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MINERALS COUNCIL
SOUTH AFRICA

Collision Prevention System EMI/EMC Test Methodology

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1. SCOPE

1.1 INTRODUCTION

EMC (Electromagnetic Compatibility) tests are designed to simulate the actual operational environment of electronic and electrical products by subjecting them to electromagnetic interference and assessing their ability to operate correctly and without causing interference to other equipment. To simulate the operational environment, EMC tests use test equipment and procedures that reproduce the electromagnetic environment that the product will be exposed to during use. This includes both electromagnetic emissions and immunity to electromagnetic interference.

EMC emissions tests simulate the electromagnetic signals that the product will produce during operation and measure the levels of radiated and conducted emissions. These tests are typically performed on an open area test site (OATS), or in an anechoic chamber or a shielded room to provide a controlled environment and minimize external interference.

EMC immunity tests simulate the electromagnetic interference that the product may be subjected to during use and measure its ability to operate correctly in the presence of interference. These tests typically use electromagnetic fields generated by a test generator to simulate the radiated interference. Pulse generators, surge generators and power supply anomaly generators are used to simulate conducted interference that the product may encounter in its intended environment.

By subjecting products to realistic simulated electromagnetic environments and assessing their performance, EMC tests help to ensure that products meet minimum levels of electromagnetic compatibility and can operate safely and effectively in their intended applications. While immunity tests confirm CPS performance, local conditions such as a large deposit of magnetic minerals and the impact on the magnetic field uniformity of an underground CPS fall outside the scope of EMC tests.

1.2 PURPOSE

This document outlines the current procedures and methods used to conduct testing of a CPS. The purpose of this document is to define a standardised approach to CPS testing, which ensures that all EMC related aspects of the CPS are tested consistently and accurately. This document includes reference to test procedures that are available in South Africa to ensure that testing is conducted consistently, accurately, and in accordance with established EMC requirements and guidelines. A continuation of this document would be a custom test procedure based on existing international standards to cater for local CPS customers and suppliers.

2. APPLICABLE AND REFERENCED DOCUMENTS

Referenced and Applicable Documents	
[1]	Mine Health and Safety Act No. 29 of 1996
[2]	Government Gazette Vol.690 No. 47790 – 21 December 2022 – *Commencement of the Regulations Relating to Trackless Mobile Machinery.*
[3]	ICASA. *National Radio Frequency Plan 2021.* No.46088
[4]	Government Gazette Vol.597 No. 38641 – 30 March 2015 – *The Radio Frequency Spectrum Regulations 2015*
[5]	Government Gazette vol. 490 Cape Town 18 April 2006 No. 36 of 2005: Electronic Communications act, 2005.
[6]	MS-02-2010: *Control over the use of radio transmitter frequencies and radiated power transmitted by equipment used in underground mines.*
[7]	NASA-STD-4003A – 2016-01-19 *Electrical bonding for NASA launch vehicles, spacecraft, payloads, and flight equipment*

3. ABBREVIATIONS AND DEFINITIONS

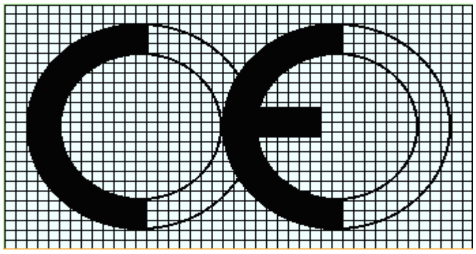
ACRONYMS AND ABBREVIATIONS	
AI	Artificial Intelligence
CAS	Collision Avoidance Systems
CE	Conformité Européene
CPS	Collision Prevention Systems
DMRE	Department of Mineral Resources and Energy
DSRC	Dedicated Short-Range Communications
EIRP	Effective Isotropic Radiated Power
EMESRT	Earth Moving Equipment Safety Round Table
EMI	Electromagnetic Interference
ESA	Electronic Subassembly
FAR	Full Anechoic Room
GPS	Global Positioning System
GSM	Global System for Mobile Communication
ICASA	Independent Communications Authority of South Africa
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISM	Industrial, Scientific, Medical
ISO	International Organization for Standardization
ITU	International Telecommunications Union
OEM	Original Equipment Manufacturer
PAT	Personal Alarm Tag
PDS	Proximity Detection Systems
RF	Radio Frequency
RFI	Radio Frequency Interference
RFID	Radio Frequency Identification
SAC	Semi-Anechoic Chamber
TMMs	Trackless Mobile Machines
UHF	Ultra-High Frequency
V2X	Vehicle-to-Anything
VLF	Very Low Frequency

Table 1: Acronyms and abbreviations

3.1 DEFINITIONS

CE Mark

The CE mark has a specific layout not to be confused with similar, but incorrect, logos.



