SAFETY CERTIFICATION FOR INTERNATIONAL SPACE STATION (ISS) PAYLOADS

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ABSTRACT

With the advent of long duration space station flights for payloads, the process for how to determine the safety of payloads must be reassessed. No longer is the design required to achieve its goals based upon relatively short flight duration on the order of days. The payload safety requirements as defined by [1] and [2] require the payload organization to submit a Certificate of NSTS/ISS Payload Safety Compliance, JSC Form 1114A. This form states The Payload Organization Hereby Certifies that: the payload complies with all Applicable requirements of the [1], [2] and/or [3], and

1) The Safe Design Life is ____________________from ____________ (date). This is the time period the payload can be retained at or restored to a specified safe condition using prescribed resources and procedures. The limiting component(s) that determined this safe design is (are) __________________________, which requires (recalibration, repair, replacement, etc.).
2) The Safe Operational Life is _____________________ from ____________ (date). The limiting components(s) that determined this safe operation is (are) _____________________, which requires (recalibration, repair, replacement, etc.).

For International Partner (IP) payloads the same information is to be reported only on a different form. This form is identified as the Flight Safety Certificate, JSC Form 906. This is specified per document [4] in paragraph 5.4.1 and only applies to basic payloads that have a very low level of complexity know as Category 1. This form is reserved for IP sponsored items (items that have been reviewed and approved by the IP safety organization that is part of the multilateral agreement), and as such, the IP only needs to send the completed JSC Form 906 to the JSC PSRP.

This paper gives the payload organization insight into how the Safe Design Life and Safe Operational Life are to be determined and describes the common misconceptions about limited-life items from a reliability perspective as opposed to a safe-life determination. What these terms mean is explained; and, more importantly, how the ISS Program uses the data. It emphasizes the need for accuracy of certification assessment, using the predicament of the post-Columbia era to illustrate what a payload may experience if the assessment is not realistic. The paper discusses what organizations need to track the data and the process for extension of life should the certification life be approaching expiration. Included in this paper are some examples of payloads that have been through the entire process and have had the life extensions, as well as examples of payloads that chose to allow the safety certifications to expire while on orbit.

Additional emphasis is placed on the realization that International Partners (IP) will soon need to establish a similar system to track payload safety certifications for which they are responsible. As we progress through the establishment of a final International Space Station configuration, and as we enter the operations phase of several International Partner Modules, it is of the utmost importance that the entire community throughout the ISS Program is aware of the on-orbit safety status.

2.0 REQUIREMENTS

ISS requirements for payloads to submit a safety certification are defined in paragraph 304 of [2]. “The flight certification shall be submitted at least 10 days prior to the Flight Readiness Review (FRR). The flight certification shall include statements that the payload design and flight operations are safe and are in compliance with the ISS safety requirements of this document.” This is again specified in [4], Section 5.7.1 under Post Phase III safety activities. The data submittal form is JSC Form 1114A (Rev February 20, 2008) and is Figure 3 of [2]. The Form 1114A was modified in 2001 for space station payloads to include information that accounts for the effects of long term flights. International

Partners use the 906 Form as specified in document [4] paragraph 5.4.1 and this only applies to very low complexity payloads know as Category 1. The life information on the Form 906 is in section IV under Description as Desgin Life and Operational Life. The portions of the forms that are discussed in this paper are Section C on the SAFE DESIGN LIFE AND SAFE OPERATIONAL LIFE of the Form 1114A; and Design Life and Operational Life in section IV of the 906 Form.

Additional changes to the data submittal requirements per document [4] and the JSC Form 1114A were made in 2008. The need for investigating and establishing the safe life was considered by the Payload Safety Review Panel (PSRP) as a significant issue that should be addressed earlier in the payload development cycle. Therefore, document [4] was updated to require these data be included in the Phase I, II and III flight safety data packages to be discussed at the phased safety reviews. This process will ensure that both the payload organization and the PSRP have insight into how the data was derived and appropriate concurence is achieved by both the payload organization, operations community, engineering disciplines, and the PSRP.

