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DTRF 150802 Generic Reliability Specification for Supplied Sub-System

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Previous reference

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Modification requested by Raoul ROLAND on May 2020

Design Office	APPLICATIONS (Series of Rolling Stock or application)	N^{er} of assembly drawings
	Railway Rolling Stock	

TECHNICAL SPECIFICATION

Generic Reliability Specification for Supplied Sub-System

			Name		
		Written by		P. Cozzarin	
		Reviewed		R. Roland	
Manufacturer's modifications		Approved		R. Roland	ALSTOM Version : English

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Index	Date	Description of change	Name
0	06/07/2015	First issue	C. Schor
1	10/2017	Update from feedback of exchanges with suppliers. Addition of Coupler and Brakes generic failure modes and default planning for deliverables.	R. Roland
C	03/2021	Update from feedback of exchanges with suppliers Addition of Toilet, Master Controller and Fire Detection generic failures	Ph. Cozzarin

CONTENTS

1 PURPOSE

The purpose of this document is to describe management requirements, deliverables and generic requirements related to Reliability.

2 TERMS AND DEFINITIONS

Terms	Definition
CGR	Critical Gate Review
FAI	First Article Inspection
FSD	Fire & Smoke Detection
MC	Master Controller
MTBF	Mean Time Between Failures, related to the indicator of reliability MTTF indicated in IEC 60 605-4.
MTTF	Mean Time To Failure, as defined in IEC 60 605-4. In this document MTTF is assumed equal to MTBF.
NFF	No Fault Found.
PGR	Preliminary Gate Review
SGR	Specification Gate Review

3 APPLICABLE STANDARDS

References	Observation
EN50126-1:2017	Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part1: Generic RAMS Process
IEC 60 605-4	Equipment reliability testing - statistical procedures for exponential distribution.

4 RELIABILITY MANAGEMENT

The supplier shall comply with EN50126 part 1 as the reference standard for this activity.

4.1 LIST OF TYPICAL DOCUMENT AND RELIABILITY ANALYSES

These following documents are typical reliability deliverables and these analyses will be carried out by the supplier (depending on project and product specificities, see §8 for details) and justify that the commitment on reliability objectives will be achieved.

Complementarily any specific requirements will be addressed in TPS.

4.1.1 RELIABILITY PLAN

The Reliability Plan is the set of Reliability activities in accordance with the Reliability Management System of the supplier that are applied throughout the product lifecycle to ensure that the subsystem delivered to Alstom is reliable and remains reliable up to dismantlement.

The purpose of a Reliability Plan is to define the Reliability requirements (targets included) of the subsystem and the methods by which the reliability performances will be assessed and managed. This will detail resources, processes and reliability management activities. It will be subject to on-going audit and verification and will contain clear deliverables. All reliability deliverables and activities are subjected to a planning.

If a Reliability plan is produced, it will be sent for acceptance before the contract award.

This document can be combined with a Safety Plan and Availability & Maintenance plan.

4.1.2 FMEA / FMECA

The Failure Modes and Effects Analysis (FMEA) is a systematic, formal procedure for analysing a subsystem to identify potential failure modes, and their causes and effects on the functionality of the subsystem.

The FMECA (Failure Modes, Effects and Criticality Analysis) is an extension of the FMEA that includes a means of classifying failure modes by severity in order to give a priority to countermeasures.

From the FMEA/FMECA, the supplier shall communicate to Alstom a summary of:

- failure rates for each failure modes having a performance defined;
- list of all critical actions under Alstom responsibility related to failure modes having a performance defined.

Standard EN 60812 can be used as a reference.

This document can be combined to include both safety and reliability point of views.

4.2 ACTIVITIES BEFORE CONTRACT AWARD

The Supplier shall send:

- The potential system functional failure modes affecting the mission of its equipment and the associated MTTF /MKTF (in hours and/or kilometer);
- The methodology used to justify that the proposed MTBF/MKBF values are achieved**;**
- Tests carried out on the product (endurance test report, aging, etc.) and tests that it plans to carry out (send the validation plan) to demonstrate that reliability objectives are satisfied;
- Reliability constraints to be manage by other if any (e.g. inspection interval, design like remote alarm,…).

