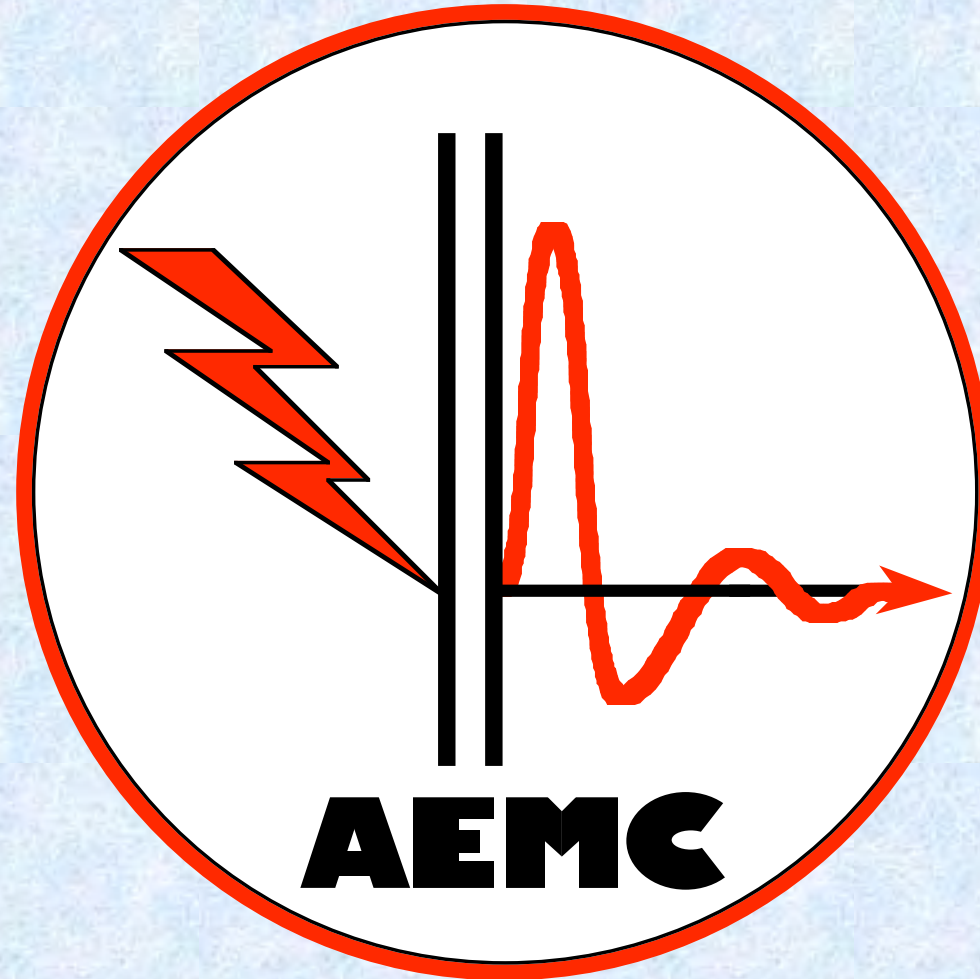


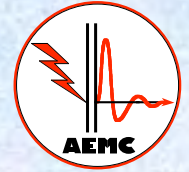
ElectroMagnetic Interference



Recurrent EMI mistakes - Good & poor practical fixes

Alain CHAROY - (0033) 4 76 49 76 76 - a.charoy@aemc.fr

Electromagnetism is electricity



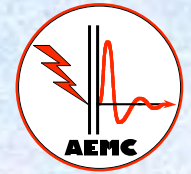
• Conducted disturbances

- Current i (in amps) 10 mA (permanent) to > 10 amps (peak)
- Voltage u (in volts) 1 V (permanent) to > 1 kV (peak)
- Impedance $Z = u / i$ (in ohms) typically 40 to 400 Ω (in HF)
- Power $P = u \cdot i$ (in watts) mW (permanent) to > MW (transient)
- Delay of propagation ≈ 5 ns/m (in any cable)

• Radiated disturbances

- Magnetic field H (in A/m) B may exceed 100 mT in DC
- Electric field E (in V/m) 1 V/m (CW) to kV/m (impulse)
- Impedance ($Z = E / H$, in Ω) 377 Ω for “far field” in air or vacuum
- Power density ($P = E \cdot H$, in W/m²) 1 W/m² (CW) to MW/m² (transient)
- Propagation speed $\approx 300\,000$ km/s in air or in vacuum

Some usual EMI Sources



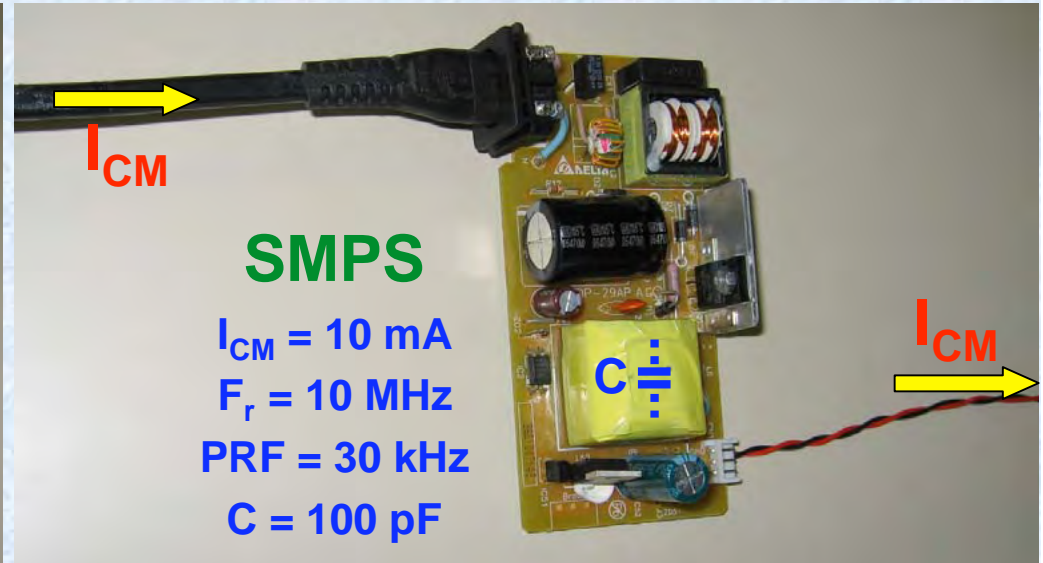
Talkie-walkie

$E = 10 \text{ V/m @ 1 m}$



Cell-phone

$E = 3 \text{ V/m @ 1 m}$



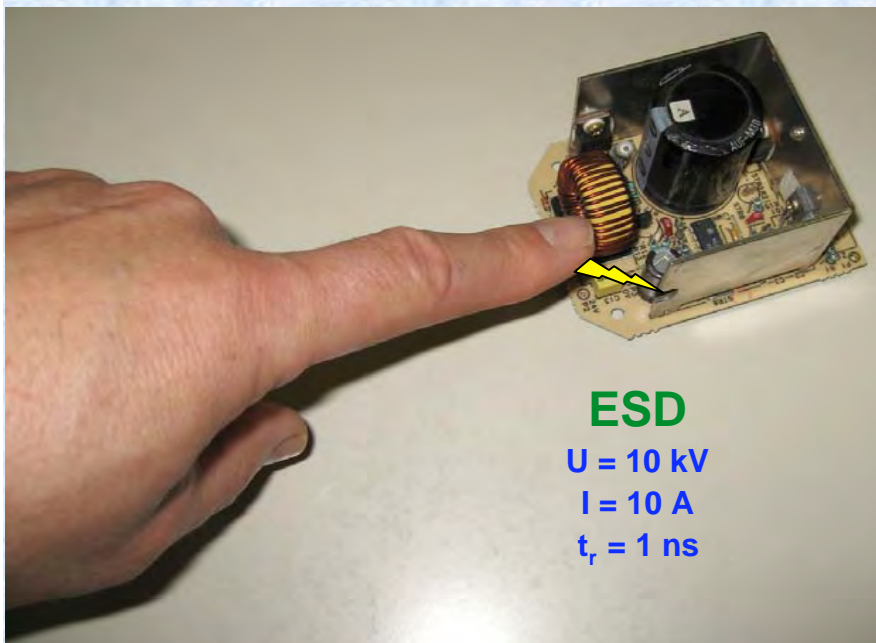
SMPS

$I_{CM} = 10 \text{ mA}$

$F_r = 10 \text{ MHz}$

$\text{PRF} = 30 \text{ kHz}$

$C = 100 \text{ pF}$



ESD

$U = 10 \text{ kV}$

$I = 10 \text{ A}$

$t_r = 1 \text{ ns}$



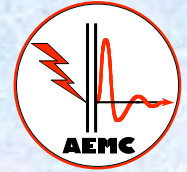
Lightning

$I = 30 \text{ kA}$

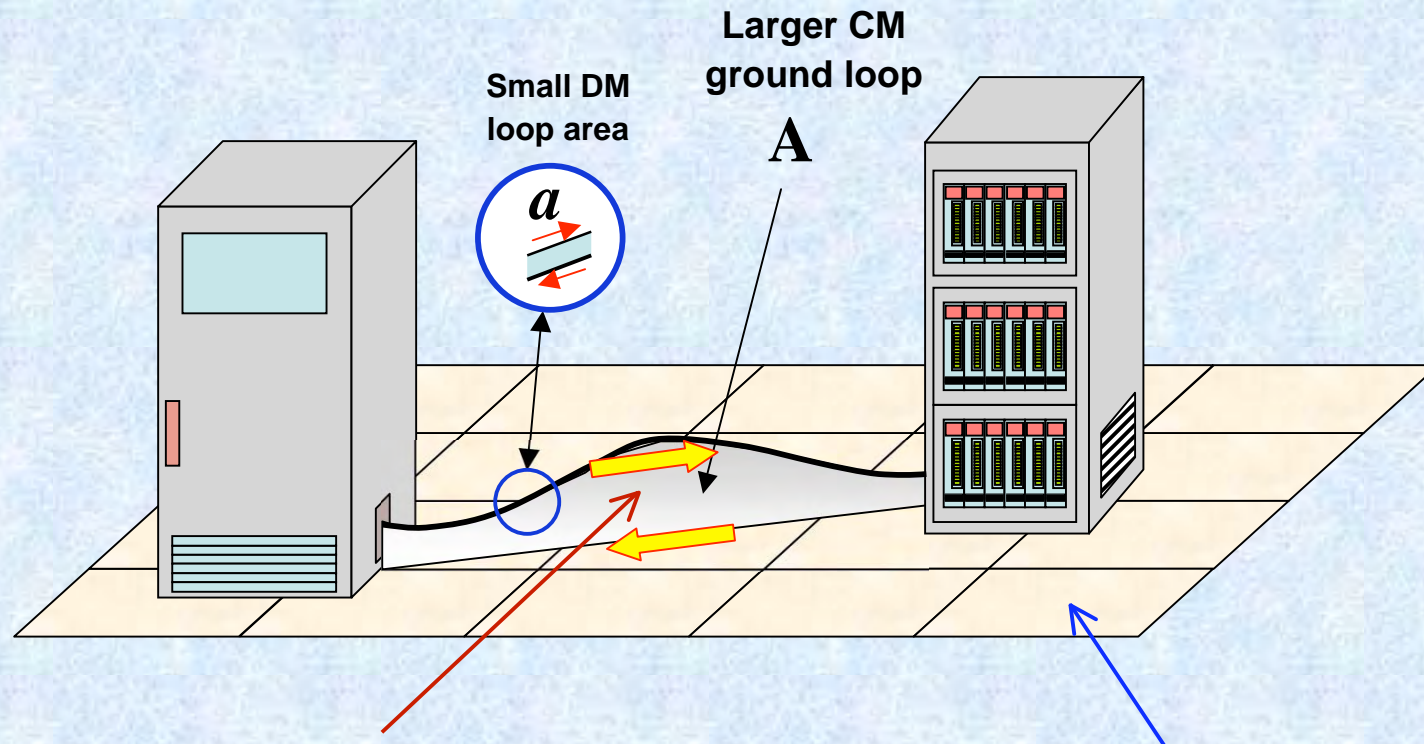
$t_r = 1 \mu\text{s}$

$t_d = 50 \mu\text{s}$

The Ground Loop problem



A variable magnetic field (difficult to shield at LF) induces voltage across loops



This ground loop area is unavoidable

It should be reduced by:

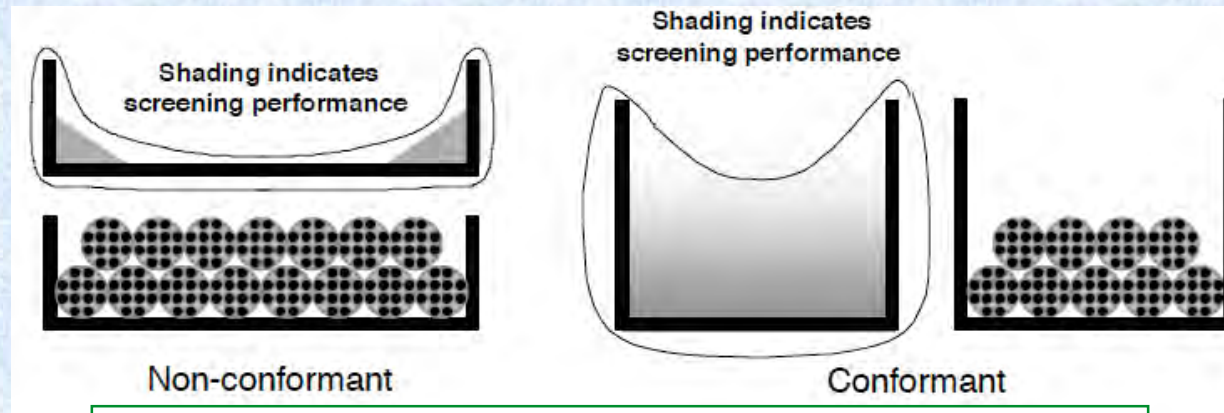
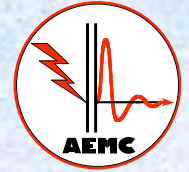
- Laying the cables down over the (metallic) ground plane
- Using cable trays (in contact from one end to the other)
- Using shielded cables with connection at both ends

A raised floor loop is not a ground loop

It is a favourable loop:

- It lowers the common mode impedance
- It divides the common mode currents
- It reduces the external EM fields