A CE Mark (CE) on a product is a manufacturer's declaration that the product complies with the essential requirements**/** performance levels, measured according to Harmonised standards, of the relevant European health, safety and environmental protection legislation and may be legally placed on the market in the European Economic Area.

CE Certificate

A written statement using a “standardised” template declaration drawn up by the manufacturer to demonstrate the fulfilment of the EU requirements relating to a product bearing the CE mark.

EMC

Electromagnetic Compatibility. The goal of EMC is the correct operation of different equipment in a common electromagnetic environment by limiting the intentional and unintentional radiation, propagation and reception of electromagnetic energy.

ERP

Effective radiated power: Power transmitted by a device including system gains and losses.
Good quality earthing and bonding
A value of <5mΩ

Intentional Transmitter

Any device that is designed to produce radio waves.

Spectrum Licensed Equipment

A spectrum license issued by ICASA relates to the right to use a portion of the radio frequency spectrum subject to conditions. 2-way radios are examples.

Type Approved Equipment

Type approval is granted to a product incorporating a radio frequency transmitter and/or receiver that meets a minimum set of regulatory technical and safety requirements and operates in a frequency band reserved for Industrial, Scientific and Medical (ISM) equipment. Type approval by ICASA is required before a product is allowed to be sold or used in South Africa. No spectrum license is required. WiFi, Bluetooth, Zigbee, Short Range Devices, GSM etc. are examples.

Unintentional Radiator/Emitter

A device that creates radio frequencies as a byproduct, which is unintentionally emitted from the device.

Permit

A permit is a document that allows a new electric/electronic device to be used on site on a temporary basis. For a device to receive a permit, it must comply with all the regulations stipulated by ICASA as well as a site-specific Frequency Register.

CoC – Certificate of Compliance

A CoC permits a new electric/electronic device to be used on site on a permanent basis. A CoC can be issued only after a permit has been issued and the device does not cause unwanted interference to existing systems (confirmed with site acceptance testing).

4. EMC INTRODUCTION

EMC is a field that addresses issues related to the emission and immunity of electronic and electrical products and systems. For interference to occur, three components must be present: a source, a coupling path, and a victim. The source emits electromagnetic signals, either intentionally (such as a 2-way radio or WiFi) or unintentionally (such as commutating noise from the brushes of an electric motor). This energy must couple to the victim, either through cables or the air, which can then be influenced by the signal.

Two crucial parameters in EMC are the amplitude of the source and the immunity threshold of the victim. If the interfering signal is below the immunity threshold of the victim, then compatibility exists. If the interfering signal exceeds the immunity threshold of the victim, interference occurs.

To simulate the operational environment, EMC tests use custom test equipment and procedures that reproduce the electromagnetic environment that the product will be exposed to during use. This includes both electromagnetic emissions and immunity to electromagnetic interference.