Alstom will work with the Supplier to put functional failure modes into groups and will define the objective to be achieved for each failure family or type. This summary shall be made contractually through the STD that will also include the measurement method.

4.3 ACTIVITIES IN DEVELOPMENT PHASE

The Supplier shall write a reliability report that will contain all demonstrations proving that the (sub-system) supplied product satisfies the specified reliability requirements, and shall include at least the following if applicable:

- Usage restrictions
- List of (functional) failure modes and their associated failure rates as a function of contractual commitments, specifying their origin
- Main components at the origin of the failure mode with a % distribution of the failure rate (for this failure mode)
- List of critical components (first level replaceable unit) in terms of reliability and actions to be implemented by other to achieve the defined objectives. They may relate to:
    - Storage,
    - Integration,
    - Commissioning,
    - Operation,
    - Tests and inspections to be done,
    - Maintenance.
- Tree structure of all first level replaceable units. This structure shall include:
    - The component description;
    - The reference to the block diagram;
    - The component identifier;
    - Quantity / train;
    - Supplier's name;
    - If identified as being critical for reliability, the functional failure modes to which it contributes;
    - If identified as being critical for reliability;
    - If identified as being critical for reliability, the failure rate.

A preliminary reliability report will be sent before start-up of series production. The preliminary reliability report includes the reliability requirements from the supplier towards Alstom to be agreed prior the First Article Inspection (IPA).

The final reliability report shall be provided and agreed between the Parties at the end of commissioning.

4.4 ACTIVITIES DURING THE OPERATION PHASE

As long as the supplied product is under guarantee, the Supplier shall send repair report and expertise to Alstom comprising at least:

- The reference to the failure mode defined in the predictive phase (or if necessary even creation of a new failure mode);
- The summary of investigations done;
- The cause of the failure;
- The description of repairs made;
- A prediction of the number of similar failures during the coming year (the spare part stock will be resized if necessary).

Alstom will provide during the period the available data to the supplier for investigation. Alstom will monitor reliability commitments.

Measurement method: The lower one-sided limit of the mean time to failure (MTTF – Mean Kilometer To Failure in fact) is calculated by using the chi-squared distribution with a confidence level of 80%. Time terminated test with replacement as defined by EN60605-4 - formula 4 applies.

If recurrent defects occur and if one or several objectives are not achieved, it is recommended that the Supplier implements corrective action plans and update them monthly.

5 TYPICAL RELIABILITY REQUIREMENTS

The reliability targets for each categories (T1/T2/T3) and associated failure modes defined in the Technical Purchasing Specification (TPS) are formalized and agreed prior contract award. These targets may vary from one subsystem to another and also project specificities (different operating conditions).

Reliability demonstrations provided by supplier will be reviewed and action closed when accepted by Alstom. The reliability measures shall be clearly documented and performances maintained over the life of the product.

The value for each category is defined in the specific relevant TPS. All clarifications from the supplier's side shall be done before the equipment entry in commercial service.

5.1 HVAC

The Table 1 defines the HVAC specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per hour under voltage and per HVAC subsystem. One can deduce that when only one failure leads to several HVACs failure, the number of failures (r) is then the number of HVAC having a failure.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure modes
T1	T1 category is defined by the following functional failure mode: All failures not part of category 3 and 2.
T2	T2 category is defined by the following functional failure modes: HVAC_T2_DM01: Water penetration into dry area HVAC_T2_DM02 : Failures leading to a repair outside schedule maintenance interventions HVAC_T2_DM03 : Fluid leakage from cooling circuit or every kind of pollution HVAC_T2_DM04 : Malfunctioning of control systems (e.g. over pressure device)
T3	T3 category is defined by the following functional failure modes: HVAC_T3_DM01: Degrading cooling (performances or HVAC capability decrease by more than 25%) HVAC_T3_DM02: Degrading heating (performances HVAC capability decrease by more than 25%) HVAC_T3_DM03: Degrading ventilation (performances HVAC capability decrease by more than 25%) HVAC_T3_DM04 : Excessive noise as defined in the technical specification

