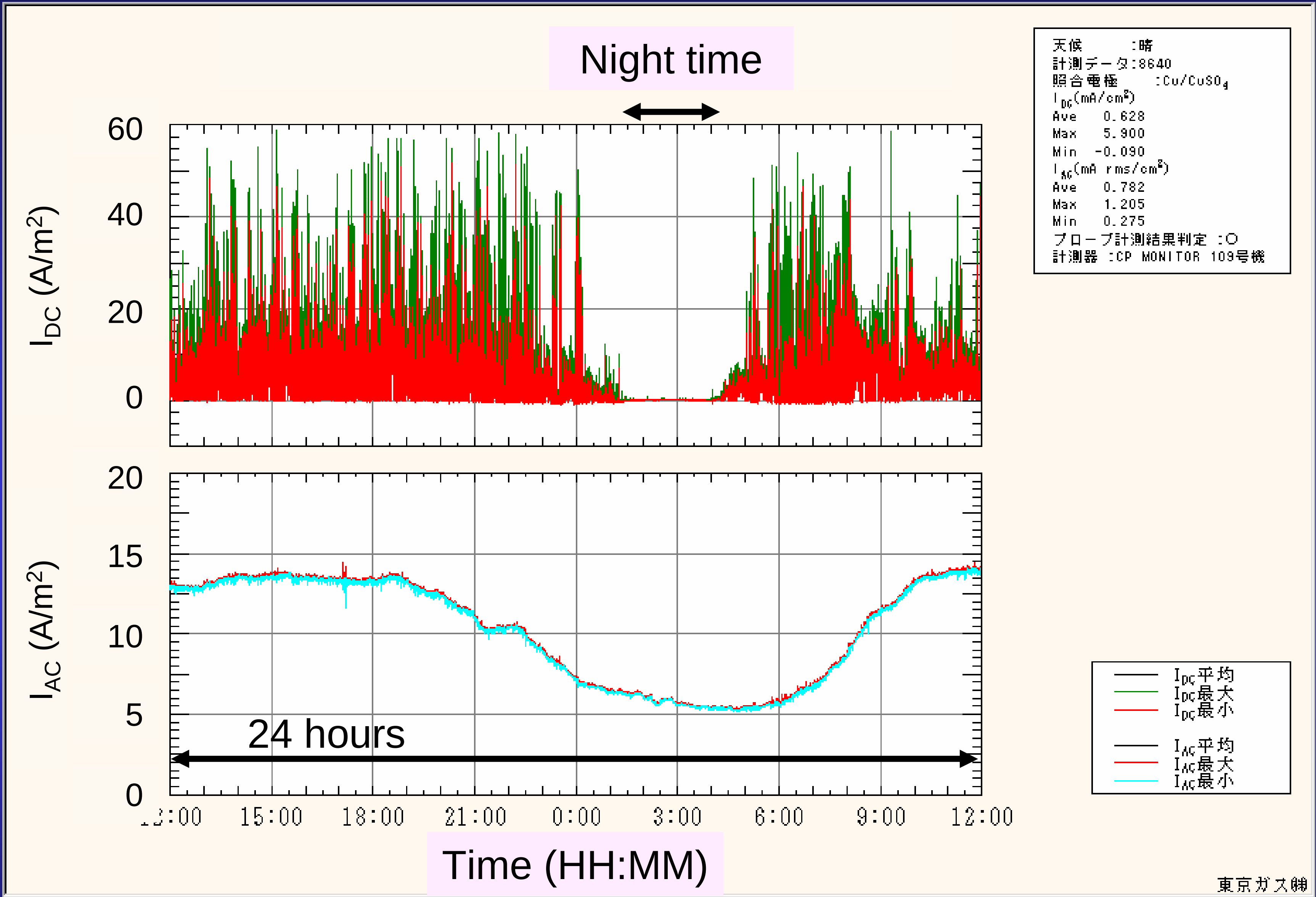
