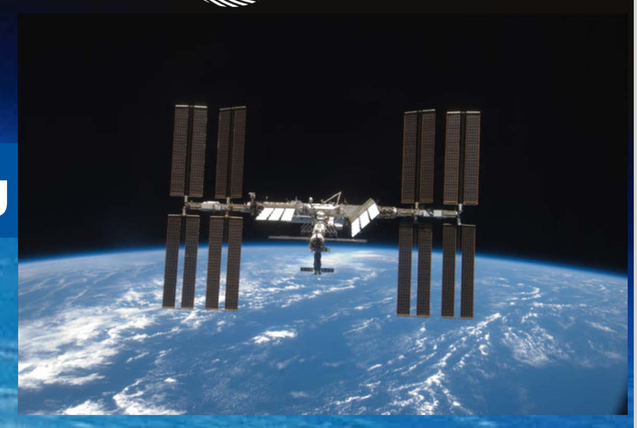
ISMSE-14

→ISS Payload Safety- A Materials and Processes Oueruiew



Cathal Mooney[1] , Mauricio Portaluppi[1] , Thomas Rohr[2]

TEC-QEE[1],TEC-QTM[2], ESTEC, ESA, Postbus 299,2201 AZ, Noordwijk, The Netherlands,
cathal.mooney@esa.int, mauricio.portaluppi@esa.int, thomas.rohr@esa.int

ABSTRACT

The European Laboratory Module Columbus has just celebrated 10 years in orbit and outstanding research has been carried out under microgravity environments which have resulted in scientific and industrial benefits. Also medium and small enterprises have the opportunity to carry out research in microgravity especially now that space is becoming more accessible. An overview to the materials and processes for payloads and experiments inside the International Space Station ISS is explained. This poster focuses on the safety hazard control approach for developers willing to prepare experiments or payloads for ISS Columbus. An overview will be presented showing the approach to materials related safety hazard controls including among others: flammability, toxicity, forbidden materials, fluid compatibility, life time extension.

The expansion on utilization scenarios and services of the International Space Station (ISS) towards medium and small enterprises and institutes has been reflected on the release of a new document entitled "Product Assurance and Safety Requirements for ISS Pressurized Payloads ESA-HRE-IPL-RQ-0002" (released 2016). This new requirements document is applicable to the ISS pressurized payloads (ISS internal only) and supersedes the previous GPQ requirements documents. Major changes include the introduction of 2 payloads categories grade A and B in terms of level of qualification from a Product Assurance perspective and also safety, the first being the highest possible achievable level in terms of mission success, whereas the second , Grade B is a compromise in terms of risk and requirements to allow greater access to space#. This paper focuses on the materials and processes aspects and recommends the payload developer to study the updates on the other competences. This poster presents an overview of the new requirements document intended as a guide towards payload developers from the space industry, small to medium enterprises and technical institutions and universities involved in payload development for the ISS.

Pressurized Payload Grade Classification

GRADE A

ISS Pressurized P/Ls of Grade A are P/Ls whose mission requires state of the art reliability and highest achievable level of mission success.

Overview

Materials and processes with heritage or verified suitability are required. ECSS-Q-ST-70C is applicable. Quality focus on each aspect of the equipment lifecycle allowing long term reproducibility and reliability.

Materials and processes

New or critical M&P require validation, qualification , verification and proper justification. COTS justification file is required.

GRADE B

ISS Pressurized P/Ls of Grade B are P/Ls whose mission allows for low to moderate risk against mission success balanced by cost, schedule constraints and mission objectives

Overview

The payload developer is responsible for the payload performance and guaranteeing that safety requirements are met. Quality is not verified to Grade A level.

Materials and processes

Materials and processes requirements apply whenever safety relevant and focusing on hazard control.

For the grade criteria details please contact ESA HRE P/L development organization to receive support on definitions

Flammability Hazard Control

Flammability hazard are catastrophic by definition thus close control of flame ignition and propagation is paramount. Typical strategies to control flammability hazard include limiting ignition sources, the use non flammable materials and enforce flame propagation control.

