“INTERIM PROCEDURE FOR TYPE APPROVAL OF 406 MHz BEACONS EQUIPPED WITH LI-ION RECHARGEABLE BATTERIES”

C/S IP (LIRB)

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COSPAS SARSAT

INTERIM PROCEDURE FOR TYPE APPROVAL OF 406 MHz BEACONS EQUIPPED WITH LI-ION RECHARGEABLE BATTERIES

The following procedure shall be used by the Cospas-Sarsat Secretariat for the review of type approval applications for 406 MHz beacons equipped with Li-Ion rechargeable batteries

1. DEFINITIONS APPLICABLE TO RECHARGEABLE BATTERIES

1.1 Beacon Modes

1.1.1 Beacon Storage Mode: No circuits are powered by the primary battery[1].

1.1.2 Beacon Stand-By Mode: The beacon 406 MHz transmitter and other ancillary devices are not activated; automatic internal checks are performed from time to time by the beacon resulting in a current drain from the primary battery.

1.1.3 Beacon Self Test Mode: Some beacon circuits are powered during the self test of the beacon, which results in specific power drain from the primary battery.

1.1.4 Beacon Active Mode: The 406 MHz transmitter is active and/or other ancillary devices powered by the primary battery are active.

1.2 Time Between Recommended Charges (TBRC)

The Time Between Recommended Charges (TBRC) is the time recommended by the beacon manufacturer between battery recharges when the beacon is in stand-by mode. The TBRC determined by the manufacturer must take into account the power drain which would result from recommended periodic self tests during TBRC. The TBRC must be clearly indicated on the beacon.

1.3 Worst Case Life Time (WCLT)

In a worst case configuration, the user might not recharge[2] the battery after the initial full charge.

In this configuration, the "Worst Case Life Time" (WCLT) is the time in beacon stand-by mode when the available capacity remains greater or equal to the capacity required to meet the declared operating life time at minimum temperature.

The Worst Case Life-Time is determined by the beacon manufacturer. The WCLT definition assumes no irreversible losses due to beacon storage prior to the first battery charge that initiates the beacon stand-by mode. The definition also assumes that no self tests are performed during WCLT. If self tests are recommended by the manufacturer during TBRC, separate from the recharge process, the corresponding current drain would also have to be considered for the determination of WCLT.

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1 The primary battery is the battery which is powering the 406 MHz function

2 It is assumed that the initial charge of the battery has been done by the user in accordance with the user manual procedure.

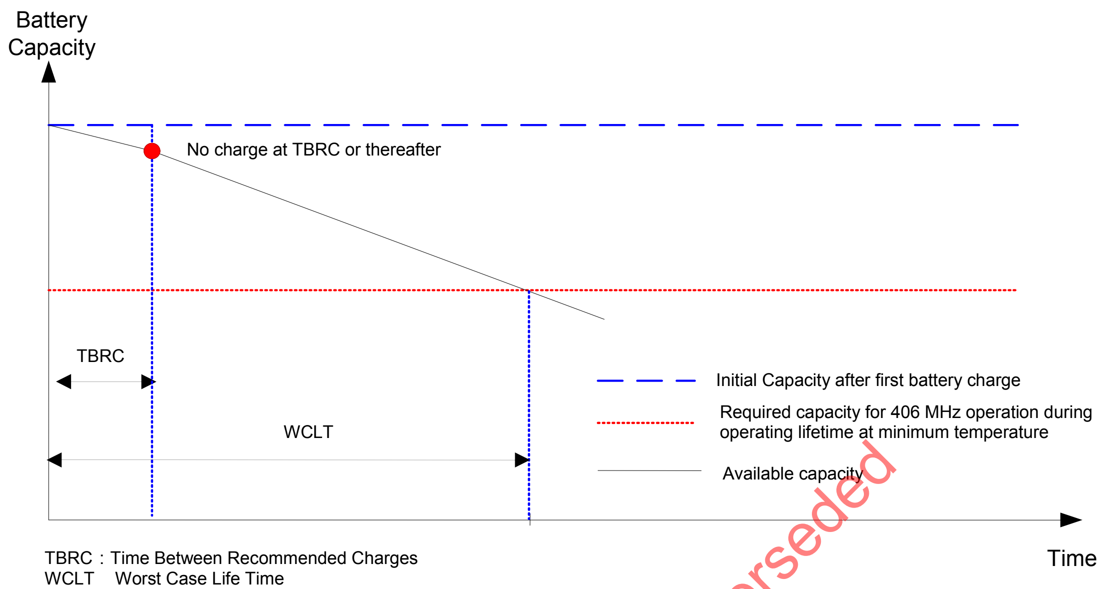

Figure 1: Illustration of Battery Capacity and Worst Case Life Time

1.4 Battery Replacement Life Time

The Battery Replacement Life Time is determined by the beacon manufacturer from the sum of the following losses and current drains:

a) irreversible capacity loss over the replacement life time and maximum storage time (including the 1.65 safety factor),

b) reversible capacity loss during TBRC (including the 1.65 safety factor),

c) average current drain resulting from constant operation of the beacon circuits in stand-by mode,

d) current drain from any device powered by the beacon battery prior to beacon activation, during TBRC (including the 1.65 safety factor), and

e) current drain due to maximum number of self tests carried out during TBRC as recommended by the beacon manufacturer.

The battery replacement life time assumes a maximum two year storage time (battery storage and beacon storage mode) prior to the first charge of the new battery by the end-user

1.5 Battery Replacement Date:

The battery replacement date is the date at which the rechargeable battery installed in the beacon must be replaced. The battery replacement date shall be clearly indicated on the beacon together with the TBRC. The replacement date is determined by the beacon manufacturer using:

- the date the batch of new batteries was manufactured,
- a maximum two year storage time,

- the specific battery replacement life time determined by the manufacturer for the beacon model.

Replacement Date = Date of Manufacture + 2-Year Storage + Battery Replacement Life Time

On the battery replacement date, the beacon shall meet the declared operating life time at minimum temperature.

1.6 Maximum Storage Time

The maximum storage time includes the battery storage time prior to its installation in the beacon and the beacon storage time before the first full charge of the battery assumed to be performed by the end user after purchasing the beacon.

A maximum storage time of two year shall be used for the determination of the battery replacement time.

2. MODIFICATIONS TO THE STANDARD C/S T.007 PROCEDURE FOR TESTING BEACONS WITH RECHARGEABLE BATTERIES[1]

Changes to Section 4.4

g. a qualitative performance test through the satellites.

At the discretion of the test authority, the manufacturer may be required to replace *or recharge* the batteries between these phases. However, no other modifications to the beacon will be allowed during the test period without a full re-test.

Changes to Section 5

Section 5 (a)

i. the list of operational configurations supported,

ii. details of the beacon battery cells and battery pack,

iii. details on the special features of the beacon (e.g. homer, strobe light, etc),

iv. information on the beacon navigation system where appropriate (i.e. navigation device manufacturer, navigation interface specifications, etc.),

v. a description of the beacon self-test characteristics and if applicable, the description of the GNSS self test mode and characteristics;

vi. for beacons using rechargeable batteries, Time Between Recommended Charges (TBRC), Battery Replacement Life Time assuming a two-year maximum storage time, and Worst Case Life Time (WCLT).

Section 5 (g)

[1] Additions to existing text in document C/S T.007, Issue 4 - Revision 3 are shown in *italic* fonts and deletions are shown with ~~strike-out~~ fonts.

g. the technical data sheet for the battery cells used in the beacon and the electric diagram of the beacon's battery pack, *and for beacons using rechargeable batteries the specific information required at Annex G*;

Changes to Section 6.2

6.2 Changes to Type Approved Beacons

The manufacturer must advise the Cospas-Sarsat Secretariat (see Annex H) of any changes to the design or production of the beacon*,* ~~or~~ power source *or charger for beacons using rechargeable batteries,* which might affect beacon electrical performance.

Changes to Section A.2.3

A.2.3 Operating Lifetime at Minimum Temperature (test no. 10 in Table F.1)

The beacon under test is operated at its minimum operating temperature for its ~~rated life~~ *operating life time [e.g. 24 or 48 hours]*. During this period, the following parameters are measured on each transmission:

a. transmitted frequency, per section A.3.2.1;

b. transmitter power output, per section A.3.2.2.1; and

c. digital message, per section A.3.1.4.

The 18-sample analysis window of the stability calculations is advanced in time through the period such that each succeeding data set includes the latest frequency sample and drops the earliest one.

If beacon is intended to be encoded with short or long format messages, this test shall be performed with a long format message. If the beacon includes an internal GNSS receiver, this test shall be performed in an environment that ensures that the GNSS receiver draws the maximum energy from the battery (e.g. ensuring that any GNSS receiver sleep time is minimised over the test duration).

