見積照会

工事番号／アイテム	部品スペック	番号
X63910		83－99139

品証レビュー		承認	点検	作成
承認	点検			

マカオ LRT　East Line

スペック名称

連結装置
（BAV 用）

5	L	H	車両部 車両設計課

符号	理由	ｱｲﾃﾑ確認	日付	査印

作成 2023 年 9 月 6 日

関連規格①MSLO-211（共通購入仕様書）

照会先　期限

番号	工事番号／アイテム	製作台数	一台分個数	数	納期	図面表番号	図面番号	備考
01	TBA	4	2	1	'26/11/25	追って指示	追って指示	BAV 用自動連結器 （機械連結器＋ｽｳｨﾝｸﾞﾃﾞﾊﾞｲｽ）
02								

購

【適用】
本スペックは，マカオ LRT East Line　Backup Access Vehicle (BAV) 向け
連結装置（自動連結器（機械連結器））に適用する.

【内容】
連結装置の設計・製作に関わる要求は次々ページ以降を参照のこと.

【提出図書】
次ページの提出図書リストを参照のこと.

【特記事項】
機器重量を見積と合わせて必ず提示のこと.

【納入場所】
三菱重工業株式会社
車両部　車両事業統括課　和田沖工場　08 検収場
〒723-0042　広島県三原市和田沖町 1 番 1 号

符号	理由	日付	承認	点検	作成

リスト規制技術　□該当　☑非該当

交通製品

重要部品

経歴：83-97124 マカオ APM 車両 連結装置，83-97201 マカオ MRV 連結装置

参考図書：

調達	
車設セ	
三原品証	
W 機品	
車両工	
車両組	
車両板	
TC 車設	
物流	
控	
合計	

	分類	客先	工事	製品	キーワード
1					
2					
3					
4					

三原技 9 号

提出図書リスト （必要事項を ✓ で記入する）

番号	提出図書	見積時提出図書 用語 和	見積時提出図書 用語 英	見積時提出図書 種別	見積時提出図書 部数	見積時提出図書 提出期限	契約後提出図書 用語 和	契約後提出図書 用語 英	契約後提出図書 種別	契約後提出図書 部数	契約後提出図書 提出期限	備考
1	仕様書		✓	A	1	'23.9.22		✓	A	1	契約後２週間	
2	見積書 ①		✓	A	1	↑		✓	A	1	契約後２週間	
3	カタログ											
4	製作実績表											
5	確認図 ② （ (1) (2) (4) ）		✓	A C	1 1	↑		✓	A C	1 1	契約後 ２週間	質量を必ず明記すること.
6	性能予想曲線及び計算書											
7	強度計算書		✓	A	1	↑		✓	A	1	契約後２週間	
8	ローディングデータ ③											
9	構成部品リスト（ ） ⑧							✓	A	1	契約後２週間	
10	潤滑油リスト ④							✓	A	1	契約後２週間	
11	予備品リスト ⑦							✓	A	1	契約後２週間	
12	付属工具リスト							✓	A	1	契約後２週間	
13	付属品リスト							✓	A	1	契約後２週間	
14	供給品リスト							✓	A	1	契約後２週間	
15	梱包リスト ⑤							✓	A	1	発送の２ヶ月前	
16	据付組立要領書											
17	取扱説明書							✓	A	1	納入後１週間	
18	試験・検査要領書							✓	A	1	納入の３週間前	
19	試験・検査成績書							✓	A	1	納入後 １週間	実測質量を明記のこと.
20	立会検査申請書							✓	A	1	立会の１ヶ月前	
21	立会検査要領書							✓	A	1	立会の１ヶ月前	
22	検査証明書							✓	A	1	納入後１週間	
23	輸出検査証明書											
24	防爆電気機器合格証明書											
25	設計・製作工程表											
26	船積予定表							✓	A	1	発送の２ヶ月前	
27	輸送要領書							✓	A	1	契約後２週間	
28	単線結線図											
29	総合接続図											
30	内部接続図											
31	展開接続図											
32	計器特性曲線											
33	器差表，器差曲線											
34	調節弁計算書及び特性曲線											
35	オリフィス計算書及び補正曲線											
36	打合せ記録							✓	A	1	都度	
37	安全設計実施報告書 ⑨											
38	製作・設計進捗状況報告書											
39	本スペックにて提出を要請した資料		✓	A	1	↑		✓	A	1	都度	

備考 1. 電動機試験成績書は当所に提出するほか，現品にも１部添付のこと.

注 ① 構成機器の単価を明示すること．予備品（含消耗品），特殊工具，据付指導員費についても項目毎の金額とその内容を明示すること.

② 確認図の種類 (1) 外形図 (2) 構造断面図 (3) 付属配管図 (4) 部品図 (5) 標準図等を記入する.
なお，外形図には外形寸法，質量を，構造断面図には構造及び，据付，配管，運転，保守等に必要なるものを明記のこと.
（主要部材質含）

③ 製品質量（kg），満水質量（kg），基礎ボルト寸法，重心位置等明記のこと.

④ 潤滑油種類，銘柄，初期交換量（ℓ）明記のこと.

⑤ 梱包容積（m3），梱包質量（kg）明記のこと.

⑥ 種別記号 A：最終図はメーカ側のコピーにて提出.
B：最終図は当所指定原紙にて提出.
C：最終図はフロッピーディスク又は，CD-ROM で提出.

⑦ 構造，据付，配管，運転，保守等に必要なるものを明記のこと．（主要部材質型番）

⑧ モータ,ベアリング等必要に応じて（ ）に記入のこと.

⑨ MSL0-211 参照のこと.

三菱重工業株式会社

PURCHASE SPECIFICATION

FOR

COUPLER

(for Backup Access Vehicle)

交通製品

		—	06 SEP 2023	First issue	Signed below	Signed below	Signed below
		Rev.	DATE	DESCRIPTION	DWN	CHK'D	APP'D
01					DESIGN SECTION		
ORDER No.		REVISIONS					

DESIGN SECTION		CUSTOMER	
APPROVED		Direcção dos Serviços de Obras Públicas (DSOP)	
CHECKED		PROJECT	REV.
DRAWN	m. Shirayama	Macau LRT East Line	
DATE	6th September 2023	DWG. NO.	
		83-99139	FI
Q/A SECTION		CAREER:	

MITSUBISHI HEAVY INDUSTRIES, LTD.

Table of Contents

List of Appendices

1. SCOPE OF SUPPLY AND WORKS

1.1 Scope of Application

This specification covers the technical requirements for the design, manufacturing, inspection and tests of the Goods for Backup Access Vehicle.

The Seller shall design the Goods in accordance with all the requirements stated in this document.

1.2 Definitions and Abbreviations

In this purchase specification, following definitions are always adopted.

1) The word "Buyer" shall mean MITSUBISHI HEAVY INDUSTRIES, LTD.
2) The word "Seller" shall mean the company with whom the Order is placed.
3) The word "Owner" shall mean the employer of this APM system.
4) The word "Goods" shall mean the plant, equipment, machinery, materials or parts thereof, and related services to be purchased by the Buyer.
5) The word "Order" shall mean the purchasing order placed by the Buyer for the supply of the Goods.
6) The word "Contract" shall mean the purchasing agreement to be entered into by and between the Buyer and the Seller.
7) The word "Site" shall mean the location where the APM system is installed. Consequently, for example, "Site test" shall mean all kinds of tests conducted at the Site.

In this purchase specification, following abbreviations are always adopted.

APM:	Automated People Mover
ATO:	Automatic Train Operation
BAV:	Backup Access Vehicle
EMC:	Electro Magnetic Compatibility
FMECA:	Failure Modes, Effects and Criticality Analysis
FRACAS:	Failure Reporting, Analysis and Corrective Action System
LRU:	Line Replaceable Unit
LLRU:	Lowest Level Replaceable Units
MKBF:	Mean Kilometre between Failures
MMIS:	Maintenance Management Information System
MTBF:	Mean Time between Failures
MTTR:	Mean Time to Restore
O&M:	Operation & maintenance
RAM:	Reliability, Availability and Maintainability
RAMS:	Reliability, Availability, Maintainability and Safety

1.3 Scope of Supply

The Seller shall supply complete sets of the Automatic Couplers as shown in Table 3.1. See Clause 3. All cables and connectors are in the Seller's scope of supply. In addition, complete sets of the connectors for the carbody side shall also be in the Seller's scope of supply.

Mounting location of Goods and definition of numeration is shown in Figure 1.1. It is in the Seller's scope to design the Automatic Coupler in a well integrated and coordinated manner.

The Seller shall supply full set of documents as requested in this document.

For interface discussions purpose, the Seller shall provide three-dimensional CAD data in a CATIA-compatible format whenever requested by the Buyer.

The Seller shall supply all the spare parts that are listed on the List of Spare Parts. The List of Spare Parts refers to Clause 8.3.

The Seller shall provide a full set of training as requested in Clause 8.4.

The Seller shall supply all the tools that are listed on the Tools' Catalogue. The Tools' Catalogue refers to Clause 8.5.

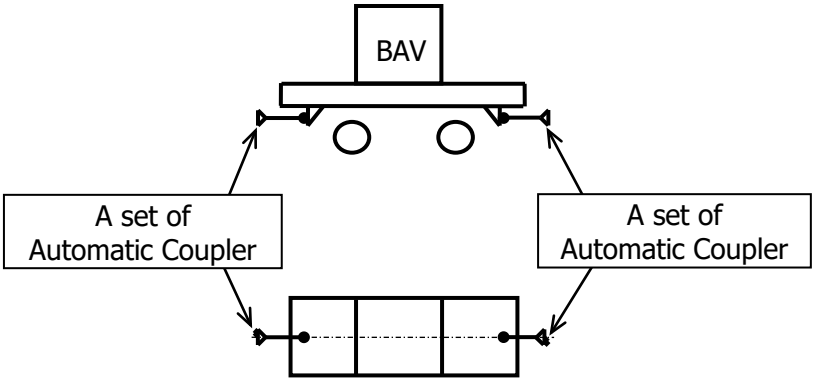


Figure 1.1 Mounting Location of Goods and Definition of Numeration for BAV

1.4 Spare Parts

In addition to the Spare Parts mentioned in Clause 8.3, the Seller shall provide his estimated lists and price quotations of additional spare parts, required in the period of the first 5 years and the second 5 years (i.e. sixth (6th) year through tenth (10th) year), in accordance with the Maintenance Plan mentioned in Clause 8.1.1, for the Buyer's acceptance.

1.5 Equipment/Parts Supplied by Buyer

Nothing

1.6 Scope of Works

Scope of works of the Seller shall include the following items, but not limited to:

(1) Design,
(2) Supply of materials,
(3) Manufacture,
(4) Painting,
(5) Inspection & test,
(6) Packing,
(7) Delivery,
(8) Submittal of documents, and
(9) Training.

2. REFERENCES

Where it is agreed to use a specification, which are not shown in this document, then these shall be in accordance with the latest edition or the specified edition of the listed documents and standards.

In case of conflict among the reference documents below, the Seller shall inform the Buyer.

2.1 Contractual Documents

The Seller shall refer to the following documents.

1) The Owner's specification documents as appended.

2) General Contract

a)	Instruction to Tenderers	To be announced
b)	Technical Requirement	To be announced
c)	General Terms and Conditions	To be announced

3) QA/QC Requirements	X00-90-877 (including appendices) Note: Old document number; CP-9-077S
4) General Inspection Specification	GM-12502
5) Shipping Procedure	GM-12574

2.2 Applicable Codes & Standards

Where it is agreed to use a specification, which are not shown in this document, then these shall be in accordance with the latest edition or the specified edition of the documents and standards listed in Table 2.1.

Table 2.1 List of Applicable Codes and Standards

»	ANSI Z535.1	Safety Color Code
»	ANSI Z535.2	Environmental and Facility Safety Signs
»	ANSI Z535.3	Criteria for Safety Symbols
»	ANSI Z535.4	Product Safety Signs and Labels
»	ANSI Z535.5	Accident Prevention Tags (for Temporary Hazards)
»	ANSI/ASCE/T&DI 21-21	Automated People Mover Standards
»	EN 13306	Maintenance - Maintenance terminology
»	EN 15085	Railway applications - Welding of railway vehicles and components
»	EN 50121-3-2	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus
»	EN 50126	Railway Applications - The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
»	EN 50128	Railway Applications - Communication, signalling and processing systems - software for railway control and protection systems
»	EN 50129	Railway Applications - Communication, signalling and processing systems - safety related electronic systems for signalling
»	EN 50133	Alarm systems - Access control systems for use in security applications
»	EN 50238	Railway applications - Compatibility between rolling stock and train detection systems
»	EN 50343	Railway applications - Rolling stock - Rules for installation of cabling
»	EN 60077-2	Railway applications - Electric equipment for rolling stock - Part 2: Electrotechnical components - General rules
»	EN 60352	Solderless connections
»	EN 60529	Degrees of protection provided by enclosures (IP code)
»	EN 61033	Test methods for the determination of bond strength of impregnating agents to an enamelled wire substrate
»	EN 61034	Measurement of smoke density of cables burning under defined conditions
»	IEEE 1478	Environmental Conditions for Transit Rail Car Electronic Equipment
»	ISO 272	Fasteners - Width across Flats for Hexagon Products
»	ISO 1459	Metallic coatings - Protection against corrosion by hot dip galvanizing - Guiding principles
»	ISO 1460	Metallic coatings - Hot dip galvanized coatings on ferrous Gravimetric determination of the mass per unit area
»	ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
»	MIL STD 461 E	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
»	NF F 61030	Electrical connectors Generalities
»	NF F 61032	Electrical connectors Type with float mounting
»	NFPA 130	National Fire Protection Association - Standard for Fixed Guideway Transit and Passenger Rail Systems
»	UTE C15-105	Determination of cross-sectional area of conductors and selection of protective devices – practical methods

2.3 Priority of Document

In case of conflict among the documents, the priority of document shall be as follows:

1) The Letter of Acceptance
2) This specification
3) General Contract
4) The Owner's Specifications

If there is a disagreement or difference between 1), 2), 3) and 4), the Seller shall inform the Buyer.

