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Safety Control for EMC Facility at AITC

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Abstract: In space area, the elements of electromagnetic compatibility such as emission, immunity and susceptibility are critically important to ascertain all the electrical and electronic components in satellite body function correctly without fatal. Every single component should has the ability to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. By setting up a fully anechoic chamber, various kind of EMC tests could be conducted thus ascertained the required ambient was maintained throughout the lifetime. On the other hand, being one of critical testing equipment in one main building, obtaining an optimal level of safety is crucial by considering both intra-system and intersystem. This is one of important step to ensure every single test that was run inside the chamber will produce and guarantee accurate and precise result according to the specified standard. Realising this, a comprehensive of safety control was established where combined all safety elements such as mechanical and electrical started from design, assembly and installation of the chamber until operation and testing phase. This study describedon the method of validation and verification to assess the safety control implemented in EMC working area at AIT Centre, National Space Agency, Banting. The establishment of comprehensive safety control in various phases also discussed throughout this study. The remainder of this study outlines some methods to improve the existing safety control.

Key words: Electromagnetic compatibility, assembly, integration and testing centre, safety control, Malaysia, Banting

INTRODUCTION

The project of setting up Malaysia's first Assembly, Integration and Testing (AIT) Centre which was completed in recent years was aimed to provide testing facilities for spacecraft and satellites manufacturers in the country and South East Asia. Among the test that are provided are like the vibration and acoustic test, environmental test and electromagnetic test. It also have the capability to measure moment of inertia and centre of gravity of the space crafts. The electromagnetic compatibility test facility is among of the six facilities installed at Assembly, Integration and Testing Centre (AITC), National Space Agency. This 5 m shielded fully-anechoic chamber is designed to achieve the related testing capabilities standard s uch as MIL-STD-461B, C, D and E, space standards SSP30237, SSP30238, SSP30243 and others related measurement standards (MIL-STD-464A, 2002).

Dealing with massive, complex and high technologies facilities in one main building is crucial and exposed to uncertainties of risk which could posed negative effects directly or indirectly. It has created a demand for a control and safe environment in handling any risks. Therefore, a safety system must be maintained adequately at low risks over entire lifetimes. A comprehensive safety control shall ensure all the activities which happened throughout the operation and testing of any project will not bring any negative impacts among each other.

Now a days, modern electronic technologies are being increasingly used so the Electro Magnetic (EM) environment is potentially being polluted day by day. The useful amounts of processing power now becoming available in low and cost effective digital devices (Armstrong, 2006). Therefore, they are likely to emit EMI at higher levels and higher frequencies than older ones. As a direct result, the whole systems may suffer the degradation of functionality, inaccuracy, errors in operation and even permanent damage or failure when exposed to such interference. And at the same, time the accuracy and reliability of such safety-related electronics increased correspondingly with these safety issues (Armstrong, 2007). In aerospace, the issue of Electro Magnetic Compatibility (EMC) is clearly important when electronic technology for devices or components control are likely dominating especially during construction and integration phase of satellite subsystem. This is due to their main function which to control any mechanism of deployment in satellite operation.

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Besides, regulations on safety are becoming commonplace but most of safety regulations and standards provide inadequate of functional safety for EMC. So, neither EMC nor safety regulations nor standards correctly address the reliability and EMI performance needs of electronics when used in safety related applications (Armstrong, 2006; Jaekel, 2007). On top of that, any foreseeable physical environment should be taken into account for every design which related to Electro Magnetic (EM) environment. Therefore, an adequate safety must also be achieved for an equipment's whole life (Armstrong, 2006; Jaekel, 2007).

Realizing these situations, a comprehensive of safety control for EMC facilities was developed to suit with the needs of development and environment of Assembly, Integration and Testing (AIT) Centre at National Space Agency, Banting. It was aimed to improve and fill any gap exists which sometimes not correctly addressed from the viewpoint of lifecycle safety. Most safety regulations and standards normally concentrate on intrinsic safety where the possibility of injury or damage could occur since employees are dealing much with electronic devices and handling high end equipment (Armstrong, 2006; Jaekel, 2007). An appropriate engineering method was also implemented in helping out to deal with Electro Magnetic (EM) issues correctly thus reduced safety risk.

MATERIALS AND METHODS

This study presents 4 main method implemented to control the safety measures in EMC facility. All the methods will be conducted with the presence of ANGKASA's staff. Appropriate methods that have been identified shall be conducted for each phase control.