The operational lifetime test is intended to establish, with reasonable confidence that the beacon will function at its minimum operating temperature for its ~~rated life~~ *operating life time* using a battery that has reached its expiration date[1]. To accomplish this, the lifetime test of a beacon with its circuits powered from the beacon battery prior to beacon activation shall be performed with a fresh battery pack which has been discharged to take into account:

[1] The beacon manufacturer shall provide data necessary to discharge a fresh battery pack at room temperature to account for current drain over the battery pack rated life time. The battery discharge figures provided by the beacon manufacturer shall be verified by the testing laboratory with measurement results reported in Table F - E.1.

i. *for non-rechargeable batteries* the depletion in battery power resulting from normal battery loss of energy due to battery ageing over the rated life of the battery pack;

ii. *the reversible and irreversible losses*[1] *of battery capacity for beacons using rechargeable batteries;*

ii*i*. the average current drain resulting from constant operation of the circuits powered from the beacon battery prior to beacon activation over the rated life of the *non rechargeable* battery pack *or, for rechargeable batteries, over the Time Between Recommended Charges (TBRC);*

~~ii~~i*v*. the number of self-tests, as recommended by the beacon manufacturer and, when the function is included, the maximum number and maximum duration of GNSS self-test transmissions, over the rated life of the battery pack (the beacon manufacturer shall substantiate the method(s) used to determine the corresponding current drain(s)); and

~~i~~v. a correction coefficient of 1.65 applied to item (ii*i*.) and item (~~ii~~i*v*) to account for differences between battery to battery, beacon to beacon and the possibility of exceeding the battery replacement time.

vi. *a correction coefficient of 1.65 applied to item (ii) to account for differences from battery to battery and the possibility of not recharging the battery at the required time.*

Changes to Section A.3.6

A.3.6 Self-test Mode

The manufacturer shall provide a list of the parameters that are monitored in the self-test mode (see Annex G). If a GNSS self-test is also provided for, this shall be noted and any additional parameters included.

Self-test operation shall not cause any operational mode transmissions.

The duration of the 406 MHz burst shall be measured, the frame synchronization pattern shall be checked and, if applicable, the encoded location checked for correct default code. In addition, if a GNSS self-test mode is provided, the encoded location shall be checked against the known location to the accuracy defined in C/S T.001 paragraph 4.5.5.3 for the applicable protocols. The format flag bit shall be reported. The self-test mode(s) shall be tested to verify that any transmission is limited to one self-test burst only. If a GNSS self-test is provided for, it shall be verified that inadvertent activation of this mode is precluded. The GNSS self-test mode shall be tested to verify that it is limited in duration (all location protocol beacons) and number of GNSS self-test transmissions (beacons with internal navigation devices only).

1 The terms are defined in section A.3.9.1

For beacons using a rechargeable battery, the battery status should be tested. If the battery is not in "normal battery mode" as defined in section A.3.9.1, the self test result should be FAILED.

Design data shall be provided on protection against repetitive self-test mode transmissions.

New Section A.3.9

A.3.9 Rechargeable batteries

A.3.9.1 Definitions

A.3.9.1.1 Normal Battery Mode

The beacon manufacturer shall state the Time Between Recommended Charges (TBRC). The beacon shall automatically check the battery condition at defined intervals ($T_{wake\text{-}up}$), which shall not be longer than one fourth of TBRC. At the end of each $T_{wake\text{-}up}$ interval, the beacon shall check the time since the last charge and the battery condition.

- *If the time since the last charge is less than TBRC and if the battery condition is good, the battery is considered to be in "Normal Battery Mode" and the beacon may go back to stand-by mode until the end of the next $T_{wake\text{-}up}$ interval.*
- *If the above conditions are not fulfilled, the user shall be warned that the battery must be recharged (see section A.3.9.2).*

A.3.9.1.2 Irreversible Capacity Loss

The irreversible capacity loss is the loss of the battery capacity which cannot be recovered by subsequent recharges of the battery. There are two components to the total irreversible capacity loss: (i) during battery and beacon storage and (ii) during the battery replacement life time while the beacon is in stand-by mode.

A.3.9.1.3 Reversible Capacity Loss

The reversible capacity loss is the loss of the battery capacity which can be recovered by subsequent recharges of the battery. This reversible capacity loss is also known as "self discharge".

