

Electromagnetic Compatibility (EMC) and Why it is Often Ineffective

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Abstract. In theory, meeting the global standards for Electromagnetic Compatibility (EMC) protects a lift or escalator from electromagnetic interference (EMI) caused by outside sources. It protects other equipment in a building by limiting the emissions generated by the vertical transportation equipment.

Installation methods and ageing often render EMC measures ineffective.

EMI and its sources are identified, both proper and improper installation methods are detailed, and the degradation of EMC equipment over time is explained.

1 INTRODUCTION

BS EN 81-20: Safety rules for the construction and installation of lifts – Lifts for the transport of persons and goods – Part 20: Passenger and goods passenger lifts [1], and BS EN 115-1, a similar standard for escalators and moving walks [2], include two normative references that address Electromagnetic Compatibility for lifts and escalators. The normative references are BS EN 12015 [3] and BS EN 12016 [4].

2 BACKGROUND

Electromagnetic compatibility, or EMC, involves the methods that permit electronic devices, such as lifts and escalators, to operate safely without interfering with other equipment through electromagnetic signals [5].

Electromagnetic interference (EMI) is the unwanted noise or signals emitted by electronic devices such as radio and television stations, mobile communication devices, variable frequency drives, switching power supplies and any circuit board with a clock or oscillator chip [6].

EMC ensures that a device does not emit too much EMI and that it is immune to a reasonable amount of interference from other sources.

2.1 BS EN 12015 Emissions

This standard establishes permissible levels of emissions over a wide frequency range. Levels for both radiated and conducted emissions are specified [3].

2.2 BS EN 12016 Immunity

This standard establishes minimum levels of electromagnetic interference that a lift or escalator must withstand for the following types of interference [4]:

1. Radio Frequency common mode from 80 MHz to 2,655 MHz.
2. Electrostatic discharge.
3. Fast transients, common mode.
4. Voltage surges.
5. Voltage dips (sags).
6. Voltage interruptions.

3 COMPLIANCE TESTING OF BS EN 12015 AND 12016

The verification of the ability of vertical transportation equipment to meet these standards is performed in a controlled laboratory environment. Typically, the electrical and electronic components of the lift or escalator system are connected electrically in an anechoic chamber. The chamber is a Faraday cage lined with Radio Frequency (RF) absorbing materials. The chamber creates a space where Radio Frequency Interference (RFI) from outside the chamber does not interfere with the testing process. Additionally, signals from the chamber do not interfere with electronic equipment outside the chamber. See Figure 1.

