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SANS 13766:2013 / ISO 13766:2006

Compared to

ISO 13766-1:2018, ISO 13766-2:2018 & ISO 21815-1:2022

Gap Analysis

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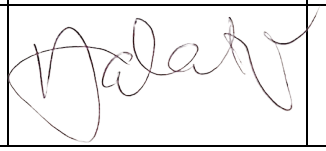
Reviewed and approved by:	S Malatji	Head: Learning Hub (MCSA)		20/10/2023

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Referenced and Applicable Documents			
[1]	SANS 13766:2013 / ISO 13766:2006	Earth-Moving Machinery – Electromagnetic Compatibility	The standard contains test methodology and acceptance criteria for the evaluation of earth-moving machinery as defined in ISO 6165.
[2]	ISO 13766-1:2018	Earth-Moving and Building Construction Machinery – Electromagnetic Compatibility (EMC) of Machines with Internal Electrical Power Supply – Part 1: General EMC Requirements Under Typical Electromagnetic Environmental Conditions	The standard contains test methodology and acceptance criteria for the evaluation of earth-moving machinery as defined in ISO 6165 as well as construction machinery as defined in ISO/TR 12603:2010.
[3]	ISO 13766-2:2018	Earth-Moving and Building Construction Machinery – Electromagnetic (EMC) of Machines with Internal Electrical Power Supply – Part 2: Additional EMC Requirements for Functional Safety	This specification is relevant only to the safety-related parts of control systems (SRP/CS) as defined in ISO 13849-1:2015 using electrical/electronic components which meet design requirements equal to or greater than safety-related performance level PL b as defined in ISO 13849-1:2015. The specification further deals with electrical and electronic components or separate ESA intended to be fitted on machinery under the restriction of PL b.
[4]	ISO 21815-1:2022	Earth-Moving Machinery – Collision Warning and Avoidance – Part 1: General Requirements	The specification only provides general guidance and terminology relating to the principles of collision warning and avoidance systems for earth-moving machinery, mobile underground mining machinery and road construction machinery. The document only covers collision avoidance by speed reduction or motion inhibition and does not include avoidance by automatic manoeuvring away from an object.

History Sheet			
Version	**Date**	**Effected by**	**Description**
Rev 0.5	17/02/2023	Z Fouché	Compilation of GAP Analysis
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Distribution List	
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ACRONYMS AND ABBREVIATIONS	
AC	Alternating Current
AM	Amplitude Modulation
BCI	Bulk Current Injection
CISPR	Comité International Spécial des Perturbations Radioélectriques
CPS	Collision Prevention Systems
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESA	Electrical/electronic Subassembly
ESD	Electrostatic Discharge
EUT	Equipment Under Test
ISO	International Organisation for Standardisation
PL b	Performance Level b
PM	Pulse Modulation
SANS	South African National Standard
SRP	Safety-Related Parts
TR	Technical Report

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1. INTRODUCTION

The SANS 13766:2013 specification is based on ISO 13766:2006 and was reaffirmed and reprinted in April 2020.
ISO 13766:2006 included the general Electromagnetic Compatibility (EMC) requirements under typical electromagnetic environmental conditions and the additional EMC requirements for functional safety into one document. These two sections were then divided into two parts in ISO 13766:2018, as follows:

- ISO 13766-1: General EMC requirements under typical electromagnetic environmental conditions
- ISO 13766-2: Additional EMC requirements for functional safety

The following document serves to compare both parts of ISO 13766:2018 (as mentioned above) to SANS 13766:2013. Note that the SANS 13766:2013 / ISO 13766:2006 specification cannot be compared to ISO 21815 – 1:2022, due thereto that the latter specification does not contain EMC requirements.

2. SCOPE

The following section contains excerpts of the applicable standard to identify the scope of each:

2.1. SANS 13766:2013 / ISO 13766:2006 *[EARTH MOVING MACHINERY – ELECTROMAGNETIC COMPATIBILITY]*

This International Standard provides test methods and acceptance criteria for the evaluation of the electromagnetic compatibility of earth-moving machinery as defined in ISO 6165.

The following electromagnetic phenomena are evaluated:

- broadband and narrowband electromagnetic interference
- electromagnetic field immunity test
- broadband and narrowband interference of electrical/electronic subassemblies
- electromagnetic field immunity test of electrical/electronic subassemblies
- electrostatic discharge
- conducted transients

2.2. ISO 13766-1:2018 [*EARTH-MOVING AND BUILDING CONSTRUCTION MACHINERY – ELECTROMAGNETIC COMPATIBILITY (EMC) OF MACHINES WITH INTERNAL ELECTRICAL POWER SUPPLY – PART 1: GENERAL EMC REQUIREMENTS UNDER TYPICAL ELECTROMAGNETIC ENVIRONMENTAL CONDITIONS]*

This document provides test methods and acceptance criteria for the evaluation of the EMC of earth-moving machinery, as defined in ISO 6165:2012, and of the following building construction machinery as defined in ISO/TR 12603:2010:

- drilling and foundation equipment
- equipment used for the preparation, conveyance and compaction of concrete, mortar and processing reinforcement
- road construction and maintenance machinery and equipment.