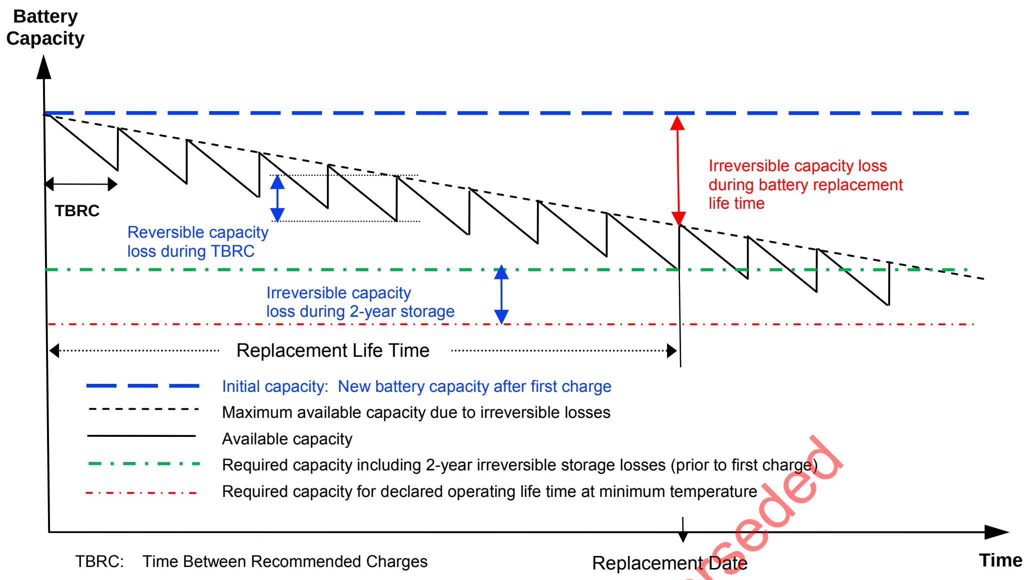

Figure 2: Determination of Battery Replacement Life Time

A.3.9.1.4 Determination of the Battery Replacement Life Time

Figure 2 illustrates the determination of the battery replacement life time. The diagram of available battery capacity assumes that, initially, the new battery installed in the beacon is fully charged and is not affected by any irreversible storage loss. To take irreversible storage losses into consideration, the battery capacity required to meet the specified performance during the declared operating life time at minimum temperature is augmented by the irreversible storage loss assuming a maximum two year storage time (battery storage and beacon storage mode).

The operating life time at minimum temperature performance of the beacon on the battery replacement date shall be verified using the procedure described in section A.2.3 of the document C/S T.007.

A.3.9.2 Charge Indication

Beacons using rechargeable batteries shall provide a clear indication when the battery has to be recharged. This should be made either by visual (e.g. led, display) and/or audio indicator (e.g. buzzer). Beacon manufacturers may choose to indicate:

a) either that the battery is in "normal battery mode" (for example by activating a green LED);

b) or that the battery is no more in "normal battery mode" (for example by flashing a red LED)

The charge indication shall be shown on the beacon and shall be fully documented in the user manual.

A.3.9.3 Measurement of the Remaining Battery Capacity at the Replacement Date

A.3.9.3.1 Battery Capacity Measurement

The capacity of the battery can be defined as $C = \int_{t_1}^{t_2} I(t).dt$

The measurement of the battery capacity shall be made using the following procedure:

- *a complete charge process is made on the battery (at time t_1 in Figure 3 the battery is fully charged);*
- *a discharge of the battery is made using a well known resistor $R_{discharge}$ until the battery is fully discharged, the voltage goes down to zero*[1] *(at time t_2 in Figure 3 the battery is "empty"); and*
- *the voltage is monitored every δt.*

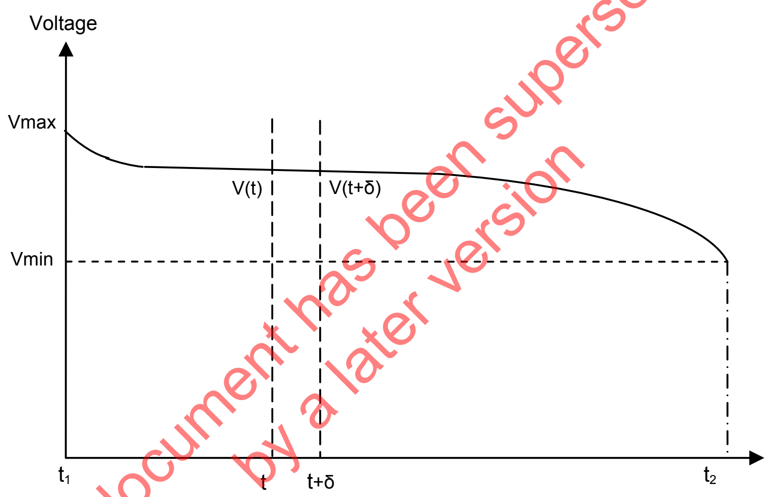

Figure 3: Battery Capacity Measurement Procedure

The capacity is calculated as follows:

$$C = \int_{Fully \cdot charged}^{Empty \cdot Battery} I(t).dt = \frac{1}{R_{discharge}} \sum_{t_1}^{t_2} \left(\frac{V(t+\delta t)+V(t)}{2} .\delta t \right)$$