3.0 LIFE DEFINITIONS

Per the instructions attached to the JSC Form, the Safe Design Life is defined as the time period a payload can be retained at or restored to the specified operational condition via prescribed resources and procedures and must include ground and on-orbit time. Safe Design Life should be considered the end of useful life of the payload/experiment without having major overhaul or rebuild of the hardware – too costly, time consuming and possibly antiquated technology. The hardware can not be placed back in a safe operational state without extensive effort and or expense, becomes a feasibility issue. The Safe Operational Life is defined as the time period that the payload will perform its intended function within specified performance limits under stated conditions without any corrective maintenance, recalibration or repair and must include ground and on-orbit time as well as the operational and stowage times. Safe Operational Life from a safety standpoint means the hardware will perform its intended functions within all envirornmental limits as planned with out anything having to be performed on the hardware, i.e., no maintenance, recalibration or repair. The payload is good to operate or be stowed without any exceptions, from a safety standpoint, and no hazard would or could occur since proper controls are in place, which will function as designed, and remain in a safe condition. This should not be confused with mission failure when a payload/experiment does not operate or fails to operate as intended, resulting in erroneous science data or no data whatsoever; however, there is no hazardous payload operation or the payload/experiment shuts down in a safe manner resulting in no hazard.

4.0 BACKGROUND/HISTORY

It is noted that both the Safe Design Life and Safe Operational Life are to account for preflight and flight times as well as operational time and stowage times. The instructions direct the payload organization to include both the ground and on-orbit times in these life numbers. This is particularly significant for polymeric type materials that are used for sealing purposes, some pressure system components, some electrical sensors and possibly structural elements used for vibration testing. The only reference or inference to this type of assessment prior to space station payloads was in the payload reflight safety assessments. Reference [1] in paragraph 216.3 on lmited life items directed that all safety critical age sensitive equipment must be refurbished or replaced to meet the requirements of the new mission. Reference [4] requires in section 9g that an assessment of limited-life items for reflown hardware be submitted to the PSRP.

5.0 GENERAL DISCUSSION

Now, one may ask, are all items of the payload hardware subject to this life assessment? The answer is, “No, not all items are required to be assessed.” Only those items or devices that have been identified as hazard controls on a hazard report have to undergo this scrunity. Or if the items are not identifed on a hazard report, but do impact the payload safety, the items need to be taken into account in determining the life calculations. From a safety standpoint the hardware, crew and vehicle are counting on these devices and items to perform their intended function to control the potential hazard for an identified period of time. As with most devices, they can wear out or not perform their intented function over extended periods of time or use/disuse. Therefore, the question comes to one of how long these devices or items can perform their intented functions or be stowed without any additional effort being expended. In other words, there does not have to be a replacement, refurbishment, maintenance or recalibration of the device to make it perform as well as it did during the original payload hardware development. Remember, here the important things are 1) only those items or devices that are controlling hazards and 2) they must operate as intended without any additonal work or effort expended on them.

This then becomes the Safe Operational Life. As with most man made manufactured items some preventative maintenace, corrective maintenance, recalibration and/or repair is probably required. Take for example something everyone is pretty familiar with, an automobile. Changing the oil and oil filter on a regular basis is a classic example of preventative maintenance. Corrective maintenance would involve replacing electrical switches that time has shown to cause electrical fires for no apparent reason. The original design seemed good; however, experience has shown these items are not performing as intended. Recalibration generally would fall within the engine performance category of changes in spark advance, emission control, and regapping spark plugs. And of course repair is obviously replacement of broken or non functioning vehicle parts, such as a broken axle or rim, ruptured diaphram in the fuel pump, broken water hose, etc. Another industry that uses the Safe Operational and Safe Design Life concept or principle is the US commercial nuclear power industry. Nuclear power plants are designed and built for a forty (40) year life. However, it is known that certain items need to be revisited at periodic intervals. The classic example is steam pressure relief valves. At every power outage, when the plant is not operating, a certain number of valves are removed and retested to assure that the pressure relief set pressure and reseat pressure are within specifications. The retesting cycle or time between retests of the pressure relief valves is an indication of Safe Operational Life. Another major industry using this approach is the aircraft industry – both military and civilian.

Until now we have been discussing only the Safe Operational Life and Safe Design Life under normal nominal flight conditions. However, there is another aspect that needs to be considered from a safety standpoint: which is what needs to be performed should the Safe Operational Life and/or Safe Design Life expire due to off nominal or unforeseen conditions, for example loss of shuttle or delay in flight schedules? In other words, what has to be done to ensure the payload/experiment is safe for storage or does the hardware need to be removed from the space station to ensure safety is not violated. This becomes particularly important for experiments containing hazardous stowage items, e.g. ziplock baggies, pressure vessels etc. If these items can become a hazard over extended periods of time then there needs to be some approved plan/procedures in place to either provide for safe long-term stowage or removal. This becomes an issue for large payload/experiment hardware that need to be retuned and which can only be returned via the orbiter, which is to be decomissioned in 2010. Early identification of these items is essential.