Table 1 – HVAC Functional failure modes

5.2 PANTOGRAPH

The Table 2 defines the pantograph specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per running hour or MKTF per kilometers and per Pantograph subsystem. One can deduce that when only one failure leads to several Pantographs failure, the number of failures (r) is then the number of Pantograph having a failure.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure modes
T1	T1 category is defined by the following functional failure mode: All failures with insignificant influence to service or safety excluding category 3 and 2.
T2	T2 category is defined by the following functional failure mode: PANTO_T2_DM01: Pantograph lowering impossible PANTO_T2_DM02: Damage of the pantograph parts to be repaired at the end of the mission
T3	T3 category is defined by the following functional failure mode: PANTO_T3_DM01: During operation loss of the current Collection PANTO_T3_DM02: Not able to raise pantograph and to collect enough current PANTO_T3_DM03: All failures repaired in more than 3 hours

Table 2 – Pantograph Functional failure modes

5.3 DOORS

The Table 3 defines the door/step specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per hour under voltage and per door subsystem. One can deduce that when only one failure leads to several doors/steps failure, the number of failures (r) is then the number of Door/Step having a failure.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category is defined by the following functional failure mode: All failures with insignificant influence to service or safety excluding category T3 and T2. Failures with insignificant influence to service or safety.
T2	T2 category is defined by the following functional failure mode: DOOR_T2_DM01: Defective door/step due to mechanical or pneumatic failure can be isolated at start-up or during operation DOOR_T2_DM02: Defective door/step due to control command failure can be isolated at start-up or during operation DOOR_T2_DM03: Improper tightness leading to excessive noise and/or presence of water in coaches (based on factual defect during operation from the Operator). Leading to repair at the end of the day and prior the train is putting back in commercial Service. DOOR_T2_DM04: Loss of communication between Door control units and TCMS
T3	T3 category is defined by the following functional failure mode: DOOR_T3_DM01: Defective door/step due to mechanical failure cannot be isolated at start-up or during operation DOOR_T3_DM02: Defective door/step due to control command failure cannot be isolated at start-up or during operation

Table 3 – Doors Functional failure modes

5.4 AUXILIARY BATTERY

The Table 4 defines the auxiliary battery specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per hour under voltage.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category is defined by the following functional failure mode: All failures with insignificant influence to service or safety excluding category T3 and T2. Failures with insignificant influence to service or safety.
T2	T2 category is defined by the following functional failure mode: BAT_T2_DM01: Failures leading to a repair outside schedule maintenance interventions BAT_T2_DM02: Leakage or every kind of Pollution
T3	T3 category is defined by the following functional failure mode: BAT_T3_DM01: Loss of battery charge (all type of failures leading to) BAT_T3_DM02: No power distribution

Table 4 – Auxiliary Battery Functional failure modes

5.5 COUPLER

The Table 5 defines the coupler specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MKTF.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category is defined by the following functional failure mode: CPL_T1_DM01: Failures leading to a repair outside scheduled maintenance interventions not included in category T3 and T2 (failures that are repaired at the next scheduled maintenance intervention are excluded).
T2	T2 category is defined by the following functional failure mode: CPL_T2_DM01: Coupling signal disruption. CPL_T2_DM02: More than one coupling/uncoupling attempt needed due to mechanical, pneumatic or electrical failures CPL_T2_DM03: Manual action required when uncoupling automatic coupler due to mechanical, pneumatic or electrical failures
T3	T3 category is defined by the following functional failure mode: CPL_T3_DM01: Impossible coupling/uncoupling due to mechanical, pneumatic or electrical failures (including heating device) CPL _T3_DM02: Loss of integrity of the safety loop, leading to undesired stop. CPL _T3_DM03: Unsuccessful coupling during rescue operation with specific coupling device.