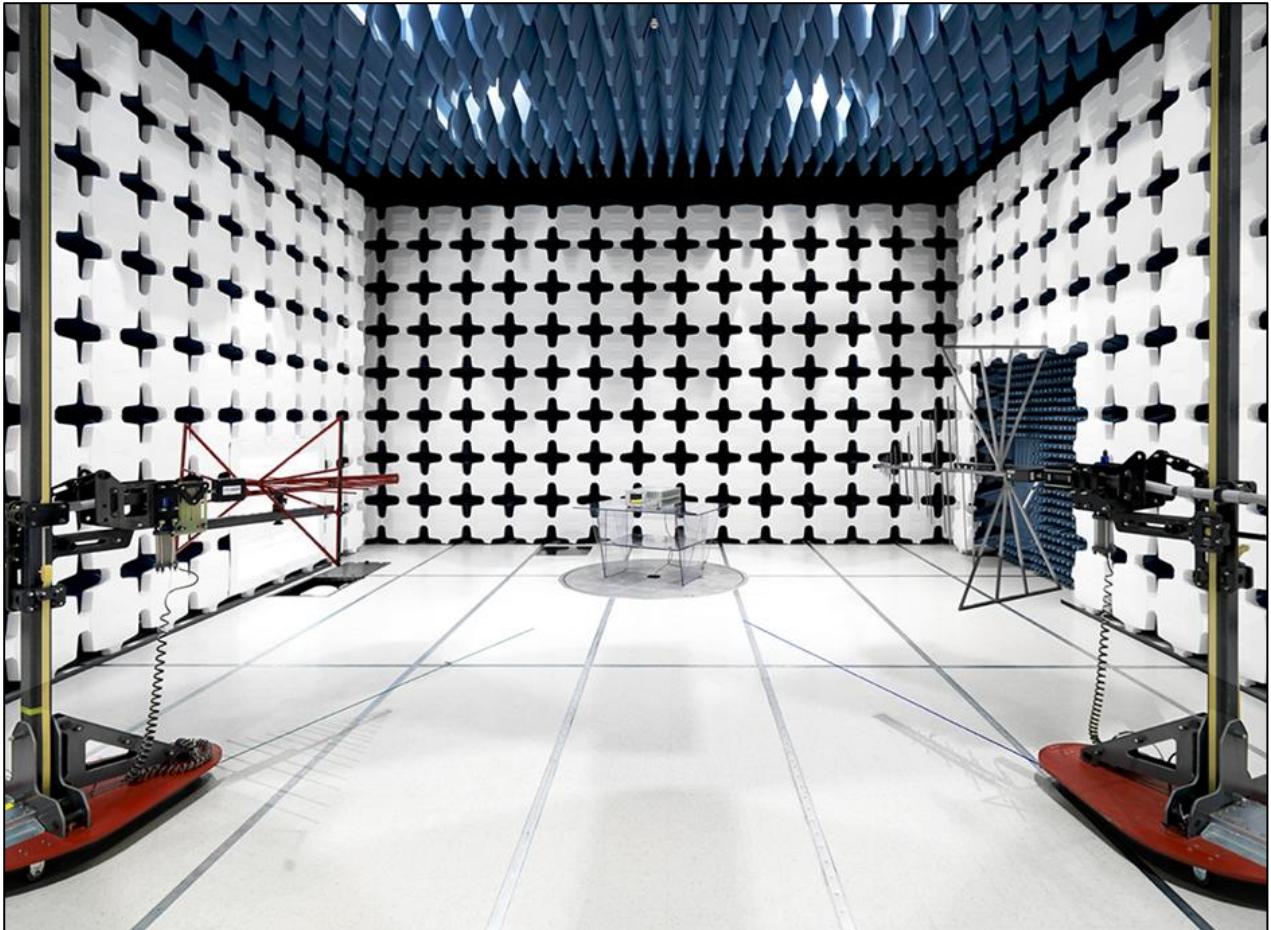


Figure 1

Figures 2 and 3 are excerpts from BS EN 12015 and BS EN 12016 that represent the components of lifts and escalators that are evaluated together in an anechoic chamber.

