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 5

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. Requirements

a) The residual and mean-slope components of the medium-term frequency stability (MTS) measured during the temperature gradient test corresponding to the appropriate class of the beacon shall be provided by the manufacturer for the specific TCXO 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 MTS performance that remains within the specified maximum oscillator limit, as measured by the oscillator manufacturer during a temperature gradient test corresponding to the appropriate class of beacon.

2. Residual Frequency Variation of the Medium-Term Frequency Stability

The residual frequency variation contributed by the beacon design, R_{beacon}, 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 frequency variation 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 MTS residual component measured during Cospas-Sarsat type approval testing at a given point of the temperature gradient profile, and

R_{osc} is the MTS residual component value provided for the specific oscillator installed in the test beacon at the same point of the temperature gradient profile, as measured by the TCXO manufacturer.

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

Note: For pairs of data points, where R_{osc} is greater than R_{tot}, the R_{osc} component shall be neglected, and $R_{beacon} = R_{tot}$.

The maximum expected beacon MTS residual component, R_{beacon_max}, is then calculated by adding the oscillator maximum MTS residual limit ($R_{MAX-OSC}$) to the worst case beacon component R_{beacon_wc}, as follows:

$$R_{beacon\_max} = \sqrt{R_{beacon\_wc}{}^2 + R_{MAX-OSC}{}^2},$$

where: R_{beacon_wc} is the worst-case MTS residual value previously determined for the beacon contribution, and
$R_{MAX-OSC}$ is the oscillator MTS residual maximum limit, specified by the TCXO manufacturer for the given TCXO model number.

The performance after five years is estimated by adding an ageing factor (0.2 ppb) to the maximum expected R_{beacon_max}. The final value obtained shall be less than the Cospas-Sarsat requirement for the MTS residual frequency variation (i.e. 3.0 ppb):

$$R_{beacon\_5\,year} = R_{beacon\_max} + 0.2\text{ ppb} \le 3.0\text{ ppb}$$

In case of a marginal non-compliance, the C/S T.008 allowance of 0.1 ppb may be added to the specification.

3. Positive and Negative Mean Slopes of the Medium-Term Frequency Stability

A similar procedure shall be used for the evaluation of the MTS positive and negative mean slope values. 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	MAX ($Sl_{tot}^2 - Sl_{osc}^2$)	$Sl_{tot} > Sl_{osc}$, $Sl_{tot} > 0$, $Sl_{osc} > 0$	$(Sl_{tot}^2 - Sl_{osc}^2)^{1/2}$
		$Sl_{tot} > Sl_{osc}$, $Sl_{tot} > 0$, $Sl_{osc} < 0$	$(Sl_{tot}^2 + Sl_{osc}^2)^{1/2}$
		$Sl_{tot} > Sl_{osc}$, $Sl_{tot} < 0$, $Sl_{osc} < 0$	$(Sl_{osc}^2 - Sl_{tot}^2)^{1/2}$
Negative	MIN ($Sl_{tot}^2 - Sl_{osc}^2$)	$Sl_{tot} < Sl_{osc}$, $Sl_{tot} < 0$, $Sl_{osc} < 0$	$-(Sl_{tot}^2 - Sl_{osc}^2)^{1/2}$
		$Sl_{tot} < Sl_{osc}$, $Sl_{tot} < 0$, $Sl_{osc} > 0$	$-(Sl_{tot}^2 + Sl_{osc}^2)^{1/2}$
		$Sl_{tot} < Sl_{osc}$, $Sl_{tot} > 0$, $Sl_{osc} > 0$	$-(Sl_{osc}^2 - Sl_{tot}^2)^{1/2}$

where: Sl_{tot} is the value of the mean slope measured during Cospas-Sarsat type approval testing at a given point of the temperature gradient profile, and

Sl_{osc} is the value provided at the same point of the temperature gradient profile for the specific TCXO oscillator device installed in the test beacon, as measured by the TCXO manufacturer.

The maximum expected beacon slope values $Sl_{(+)beacon\_max}$ - for positive slope, and the minimum expected beacon slope values $Sl_{(-)beacon\_min}$ - for negative slope, are then calculated by adding the oscillator mean-slope limits specified for steady and for changing temperature conditions, as follows:

$$Sl_{(+)beacon\_max} = (Sl_{(+)beacon\_wc}^2 + Sl_{(+)MAX\text{-}OSC}^2)^{1/2}, \text{ and}$$

$$Sl_{(-)beacon\_min} = -\,(Sl_{(-)beacon\_wc}^2 + Sl_{(-)MIN\text{-}OSC}^2)^{1/2},$$

where: $Sl_{(+)beacon\_wc}$, $Sl_{(-)beacon\_wc}$ are the worst-case MTS mean slope values previously determined for the beacon positive (+) and negative (-) slope contributions, and

$Sl_{(+)MAX\text{-}OSC}$, $Sl_{(-)MIN\text{-}OSC}$ are the oscillator MTS positive (+) and negative (-) mean slope limits, specified by the TCXO manufacturer for the given TCXO model number, for steady temperature and for changing temperature conditions.