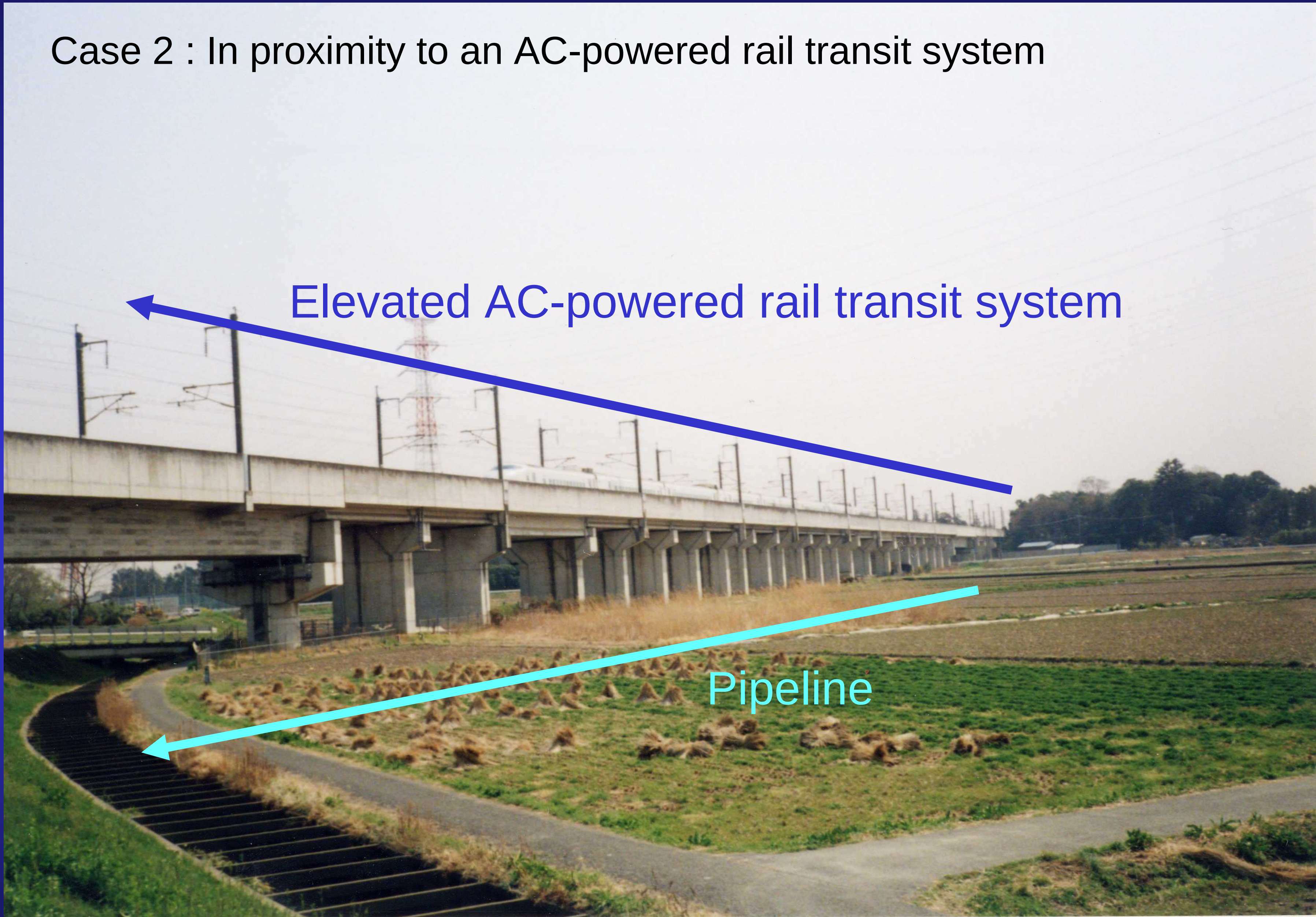