Should payloads be planned for numerous missions as reflight hardware, the Safe Operational Life and Safe Design Life needs to reflect the same methodology for each mission as if it were a single mission. The replacement of seals, batteries, filters, etc. will bring the hardware back to a Safe Operational Life; however, the Safe Design Life still must reflect the point at which the return to a Safe Operation Life condition is no longer possible.

5.1 Polymerics Specific Discussion

When one speaks of polymeric materials it generally relates to seals, whether an O-ring type seal or a gasket seal. The use of polymeric materials has many aspects to investigate as the useful life begins at the time of manufacture or cure date for the specific item. Unfortunately many different terms are used by the various manufacturers, distributors, and vendors of these products, ranging from shelf life, useful life, rated life, operational life, cure date, storage life, design life and end of life. According to the Society of Aerospace Engineers, [6], storage-life is the maximum period of time, starting from the time of manufacture, that a polymeric seal, appropriately packaged, may be stored under specific conditions, after which time it is regarded as unserviceable for the purpose for which it was originally manufactured. The time of manufacture is the cure date for thermoset elastomers or the time of conversion into a finished product for the thermoplastic elastomers.

After the cure date the most important aspect to determine is the storage/shelf-life. Experience has demonstrated that storage conditions are much more important than time in determining the useful life of O-rings. Reference [6] addresses the general requirements for data recording procedures, packaging, and storing of aerospace elastomeric seals as follows:

1. Temperature – the storage temperature shall be below 100ºF, with a preferred average not exceeding 75ºF to 80ºF. Avoid direct sources of heat such as boilers, radiators, heaters or direct sunlight.
2. Humidity – the relative humidity shall be such that, given the variations in temperature in storage, condensation does not occur. This is particularly important if items are not

individually sealed in storage containers, e.g. heat sealed bags.

3. Light – protection from light sources shall be provided, in particular direct sunlight or intense artificial light having an ultraviolet content.
4. Radiation – precautions shall be taken to protect stored articles from all sources of ionizing radiation.
5. Ozone – storage rooms shall not contain any equipment that is capable of generating ozone such as mercury vapor lamps, welding equipment, and/or high voltage equipment giving rise to electrical sparks or silent electrical discharges. Combustion gases and organic vapor shall be excluded as they may give rise to ozone via photochemical processes.
6. Deformation – elastomeric seals shall be stored free from superimposed tensile and compression stresses or other causes of deformation.
7. Contact with liquid and semi-solid materials – seals shall not be allowed to come in contact with, e.g., gasoline, greases, acids, disinfectants, and cleaning fluids or their vapors during storage.
8. Contact with metals – certain metals and their alloys (in particular, copper, manganese and iron) are known to have deleterious effects on elastomers. Therefore do not store them in contact with such metals.

As indicated by the discussion above, the time for elastomeric or polymeric seals safe-life is some times difficult to obtain unless the payload takes explicit care in the purchase of the seals and/or hardware. It is incumbent upon the payload organization to obtain specific information from the manufacturer at the time of hardware acquisiton so as to be able to establish a realistic Safe Operational Life. Not even mentioned above is the media compatability that needs to be examined for each seal application. This means, will the elastomeric seal retain its sealing ability over the extended time that the payload will experience, including both the ground time and flight time, plus some margin?