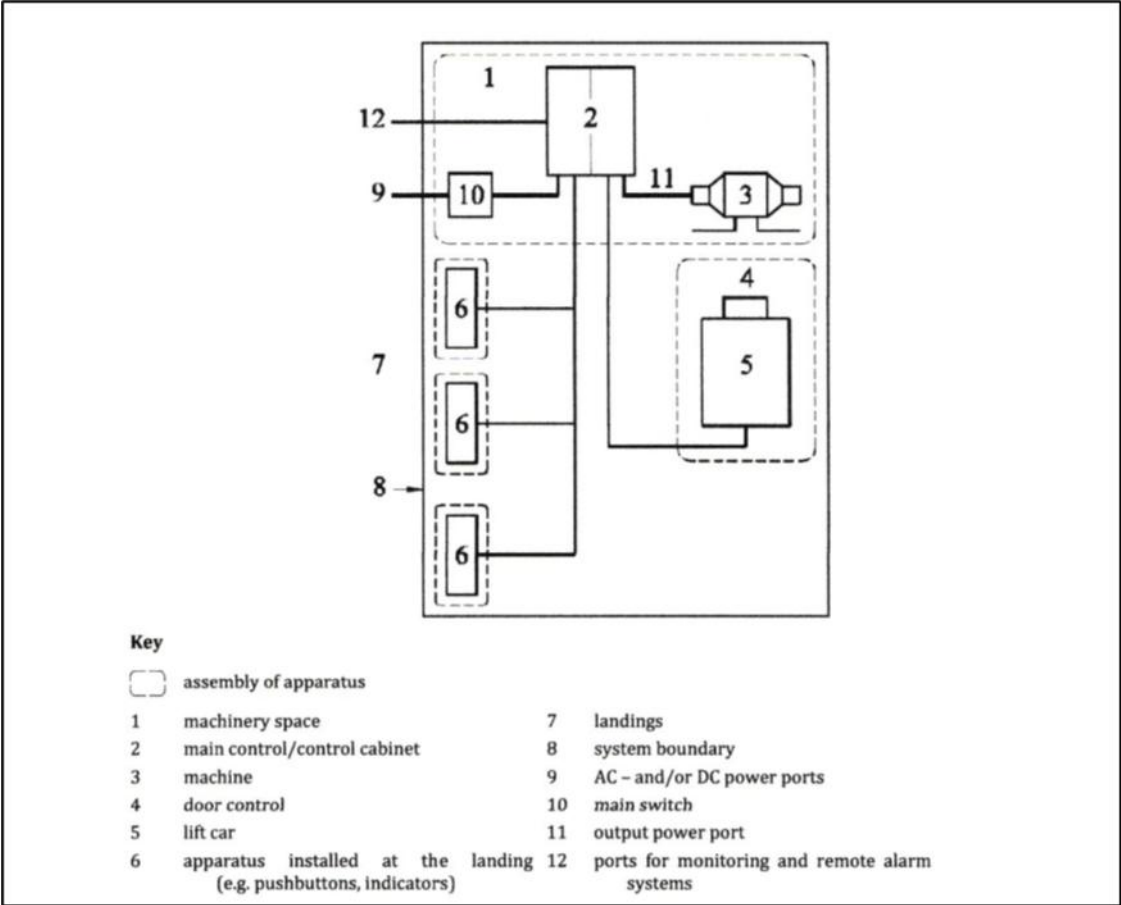


Figure 2

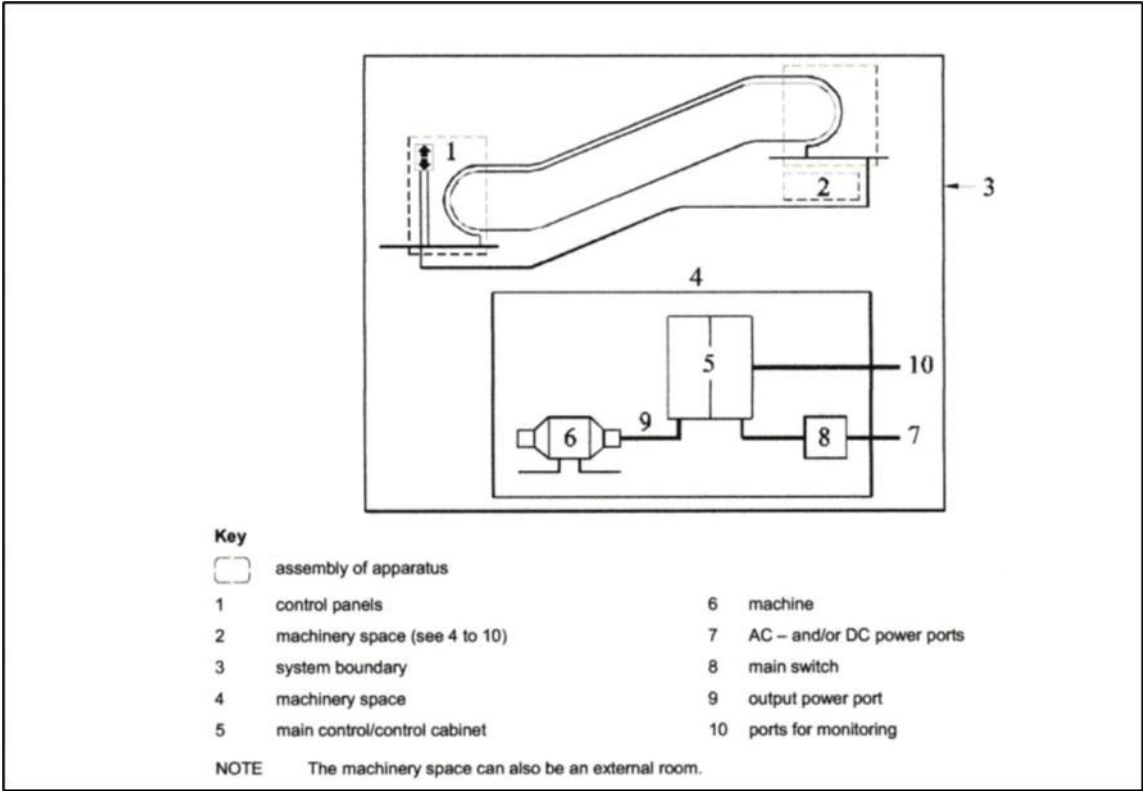


Figure 3

In lift and escalator installations, it is common to have long cables between components. Travelling cables, hoistway wiring, and wiring between upper and lower pits on escalators are examples of such long cables. When the cable length is anticipated to be longer than five meters in length, then a 5-meter length of cable is evaluated in the chamber.