Fig.4 I_{DC} and I_{AC} before and after grounding in proximity to an overhead HVAC power line.



I_{DC} and I_{AC} measured for 24 hours after grounding in proximity to an overhead HVAC power line.

Case 2 : In proximity to an AC-powered rail transit system



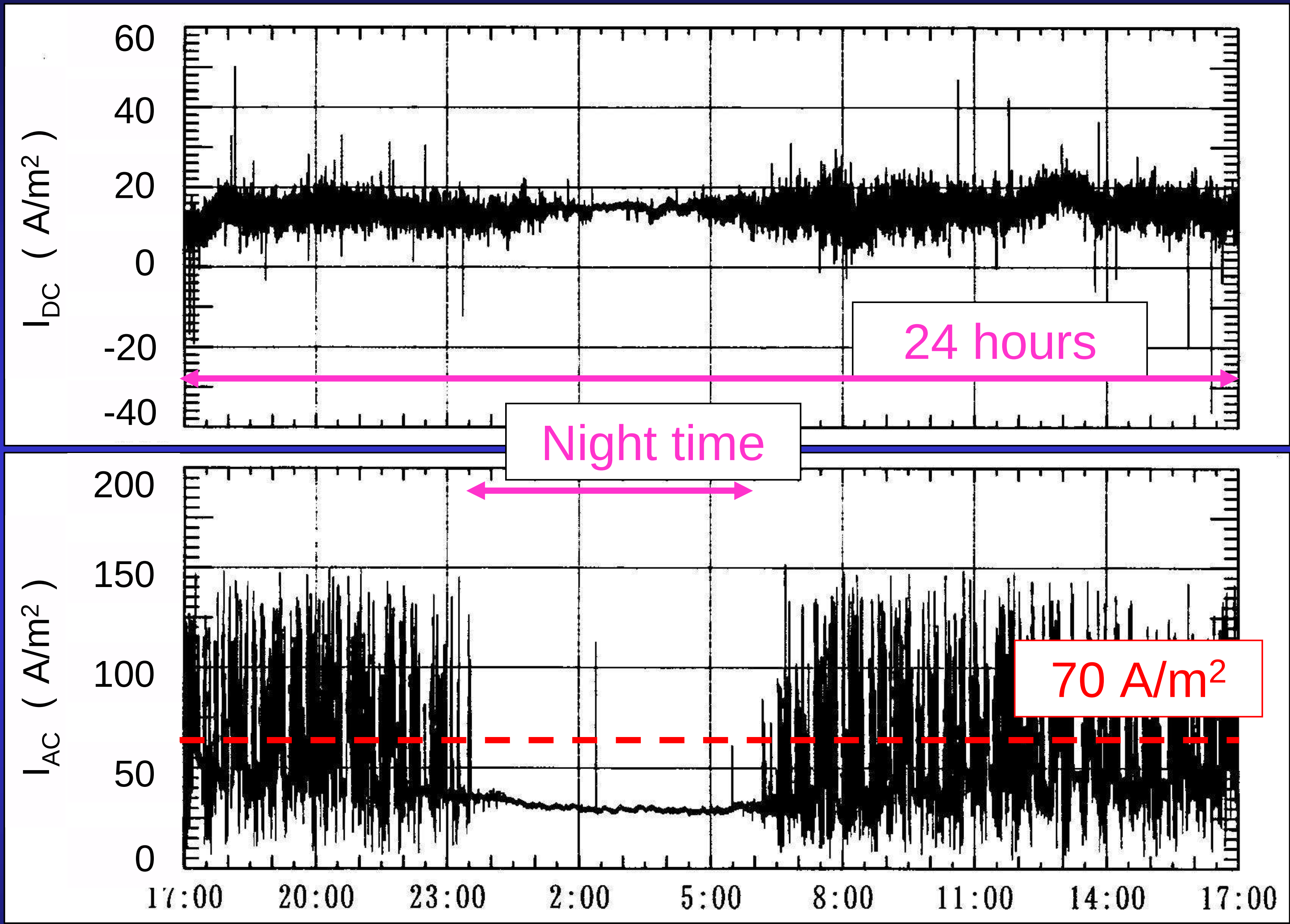


Fig.5 I_{DC} and I_{AC} before grounding in proximity to an AC-powered rail transit system.