Cable tray shielding effectiveness

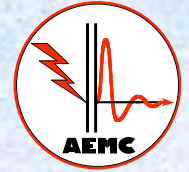


Cable arrangement in a metallic section



**Excellent solution:
Continuous cables
shielding with nuts**

Properly shielded cable trays

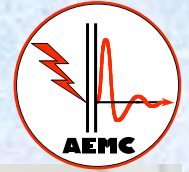


Excellent solution:
Shielded cable trays

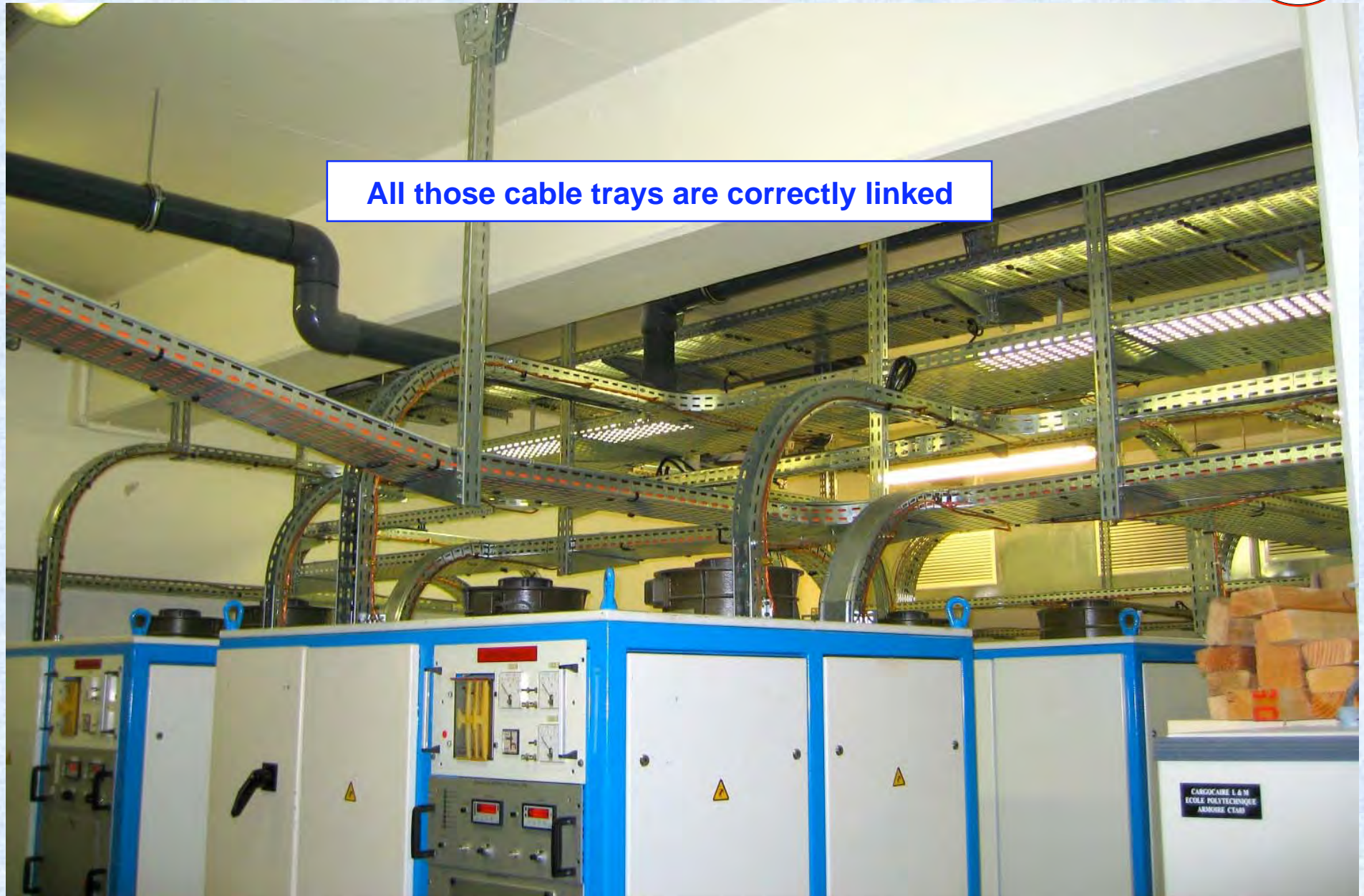
Cable tray to cabinet
transition



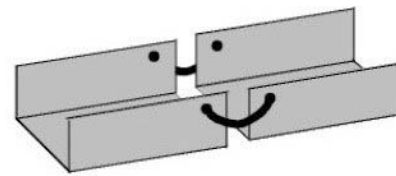
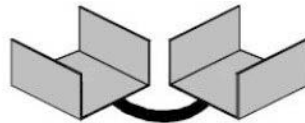
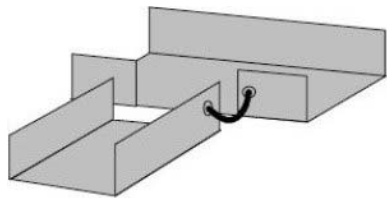
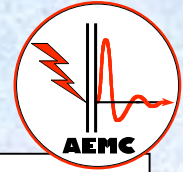
Correctly used cable trays



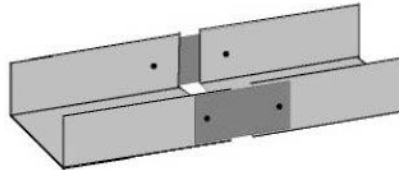
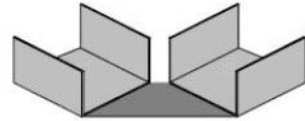
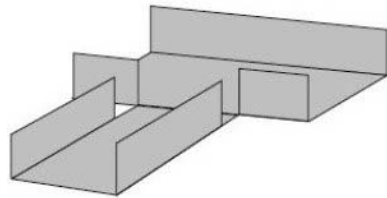
All those cable trays are correctly linked



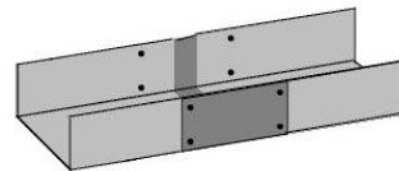
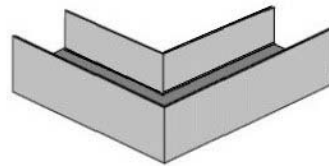
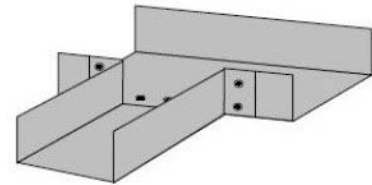
Some EMC alternatives - 1



Poor (high HF impedance)



Correct (lower impedance)



Excellent (no slit)

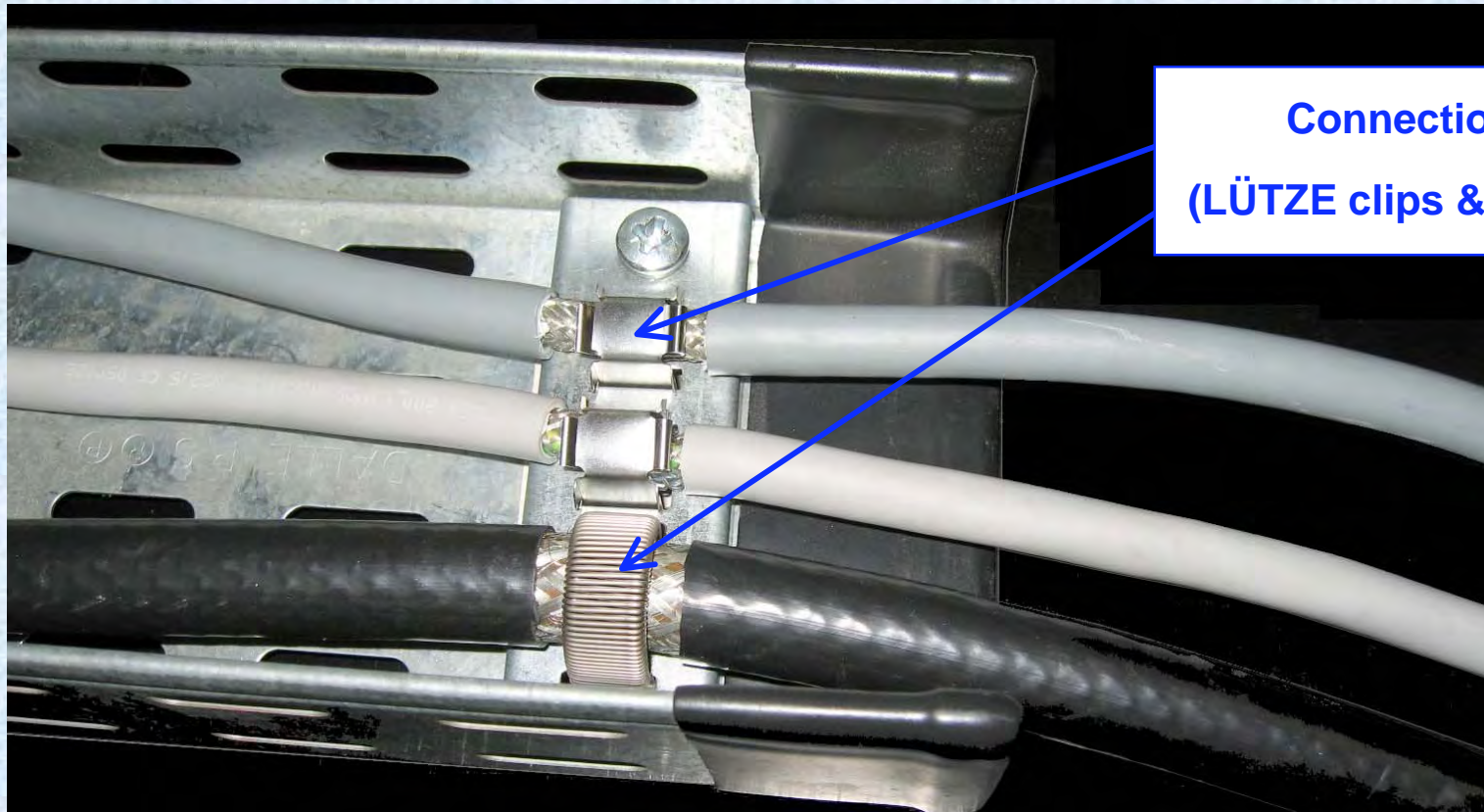
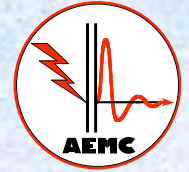


Correct cable tray to Cablofil transition



Poor HF cable tray continuity

Some EMC alternatives - 2

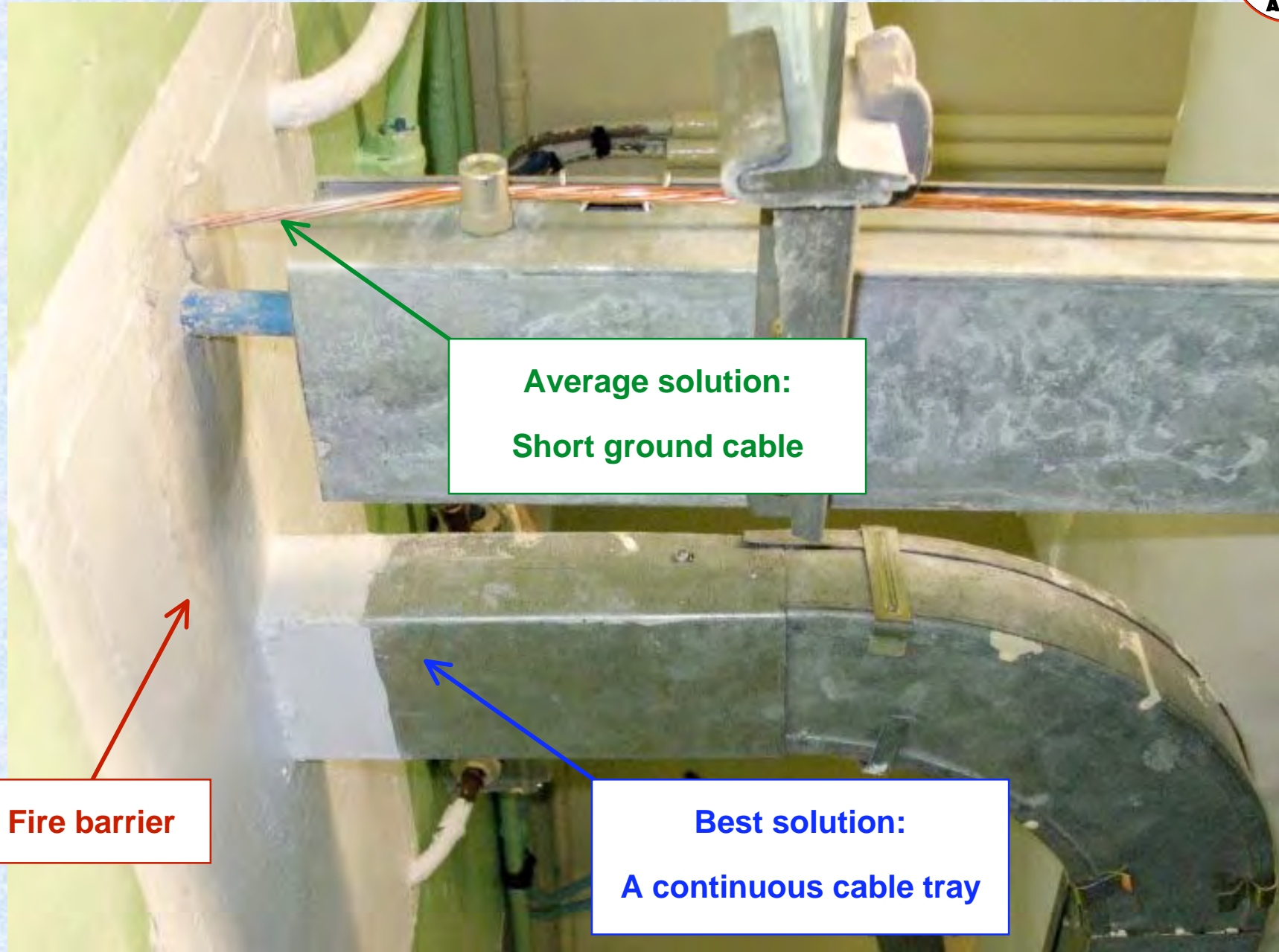
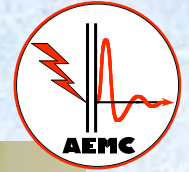


Connections
(LÜTZE clips & spring)



Cable tray junction
(CES)

Some EMC alternatives - 3

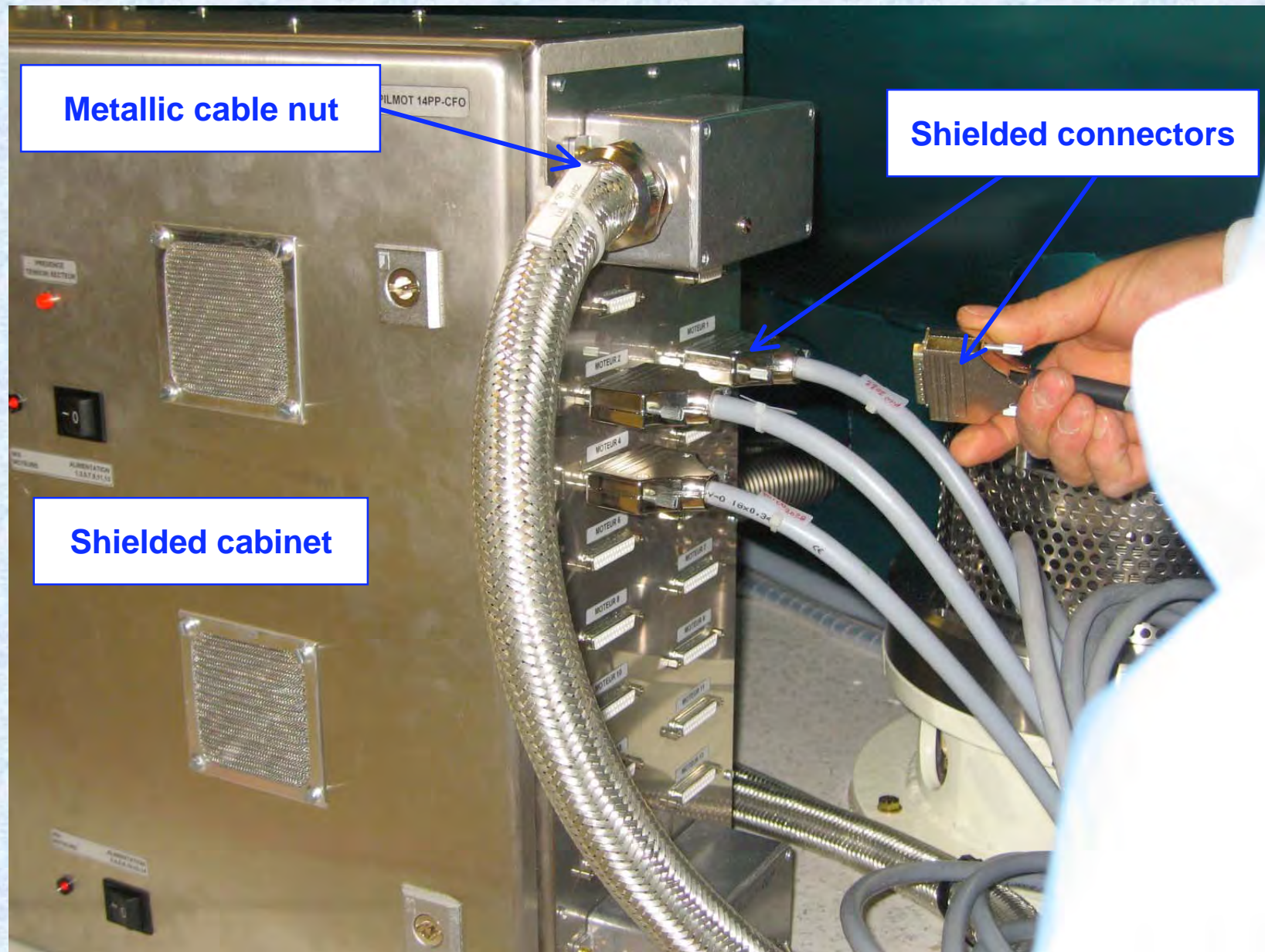
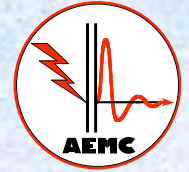