The use of non flammable materials is required, this requirements implies passing ECSS-Q-ST-70-21C or NASA-STD-6001. For materials selection a database of flammability ratings is available in ESMAT, MAPTIS (NASA) and ECSS-Q-ST-70-71A. O_2 requirements are 24.1% for ISS cabin and 30% for ISS airlock.

Commercial flammability standards – e.g. UL94 - are not accepted for approval. Flame propagation path shall be avoided and a flammability assessment under configuration is required following the requirements in JSC29353C. When flammable materials are used or flame propagation cannot be avoided the implementation of an operational constraint (eOCAD) shall be used.

COTS equipment/items require special attention since material and processes selection follows industrial standards. In some cases flammability testing of COTS is advised and follows requirements of ECSS-Q-ST-70-21C and NASA-STD-6001.

Further attention must be given to Enriched Oxygen atmospheres and GOX and LOX systems. The P/L developer should follow an Oxygen Compatibility Assessment as per the NASA/TM-2007-213740 requirements.

Unique materials and processes hazard control

Standardisation of hazard control is a useful strategy to reduce the major and more commonly hazards due to materials as per SSP30599 and are reviewed by ESA ISS safety review process. Nevertheless the materials engineer should always assess other potential causes of hazards caused by unexpected or indirect effects. Reaction by-products may be corrosive or produce toxic substances, experiments can lead to exothermic reactions , use of soft goods outside the expected temperature range may cause loss of functionality and increased degradation, high surface area materials are susceptible to chemical reaction compared to the same bulk material. UV and laser exposure can source of degradation. The assessment should be holistic taking into account life and exposure on ground, during launch and in-orbit scenarios.

Materials related hazards

Offgassing and toxicity

In the closed atmosphere of ISS, maintaining the atmosphere clean from toxic substances is of paramount importance. System and payloads shall perform an offgassing test and toxicity level should be lower than T=0.5. Payloads with less than 9 kg of non metallic materials are exempted. Un-cured adhesives, gels, lubricants, wipes with alcohol, foamed fluorocarbons are not exempted.

Toxic materials

Chemicals toxicity shall be assessed and not exceed required concentration thresholds.

Corrosion and stress corrosion

Fracture critical or safety critical components shall use stress corrosion resistant materials (see ECSS-Q-ST-70-36C). Galvanic corrosion assessment is necessary to avoid corrosion in orbit due to incompatibility of metals.

Chemical compatibility

Chemicals used on experiments may cause degradation to materials with loss of functionality or performance. A fluid compatibility test on all safety relevant wetted materials is required. Loss of performance is evaluated case by case, in general soft goods are evaluated by swelling, mass change ,mechanical properties loss, embrittlement, change in color. The test implies long duration exposure on worst case scenario thus early testing is recommended.

Water soluble volatile organic compounds

The use of volatile organic water soluble compounds may affect the life support system performance on board the ISS and their use is controlled. Examples include methanol; ethanol; isopropyl alcohol; n-propyl alcohol; n-butyl alcohol; acetone; ethylene glycol; propylene glycol

Fungus Growth Resistance

Fungus growth resistance of materials shall be assessed in terms of NASA-STD-6016 and COL-RIBRE-TN-1332 in high humidity or wetted conditions

Forbidden materials

The following materials are forbidden: Beryllium on structures, beryllium oxide, mercury, cadmium, zinc, lithium, magnesium, PVC, radioactive materials, polyamide insulated cables. If needed specific approval is required.

Life extension of materials

Life extension of materials should be justified under configuration through assessment or test. The possibility of acceptance through payload performance monitoring may be accepted on a case by case basis.

Conclusions

The access to microgravity experiments is becoming increasingly affordable to small and medium companies as well as institutes improving the agility to develop and run experiments in microgravity. However safety hazard controls remain of paramount importance to the ISS systems and crew. This poster intends to help the payload developer community to have a guideline on materials and hazard controls expanding the spectrum of ISS users and scientific knowledge under microgravity.

Further Information on this and other safety related issues may be found on the ESRP website :
https://qexchange.esa.int/esaisssafety/User/Registration.aspx