2.4 Language and Unit

Language and unit that are used for the Goods (including all documents) shall be as follows, except the manuals and the as-built drawings:

Language: English
Unit: SI unit (metric unit)

For the manuals and as-built drawings, the language and unit shall be as follows:

Language: English
Unit: SI unit (metric unit)

3. DELIVERY CONDITIONS

Delivery schedule is indicated in Table 3.1. The Seller shall deliver the Goods in accordance with this delivery schedule. Definition of numeration shall be in accordance with Figure 1.1.
The delivery due date stated in Table 3.1 is the arrival due date at Mihara.

The Seller shall submit complete sets of packing procedure for the Buyer's acceptance.
The Seller shall also submit packing list for the Buyer's acceptance.

Delivery Place:
Nearest international port (to be proposed by the Seller at the Bid)

Terms of Delivery:
FOB (export packing is in the Seller's scope)

Packing List:
To be submitted Profoma Packing List prior to delivery by the Seller at the Buyer's request.

Packing Procedure:
The Seller shall pack, mark, and protect the Goods in accordance with the Shipping Instruction of the Buyer in order to forestall any loss or damage to the Goods during transport, and in absence of specific instruction concerning the method of packing in the Shipping Instruction, the Seller shall, in accordance with customary seaworthy export packing standards and anti-rust standards, take all reasonable steps to prevent damage to or deterioration of the Goods during transport.

Table 3.1 Delivery Schedule

Item No.	Name	Quantity	Delivery due date (arrival at Mihara)	Remarks
01	Automatic Coupler (Mechanical coupler and swing device)	8 sets	25th November 2026	For 4 units Backup Access Vehicle

4. GUARANTEE PERIOD

The Seller guarantees and warrants that the Goods are free from any defects.

The guarantee period shall count from the date of issue and signature of the Provisional Acceptance Certificate, on the condition of it being homologated by the Owner.

The guarantee of the Goods shall finish after an effective period of service of five (5) years from the date the Provisional Acceptance Certificate is homologated by the Owner.

However, regardless of the above conditions, the Seller shall always be responsible in connection with the Goods in the event that the cause of the defects in the Goods is the acts, omissions deliberateness and gross negligence.

In case any component of the Goods shows to have, during the guarantee period, a MTBF shorter than the one stated in the RAM Studies for them, the Guarantee Period may be extended until a normal behaviour of operation is achieved. In these situations, replacement of these pieces of component shall always be considered the first solution.

The Seller shall make available renewed, repaired, and replacement parts for the Buyer at fair and reasonable price for a period not less than fifteen (15) years after start of the guarantee period.

5. QUALITY ASSURANCE (QA) / QUALITY CONTROL (QC) REQUIREMENT

5.1 Quality Requirement

The QA/QC requirements are specified in the "Mitsubishi Transportation Quality Assurance Specifications" X00-90-877. The Seller shall meet the requirements in this document.

5.2 QA/QC System

5.2.1 Requirement of Submission / Approval of QA/QC Program

Qualification manual of the Seller shall be submitted at the Bid.

5.2.2 Suitable Qualification System and Standard for Control

Qualification control shall be based on ISO 9000 series.

5.3 Authority On-The-Spot Inspection

If the Buyer and/or the Owner require on-the-spot inspection such as described hereunder, the Seller shall accept it and enable free access to the Seller's and their subcontractors' facilities.

a. Audit / survey based on QA / QC manual
b. Inspection, investigation, examination, presentation of qualification data and expedition based on qualification manual
c. Implementation of expedite
d. Cooperation on-the-spot inspection
e. On-the-spot inspection by the Buyer, the Owner and/or third party

5.4 Procedure for Manufacturing

5.4.1 General

5.4.1.1 Approval of Schedule of Manufacturing
Schedule of manufacturing shall be submitted at the Bid.

5.4.1.2 Submission of Progress Report for Manufacturing
Progress report shall be submitted monthly after the Contract.

5.4.1.3 Approval of Procedure for Manufacturing
Procedure for manufacturing shall be submitted at the Contract.

5.4.2 Special Manufacturing Process

5.4.2.1 Approval of Welding Procedure
If welding is used for products, welding procedure shall be submitted.
All welding shall be in accordance with American Welding Society Structural Welding Code: ANSI/AWS D1.1 for steel and ANSI/AWS D1.2 for Aluminium.

5.4.2.2 Approval of Welding Engineer
If welding is used for products, welding license shall be submitted.

5.4.2.3 – Reserved

5.4.3 Subcontracting

5.4.3.1 Responsibility and Obligation for Subcontracting
The Seller shall take the responsibility for claim and objection from subcontractor.

5.4.3.2 Submission of List of Subcontractors
List of subcontractors shall be submitted at the Contract.

5.4.3.3 On-the-Spot Inspection in Subcontractors
If the Buyer and/or the Owner require on-the-spot inspection in subcontractor, the Seller shall accept it and ensure free access to their facilities.

5.5 Test and Inspection

5.5.1 Approval of Program/Procedure for Test·Inspection and Criteria

Program/procedure for test and inspection and criteria for them shall be submitted at the Contract.

5.5.2 – Reserved

5.5.3 Specified Items of Test and Inspection with Witness (including Inspection for Shipping)

The standard inspection and test procedure shall be submitted by Seller for the Buyer's acceptance. The Seller shall obtain acceptance by the Buyer before the witness inspection.

5.5.4 – Reserved

5.5.5 Application for On-the-Spot Inspection/Test

If the Buyer and/or the Owner require on-the-spot inspection and/or test, the Seller shall accept it and enable free access to the Seller's and their subcontractors' facilities.

5.5.6 – Reserved

5.5.7 – Reserved

5.5.8 Change/Addition of Test/Inspection

If there is a change and/or addition of test and inspection, the Seller shall report to the Buyer.

5.6 Non Conformation

5.6.1 Obligation for Non Conformation Report

If the Seller's specification does not conform to this specification, the Seller shall submit the non-conformance report.

5.6.2 Method of the Changing/Modification for Non Conformation

Method of the changing/modification for non-conformation shall be proposed by the Seller for the Buyer's acceptance.

5.7 Quality Record

5.7.1 Items of Quality Record

Items of quality record by the Seller's standard shall be submitted at the Contract.

5.7.2 Number of Copies of Submission and Due Date

Number of Copies shall be 3 sets. Due date shall be at the Contract.

5.7.3 Keeping of Quality Record

Keeping of quality records shall be arrangement with the Seller and the Buyer.

5.8 Special Requirement for APM System

If at least one of the following works is carried out by subcontractor, the Seller shall inform beforehand:

a. Forging or casting,
b. Welding,
c. Heat treatment, and
d. Plating or special painting

If the Buyer and/or the Owner require on-the-spot inspection and check up on the condition of quality control in subcontractor's facility, the Buyer shall arrange free access to the subcontractor's facility for the Buyer and/or the Owner.

6. DOCUMENT SUBMISSION BY THE SELLER

6.1 Format of Submission

Regarding the CAD data, which is necessary for discussions between the Seller and the Buyer (e.g. CAD data for mounting interface coordination), the Seller shall provide the CAD data both in AutoCAD-compatible format (two-dimensional data) and CATIA-compatible format (three-dimensional data).

For the documents, other than the CAD data, the Seller shall provide all in the following formats:

- » Hard copy (for official record, 3 copies unless otherwise specified),
- » Soft copy in PDF format (for easy transportation, electronic distribution, quick reference, etc.), and
- » Soft copy in an editable format (i.e. in the format of the original software, the one before converted to PDF format) (for possible modifications by the Buyer for submission to the Owner).

6.2 Submission at Bid

The Seller shall submit complete set of the documents listed on Table 6.1 in addition to those required by "Instruction to Bidders".
Regarding the formats of the submission, the Seller shall comply with Clause 6.1.

Table 6.1 List of Document to Be Submitted by Seller at Bid

No.	Items	Language	Reference Clause	Due date
01	Lists of price quotations of spare parts required in the period of the first 5 years	E	1.4	At Bid
02	Lists of price quotations of spare parts required in the period of the second 5 years	E	1.4	At Bid
03	Delivery schedule and delivery place (international port)	E	3	At Bid
04	Qualification manual	E	5.2.1	At Bid
05	Schedule of manufacturing	E	5.4.1	At Bid
06	Sample of Factory Test and Inspection Plan	E	5.5.1	At Bid
07	Sample of Maintenance Plan	E	8.1.1	At Bid
08	Sample of Maintenance Manual	E	8.1.4.1	At Bid
09	Sample of List of Spare Parts	E	8.3.4.1	At Bid
10	Proposal specification	E	10.1	At Bid
11	Interface drawings with mass	E	10.1	At Bid
12	Collision analysis	E	10.9	At Bid
15	Fire load calculation	E	15	At Bid
16	Heat load calculation	E	15	At Bid

Note: 1. Regarding language and unit to be used, see Clause 2.4. E and C represent English and Chinese, respectively.
2. 2D drawings shall be in accordance with third angle method.
3. Regarding the format of the submission, see Clause 6.1.

6.3 Submission after Contract

Documents to be submitted by the Seller after the Contract are listed on Table 6.2 through Table 6.4. The Seller shall submit complete set of each document in accordance with Table 6.2 through Table 6.4, for the Buyer's acceptance.

Table 6.2 List of Document to Be Submitted by Seller after Contract (Part 1 of 3)

No.	Items	Language	Reference Clause	Due date
3a	Packing procedure	E	3	The Seller shall obtain acceptance by the Buyer 2 months before the first shipment
3b	Packing list	E	3	2 months before every shipment
5a	Progress report	E	5.4.1.2	Every month after the Contract
5b	Procedure of manufacturing	E	5.4.1.3	2 weeks after the Contract
5c	Welding procedure and (if applicable)	E	5.4.2.1	1 month after the Contract
5d	Welding licence (if applicable)	E	5.4.2.2	1 month after the Contract
5e	List of subcontractors	E	5.4.3.2	1 month after the Contract
5f	Factory Test and Inspection Plan	E	5.5.1	The Seller shall obtain acceptance by the Buyer 2 months before test or inspection
5g	Factory Inspection Procedure	E	5.5.1	The Seller shall obtain acceptance by the Buyer 2 months before inspection
5h	Factory Inspection Report	E	5.5.1	2 weeks after inspection
5j	Factory Test Procedure	E	5.5.1	The Seller shall obtain acceptance by the Buyer 2 months before test
5k	Factory test Report	E	5.5.1	2 weeks after test
5m	Standard inspection and test procedure	E	5.5.3	The Seller shall obtain acceptance by the Buyer 2 months before inspection and test
5n	Method of the changing/modification for non-conformation	E	5.6.2	1 month after the Contract
5p	Items of quality record by the Seller's standard	E	5.7.1	1 month after the Contract
7a	RAM Studies	E	7	1 month after the Contract
7b	Simulated 5500 cycles operation test procedure	E	7.2	The Seller shall obtain acceptance by the Buyer 2 months before test
7c	Simulated 5500 cycles operation test report	E	7.2	2 weeks after test

Note: 1. Regarding language and unit to be used, see Clause 2.4. E and C represent English and Chinese, respectively.
2. 2D drawings shall be in accordance with third angle method.
3. Regarding the format of the submission, see Clause 6.1.