$R_{discharge}$ is chosen in order to provide an equivalent discharge current equal to the maximum charge current of the charger when the battery is at its maximum (i.e. fully charged at Vmax in Figure 3 above).[2]

The value of the resistor $R_{discharge}$ has to be known to an accuracy better than 1%.

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1 In most cases, the battery is not really fully discharged but an internal protection switch (inside PCM: protection circuit modules) is activated when the voltage is below V_{min} (usually 2,5V) to avoid deep discharge of the battery not recommended for Li-Ion technology. This protection is usually deactivated by a charge process. This PCM is also used to protect against overcharge and short-circuits.

2 For example, most of Li-Ion cells are to be charged at 4,2V. So if the battery is 2000mAH, and if the maximum charge current is C/5=2000/5=400mA, R is 4.2/0.4=10.5 Ohms.

A.3.9.3.2 Measurement of Reversible Capacity Loss at Room Temperature

The measurement is performed by the beacon manufacturer. In this section, when a battery is recharged, the charger to be used shall be as described in section A.3.9.6.

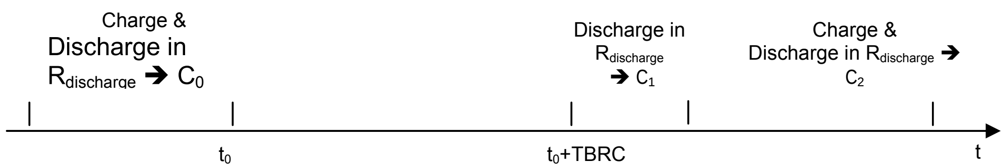

Figure 4: Time Line for Capacity Loss Measurements during TBRC

The measurement is performed using a batch of 10 batteries. The batteries shall be initially fully charged ($V_{charge\_final} = V_{max}$). The first capacity measurement shall be made at room temperature at time t_o on each battery of the batch (as detailed in section A.3.9.3.1). The average C_{0_mean} is then calculated.

The batteries are then fully recharged, disconnected and left unconnected during TBRC.

At t_0+TBRC, a voltage measurement is made on each battery to provide the battery voltage after TBRC. The average $V_{partial\_discharge\_mean}$ is calculated[1]*.*

A second capacity[2] *measurement is made on each battery at room temperature at t_0 + TBRC. The average $C_{1\_mean\_TBRC}$ is calculated.*

After the capacity measurement at t_0+TBRC, a complete recharge of all batteries is performed. A third capacity measurement is made on each battery at room temperature and the average $C_{2\_mean\_TBRC}$ is calculated.

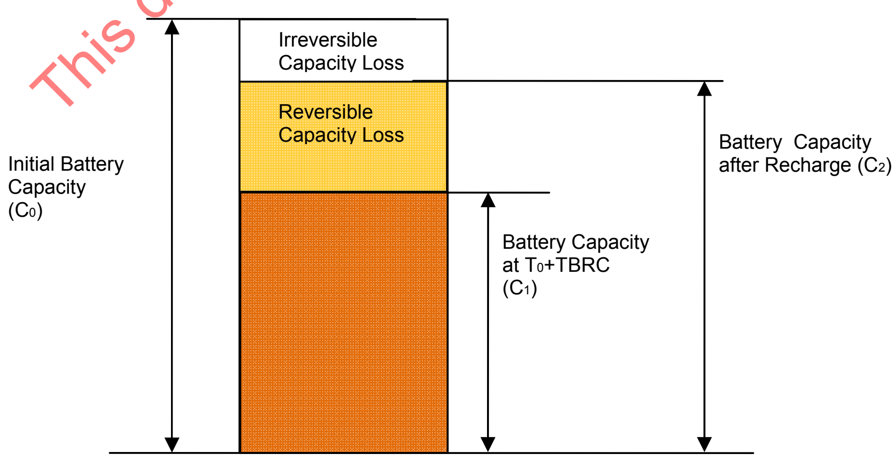

Figure 5: Illustration of Battery Capacity and Losses

1 *This information is important to take into account the impact of multiple charge-discharge processes on irreversible capacity losses as described in section A.3.9.3.3(ii).*