Review and assessment: Review and assessment is an activity to examine what are the requirement and need for safety control at that particular area. This process is aimed to ensure compliance with the objectives of each phase of the lifecycle and meet the requirement of safety including any foreseeable physical environment.

Confirm the implementation (inspections-visual and physical): Check the engineering documentation or physical condition of the product to ensure compliance with the technical specifications. Examine the physical characteristics, documentation and data processing to verify compliance with the technical specifications.

Validation and verification

Computer modelling: Computer-aided was used to validate any function/setup of selected design/ component produce predictions of measuring for any testing inside the anechoic chamber.

Testing or non-standardized checks: Verify or prove that equipment be tested in specific situations are included with the collection of data using special instrumentation to determine pass or fail status. Running the unit/subsystem, element, partial or overall level elements. Meanwhile, a non-standard EMC checks and tests can improve confidence in safety integrity. This is a qualitative, rather than quantitative technique that can be very useful in improving confidence. It can also be applied during the operational lifetime to check that the performance of EM mitigation measures is not degrading too much.

Individual and/or integrated hardware tests: Different parts of the safety system are assembled step-by-step. Thus, checks and tests applied to ensure that they function correctly at each step.

Demonstrations: Verify the operation or movement of equipment tested under specified conditions without the presence of the special equipment. Running the unit/subsystem partial element or elements of the overall level. Observations were made to verify the pass or fail mode.

Checklists: A complete checklist was reviewed to ensure that design/activities completely installed/measured and complied with requirement specified.

Audits: These include checking or examine that the correct specification, design, assembly, installation and verification processes have been followed. Audits can be seen as a quality assurance activity and it helps much in design, during and post installation phase.

RESULTS AND DISCUSSION

Safety control: The safety control for EMC facility in AITC was developed in conceptually simple but conscientious design is required to achieve an optimum level of safety performance. It is designed with 5 important phase to ease the monitoring and evaluation by responsible personnel.

Phase 1 (design and pre installation)

Design reviews and independent experts: Session of Critical Design Reviews (CDRs) and Final Design Reviews (FDRs) was held and participated by ANGKASA team, suppliers and main principal. With the aim to avoid any problems caused by blind spots and/or lack of sufficient information, the experts from SIRIM were appointed to be a member of independent review board for their competency and wide knowledge.

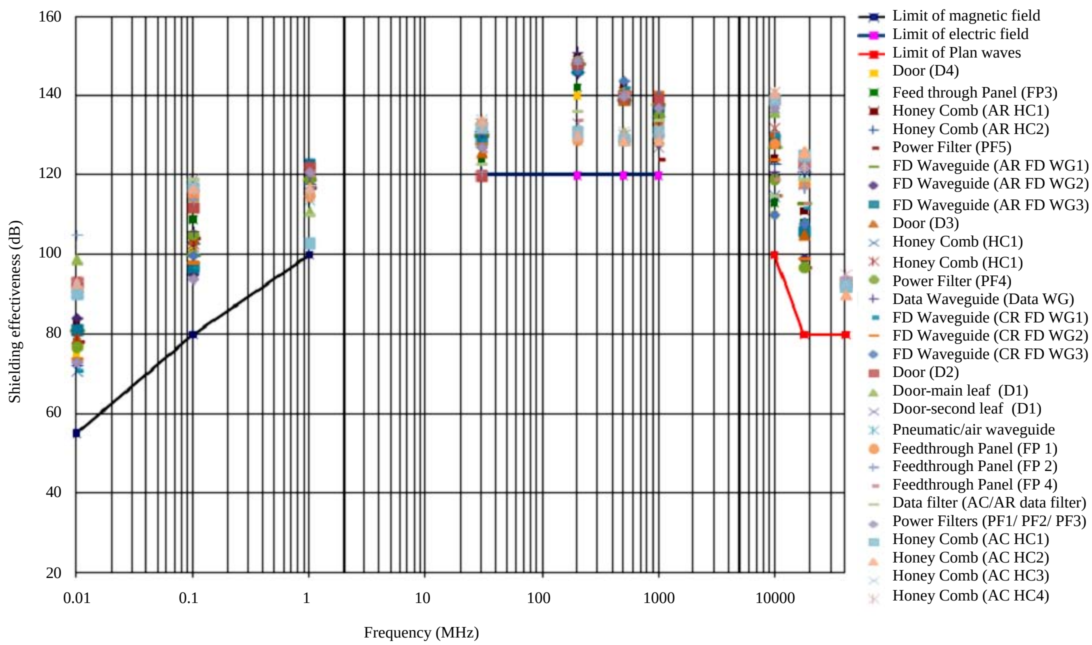

Fig. 1: Shielding effectiveness performance of chamber

General and specific requirement from users was discussed and agreed upon FDR session. The decision has taking into considerations of physical environment, safety factors and hazard during the operation and also whole life cycle. This is important since poor EMC design for equipment's environment can result in corrosion that significantly reduces shielding effectiveness and immunity performance.