Obtaining polymeric data for the safe life may be very challenging. There is extensive literature, MIL-HDBK, and polymeric material manufactuers data which can provide some useful insight into safe life limits. However, care needs to be taken to ensure these data reflect the specific PO application including usage, environments and media. When attempting to obtain the life of polymeric materials from the manufacturer or vendor it is often helpful to keep in mind that the sales staff may or may not be able to answer your questions on useful life. The PO then needs to ask for technical support personnel within the company, e.g. engineering, designer, test personnel or research department. In some limited cases, if the company is large enough, a "good sales application engineer person" can be helpful, otherwise ask for technical support personnel as listed above. Should the original equipment manufacturer not be able to provide the safe life data, ask what company supplied the polymeric materials and then do the same within this company. On more than one instance the research department of the supplier was able to eliminate any doubt as to the stability of their product and its useful life. Another potential source of valuable data is the NASA materials and processes engineering department. This organization has done extensive research into extending the life of polymeric materials used in the Orbiter/Space Shuttle program, which has a design life of 10 years. Many of the polymeric materials life has been extended from 10 years to 30 years; and, for some materials 40 years. On the flip side there are a few where the life could not be extended, in fact they were shortened below 10 years. With some degree of due diligence the PO can arrive at good realistic numbers for the safe operational life for polymeric materials for their application. In summary literature can ususally provide insight into generically how the material will behave, the manufacturer of the end item/assembled hardware may have safe life information, or the original polymeric materials company should have these data, and as a last resort NASA may be able to provide data (keep in mind that NASA does not currently have budget to provide this service for payloads).

5.2 Pressure System Components Specific Discussion

The PSRP and JSC Engineering Directorate personnel have set forth some basic principles for the certification and verification of pressure system control hardware. The data identified and requested for establishing the initial Safe Design Life and Safe Operational Life certification, as well as recertification are identified in letter [7] of July 25, 2002. For initial certification the payload organization is to provide the following information/data to assist in establishing the control hardware Safe Design Life and Safe Operatonal life:

1. Component Materials Listing – Include metallic and non-metallic materials utilized in the hardware construction.
2. Fluids Listing – Encompass both internal and external media, as well as cleaning fluids. This listing should include details for all fluids (e.g.,

concentration, quantity, type, etc.) to which components will be or have been exposed.

3. Component Schematics – Provide full schematics and cut-away drawings, illustrating component architecture and details.
4. Shelf and Limited Life Assessment – As applicable, demonstrate compliance to shelf- and limited- life requirements for both metalic and non-metallic materials.
5. Operational History and Manufacturer's Design Life Data – Demonstrate that planned component usage is within the Operational and Design life limits established by the manufacturer, including the payload's pressure system specifications and the manufacture's qualification data for the intended usage.
6. Environmental Verification – Demonstrate through required verification that the planned usage is within the qualified environment of the part, asuming that component certification encompasses the actual payload environment.
7. Ground Verification – Document proper operation of the component prior to flight by providing the following:
    a. Last ground verification date,
    b. Time duration between final ground operation and payload launch, and
    c. Expected operational duration on orbit.

Emphasis is to be given to selecting and utilizing proper pressure system control hardware. Pressure relief devices that are designed and solely identified specifically as relief valves are encouraged. Other unique engineering rationale for certification of Safe Operational Life, such as parallel ground monitoring, fleet lead testing, certification by similiarity, or in-flight verification is encouraged.

Re-certification is required when the Safe Operational Life certification for pressure system control hardware is near its expiration and the payload mission is not complete or should extended stay on orbit be a result of an unforeseen event. In this circumstance, the Payload Organization (PO) must request re-certification from the PSRP. The PO should use operational history or in-flight data to establish an environment that is less rigid than the original certification environment prior to ascertaining the new Safe Operational Life. Note that this Safe Operational Life re-certification will not extend the original specified Safe Design Life.

In addition to a re-examination of the items required for the initial certification, the following data should also be provided:

8. Re-certification Rationale – Describe nominal certification methods that cannot be performed due to limitations in environment or conditions (e.g., installation within hardware structures that limit access, or locations/conditions on-orbit that preclude removal or inspection by the crew). Provide rationale and reasoning for re-certification without nominal verification procedures (e.g., physical inspection and/or system pressure tests).
9. Operational History and Comparisons to Manufacturer's Design Life – Demonstrate that component usage was maintained within the Operational and Design life limits of the component. This should include correlations and comparisons to pressure system specifications and manufacturer's qualification data originally provided by the PO.

Acceptability of other unique engineering rationale (e.g., parallel ground monitoring, fleet lead testing, certification by similarity, or in-flight verification) for re-certification of Safe Operational Life is dependent upon its evaluation and acceptance by the PSRP.

The PSRP may request additional data from the payload organization as required to approve the re-certification. Furthermore, only the PSRP has the authority to approve this request.

The PO must provide information required to approve the Safe Operational Life recertification in an updated Flight Safety Data Package and may be subject to a Delta Flight Safety Review.

