

Application Guidance Notes: Technical Information from Cummins Generator Technologies

AGN 011 – Electromagnetic Compatibility (EMC)

ELECTROMAGNETIC RADIATION

Preliminary

Concern has been expressed from many quarters regarding the level of magnetic flux radiating from electrical equipment. Various study groups have examined the situation in recent years and internationally recognised direction has been issued. In the United Kingdom, the Health and Safety Executive [HSE] have provided some preliminary guidance suggesting that, at mains frequency [50 Hz] an “investigation level” is where the measured Electromagnetic Radiation (EMR) is above 1.6 milli-Tesla [1600 micro-Tesla]. Measurements of EMR have been taken in the vicinity of some Generating Sets.

Measuring Equipment

Measurements were made using a HIRST Flux meter and were taken around the different generator types being tested under various loading levels. Measurements were taken right next to the alternator frame and then again some 0.5m away from the alternator. The Flux meter used had a flat probe which enabled measurements to be taken in two different planes by rotating the probe through 90°.

Maximum Measured Levels

EMR measured on Generating Sets with alternators manufactured by Cummins Generator Technologies are as follows:

- Measurement taken adjacent to Alternator frame: 200 to 210 micro-Tesla.
- Measurement taken 0.5m away from Alternator frame: Less than 10 micro-Tesla.
- Measurement taken adjacent to Generating Set output cables: 4000 micro-Tesla.

The tests were carried out on Generating Sets with output cables that had individual single-core cables for each phase. Therefore, there was no flux self-cancelling effect as would be the case if one multi-core output cable, with 3 phase cables with twisted strands, was used.

Observations

The measured Flux levels around alternators with sheet metal as their outer frame emanate a higher Flux level than those that have a thick rolled steel fabricated frame. It was found that the Flux emanating from the sheet metal framed alternators radiates radially from the machine, whereas the Flux around the rolled steel frame flows circumferentially. It would seem that the rolled steel frame acts as a circuit which absorbs the Flux; therefore, the measured Flux is the result of what is happening in the rolled steel frame. The sheet metal frame being a discontinuous metal circuit offers too greater resistance for the Flux to effectively couple and therefore, the Flux is not absorbed.

Probably the most surprising result was the level of Flux found around the Generating Set output cables, indicating that this situation must be carefully considered when nominating cable sizes, cable types and cable routing along cable trays in an installation.

Conclusion

Around the alternator, the above measured Flux levels are considerably lower than the HSE investigation level.

Reference

Further information may be obtained from the recognised authority on this topic; The National Radiological Protection Board, Chiltern, Didcot, Oxon, OX11 0RQ.

Telephone Number: +44 (0)1235 831 600

Pacemakers

Alternators manufactured by Cummins Generator Technologies are within the Health and Safety Executive's investigation levels for Electromagnetic Radiation and should not pose a problem for people with Pacemakers.

However, we would draw your attention to Electromagnetic fields from Electrical installations, which could pose a problem. Confusion may arise between electromagnetic fields that can interfere with metallic implants or medical electronic devices, as against the recommended investigation level for electromagnetic radiation, as mentioned above, can effect anyone.

Measurements for both electromagnetic fields and radiation should be established at all sites where any person fitted with a Pacemaker or, any medical device, may visit, or be present, in order to ensure that he, or she, will not be exposed to such risks.

Advice should be sort from the Government Agency responsible for the enforcement of Health and Safety in the country concerned.

Advice on acceptable exposure levels for people with pacemakers should be obtained from the manufacturers and those responsible for implanting such devices.

RADIO FREQUENCY INTERFERENCE, ELECTROMAGNETIC COMPATIBILITY AND CE MARKING STANDARDS.

Radio Frequency Interference RFI

National and International Standards, along with Military Standards, are often identified to as being required as part of the total specified performance requirement for a Generating Set. RFI testing by an approved competent body has been conducted on the Cummins Generator Technologies range of alternators, in conjunction with all options of available excitation systems. The results from these tests have been analysed, and compared with the allowable RFI levels, identified within the different RFI Standards. In some instances specific tests, as identified within a Standard, have also been performed. Standards are documents that identify a required level of capability or excellence. The Standards issued by Institutes do not conduct product tests to confirm compliance to their Standard. However, the manufacturer of a component part, or equipment should have in place a Quality Assurance System that will ensure that a manufacturer's claims of compliance to a Standard is supported by a controlled, design and manufacturing system. Cummins Generator Technologies have such a Quality Assurance System in place.