The ISO 13766-1:2018 specification further deals with general EMC requirements under typical electromagnetic environmental conditions, as well as with electrical/electronic subassemblies (ESA) and separate ESA intended to be fitted to the machinery.

The following electromagnetic disturbance phenomena are evaluated:

- broadband and narrowband electromagnetic interference
- electromagnetic field immunity
- electrostatic discharge
- conducted transients

The machinery can have Direct Current (DC) or Alternating Current (AC) or a combination of both as the internal electrical power supply system. This specification is not applicable to machines that are designed to be supplied by an external mains network or to phenomena caused by military applications.

NOTE 1: Grid-connected machines are covered by IEC 61000.
NOTE 2: Hybrid machines are covered in UN ECE R10-Rev. 5.

2.3. ISO 13766-2:2018 *[EARTH-MOVING AND BUILDING CONSTRUCTION MACHINERY – ELECTROMAGNETIC COMPATIBILITY (EMC) OF MACHINES WITH INTERNAL ELECTRICAL POWER SUPPLY – PART 2: ADDITIONAL EMC REQUIREMENTS FOR FUNCTIONAL SAFETY]*

This document provides test methods and acceptance criteria for the evaluation of the EMC of earth-moving machinery, as defined in ISO 6165:2012, and of the following building construction machinery as classified in ISO/TR 12603:2010:

- drilling and foundation equipment
- equipment used for the preparation, conveyance and compaction of concrete, mortar and processing reinforcement
- road construction and maintenance machinery and equipment.

It deals with EMC requirements related to the functional safety of the machinery, its ESA and of separate ESA. This specification is relevant only to the safety-related parts of control systems (SRP/CS) as defined in ISO 13849-1:2015 using electrical/electronic components which meet design requirements equal to or greater than safety-related performance level PL b as defined in ISO 13849-1:2015.

The abovementioned specification further deals with electrical and electronic components or separate ESA intended to be fitted on machinery under the restriction of PL b. The following electromagnetic disturbance phenomena are evaluated with the utility of the specification:

- radiated electromagnetic fields from off-board sources with various field strengths and frequencies
- radiated electromagnetic fields from on-board sources (antenna inside/outside) with various field strengths and frequencies
- electrostatic discharge
- conducted and coupled electrical transients.

The machinery can have DC or AC or a combination of both as the internal electrical power supply system.

This document is not applicable to machines that are designed to be supplied by an external mains network or to phenomena caused by military applications.

NOTE: *Grid-connected machines are covered by IEC 61000*

2.4. ISO 21815-1:2022 *[EARTH-MOVING MACHINERY – COLLISION WARNING AND AVOIDANCE – PART 1: GENERAL REQUIREMENTS]*

This document provides terminology and general guidance on the principles of collision warning and collision avoidance systems for:

- earth moving machinery as defined in ISO 6165
- mobile underground mining machinery as defined in ISO 19296, and
- road construction machinery as defined in ISO 22242.

This document provides general requirements for detection of objects, warnings to the operator, automatic intervention control to avoid collision, and test procedures. It is intended to be used in conjunction with

the other parts of the ISO 21815 series, which provide detailed guidance and requirements for collision warning and collision avoidance systems and determining risk areas and levels.

The specific requirements and definitions for particular types of machines are defined in the use case parts of the ISO 21815 series.

Note that the ISO 21815-1:2022 document covers collision avoidance by speed reduction or motion inhibition; however, it does not cover avoidance by automatic manoeuvring (e.g. steering) away from the intended object.

The systems described in this specification are only intended to assist the operator of the machine. The responsibility for safe operation of the machine remains with the operator of the same.

This document is not applicable to collision warning and collision avoidance systems installed to the machine before the date of its publication.