Point “c” : Solid-state DC decoupling device + bare steel casing

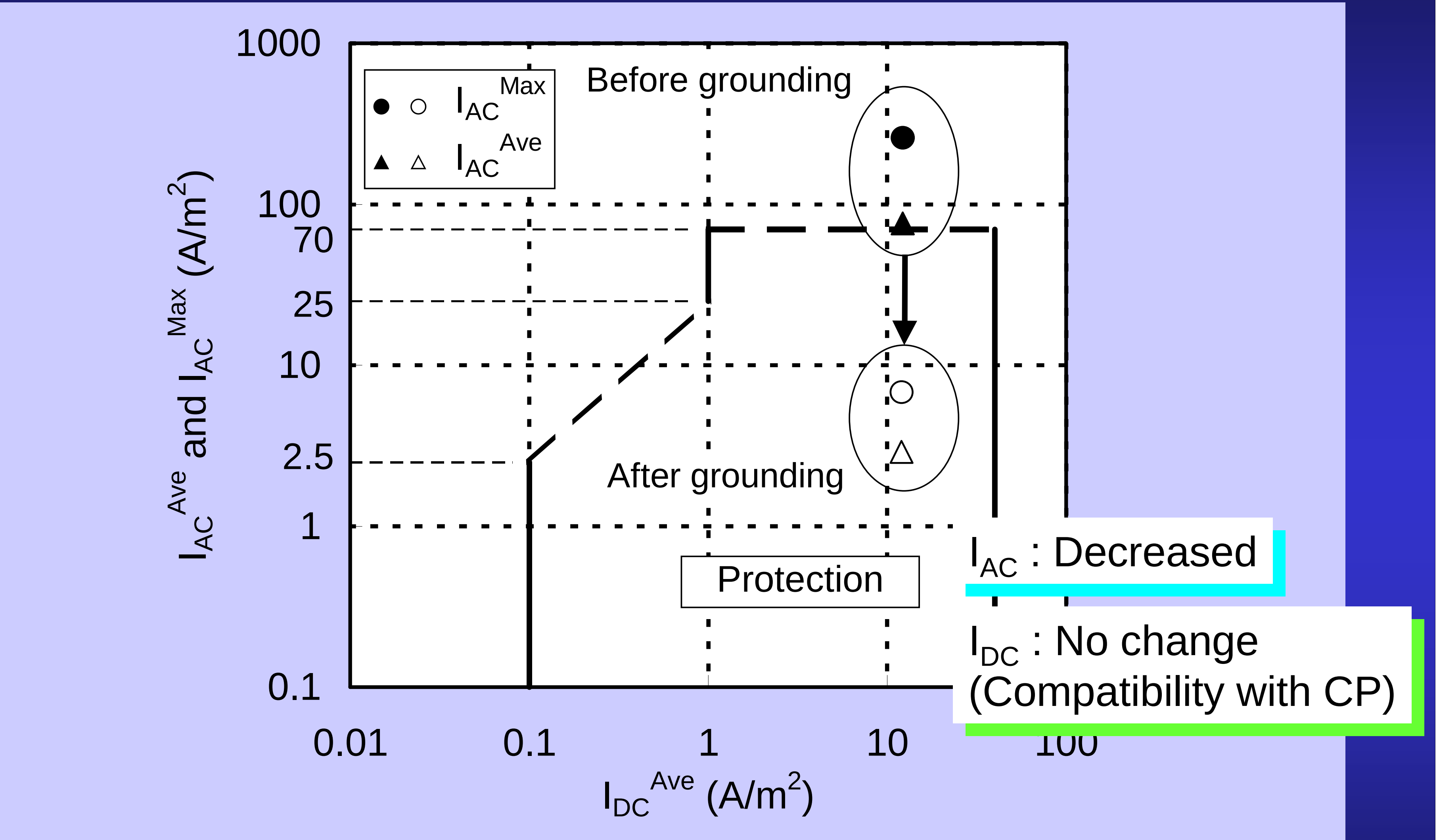