Electromagnetic Compatibility EMC.

The European Union [EU] was responsible for legislation being issued by each Member State for the design and performance of electrical equipment, including Generating Sets, with regard to required EMC performance. This legislation requires electrical equipment – but can include electrical components – to be tested specifically for EMC compliance by an Approved Test House. A successful test will allow the manufacturer of this electrical equipment, or component, to then use these test results in conjunction with appropriate design and manufacturing documentation to form a Technical Construction File [TCF] that assures EMC compliance. The Cummins Generator Technologies TCF includes; material specifications, component design and manufacturing instructions, and final test procedures, all of which are enforced by the Cummins Generator Technologies Quality Assurance System. The TCF is therefore a system, rather than a certificate, available to be issued for an individual alternator. However, each alternator is issued with a Certificate of Conformity [C of C] that is a statement of compliance with the Quality Assurance System.

CE Marking.

The EU have introduced and assigned the CE mark to signify that the product carrying this mark complies with the relevant standard(s) or technical approval. In the case of an alternator, which is a component part of equipment that forms a generating set, then various standards must be complied with. They are: The EMC Directive, The Machinery Directive, and the Low Voltage Directive. Cummins Generator Technologies does CE Mark its alternators, and for compliance with the required EU directives maintains a TCF for CE Marking. The EU Directives clearly state that a Generating Set comprised of major components that are CE Marked, DOES NOT entitle the manufacturer of the Generating Set to claim compliance of the complete equipment without appropriate testing by an Approved Test House, and having in place an appropriate TCF.

In 2001, the European Union (EU) Legislation issued revised CE marking rules, and this included EMC revisions. Partly, the changes came about because certain countries had not applied a firm enough control over their local manufacturers (Spain, Greece & Italy) with regard to all aspects of CE marking which include; Low Voltage Directive, Machinery Directive, and the EMC Directive. Therefore the BSEN50081 was replaced by BSEN 61000-6. This new standard had four parts:

- BSEN 61000-6-1 covers immunity for residential, commercial and light industrial environments.
- BSEN 61000-6-2 covers immunity for industrial environments.
- BSEN 61000-6-3 covers emissions for residential, commercial and light industrial environments.
- BSEN 61000-6-4 covers emissions for industrial environments.

All designs of Cummins Generator Technologies alternators and Automatic Voltage Regulators (AVR's) have been submitted for testing by a Competent Body [ERA] to establish compliance with the requirements of the EU Directives associated with EMC legislation.

Cummins Generator Technologies hold a Technical Construction File which covers the ERA report, along with the design specification of range of alternators, and this file is available for inspection on request.

The EMC compliance of an alternator that is incorporated within a Generating Set does not automatically guarantee EMC compliance of the Generating Set.

Compatibility and Compliance.

Document N4/X/011 entitled; **EMC considerations for Stamford Generators with fitted AVR**, summarises compliance with the most commonly encountered EMC Directives and Specifications.

		SX460	AS440 AS480	SA421	MX341	MX321	MA330	DM110	
Specification:	Date								
BS EN 61000-6-3 (emissions)	2007	RIS	RIS	RIS	#	#	#		RTF
BS EN 61000-6-1 (immunity)	2007	#	#	#	#	#	#		RTF
BS EN 61000-6-4 (emissions)	2007	#	#	RIS	#	#	#		RTF
BS EN 61000-6-2 (immunity)	2005	#	#	#	#	#	#		RTF
VDE 0875 part 3 (Level G)	1984	#	#	RIS	#	#	#		RTF
VDE 0875 part 3 (Level N)	1984	RIS	RIS	RIS	#	#	#		RTF
VDE 0875 part 3 (Level K)	1984	SM	SM	SM	SM	SM	SM		RTF
New Zealand P.O	1958	RIS	RIS	RIS	RIS	RIS	RIS		RTF
BS 1597 / 1	1975	RIS	RIS	RIS	RIS	RIS	RIS		RTF
BS 1597 / 2	1975	RIS	RIS	RIS	RIS	RIS	RIS		RTF
MIL-STD-461	1980	N.A.	N.A.	N.A.	RIS+ SM	RIS+ SM	RIS+ SM		RTF
DEF STAN 5941 B2	1971	RIS	RIS	RIS	RIS	RIS	RIS		RTF
DEF STAN 5941 A and B1	1971	N.A	N.A	RIS	RIS	RIS	RIS		RTF
SRDE 1400 B2	1971	RIS	RIS	RIS	RIS	RIS	RIS		RTF
SRDE 1400 A and B1	1971	N.A	N.A	RIS	RIS	RIS	RIS		RTF
A.S 1044	1973	#	#	#	#	#	#		RTF
Requirement:	Note								
EMP (NATO pulse)	(2)	N.A	N.A	N.A	SS	SS	N.A		RTF