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3. COMPARISON OF IMPORTANT PARAMETERS

Parameters	SANS 13766:2006	ISO 13766-1:2018	ISO 13766-2:2018
Emissions Tests	Radiated Emissions: CISPR 12 – See **Figure 10 – Radiated Emissions Limits - Graph** (Narrowband and Broadband) Conducted Emissions: Minimum values regarding emission and immunity for ESA and earth-moving machinery are required (as per section 5.10.1). Tests are to be conducted to level III as per Table A.1 for 12V systems and Table A.2 for 24V systems as referenced in the ISO 7637-2:2004. *Note: The above-mentioned tables are included below. See* **Figure 1 - Extract A from ISO 7637-2:2004 (Table A.1)** *and* **Figure 2 - Extract B from ISO 7637-2:2004 (Table A.2).**	Radiated Emissions: CISPR 12 – See **Figure 10 – Radiated Emissions Limits - Graph** (Narrowband and Broadband) Conducted Emissions: The levels of conducted emissions must be less than the reference limits of the immunity tests conducted for ESA systems. This specification relies on limits and examples as classified in ISO 7637-2:2011. See the following: **Figure 3 - Extract A from ISO 7637-2:2011 (Table A.1)** **Figure 4 - Extract B from ISO 7637-2:2011 (Table A.2)** **Figure 5 – Extract A from ISO 13766-1:2018** **Figure 6 – Extract B from ISO 13766-1:2018**	Radiated Emissions: Not applicable Conducted Emissions: Not applicable
Immunity Tests	Radiated Immunity: The substitution method and the 80 % amplitude modulation (AM) with sinusoidal wave of 1 kHz (see ISO 11451-1) are determined as a test method. The testing shall be done in the frequency band of 20 MHz to 1 000 MHz using Table 1 criteria. Conducted Immunity: Refer to the 'emissions tests' section above. ESD: 8kV – Contact Discharge 15kV – Air Discharge	Radiated Immunity: The substitution method and 80 % amplitude modulation (AM) with sinusoidal wave of 1 kHz is determined as a test method in the frequency band 20 MHz to 800 MHz (see ISO 11451-1:2015). PM with t_{on} 577 µs, period 4 600 µs is determined as a test method in the frequency band 800 MHz to 2 000 MHz (see ISO 11451-1:2015). Conducted Immunity: Refer to the 'emissions tests' section above. ESD: Functional status Class A (see **Figure 7 - Extract C from ISO 13766-1:2018 (Table 3):** 4kV – contact and air discharge.	Radiated Immunity: The specification distinguishes between immunity of machinery to radiated electromagnetic fields from on-board and off-board sources. For off-board sources, values in Table 1 (as depicted in **Figure 8 - Extract A from ISO 13766-2:2018 (Table 1)**) applies. For on-board sources, evaluations should be conducted at maximum output power and in accordance with ISO 11452-3:2016. Conducted Immunity: Not applicable ESD: 8kV – Contact Discharge 15kV – Air Discharge
Test facility requirements	CISPR 16	CISPR 16	CISPR 16

Table 3-1 - Comparison between SANS 13766:2013 / ISO 13766:2006 and ISO 13766:2018

Table A.1 — Suggested test levels for 12 V system

Test pulse[a]	Selected test level[b]	Test level, U_s[c] V				Min. number of pulses or test time[f]	Burst cycle/pulse repetition time	
		I	II	III min.	IV max.		min.	max.
1		g	g	– 75	– 100	5 000 pulses	0,5 s	5 s
2a		g	g	+ 37	+ 50	5 000 pulses	0,2 s	5 s
2b		g	g	+ 10	+ 10	10 pulses	0,5 s	5 s
3a		g	g	– 112	– 150	1 h	90 ms	100 ms
3b		g	g	+ 75	+ 100	1 h	90 ms	100 ms
4		g	g	– 6	– 7	1 pulse	d	d
5 [e]		g	g	+ 65	+ 87	1 pulse	d	d

[a] Test pulses as in 5.6.

[b] Values agreed to between vehicle manufacturer and equipment supplier.

[c] The amplitudes are the values of U_s as defined for each test pulse in 5.6.

[d] Since the minimum number of test pulses is 1, no pulse cycle time is given. When several pulses are to be applied, a minimum delay of 1 min between pulses shall be allowed.

[e] See 5.6.5 c). The test levels reflect the situation of load dump at generator rated speed. If a central load dump protection is used, apply test pulse 5b as defined in Figure 12 and use the values in table 10.

[f] The number of pulses/time is for durability test purposes.

[g] The former levels I and II were deleted because they do not ensure sufficient immunity in road vehicles.

Figure 1 - Extract A from ISO 7637-2:2004 (Table A.1)

Table A.2 — Suggested test levels for 24 V system

Test pulse[a]	Selected test level[b]	Test level, U_s[c] V				Min. number of pulses or test time[f]	Burst cycle/pulse repetition time	
		I	II	III min.	IV max.		min.	max.
1		g	g	– 450	– 600	5 000 pulses	0,5 s	5 s
2a		g	g	+ 37	+ 50	5 000 pulses	0,2 s	5 s
2b		g	g	+ 20	+ 20	10 pulses	0,5 s	5 s
3a		g	g	– 150	– 200	1 h	90 ms	100 ms
3b		g	g	+ 150	+ 200	1 h	90 ms	100 ms
4		g	g	– 12	– 16	1 pulse	d	d
5 [e]		g	g	+ 123	+ 173	1 pulse	d	d

[a] Test pulses as in 5.6.