Average solution:
Short ground cable

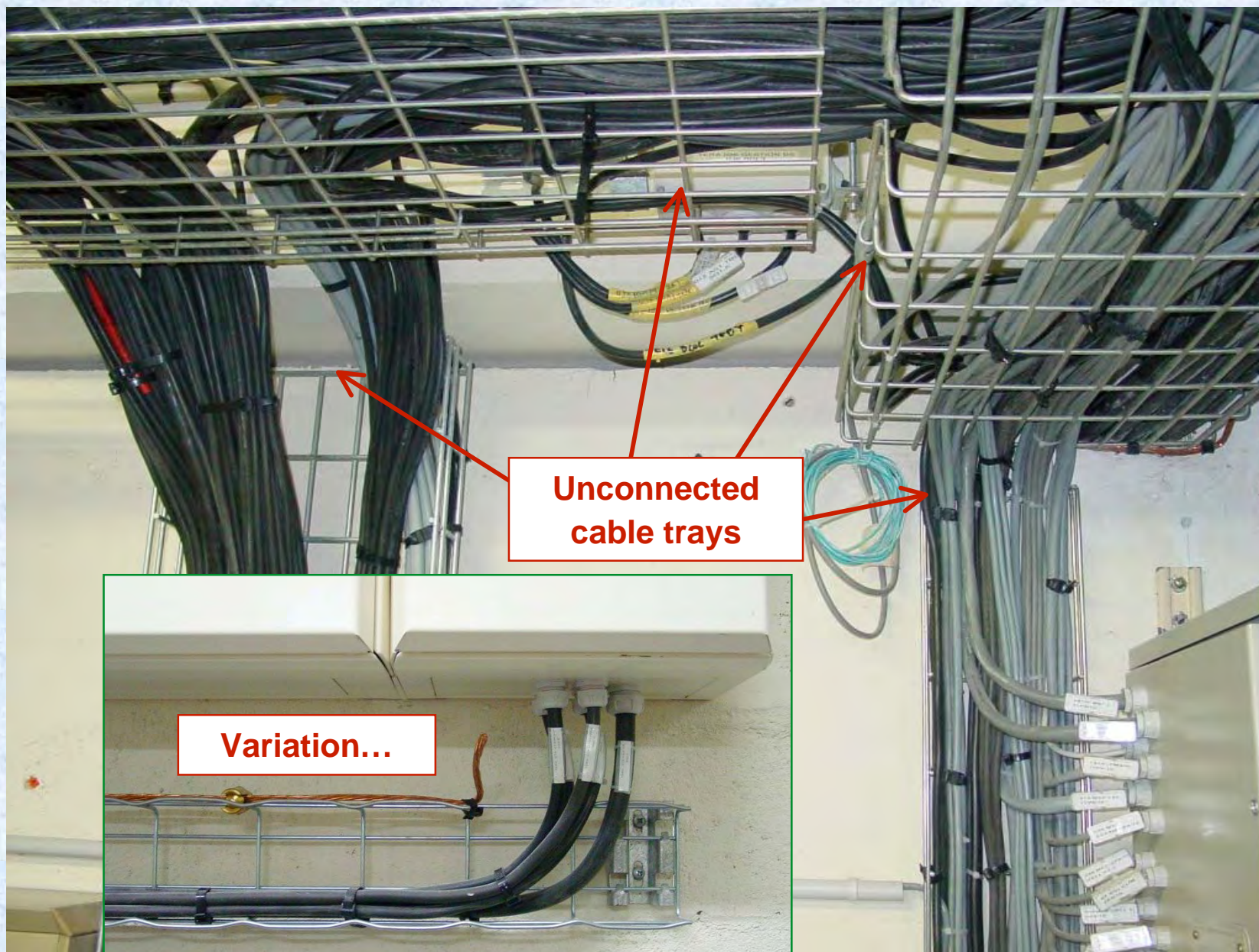
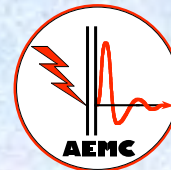
Fire barrier

Best solution:
A continuous cable tray

Some EMC alternatives - 4



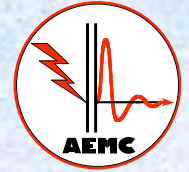
Usual EMC mistakes - 1



**Unconnected
cable trays**

Variation...

Usual EMC mistakes - 2

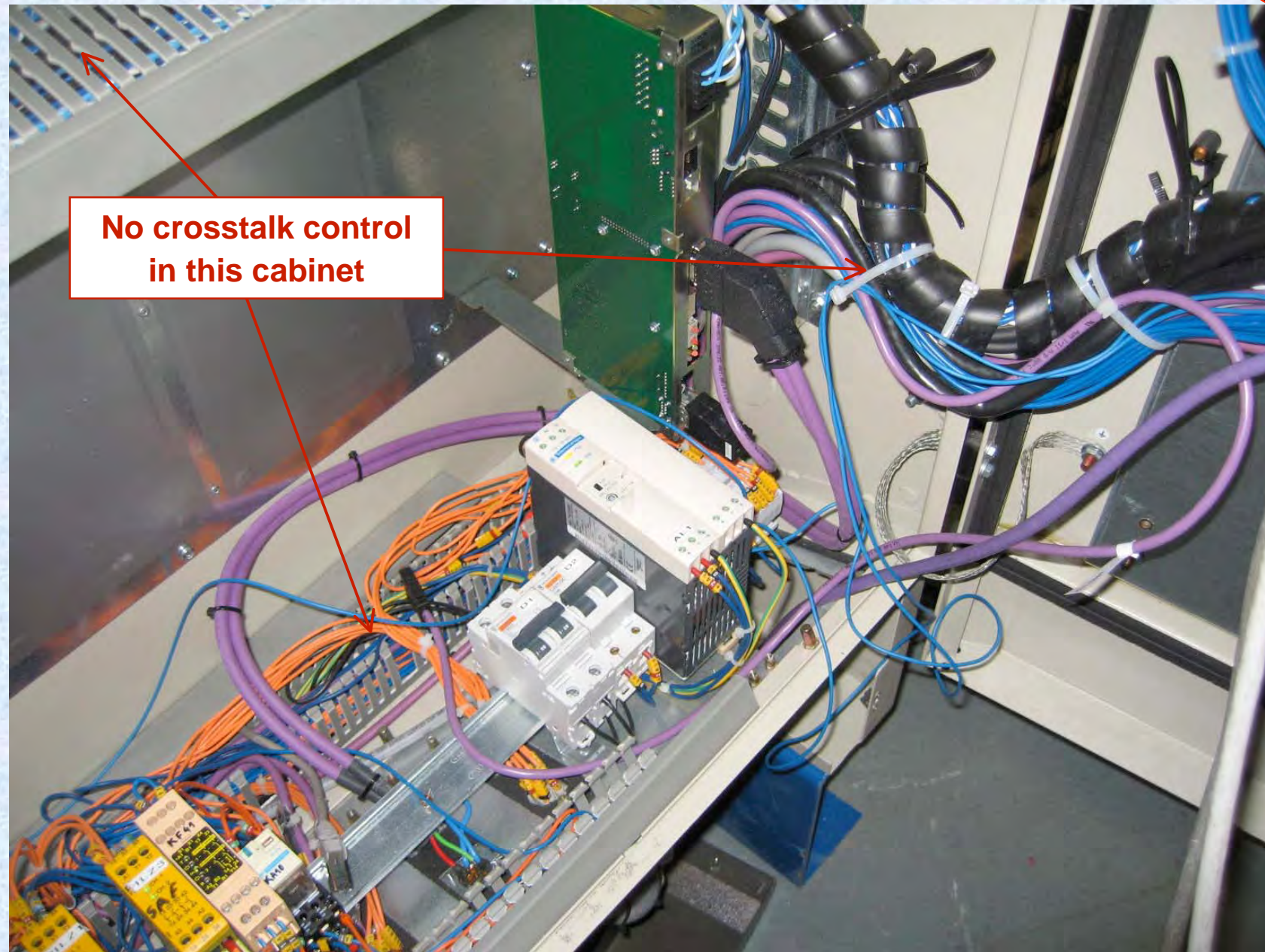
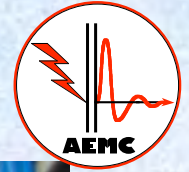


**m² of radiating loops
(with kAmps pulses)**



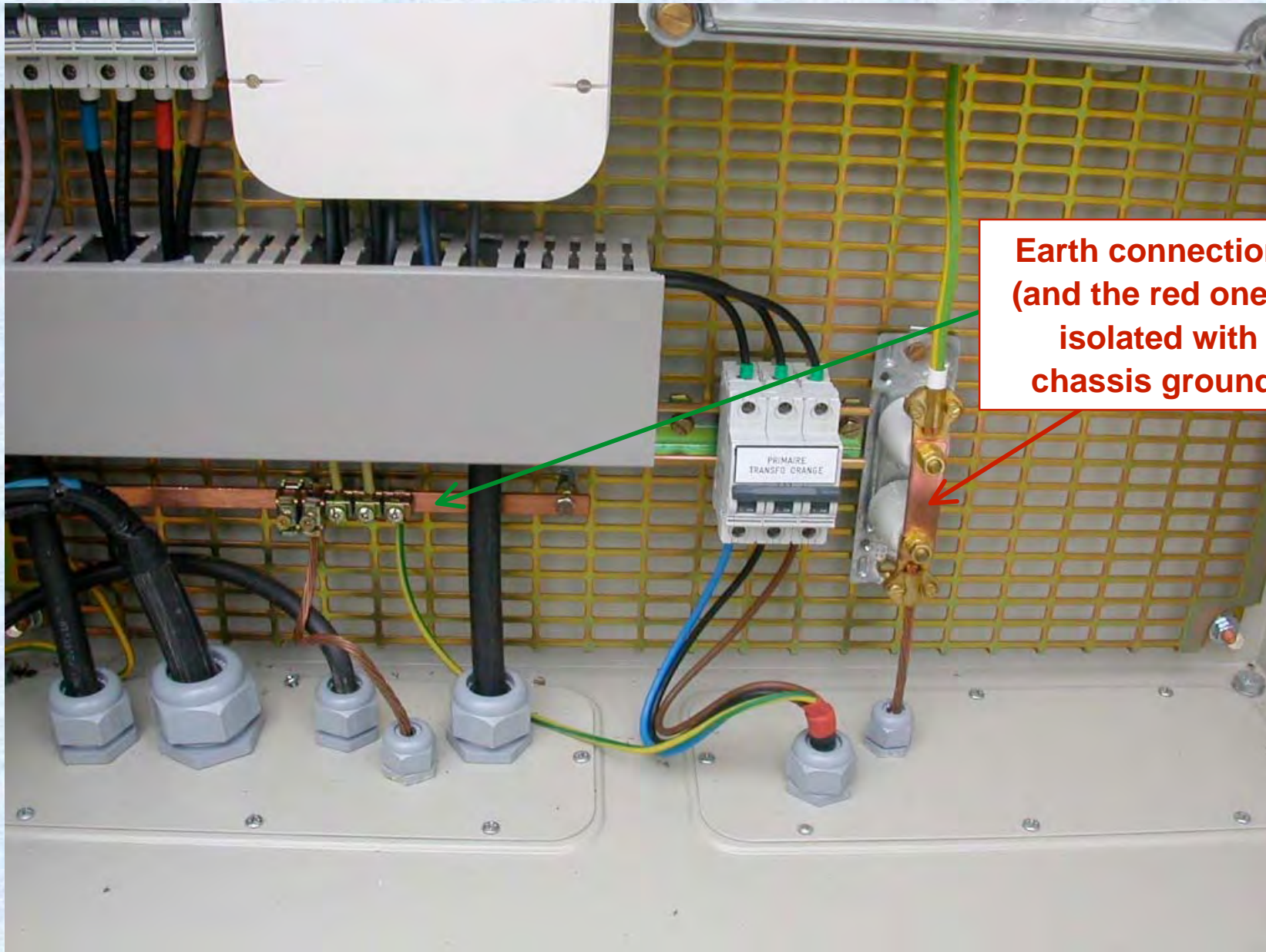
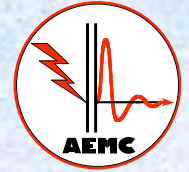
**Separated one way
and return wires of
those 4 field-bus
unshielded pairs**

Usual EMC mistakes - 3



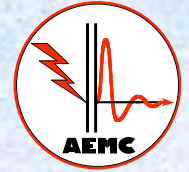
**No crosstalk control
in this cabinet**

Usual EMC mistakes - 4

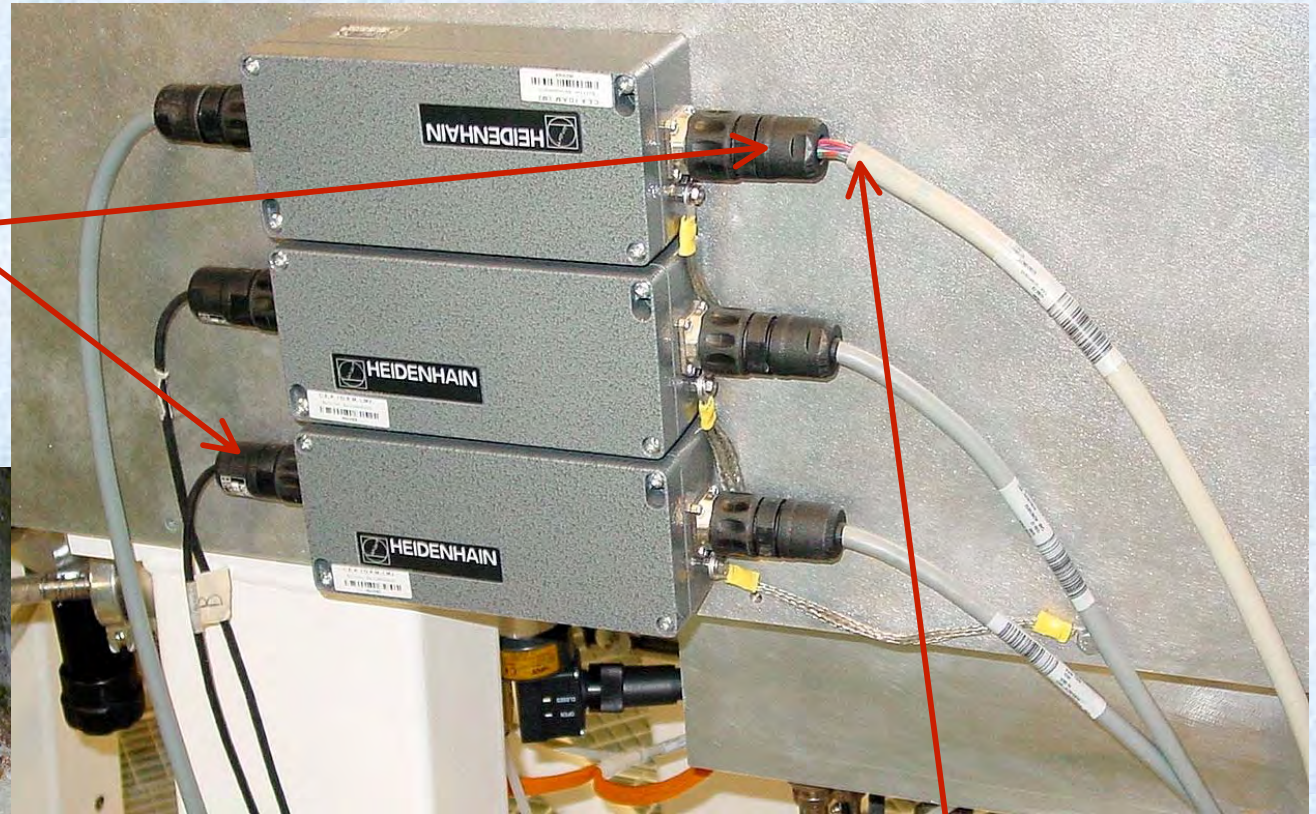


Earth connections
(and the red one is
isolated with
chassis ground)