Of particular concern are pressure relief valves, since they typically have a generic requirement to have an annual retest of the pressure relief setting. These devices may have had an extensive program, established by the pressure relief valve manufacturer, that indicates that an annual retest is not necessary. Additional data may also be provided by the manufacturer dealing with pressure relief valves that have not been exercised over an extended period of time, which states that the pressure relief setting may increase by an additonal percentage of the original set pressure. These data need to be obtained and factored into the original design of the pressure system if they are to be of any significance in determining the Safe Operational Life. Pressure switches, pressure regulators and flow metering devices need to have a similar investigation as to how long the devices maintain the original funtional specifications, which will determine the Safe Operational Life. Should the Safe Operational Life not cover the anticipated payload time of operations (both the ground and flight times with some margin), then a method of repair, recalibration or corrective maintenace needs to be defined and planned into the operations planning.

Because the stored energy in pressure vessel represents one of the most hazardous components of a pressure system, demanding requirements have been placed on them such as nondestructive inspections, qualification testing, periodic inspections, counting tank pressure cycles, damage control plan, assurances of materials compatability including factors affecting stress corrrision to name a few. This listing is not all inclusive and pressure vessel documents [8], [9], and [10] need to be reviewed, understood and followed. It is believed that pressure vessels should not be the limiting item which would establish either the Safe Operating life or the Safe Design Life. Should this be the case exacting details need to be supplied to show how these pressure vessels will be safe to be placed the space station.

5.3 Electrical/Electronics Specific Discussion

Most electrical/electronics component manufactures have performed some very extensive reliability type testing of their product lines that have resulted in what is commonly called the “bathtub” curve. A bathtub curve plots failure rates (y-axis) versus time of operation (x-axis). The initial failure of components is termed the “infant mortality rate.” Items which have manufacturing and/or workmanship defects generally have a very short life and can be screened out within a very short time and limited testing. Intial failure rate is relatively high and decreases rapidly with time of operation. The lower or flat part of the bath tub curve reflects limited failures, steady failure rate and is used to determine the components’ useful life. When the bathtub curve starts to increase, the failure rate starts an increase and is considered to have reached the end of useful life or component wear out. These types of data are particularly important to the electronics industry as they set the useful life of component ratings characterists. Based on these data, the manufacture can state that, if used within these ratings or parameters, the device will operate as intended for a defined period of time. These are usually given as the voltage, current and temperature ratings or deratings for electronic componets. These data are of particular interest to the PO in establishing the Safe Operational Life of any electronic or electrical component used in a hazard control. The test data are used by the manufactures to determine if the components meet MIL Standards and are used to establish EEE parts listings. These components are considered to meet high reliabilty standards and the PO is encouraged to use them in all hazard control applications.

Other electrical components that need to be investigated are sensors. Whether these are temperature, pressure, humidity, flow, or some other parameter sensing device, they need to be checked for a useful life. For parameter sensing devices generally, it is a matter of how long or for what period of time the device will operate as intended before the device goes out of calibration resulting in erroneous indications. Most manufacturers have this kind of data on their products. For example a temperature switch or temperature sensor which is to have a set point or readout of 100º F ± 2º F may drift or change with time so that the device now reads out at 96º F ± 2º F. Should this be the case, the device will either have to be replaced with one within specification or recalibrated. Temperature switches, thermostats, relays and other cycle devices need to be addressed in terms of enough operational capability for the Safe Operational Life and Safe Design Life aspects. Once again, this is only necessary for those devices or items used in the control of hazards, i.e., used to maintain the safe status of the payload when aboard the space vehicle. As mentioned above it is good engineering practice to use MIL-STD EEE components for hazard control applications.

5.4 Unique Hazard Situations

Occasionally a very unique hazard control is in place that does not appear to fit within the Safe Operational Life determination. A classic example of this is the capturing of a hazardous substance in a filter or some other means such as a catalytic bed. This may be a planned event or the result of some other off nominal operations. Should the event be a planned event it can be embraced by the Safe Operational Life definition; however, the real time tracking of the timed event will have to be tracked via the ground operations and not relie on the flight crew to track such an event. Consequently, a plan must be in place for this and agreed to by both the safety and operations communities. The same is true for an unplanned event; however, this time would not be expected to be reflected in the Safe Operational Life. However, a plan for tracking these data will need to be in place and agreed to by the safety and operations organizations.