[b] Values agreed to between vehicle manufacturer and equipment supplier.

[c] The amplitudes are the values of U_s as defined for each test pulse in 5.6.

[d] Since the minimum number of test pulses is 1, no pulse cycle time is given. When several pulses are to be applied, a minimum delay of 1 min between pulses shall be allowed.

[e] See 5.6.5 c). The test levels reflect the situation of load dump at generator rated speed. If a central load dump protection is used, apply test pulse 5b as defined in Figure 12 and use the values in Table 10.

[f] The number of pulses/time is for durability test purposes.

[g] The former levels I and II were deleted because they do not ensure sufficient immunity in road vehicles.

Figure 2 - Extract B from ISO 7637-2:2004 (Table A.2)

Table A.1 — Examples of test pulse severity levels for nominal 12 V system

Test pulse[a]	Selected test level[b]	Test pulse severity level, U_s[cd] V			Min. number of pulses or test time	Burst cycle/ pulse repetition time	
		IV	III	I / II		min.	max.
1		−150	−112	−75	500 pulses	0,5 s	[e]
2a		+112	+55	+37	500 pulses	0,2 s	5 s
2b		+10	+10	+10	10 pulses	0,5 s	5 s
3a		−220	−165	−112	1 h	90 ms	100 ms
3b		+150	+112	+75	1 h	90 ms	100 ms

[a] Test pulses as in 5.6.

[b] Values agreed between vehicle manufacturer and equipment supplier.

[c] The amplitudes are the values of U_s as defined for each test pulse in 5.6.

[d] The former levels I and II are revised because they did not ensure sufficient immunity in subsequent road vehicles' design.

[e] The maximum pulse repetition time shall be chosen such that it is the minimum time for the DUT to be correctly initialized before the application of the next pulse and shall be ⩾0,5 s.

Figure 3 - Extract A from ISO 7637-2:2011 (Table A.1)

Table A.2 — Suggested test pulse severity levels for nominal 24 V system

Test pulse[a]	Selected test level[b]	Test pulse severity level, U_s[cd] V			Min. number of pulses or test time	Burst cycle/ pulse repetition time	
		IV	III	I / II		min.	max.
1		−600	−450	−300	500 pulses	0,5 s	[e]
2a		+112	+55	+37	500 pulses	0,2 s	5 s
2b		+20	+20	+20	10 pulses	0,5 s	5 s
3a		−300	−220	−150	1 h	90 ms	100 ms
3b		+300	+220	+150	1 h	90 ms	100 ms

[a] Test pulses as in 5.6.

[b] Values agreed between vehicle manufacturer and equipment supplier.

[c] The amplitudes are the values of U_s as defined for each test pulse in 5.6.

[d] The former levels I and II are revised because they did not ensure sufficient immunity in subsequent road vehicles' design.

[e] The maximum pulse repetition time shall be chosen such that it is the minimum time for the DUT to be correctly initialized before the application of the next pulse and shall be ⩾0,5 s.

Figure 4 - Extract B from ISO 7637-2:2011 (Table A.2)

Testing of conducted transients is applicable for ESA configuration only.

The method specified in ISO 7637-1:2015, ISO 7637-2:2011 and ISO 16750-2:2012 shall be used as the method of testing.

4.9.3 Conducted emission — Reference limits

The user shall ensure that, for those devices likely to create higher pulses, such as solenoids, other highly inductive devices (including harnesses) and fast switching loads only create pulses that are less than the reference limits of the ESA testing as defined in 4.9.4.

4.9.4 Conducted immunity — Reference limits and functional status

The test levels at functional status class according to Table 1 shall apply. The function performance status shall be specified before the testing of every different check pulse. Table 2 shows the field of application of the different check pulses in the 12 V and 24 V on-board systems.

For each ESA, as applicable, instructions should be added to describe the correct installation and connections to the machinery or its devices to avoid malfunction of the ESA and the machinery.

Table 1 — Check pulse in 12 V and 24 V on-board systems

Test pulse	Standard reference	12 V on-board system Severity level [a] or Supply test level U_S V [b]	24 V on-board system Severity level [a] or Supply test level U_S V [b]	Functional status for systems
1	See ISO 7637-2:2011	III [a]	III [a]	C [e] / D [h]
2a	See ISO 7637-2:2011	III [a]	III [a]	B [e] / D [h]
2b	See ISO 7637-2:2011	III [a]	III [a]	C [e] / D [h]
3a	See ISO 7637-2:2011	III [a]	III [a]	A / D [h]
3b	See ISO 7637-2:2011	III [a]	III [a]	A / D [h]

