INTERIM PROCEDURE FOR THE DETERMINATION OF COMPLIANCE OF 406 MHz BEACONS EQUIPPED WITH A TCXO WITH COSPAS-SARSAT TYPE APPROVAL REQUIREMENTS
C/S IP (TCXO) - Revision 2
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The following procedure is to be used for the purpose of determining the compliance of beacons equipped with a TCXO with the Cospas-Sarsat requirements concerning the beacon medium-term frequency stability (i.e. the slope and residual component). This procedure takes into consideration the compounded effects of the variation of performance between TCXO devices and their potential ageing. It is assumed that both the TCXO and the beacon design contribute to the overall medium-term frequency stability performance of the beacon.

1. Residual Component of the Medium-Term Frequency Stability

Requirements:

a) The residual component of the medium-term frequency stability measured during the temperature gradient test corresponding to the appropriate class of the beacon shall be provided by the manufacturer for the specific oscillator used in the tested beacon prototype.

b) As part of the quality assurance plan, the beacon manufacturer shall provide assurances that all TCXOs used for the production of the beacon model will exhibit a residual component of the medium-term frequency stability no greater than 2.0 ppb, as measured during a temperature gradient test corresponding to the appropriate class of beacon.

The contribution of the beacon design is determined by removing the contribution of the oscillator (on a root-mean-square basis) from the measurement of the beacon medium-term frequency stability residual component provided by the testing laboratory per the following equation:

$$R_{beacon} = \sqrt{R_{tot}^2 - R_{osc}^2}$$

Where: R_{tot} is the value of the residual measured during Cospas-Sarsat type approval testing at a given point of the temperature gradient profile, and

R_{osc} is the value provided for the specific oscillator in the beacon prototype at the same point of the temperature gradient profile.

The calculation of R_{beacon} shall be made for every matched data pair in order to find the worst case R_{beacon_wc} . R_{beacon_wc} is observed when ($R_{tot}^2 - R_{osc}^2$) reaches its maximum. Beacon manufacturers and the beacon test laboratory shall provide the oscillator (R_{osc}) and the beacon (R_{tot}) performance characteristics in tabulated electronic format (e.g. MS Excel spreadsheet) with data points taken at least once every minute over the temperature gradient test. The test laboratory shall combine and synchronise the data sets in each phase of the temperature gradient profile to match data points.

Note: If R_{osc} is greater than R_{tot}, then allowance may be made for measurement inaccuracies by adding/subtracting the measurement uncertainty contained within document C/S T.008 from R_{tot} and R_{osc} as appropriate.

For example: If the values obtained for R_{tot} = 1.2 ppb and R_{osc} = 1.3 ppb, the C/S T.008 tolerance of ±0.1ppb would in this case be added to R_{tot} and subtracted from R_{osc}, giving new values for R_{tot}= 1.3 ppb and R_{osc} = 1.2 ppb. The interim MTS calculations would then be applied to the revised figures to determine R_{beacon}.

The maximum expected beacon residual component performance is then recalculated by adding the maximum oscillator contribution (i.e. 2.0 ppb) as follows:

$$R_{beacon\_max} = \sqrt{R_{beacon\_wc}^{2} + R_{osc\_max}^{2}}$$

Where: R_{beacon_wc} is the worst case value previously determined for the beacon contribution, and
R_{osc_max} is the maximum oscillator contribution (2.0 ppb).

The performance after five years is estimated by adding an ageing contribution (0.2 ppb). The final value obtained shall be less than the Cospas-Sarsat requirement for the medium-term frequency stability residual (i.e. 3.0 ppb):

$$R_{beacon\_5\_year\_max} = R_{beacon\_max} + 0.2\text{ ppb} \leq 3.0\text{ ppb}$$

2. Positive and Negative Slopes

A similar procedure is used for the evaluation of the positive and negative slopes of the medium-term frequency stability. Criteria for selection of the worst case points and formulas for calculation of the beacon worst case mean slope contributions are presented in the table below:

Beacon mean slope sense	Worst case selection criteria	Sl_{tot} and Sl_{osc} Values	Worst case beacon contribution Sl_{beacon_wc}=
Positive	$(Sl_{tot} - Sl_{osc})$ =>MAX	$Sl_{tot} > Sl_{osc}$, $Sl_{tot} > 0$, $Sl_{osc} > 0$	$SQRT(Sl_{tot}^2 - Sl_{osc}^2)$
		$Sl_{tot} > Sl_{osc}$, $Sl_{tot} > 0$, $Sl_{osc} < 0$	$SQRT(Sl_{tot}^2 + Sl_{osc}^2)$
		$Sl_{tot} > Sl_{osc}$, $Sl_{tot} < 0$, $Sl_{osc} < 0$	$SQRT(Sl_{osc}^2 - Sl_{tot}^2)$
Negative	$(Sl_{tot} - Sl_{osc})$ =>MIN	$Sl_{tot} < Sl_{osc}$, $Sl_{tot} < 0$, $Sl_{osc} < 0$	$- SQRT(Sl_{tot}^2 - Sl_{osc}^2)$
		$Sl_{tot} < Sl_{osc}$, $Sl_{tot} < 0$, $Sl_{osc} > 0$	$- SQRT(Sl_{tot}^2 + Sl_{osc}^2)$
		$Sl_{tot} < Sl_{osc}$, $Sl_{tot} > 0$, $Sl_{osc} > 0$	$- SQRT(Sl_{osc}^2 - Sl_{tot}^2)$