Table 5 – Coupler Functional failure modes

5.6 BRAKES

The Table 6 defines the brakes specific failure modes per category T1 to T3.

The defined failure modes consider the "full-scope" of brake system including brake control, air supply, bogie brake).

For each category, Reliability Performances shall be defined by a MTTF per hour under voltage.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category corresponds to the failure modes to be repaired outside of the schedule maintenance intervention and not included in category T3 and T2 and those defined by the following functional failure modes of the Brake System: BRK_T1_DM1: All brakes defect detected during brake tests performed at start-up BRK_T1_DM2: Loss of automatic brake test function BRK_T1_DM3: Failures of Brake System components leading to Coupling impossible at start-up BRK_T1_DM4: Pantograph is not rising at start-up BRK_T1_DM5: Loss of Xsd sanding functions at wheel level (Xsd as stated in the TPS) or continuous sanding function.
T2	T2 category corresponds to failures defined by the following functional failure modes of the Brake System: BRK_T2_DM01a: Loss of Xs Service Brake at axle/bogie/car level identified (Xs as stated in the TPS). BRK_T2_DM01b: Loss of Xe Emergency Brake at axle/bogie/car level identified (Xe as stated in the TPS). BRK_T2_DM01c: Loss of Xm Magnetic Brake at axle/bogie/car level identified (Xm as stated in the TPS). BRK_T2_DM01d: Loss of one or more WSP (regulation part). BRK_T2_DM02: All failures during operation that require a manual isolation BRK_T2_DM03: Undue application of Brake (all types of brake) on axle/bogie/car with possibility of automatic isolation if needed to continue operation. BRK_T2_DM04: Failures of Brake System components leading to Coupling/Uncoupling impossible during operation. BRK_T2_DM05: Loss of Xa air suspension at bogie/car level identified (Xa as stated in the TPS) *Remark: The instrumentation leading to state one air suspension system is lost is included in this failure mode (equivalent at train level to a mechanical failure leading to an air suspension issue).* BRK_T2_DM06: Braking effort higher than the maximum one specified in TPS (all types of brake) on Rolling Stock not fitted with WSP *Remark: At design phase a qualitative explanation to document this failure mode is negligible is accepted.* BRK_T2_DM07: Loss or continuous horn function BRK_T2_DM08: Loss of brakes override in case passenger alarm actuation BRK_T2_DM09: Loss of communication between Brake control units or between brake control units and TCMS

Category	Functional Failure mode
T3	T3 category corresponds to failures potentially leading to a Rolling Stock withdrawal and is defined by the following functional failure modes of the Brake System: BRK_T3_DM01a: Loss of Ys Service Brake at axle/bogie/car level identified (Ys as stated in the TPS). BRK_T3_DM01b: Loss of Ye Emergency Brake at axle/bogie/car level identified (Ye as stated in the TPS). BRK_T3_DM01c: Loss of Ym Magnetic Brake at axle/bogie/car level identified (Ym as stated in the TPS). BRK_T3_DM02: Undue permanent application of Brake (all types of brake) without possibility of isolation. *Remark: This functional failure mode includes central command devices (like Pneumatic EB button, EB valve, Driver's brake valve) as well the failure of the pressure switch on main pipe used to order an EB when low threshold setting is reached.* BRK_T3_DM03: Unable to maintain the minimum specified pressure (as stated in TPS) in the main pipe. *Remark: The instrumentation leading to loss compressor monitoring is including in this failure mode (same consequence than a compressor failure).* BRK_T3_DM04: Pantograph is not rising / lowering during operation BRK_T3_DM05: Loss of brake bus (service brake no more available at axle/bogie/car level)