[a] Severity levels are based on recommendations from ISO 7367-2:2011 and ISO 16750-2:2012.
[b] The calculation in ISO 16750-2:2012 should be used.
[c] Functional status of ESA that are relevant for EUT (equipment under test) operation during cranking
[d] Functional status of ESA other than for Footnote b.
[e] Without uncommanded movement and without creating hazardous machine behaviour
[f] In accordance with ISO 16750-2:2012, 4.6.3.
[g] In accordance with ISO 21848:2005.
[h] Functional status "D" is only allowed for devices only providing convenience

Figure 5 – Extract A from ISO 13766-1:2018 (Table 1)

Table 1 *(continued)*

Test pulse	Standard reference	12 V on-board system Severity level [a] or Supply test level U_s V [b]	24 V on-board system Severity level [a] or Supply test level U_s V [b]	Functional status for systems
Starting profile [f]	See ISO 16750-2:2012	IV [a]	II [a]	A [c] / C [d]
Load dump [g]	See ISO 16750-2:2012 (unclamped)	See Table 5 [b]	See Table 5 [b]	C [e]
Load dump [g]	See ISO 16750-2:2012 (clamped)	See Table 6 [b]	See Table 6 [b]	C [e]

[a] Severity levels are based on recommendations from ISO 7367-2:2011 and ISO 16750-2:2012.

[b] The calculation in ISO 16750-2:2012 should be used.

[c] Functional status of ESA that are relevant for EUT (equipment under test) operation during cranking

[d] Functional status of ESA other than for Footnote b.

[e] Without uncommanded movement and without creating hazardous machine behaviour

[f] In accordance with ISO 16750-2:2012, 4.6.3.

[g] In accordance with ISO 21848:2005.

[h] Functional status "D" is only allowed for devices only providing convenience

Table 2 — Application of test pulses

Test pulse	Application
1	This test pulse is a simulation of transients due to supply disconnection from inductive loads; it applies to a device under test if, as used in the machinery, it remains connected directly in parallel with an inductive load.
2a	This test pulse is a simulation of transients due to the sudden interruption of current in an inductor (e.g. the wiring harness) connected in series with a device under test.
2b	This test pulse is a simulation of transients due to the castor of a DC motor when the ignition switch is opened and the motor is connected in parallel with a device under test.
3a, 3b	These test pulses are a simulation of transients, which occur as a result of the switching processes. The characteristics of these transients are influenced by distributed capacitance and inductance of wiring harness.
Starting profile	This pulse simulates supply voltage reduction caused by energizing the starter-motor circuits of internal combustion engines (excluding spikes associated with starting).
Load dump	This test pulse is a simulation of a load dump transient occurring in the event of a discharged battery being disconnected while the alternator is generating charging current at the moment of the battery being disconnected with other loads remaining on the alternator circuit at this moment. The load dump amplitude depends on the alternator speed and on the level of the alternator field excitation at the moment of the battery being disconnected. The load dump pulse duration depends essentially on the time constant of the field excitation circuit and on the pulse amplitude.

Figure 6 – Extract B from ISO 13766-1:2018 (Table 2)

Table 3 — Functional status

Functional status	Description
A (I)	All functions of a device/system perform as designed during and after exposure to a disturbance.
B (II)	All functions of a device/system perform as designed during exposure; however, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain criterion A.
C (III)	One or more functions of a device/system do not perform as designed during exposure but returns automatically to normal operation after exposure is removed.
D (IV)	One or more functions of a device/system do not perform as designed during exposure and does not return to normal operation until exposure is removed and the device/system is reset by simple "operator/use" action.
E (V)	One or more functions of a device/system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

NOTE Roman numerals refer to the system used in ISO 16750-1:2006.

Figure 7 - Extract C from ISO 13766-1:2018 (Table 3)

Table 1 — Test levels for electromagnetic fields from off-board sources in 20–2 700 MHz frequency range

Phenomena	Acceptance criteria[a]	Test level	Frequency range value	Frequency range unit	Modulation type	Test method
Bulk current injection method (suitable to cover 20 MHz–1 000 MHz)						
Simulated field strength by injected current	A or FS	60 mA	20–80	MHz	AM	BCI-method according to ISO 11451-4:2013
		100 mA	80–800			
			800–1 000		PM	
Tubular wave coupler method (suitable to cover 20 MHz–1 000 MHz)						
Simulated field strength by injected current	A or FS	25 dBm	20–80	MHz	AM	TWC-method according to ISO 11452-4:2011
		27 dBm	80–800			
			800–1 000		PM	
Radiated electromagnetic field method (suitable to cover 20 MHz–2700 MHz)						
Radiated electromagnetic field	A or FS	60 V/m	20–80	MHz	AM	Absorber-lined chamber testing method according to ISO 11451-2:2015
		100 V/m	80–800			
			800–1 000		PM	
		10 V/m	2,0–2,4	GHz		
		5 V/m	2,4–2,7			
The TWC method according to ISO 11452-4:2011 is normally only applicable for component testing, but can be a suitable alternative to BCI at the machine level.						