5.5 Fasteners

Although these devices may be considered as not having a Safe Operational Life associated with them, this may or may not be the case depending upon the application. A classic example is a door latch which is operated continually on orbit and then must be latched for the return portion of the flight. The cyclic life must then be considered and the device must have enough life or capability for the return flight. Other fasteners that require torquing may be used in safety applications and therefore need to be examined for safe life considerations. Fasteners under vibrational loading conditions including launch and landing loads should be considered as well. For example bolts used to mount motors need to have the cycle loading conditions examined for the life of the motor operation plus margin. Consideration needs to given threaded fasteners that are threaded into and removed from threaded inserts as there is a limited number of times this is allowed so as to maintain the original strength conditions.

5.6 Batteries [11]

Batteries and cells have both shelf (or calendar) life and service life. For simplicity, single cells and multi-cell packs will be described as batteries. Both parameters are dependent on the battery chemistry. Both parameters should be specified while obtaining safety certification for the cells and batteries used for each unique application. The shelf life and service life vary depending on whether the batteries are primary (non-rechargeable) or secondary (rechargeable).

The shelf or calendar life is described as the life of the battery wherein its components (internal and external) have been historically and by test proven to be stable and safe. The shelf life of batteries is affected by factors such as environment and usage. For example, high thermal environments can affect the shelf life of the batteries. Usage in environments beyond the manufacturers recommendation can cause irreversible damage to the batteries lowering their shelf life. Tab. 1 provides the shelf life for the various chemistries. The shelf life of primary batteries cannot be extended as the components of the cell are manufactured to meet only the manufacturer's stated shelf life. For rechargeable batteries, this shelf life can be extended by carrying out cycle life testing as this data will provide adequate evidence of the robustness of the cell components. This testing typically includes performing at least five charge and discharge cycles. Typically, if at least 90 % of the required performance is obtained from the batteries, the life of the battery can be extended for two years and if at least 80 % of the required performance is otained, the life can be extended for one year. At the end of this period, testing can be repeated to extend the life again and so on, until the battery is incapable of meeting the minimum performance requirements.

The service life of the battery is the performance a battery can provide in a certain application. This is also affected by factors such as environment and usage. For example, exposure to long periods of high temperatures will cause the batteries to exceed performance at the beginning of life due to the lowered internal resistance at high temperatures but will reduce their service life rapidly due to the decomposition of active materials. The service life depends on the application and the battery capacity. For a primary battery, the capacity of the batttery should be chosen to provide the required performance. For example, if a primary battery is required to power a device continually, the load on the battery and the period it is expected to provide that power should be taken into consideration to determine the size (capacity) of the battery. When obtaining battery certification, both the load as well as the period of use will have to be provided. For rechargeable batteries, apart from the capacity factor, the service life is also provided as cycle life or the number of times it can be recharged. This is dependent on the battery chemistry. For example, rechargeable Ag-Zn batteries have a maximum cycle life of 30 cycles unless specified otherwise by the battery manufacturer. Nickel metal hydrides, NiCds and Lithium-ion (liquid electrolyte systems only) have a cycle life of greater than 500 cycles. Some of these have been shown to provide thousands of cycles especially those used in portable electronic equipment. The service life of rechargeables is dependent on the minimum capacity or performance required from the battery and hence may exceed the shelf life of the battery in which case the latter can be extended as indicated in the above paragraph. Rechargeable batteries that have been safety certified will not cause safety hazards as all the controls will be in place to protect the battery in the event of unbalanced cell performances due to age.

Table. 1: Shelf life of Commonly Used Battery Chemistries

Chemistry	Shelf life
Li-BCX, Li-$SOCl_2$, Li-SO_2Cl_2, Li-SO_2, Li-MnO_2, $LiCF_x$	10 years
Li-FeS_2	15 years

Alkaline	8 years (in freezer storage); 3 years at ambient
Ag-Zn primary	30 to 45 days wet life
Li-ion (liquid), NiMH, NiCd	5 years
Li-ion (polymer)	3 years
Ag-Zn rechargeable	3 years

In summary, both shelf and service life of batteries should be provided for safety certification. The life data should be tracked and the batteries exercised or disposed of as required.