Usual EMC mistakes - 5



Plastic connectors

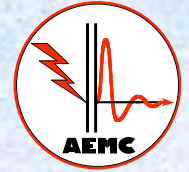


Unshielded signal cable

Useless terminals in series



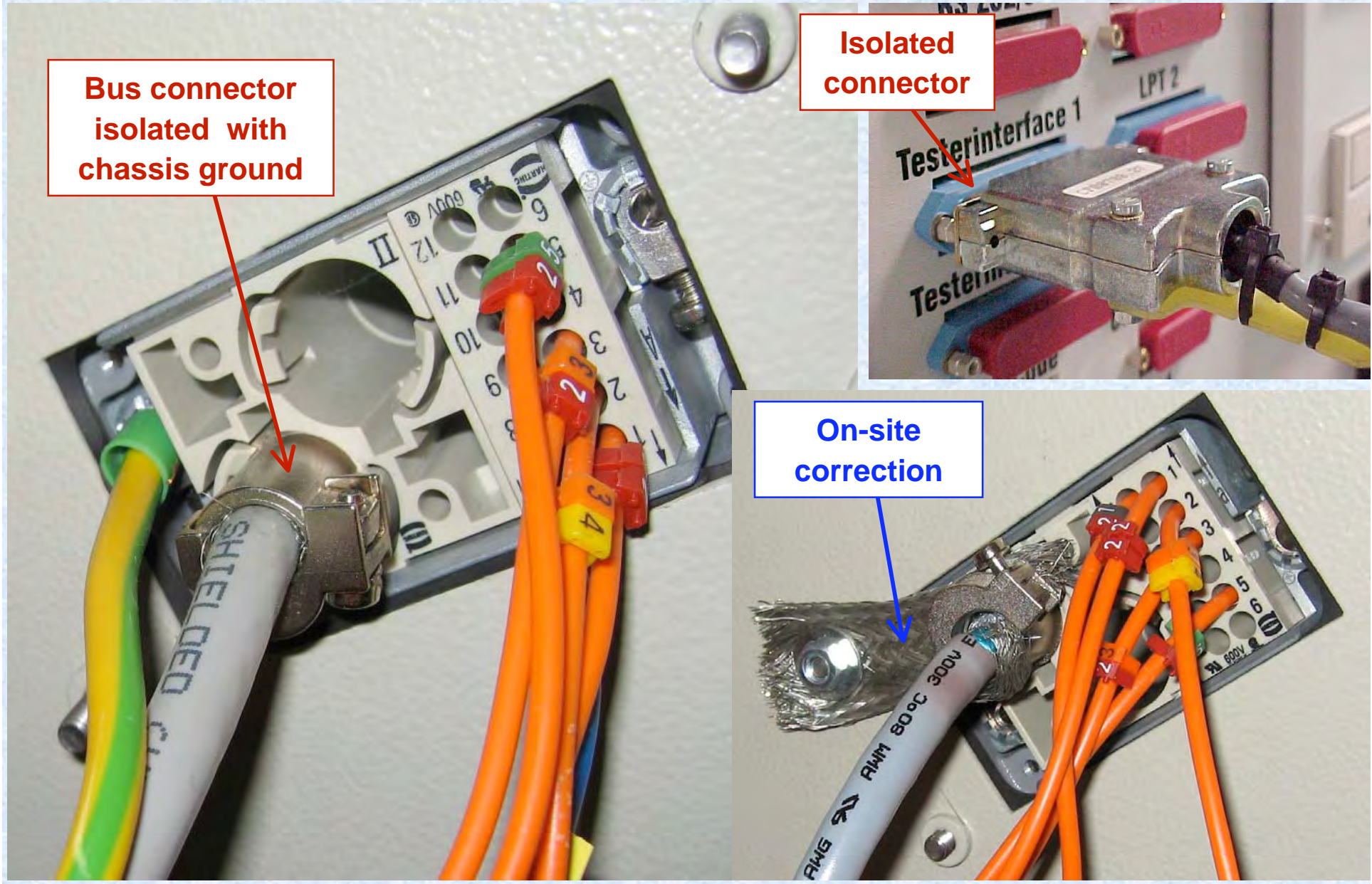
Usual EMC mistakes - 6



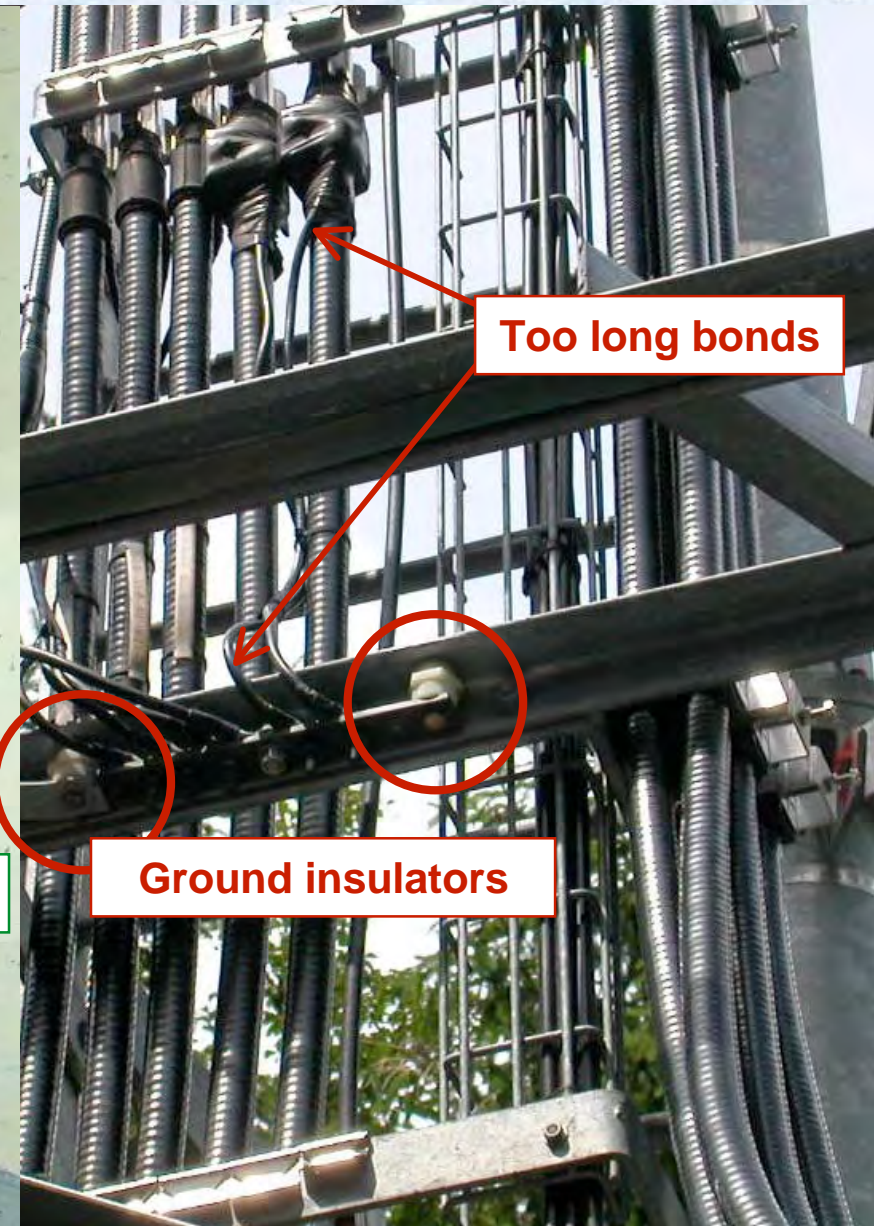
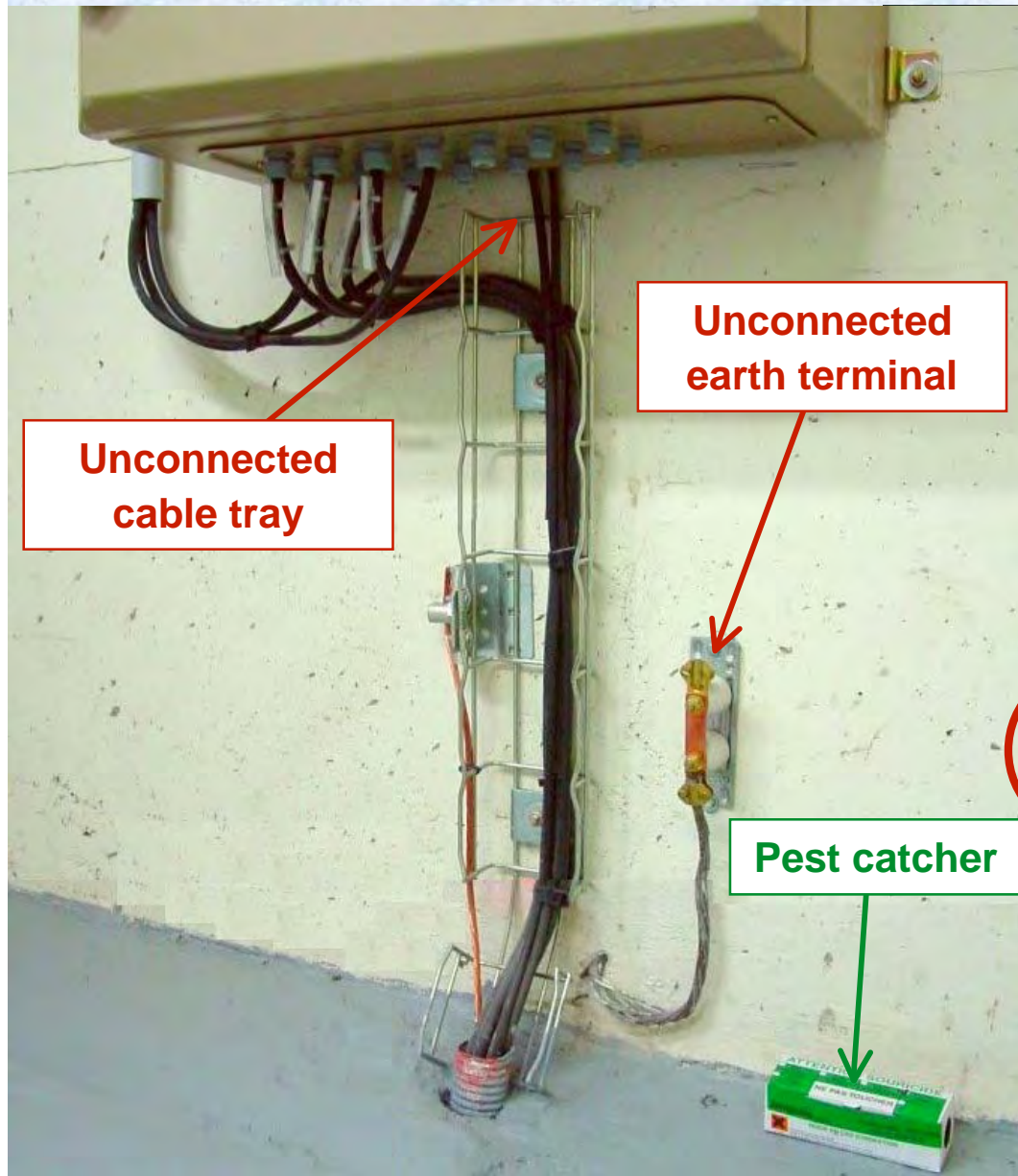
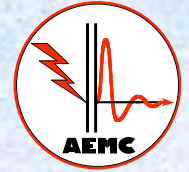
Bus connector
isolated with
chassis ground

Isolated
connector

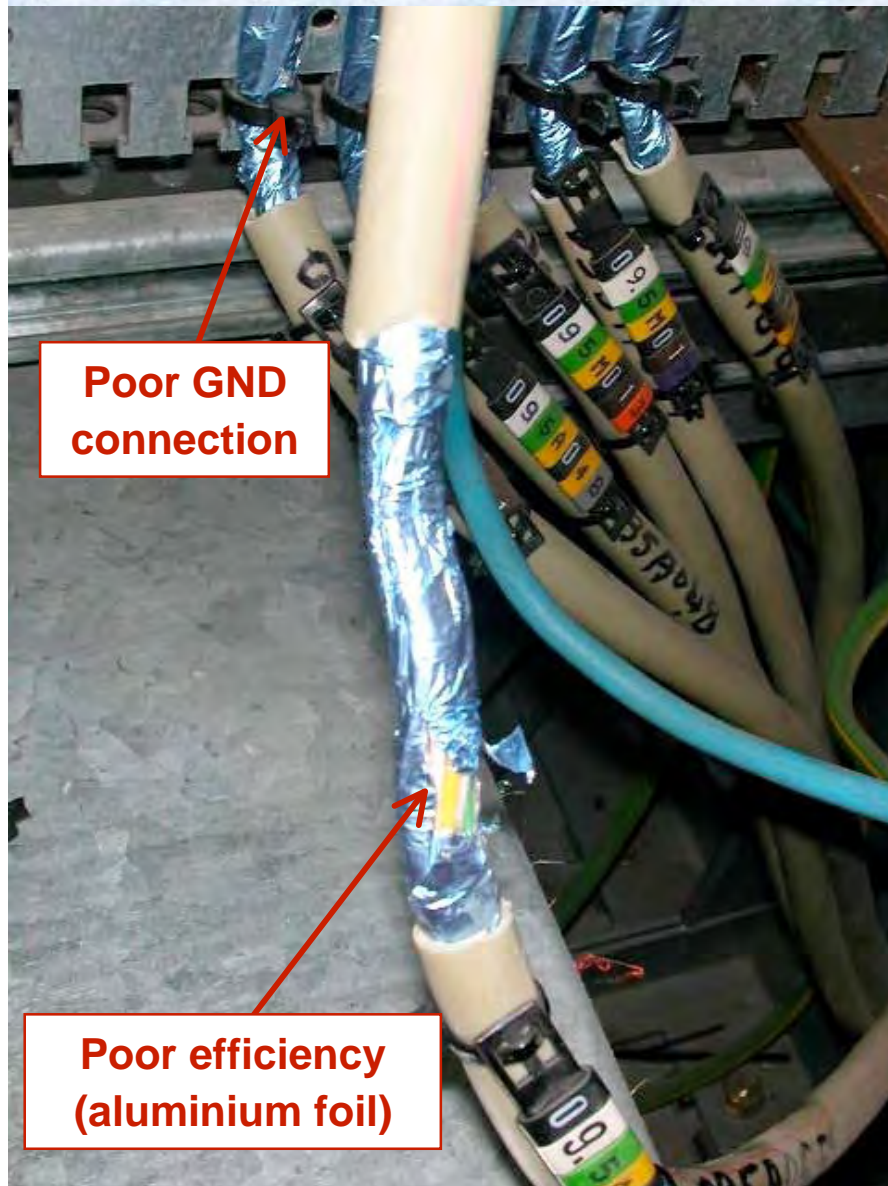
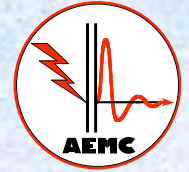
On-site
correction