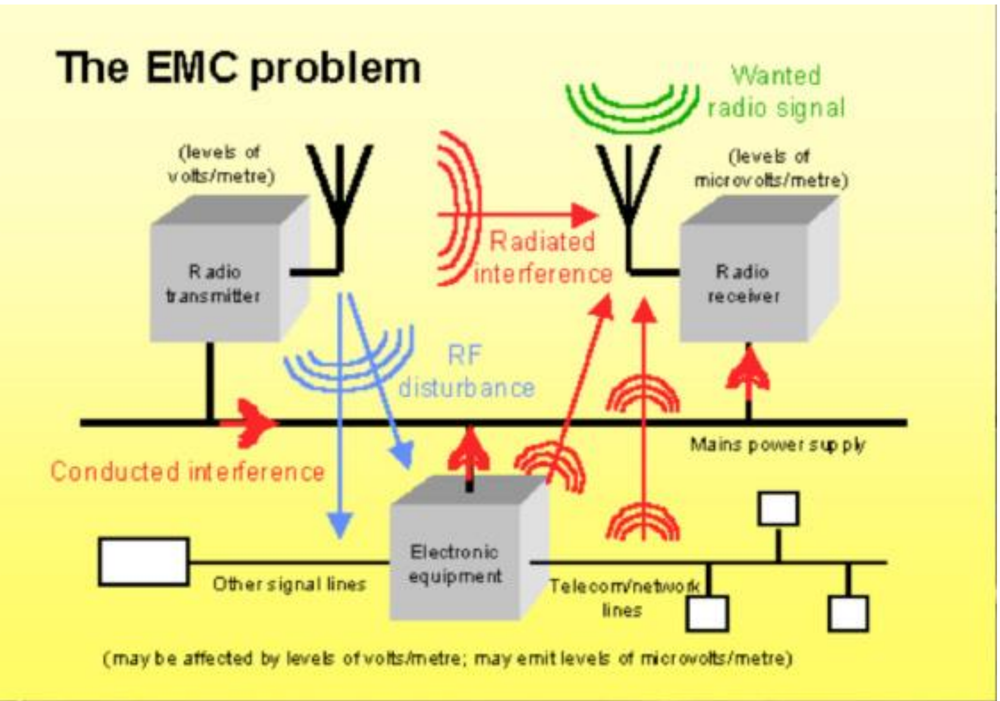
EMC emissions tests simulate the electromagnetic signals that the product will produce during operation and measure the levels of radiated and conducted emissions. These tests typically use an anechoic chamber or a shielded room to provide a controlled environment and minimise external interference.

EMC immunity tests simulate the electromagnetic interference that the product may be subjected to during everyday use and measure its ability to operate correctly in the presence of interference. These tests typically use electromagnetic fields generated by a test generator to simulate the interference that the product may encounter in its intended environment.

EMC tests also consider factors such as the frequency range, modulation type, and signal strength of the electromagnetic emissions and interference, as well as the specific conditions and scenarios under which the product will be used. By subjecting products to realistic electromagnetic environments and assessing their performance, EMC tests help to ensure that products meet minimum levels of electromagnetic compatibility and can operate safely and effectively in their intended applications.

4.1 AN OVERVIEW OF THE EMC CONCEPT

The diagram below depicts different sources of electromagnetic disturbances that can influence the unit under test or victim:



**Sourced from OFCOM – UK as used by the LBA Group (https://www.lbagroup.com/blog/emc-test-snapshot/)*

Wireless electronic communication equipment operates by intentionally transmitting data, but these transmissions can be perceived by perceived as radiated radio frequency disturbances by sensitive equipment. When these radio frequencies couple with power or interconnecting lines, they may be interpreted as conducted interference by susceptible electronic devices. Additionally, unintentional radiofrequency signals emitted from equipment can interfere with sensitive radio receivers, potentially masking desired radio signals.

CPS consist of intentional transmitters and sensitive receivers. In mining environments, various intentional and unintentional emitters are present, including WiFi, Bluetooth, variable speed drives, lighting units, TMMs etc. These diverse sources can contribute to electromagnetic interference and must be carefully managed to ensure reliable communication and operation of sensitive equipment.

4.2 EMC STANDARDS

EMC standards are developed by standards organisations or regulatory bodies to ensure that electronic and electrical products meet minimum levels of electromagnetic compatibility. They establish the maximum levels of electromagnetic emissions that a product or product family can produce and the minimum levels of immunity that it must have to withstand electromagnetic interference from other devices.

Compliance with EMC product standards is necessary to ensure that products do not cause interference with other electronic or electrical equipment and to ensure that they can operate correctly in the presence of electromagnetic interference. Testing of products to demonstrate compliance with EMC standards is usually required before they can be sold or imported into a particular market.

Although EMC standards can be divided into three categories, they always refer to Basic EMC Standards. Product-specific EMC standards will take precedence over Product-family EMC standards. Product-family standards will take precedence over Generic standards.