2 *The second capacity measurement is made before performing any recharge.*

The reversible battery capacity loss during TBRC (after the first recharges) is then:

$$C_{reversible\_loss} = C_{2\_mean\_TBRC} - C_{1\_mean\_TBRC}$$

The irreversible battery capacity loss during TBRC is also calculated as follow:

$$C_{irreversible\_losses\_during\_TBRC} = C_{0\_mean\_TBRC} - C_{2\_mean\_TBRC.}$$

A.3.9.3.3 Evaluation of Irreversible Capacity Losses: Accelerated Aging

This evaluation is performed by the beacon manufacturer.

The Arrhenius equation states that the dependence of the rate constant k of chemical reactions to the temperature T (in Kelvin) and activation energy Ea is given by the following equation:

$$k = A \cdot e^{-\frac{E_a}{RT}}$$

Where: k : rate of capacity fade
A : pre exponential factor
Ea : activation energy (in kCal • mol^{-1})
R: gas constant (in kCal • mol^{-1} • K^{-1})
T: temperature (in Kelvin)

For the Li-Ion reaction, Ea is 15 kCal • mol-1, the gas constant R is 1.987 kCal • mol-1 • K-1.

The Arrhenius law indicates that an accelerated equivalent aging of the battery capacity can be achieved by placing the battery at a higher temperature than the assumed ambient temperature of 25°C. The beacon manufacturer can use one of the following temperatures to achieve reduced equivalent test times:

- *42°C → corresponding to a test time divided by 4 compared to 25°C*
- *50°C → corresponding to a test time divided by 7.3 compared to 25°C*

The selected test temperature shall correspond to a test period greater than 6 months.

(i) <u>Estimation of Irreversible Capacity Loss during Storage</u>

This test is performed using a batch of 10 new batteries. These batteries are to be supplied by the battery manufacturer as they will be supplied in production (i.e. most of the time they will not be fully charged).

At time t_0, C_0 capacity measurements are made at room temperature on a set of five batteries using the procedure described in 3.9.3.1. These five batteries are not used for the remainder of the test. The average C_{0_mean} is calculated from the measurements obtained for these five batteries.

The other set of five batteries is left unconnected and not charged. The batteries are placed in a climatic chamber at the selected temperature during the test period equivalent to the maximum storage period at ambient temperature, as described above in section 3.9.3.3. The batteries are then removed from the climatic chamber.

A complete charge is performed on these batteries and capacity measurements are made on all five batteries at room temperature to provide the average $C_{2\_mean\_storage}$.

The irreversible capacity loss due to storage is calculated as follow:

$$C_{irreversible\_loss\_in\_storage} = C_{0\_mean} - C_{2\_mean\_storage}$$

(ii) Estimation of Irreversible Capacity Loss During Beacon Stand-by Mode

This test is performed using a batch of 10 new batteries, as supplied by the manufacturer.

At time t_0, C_0 capacity measurements are made at room temperature on a set of five batteries using the procedure described in 3.9.3.1. These five batteries are not used for the remainder of the test. The average C_{0_mean} is calculated from the measurements obtained for these five batteries.

The other set of five batteries is charged and placed in a climatic chamber at the selected temperature for the test period equivalent to the battery replacement life time at ambient temperature, as described above in section 3.9.3.3.

At time $t_{0\ +}$ test period, the five batteries are taken out from the climatic chamber. To take into account the aging linked to the repetitive charge-discharge process, N successive charge-discharge cycles are performed as follows.

The charge process is made using the charger as described in section A.3.9.6 and the discharge process is made from V_{charge_final} [1] to $V_{partial\_discharge\_mean}$ in $R_{discharge}$ [2]. This step is repeated N times on all five batteries, with N defined as the ratio: Battery Replacement Life Time / TBRC, rounded down to the nearest integer.

Finally a charge process is applied on all five batteries and new capacity measurements C_2 are made. The average $C_{2\_mean\_Stand\text{-}by}$ is calculated.

The irreversible capacity loss in stand-by mode during the battery replacement life time, including the partial discharge/recharge cycles applied in beacon stand-by mode, is calculated as follow:

$$C_{irreversible\_loss\_in\_Stand\text{-}by\_mode} = C_{0\_mean} - C_{2\_mean\_Stand\text{-}by}$$

[1] See definitions in A.3.9.6.2 and Figure 7. V_{charge_final} = battery voltage at end-of-charge.