Usual EMC mistakes - 7

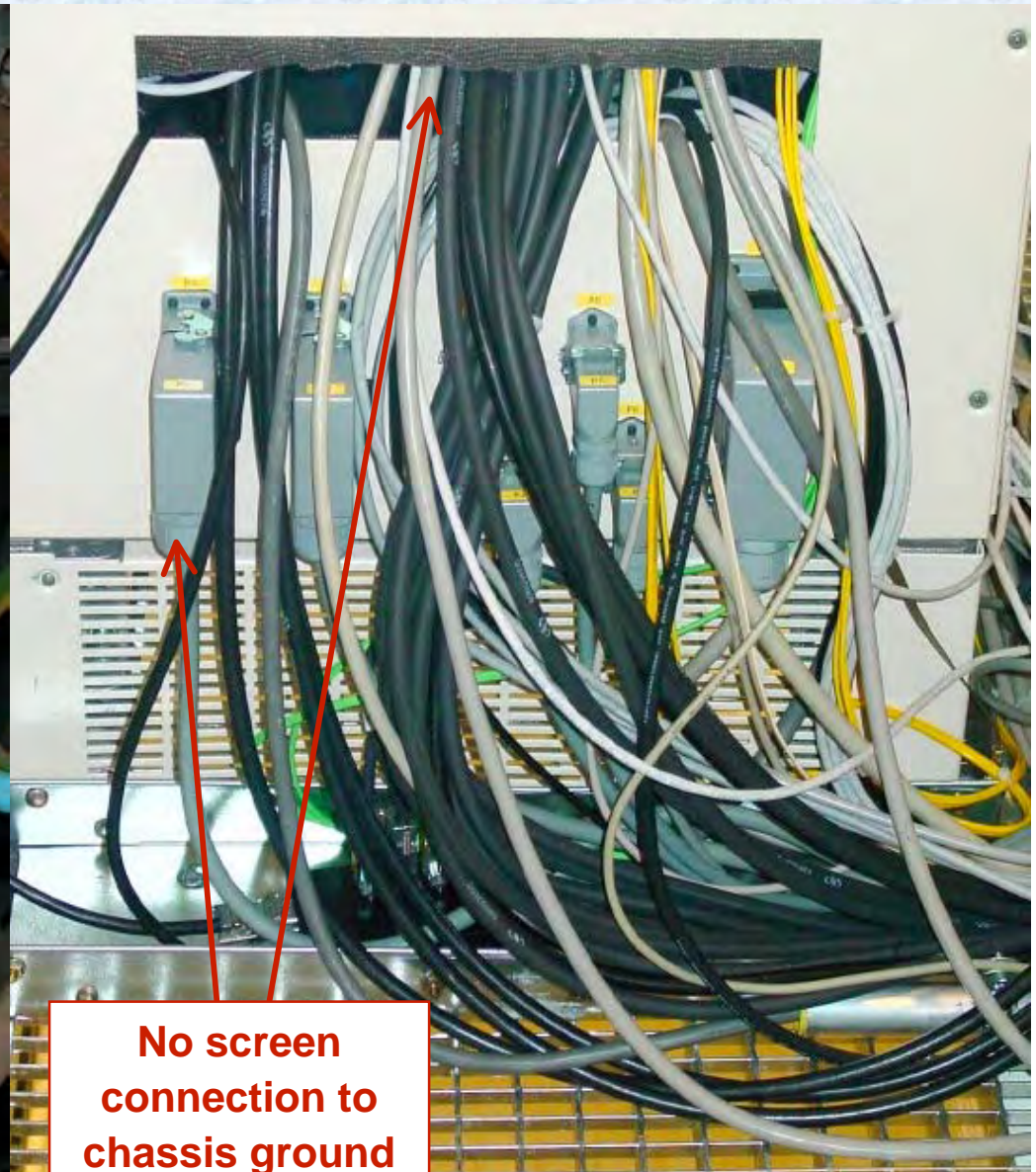


Usual EMC mistakes - 8



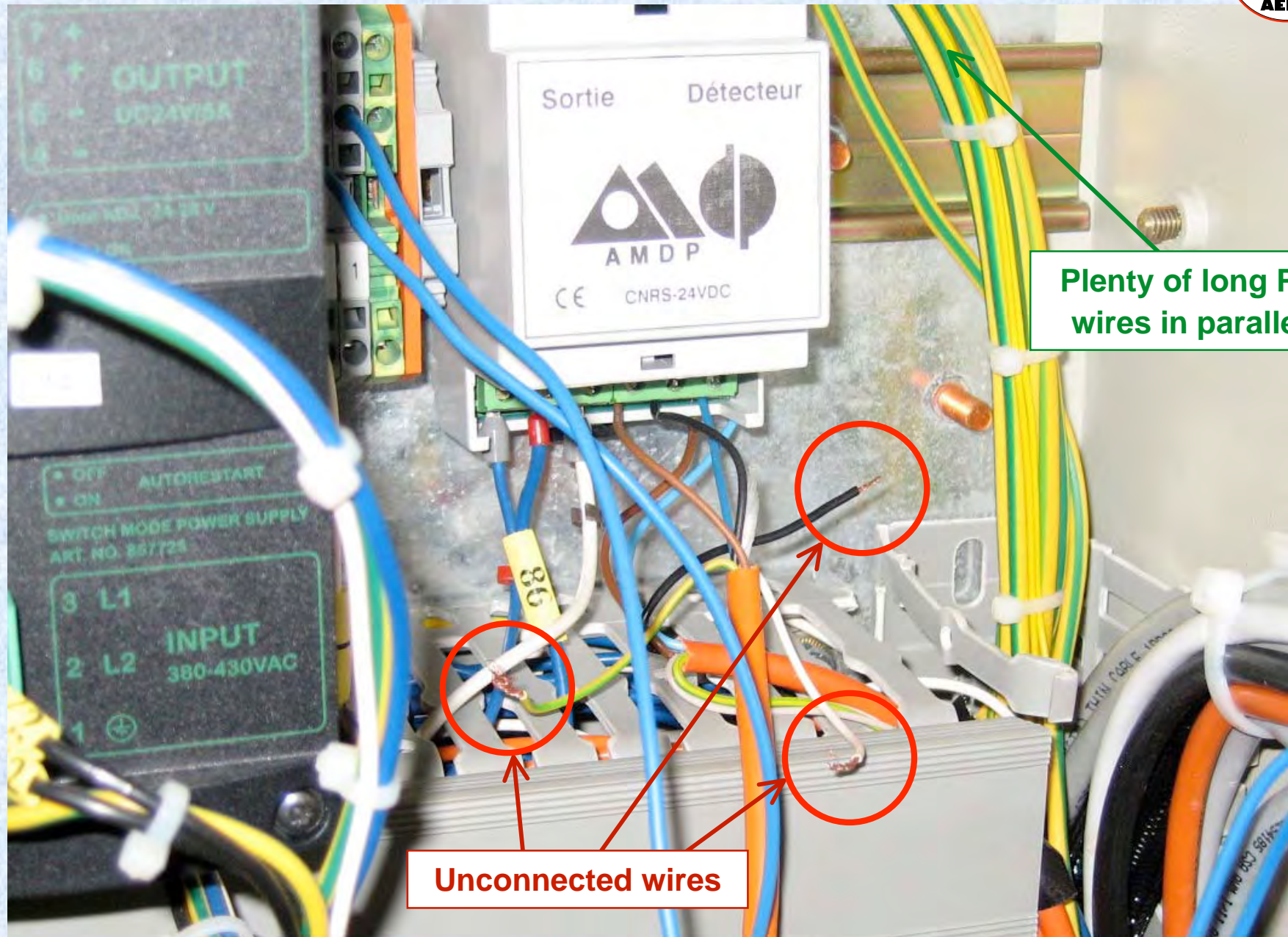
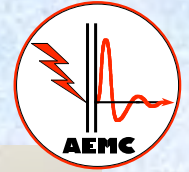
Poor GND connection

Poor efficiency (aluminium foil)



No screen connection to chassis ground

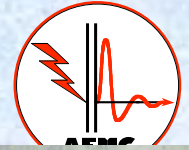
Usual EMC mistakes - 9



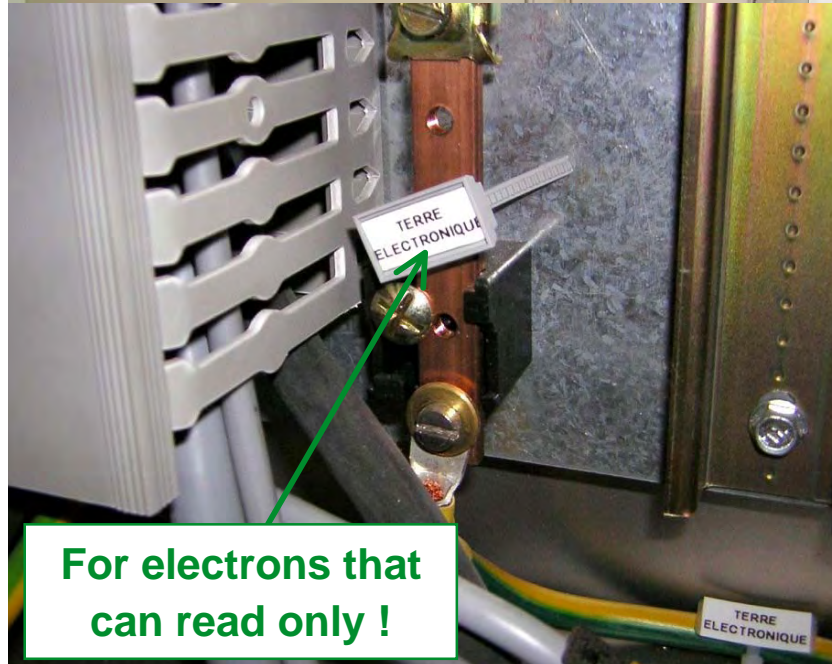
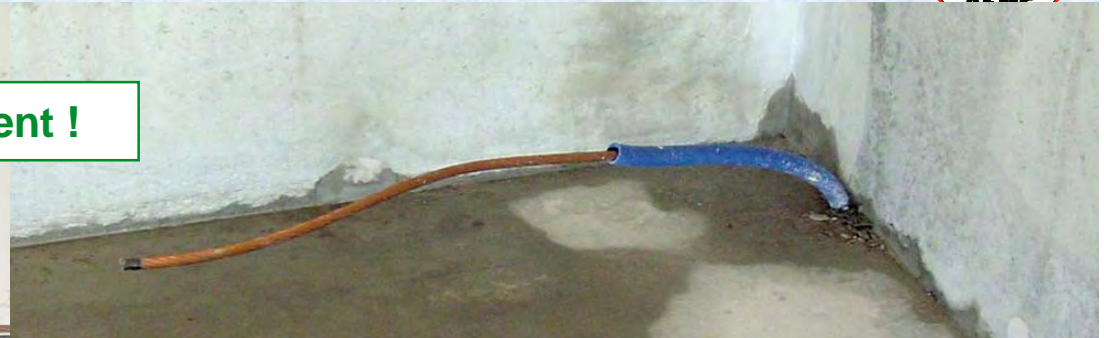
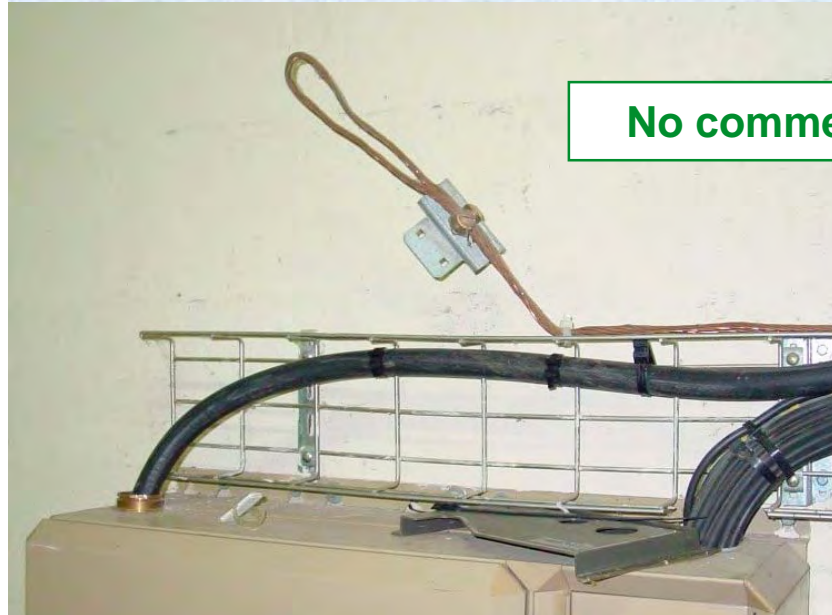
Plenty of long PE wires in parallel

Unconnected wires

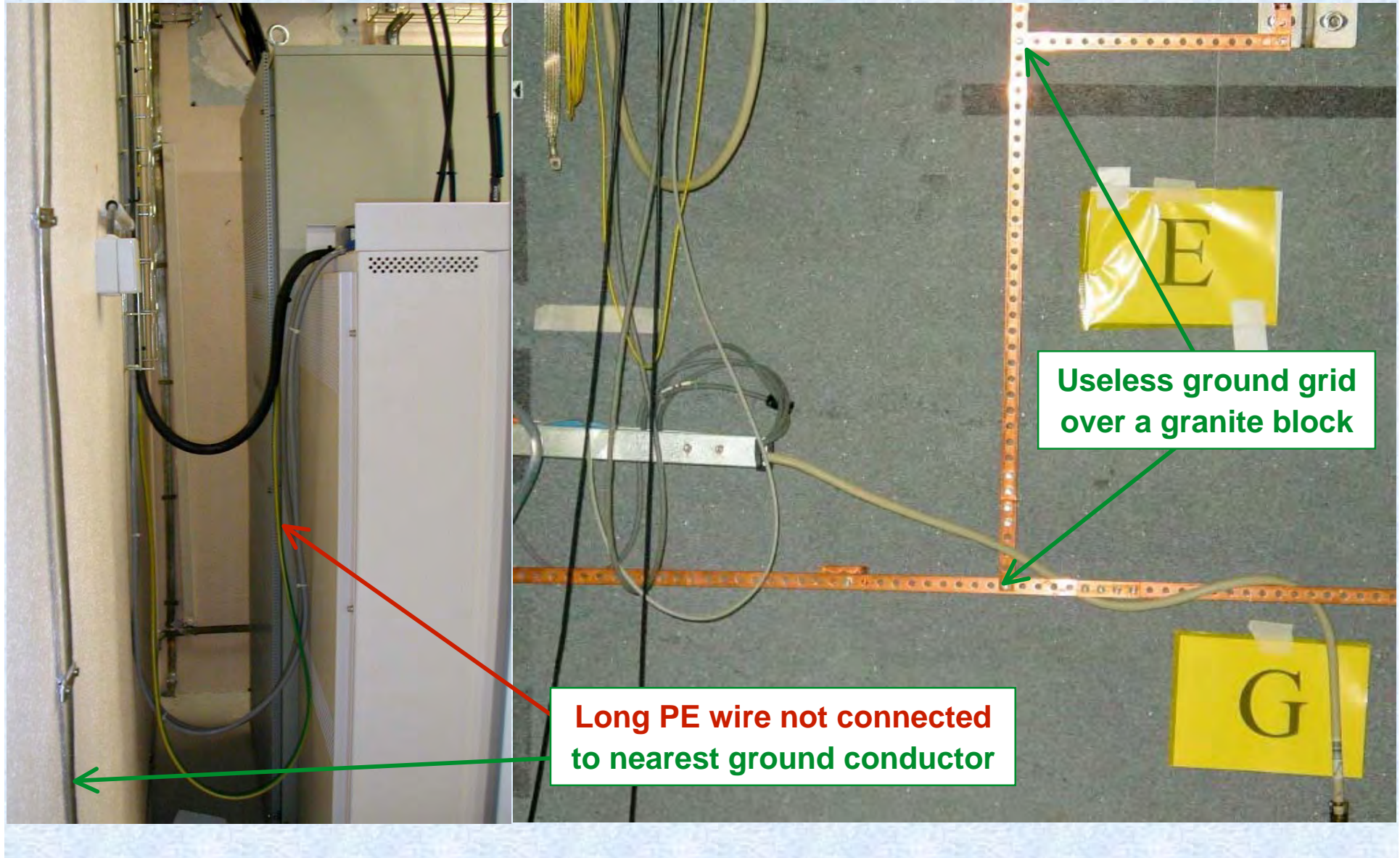
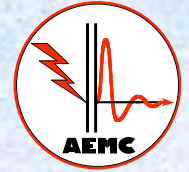
Usual EMC mistakes - 10