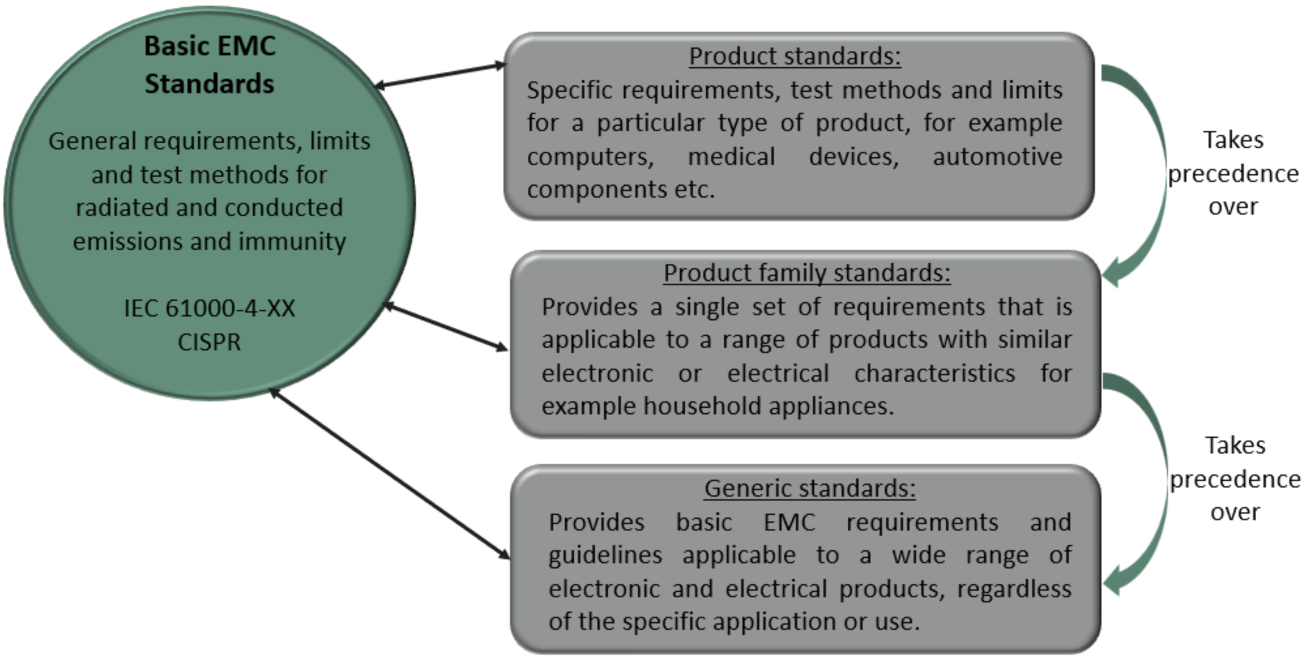


Figure 1: Standards Relationship

4.2.1 Basic EMC Standards

Basic EMC standards typically set out general requirements for electromagnetic emissions and immunity, including limits and test methods for radiated and conducted emissions and immunity to electromagnetic interference. They also provide guidance on the selection and use of test equipment and instrumentation required for EMC testing.

Basic EMC standards form the basis for more specific EMC product standards or EMC product family standards that provide more detailed requirements and guidelines for specific types of products.

4.2.2 EMC Product Standards

An EMC product standard sets out specific requirements, test methods, and limits for electromagnetic emissions and immunity of a particular type of product, such as computers, medical equipment, or automotive components. This test methodology will be based on the CPS product standards/ requirements.

4.2.3 EMC Product Family Standard

The purpose of an EMC product family standard is to provide manufacturers with a single set of requirements that can be applied to a range of products, rather than having to comply with separate standards for each individual product. Compliance with EMC product family standards helps to ensure that products within a family do not cause interference with each other or with other electronic or electrical equipment and can operate correctly in the presence of electromagnetic interference.

EMC product family standards typically cover a range of products that have similar electrical or electronic characteristics or are intended for similar applications. For example, a product family standard might cover a range of household appliances or a range of telecommunications equipment.

4.2.4 Generic EMC Standard

A Generic EMC standard is a document that provides a set of basic EMC requirements and guidelines applicable to a wide range of electronic and electrical products and ensures that products meet a minimum level of electromagnetic compatibility, regardless of the specific application or intended use of the product.