NOTE The frequency range 1 GHz–2 GHz is already covered by requirements of ISO 13766-1:2018.

[a] Functional class A or defined safe state (FS).

Figure 8 - Extract A from ISO 13766-2:2018 (Table 1)

4. RADIATED IMMUNITY LEVELS

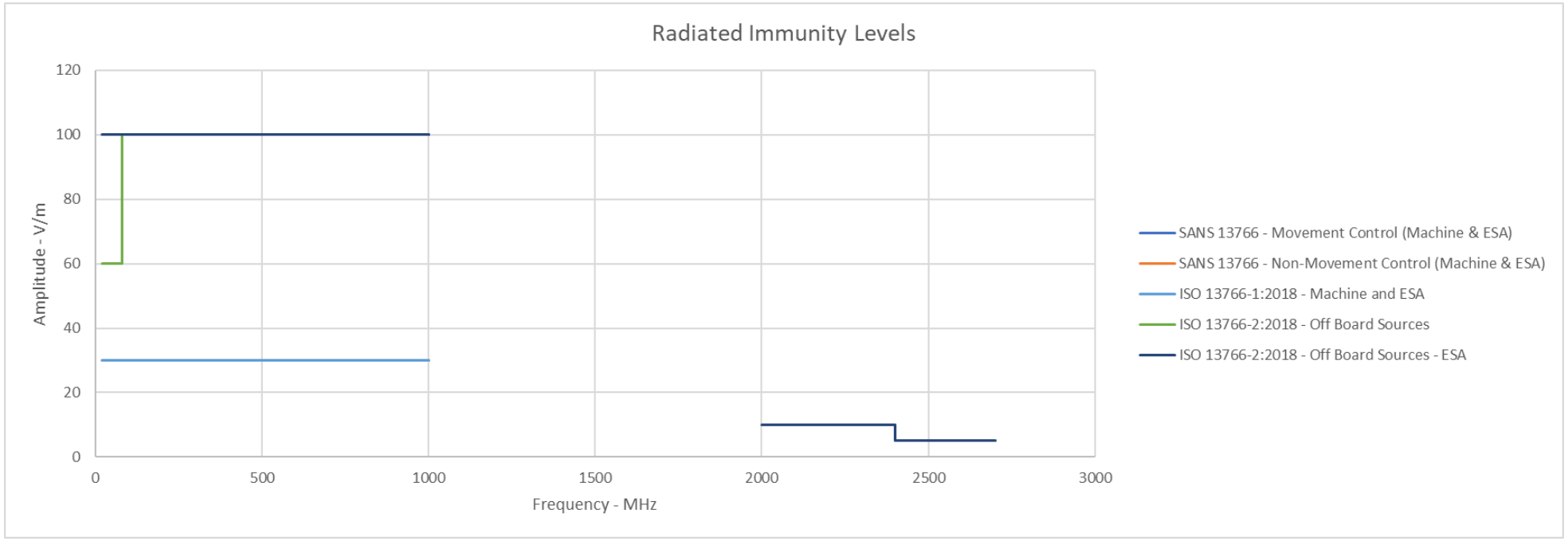

Figure 9 – Radiated Immunity Levels - Graph

5. RADIATED EMISSION LIMITS

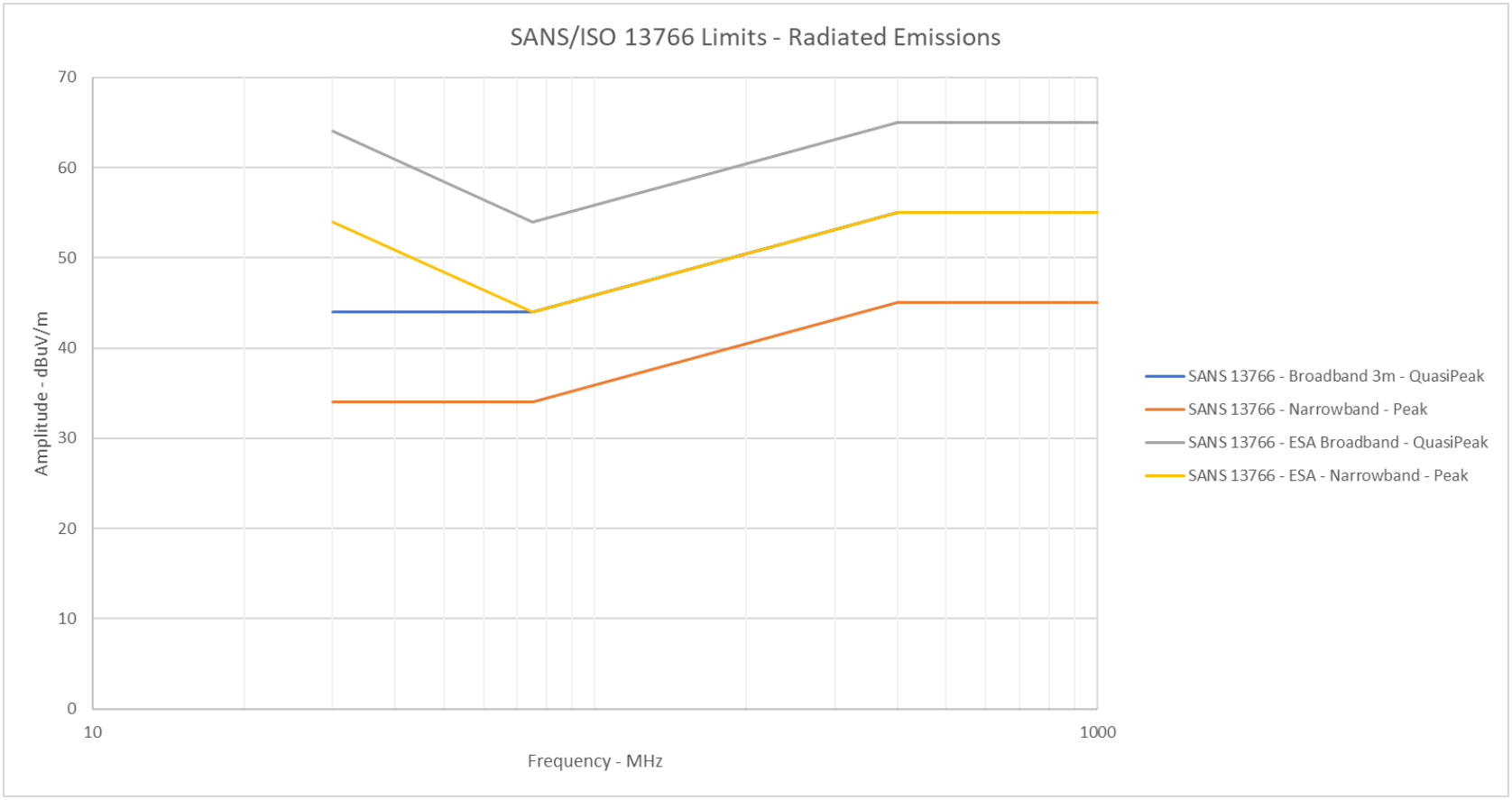

Figure 10 – Radiated Emissions Limits - Graph

6. COMPARISON BETWEEN SANS 13766:2013 / ISO 13766:2006 AND ISO 13766-1:2018

SANS 13766:2013 / ISO 13766:2006 Clause Number	Corresponding ISO13766-1:2018 Clause Number	Summary of text / extract from SANS 13766:2013 / ISO 13766:2006	Significance	Comments / Changes
5.5	4.4	**Immunity of earth-moving machinery to electromagnetic radiation**	Major	Addition of BCI test method and limits included in ISO 13766-1:2018.
5.5.3	4.4.2	**Limits – Earth-moving machinery Immunity**	Major	SANS 13766:2013 includes immunity levels for functions other than movement control.
5.8.2	4.7.2	**Limits – ESA Immunity**	Major	SANS 13766:2013 has higher levels for ESA Immunity reference limits than ISO 13766-1:2018.