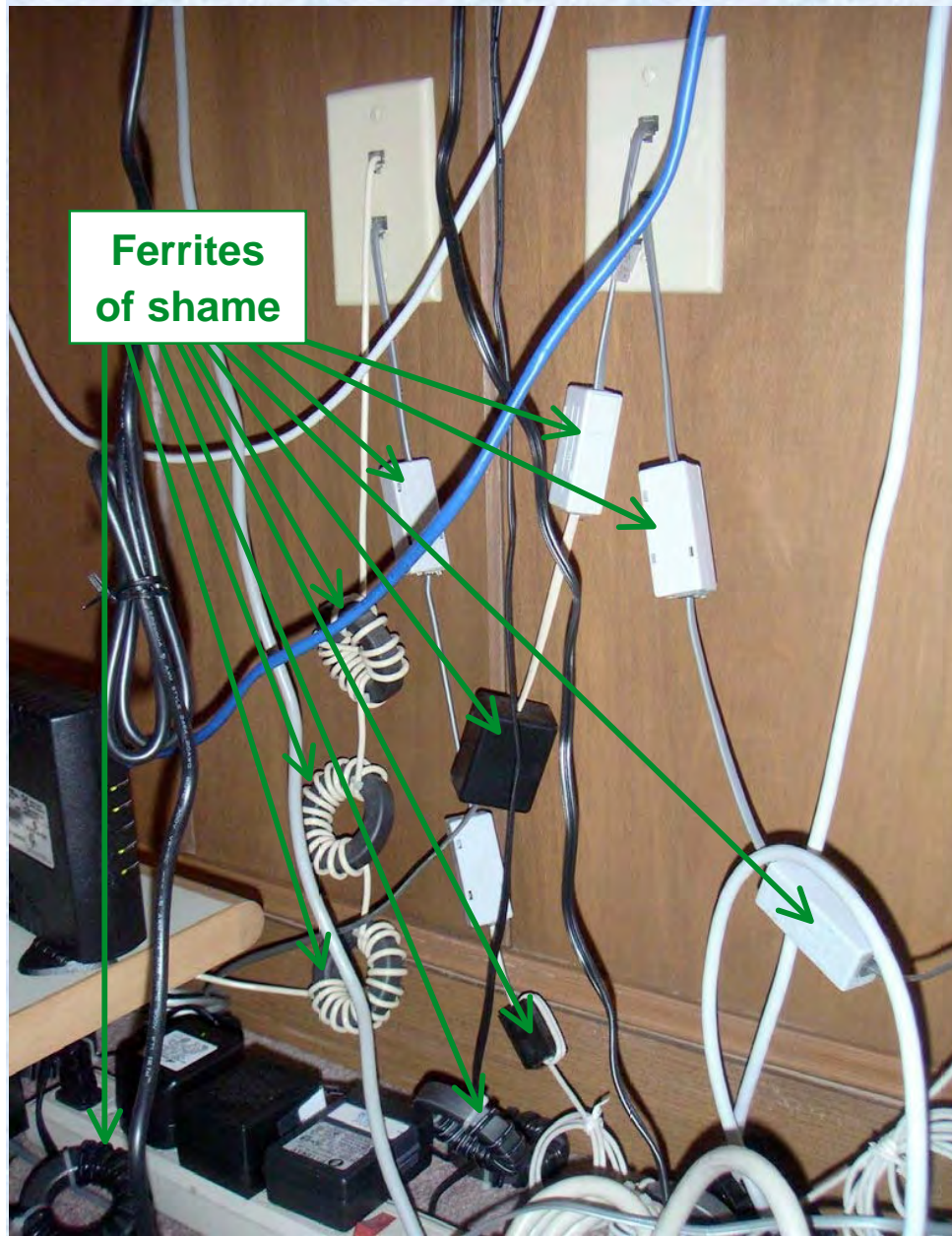
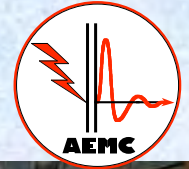
No comment !



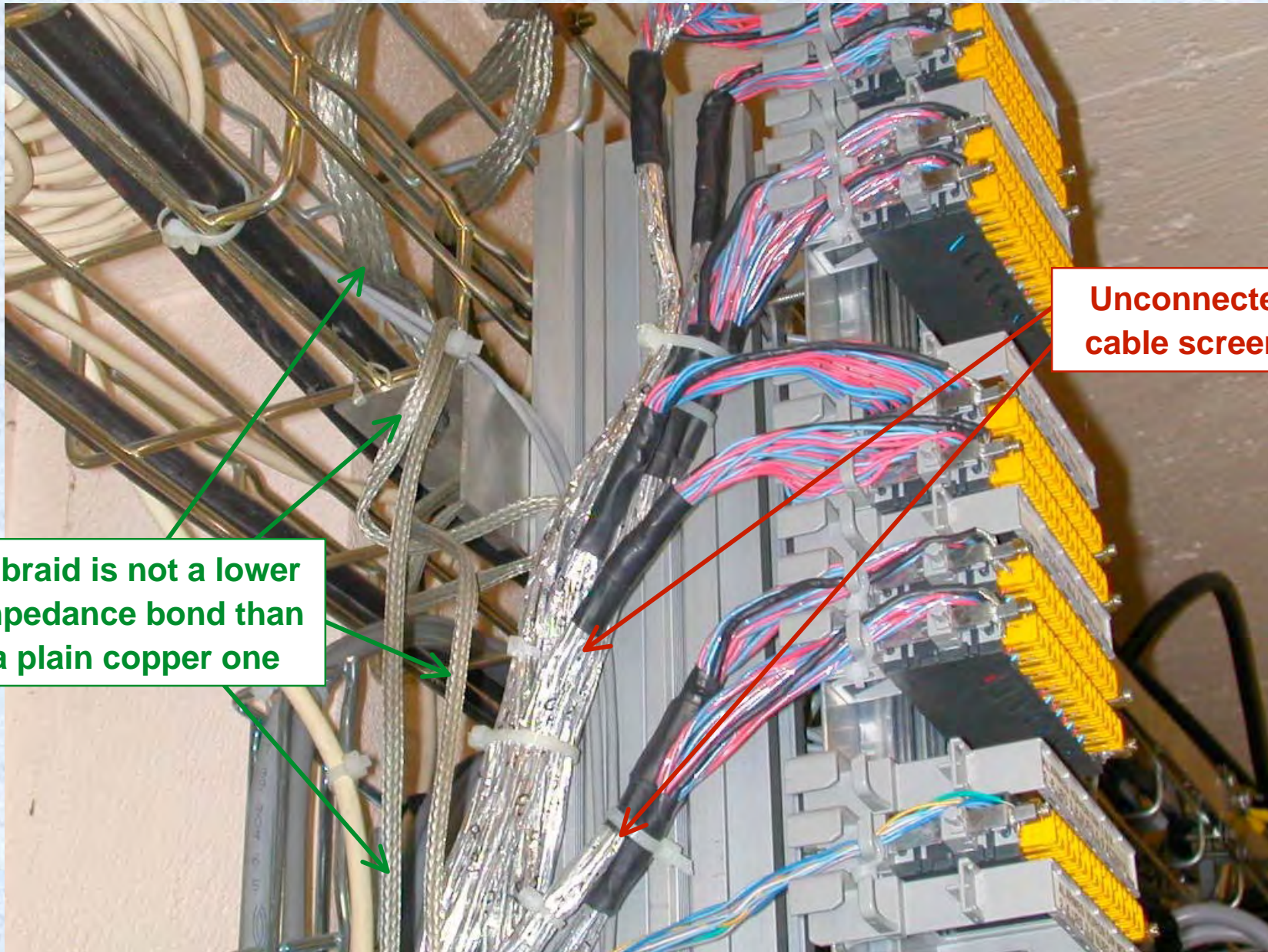
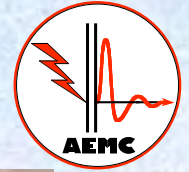
Usual poor EMC fixes - 1



Usual poor EMC fixes - 2



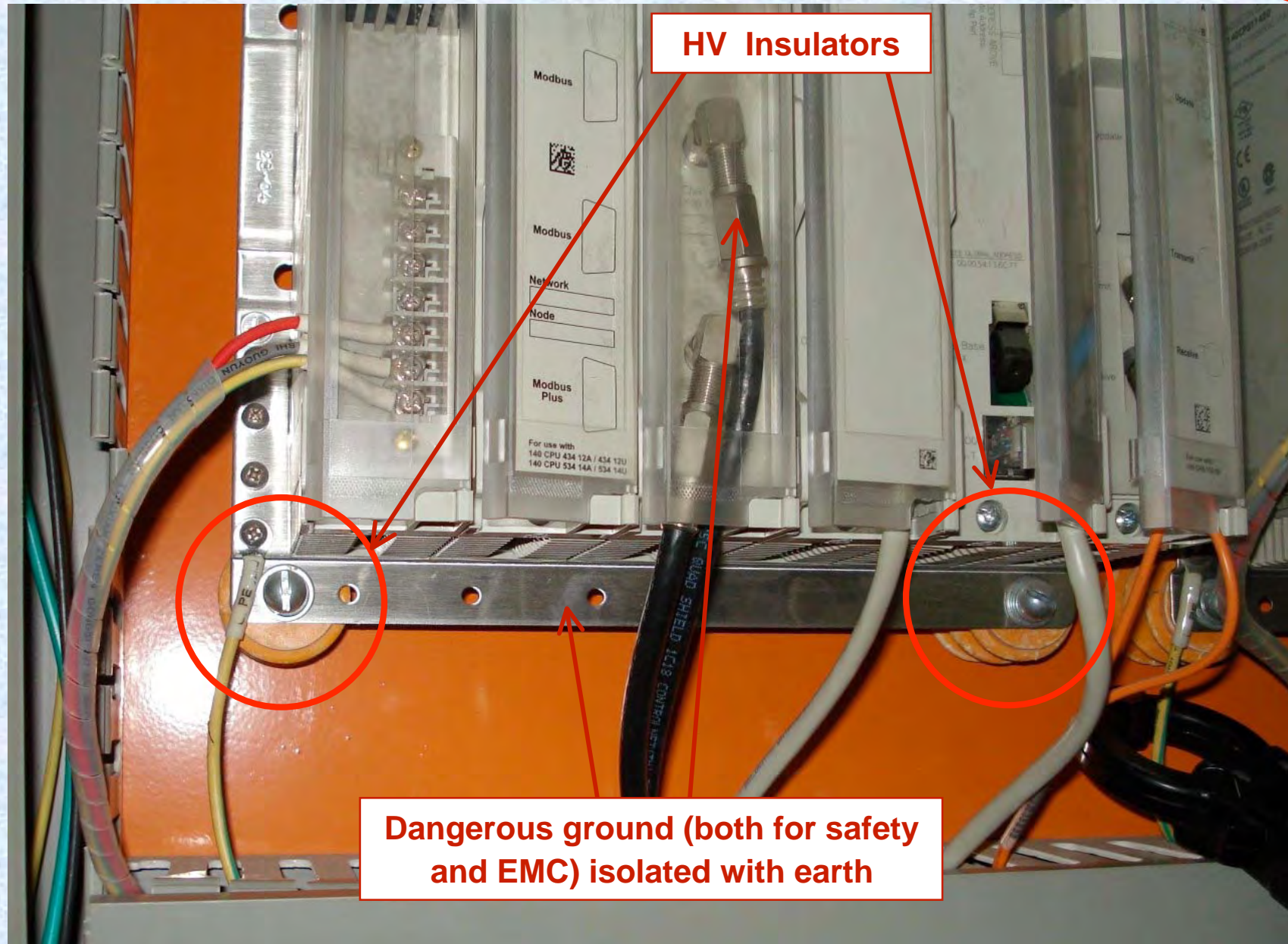
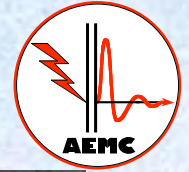
Usual poor EMC fixes - 3



A braid is not a lower impedance bond than a plain copper one

Unconnected cable screens

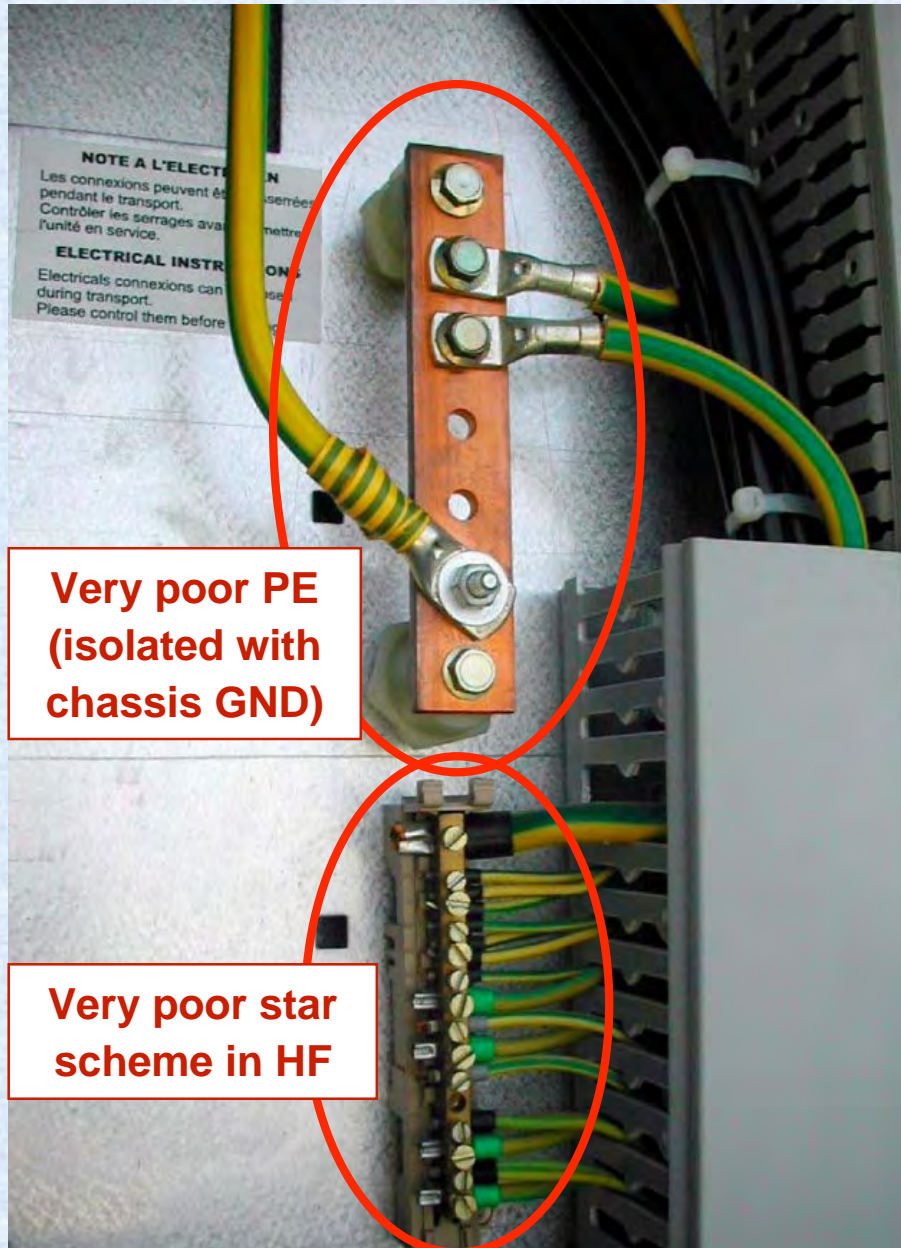
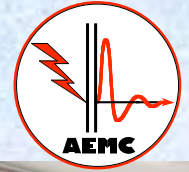
Usual poor EMC fixes - 4