For each slope the procedure is repeated for the steady state temperature and temperature change portions of the temperature gradient test, as defined in paragraph A.2.4 of document C/S T.007, using the following limits:

- For the positive slope measured during the steady state temperature portion of the temperature gradient test, the maximum contribution of the oscillator shall be 0.7 ppb/min[(1)]. The Cospas-Sarsat performance requirement is 1.0 ppb/min.

- For the positive slope measured during the temperature change portion of the temperature gradient test, the maximum contribution of the oscillator shall be 1.7 ppb/min[(1)]. The Cospas-Sarsat performance requirement is 2.0 ppb/min.

- For the negative slope measured during the steady state temperature portion of the temperature gradient test, the maximum contribution of the oscillator shall be -0.7 ppb/min[(1)]. The Cospas-Sarsat requirement is -1.0 ppb/min.

- For the negative slope measured during the temperature change portion of the temperature gradient test, the maximum contribution of the oscillator shall be -1.7 ppb/min[(1)]. The Cospas-Sarsat requirement is -2.0 ppb/min.

No ageing factors are to be applied for the calculations of the negative and positive slopes.

3. Fast Track Approach

As described above, determination of the worst case beacon components requires matching and synchronisation of MTS results from a test facility and the TCXO manufacturer, point-by-point calculations and search for the extreme (i.e. minimum and maximum) values. This process is generally applicable to all beacons. However, the MTS analysis can be significantly facilitated for beacons with good medium term frequency stability characteristics. For such beacons, the Fast Track Approach (FTA) described below could be used.

If the results of FTA check remain within the residual frequency variation and mean slope limits, no point-to-point analysis is required for the determination of the worst case points of the MTS. However, a point-to point analysis is needed for beacons that fail this FTA check.

3.1 Residual Frequency Variation

For the FTA check of the residual frequency variation, the worst case situation is to assume that the oscillator component is negligible, i.e. $R_{osc} = 0$. For this case, the worst case beacon component (R_{bcn_wc}) would be equal to the maximum residual value (R_{tot_max}) measured at the test facility:

$R_{bcn\_wc} = SQRT\ (R_{tot\_max}^2 - R_{osc}^2) = R_{tot\_max}$, and

$R_{beacon\_max} = SQRT\ (R_{tot\_max}^2 + R_{osc\_max}^2)$.

(1) Values provided by TCXO manufacturer in an email to the Secretariat on 23 June 2008.

If $R_{beacon\_5\_year\_max} = R_{beacon\_max} + 0.2$ ppb ≤ 3.0 ppb, the FTA check is considered to be passed and there is no need to perform point-by-point analysis for the residual frequency variation.

3.2 Positive Mean Slope

For the FTA check of the positive mean slope, the absolute worst case is assumed to occur when the maximum value of positive slope measured at the test facility ($Sl_{(+)tot\_max}$) is placed against the minimum value of negative slope determined by the TCXO manufacturer ($Sl_{(-)osc\_min}$), at any time during the test phase considered:

$$Sl_{(+)beacon\_max} = SQRT(Sl_{(+)tot\_max}^{2} + Sl_{(-)osc\_min}^{2}).$$

If $Sl_{(+)beacon\_max} \leq 1.0$ ppb/min (for static slope) or $Sl_{(+)beacon\_max} \leq 2.0$ ppb/min (for gradient slope), the FTA check is considered to be passed and there is no need to perform a point-by-point analysis for the positive mean slope. The FTA check shall be repeated for static and gradient slopes.

3.3 Negative Mean Slope

For the FTA check of the negative mean slope, the absolute worst case is assumed to occur when the minimum value of negative slope measured at the test facility ($Sl_{(-)tot\_min}$) is placed against the maximum value of positive slope determined by the TCXO manufacturer ($Sl_{(+)osc\_max}$), at any time during the test phase considered:

$$Sl_{(-)beacon\_min} = -SQRT(Sl_{(-)tot\_min}^{2} + Sl_{(+)osc\_max}^{2}).$$

If $Sl_{(-)beacon\_min} \geq -1.0$ ppb/min (for static slope) or $Sl_{(-)beacon\_min} \geq -2.0$ ppb/min (for gradient slope), the FTA check is considered to be passed and there is no need to perform a point-by-point analysis for the negative mean slope. The FTA check shall be repeated for static and gradient slopes.

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