3.1 Emissions testing

The components are placed in the anechoic chamber, connected, and powered from an external source.

3.1.1 Radiated Emissions

Antennas are also placed in the chamber and connected to a receiver such as a spectrum analyser that is located external to the chamber.

The emission levels are recorded over a wide range of frequencies, and all the levels must be at or below the maximum levels required by the standard.

Examples of emitters are variable frequency drives, switching power supplies and any circuit board with a clock or oscillator chip.

3.1.2 Conducted Emissions

The antennas are replaced by a coupling transformer connected to the power supply cables and the spectrum analyser. Note, the coupling transformer is located externally to the chamber. Emission levels are recorded over a wide range of frequencies, and all the levels must be at or below the maximum levels required by the standard.

3.2 Immunity testing

3.2.1 Radiated interference

The antennas are reconnected to RF transmitters, and the transmitters bombard the systems with elevated levels of RF energy over the same frequency ranges. The RF radiation should not cause the system to malfunction.

3.2.2 Conducted interference

A coupling transformer is connected to the power supply cable, and several types of interference are induced into the external power supply cable. The interference should not cause the system to malfunction.

3.2.3 Electrostatic Discharge

An electrostatic discharge gun is used to subject the system to discharges of between 8 kV and 15 kV, depending on circuit type and whether the discharge is by contact or through the air.

3.3 Installation Instructions

Both standards contain a section titled *Documentation for the installer of the apparatus/assembly of apparatus*. This documentation must include the following:

1. Instructions for assembly and physical arrangement with other apparatus.
2. Instructions and precautions for interconnection to other apparatus.
3. Specifications of interconnection cables and devices.
4. Instructions for commissioning and testing.
5. Guidance on avoiding incorrect actions and assembly of apparatus which are known to cause noncompliance with the standard.

3.4 Efficacy of the standards

These standards have been in use for over 25 years. They have been upgraded periodically to keep up with changes in technology. The author has been involved with lift and escalator installations on six continents, where the equipment was built in compliance with these two standards. The only EMC issues encountered have been either units installed incorrectly or units that have been in operation for more than 10 years.

These two issues, which are quite common, will be explored in the next sections of this paper.

4 EMC INSTALLATION PROBLEMS

Most installation issues are related to the following:

1. Earthing
2. Coupling

4.1 Earthing

Earthing has two functions [7]:

1. Safety
2. EMI control

Safety: Most lift installers are familiar with how earthing prevents shock. If a controller cabinet were not earthed and a high-voltage power supply wire were to contact the cabinet, then a person contacting the cabinet and earth would be shocked. With an earthed cabinet, when the wire contacted the cabinet, a short circuit would occur, and the circuit would be interrupted by a fuse or circuit breaker.

EMI Control: High-frequency EMI tends to follow the path of least impedance (resistance). The grounding system offers that path, directing interference to earth and away from sensitive components [8].

Earthing for safety only requires that there be continuity between the object and earth. However, for alternating currents, particularly high-frequency alternating currents such as EMI, the currents are only conducted in the skin of the conductor. This is known as the **skin effect** [9].

4.2 Coupling

In addition to direct conduction, EMI can enter a system through coupling [10] [11]. The following are the three types of coupling:

1. Inductive
2. Capacitive
3. Radiative

These three types of coupling can be created by improper installation.

Inductive coupling occurs when wiring is placed close enough to create a transformer. When one thinks of a transformer, one usually thinks of coils of wire. However, electricity can be induced from one wire to another even if both wires are straight.

Capacitive coupling occurs when wires are placed close enough to behave like plates of a capacitor.

Radiative coupling occurs when wires function as a receiving antenna and interference is transmitted to the antennas of a system.