5. CPS SYSTEM OVERVIEW

5.1 CPS FUNCTIONAL BLOCK DIAGRAM

CPS consists of several elements. For underground systems, these include an electromagnetic field generator (proximity generator) that generates electromagnetic zones and detects zones of other vehicles or equipment. An in-vehicle display screen provides visual feedback to the operator. The vehicle mount interface module controls the CPS and manages vehicle interlocks typically via the CAN bus. Older vehicles and vehicles without a CAN bus might require extensive rework and additional modules to interface between eg the braking system and CPS controller. Additionally, a personal alarm tag (PAT) is worn by personnel and interacts with the electromagnetic field generated by the vehicle-mounted proximity generator. The tag's response is then processed by the vehicle mount interface to determine the appropriate action. For surface systems, RF generators (time of flight principle) enhanced with cameras and Global Navigation Satellite Systems (GNSS) are popular to generate protection zones and detect zone violations.

Figure 2: Example of Underground Mining CPS Element Interaction

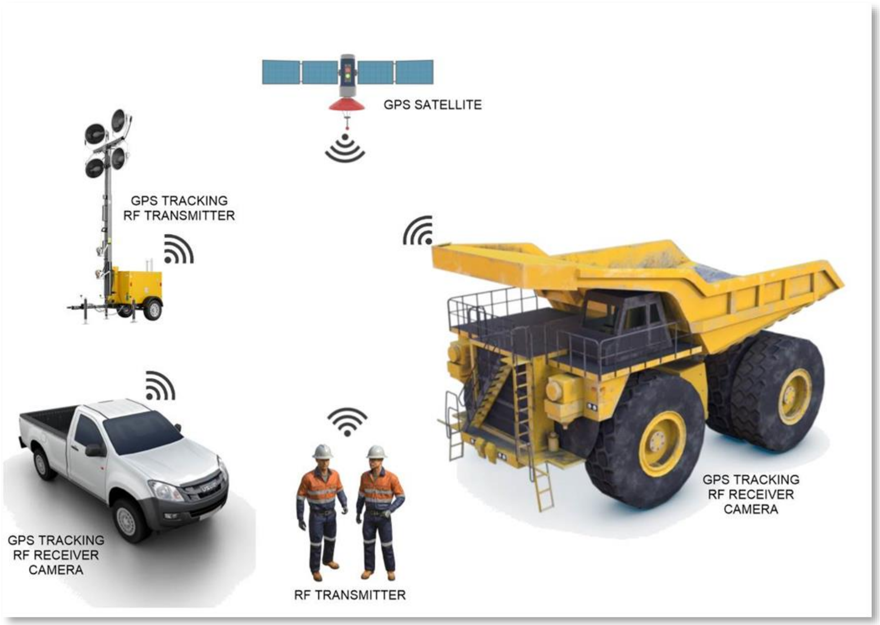


Figure 3: Example of Surface Mining CPS Element Interaction

5.2 CPS OPERATIONAL CONSIDERATIONS

The following operational considerations should be among those considered when deploying a CPS:

i. **Electromagnetic interference:** The mining environment is rife with electromagnetic activity that can cause false triggers or prevent a trigger in CPS. As such, it is essential to ensure that the vehicle CPS elements are properly installed and designed to prevent EMI. An installation that is not according to the OEM standards eg earthing and bonding could lead to reduced performance.

ii. **Equipment failure:** The harsh operating environment (including the electromagnetic environment) in a mine can cause equipment and sensor failure. The CPS must be designed to withstand these conditions and operate reliably to ensure that it is effective in preventing collisions.

iii. **Interference with other systems:** The CPS may emit intentional transmissions that could interfere with other systems in the mining environment, such as blast controllers. It is essential to ensure that the CPS does not interfere with the operation of other systems or cause safety hazards.

iv. **Ease of operation:** The CPS must be easy to use, with clear and concise indications and warnings to avoid operator errors.

The first three above aspects can be mitigated by implementing a rigorous EMC test campaign.

6. TEST REQUIREMENT

Tests serve different purposes, including regulatory compliance, performance verification, fault finding, and equipment characterisation. In this project, we have categorised the testing requirements into three distinct categories as outlined below.

6.1 REGULATORY REQUIREMENT

Regulatory requirements for collision prevention systems (CPS) in mining are not specified in the Government Gazette No. 39182 of 9 September 2015 (also referred to as the Official List), which was later amended in Government Gazette No. 43132 of 24 March 2020. These documents do not specifically reference CPS in Product Specific or Product Family EMC Standards.