HV Insulators

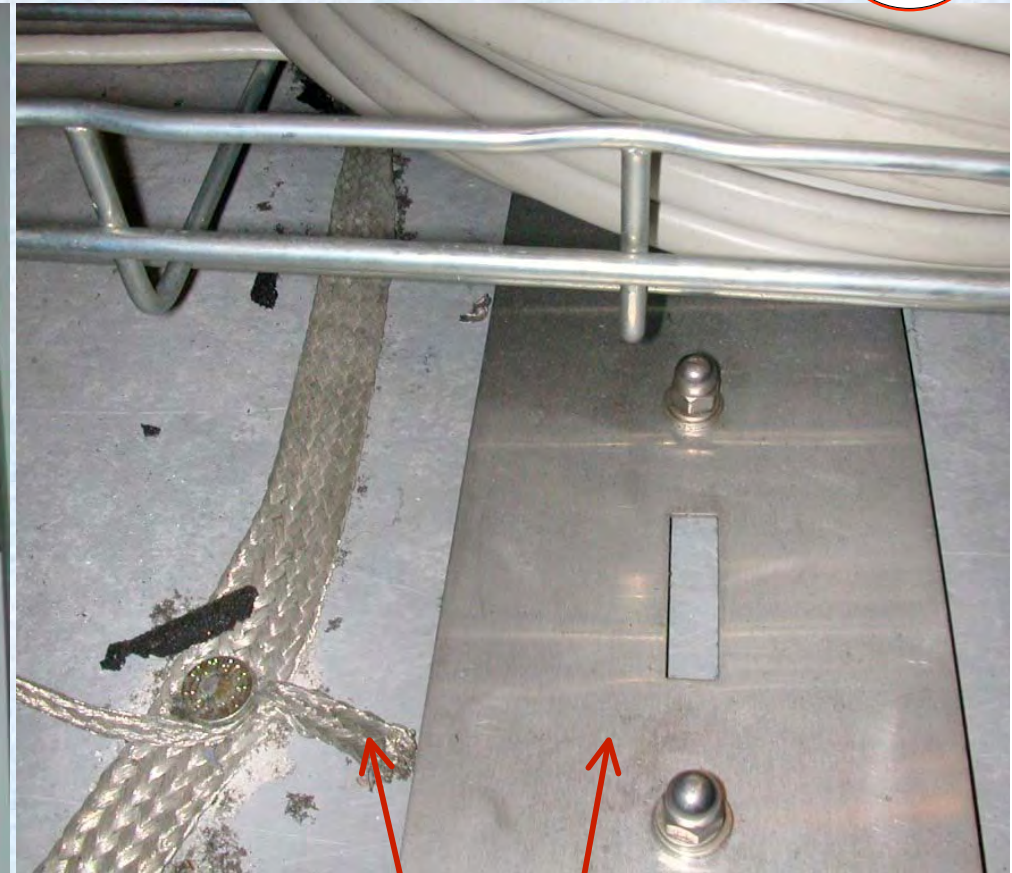
Dangerous ground (both for safety and EMC) isolated with earth

Usual poor EMC fixes - 5



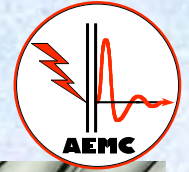
**Very poor PE
(isolated with
chassis GND)**

**Very poor star
scheme in HF**



**Poor added ground grid
(no contact between the braid
and the stainless steel plate)**

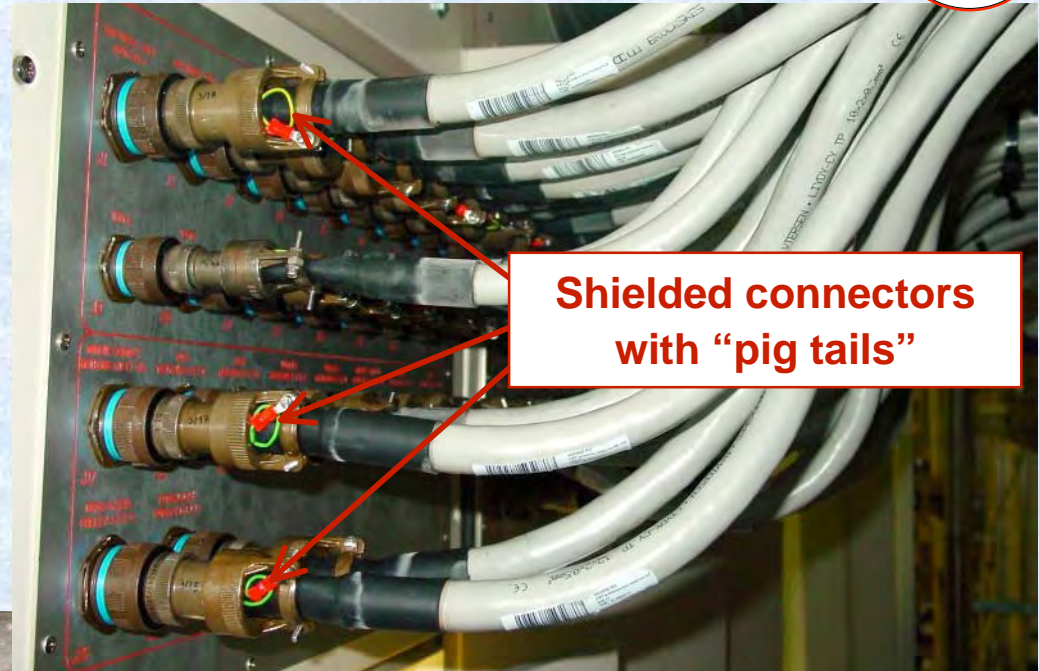
Usual poor EMC fixes - 6



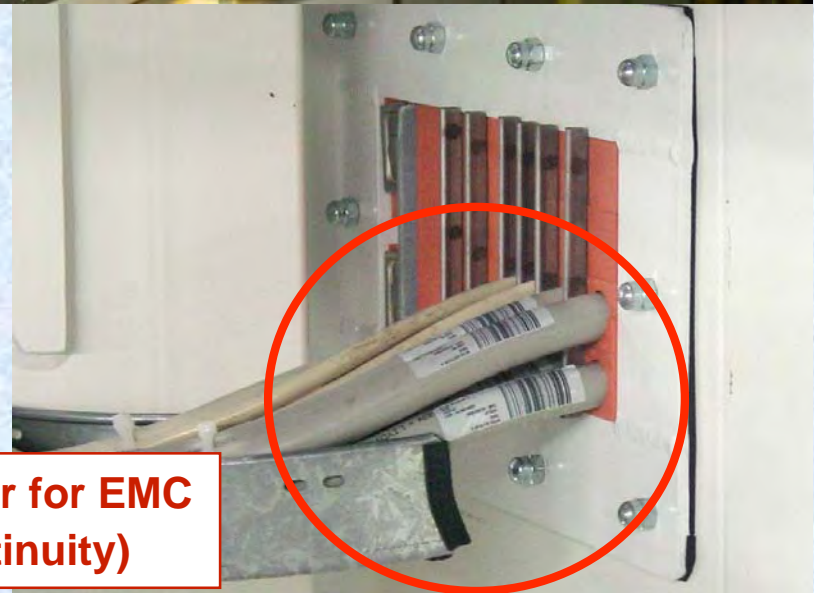
Very poor shielded connector (drain wire)



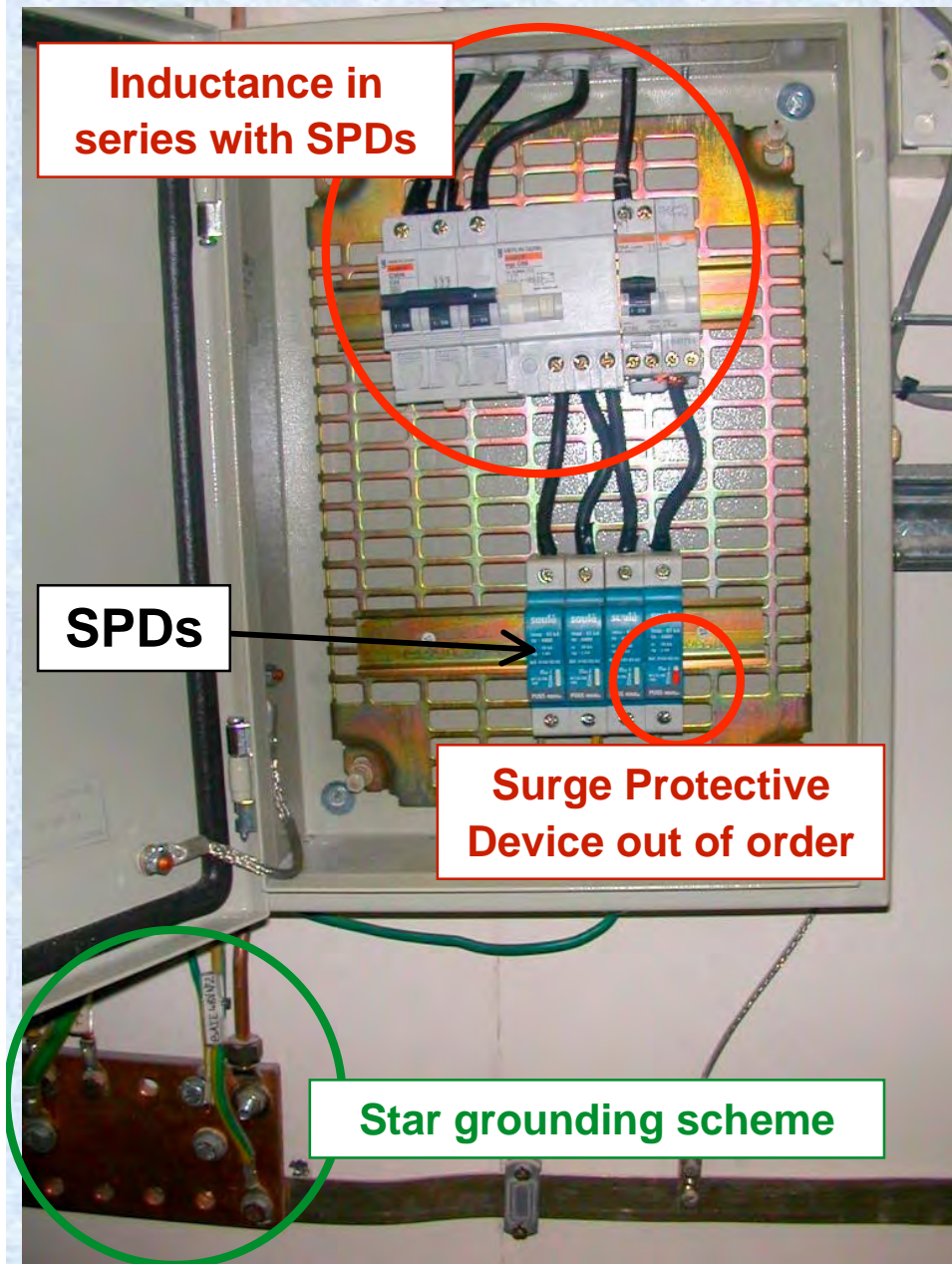
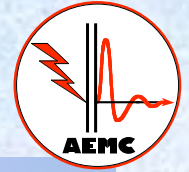
Shielded connectors with "pig tails"



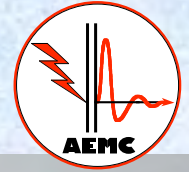
Fire barriers very poor for EMC (no cable tray continuity)