Coupling can be reduced through separation, shielding, and by a combination of both separation and shielding [12]. See Figure 4.

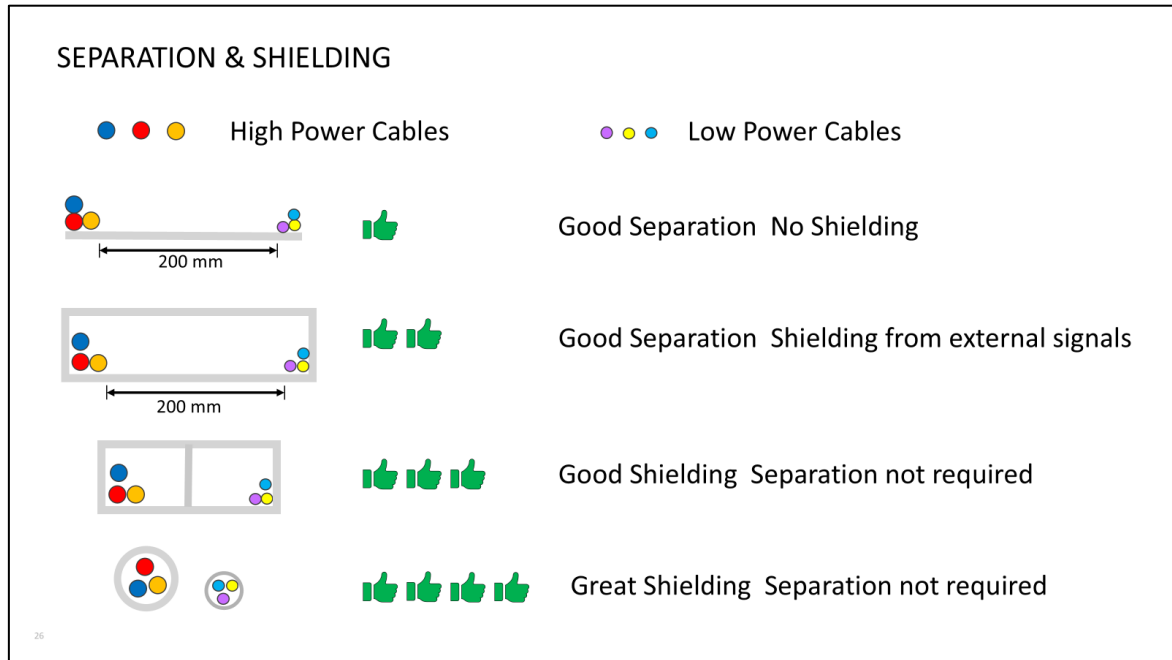


Figure 4

Figure 5 shows power and data cables laced together as they enter a Variable Voltage Variable Frequency (VVVF) drive.