To ensure compliance with relevant standards, CPS can be broken down into functional circuit blocks, and applicable standards can be applied from the Official List. This allows for the CPS to be evaluated in a test laboratory as a vehicle Electronic Subassembly (ESA) and a radio frequency (RF) tag.

It is important to stay up to date with any changes or updates to regulatory requirements to ensure continued compliance. Although the 2020 amendment of the Official List does not specify the revision dates or edition numbers of the standards, it is generally accepted in the industry to conduct testing according to the latest version of a standard. As such, it is recommended to utilise the most current versions of standards, particularly ISO 13766-1 and ISO 13766-2, for CPS in mining applications. Until such time that the two aforementioned specifications are adopted and issued as SANS standards, the ISO/SANS 13766 as published in 2013 may be more accessible (for example, more cost-effective to purchase) for the South African mining industry.

6.2 LABORATORY TEST AVAILABILITY IN SOUTH AFRICA

In South Africa, accredited EMC testing is currently conducted by four SANAS-accredited test facilities, Gerotek Test Facilities (T005), iSert (T812), ITC Services (T0175), and SABS (T0066). Additionally, Spaceteq offers EMC testing at their Houwteq facility.

6.2.1 Tests Applicable to CPS

ISO 21815-1 does not specify EMC limits or test methods within the document itself. However, it does require compliance with ISO 13766-1 and ISO 13766-2. The CPS can be tested either as an individual entity (ESA) or as part of the machine in which it is incorporated.

Table 2 below lists the specifications called for in ISO 13766-1 and ISO 13766-2, as well as the corresponding tests conducted in South Africa:

TEST TYPE	SPECIFICATION	TEST DONE IN SA
Radiated Emissions	CISPR 12/ CISPR 25	CISPR 12/ CISPR 25
Conducted Emissions	<ISO 7637-2 (Time domain)	CISPR 25
Electrostatic Discharge	ISO 10605	IEC 61000-4-2/ ISO 10605
Radiated immunity	ISO 11451-2/ ISO 11451-2/ ISO 11452-9	IEC 61000-4-3
Electrical fast transient/ burst immunity	ISO 7637-1/ ISO 7637-3	IEC 61000-4-4
Surge immunity	ISO 7637-2/ ISO 16750-2	IEC 61000-4-5
Conducted immunity	ISO 11452-4	IEC 61000-4-6 / ISO 11452-4
Power frequency magnetic field immunity	None	IEC 61000-4-8
Voltage dips/ short interruptions and voltage variation immunity	ISO 16750-2	IEC 61000-4-11

Table 2: Specification vs Tests in South Africa

It is important to note that ISO 13766-1 and ISO 13766-2 are only applicable to machines with internal AC or DC power systems, or both. Machines that are powered by internal combustion engines, hybrid systems, or connected to the grid are excluded from these standards and are instead covered by the UN ECE R10 and IEC 61000 series of specifications.

One critical omission in the listed standards is the absence of immunity tests below 150kHz, specifically magnetic field immunity tests at frequencies other than the power frequency of 50 Hz. This could be a significant gap when testing CPS that operate in the 70kHz to 135kHz frequency range. However, it's worth noting that military and aircraft test methods conducted at local test laboratories can cover this by performing a MIL STD 461 RS101 (radiated immunity) and CS101 (conducted immunity) test.

6.3 FUNCTIONAL TESTS

Interference issues can only be prevented if the amplitude of the source is lower than the sensitivity of the victim. While a test laboratory can evaluate the characteristics of the source and victim, factors such as co-location, earthing and bonding quality [7], and installation quality can impact the interference scenario in the actual operating environment. To ensure compatibility, it is essential to compare the electromagnetic characteristics of the CPS and its operating environment. An effective approach involves conducting ambient scans at mines and subsequently comparing the results with immunity requirements.

Although Par 6.1 and Par 6.2 mainly focus on the characteristics of the CPS as an ESA or sub-system, full functionality can only be assessed once the CPS is integrated into a vehicle. The CPS performance can differ between different vehicle types. To test as ESA confirm that the CPS meets the performance specifications on the data sheet.
If the installation is not of high quality and according to the original equipment manufacturer (OEM) requirements, the CPS supplier cannot be responsible for reduced performance. If the installation is according to the CPS OEM requirements and the performance is poor, it could point to vehicle-related EMI.