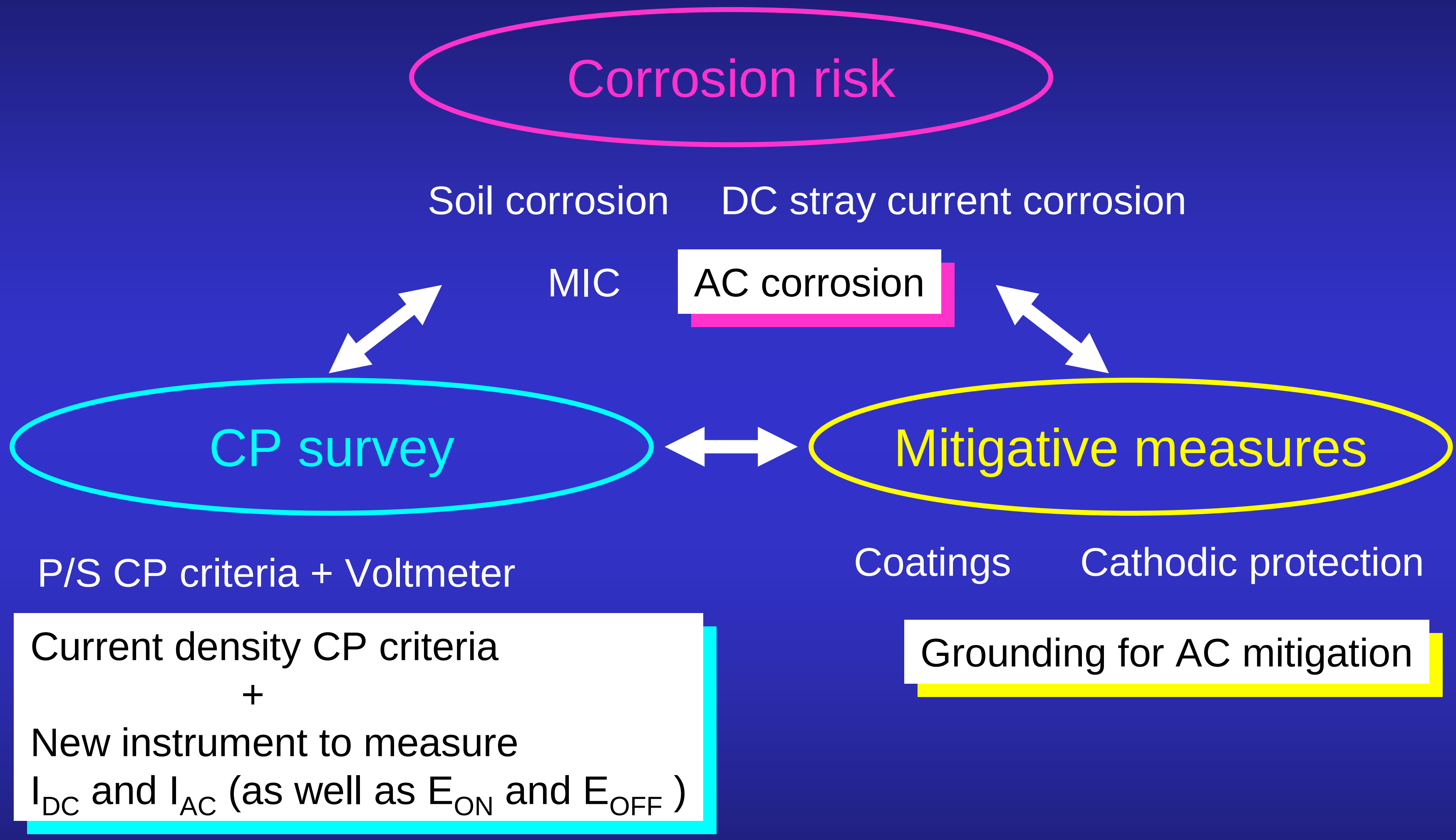
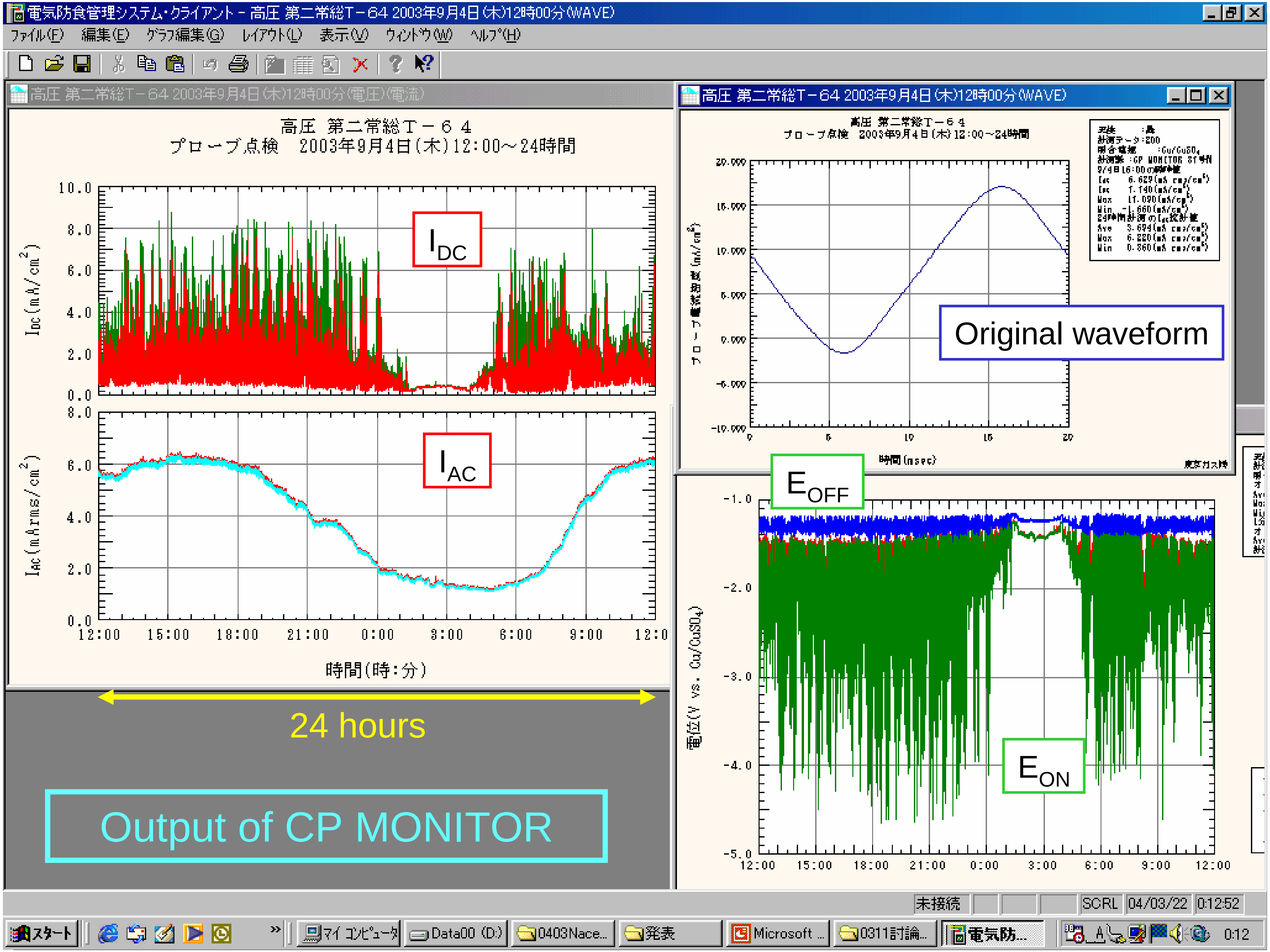