The mean-slope performance after five years is estimated by adding the ageing factor (0.1 ppb/min) to the maximum expected positive mean slope $Sl_{(+)beacon\_max}$ value, and by subtracting the ageing factor (0.1 ppb/min) from the minimum expected negative mean slope $Sl_{(-)beacon\_min}$ value. The IP (TCXO) requirements are met, if the final value obtained does not exceed the Cospas-Sarsat requirement for the MTS mean slope:

$Sl_{(+)beacon\_5\ year} = Sl_{(+)beacon\_max} + 0.1$ ppb/min ≤ 1.0 ppb/min, for positive MTS mean slope values during steady temperature;

$Sl_{(+)beacon\_5\ year} = Sl_{(+)beacon\_max} + 0.1$ ppb/min ≤ 2.0 ppb/min, for positive MTS mean slope values during gradient temperature;

$Sl_{(-)beacon\_5\ year} = Sl_{(-)beacon\_min} - 0.1$ ppb/min ≥ -1.0 ppb/min, for negative MTS mean slope values during steady temperature;

$Sl_{(-)beacon\_5\ year} = Sl_{(-)beacon\_min} - 0.1$ ppb/min ≥ -2.0 ppb/min, for negative MTS slope values during gradient temperature.

In case of a marginal non-compliance, the C/S T.008 allowance of ± 0.1ppb may be added to the specification. The procedure shall be 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.

4. Fast Track Approach

As described above, determination of the worst-case beacon MTS components requires a point-by-point analysis of data pairs matching and comparison of MTS result sets obtained from a test facility and the TCXO manufacturer to identify the extreme (i.e. minimum and maximum) values. This process can be applied to all beacons. However, the MTS analysis can be significantly facilitated for beacons with good MTS characteristics. For such beacons, the Fast Track Approach (FTA) described below could be used.

If the results of FTA check demonstrate compliance with Cospas-Sarsat requirements, no point-to-point analysis is required for the determination of the worst-case MTS values. However, a point-by-point analysis is needed for beacons that fail the FTA check.

4.1 Residual Frequency Variation

For the FTA check of the residual frequency variation, the worst case situation would be observed when the MTS residual value measured at the test facility reaches its maximum while the oscillator component is negligible, i.e. $R_{osc} = 0$. For this case, the worst case beacon component (R_{beacon_wc}) would be equal to the maximum residual value (R_{tot_max}), as measured at the test facility during temperature gradient test:

$$R_{beacon\_wc} = R_{tot\_max}\text{ , and}$$

The maximum expected beacon MTS residual value, R_{beacon_max}, is then calculated, as follows:

$$R_{beacon\_max} = (R_{beacon\_wc}{}^2 + R_{MAX\text{-}OSC}{}^2)^{1/2} = (R_{tot\_max}{}^2 + R_{MAX\text{-}OSC}{}^2)^{1/2}$$

where $R_{MAX\text{-}OSC}$ is the oscillator MTS residual maximum limit, specified by the TCXO manufacturer for the given TCXO model number.

The beacon MTS residual after five years is estimated by adding the ageing factor (**0.2 ppb/min**) to the maximum expected R_{beacon_max}:

$$R_{beacon\_5\ year} = R_{beacon\_max} + 0.2\text{ ppb}$$

If $R_{beacon\_5\ year} \leq 3.0$ ppb, the FTA check is considered to be passed and there is no need to perform a point-by-point analysis for the residual frequency variation.

In case of a marginal non-compliance, the C/S T.008 allowance of 0.1ppb may be added to the specification.

4.2 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 the positive mean slope measured at the test facility ($Sl_{(+)\ tot\_max}$) is placed against the minimum value of the negative mean slope determined for the specific oscillator device installed in the test beacon ($Sl_{(-)osc\_min}$), during the temperature gradient test phase under consideration.