The following is a non-exhaustive list of parameters that could influence the CPS performance once integrated:

i. Detection zone distortion due to the generator installation location
ii. Generator performance due to bonding and earthing inefficiency
iii. Antenna pattern distortion due to vehicle body metal
iv. Detection desensitisation due to vehicle noise floor
v. External ambient at the operating location
vi. PAT desensitisation due to external ambient
vii. PAT desensitisation due to the proximity of other body-worn equipment such as cap lamps, air quality sensors etc.

The above must be evaluated by performing custom tests such as:

i. Antenna pattern measurements
ii. Generator signal amplitude at various distances from the vehicle.
iii. Using a PAT to verify sensitivity with the vehicle on OFF mode and adding vehicle systems/functionality while logging CPS performance.
iv. Measuring the operational ambient environment and comparing that to CPS immunity levels
v. Comparing other body-worn equipment emissions with PAT sensitivity levels

To ensure that the CPS functions properly after installation on a vehicle, it is important to develop a specific test plan for each type of CPS technology used. By doing so, the specific functionality of each technology can be tested and diagnosed accordingly. This will help to identify any potential issues that may arise once the CPS is integrated into the vehicle and ensure that it operates as intended. Developing a detailed test plan can also help to streamline the testing process and ensure that all relevant aspects of the CPS are thoroughly evaluated.

6.4 TEST SITE/ TEST LOCATION

To ensure test repeatability, a controlled electromagnetic environment is crucial. However, testing the installed CPS at the operating location may pose challenges in terms of repeatability and reliability. In case of CPS malfunction, fault-finding must be carried out at the operating location if the symptom cannot be repeated in the controlled environment. It is important to note that several critical parameters may affect the validity of the results, including:

i. Variations in ambient electromagnetic noise levels
The ambient emissions amplitude needs to be 6dBμV/m below the wanted signal amplitude at the frequency of interest. If the environment is not controlled, there might be vehicles with trackers in close proximity, personnel with cell phones, LED flood lights (LED lights are normally pulsed to increase intensity, but to control heat, and the electromagnetic spectrum emitted by the LED will change according to pulse rise and fall time). The way to mitigate the impact of ambient is to perform an ambient test before and after the measurement campaign.

ii. Differences in the positioning and orientation of the vehicle and surrounding objects
The impact of surrounding objects is mostly because of reflections (multipath) and antenna pattern distortion due to proximity to metal objects. If the vehicle is always oriented in the same way and antenna positions are kept consistent, the deviations in measurement should be within 6dB if no other factors impact the measurements. The signal variations due to personnel/ moving bystanders should also be mitigated by restricting access to the measurement site.

iii. Variations in ground characteristics, such as resistivity and conductivity
Ground moisture content will influence resistivity and conductivity as well as having to change from one measurement location to the next. The magnitude of the impact is variable. One mitigation technique is to use a known signal source, such as a comb generator, to confirm site integrity before the measurement campaign. It is also commonly referred to as a system verification test, as the complete signal path is verified (antenna, cables and receiver/ spectrum analyser).

iv. Changes in weather conditions, such as precipitation and temperature
The measurement equipment ratings will dictate whether the moisture and temperature conditions are within the measurement equipment tolerance.

v. Interference from nearby electrical equipment, such as power lines and communication towers.
This relates to i and typically involves a visual assessment of the surroundings before selecting the site. Electrical services normally do not jump up overnight.

Therefore, to ensure accurate and reliable test results, it is recommended to perform testing in a controlled environment.

6.4.1 Open Area Test Site Requirements

Due to the size of the mining vehicles, this would most likely be the most often use case.

i. A reflective free area should have a radius of at least 2x measurement distance (6m radius for a 3m measurement distance). A 20m radius is recommended.

ii. Ambient emissions within the CPS operational frequency band should be well-known and special precautionary measures should be implemented to ensure that external wireless services do not mask intentional transmissions from the CPS, and that the CPS is not desensitised by external wireless services.

6.4.2 Shielded Chamber requirements

Recommended for evaluating the CPS as a subsystem or ESA.

i. Absorber material should be installed if it is not a reverb chamber to eliminate reflections of the walls, floor and ceiling.
ii. For SAC and FAR, all polarisations and orientations should be evaluated.