[2] *See definitions in section A.3.9.3.2*

(iii) Estimation of Total Irreversible Losses

The total irreversible losses, which include storage loss and loss during normal mode, are:

$$C_{irreversible\_losses} = C_{irreversible\_loss\_in\_storage} + C_{irreversible\_loss\_in\_Stand\text{-}by\_mode}$$

An additional safety factor of 1.65 is to be applied to this value when performing the operating life time at minimum temperature test per section A.2.3.

A.3.9.4 Verification of Reversible and Irreversible Capacity Losses

In order to partially verify the results provided by the beacon manufacturer, the following measurements shall be performed at a Cospas-Sarsat accepted test laboratory.

The measurements are performed on a batch of 5 batteries. The batteries are initially fully charged. At time t_0, the first capacity measurement is made at room temperature on each battery of the batch. The average $C_{0\_mean\_lab}$ is calculated.

The batteries are recharged, disconnected and left unconnected during TBRC.

At t_0 + TBRC, a second capacity measurement is made at room temperature. The average $C_{1\_mean\_lab}$ is provided. After this capacity measurement, the batteries are recharged. A third capacity measurement is then made at room temperature. The average $C_{2\_mean\_lab}$ is calculated.

The following battery capacity losses are derived from the above measurements:

(i) Reversible loss between successive charges = $C_{2\_mean\_lab} - C_{1\_mean\_lab}$

This value has to be compared with $C_{reversible\_losses}$ provided by the beacon manufacturer as described in section A.3.9.3.2. The difference between the values obtained by the laboratory and the manufacturer shall be less than ±10%

(ii) Irreversible loss after TBRC = $C_{0\_mean\_lab} - C_{2\_mean\_lab}$

This value has to be compared with $C_{irreversible\_losses\_during\_TBRC}$ provided by the beacon manufacturer as described in section A.3.9.3.2. The difference between the values obtained by the laboratory and the manufacturer shall be less than ±10%

A.3.9.5 Verification of Worst Case Life Time

This test is performed by the beacon manufacturer using two 2 complete beacons.

At t_0, the batteries of the beacons are charged. After the charge, the beacons in stand-by mode are placed in a climatic chamber at a specific temperature (either 42°C or 50°C) for a duration equivalent to the declared Worst Case Life Time at ambient temperature. This equivalent Worst Case Life Time duration is the Worst Case Life Time divided by 4 at 42°C and by 7.3 at 50°C.

At the end of the test period the beacons are removed and kept at ambient temperature for at least 2 hours. Then the beacons are put in a climatic chamber at their minimum operating temperature and, after at least 2 hours, the beacons are turned on. An operating life time test at minimum temperature is then carried out on both beacons as described in section A.2.3, but without any further pre-conditioning of the battery. If the operating life-time test is successful for both beacons (i.e. the beacons meet Cospas-Sarsat requirements for the declared operating lifetime at minimum temperature), the declared Worst Case Life Time is deemed to be confirmed by the test.

A.3.9.6 Battery Charger

A.3.9.6.1 Charger Information

The electric diagram of the charger shall be provided and the charge process shall be described. For CCCV (Constant Current and Constant Voltage) charge, the following information shall be provided:

a) charge current during constant current phase (this value could be provided as a function of the battery capacity[1]),

b) charge voltage and tolerance during constant voltage phase (for example 4,2V for most Li-Ion cells),

c) current limit below which the charging process is ended,

d) estimated time to fully recharge a battery, and

e) confirmation that the charger is compliant with national safety/EMC requirements.

A.3.9.6.2 Charger Test Procedure for CCCV Charge Process

These tests can be made by the beacon manufacturer and verified by a test laboratory accepted by Cospas-Sarsat.

a) Test set-up

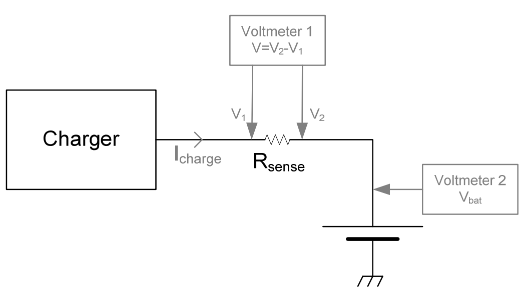

Figure 6: Diagram of Beacon charger Test Set-up

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[1] For example, for a 2000 mAh battery, a charge at C/5 would mean a charge current of 2000/5=400 mA.