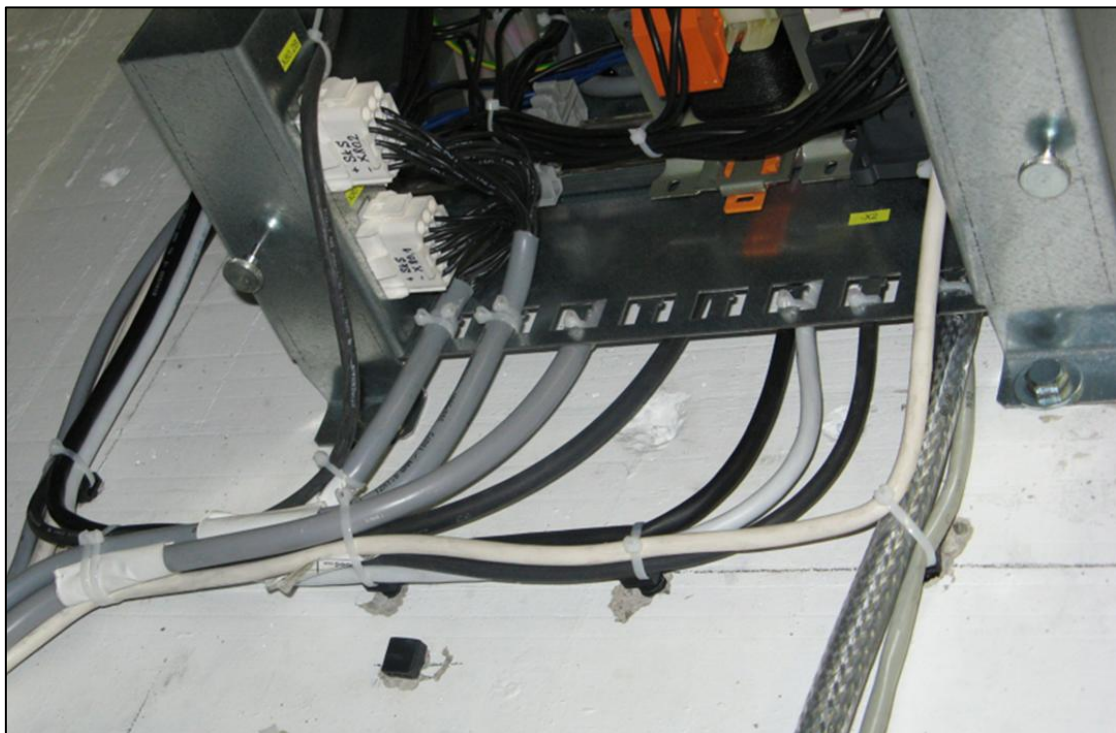


Figure 5

Figure 6 also shows power wires laced to data wires. However, in this case, the wires are looped to improve induction.

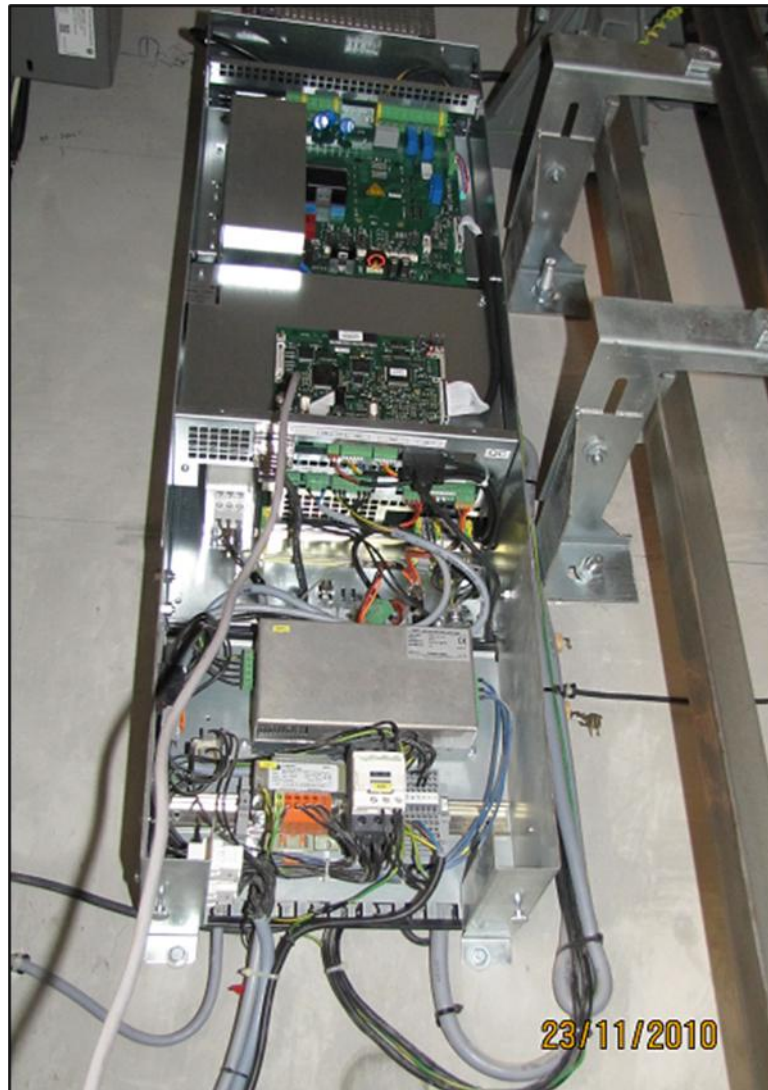


Figure 6

Figure 7 shows shielded cables correctly installed. Note how the entire circumference of the shields is connected to the control panel. This connection technique takes advantage of the skin effect to conduct the interference to earth.