Table 6.3 List of Document to Be Submitted by Seller after Contract (Part 2 of 3)

No.	Items	Language	Reference Clause	Due date
8a	Maintenance Plan	E	8.1.1	2 months after the Contract
8b	Capital Assets Replacement Plan	E	8.1.2	2 months after the Contract
8c	System User Manual	E	8.1.3	2 months before the first shipment
8d	Maintenance Manual	E	8.1.4.1	2 months before the first shipment
8e	Special tools User manuals	E	8.1.4.2	2 months before the first shipment
8f	Storage Manuals	E	8.1.4.3	2 months before the first shipment
8g	Handling Manuals	E	8.1.4.4	2 months before the first shipment
8h	Delivery Acceptance Manuals	E	8.1.4.5	2 months before the first shipment
8j	Cables and Wiring Database	E	8.1.4.6	2 months before the first shipment
8k	Assembly Tools Documentation	E	8.1.5	2 months before the first shipment
8m	Technical Database Files	E	8.2	2 months before the first shipment
8n	List of Spare Parts	E	8.3.4.1	2 months before the first shipment
8p	Spare Parts Justification Report	E	8.3.4.2	At the first shipment
8q	Spare Parts Follow up Report	E	8.3.4.3	Every 2 months after start of train operation
8r	Training and Qualification Plan	E	8.4.2	2 months after the Contract
8s	Training Material	E	8.4.2	The Seller shall obtain acceptance by the Buyer 2 months before training
8t	Engineering Training Program	E	8.4.3	2 weeks after the Contract
8u	Tools' Catalogue	E	8.5.4	2 months before the first shipment
8v	As-built Drawing	E	8.6	2 months before the first shipment

Note: 1. Regarding language and unit to be used, see Clause 2.4. E and C represent English and Chinese, respectively.
2. 2D drawings shall be in accordance with third angle method.
3. Regarding the format of the submission, see Clause 6.1.

Table 6.4 List of Document to Be Submitted by Seller after Contract (Part 3 of 3)

No.	Items	Language	Reference Clause	Due date
10a	Specification documents	E	10.1	2 weeks after the Contract
10b	Complete set of drawings with mass	E	10.1	2 weeks after the Contract
10c	Wiring diagram	E	10.1	2 weeks after the Contract
10d	Piping diagram	E	10.1	2 weeks after the Contract
10e	Structural calculation	E	10.1	2 weeks after the Contract
10f	Instruction documents and drawing for installation to car	E	10.2	2 weeks after the Contract
10h	Collision analysis	E	10.9	2 weeks after the Contract
11a	Watertightness Test Procedure	E	11	The Seller shall obtain acceptance by the Buyer 2 months before test
11b	Watertightness Test Report	E	11	2 weeks after test
12a	Selection and Justification of Cable	E	12.2	1 month after the Contract
12b	Selection and Justification of Circuit Breaker and Current Interrupter	E	12.3	1 month after the Contract
12c	Insulation Test Procedure	E	12.6	The Seller shall obtain acceptance by the Buyer 2 months before test
12d	Insulation Test Report	E	12.6	2 weeks after test
12e	Dielectric Test Procedure	E	12.6	The Seller shall obtain acceptance by the Buyer 2 months before test
12f	Dielectric Test Report	E	12.6	2 weeks after test
12g	EMC Test Procedure	E	12.7	The Seller shall obtain acceptance by the Buyer 2 months before test
12h	EMC Test Report	E	12.7	2 weeks after test
14a	Vibration and Shock Test Procedure	E	14	The Seller shall obtain acceptance by the Buyer 2 months before test
14b	Vibration and Shock Test Report	E	14	2 weeks after test
15a	Fire load calculation	E	15	2 months after the Contract
15b	Heat load calculation	E	15	2 months after the Contract

Note: 1. Regarding language and unit to be used, see Clause 2.4. E and C represent English and Chinese, respectively.
2. 2D drawings shall be in accordance with third angle method.
3. Regarding the format of the submission, see Clause 6.1.

7. RAM REQUIREMENTS

7.1 Service Availability

The Service Availability of the Goods shall be 99.998 % or more.

7.2 Design Life

Entire design life of the Goods shall be 30 years or more, or 5500 times of switching ON and OFF operation cycles, whichever is later, after start of commercial service of the train, with satisfying the requirements in this document without failure with adequate maintenance in accordance with the Maintenance Plan mentioned in Clause 8.1.1.

The Seller shall demonstrate that, by means of simulated life cycle testing, no failure occurs for a minimum of 5500 times of switching ON and OFF operation cycles.

7.3 Maintainability Requirements

The design of the Goods shall take into account the following requirements regarding the maintainability.

7.3.1 Maintenance Interval

The preventive maintenance intervals of vehicle are three (3) days, three (3) months and one (1) year. And intervals of semi-overhaul and overhaul of vehicle is four (4) years and eight (8) years, respectively. The Seller shall propose a maintenance schedule accordingly, for the Buyer's acceptance.

Overhaul cycle, necessary to maintain the required specification of the Goods, shall be 8 years or more, whilst semi-overhaul at every 4 years is accepted.
List of consumable parts shall be submitted by the Seller.

7.3.2 Failure Diagnosis

The Goods shall inform the vehicle control system of any failure, dysfunction or disrupting event that could occurs on the Goods. The understanding of diagnosis data by the O&M personnel shall be of a simple nature and shall not require any specific expertise of the system.
Diagnosis data shall indicate which LRU/s are suspected as responsible of the detected failure.
Maintenance documentation shall support O&M personnel for diagnosis data interpretation. A link between the maintenance documentation and diagnosis data shall be established.
The Seller shall identify each LRU with tags containing the following data: name, serial number and part number.
The Seller shall identify with tags: cables, connectors, relay, switches, fuses, circuit breakers, test spots as well as any devices that the O&M personnel should have to manipulate.
The whole process of identification of the failed LRU shall not exceed 15 minutes. The identification process represents the diagnosis time and does not include logistic time.
This time include all troubleshooting operations, including identification of failed piece of equipment within the system and the identification of the failed LRU within the failed piece of equipment.

7.3.3 O&M Personnel

Maintenance procedures shall need only one O&M personnel for 90% of cases of occurrence and two (2) O&M personnel for the remaining cases.

7.3.4 Maintenance Operations

The Seller shall specify, for each LRU, the mean time needed to recover to a normal operation configuration (i.e. Mean Time to Restore or MTTR). The Seller shall specify the estimated value for which 90% of these recovery times are lower.
The possibility of disassembly of each LRU shall not interfere with other LRUs.
The Seller shall design the Goods in order to allow easy cleaning operations. For equipment interfaced with the Public, the Seller shall design solutions and typologies of materials that minimise cleaning operations and damage repairs.
The access for removal and installation of LRUs and LLRUs shall be simple and fast.
Accessibility to test and diagnose interfaces, to event recorders shall be effortless.
Their access shall be designed and located accordingly.

7.3.5 Handling

LRUs shall not weigh more than 25 kg if to be moved by only one person or no more than 50 kg if to be moved by two persons. If the weight of any LRU exceeds the expected value, the Seller shall provide specific handling tools as a part of the Tools mentioned in Clause 8.5.
The Seller shall equip each piece of equipment to be handled by handling and anchoring supports.
The Seller shall design pieces of equipment robust enough to support successive removals and assembly in the workshop.

7.3.6 General maintenance requirements

The Seller shall consider the realistic logistical times in the recovery time calculations of the RAM predictions studies.
The Seller shall define in the maintainability prediction studies, the unavailability and maintainability times of each failure of the Goods. The Seller shall perform all tests that the Buyer shall require before and after the revenue service, in order to control the times defined by the Seller. If the times measured during the tests are higher than the times defined by the Seller, the Seller shall update the RAM Studies.
In case of an abnormal situation, if the time needed by the O&M party to recover is higher than the one defined in the prediction studies and the Seller demonstrates that the required recovery time should have been lower, then the responsibility of the Seller is limited. This responsibility is the part of unavailability corresponding to the demonstrated necessary time to recover.

7.4 Responsibility of the Seller

7.4.1 Use of Spare Parts

Spare Parts should be used for their original purpose only, but the O&M party shall use any available spare parts to assure the required level of service.
Nevertheless, the Contractual Quality of Service shall be revised considering the following principles.

The Service Availability shall be revised as if the number of the Goods unavailable for preventive maintenance reasons was never lower than the number of the Goods for spare defined for preventive maintenance purpose. The purpose of this requirement is to avoid an unrealistic improvement of the Service Availability during periods where the preventive maintenance workload does not need to immobilise the whole quantity of the Goods for preventive maintenance spare.
The Service Availability shall be revised as if the number of the Goods unavailable for corrective maintenance reasons was always equal to the number of the Goods for spare defined for corrective maintenance purpose. The purpose of this requirement is to avoid an unrealistic value of the Service Availability during periods where the corrective maintenance workload needs to immobilise more or less of the Goods than the Goods for corrective maintenance spare. This requirement does not apply to the Goods damaged by a failure of the other system.

7.4.2 External Events

The impact of the following events shall be cancelled:

- Force majeure,
- Environmental conditions outside of the environmental specification,
- Impact of requests from the Owner or Emergency Services for events not related to the APM system,
- Acts of terrorism and acts of war,
- Acts of vandalism,
- Wrongful suspension or operation of the APM system by the O&M party, and
- Overrun of maintenance times, unless for maintenance performed by the Seller.

7.4.3 Quality of Service Achievement

During the whole Defect Notification Period, should one or several of the Quality of Service criteria not be achieved for reasons under the responsibility of the Seller, the Seller shall improve the Goods by modifications of software, material, or procedures until the Goods meet all the requirements. In this case, no extension of guarantee is foreseen nevertheless the Seller shall be fined according to the Contract.

7.5 RAM Studies

7.5.1 Reference Documentation

The Seller shall comply with the following reference documents:

- » CEI 62278 / EN 50126: Railway Applications - The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
- » CEI 62279 / EN 50128: Railway Applications - Communication, signalling and processing systems - software for railway control and protection systems
- » CEI 62425 / EN 50129: Railway Applications - Communication, signalling and processing systems - safety related electronic systems for signalling

The Seller shall submit a complete set of RAM Studies to respond to the requirements in this clause, for the Buyer's acceptance.

7.5.2 Responsibilities of the Seller

This clause describes the responsibilities of the Seller related to RAM activities.
The Seller shall supply the Goods that fulfil the specified requirements during the required design lifetime, considering that the O&M conditions are complied with.
In order to ensure that the RAM specifications and objectives are satisfied, the Seller shall:

- » Define RAM objectives for each sub-system of the Goods,
- » Define a RAM organization,
- » Define the general RAM specification and the tasks related to this activity,
- » Coordinate and control the RAM activities inside its organisation and manage the interfaces between the different sub-systems,
- » Define the operating specifications and recommendations, as well as the maintenance policy that the O&M party has to comply with to achieve the specified performances. These operating rules and maintenance policies shall be relevant and realistic, and shall be compliant with the Maintenance Plan,
- » Define the O&M work charges for the O&M party,
- » Define the tools, methods and processes to measure the RAM performances,
- » Ensure monitoring of the RAM performance of the Goods until the end of the Defect Notification Period, and
- » Perform a quantified RAM synthesis which presents performed tasks, achieved objectives and RAM performances.

Therefore, the Seller shall satisfy the following RAM requirements.

7.5.3 RAM Activities

The Seller shall perform the following RAM activities as a minimum:

- » RAM plan describing how the Seller intends to evaluate, build, demonstrate and ensure that the Goods shall reach the RAM requirements during the whole life span of the Goods,
- » The operating rules to respect in order to reach the specified performances, and
- » Maintenance Plan.

The Seller shall consider, in RAM Studies, hardware failures and software failures.
All RAM Studies shall be consistent with the Maintenance Plan and the RAM Plan.
The following clauses specify the minimum and non-exhaustive list of the RAM tasks that the Seller shall carry out to achieve the RAM requirements.

7.5.3.1 RAM tasks at system level

a. RAM plan

The RAM plan shall cover the design, development, manufacture, test, installation, commissioning, and operation phases of the APM system.
The RAM Plan shall define the process for the specification, verification and control of the reliability, availability, maintainability and operability requirements for the Goods. It shall describe in particular:

a1. The retained RAM and operability approach,
a2. The management of the RAM and operability activities,
a3. Task listing and time phasing for each task related to these activities,
a4. List of RAM and operability documents to be produced,
a5. The description of RAM and operability analysis methods and tools to be used during the design and development of the Goods, and
a6. The description of the method of verification.

The RAM plan shall address how the Seller shall monitor the contractual performance of the Goods, on a technical basis and for each purpose of the performance monitoring.

It shall address at least the following items:

a7. Contractual and technical performances criterions to be monitored,
a8. Definition of each criterion,
a9. Means and procedures for measurement of each criterion,
a10. Templates for performances reports, and
a11. Performance reports acceptance process.

The Seller shall define in the RAM plan a RAM methodology that respects the CEI 62278 / EN 50126.

b. FMECA

The Seller shall carry out a FMECA for the Goods. The purpose of this FMECA is to analyse the effects of each failure on the Goods, from the point of view of the Quality of Service, of the O&M. The objective is to determine the reliability, availability and maintainability critical items, determine the applicable requirements for each item of equipment or sub-system and highlight the most critical elements (elements whose product of probability of failure by recovery time exceeds a threshold to be defined by the Seller).
The Seller shall use a common FMECA table for the RAM analysis. The Seller shall use a model reviewed by the Buyer.

For each sub-system of the Goods, the Seller shall describe the following items:

b1. List of the modes of failure,
b2. Description of their effects on the Quality of Service, on O&M
b3. Their criticality level,
b4. Applicable availability or maintainability requirements, and
b5. For the most critical items, requirements, procedures and recommendations about the design, construction, operation and maintenance, in order to improve reliability, availability and/or reduce recovery times.