Table 6 – Brakes Functional failure modes

5.7 FIRE & SMOKE DETECTION (AND EXTINGUISHING) SYSTEM (FSD)

The Table 7 defines the fire and smoke detection (and extinguishing) system specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per running hour.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category is defined by the following functional failure mode: All failures with insignificant influence on service or safety excluding category 3 and 2.
T2	T2 category is defined by the following functional failure mode: FSD_T2_DM01: Fire detection error reported at start-up or during operation FSD_T2_DM02: Smoke detection error reported at start-up or during operation FSD_T2_DM03: Fire extinguishing error reported at start-up or during operation
T3	T3 category is defined by the following functional failure mode: FSD_T3_DM01: Erroneous fire detection FSD_T3_DM02: Erroneous smoke detection FSD_T3_DM03: Erroneous fire extinguishing application

Table 7 – FSD Functional Failure Modes

5.8 MASTER CONTROLLER (MC)

The Table 8 defines the master controller specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per running hour (time divided by 2 will be considered per master controller).

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category is defined by the following functional failure mode: All failures with insignificant influence on service or safety excluding category 3 and 2.
T2	T2 category is defined by the following functional failure mode: MC_T2_DM01: No or erroneous order for Traction/Brake sent MC_T2_DM02: Erroneous position of Master Controller(1) communicated at start-up MC_T2_DM03: Master Controller(1) blocked in a position identified at start-up
T3	T3 category is defined by the following functional failure mode: MC_T3_DM01: Erroneous position of Master Controller(1) communicated once the train is in operation MC_T3_DM02: No Deadman acknowledgement MC_T3_DM03: Master Controller(1) blocked in a position communicated once the train is in operation

Table 8 – Master Controller Functional Failure Modes

(1) Applies for all contacts of Master Controller including Train Direction, Key Switch, Mode Selector and Running Direction, if any.

5.9 TOILET

The Table 8 defines the toilet specific failure modes per category T1 to T3.

For each category, Reliability Performances shall be defined by a MTTF per running hour or MKTF per kilometers.

Remark: on specific application, the distribution of failure modes per category may be adjusted through the TPS.

Category	Functional Failure mode
T1	T1 category is defined by the following functional failure mode: All failures with insignificant influence on service or safety excluding category 3 and 2.
T2	T2 category is defined by the following functional failure mode: TLT_T2_DM01: Hand washing device failure (soap included) TLT_T2_DM02: Hand dryer failure TLT_T2_DM03: Any leakage TLT_T2_DM04: Audio system failure (parasite noises) TLT_T2_DM05: Call button failure TLT_T2_DM06: Loss of ventilation
T3	T3 category is defined by the following functional failure mode: TLT_T3_DM01: Any failure leading to isolate automatically or manually the toilet TLT_T3_DM02: Door cannot be opened TLT_T3_DM03: Door close and lock failure TLT_T3_DM04: Pneumatic supply failure TLT_T3_DM05: Hydraulic supply failure TLT_T3_DM06: Electrical supply failure TLT_T3_DM07: Waste Water Tank failure TLT_T3_DM08: Complete loss of lighting

Table 9 – Toilet Functional Failure Modes

5.10 OTHER COMMODITIES

For other commodities not specifically detailed in the current revision of the present document the functional failure mode will be defined in the relevant TPS.

6 PROCEDURE FOR DEMONSTRATING THE RELIABILITY TARGETS ARE REACHED

The satisfaction of our customers depends on the achievement of Suppliers reliability performances. For this reason, reliability targets have been defined for the equipment in the Technical purchasing specification.

The aim of this chapter is to define the process and rules to apply in order to verify during operation that the equipment reaches reliability performances/targets defined in the Technical purchasing Specification.

This document presents the following points:

- Procedure for measuring the reliability
- Criteria for applying penalties if ever applicable (the aim is not to apply penalties but to achieve and sustain the expected reliability performances).

6.1 MAIN STEPS OF THE RELIABILITY FOLLOW-UP

6.2 CALCULATION OF THE RELIABILITY PERFORMANCES DURING THE WARRANTY PERIOD

The assessment of the reliability performances relies on calculations at the end of the warranty period based on all the failures reported. Every failure will be analysed in details and validated by both parties (mutual agreement reached, refer to §6.3). In case of long delivery schedules the reliability may be assessed on a per batch basis with rules to be defined in between both parties for the relevant projects.