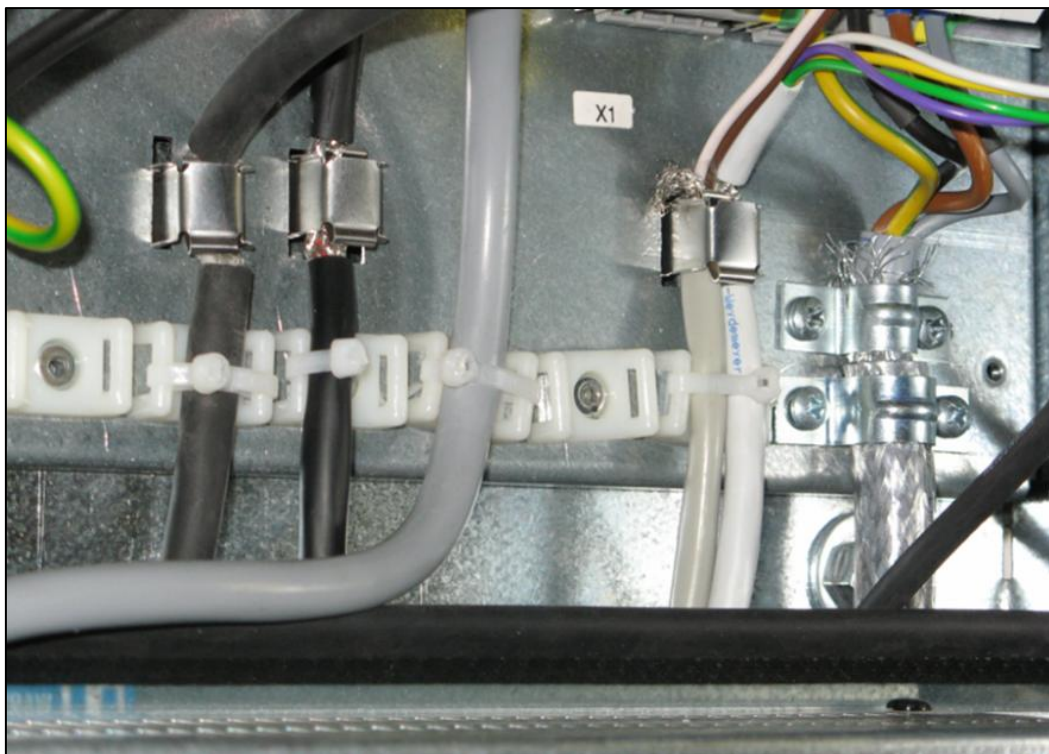


Figure 7

Figure 8 shows shielded cables improperly installed. The braided shield has been formed into a wire pig tail, and the pig tail is then earthed.