5.8.3	4.7.2	**Limits – ESA Immunity**	Major	SANS 13766:2013 includes reference limits for ESA or ESA functions that do not control machine movement.
5.9	4.8	**Limits/Levels - Immunity**	Major	SANS 13766:2013 has higher levels of ESD limits than ISO 13766-1:2018.
6	5	**Exceptions**	Minor	ISO 13766-1:2018 includes additional exceptions in regard to tests to be performed; however, such exceptions do not apply to CPT.
7	6	**Test Report**	Minor	ISO 13766-1:2018 includes additional requirements to be included in the test report.

Table 6-1 - Comparison between SANS 13766:2013 / ISO 13766:2006 and ISO 13766:2018

7. COMPARISON BETWEEN SANS 13766:2013 / ISO 13766:2006 AND ISO 13766-2:2018

SANS 13766:2013 / ISO 13766:2006 Clause Number	Corresponding ISO 13766-2:2018 Clause Number	Summary of text / extract from SANS 13766:2013 / ISO 13766:2006	Significance	Comments / Changes
5.8	5.3	**Immunity to radiated electromagnetic fields form on-board and off-board sources and supply & other lines of machinery**	Major	Addition of other methods and higher limits included in ISO 13766-2:2018. The latter specification distinguishes between test methods applied to on – and off-board sources.