Failure allowing to put back subsystem into service without repair or replacement ("No Fault Found Failure") are managed in accordance with the §6.4

Recurrent failures will be counted up to the root cause and schedule of corrective actions on train are agreed by the Operator. If commitment and efficiency of the corrective actions are not meet, then recurrent failures will be also counted.

According to the cumulated operating hours of the subsystem during the warranty period and the reliability targets, the rules to be applied to assess the reliability performances are defined:

Situation	Rules
MTTF target >T^1	N° 3 : Maximum one failure allowed
MTTF ≤ T^1 ≤ 3*MTTF	N° 2: Point estimate is applicable (smooth transition from point estimate to chi-squared distribution)
3*MTTF < T^1	N° 1: Chi-square rule applies

T^1 = cumulated operating hours

6.2.1 RULE N°1

MTTF is calculated by using the chi-squared distribution (EN60605-4 - formula 4 applies):

$$MTTF = \frac{2 \times T}{\chi^2_{1-\alpha}(2r+2)}$$

Parameters	Definition	Method of determining
T	Cumulated operating hours	Sum of the operating hours of all the subsystems in operation over the follow-up period
r	Number of failures per category	/
1-α	The confidence level at which confidence intervals and limits are calculated	80%
MTTF	Reliability performance measured to be compared with the target.	MTBF assimilated to MTTF

The maximum number of failures allowed (N) can be deduced by applying the following steps:

Step A: to determine the maximum number of failures (r) that complies with the following equation:

$$\chi^2_{1-\alpha}(2r+2) < \frac{2 \times T}{MTTF}$$

Step B: to calculate a rounded Target using the following formula:

$$\frac{\chi^2_{1-\alpha}(2r+2) + \chi^2_{1-\alpha}(2r+4)}{2} = rounded T \arg et$$

Step C: to determine whether r or r+1 is the maximum number of failures allowed (N):

- N = r+1 when:

$$roundedTarget \leq \frac{2 \times T}{MTTF}$$

- N = r when:

$$roundedTarget > \frac{2 \times T}{MTTF}$$

6.2.2 RULE N°2

When rule N°1 cannot be used and cumulated operating hours over the follow-up period is greater than the required MTTF, point estimate applies up to 3 failures (smooth transition from point estimate to chi-squared distribution).

$$MTTF = \frac{T}{r}$$

Parameters	Definition	Method of determining
T	Cumulated operating hours	Sum of the operating hours of all the subsystems in operation over the follow-up period
r	Number of failures per category	r ≤ 3
MTTF	Reliability performance measured to be compared with the target.	MTBF assimilated to MTTF

From this formula, the maximum number of failure allowed can be deduced:

$$r = \frac{T}{MTTF}$$

6.2.3 RULE N°3

When we are not able to demonstrate statistically if the MTTF target is reached (MTTF>T), by default one failure is allowed over the warranty period..

Parameters	Definition	Method of determining
T	Cumulated operating hours	Sum of the operating hours of all the subsystems in operation over the follow-up period
r	r ≤ 1	/
MTTF	Reliability performance measured to be compared with the target.	MTBF assimilated to MTTF

If the reliability targets are not reached, strong supplier involvement is expected to improve the system. Warranty extension applies and penalties also if needed.

6.3 RELIABILITY FOLLOW UP ORGANIZATION DURING WARRANTY

6.3.1 RECORD OF FAILURES

Every incident/event in commercial operation will be recorded by warranty team in the Alstom database.

The supplier shall communicate the first Root Cause Analysis and/ or action plan within no more than one week after the notification of incident/event is received.

6.3.2 SUPPLIER FAILURE REVIEW BOARD

A committee in charge of the monitoring of the reliability performance (Alstom/Supplier) will be set-up at the beginning of the commercial service.