The criticality levels shall be grouped in categories that shall be reviewed by the Buyer.

c. RAM assessment

The Seller shall perform RAM assessment and report that shall demonstrate the achievement of the RAM requirements of the Goods.
The Seller shall develop procedures and performance analysis routines to confirm that the Goods achieve the RAM performances.
The Seller shall estimate the RAM performances of the Goods taking into account:

c1. The reliability and maintainability predictions performed for all sub-systems,
c2. The RAM studies performed at the level of the Goods,
c3. The Maintenance Plan, and
c4. Any other factor that could have any impact on RAM performances.

The Seller shall use an adapted methodology as reliability block diagrams to explain demonstrations.

d. RAM reviews

The Seller shall carry out RAM reviews after designing phase on an on-going basis and at the Buyer's request.

The aim of RAM review is to assess the conclusions of the RAM tasks in order to:

d1. Estimate whether the RAM requirements have been correctly taken into account,
d2. Identify the consequences of these conclusions on the remaining RAM tasks,
d3. Identify the consequences of these conclusions on the design, and
d4. Any potential concern shall be identified as soon as possible and tracked for remedial action

During these reviews, the Seller shall pay particular attention to changes that may affect earlier decisions.

e. FRACAS

The Seller shall provide FRACAS software for the Goods. The purpose of this is to report, classify, and analyse failures and then plan corrective actions in response to field failures. It produces a history of failure and corrective action. The objective is to have, among others, for each sub-system:

e1. Field MTBF,
e2. MTTR,
e3. Spare consumption,
e4. Reliability growth,
e5. Failure type and location, and
e6. Etc.

7.5.3.2 RAM tasks at sub-system level

a. FMECA

The Seller shall carry out FMECA for each sub-system.

The purpose of the FMECA is to analyse the possible effects of each failure on the Goods, from the point of view of reliability, availability and maintainability and highlight the most critical elements (elements whose product of probability of failure by recovery time exceeds a threshold to be defined by the Seller).

The Seller shall use a common FMECA table for the RAM analysis. The Seller shall use a model reviewed by the Buyer. This model shall include for each sub-system:

a1. LRUs or LLRUs making up the sub-system and which may fail,
a2. All identified modes of failure for these LRUs or LLRUs,
a3. Effects of the failure on the sub-system and the Goods,
a4. Their criticality level,
a5. Failure rate of these LRUs or LLRUs, according to experience or predicted data,
a6. Recovery time for each type of failure,
a7. For the most critical elements, requirements about the maintenance, in order to reduce recovery times, and
a8. Methods of detection of the failure such as Built-in Test.

b. Reliability prediction

The Seller shall estimate the reliability of each LRU and LLRU of the Goods taking into account the operating conditions of the Goods.

The Seller shall perform reliability predictions based upon the knowledge of previous equivalent systems or based on part failure rates.

c. Maintainability prediction

Maintainability prediction is the estimation of the duration and workload of maintenance tasks at all maintenance levels as defined in the Maintenance Plan, and for both corrective and preventive maintenance.

The maintenance time shall include:

c1. Time to secure the item for maintenance intervention, regarding safety and availability,
c2. Time to prepare the maintenance tools (plugging, powering and initialisation),
c3. Time to troubleshoot the item (for corrective maintenance),
c4. Time to replace the parts or consumables,
c5. Time to configure the installed part (if necessary),
c6. Time to check that the item is working properly and to check the condition of the item, and
c7. Time to get the item ready for service.

The Seller shall perform maintainability predictions in accordance with the operating conditions of the Goods.
The Seller shall also present a synthesis of the maintenance time and workforce for every mode of failure of each sub-system.

Therefore, the Seller shall define:

c8. The technical means and procedures necessary for the O&M personnel to perform his maintenance operations,
c9. For corrective maintenance, the minimum information necessary for the O&M personnel to define, when an alarm occurs, the exact nature of the failure, as well as the precautions to be taken (by the O&M personnel) to perform efficient maintenance tasks, and
c10. For corrective maintenance, the tests and controls to perform in order to identify the exact nature of the failures, and after repair, to ensure the compliance of the equipment and their proper and safe operating condition.

The Seller shall provide a complete list of preventive maintenance procedures for each type of piece of the Goods.

For each preventive maintenance task, the Seller shall issue a study in order to:

c11. Identify the RAM or safety risk covered by the preventive maintenance task, and
c12. Justify the periodicity of the maintenance task.

d. FRACAS

The Seller shall carry out FRACAS for the sub-systems of the Goods. The purpose of this is to report, classify, and analyse failures and then plan corrective actions in response to field failures. It produces a history of failure and corrective action.

The objective is to have, among others, for LRU and LLRU:

d1. Field MTBF,
d2. MTTR,
d3. Spare consumption,
d4. Reliability growth,
d5. Failure type and location, and
d6. Etc.

8. DOCUMENTATION

8.1 O&M Documentation

8.1.1 Maintenance Plan

The Seller shall develop a Maintenance Plan.

This plan shall address how the O&M party shall maintain the Goods during its life cycle from a technical and organizational point of view.

It shall address the following items but not be limited to:

a. Technical breakdown of the Goods from a maintenance point of view. The highest node of the technical breakdown shall be the Goods. The lowest nodes shall be the LLRU.

b. Maintenance information for each node, including, but not limited to:
   - b1. Name and acronym of the related item
   - b2. Name and acronym of the upper node
   - b3. Quantity installed on the Goods and quantity installed on the upper node
   - b4. List of the modes of failure including:
     - b4a. MTBF of this mode of failure, or Mean Activity Between Failures (Activity could be mileage, time of functioning or any other relevant criteria). When relevant, the mean time between failures shall be replaced by the life duration of the considered node
     - b4b. How the operation personnel can detect the failure
     - b4c. Consequences of the failure on passenger service
     - b4d. Consequences of the failure on operation mode
     - b4e. How the maintenance personnel can identify the faulty piece of equipment
     - b4f. Description of corrective maintenance to perform, including but not limited to: location of the maintenance work (field, shop), maintenance staff (number and level of qualifications), list of tools, list of parts and consumables, time and workload, main tasks to perform. This shall deal with the entire maintenance process including failure detection, troubleshooting, replacements, adjustments, reconfigurations, tests and other relevant tasks. This shall describe only the principles and main actions to perform, and shall not be a step-by-step procedure.
     - B4g. For modes of failure that the O&M party cannot repair, it shall be specified if the part has to be repaired by the Seller or his subcontractor or if the part needs to be disposed of and replaced with new. The plan shall indicate the list of authorised repairers and suppliers for this part, contact information, turnaround time for repairs and delivery time for supplies, price for repair and supply of a new part. For supplies, the plan shall specify the recommended stock level to trigger the order and the recommended quantity to order.
     - b4h. Required conditions to perform the corrective maintenance activity
     - b4j Consequences of the corrective maintenance activity on passenger service
     - b4k. Consequences of the corrective maintenance activity on operation

c. Preventive maintenance program, including:
   c1. Periodicity and periodicity criteria (calendar time, functioning time, mileage, number of cycles or any other relevant criteria)
   c2. Tolerance on periodicity
   c3. Description of preventive maintenance to be performed, including but not limited to: location of the maintenance work (field, shop, the Seller's facility), maintenance staff (number and level of qualification), list of tools, list of parts and consumables, time and workload, main tasks to be performed. This shall deal with the entire maintenance process including servicing, cleaning, replacements, adjustments, tests, controls and other relevant tasks
   c4. For preventive maintenance that the O&M party cannot perform, the plan shall specify the list of the authorised companies that are able to perform the work, their contact information, turnaround times and prices for performing the expected preventive maintenance
   c5. Required conditions to perform the preventive maintenance activity
   c6. Consequences of the preventive maintenance activity on passenger service
   c7. Consequences of the preventive maintenance activity on operation

d. Description of the maintenance organization. This section shall describe how the maintenance activity is organised, including:
   d1. Attendance program requirements, including time and place of attendance of each Maintenance position
   d2. On call duty requirements
   d3. Duties and main tasks of each maintenance position
   d4. Necessary means for each maintenance position
   d5. Interfaces with operation, safety and security activities

The Maintenance Plan shall be consistent with the RAM Studies.

8.1.2 Capital Assets Replacement Plan

The Seller shall develop a Capital Assets Replacement Plan.

This plan shall describe the Capital Assets Replacement program that the Owner will need to set up during the life cycle of the Goods. It shall also consider heavy refurbishment operations.

For each sub-system of the Goods, or for any relevant part of the Goods, the Capital Assets Replacement Plan shall specify, describe or indicate:

a. The anticipated date for replacement or substantial refurbishment.

b. The reason for replacement or substantial refurbishment. This can include:
   b1. Obsolescence
   b2. Life cycle less than the Goods' life cycle
   b3. Non-acceptable increase of operation or maintenance costs
   b4. Inadequate performance of the specified equipment
   b5. Wear or aging
   b6. Any other reason

c. The main structure for the replacement strategy to maintain the service during replacement or substantial refurbishment operations

d. The main issues for the heavy refurbishment program

e. The expected cost for the replacement or substantial refurbishment operations

For each replacement or substantial refurbishment operation, the Seller shall make reference to similar operations performed on similar systems, and shall indicate the corresponding relevant technical and economical information to align with the Capital Assets Replacement Plan.

8.1.3 System User Manual

The Seller shall prepare a System User Manual.

The Seller shall prepare the System User Manual before preparing the training material related to the Operation of the Goods.

The System User Manual shall:

a. Describe all information provided by the Goods to the operator including, object related to the information, description of the media, meaning of the different possible status of the information regarding the functioning of the Goods, further impact on the functioning of the Goods, when and how the operator shall consider the information, possible or required actions and impact on safety

b. Describe actions the operator shall set up in abnormal and/or unexpected situations, especially with regard to safety, and which means the operator shall use for such cases

c. Describe all resources and actions the operator can use to effect the function of the Goods including location of the object related to the action subject, description of the media, impact on the functioning of the Goods, when and how the operator shall use this action subject, feedback information, precautions of use, impact on safety

d. Provide an overall structure to set up the different normal and emergency modes of operation

e. Provide step-by-step procedures for using the Goods' functions or devices in their different possible cases of use

The Operation Procedures are written by the O&M party, based on the System User Manual and the O&M parity's operation policy.
The Seller shall review and approve the Operation Procedures in every aspect related to the Goods. This includes:

a. Checking that every safety related topic is properly addressed
b. Checking that the procedures allow the Operator addressing the related situations
c. Checking that the procedures allow reaching the required performances, including RAMS performances

8.1.4 Maintenance Documentation

The Seller shall write a complete set of maintenance documentation.
The maintenance documentation shall cover all aspects of maintenance of the Goods, including tools and facilities, for activities performed in the field or in local premises.
The Seller shall write the complete set of maintenance documentation and obtain acceptance by the Buyer before preparing the training materials related to the Maintenance of the Goods.

8.1.4.1 Maintenance manual

The maintenance manuals organization shall be consistent with the maintenance breakdown of the Goods, as described in the Maintenance Plan.

The Seller shall write:

- A maintenance manual for the Goods,
- A maintenance manual for each sub-system,
- A maintenance manual for each piece of equipment,
- A maintenance manual for each LRU, and
- A maintenance manual for each LLRU.

When two levels are identical (for example, when a piece of equipment is composed of a single LRU), it may be necessary to write one manual for each level (maintenance activities performed in the field for the equipment level, maintenance activities performed in the shop for the LRU level).

The content of the maintenance manuals shall be, but not limited to, as required in the followings.
In the following sections, the item under consideration is deemed to be the Goods, sub-system, equipment, LRU or LLRU. Sub-items are constituents at the lower level.

a. Description of the item
   This section shall describe the item from a physical point of view:
   a1. Overview schematics
   a2. Physical and technical characteristics
   a3. Location of the sub-items
   a4. Performance
   a5. Architecture
   a6. Physical interfaces between internal sub-items
   a7. Physical interfaces with external items
   a8. Information related to software, including name of software, media, licenses, version number, editor

b. Functioning of the item

This section shall explain how the item works, including:

b1. Main functions provided
b2. Theory of operation
b3. Functional interfaces between internal sub-items
b4. Functional interfaces with external equipment
b5. Human Machine Interfaces description, covering remote control and remote monitoring, built-in displays, lights, switches and any other Human Machine Interface, with full description of meaning and usage

c. Troubleshooting

This section shall describe, with step-by-step procedures, how to troubleshoot the item and identify further action to perform. It shall include, but not be limited to :

c2. Use of tools and special tools for troubleshooting, with reference to the tool User Manual when applicable
c3. Identification of further actions to perform:
  c3a. Reference to further troubleshooting procedure at a lower level
  c3b. Reference to a corrective maintenance procedure

d. Corrective maintenance

This section shall provide necessary procedures to fix the failure at the considered level. It comprises all corrective maintenance procedures required in the troubleshooting section. It also comprises all replacement procedure of any Replaceable Unit of the considered item. Each procedure shall identify the following information, but not be limited to:

d1. Necessary information to prepare the execution of the procedure (number of maintainers, qualifications, necessary time, access requirements, tools, parts, consumables, logistical means, condition of execution)
d2. Step-by-step procedure to secure safety of the Public and of Staff, and to secure availability of the service during the maintenance activity
d3. Step-by-step procedure to fix the issue at the considered level, including replacement procedures, adjustment procedures, lubrication, cleaning and servicing procedure, configuration procedure etc
d4. Step-by-step procedure to check that the item is good for service
d5. Step-by-step procedure to start up the item and restore its availability
d6. Further actions to be performed, with reference to the corresponding procedure (for example, troubleshooting of the sub-item at the shop)
d7. Use of tools and special tools for corrective maintenance, with reference to the tool User Manual when applicable

e. Preventive maintenance

This section shall provide necessary information to perform the preventive maintenance at the considered level. It shall provide a preventive maintenance program, which includes, but is not limited to the following information for each preventive maintenance step:

e1. Periodicity of the preventive maintenance step
e2. Tolerance for the periodicity
e3. List of preventive maintenance procedures to be performed during this preventive maintenance step
e4. Global workforce necessary to execute the step on one of the considered items
e5. Unavailability time of the item due to the preventive maintenance activity

The section shall provide the full set of preventive maintenance procedures required by the preventive maintenance program.