Table 7-1 - Comparison between SANS 13766:2013 / ISO 13766:2006 and ISO 16766-2:2018

8. COMPARISON BETWEEN SANS 13766:2013 / ISO 13766:2006 AND ISO 13766-1:2018 – IMMUNITY LEVELS

SANS 13766:2013 / ISO 13766:2006 Clause Number	Corresponding ISO 13766-1:2018 Clause Number	SANS 13766:2013 / ISO 13766:2006	ISO 13766-1:2018
5.5.2	4.4.2	**For earth-moving machinery for movement control:** Reference Limit: 80V/m *Note: For a single test specimen, immunity requirements are fulfilled by a field strength of 100V/m (25% above the reference limit).*	Reference Limit: 24V/m Test Specimen: Immunity requirements are fulfilled by a field strength of 30V/m (25% above the reference limit). No additional test limits were provided, as no distinguishing between machinery for movement control and machinery for functions other than movement control is provided for.
5.8.2	4.7.2	BCI test method: 80mA Radiated field (absorber lined chamber): 80V/m *Note: Reference limits increased by 25% apply for a single test specimen.*	BCI test method: 48mA Radiated field (absorber lined chamber): 24V/m *Note: Reference limits increased by 25% apply for a single test specimen.*
5.8.3	4.7.2	**Not required if the ESA passes at the above-said levels.** BCI test method: 24mA Radiated field (absorber lined chamber): 24V/m *Note: Reference limits increased by 25% apply for a single test specimen.*	N/A – The specification does not provide for reduced limits or limits specific to ESA functions that do not control machine movement.
5.9	4.8	8kV – Contact Discharge 15kV – Air Discharge	4kV – Contact Discharge 4kV - Air Discharge (as for functional status class A. See **Figure 7 - Extract C from ISO 13766-1:2018 (Table 3)**)

Table 8-1 - Comparison between SANS 13766:2013 / ISO 13766:2006 and ISO 13766-1:2018 - Immunity Levels

9. COMPARISON BETWEEN SANS 13766:2013 / ISO 13766:2006 AND ISO 13766-2:2018 – IMMUNITY LEVELS

SANS 13766:2013 / ISO 13766:2006 Clause Number	Corresponding ISO 13766-2:2018 Clause Number	SANS 13766:2013 / ISO 13766:2006	ISO 13766-2:2018
5.5.2	5.2.1	**For earth-moving machinery for movement control:** Reference Limit: 80V/m *Note: For a single test specimen, immunity requirements are fulfilled by a field strength of 100V/m (25% above the reference limit).*	***Machinery (Radiated electromagnetic field method)*** 20MHz – 80MHz – 60V/m 80MHz – 1GHz – 100V/m 2GHz – 2.4GHz – 10V/m 2.4GHz – 2.7GHz – 5V/m ***Machinery (BCI Method)*** 20MHz – 80MHz – 60 mA 80MHz – 1GHz – 100 mA
5.8.2	5.3.1	**BCI test method:** 80mA **Radiated field method (absorber lined chamber):** 80V/m *Note: Reference limits increased by 25% apply for a single test specimen.*	***ESA (Radiated electromagnetic filed method)*** 20MHz – 1GHz – 100V/m 2GHz – 2.4GHz - 10V/m 2.4GHz – 2.7GHz – 5V/m ***ESA (BCI Method)*** 1MHz – 1GHz – 100mA
5.9.2	5.2.4	8kV – Contact Discharge 15kV – Air Discharge	8kV – Contact Discharge 15kV - Air Discharge

Table 9-1 - Comparison between SANS 13766:2013 / ISO 13766:2006 and ISO 13766-2:2018 Immunity Levels

10. COMPARISON BETWEEN SANS 13766:2013 / ISO 13766:2006 AND ISO 21815-1:2022

A comparison of SANS 13766:2013 / ISO 13766:2006 and ISO 21815-1:2022 cannot be done as ISO 21815-1:2022 does not contain EMC test methodology and refers to the methods contained in ISO 13766-1 and ISO 13766-2. ISO 21815-1:2022 focuses on safety requirements and protective/risk reduction methods.

11. CONCLUSION

Limits between SANS 13766:2013 / ISO 13766:2006, ISO 13766-1:2018 and ISO 13766-2:2018 should be analysed and a decision should be made between testing laboratories and clients to confirm if a harmonized test plan could be used to determine EMC compliance on Earth Moving machinery in South Africa. While the use of more recent versions of specifications (in this case ISO 13766-1:2018 and ISO 13766-2:2018) are usually advised so as to conduct measurements that are comparable to international laboratories, industries and standards, the use of SANS standards (in this case SANS 13766:2013 / ISO 13766:2006) may be more applicable since the standard is approved and accessible in South Africa.

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