Phase 2 (during installation): As to achieve a level of confidence in EMC performance in context of functional safety, an appropriate of EMC design techniques discussed below have been implemented throughout of project implementation.

Shielding gasket: As part of design, shielding gaskets were chosen to have sufficient compression to cope with foreseeable movements in the gaps they fill, despite the physical stresses that could be applied. Materials should be chosen that will not suffer excessively from galvanic corrosion or other ageing effects due to the physical environment for the anticipated life. Gaskets were designed to withstand foreseeable lifecycle wear-and-tear especially at personal or main doors and feedthrough panels that might be frequently opened.

Filter for power and grounding: As an adequate safety practise, 5 units of power filter were installed dedicated for main chamber, control room and amplifier room. This power filters were installed outside chamber and lay down into the chamber and rooms. It were functioned as medium of protection for equipment inside the chamber and control and amplifier room from external building powerline system. The power filters are exclusively for power supplies only with conducted attenuation on load 100 dB according to MIL STD 220A for frequency range of 20 kHz to 40 GHz. By having power filters, conducted radio frequencies or electromagnetic interference between the AC or DC power line and the equipment could be attenuated. Other than that, filter grounding has been installed using multiple electrical bonds with features of anti-vibration fixings to reduce the likelihood of an open circuit to acceptably low levels. Besides, component over rating and encapsulation can reduce any possible damage from shock, vibration and many other potential environmental threats.

Replacing conductors with fibre optics: Considering that fibre optic cables carrying signals or data which perfectly immune to all Electromagnetic (EM) phenomena, at all conceivable levels over any period of time, ANGKASA's EMC system has used fibre optics as whole. Any system from inside chamber will be connected by fibre optics through two access point laid underneath of raised floor and pass thru feedthrough panel into control and amplifier room. This installation also applied to hardened video system and antenna mast.

Fire detection system: Very Early Detection System (VESDA) was chosen as fire detection system for EMC facility. It has conform to the Harmonised and International Standard which are EN50130-4:1996, EN61000-6-3:2001 and EN61000-6-4:2001. Total 6 points were determined inside the chamber and 3 points for each control and amplifier room. All points were controlled thru control alarm panel. Any status of detectors for fault event or alarm system monitored and accessed remotely from main system. Presently, this features has found very comfortable and easy access for users.

Phase 3 (post installation)

On-Site Acceptance Test (OSAT): Series of specific tests were carried out in the 5 m anechoic chamber as to determine the accuracy of chamber performance. The tests characterized the shielding effectiveness of RF shielded enclosure, the Field Uniformity Area (FUA), site VSWR and Normalised Site Attenuation (NSA) of anechoic chamber. From the test results obtained, it were clearly indicated that all of 4 tests have achieved the target level or performance limit according to the specified standard. Besides the specific tests, validation through physical inspection were conducted on sample of absorbers, feedthrough panels, honeycomb air vents, doors and ramp, CCTVs, turntable, antenna mast and electrical networks. Figure 1 shown the shielding effectiveness of the chamber.

Calibration and functional test: As for DAQ system, every independent device or any physical hardware, e.g., cabling or metal chassis which received from manufacturer have been undergone non-standardized checks before entering integration and commissioning process. In order to characterise the generated field and demonstrated the conformity, calibration process on each setup system was carried out together after series of functional test. The tests were simulate and analysed using EMC 32 Software and all the results obtained within the specified limit.

Immunity test system: Tests are carried out on the same positions as in the EMI measurements figured in Fig. 2. On each frequency selected, interference is generated by a signal generator. It is then amplified by a radio power amplifier and radiated out by a radiation antenna. The interference level is recorded by a field probe by which the output level of the generator is adjusted. After the interference arrives to the target level, it will be retained for a few seconds to wait for the response of the System Under Test (SUT) (Kang *et al*., 2010). According to the result, it has shown that the immunity level exists below the defined radiation safety margin, 6 dB therefore an overall system was acceptable for safety since no performance degradation detected.