Each procedure shall identify, but not be limited to, the following information:

e6. Necessary information to prepare the execution of the procedure (number of maintainers, qualifications, necessary time, access requirements, tools, parts, consumables, logistical resources, condition of execution
e7. Step-by-step procedure to secure safety of the passengers and of O&M personnel, and to secure availability of the service during the maintenance activity
e8. Step-by-step procedure to perform the preventive maintenance
e9. Step-by-step procedure to check that the item is good for service
e10. Step-by-step procedure to start up the item and restore its availability
e11. Further actions to be performed, with reference to the corresponding procedure (for example, corrective or preventive maintenance on a removed sub-item)
e12. Use of tools and special tools for preventive maintenance, with reference to the tool User Manual when applicable

When the preventive maintenance includes conditional maintenance, the procedure shall clearly indicate:

e13. The criterion to be checked
e14. The step-by-step procedure to check the criterion
e15. The step-by-step procedures to perform if criterion are not met

f. Illustrated Part Catalogue

This section provides the necessary information to identify the different sub-items of the considered item. The section shall include clear three-dimensions exploded schematics showing the arrangement of the sub-items in the considered item. Each sub-item shall refer to the nomenclature table. The nomenclature table shall be printed at the side the corresponding three-dimensions schematics and shall provide the following information:

f1. Reference in the schematic
f2. Name of the sub-item
f3. The Seller's part number
f4. OEM's part number
f5. OEM's name and contact information for both supply and maintenance services
f6. Quantity installed in the considered item
f7. Reference to the sub-item schematic

The section shall also provide for each sub-item a schematic showing:

f8. Each relevant view of the sub-item
f9. The location of the identification plate or tag on the sub-item
f10. An enlargement of the identification plate or tag with identification and explanation of printed information

8.1.4.2 Special tools User manuals

The Seller shall provide the user manuals of the special tools necessary to maintain the Goods. Each manual shall provide the following information:

- Purpose of the tool,
- Cases of use,
- Physical description,
- Functional description,
- Human Machine Interfaces description,
- Step-by-step procedure for starting up and closing down the tool (when applicable),
- Step-by-step procedure for using the tool in each case of use,
- For troubleshooting tools: interpretation of the outcomes and further procedures to perform, with reference to the maintenance manuals, and
- Requirements for tool servicing and calibration.

8.1.4.3 Storage Manuals

The Seller shall provide manuals with the requirements for storage of the necessary spare parts, consumables, tools and maintenance means. These manuals shall also specify, when applicable, the durable life of stored items.

8.1.4.4 Handling Manuals

The Seller shall provide manuals with the requirements for handling spare parts, consumables, tools and maintenance means.

8.1.4.5 Delivery Acceptance Manuals

The Seller shall provide manuals with the checking-in procedure for delivery acceptance of new or repaired parts and for consumables. These manuals shall highlight safety related criterion.

8.1.4.6 Cables and Wiring Database

The Seller shall deliver a Cables and Wiring Database that allows the O&M party to easily retrieve the following information:

- All information relating to the path of a given signal, including: origin and destination of the signal, list of cables, wires, terminal boards, connectors, pins, plugs, outlets, relays and any other device that participate to the transmission of the signal, sorted from the origin to the destination,
- The list of signals transmitted by a given device, such as a cable, a wire, a terminal board, a connector, a connector's pin, a plug, an outlet, a relay or any other device, and
- The list of devices connected to any given device.

The Cables and Wiring Database shall cover the whole Goods, including all kinds of cables and wiring, including but not limited to:

- Power supplies of any voltage, and
- Communications and low voltage.

The Seller shall provide the Cables and Wiring Database. It shall be accessible through the O&M management's tool network and from workstations of the O&M party.

The Seller shall enter into the Cables and Wiring Database all necessary information and records that relate to the Goods.

8.1.5 Assembly Tools Documentation

The Seller shall provide the drawings, pictures any relevant documentation of the assembly and control tools that are required for the repair of the Goods.

8.2 Technical Database Files

The Seller shall provide files containing all technical information related to the Goods that is useful for initializing a MMIS.
This includes but is not limited to:

- The technical breakdown structure of the Goods with list of all parts, part numbers, main description of the parts, and primary-secondary relationships between parts,
- List of all types of spare parts with part number, authorized version numbers, quantities installed in the Goods, quantities in stock, storage location in the warehouses, dimensions, weights, authorized suppliers, authorized repairers, delivery times, repair turnaround times, life cycle and reliability,
- Inventory of the stocks, with serial numbers of serialized parts that are in the warehouses,
- Asset management files, describing the actual site configuration of the delivered Goods, with list of all parts with name, part number, serial number and primary-secondary relationships between serialized parts,
- Software configuration files, describing which files and versions are installed on each serialized part that contain software, firmware and any file that shall be managed from a configuration point of view, and
- Preventive maintenance program file, with list of all preventive maintenance procedures, related equipment, periodicity, tolerance on periodicity, necessary time to perform the procedure, number of people necessary to perform the procedure, list of necessary tools and spare parts, special condition of performance.

All files shall be structured and organized as database files, with a line per record and columns to record information as required.
The Seller shall write and submit for the Buyer's acceptance, a document that describes the structure of the files and the exact meaning of each field.

8.3 Spare Parts

8.3.1 Definition

8.3.1.1 Equipment

Assembly of parts designed to perform a function or a set of functions in the Goods. A piece of equipment is a non-replaceable unit under regular maintenance activity.

8.3.1.2 Line Replaceable Unit (LRU)

Part replaced on a piece of equipment to restore its full availability after a failure. The O&M party replaces LRUs during Line Maintenance.

8.3.1.3 Lowest Level Replaceable Unit (LLRU)

Lowest Level part that the O&M party can replace to maintain the Goods according to the maintenance policy. A LLRU can be either:

- A whole LRU. In this case, the failed LRU/LLRU is sent to the Seller for repair or is replaced by a new part. The part is considered as a LRU for Line maintenance and as a LLRU for repairs.
- Or a part of a LRU among other parts of the LRU. In this case, the operator can repair the LRU by replacing the failed LLRU (shop maintenance) and the failed LLRU is sent to the Seller for repair or is replaced by a new part.

8.3.1.4 Component

Part replaced to repair a LLRU.

8.3.1.5 Consumable part

Non-repairable LLRU, of low cost, used regularly to maintain the Goods, such as hardware (screws, nuts, and bolts), filters, seals, worn-out parts.

8.3.1.6 Consumable product

Product used regularly to maintain and service the Goods, such as oils, greases, solvents, glues, cleaning products, washing products, inks.

8.3.1.7 Investment part

Part that needs to be replaced only in case of exceptional condition, such as accidents or external events. Spare Parts cover the following:

- Line Replaceable Units,
- Lowest Level Replaceable Units,
- Consumable products,
- Consumable parts, and
- Investment parts.

Any part of the Goods that the O&M party can remove and replace according to the maintenance policy as described in the Maintenance Plan.

8.3.2 Coverage

The Spare Parts shall cover the whole Goods and shall be consistent with the Maintenance Documentation and the maintenance means. The Spare Parts shall cover the needs of preventive maintenance and corrective maintenance during the whole life span of the Goods.

8.3.3 Quantities

The Seller shall provide a quantity of Spare Parts that is sufficient:

- For avoiding any stock failure, and
- For achieving RAM requirements.

A stock failure is defined as the unavailability of a Spare Part in the O&M party's warehouse when needed by the maintenance personnel to perform the required maintenance. If any stock failure occurs during the Defect Notification Period, the delivered quantity of Spare Parts is deemed insufficient and the Seller shall, at its own cost and expense, provide an additional quantity of Spare Parts that equals the missing quantity. Where, the Defect Notification Period is the period to demonstrate that the Goods achieve the Service Availability performance in a sufficient manner. See Clause 7 for the requirements regarding RAM Studies that is related to the Service Availability.

8.3.3.1 General case

The quantity of spare parts shall take into account:

- The quantity installed on the System,
- The reliability of the part,
- The life of the part,
- The preventive maintenance program, and
- The turn around time between the replacement of the part on the Goods and the date when a replacement part (repaired or replaced) is back in the O&M Party stock.

8.3.3.2 Consumable parts and consumable products

For consumable parts and consumable products, the initial stock shall cover:

- The consumption during two years, and
- The consumption during twice the delivery time if the delivery time exceeds six (6) months. The delivery time is the time between the date of the order and the date of delivery to the O&M party warehouse. The Seller shall provide a minimum quantity of ten (10) parts for each consumable part whatever the expected consumption is.

8.3.3.3 Investment parts

The Seller shall provide one (1) complete, assembled and tested piece of equipment for any fixed equipment that is necessary for normal operation of the APM system.

If different configurations of a piece of equipment are installed on the Goods, the Seller shall provide the highest configuration and provide the necessary means to adapt the Investment Parts to all possible configurations.

8.3.4 Spare Parts Studies

8.3.4.1 List of Spare Parts

The Seller shall write a complete List of Spare Parts. This List of Spare Parts shall indicate for each part:

- The name and acronym of the part,
- The part number,
- The type of spare part,
- The quantity to be delivered, and
- Indicative unit price.

The Seller shall organize the List of Spare Parts by sub-system and item of equipment.

8.3.4.2 Spare Parts Justification Report

The Seller shall write a Spare Parts Justification Report. This report shall demonstrate that the List of Spare Parts and the associated quantities are compliant with the requirements. This report shall be consistent with RAM studies.

8.3.4.3 Spare Parts Follow up

During the Defect Notification Period, the Seller shall follow up the use and consumption of the Spare Parts, and regularly issue a Spare Parts Follow up Report.

The Seller shall issue this report every 2 months and it shall address the following:

- Spare Parts consumption,
- Stock failures,
- Unexpected requirements for Spare Parts,
- Spare part orders,
- Repair orders,
- Delivery times (minimum, maximum and mean values),
- Turnaround times (minimum, maximum and mean values), and
- Discrepancies between data in the Spare Parts Follow up and assumptions made in the Spare Parts Justification Report.

All figures shall be given since the Take Over.

In case a discrepancy is identified between data in the Spare Parts Follow up and assumptions made in the Spare Parts Justification Report, the Seller shall recalculate the Spare Parts Justification Report and update the List of Spare Parts accordingly. If the delivered quantity of any Spare Part is lower than those defined in the update, the Seller shall provide the missing Spare Parts at its own cost and expense.

8.3.5 Spare Parts List

The spare part list, in Table 8.1, is given as a reference and is not limited to its content. The details, quantities will need to be defined and justified by the Seller in accordance with the specification of the Goods in order to guarantee the performance of the Goods and its maintenance up to level 3 according to EN 13306 or equivalent.

Table 8.1 Spare Parts List (for Reference)

Name of component	Quantity
Automatic Coupler (convertible for both Types A and B), complete	1 set
Set of centring mechanism of Automatic Coupler	4 sets
Set of all protection bellows of Automatic Coupler	30 sets
Set of all cables harness of Automatic Coupler	4 sets
Set of all connectors and receptacles of Automatic Coupler	4 sets
Set of all gaskets and O-rings of Automatic Coupler	4 sets
Set of all bearings and bushes of Automatic Coupler	4 sets
Set of electromagnet valves of Automatic Coupler	4 sets
Set of pneumatic actuator of Automatic Coupler	4 sets
Set of pneumatic actuator of Automatic Coupler	4 sets
Set of pneumatic control device of Automatic Coupler	4 sets
Set of cover of electric coupler of Automatic Coupler	4 sets
Set of contacts of electric coupler of Automatic Coupler	4 sets
Set of all warning and caution labels of Automatic Coupler	6 sets
Set of all warning and caution labels of Automatic Coupler	6 sets

8.4 Training

The Seller must provide detailed and efficient training to all kinds of personnel of the O&M party with an objective to deliver sufficient knowledge to maintain and operate the Goods and also to train future employees.