Legend:				Note
#	=	No additional suppression required		
RIS	=	Radio Interference Suppression kit required	(1)	
RIS-PC	=	Partial Compliance - Conducted Interference Only	(1)	

RIS+HS	=	Radio Interference Suppression kit + Harness	(1)
SS	=	Sensing Suppression Kit required	(1)
SM	=	Special measures must be taken by the customer	(1)
N.A	=	Not Available	
RTF	=	Refer to Factory	

Notes:

1. Certain loads (in particular those employing non-linear elements) can produce high levels of RFI noise affecting the Generating Set output. In these cases the installation may need additional suppression external to the generating equipment.
2. The EMP suppression provided is for the protection of components within the alternator and is insufficient (in itself) for the protection of the complete generator installation.
3. Where 'no additional suppression' is indicated, this refers to the alternator and control system only. When the alternator is incorporated into electrical apparatus, the engineer responsible must ensure that the complete electrical apparatus package meets the relevant standard / directives.

Need requirement for Electromagnetic compliance has been addressed by the manufacturers of AvK alternators. All AvK alternators are fitted with Digital AVRs. We ask customers to '**Refer to Factory**' (RTF), via applications@cummins.com if compliance details are required.

Where **Radio Interference Suppression (RIS)** is tabulated, the entry is based on test results indicating that in order for the Generating Set assembler to meet his commitment under the Directive, this option is recommended.

Under certain combinations the table shows SM, indicating that the Customer must take **Special Measures (SM)**.

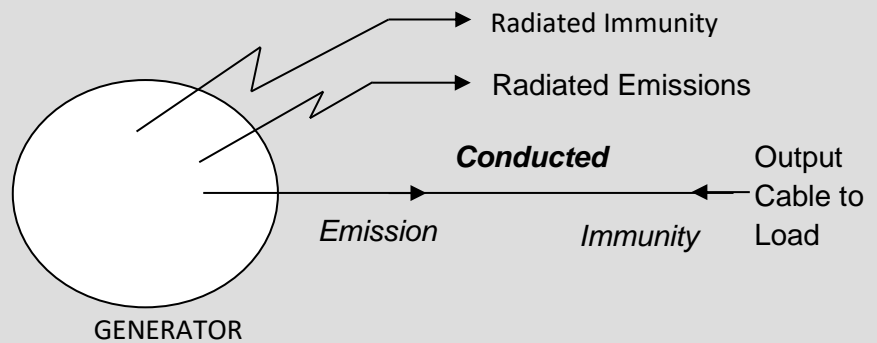
This situation occurs when the required EMC standard is of high expectation, and compliance will require careful consideration of the COMPLETE Generating Set, and its associated equipment at the installation site. Under consideration for the Engine will be such components as its electronic speed governor, battery-charging alternator, control system electronics and actuators, and spark ignition system when used. The Generating Set will no doubt be housed within a canopy designed to contribute to the overall EMC requirements, but this canopy must have openings designed to incorporate an EMC screening material. The Generating Set's control panel must similarly have been designed with a high specification EMC screening capability. For the Generating Set Site Installation, consideration must be given to the effective screening of the power and control cabling.

If the Generating Set designer has to satisfy a high-expectation EMC specification, then **Special Measures** will need to be taken with the design of the **complete Generating Set**. These **Special Measures** could therefore include consideration of the alternator's excitation system, and so starting with the cost effective SX/SA AVR system may well be an acceptable option.

Conclusion.

Most specifications contain requirements for both conducted and radiated **emissions** (i.e. the 'noise' the AVR or alternator generates either on the output lines or in the atmosphere as unwanted radio interference). In addition, some of the specifications contain requirements for

conducted and radiated **immunity** (i.e. the ability of the AVR, or machine, to continue to perform in strong radio fields). The harmonised European standards (BS ENs) also specify performance criteria for exposure to **electrostatic discharge, fast transients, power frequency magnetic fields** and more.