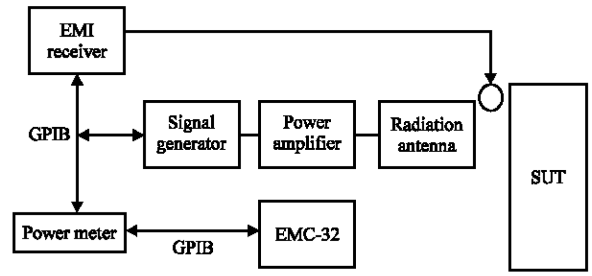

Fig. 2: Immunity test setup

Phase 4 (during operation/testing): Frequently access on the physical environment and search any foreseeable faults was definitely important before and during conducting any testing. Variation of warning sign or symbol provided at all access point/area to control and give awareness of other equipment owner for any operation/testing conducted inside the chamber. During operation, operation team shall be provided with all Electrostatic Discharge (ESD) control and protection. In addition to that element below shall closely monitored.

Interlock system and safe shut-down: System interlock is made up of a numbers of relays. Protection circuits were used to detect malfunction and shut down safely or force operation in a safe default mode. The EM environment can be monitored and safe shut down if extreme EM events occur. For example, the installation of protection circuit for personnel and main door will help to abort if the door not properly close. Other than that, the amplifier system also provided with this features where it was controlled remotely from EMC-32. This features has provide safety control especially when handling couple of equipment at the same time with less number of personnel.

Cable handling: EMC testing require for various connection and installation of power and signal cable, therefore proper handling of these cable shall be taken into consideration to avoid any hazard in testing area. Every bunch of cable shall be tied together to avoid minor accident, clearly tagged and designated for particular test path. Every cable loss was calculated during integration and upload into test system for each tests.

Phase 5 (scheduled activities)

Maintain equipment readiness: As a part of operation procedures in AITC, every personnel for each equipment shall perform routine check-up at least once a week to ensure the readiness of equipment. This routine shall include physical check and assessment, individual hardware test, dry run test as well as perform system backup for both chamber and data acquisition system. This pre-testing activities will help to identify any possible error that might occur during testing. If there is any error found from this activities, corrective action shall be conducted. Besides, every personnel involved shall be trained which focused on equipment handling, potential hazards, established procedures besides their main responsibility hence, increase their competency.

Safety screening and HIRAC: At least one in a year, a screening session shall be conducted by appointed safety committee. They shall access and inspect every equipment in AITC. The assessment shall include but not limited on the personnel, equipment, handling operation and storage. On top of this, Hazard Identification Risk Assessment and Control (HIRAC) will be issued by each equipment personnel on potential foreseeable hazard that may induce risk for health and safety. The HIRAC shall be control to keep every identified risk of injury or illness as low as possible.

CONCLUSION

In any timescale, safety control for each and specific Electro Magnetic (EM) environment like in AITC shall be a continuous monitoring and control over their life cycle. This is utmost important to ensure every single potential risks or hazard identified, mitigated/minimized to acceptable level or avoided. The safety control presented were completely done until Phase 3 Post installation whereby Phase 4 and 5 was on-going. Having a comprehensive safety control shall contribute for a better management of EMC facility in AITC environment. As for present, the anechoic chamber at AITC has demonstrated all conformity factor of safety and ready for testing purposes hence, capable to produce reliable output.

SUGGESTIONS

As moving forward in next few years, AITC is aimed to have numbers of project in satellite testing programme. Therefore, here are some approach of enhancement for the existing EMC system in helping and contribute towards the goal.

Redundant channels: As to improve the reliability of systems, employing multiple redundant channels of testing with a voting arrangement is believe can improve any fault tolerance detected for common cause faults. Therefore, if one or more channels malfunction the preponderance of other channels providing the correct output will maintain correct operation.

Quality Control (QC): Achieving adequate levels of safety requires safety-related design, assembly and installation. Some changes/adjustment to a design, parts or assembly and construction methods, can have very significant consequences for EM performance. Thus, quality control is also required for all design changes to make sure that adequate levels of safety are maintained. A quick low-cost tests should be designed, so that normal operation could be perform as usual.

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