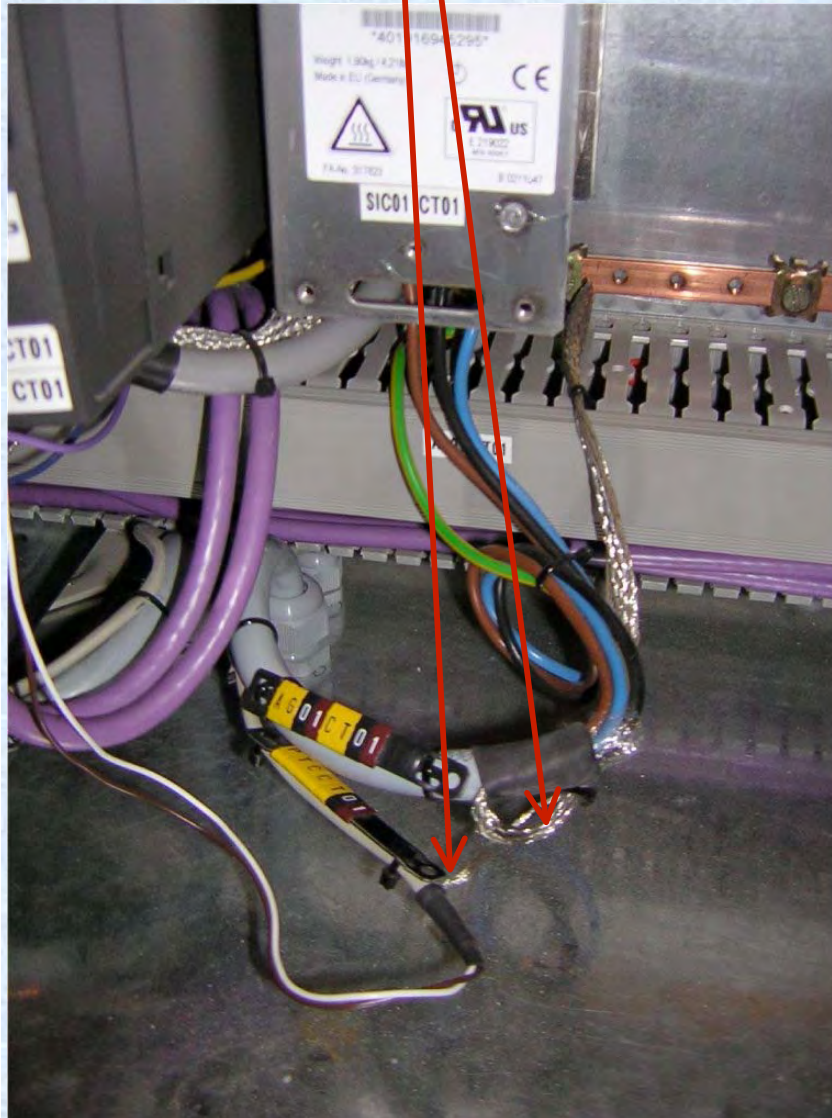
Usual poor EMC fixes - 7



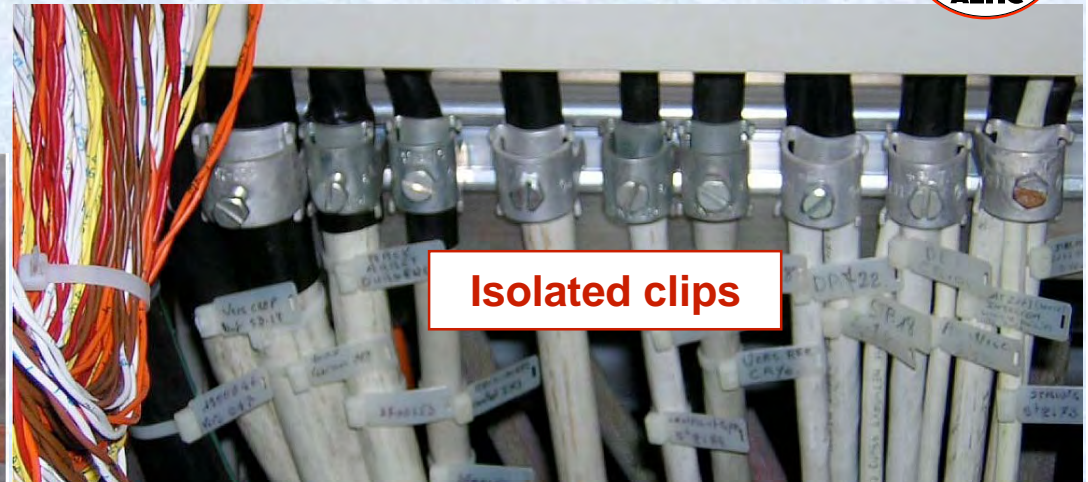
Usual poor EMC fixes - 8



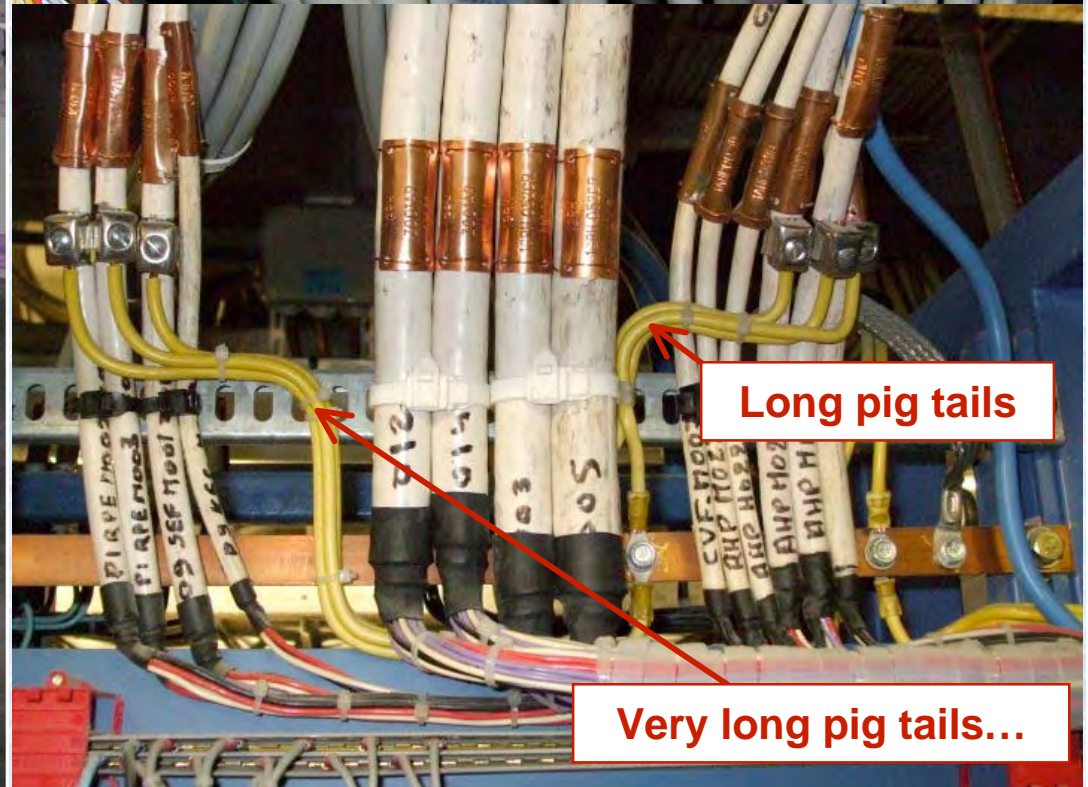
Too long pig tails



Isolated clips

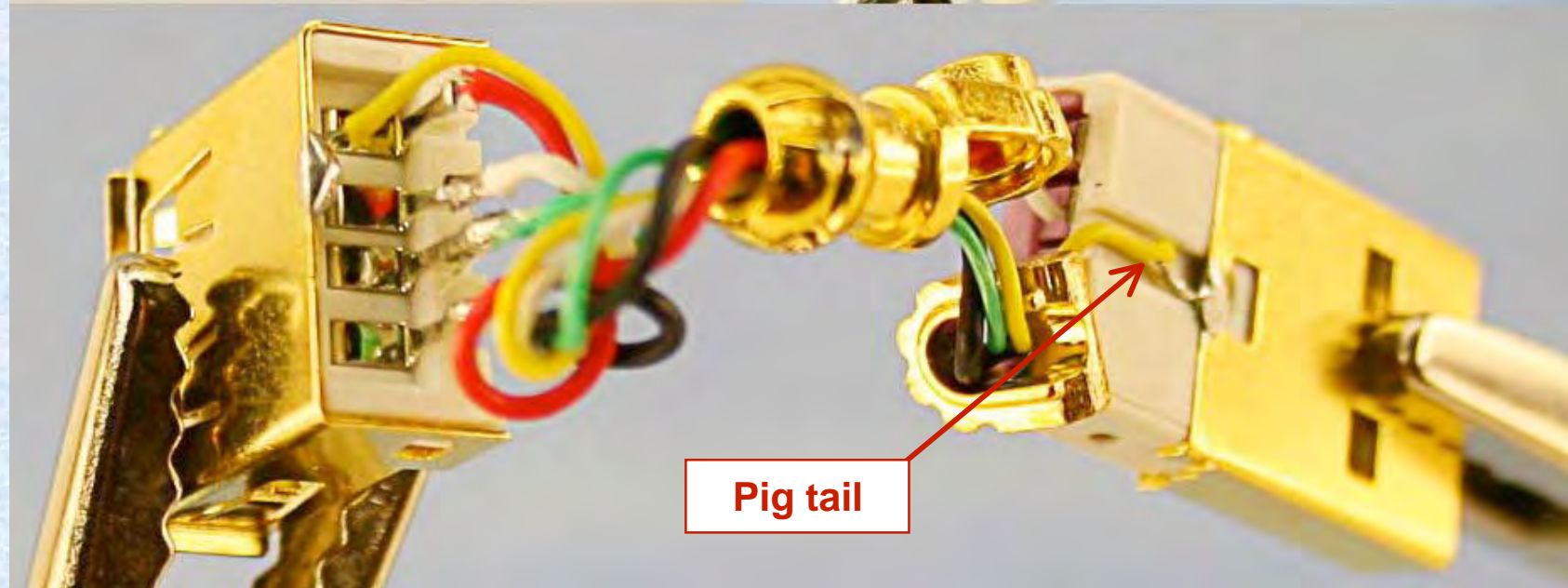
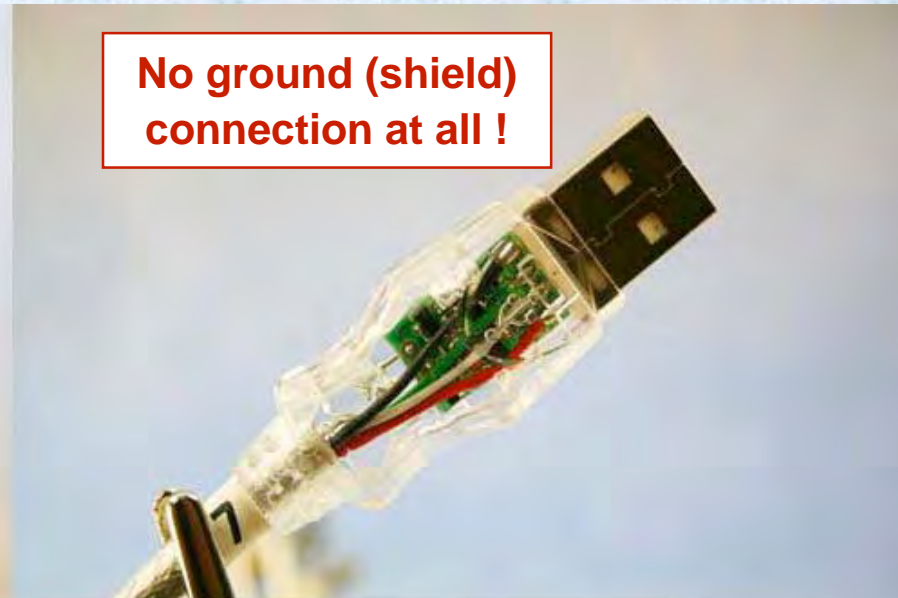
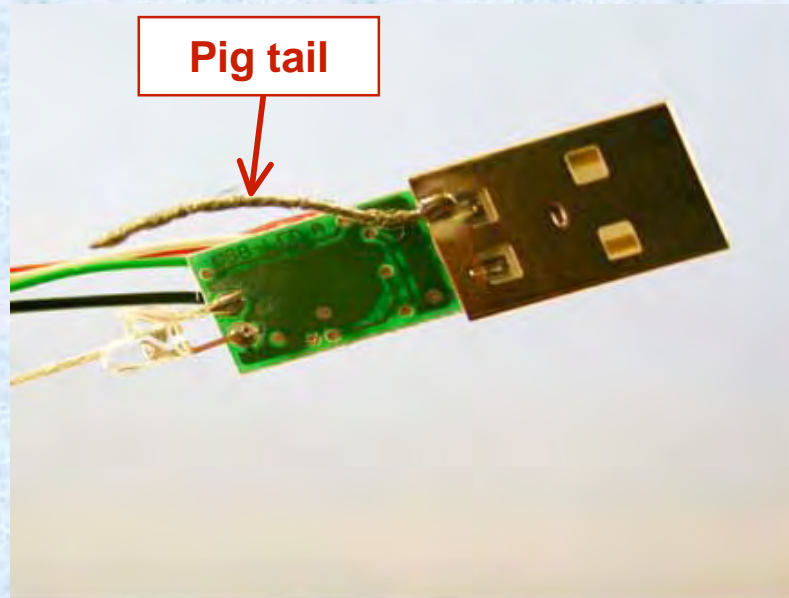
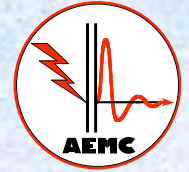


Long pig tails

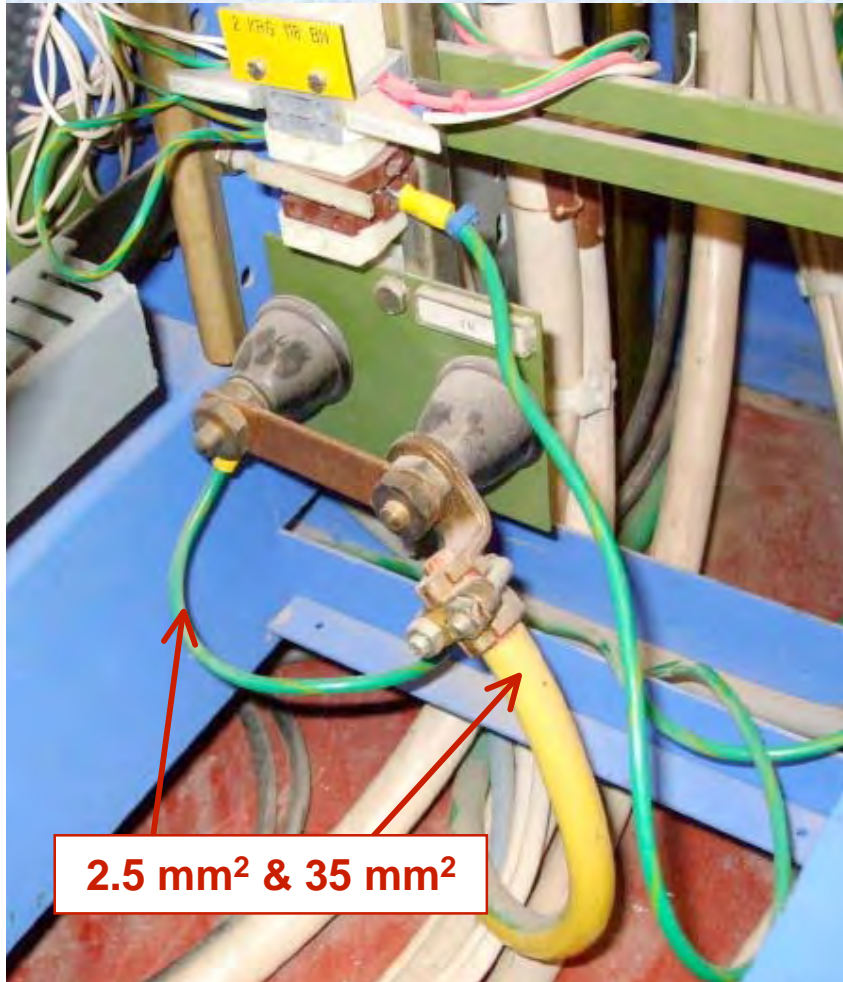
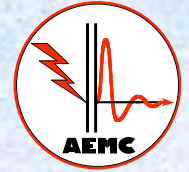


Very long pig tails...

Usual poor EMC fixes - 9

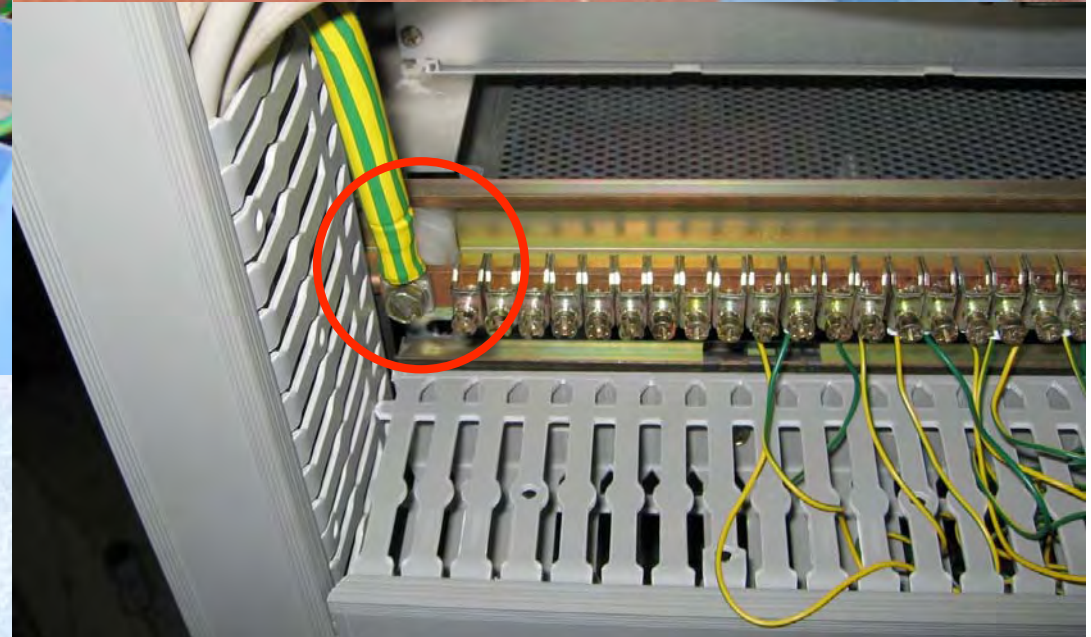
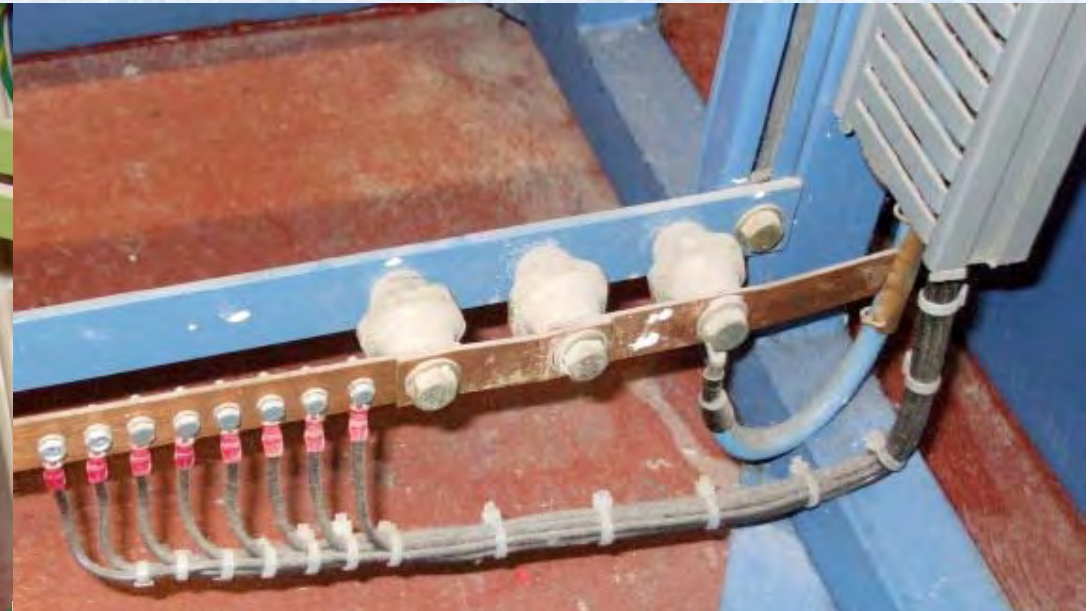


Usual poor EMC fixes - 10

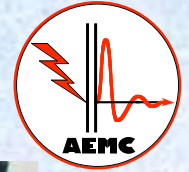


2.5 mm² & 35 mm²

Separate grounds...
and star grounding



An ultimate EMC fix - 11



**An effect of the
law of causality...**

Thank you for your attention