6.0 SPACE STATION PAYLOAD SAFETY CERTIFICATION TRACKING

The NASA/JSC/OZ3 Payload Engineering Integration (OZ3) Safety organization/team tracks all safety certification expiration dates for United States payloads/experiments and International Partners payloads/experiments operating in the United States On-Orbit Segment (USOS) to ensure a safe environment is maintained onboard the space station (from payloads perspective). This process is defined in [12]

The OZ3 Safety Team follows each USOS payload through the PSRP safety review process. OZ3 Safety begins collecting safety certification expiration data for a given flight/launch just prior to Stage Operations Readiness Review (SORR). Safety certification expiration dates (operational and design) are collected from the JSC Form 1114A as submitted to the PSRP ten days prior to the FRR.

OZ3 Safety enters safety certification expiration dates into the safety certification subset of the Payload Data Library (PDL), which automatically tracks these dates. The PDL generates expiration date notices (E-notice) and sends them to OZ3 Safety at appropriate times until the safety certification is renewed/extended.

Upon receipt of an E-notice for Safe Operational/Design life pending safety certification expiration, OZ3 Safety notifies the payload/experiment Payload Integration Manager (PIM) and the Payload Safety Engineer (PSE) of the expiring certification and that the payload organization must renew or extend the safety certification for either continued operations beyond the Safe Operational Life or remain on-orbit beyond the Safe Design Life expiration date. If information has not yet been submitted to the PSRP by the payload organization for renewal/extension, the PIM will remind them that the paperwork, e.g., updated Form 1114A or Form 906, must be submitted to the PSRP in a timely manner to obtain concurrence from the PSRP. OZ3 Safety will monitor the safety data submittal/review process to confirm safety certification renewal/extension is reviewed and approved by the PSRP and will update the safety certification dates (operational and/or design) in the PDL safety certification subset for continued tracking.

If the Safe Operational Life certification expires before the renewal/extension approval is obtained, OZ3 Safety will notify the Payload Operations Integration Center (POIC) Payload Operations Manager (POM) that an operations constraint will be needed for the expiring payload. This is done via an Operational Change Request (OCR) to the payload regulations for an expiring payload/experiment on the date of expiration. The operations constrainst will be deleted once renewal/extension is approved. Should an update to the Safe Operational Life not be generated and approved by the PSRP, the hardware will either be demanifested or removed from service depending upon the hardware safe state.

7.0 EXAMPLES OF SAFETY CERTIFICATION RENEWEL/EXTENSION

Over the relatively short period of space station payload operations there have already been some safety life certification renewals/extensions. At least half of the safety recertifications/extensions so far were not safety related. In addition, several POs chose not to recertify/extend at all since they were just waiting for return with no more operations intended, hence an operations constraint was placed upon them. These payloads did not correctly identify their safety certification dates, basing them instead on intended flight duration or mission success sample returns. The PSRP attempted to warn POs about choosing dates on the basis of intended on-orbit stay or mission success reasons rather than safety in case they get detained on orbit (like the Columbia tragedy), but several payloads did not heed these warnings. Although most POs are now providing more adequate safety certification dates, it is stressed how important it is to correctly identify the safety certification dates in the first place. The PSRP is investigating and questioning the accuracy of the Safe-life determination at the phased reviews; therefore there should not be any need for recertification of hardware once this process is completed.

Some of the genuine safety recertification's that have occurred include: reverification of sensors being used for environmental control/monitoring; replacement/reverification of seals used for containment of hazardous substances (after seal life expiration); relief valve reverification for pressurized container rupture control; and extension of materials compatibility. However, these recertifications should only have applications to the Operational life and not the Design life as defined in this paper.

8.0 INTERNATIONAL PARTNERS

When the International Partner Segments are assembled to the existing space station and have payloads/experiments within them, the need arises for the International Partners to organize a similar tracking system/process to track the Safe Operational Life and Safe Design Life for each payload/experiment within their segment. This would follow the same logic of the International Partners having their own programs and; therefore, track their own safety certifications similar to that performed for USOS payloads. The Space Station Program will expect feedback of this type in the future.

9.0 CONCLUSION

It is encumbent on the PO to understand the meanings of what the Safe Operational Life and Safe Design life are, as well as the on-orbit duration of a payload/experiment. And, although maintaining the safety of a payload is the responsibility of the PO, the certifications are tracked by the operations community and lapsed or inadequate safety certification could cause operatonal constraints against the payload. Therefore with some forethought on the meanings and definitons of the times called for by the JSC Form 1114A (Payload Safety Compliance), realistic values for safe operations will allow smooth station payload operations with minimal impact and updating of the safety certifications.

10.0 REFERENCES

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