Two voltmeters are necessary, one for differential measurement (image of the charge current), the second for monitoring the voltage of the battery.

$$I_{charge} = \frac{V_2 - V_1}{R_{sense}}$$

R_{sense}*=0.1 Ohms (with accuracy lower or equal to 1%)*

b) Test result

In a first step, the battery has to be fully discharged in a defined resistor as described in section A.3.9.3.1. The battery is then charged and I_{charge} *and* V_{charge} *are monitored.*

At least 50 values (I_{charge} *and* V_{charge}*) are to be provided and the time between two measurements shall not be longer than 1 minute.*

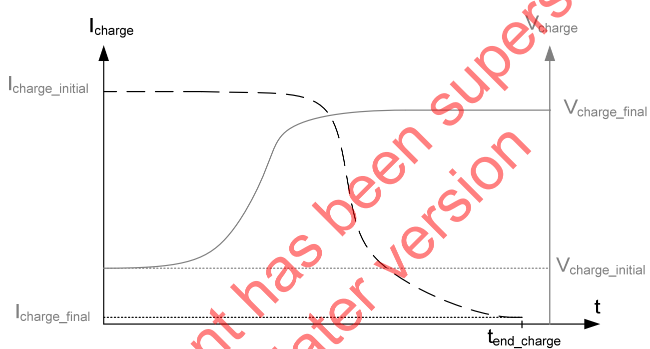

Figure 7: Voltage and Current Intensity Measurements during Battery Charge

The charge applied to the battery shall then be calculated. The applied charge shall be equal or greater than the battery capacity measured in section A.3.9.3.1.

A.3.9.7 Interaction between Charge Process and Self Test

A self test should be automatically started after each charge process. This would generate a self test at least every TBRC.

The battery mode should be tested as described in section A.3.6, during the self test. If the battery is not in normal mode, the self test result is FAILED.

A.3.9.8 Data to be Provided by Beacon Manufacturers

All information specific to the use of rechargeable batteries is documented at Annex G.1

Changes to Annex G

Beacon Characteristics (for rechargeable batteries)

Characteristic	**Specification**
Operating temperature range	Tmin =___ Tmax=___
Operating lifetime	_______Hours
Battery chemistry	
Battery cell model name, size and number of cells	
Battery cell manufacturer	
Battery pack manufacturer and part number	
Initial capacity of new battery after first charge	*___mAh*
Required capacity to meet the operating life time at minimum temperature	*___mAh*
Battery replacement life time	*___Months______Years*
Charge indication	☐ *Visual* / ☐*Audio* ☐ *In Normal Mode* / ☐*Not in Normal mode* *Type :*
Time Between Recommended Charges (TBRC)	*___Months*
$T_{wake-up}$ *(wake-up period to check battery)*	*___Days*
$R_{discharge}$ *(resistor for discharge process)*	___Ω
Reversible losses between TBRC: $C_{reversible\_losses}$	*___%*
Voltage drop after TBRC: $V_{partial\_discharge\_mean}$	*___V*
Irreversible losses during TBRC: $C_{irreversible\_losses\_between\_TBRC}$	*___%*
Test temperature (if applicable) for measurement of irreversible capacity loss during storage	☐ *42°C* / ☐ *50°C*
Worst Case Life Time (WCLT)	*___Months - ____Years*
Irreversible losses in two-year storage: $C_{irreversible\_loss\_in\_storage}$	*___%*
Test temperature (if applicable) for measurement of irreversible capacity loss in stand-by mode	☐ *42°C* / ☐ *50°C*

Characteristic	Specification
Irreversible losses in stand-by mode: $C_{irreversible\_loss\_in\_stand\text{-}by\_mode}$	*___%*
Measured operating life time in Worst Case Life Time configuration	*___Hours*
Battery Charger	
$I_{charge\_initial}$	*___mA*
I_{charge_final}	*___mA*
$V_{charge\_initial}$	*___V*
V_{charge_final}	*___V*
Charge time : t_{end_charge}	*___Mn*
Charge capacity	*___mAh*
Oscillator type (e.g. OCXO, MCXO, TCXO) …	

[…]

Characteristic	Specification	
Self-Test Mode Characteristics:	Self-Test Mode	Optional GNSS Self-Test Mode
[…]		
- Maximum number of GNSS Self Tests (beacons with internal navigation devices only)	N/A	
- Self-test automatically activated after each charge process (for beacon using rechargeable batteries)		

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