The members of the Committee will meet regularly in order:

- To assess the reliability performances of the subsystem based on incident/event recorded and operating data of the fleet of sub-system.;
- To review the investigations/analysis done by both parties on incident/event occurring in commercial service (Cf. chapter 4.4);
- To review the No Fault Found failures
- To determine for each incident/event the entity accountable;
- To validate the consistency and completeness of incident/event data recorded;
- To define action plans and follow the on-going actions.

The frequency of these meetings will be monthly. On case by case basis based on the occurrence and severity of incident/event, frequency can be adjusted mutually. After each meeting, a report will be written and signed by both Parties.

6.4 TREATMENT OF NO FAULT FOUND FAILURE

The No Fault Found (NFF) failures are incident/event during the commercial service without damage identified.

Generally, the NFF failure disturbs the nominal operation of a function or subsystem. This kind of event can be difficult to reproduce with basic diagnostic and troubleshooting tools.

6.4.1 NO FAULT FOUND FAILURE MANAGEMENT

In this section, the No Fault Found events considered are those service reliability affecting events. After investigation on the train and / or equipment, either the event is classified as failure or as a NFF failure. In case of NFF failure, the concerned subsystem is put under observation to check for a possible recurrence.

If another NFF failure of the same type occurs again, the Supplier and Alstom shall investigate to identify the root cause as soon as possible.

From 5% of NFF Failures (total number of NFF Failures divided by the total number of failures) but not less than 15 NFF Failures per annum, the NFF Failures are integrated in the calculation of the reliability performances.

NFF events confirmed as not part of the supplier responsibility are removed from the reliability calculation of that supplier. The percentage of remaining NFF will be computed at the end of the warranty period for penalty calculation purpose.

7 PENALITIES APPLICATION

The calculation of penalties is relative to the observation period:

- Case n°1:

Calculations are performed at the end of warranty period.

- Case n°2:

Calculations are performed on a 12 months* sliding period at the end of each month during extension of warranty period up to demonstrate the performances reach the target.

* the sliding period can be reduced up to a period compliant with the rule 1 (6.2.1).

The following table summarizes the procedure for calculating penalties.

Type of failure	Calculation at the end of warranty period	Monthly calculation given warranty extension.
Type Ti	(Xi% of the amount of the relevant Order)*(ni+Ni)/Ni	(Yi% of the amount of the relevant Order)* (ni+Ni)/Ni

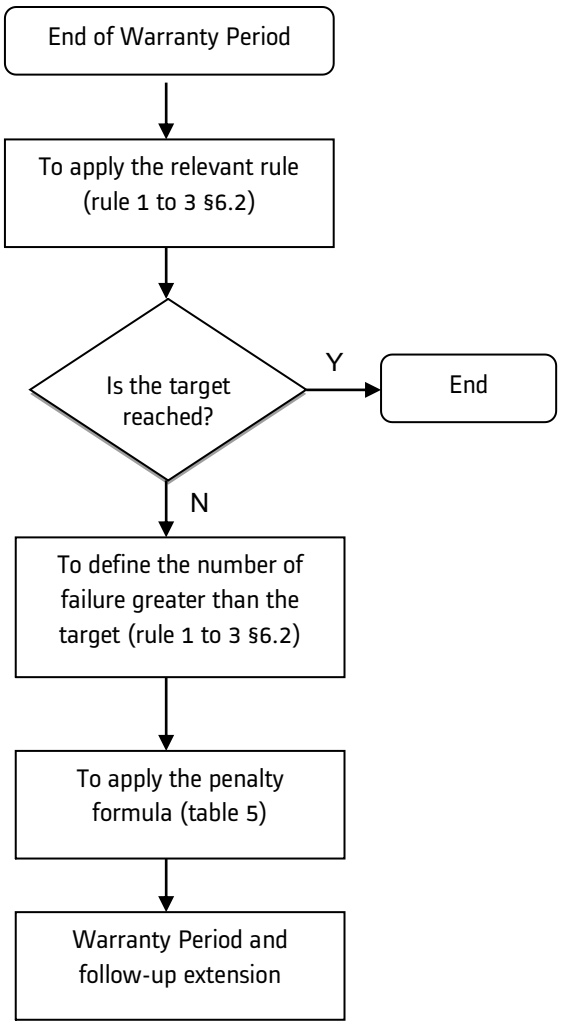
Table 5 : Penalty formula

Note:

The penalties are applied when: (N+n/N) >1.