This training shall be scheduled in accordance with the project planning and the different hand over dates. The level of knowledge transfer shall be in accordance with the technical knowledge level of each category of trainees.

8.4.1 Training and Qualification Plan

The Seller shall develop and submit for the Buyer's acceptance a Training and Qualification Plan. The training must be defined in order to comply with a maintenance policy up to level 3 as defined in EN 13306 or equivalent.
This plan shall address how the Seller will train and qualify the O&M personnel, from a technical and organizational point of view.

The Training and Qualification Plan shall address the following items but not be limited to:

a. List of the training modules and for each module:
   - a1. Name of the module
   - a2. Type of training, i.e. theoretical or practical
   - a3. Position held by the trainees
   - a4. Number of trainees for each session of the training module
   - a5. Number of sessions expected for the training module
   - a6. Duration of the module for one session
   - a7. Objectives of the module
   - a8. Pre-requisites for attending the module
   - a9. Location of the training
   - a10. Resources including training materials
   - a11. Main topics of the module
   - a12. For practical training: list of actions, situations and procedures the trainees will have to handle during the module
   - a13. Description of the final test for evaluation of trainees' knowledge and abilities

b. List of qualification modules, including:
   - b1. Name of the qualification module
   - b2. Positions that shall pass the qualification module
   - b3. Number of people expected to pass the qualification module
   - b4. Duration of the qualification
   - b5. Pre-requisite for passing the qualification
   - b6. Location of the qualification
   - b7. Means necessary to pass the qualification
   - b8. List of actions or procedures authorized by the qualification module
   - b9. Description of the theoretical tests
   - b10. Description of the practical tests
   - b11. Criterion for qualifying the trainee

c. Schedule of the training and of the qualification, including dates of the beginning of each session of each training module, and logical order between modules. The schedule shall be consistent with the general schedule of the Project. It shall address the compatibility of the training and the qualification with other works, such as testing and commissioning activities.

The Training and Qualification Plan shall address two different stages comprising, 'train the trainers' and 'train the trainees'.

8.4.2 O&M Personnel Training and Qualification

The Seller shall train and qualify the O&M personnel in compliance with the Training and Qualification Plan. The training shall be based on classroom courses and on on-the-job training.
It shall address every technical aspect of O&M of the Goods.
The training of the O&M personnel is based on a "Train the trainers" process that takes place in two stages:

- First stage (training for the trainers): The Seller shall train trainers designated by the O&M party, and
- Second stage (training for the trainees): The O&M party trainers train the trainees.

For each course, the Seller shall write and submit to the Buyer the training material for acceptance. The training material is composed of trainee documentation, a trainer manual and a qualification set of tests.
The trainer manual shall provide instructions to the trainer regarding the necessary means and conditions to perform the course, the expected duration of the course, the points where it is necessary to insist or where it is necessary to check good understanding by the trainees and a final test for the trainees. The trainer manual shall provide all necessary information to run the courses successfully, especially for on-the-job training.
The training shall deal with technical topics such as knowledge of the Goods and O&M of the Goods.
When the O&M personnel are trained, the Seller shall qualify each member of the staff, by organising theoretical and practical tests. These tests shall cover a range of issues but always with a focus on safety related topics. The qualification is mandatory to execute operational duties on the Goods. The list of the qualified personnel shall be provided by the Seller to the Buyer on a regular basis.
All the training and qualification activity shall be completed before the Take Over.

8.4.2.1 Training locations

The training shall be carried out at such locations where the greatest benefit for trainers may be gained. This may be in places of the Seller, assembly or testing, or at such other locations as may be necessary. All places of training are subject to prior acceptance by the Buyer.
Dedicated accommodation for training shall be provided, of a type suitable for use as a class room or lecture room. Facilities shall include, but not be limited to:

- Sufficient desks and chairs for the trainees, and
- Visual aids, including video player/monitor, overhead projector/screen, large white board, flip chart easel etc.

8.4.2.2 Training equipment

In general, the Seller shall use the actual Goods specifically set aside for training purposes. However, he may use as may be agreed, Plant being erected, tested or commissioned for the training of the O&M personnel, when Goods is not available. The Seller shall not use spare parts for this purpose that are to be delivered to the Buyer.

The Seller shall provide, at no cost to the Buyer, such written or printed matter, samples, models, cut-away equipment, slides, films and other instructional material as may be necessary for training. Such materials shall be retained by the Owner at the end of the training programmes.

The supply of equipment and materials shall be sufficient both for the persons trained by the Seller and for those to be subsequently trained.

8.4.2.3 Administration

The Seller shall:

a. Be responsible for the reception of, and hotel and travel arrangements for, each trainer in countries other than Macau.
b. Be responsible for the general welfare of trainers under his control.
c. Submit, for Buyer's acceptance, procedures which will enable him to control, and to repatriate where necessary, those trainers not found to be responding to training as a result of:
   c1. Aptitude
   c2. Discipline
   c3. Incorrect Selection
   c4. Any other cause

8.4.3 Engineering Training

At the very beginning of the Contract, the Seller shall train the Buyer, the Owner, and/or his representatives to the main principles of the Goods.
The scope of the training shall cover the following topics but not be limited to:

a. The Goods performances
b. Architecture and principles of functioning
c. Presentation of main pieces of equipment
d. Nominal modes of operation
e. Emergency modes of operation
f. Maintenance policy
g. Main maintenance activities and maintenance means
h. Main constraints stakes for O&M
j. Main constraints stakes at design level

The objective of this training is to provide the necessary knowledge to understand in the best way, the Seller's documents and to make the most relevant comments on these documents.
The quality of this training is of priority importance for the efficiency of all parties involved in the Contract, including the Seller, as it will ease the whole project process, especially the approval process.
The Seller shall run each course once and for a maximum of 15 trainees.

The Seller shall submit to the Buyer for acceptance an Engineering Training Program that shall detail the objective and the main topics addressed during the course.
The Seller shall then write the corresponding training material and submit to the Buyer for acceptance prior to course commencement.
If during the design reviews, it appears that the Engineering Training did not cover a topic, the Buyer can request the Seller to organise specific training to cover the particular topic. In this case, the Buyer can postpone the acceptance of the related design documents.

8.5 Tools

This clause refers to all tools required to maintain the equipment of the Goods.
Each of them can be categorized into the following three categories:

- Specific tools
- Special tools
- Standard tools

It also includes any tools that are complex and specially made for the job of maintenance and set up.

It shall allow maintenance personnel to:

- disassemble and reassemble sub-assemblies and parts,
- check and diagnose defaults and breakdowns which can occur at lowest line replaceable units,
- check and diagnose defaults and breakdowns of shop replaceable units,
- measure, test, control and validate, at equipment set levels, sub-assemblies functioning conditions,
- measure, test, control and validate, shop/line replaceable units, functioning conditions, and
- adjust mechanical and electrical parameters on sub-assemblies.

The tools to be provided by the Seller must be defined in order to comply with a maintenance policy up to level 3 as defined in EN 13306 or equivalent.

The Seller shall supply special tool/s for installation operation and maintenance, if necessary.

The Seller shall provide all tools, monitoring means, recording means and documentation that allow the following activities:

- Checking that a train is ready for operation after any maintenance activity performed on the train,
- Testing and troubleshooting a train on the track, and
- Performing dynamic reception tests after major maintenance activity.

8.5.1 Specific Tools

Specific tools are defined as tools that are designed to perform a particular activity or a particular set of activities on the Goods or its sub-system, and that are provided only by the Seller or his subcontractor.

The Seller shall provide all specific tools that are necessary to operate and maintain the Goods, in compliance with the Maintenance Plan, the Operation Plan, the Operation and Maintenance Concept and the O&M Documentation.

The nature and quantities of the specific tools shall be compatible with the RAM Requirements.

Measurement and control tools shall have a calibration certificate and shall be able to be calibrated.

8.5.2 Special Tools

Special tools are defined as tools that are designed to perform a particular activity or a set of activities on the Goods or its sub-system, and that are available on the market through several suppliers and brands.

The Seller shall provide all special tools that are necessary to operate and maintain the Goods in compliance with the Maintenance Plan, the Operation Plan, the O&M Concept and the O&M Documentation.

The nature and quantities of the special tools shall be compatible with the RAM Requirements.

8.5.3 Standard Tools

Standard tools are defined as tools that are designed to perform a particular activity or a particular set of activities on the Goods or its sub-systems, and that are available on the market through several suppliers and brands.

The Seller shall provide a list of recommended standard tools that are necessary to operate and maintain the Goods, in compliance with the Maintenance Plan, the Operation Plan, the O&M Concept and the O&M Documentation.

The nature and quantities of the recommended standard tools shall be compatible with the RAM Requirements.

If the cost of a tool is higher than 4.500 MOP, and/or if the tool is not available in Macau, the tool shall be considered as a special tool.

8.5.4 Tool Catalogue

The Seller shall issue a Tools' Catalogue that allows the O&M party to purchase additional tools if necessary. The Tools' Catalogue shall include the following information for all tools that are necessary for operating and maintaining the Goods:

- Name of the tool,
- Type of the tool (specific, special, standard),
- The characteristics of the tool,
- Pictures of the tool,
- Recommended manufacturer with contact information;
- Part number of the tool,
- Delivered (for specific and special tools) or recommended (for standard tools) quantities, and
- Sub-component of the Goods related to the tool.

The main usages and purposes of the tool for operating and/or maintaining the Goods, are to be cross referenced to the procedures that requires the tool.

8.5.5 Tool List

The following tool list, in Table 8.2, is given as a reference and is not limited to its content. The detail, the quantities will have to be defined and justified by the Seller in order to guarantee the performance of the Goods and its maintenance up to level 3.

Table 8.2 Tool List (for Reference)

Name of component	Quantity
Complete set of wear gauges	1 set
Complete set of maintenance work bench	1 set
Complete set of jigs for overhaul	1 set
Complete set of tools for contact replacement	1 set

8.6 As-built Drawing

The Seller shall submit the complete set of as-built drawings of the Goods.

9. VEHICLE SPECIFICATION

The specification and dimensions of vehicle is shown in Table 9.1 through Table 9.3 of 83-97124.
The specification of BAV is shown in Table 9.1.

Table 9.1 BAV Specification

Items	Specification	Remarks
Vehicle type	Rubber tyred	
Guidance system	Side guided system	
Dimensions	Maximum length 10,250 mm Maximum width 2,646 mm Maximum height 3,581 mm	
Maximum mass	Loaded condition 23,000 kg	
Carbody structure	Steel structure	
Operation pattern	Operating system: Manual operation Operating time average: 5 h/day 365 day/year	
Running performance	Maximum speed (single) 22 km/h Maximum acceleration 4.59 km/h/s Maximum deceleration (normal) 4.59 km/h/s (emergency) 5.64 km/h/s Maximum jerk 0.10 g/s Tightest Curve (horizontal) 30 m (vertical curve) 500 m Maximum grade 6 %	
MR pressure from carbody to the Goods	780 to 880 kPa (8 to 9 kgf/cm^2)	
Equilibrium inertia mass	10% of empty load	
Running resistance	Rr = 10 x (1+3.3/W) + A x V^2/W Rr: Running resistance (kgf/tonf) V: Train speed (km/h) W: Train weight (tonf) A: 0.0267	
Running wheel	Nitrogen-filled rubber tire, equipped with inner safety wheel	

10. TECHNICAL SPECIFICATION OF COUPLER SYSTEM

10.1 General

The Goods shall be designed to withstand all forces generated under normal operating conditions and all steady state and dynamic forces generated under the specific emergency train operating conditions.

The Seller shall submit specification document with drawings and mass information, wiring diagram, piping diagram and structural calculation, for the Buyer's acceptance.

10.2 Layout of Coupler

The layout of the Coupler is shown in Figure 1.1.

The Seller shall submit instruction document/s and drawing/s for installation to car, for the Buyer's acceptance.

10.3 Mounting Dimension of Coupler

The mounting dimension of the Coupler is shown in Figure 10.1. Automatic Coupler is mounted to the carbody underframe as shown in Figure 10.1. The Seller may propose minor deviation from the dimensions specified above for the Buyer's acceptance.