Conducted noise is at low frequency, typically $0.5 < 30$ Meg Hz.
Radiated noise is at higher frequency.

EU Directive 2014/30/EU.

It should be noted that in most cases there are parts of the standards listed that are not relevant to bare shaft A.C. generators (alternators). This is certainly true in the case of the harmonised Euronorm Standards (ENs) and their British Standards (BSENs) equivalent. This being the case, the means of compliance with the European EMC Directive 2014/30/EU is by the Technical Construction File (TCF) route and the parts of the standards which have been applied to the product are listed therein. It is not therefore, meaningful to say that the product does or does not meet the 'standards'. The TCF gives a technical rationale which is assessed and approved by our Competent Body (CB) to indicate our compliance with the 'essential protection requirements of the directive'.

Hand Voltage Trimmers

Users of Hand Voltage Trimmers are advised of the following recommendations regarding the compliance of the electrical generator with European EMC Directives.

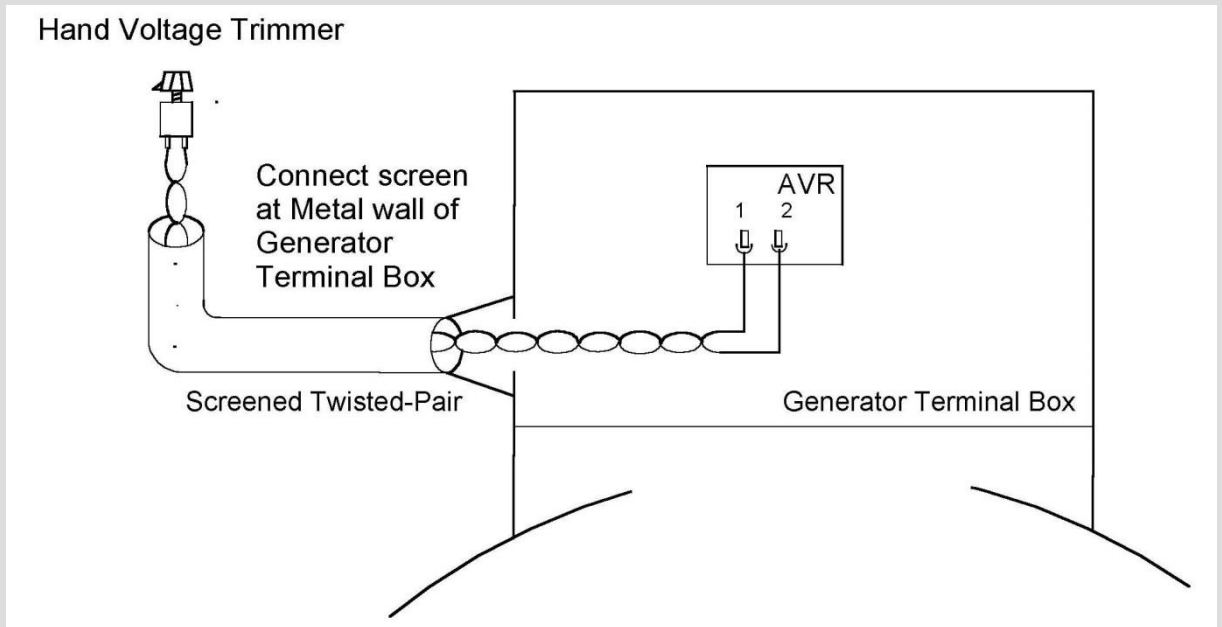
All alternators and associated AVRs produced by the company have been tested and assessed for compliance with **EU Directive 2014/30/EU** and the details of this assessment are embodied in a 'Technical Construction File' available for inspection at the company.

Tests were carried out with configurations of AVR's and Hand Voltage Trimmers that would represent typical OEM equipment/site conditions. Any wiring external to the alternator and outside the company's scope of supply is the responsibility of the Generating Set assembler, but in order to maintain compliance with the Directives the following recommendations are made:

- Hand Voltage Trimmer leads should be made up of screened twisted-pair cable.
- Cables are kept as short as possible and physically separate from other control/power wiring.

Where the Hand Voltage Trimmer cable runs outside any earthed metalwork/conduit then the cable screen should be bonded at the metal wall of the alternator terminal or control-box (preferably by 360° gland).

The following sketch illustrates an example of a Hand Voltage Trimmer installation:



The suggested cable specification for this example is: 0.75mm², 3A/500Vac minimum screened and jacketed twisted-pair.