The worst case of the beacon positive slope contribution $Sl_{(+)beacon\_wc}$ value is calculated as follows:

$$Sl_{(+)beacon\_wc} = (Sl_{(+)tot\_max}{}^2 + Sl_{(-)osc\_min}{}^2)^{1/2}.$$

The maximum expected value of the beacon positive slope $Sl_{(+)beacon\_max}$ is then calculated as follows:

$$Sl_{(+)beacon\_max} = (Sl_{(+)beacon\_wc}{}^2 + Sl_{(+)MAX\_OSC}{}^2)^{1/2},$$

where:

$Sl_{(+)MAX\_OSC}$ is the oscillator MTS maximum positive mean slope limit, specified by the TCXO manufacturer for the given TCXO model number at the appropriate steady and changing temperature conditions.

The value of MTS positive mean slope after five years is estimated by adding the ageing factor (0.1 ppb/min) to the maximum expected $Sl_{(+)beacon\_max}$:

$$Sl_{(+)beacon\_5\ year} = Sl_{(+)beacon\_max} + 0.1 \text{ ppb/min}$$

If $Sl_{(+)beacon\_5\ year} \leq 1.0$ ppb/min (for static slope) or $Sl_{(+)beacon\_5\ year} \leq 2.0$ 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 MTS positive static or gradient mean slope.

In case of a marginal non-compliance, the C/S T.008 allowance of ±0.1ppb may be added to the specification.

The FTA check shall be repeated for static and gradient slopes.

4.3 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 ($Sl_{(+)osc\_max}$) determined for the specific oscillator device installed in the test beacon, during the temperature gradient test phase under consideration.

The worst case of the beacon negative slope contribution $Sl_{(-)\ beacon\_wc}$ value is calculated as follows:

$$Sl_{(-)beacon\_wc} = -\left(Sl_{(-)tot\_min}^{2} + Sl_{(+)osc\_max}^{2}\right)^{1/2}.$$

The minimum expected value of the beacon negative slope $Sl_{(-)\ beacon\_min}$ is then calculated by adding to the above value the oscillator minimum MTS negative mean slope limit specified by the TCXO manufacturer for a given TCXO model at the appropriate steady or changing temperature conditions, as follows:

$$Sl_{(-)beacon\_min} = -\left(Sl_{(-)beacon\_wc}^{2} + Sl_{(-)MIN\text{-}OSC}^{2}\right)^{1/2},$$

where: $Sl_{(-)MIN\text{-}OSC}$ is the oscillator MTS minimum negative mean slope limit, specified by the TCXO manufacturer for the given TCXO model number, at the appropriate steady and changing temperature conditions.

The performance after five years is estimated as follows:

$$Sl_{(-)beacon\_5\ year} = Sl_{(-)beacon\_min} - 0.1 \text{ ppb/min}$$

If $Sl_{(-)beacon\_5\ year} \geq -1.0$ ppb/min (for static slope) or $Sl_{(-)beacon\_5\ year} \geq -2.0$ ppb/min (for gradient slope), the FTA check is considered to be passed, and there is no need to perform a point-to-point analysis for the MTS negative static or gradient mean slope.

In case of a marginal non-compliance, the C/S T.008 allowance of ±0.1 ppb/min may be added to the specification. The FTA check shall be repeated for static and gradient slopes.

5. Reporting Results of MTS Analysis

Results of FTA and point-by-point MTS analysis shall be reported in the format of Tables A-1 and A-2, presented at Annex A to this document.

ANNEX A

Table A-1: Fast Track Analysis

MTS Characteristic	tot_max / tot_min	osc_max / ocs_min	beacon_wc	MAX-OSC / MIN-OSC	beacon_ max/_min	ageing factor	beacon_ 5 year	C/S spec	Pass/Fail
Residual, ppb						**0.2**		**3.0**	
Static Positive Mean Slope, ppb/min						**0.1**		**1.0**	
Static Negative Mean Slope, ppb/min						**0.1**		**-1.0**	
Gradient Positive Mean Slope, ppb/min						**0.1**		**2.0**	
Gradient Negative Mean Slope, ppb/min						**0.1**		**-2.0**	

Table A-2: Point-By-Point Analysis

MTS Characteristic	Time	Temp. C°	tot	osc	beacon_wc	MAX-OSC / MIN-OSC	beacon_ max/min	ageing factor	beacon_ 5 year	C/S spec	Pass/Fail
Residual, ppb								**0.2**		**3.0**	
Static Positive Mean Slope, ppb/min								**0.1**		**1.0**	
Static Negative Mean Slope, ppb/min								**0.1**		**-1.0**	
Gradient Positive Mean Slope, ppb/min								**0.1**		**2.0**	
Gradient Negative Mean Slope, ppb/min								**0.1**		**-2.0**	

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