FOR REFERENCE

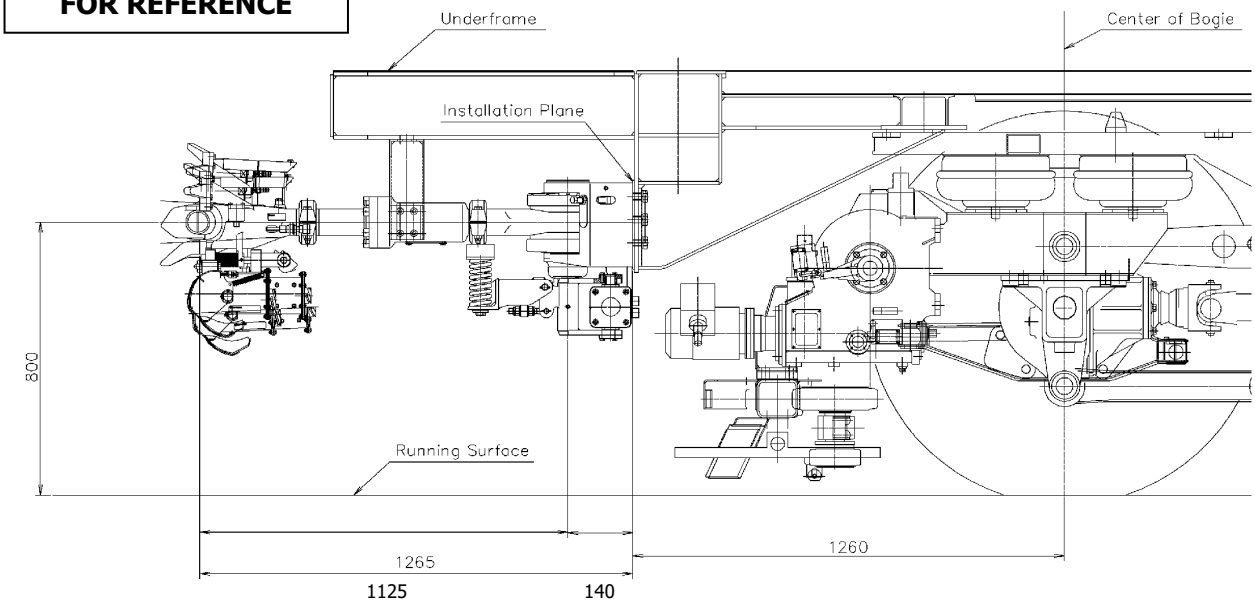


Figure 10.1 Mounting Dimension of Goods

10.4 Mass of Goods

The target mass of the Goods is shown in Table 10.1. The mass of the Goods shall be less than the mass shown in Table 10.1.

Table 10.1 Mass of Goods

Items	Mass	Remarks
Automatic Coupler	245 kg/set	

10.5 Required Function of Automatic Coupler

The Automatic Coupler shall have the mechanical couple and swing device. The functionality of the pneumatic coupler is not required.

The Automatic Coupler shall be able to couple and uncouple fully automatically.

The Automatic Couplers shall be designed for repeated coupling/uncoupling between single unit trains with impact speeds not exceeding 3 km/h.

10.5.1 Mechanical Coupler of Automatic Coupler

10.5.1.1 Coupling

The mechanical coupler shall be able to couple fully automatically.
A positive lock shall assure that the mechanical coupler, once engaged, cannot release without prior, on-board release of this lock.
Immediately after completion of coupling, the mechanical coupler shall recover the initial length regardless of stoke of shock absorber or equivalent device at the time of coupling action.

10.5.1.2 Uncoupling

The mechanical coupler shall be able to uncouple automatically and manually.
Air cylinder or air motor shall be provided in coupler head of the mechanical coupler for uncoupling from on-board.
Manual release handlebar as shown in Figure 10.2 shall be provided in coupler head of the mechanical coupler for manual uncoupling. The mechanical coupler shall be compatible with manual uncoupling by using this handlebar of only one side as shown in Figure 10.3.

10.5.1.3 Coupling/Uncoupling

Any non-automatic coupling and uncoupling operations shall required local manual supervision and shall not require special tools.
There shall be means to uncouple from both inside and outside the vehicles.
A person shall not be required to stand between vehicles during the coupling or uncoupling process.

10.5.1.4 Collision

Shock absorber or equivalent device as shown in Figure 10.2 shall be provided to absorb collision energy in coupling and in unexpected collision.

Coupling reaction force shall be less than 400 kN and coupling stroke shall be less than 90 mm under the collision cases stated in Clause 10.9.

The Seller may propose to utilise a collapsible component. In such a case, deformation of the collapsible component shall be impossible at the coupling/collision speed of 3 km/h or less.

The Automatic Coupler shall at least comply with ANSI/ASCE/T&DI 21-21, EN 12663 or an equivalent recognised international standard.

10.5.1.5 Centring device

The mechanical couplers shall be equipped with a suitable centring device to prevent the Automatic Coupler from swinging transversally when uncoupled.

The centring device shall not interfere with the coupling/uncoupling action, the coupled train operation, or the functionality of the swing device mentioned in Clause 10.5.2.

10.5.1.6 Others

Limit switch or equivalent device and those cables as shown in Figure 10.2 shall be provided on coupler head of the mechanical coupler to detect completion of normal mechanical coupling and uncoupling and abnormal disengagement.

Where, "completion" means that the state of mechanical connection is engaged and locked completely.

Swing angle of the mechanical coupler shall be as follows. The mechanical coupler shall be designed to limit the horizontal swing angle accordingly.

Vertical:	± 6 degrees
Horizontal:	± 23 degrees

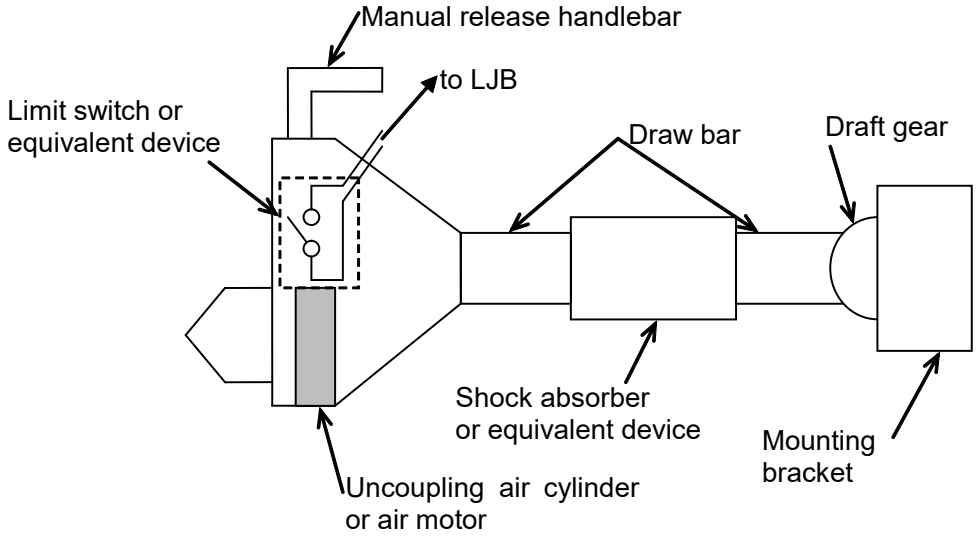
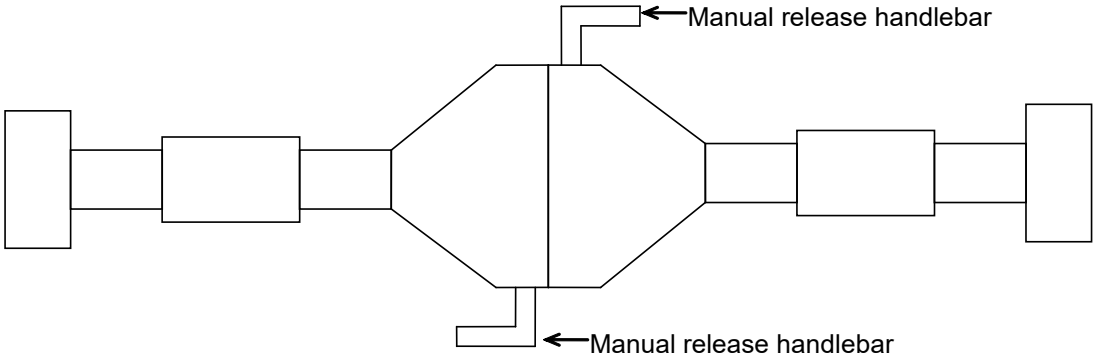
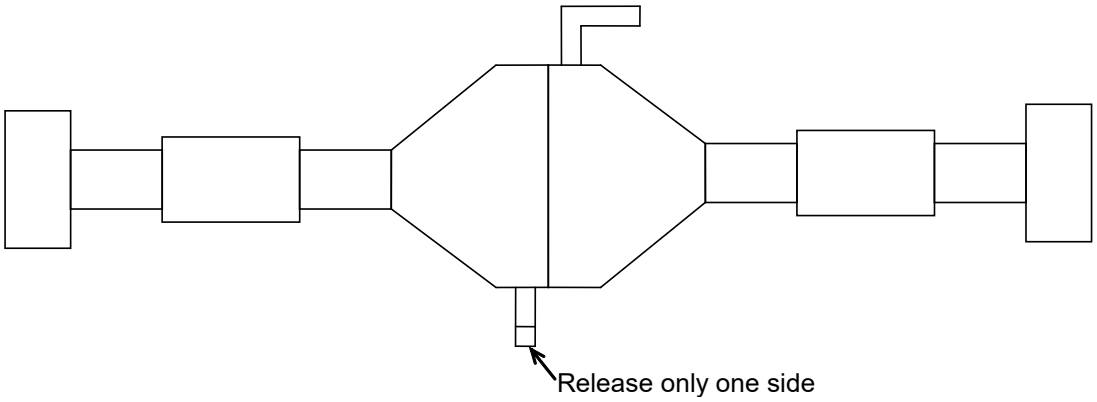


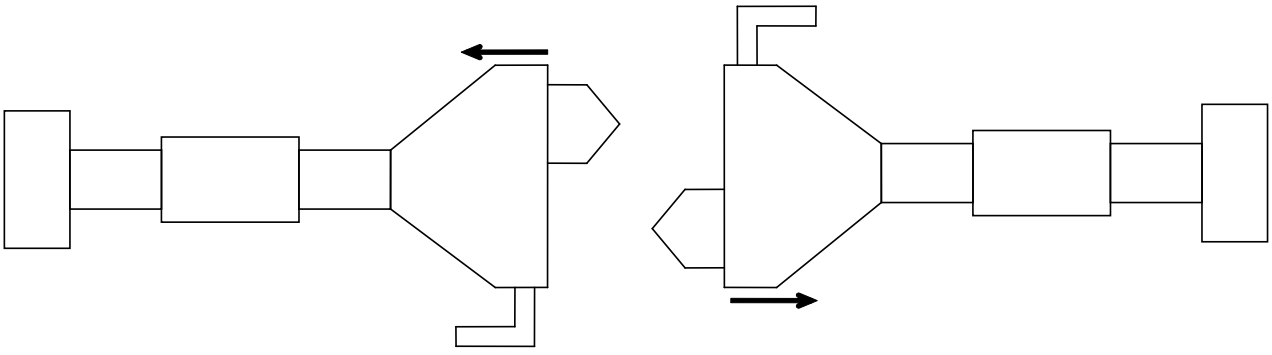
Figure 10.2 Conceptual Illustration of Mechanical Coupler



Coupling



Release one side only



Uncoupling

Figure 10.3 Conceptual Drawing of Manual Uncoupling

10.5.2 Swing Device of Automatic Coupler

The Automatic Coupler shall be equipped with the swing device.
In an attempt of coupling on a curve track, the mating two Automatic Couplers may be out of the gathering range. In consideration of such a case, the swing device shall enable the train driver to swing the Automatic Coupler in order to realise an appropriate coupling engagement.
The Seller shall design the swing device so that the train driver can remotely swing the Automatic Coupler via the manual operation panel in car.

10.5.3 Reserved

10.6 Reserved

10.7 Strength

The Goods shall withstand tensile/compressive load of more than 400 kN with safety factor of 1.5.
The Goods shall also withstand tensile load of more than 200 kN and compressive load of more than 400 kN without any permanent deflection.
All exposed parts of the Goods on which a person can stand shall withstand a downward vertical load of 1569 N (160 kgf) without damage or permanent deformation.

10.8 Coupling Condition

10.8.1 Coupling Speed

Train speed for coupling operation is as follows:

Normal coupling speed: 3 km/h
Absolute coupling speed: 5 km/h at the maximum
(accidental coupling speed due to erroneous operation by a train driver)

Abnormal speed for BAV: 22 km/h at the maximum
(maximum speed in BAV manual operation)

Abnormal speed shall be counted for the collision (i.e. the Goods shall withstand train-to-train and train-to-buffer collisions without any permanent failure or damage, except surface cosmetic scratch).

10.8.2 Coupling Alignment

The envisaged coupling alignment is shown in Table 10.2. The Automatic Coupler shall be designed so that coupling engagement is possible on any location on the guideway of the APM system.

Table 10.2 Envisaged Coupling Alignment

Case	Guideway alignment condition		Remarks
Horizontal misalignment	Straight	Both trains are on straight track	
	Straight - curve	One train is on straight track, and the other train is on pure curve track (30 m radius)	Without transition curve
	Curve	Both trains are on pure curve track (30 m radius)	
Vertical misalignment	Level	Both trains are on level track	
	Level - curve	One train is on level track, and the other train is on upgrade vertical curve track (1000 m radius)	Without transition curve
		One train is on level track, and the other train is on downgrade vertical curve track (1000 m radius)	Without transition curve
	Curve	Both trains are on upgrade vertical curve track (1000 m radius)	
		Both trains are on downgrade vertical curve track (1000 m radius)	

10.8.3 Offset of Car

Offset value of car at the coupler position is shown in Table 10.3. The Goods shall be compatible with coupling under any combination of alignment and offset of car.