7. FAULT FINDING GUIDELINE

A general fault-finding method based on limited industry feedback demonstrates a fault-finding methodology without additional equipment to verify CPS operation. This can be expanded to cover more types of systems as CPS suppliers' participation in the project grows.

7.1 DUAL FREQUENCY SYSTEM (UNDERGROUND SYSTEM)

7.1.1 System Description

A low-frequency transmitter on the vehicle transmits in the < 100kHz range to set a detection zone around a TMM as shown in Figure 4. The personal alarm tag (cap lamp) receives the signal and responds in the 900MHz frequency band.

The following scenarios were identified and are expanded upon below:

- Low-level transmission from the vehicle (kHz range)
- Distorted vehicle detection zone (kHz range)
- Desensitised cap lamp receiver (kHz range)
- Defective cap lamp transmitter (900MHz band)
- Desensitised vehicle receiver (900MHz band)

Figure 4: Detection zone illustration (Strata Worldwide product sheet)

7.1.2 Low-level transmission from the vehicle (kHz range)

Confirm the transmitted kHz signal by using at least 2 cap lamps as sensors and walking around the vehicle. Knowledge of the zone distances and patterns is required to confirm the cap lamp is detected at the required distance. Low transmission levels could be a result of transmitter (generator) failure or installation errors such as tilt angle, earthing etc. The symptom would be reduced zone distances at all angles.

7.1.3 Distorted vehicle detection zone (kHz range)

Confirm the transmitted kHz signal by using at least 2 cap lamps as sensors and walking around the vehicle. Knowledge of the zone distances and patterns is required to confirm the cap lamp is detected at the required distance. Zone distortion will manifest as gain or loss of detection in a specific direction. This could be indicative of cases mentioned in 7.1.2 as well as environmental factors such as transformers (high permeable materials) in close proximity, signal propagation via trailing cables or water pipes, high permeable materials as part of the standard installation in close proximity etc. Magnetic fields have an affinity for high permeable materials and the flux lines will be drawn to this material, causing the distorted detection zone.

7.1.4 Desensitised cap lamp receiver (kHz range)

Should one of the cap lamps respond to the vehicle transmission and the other cap lamp not respond to the signal, the non-responding cap-lamp could have a desensitised receiver. A visual inspection of the environment will also aid in the identification of ambient sources that might mask vehicle transmission. Transformers, variable speed drives, conveyor belt systems etc. are known interfering sources in the kHz range.

7.1.5 Defective cap lamp transmitter (900MHz band)

Should all the indications show that the cap lamp received the vehicle transmission, but the vehicle receiver does not receive the cap lamp response, it might point to a defective cap lamp transmitter.

7.1.6 Desensitised vehicle receiver (900MHz band)

Should the vehicle not respond to the cap lamp transmission at the correct distance, but does respond at closer distances, it could point to vehicle receiver desensitisation. This could be a result of an onboard noise source or environmental interference such as a wireless communication system in the 900MHz band. An RF spectrum register would serve to prevent different systems from using the same frequency band without additional mitigation measures such as separation distance, directivity etc.

8. CONCLUSION

i. EMC Test facilities in South Africa are not equipped to perform the tests as required by ISO 13766-1 and ISO 13766-2 for the international market.
ii. EMC Test facilities in South Africa are adequately equipped to perform tests on a CPS for local conditions by using the CISPR/ IEC 61000-4-XX series of tests.
iii. EMC Test facilities in South Africa are adequately equipped to perform diagnostic tests in collaboration with CPS suppliers and end users at the point of operation.

9. RECOMMENDATION

A Recommended Practise document that includes an EMC test plan should be developed as a joint effort by CPS suppliers, EMC specialists, EMC Test laboratory and CPS end users. To this end, the formation of a technical working group, inclusive of technical personnel from all of the mentioned parties, is recommended. The resulting document should include the following elements:

i. Test setup: A description of the test setup, including the test equipment, measurement instruments, and test fixtures required for the testing.
ii. Test procedures: A step-by-step procedure for conducting the tests, including the test configuration, test duration, and data acquisition procedures.
iii. Test results: A reporting format for the test results, including the data analysis and interpretation, as well as the pass/fail criteria.

END OF DOCUMENT