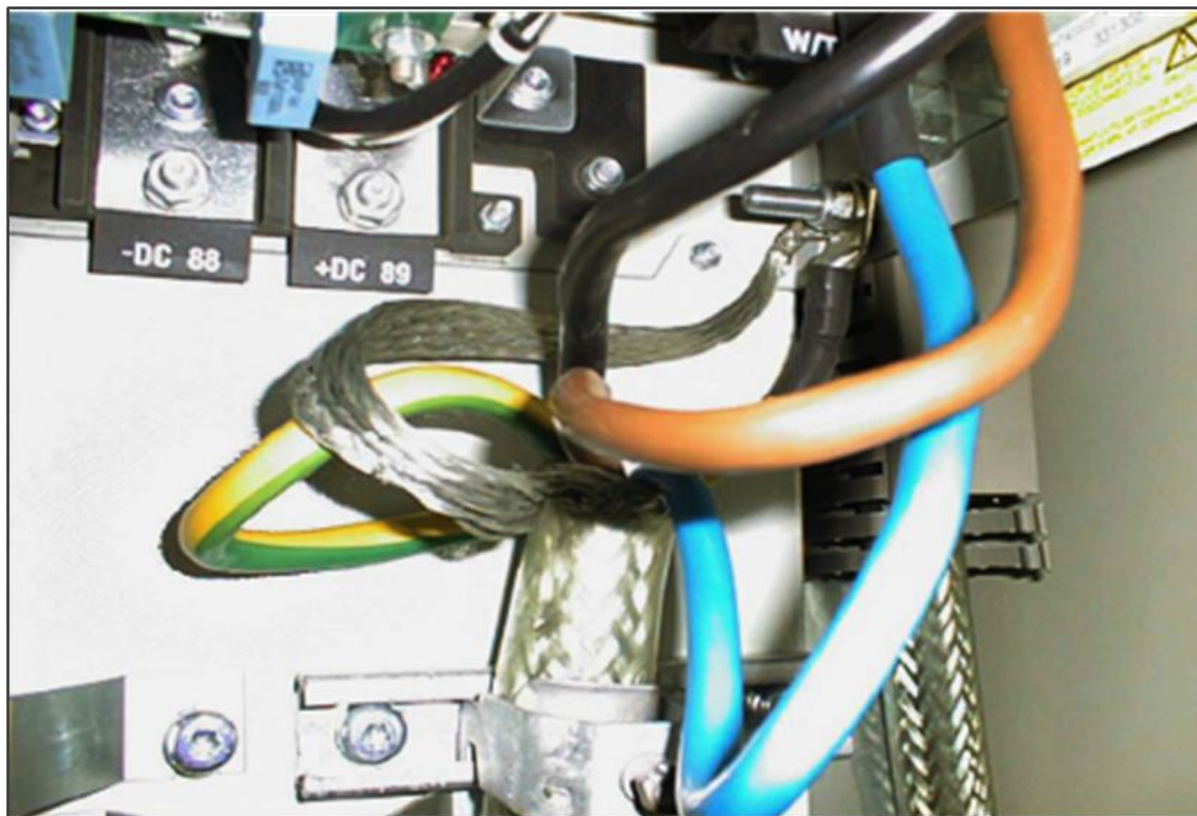


Figure 8

5 EQUIPMENT AGEING

Most lifts and escalators with VVVF drives are fitted with an EMC Filter to comply with the conducted emissions standard. See Figure 9.



Figure 9

These filters are located on the Line side of a VVVF drive. These devices contain Inductors, Capacitors, and Resistors that impede the EMI emitted by the drive from entering the power mains and provide an easy path for EMI to travel to earth.

Whilst these filters are provided to control conducted emissions, they also prevent EMI from external sources from entering the lift or escalator system.

EMI filters and transient protection devices such as Metal Oxide Varistors (MOV) have a limited life.

Capacitors, which are an integral part of EMI filters, have a life span of about 10 years [13].

MOVs degrade slightly each time they absorb a voltage surge. Their life span is a function of both the quantity and intensity of the surges they absorb. Ten years is a typical life span [14].

It is therefore logical to assume that lifts and escalators with VVVF drives and/or MOVs are operating with EMC devices that are no longer functioning because they are over 10 years old. If these units were retested after 10 years in service, they would most likely fail the EMC tests.

6 SYMPTOMS OF EMI PROBLEMS

EMI problems usually result in lift and escalator shutdowns for which no cause can easily be determined. For example, an escalator intermittently shuts down, but none of the safety switches have been actuated. The escalator can be returned to service simply by cycling the isolator switch.

Another symptom of EMC problems is the appearance of error codes that seem either illogical or impossible.

EMC problems often come to light when a customer calls the service manager to complain about constant breakdowns, and the technician had informed the customer that either he could find nothing wrong, or the unit was running on arrival (ROA).

7 CONCLUSION

Electromagnetic Compatibility is dependent upon not only proper design and fabrication, but also proper installation. Whilst installation instructions are required by the EMC standards, the author has never encountered such instructions at installation sites.

Successful EMC installations are possible if the installation and commissioning teams are trained.

To ensure that EMC measures continue to function over time, a filter replacement program should be implemented.

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BIOGRAPHICAL DETAILS



Rory Smith is a Consultant at Peters Research Ltd. and a Visiting Professor in Engineering/Lift Engineering at the University of Northampton. He has over 56 years of lift industry experience during which he held positions in research and development, manufacturing, installation, service, modernisation, and sales. His areas of special interest are Machine Learning, Operations Management, Traffic Analysis, dispatching algorithms, and ride quality. Numerous patents have been awarded for his work.