Fig.6 The Max. and Ave. of I_{AC} before and after grounding in proximity to an AC-powered rail transit system.

5. Conclusion



New concept of CP management considering AC corrosion risk



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Iac(mArms/cm²)
時間(時:分)
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IDC
IAC
高圧 第二常総T－64 2003年9月4日(木)12時00分(WAVE)
Original waveform
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EOFF
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Output of CP MONITOR
未接続 SCRL 04/03/22 0:12:52
スタート
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Data00 (D:)
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発表
Microsoft ...
0311討論...
電気防...
0:12

Conclusion (cont'd)

1) New CP criteria

that can appropriately assess the AC corrosion risk were developed based on DC and AC coupon current densities.

2) AC mitigation methodology

that includes grounding using solid-state DC decoupling device and Mg anodes was established considering the compatibility with CP.

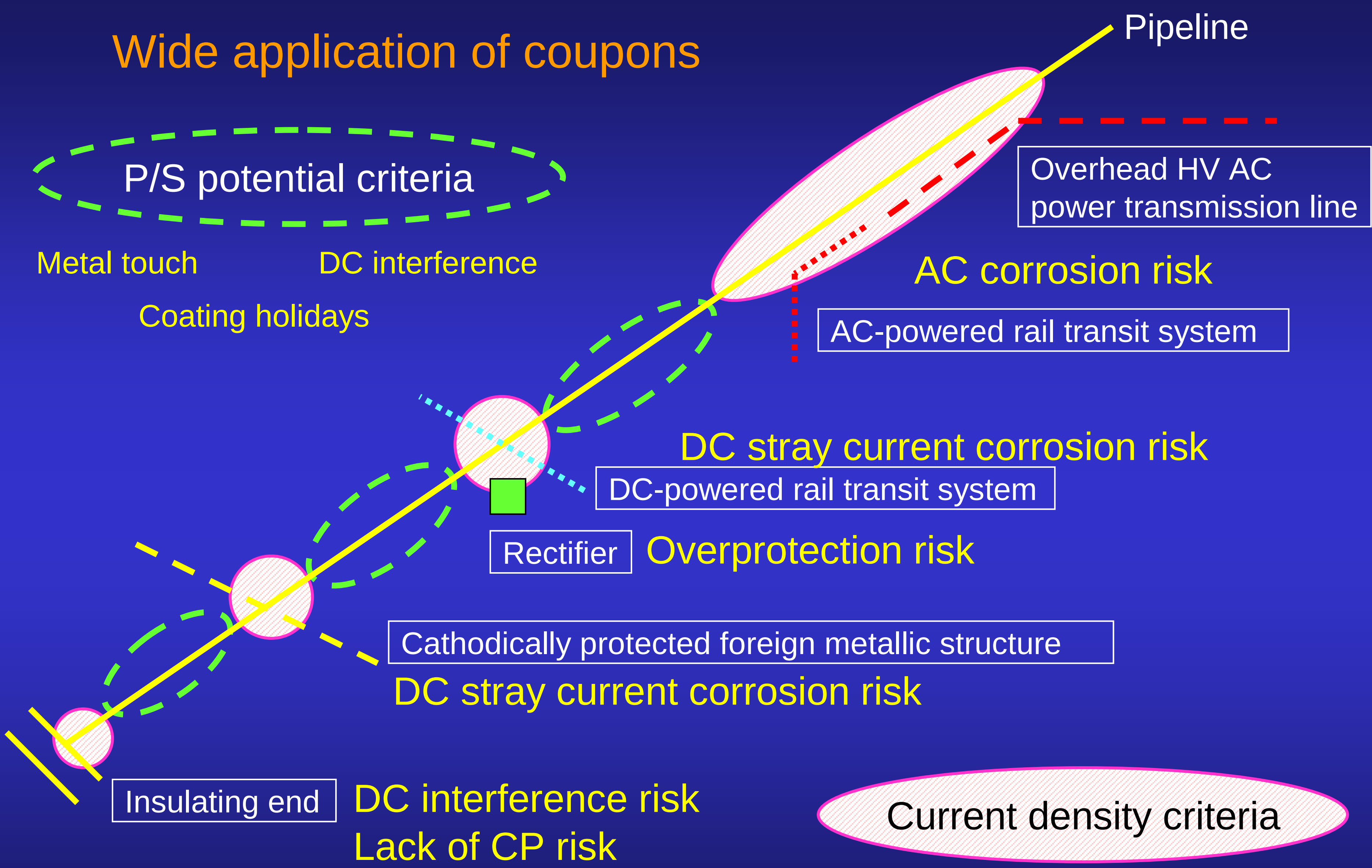
3) The criteria and AC mitigation methodology

was proven to be effective through field survey.

4) Simultaneous measurement of DC and AC coupon current densities

should be conducted periodically on pipelines where AC corrosion is likely to occur.

Wide application of coupons



Current density and pipe-to-soil potential

Needs to establish new CP criteria

Pipe-to-soil potential CP criteria (ex. -0.85V_{CSE}) are not applicable for the assessment of AC corrosion risk.

Printz (1992)

AC current density < 20 A/m^2 = No AC corrosion risk

AC current density > 100 A/m^2 = AC corrosion of 0.1 mm/y can occur

DIN 50 925 (1992)

AC current density < 30 A/m^2, DC current density = approx. 1 A/m^2

New CP criteria based on DC and AC current densities (AC = 50Hz)

- Simultaneous measurement of I_{DC} and I_{AC}
- Weight loss measurement