- Xi% or Yi%: percentage of the amount of the relevant order, which will be refunded if there are number of failures exceeding the number of contractual failures;
- Ni : Maximum failures accepted by Alstom for a category of failure Ti;
- ni: Number of failures exceeding Ni;
- Ti: category of failures having a target defined in technical purchasing specification.

7.1 FLOWCHART



7.2 EXAMPLE

Considering the status below at the end of the warranty period:

- Reliability target (MTTF) : 20000 hours;
- Cumulated number of subsystems operating hours (T) : 166 140 hours;
- Number of failures recorded: 9;
- Xi%= 2,2%;
- Amount of the relevant order: 50 000 Euros.

First step: To define and apply the relevant rule

- Rule N°3 is not relevant, T < reliability target (§6.2.3);
- Rule N°2 is not relevant, r>3 and then 3*MTTF < T (§0)

$$MTTF = \frac{T}{r} = \frac{166140}{9} = 18460h$$

- Rule N°1 applies (§6.2.1)

$$MTTF = \frac{2 \times T}{\chi^2_{1-\alpha}(2r+2)} = \frac{2 \times 166140}{\chi^2_{1-\alpha}(20)} = \frac{332280}{25} = 13271\ h$$

Second step: To define the number of failure greater than the target

- Rule N°3 is not relevant, T < reliability target (§6.2.3);
- Rule N°2 is not relevant, r>3 and then 3*MTTF < T (§0)

$$r = \frac{T}{MTTF_{Target}} = \frac{166140}{20000} = 8$$

- Rule N°1 applies (§6.2.1)

$$\chi^2_{1-\alpha}(2r+2) < \frac{2 \times T}{MTTF} = 16.61$$

r	$\chi^2_{1-\alpha}(2r+2)$
5	15.81
6	18.15

Step A: The maximum value of r that complies with the previous equation is 5.

Step B: Then the corresponding rounded Target is:

$$roundedTarget = \frac{\chi^2_{1-\alpha}(2r+2) + \chi^2_{1-\alpha}(2r+4)}{2} = \frac{15.81 + 18.152}{2} = 16.98$$

Step C: as 16.98 > 16.61 the maximum allowed number of failures allowed is N = 5

$$roundedTarget > \frac{2 \times T}{MTTF}$$

The number of failures greater that the target is n = 9 – 5 = 4

Third step: To apply the penalty formula

Penalty = (Xi% of the amount of the relevant Order)*(ni+Ni)/Ni = 0,022*50000*(4+5)/5= 1980€

8 RELIABILITY DELIVERABLES

The below list of reliability deliverables is the by default list to be applied for each commodity. It can be adjusted based on project and product specificities (e.g. for product already developed and in commercial use in order to optimize costs and resources of both parties). In case of specific requirements this shall be stated in the corresponding TPS.

Ref	Subsystem Reliability Typical deliverables list	BRAKES	DOORS	HVAC	COUPLER	BATTERY	PANTO	MC	FSD	TOILET
1	Reliability Plan	M	M	R	-	-	R	-	R	-
2	FMEA/FMECA	M	M	HR	R	R	HR	M	M	HR
3	Reliability report (§4.3)	M	M	M	M	M	M	M	M	M

M : Mandatory
HR : Highly Recommended
R : Recommended

The below table provides the by default planning of expected delivery to Alstom of the reliability deliverables.

Ref	Subsystem Reliability Deliverables	Consultation	SGR	PGR	CGR	FAI	Warranty
0	Technical information as per §4.2	P					
1	Reliability Plan	P as per §4.2	F				
2	FMEA / FMECA			P	F		
3	Reliability report				P	F	

P = Preliminary. F= Final.