Table 10.3 Allowable Offset Range

Case	Offset value	Remarks
Horizontal offset	+/- 90 mm	
Vertical offset	+/- 90 mm	

10.9 Collision Analysis

The collision cases are summarised in Table 10.4 and Table 10.5. The detail of each case is schematically illustrated in Clause 10.9.1 and 10.9.2.

For the cases, with the "Seller shall comply" box being checked", the Seller shall design the Automatic Coupler and the Semi-permanent Coupler to have enough shock absorption capability to withstand without damage. Only for the other cases with the "Seller shall comply" box being empty, the Goods may not withstand, and the Seller shall perform the analysis so that the Buyer can acknowledge the consequences.

The following assumption shall be made for the collision analysis:

- When brake is ON, the friction coefficient of APM tyre and the running surface is 0.3,

The Seller shall provide a full set of the collision analysis, for the Buyer's acceptance. At Bid the Seller shall submit only for the cases with the "Bid" box being checked. After the Contract, the Seller shall submit all.

In the collision analysis report, the following items shall be included for each collision cases listed in Table 10.4 and Table 10.5:

- Stroke-vs-time diagrams at each shock absorber
- Force-vs-time diagrams at each shock absorber
- Force-vs-stroke diagrams at each shock absorber
- Maximum stroke value
- Maximum force value
- Absorption energy value
- Stored energy value

The buyer will provide the characteristics of the wayside track end buffer later.

Table 10.4 List of Conditions of Train-to-train Collision

Case No.	Moving train		Parked train		Seller shall comply	Seller's submission due at:	
	Train configuration	Speed (km/h)	Train configuration	Brake		Bid	Contract
Case 101	BAV	3	2 x AW0	OFF	✓		✓
Case 102	BAV	22	4 x AW0	OFF	✓		✓
Case 103	BAV	22	2 x AW3	OFF	✓	✓	✓
Case 104	BAV	22	4 x AW3	OFF	✓	✓	✓
Case 105	BAV	22	2 x AW3	ON	✓		✓
Case 106	BAV	22	4 x AW3	ON	✓		✓

Note 1: The numbers, such as "2" of "2 x AW0", represents number of cars.

Table 10.5 List of Conditions of Train-to-buffer Collision

Case No.	Train		Seller shall comply	Seller's submission due at:	
	Train configuration	Speed (km/h)		Bid	Contract
Case 121	BAV	3	✓		✓
Case 122	BAV	22	✓		✓

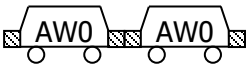
Note 1: The numbers, such as "2" of "2 x AW0", represents number of cars.

10.9.1 Train-to-train Collision Cases

Train-to-train collision cases summarised in Table 10.4 are detailed below:

Case 101: BAV (3 km/h) and single unit train (AW0, brake OFF)

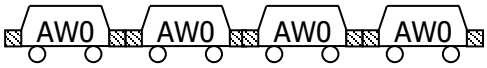
Running



Parked train without brake

Case 102: BAV (22 km/h) and double unit train (AW0, brake OFF)

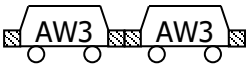
Running



Parked train without brake

Case 103: BAV (22 km/h) and single unit train (AW3, brake OFF)

Running



Parked train without brake

Case 104: BAV (22 km/h) and double unit train (AW3, brake OFF)

Running

Parked train without brake

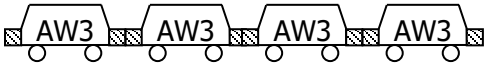
Case 105: BAV (22 km/h) and single unit train (AW3, brake ON)

Running

Parked train WITH brake

Case 106: BAV (22 km/h) and double unit train (AW3, brake ON)

Running

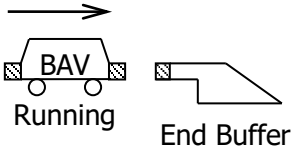


Parked train WITH brake

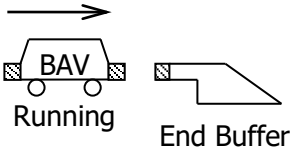
10.9.2 Train-to-buffer Collision Cases

Train-to-buffer collision cases summarised in Table 10.5 are detailed below:

Case 121: BAV (3 km/h) and wayside track end buffer



Case 122: BAV (22 km/h) and wayside track end buffer



10.10 Ambient Condition

Ambient condition at Site is shown in Table 10.6. The Goods shall be operable under this ambient condition without damage. Material selection shall minimise the deleterious effects of ultraviolet radiation.

Train of this APM system will operate mostly on open track, while there are tunnel section and bridge section (Sai Van Bridge, flying over the sea) in the APM system. So the Goods shall be designed to withstand sea wind, wind-blown sand, dust, metal powder, litter, etc.
Train factory testing will be conducted on open track in the Buyer's test facility (near coastal line) in Japan. Cars will be transported by sea shipping from Japan to the Site. The Goods shall be designed to withstand all these envisaged conditions without any damage, in consideration of temperature, humidity, precipitation and freezing.

Table 10.6 Ambient Condition

Item	Description	
Ambient condition	Temperature:	0 to 40 °C
	Humidity:	10 to 100% RH
	Maximum wind speed:	30 m/s (for normal operation)
	Maximum gust wind speed:	60 m/s
	Precipitation:	443.1 mm/hour
	Airborne salt level:	10 micrograms of salt per cubic meter of air
	Fungi and Corrosion:	Metals and equipment shall be selected and designed according to fungi and various corrosion reactions on metals
	Applicable standard for dust/sand: IEEE 1478	

10.11 Accessibility to Equipment

Opening and closing positions of locking components shall be marked.
All switch ON and OFF devices shall be easily reachable, marked and located in the same area. All valve, switch or selector location shall be marked.
Equipment and connectors shall be equipped with devices to prevent misalignment and incorrect polarization.
Equipment design shall allow easy diagnosis and easy put down.

10.12 Safety Signs

The Goods shall be equipped with safety signs not only for passengers but also for operation and maintenance personnel. ANSI Z 535.1 through Z 535.5 shall be compiled.
Regarding the languages used, the Seller shall comply with Clause 2.4.

10.13 Supplier Name plate

The Goods shall be equipped with a name plate of the Seller with showing production date, parts number, and serial number. This name plate shall be easily and visually accessible.
Regarding the languages used, the Seller shall comply with Clause 2.4.

11. WATERTIGHTNESS

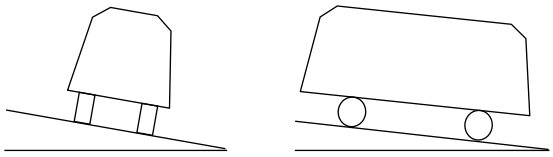
The watertightness of the Goods shall comply with a minimum of IP66 as described in EN 60529, with being installed to the carbody.
The Goods shall also be appropriately protected against the accumulation of moisture due to condensation.
Because of possible heavy rain and typhoons at the Site, the Seller shall provide guards against water penetration into the Goods.

The Seller shall perform watertightness test, for the Goods under the following condition:

- A gantry water splay bar which is made of piping with holes (diameter: 3 mm) is used,
- Water flow rate is 185 L/min or more and the pressure is 3 bar or more,
- Distance from the Goods to the water splay bar is 300 mm or less,
- The water splay bar moves longitudinally for two directions at the speed of 0.03 m/s.

In this test, water ingress (including trace of water ingress) is not allowed into the watertight part of the Goods.

The Seller shall take into account the dynamic displacement of vehicle due to vibration (vertical: 0.2 g, lateral 0.2 g, longitudinal: 0.15 g, where "g" represents acceleration of gravity), and tilting of carbody (6 % grade and 10 % cant). Watertightness shall be ensured mainly by the mechanical configuration and integrity of the Goods and only little dependence on sealant material is accepted.



10 % cant 6 % grade

Figure 11.1 Tilting of Carbody

12. ELECTRIC REQUIREMENTS

12.1 Electrical protection and safety

All voltage-free metal parts shall be grounded.

12.2 Electric Cabling and Wiring

Selection and sizing of electric cable and wire shall comply with NFPA 130 and UTE C15-105. The Seller shall comply with the requirements from the Owner. The Seller shall submit a document showing calculation and justification of the selection.

Each interfacial electric cabling and wiring, including those in inside of the Goods, shall be equipped with a ring mark to show wiring identification number. The wiring identification numbers, for the carbody interfacing ones, are specified by the Buyer. The Seller shall arrange the ring marks accordingly.

12.3 Circuit Breaker and Current Interrupter

The circuit breakers and current interrupters shall be located in the appropriate location for protection of the circuit and maintenance access. The design concept and selection shall comply with the Owner's requirements. The Seller shall submit a document showing calculation and justification of the selection.

12.4 Connector and Terminal

Connections shall comply with the EN 61033 and EN 61034. Connectors shall comply with the EN 60352 and NF F 61030 and NF F 61032.

All connectors shall be weather-proof, with sealing gaskets on the mating surface and on the back at cable entry. Connectors shall be metal shelled, positive-locking, 1/4 or 1/3 turn bayonet-type lock, quick-disconnect and environmentally sealing. One piece of the connector shall be rigidly mounted.
Connections shall be effected through locking-type plugs or bolt-on terminal strips. Wires between terminals shall be continuous without joints.
Conductors subject to motion relative to the terminal shall be protected, to eliminate fracture of the conductor near the terminal.
All connectors shall be identified by number. Where connectors could be mistaken with one another, they shall be dissimilar or mechanically keyed so that mistake is avoided.

The Goods shall electrically interface with the vehicle control system by means of connectors. Quantity of spare pins of connector shall be within 10 to 15 %.

The terminal used for the Goods shall be screw type or Weidmuller type. All terminals shall be equipped with transparent cover to avoid electric shock to operation and maintenance personnel and short circuit accident.

The connectors and terminals shall comply with the Owner's requirements.

12.5 Spacing and Creepage Distance

Spacing and creepage distance shall comply with NFPA 130 Section 8.6.2.

12.6 Insulation Test and Dielectric Test

The Seller shall perform insulation resistance test which complies with APTA SS-E-001-98.
The Seller shall also perform dielectric test which complies with APTA SS-E-001-98.

12.7 EMC

The Seller shall perform full EMC test to demonstrate that the Goods comply with both MIL STD 461E and EN 50121-3-2.

13. NOISE

Not applicable unless the Goods generates any noticeable noise.

14. VIBRATION AND SHOCK ENDURANCE

The Goods shall be robust against shock and vibration occurred in transit application.

The required capability for the Goods is defined in Table 14.1. The Goods shall withstand vibration and shock loads without any damage or permanent deformation.

Vibration and shock load test shall be in accordance with IEEE 1478.

Table 14.1 Vibration and Shock Loading Condition and Criteria

Items	Direction	Load	Criterion	Remarks
Vibration load	Vertical	1 ± 0.2g	Stress shall not exceed fatigue strength of material	
	Lateral	± 0.2g		
	Longitudinal	± 0.2g		
Shock load	Vertical	2.0g	Stress shall not exceed yield strength of material with safety factor 1.5.	
	Lateral	2.0g		
	Longitudinal	3.0g		

15. FIRE SAFETY

Design of the Goods shall avoid the use of materials, which are flammable or produce excessive or toxic smoke and gases as required by NFPA 130 Section 8.
The Goods shall not contain poly vinyl chloride in any shape or form.
The Seller shall submit fire load calculation and heat load calculation of the Goods.

16. SOFTWARE AUDIT

Not applicable unless the Seller uses any software.

17. OTHER TECHNICAL REQUIREMENTS

17.1 Plating

All interfaces between different metals shall be properly arranged in order to prevent electrolytic corrosion through the design life.

17.2 Painting

Painting should be done with the Seller's standard painting specification not to sustain corrosion damage during design life with appropriate maintenance. Before painting works, painting specification shall be submitted by the Seller for the Buyer's review. Colours are to be advised by the Buyer.

17.3 Thread

Thread bolts shall be metric (ISO).
All fasteners that are not stainless steel or aluminium shall be plated with zinc.

17.4 Pipe thread

Tapered pipe thread shall be used for air connection between the Goods and car. Reference standard is ISO 7-1, "Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances and designation", or equivalent to JIS B 0203 "Taper Pipe Threads" (Japanese Industrial Standard).

17.5 Welding

All welding shall be ANSI/AWS D1.1 for steel and ANSI/AWS D1.2 for aluminium.

17.6 Inspection & Test

Inspection & test shall be carried out in accordance with the Seller's standard. The standard inspection & test procedure shall be submitted by the Seller for the Buyer's acceptance.
A complete set of factory tests and inspections shall be carried out at the Seller's facility and/or his subcontractor's facility. The Seller shall enable full access, and shall fully cooperate for these tests and inspections at the Buyer's and/or the Owner's request.

The Seller shall also add in the test plan the tests required by the Buyer and/or the Owner.

17.7 Deviation

If the Seller has any deviation from this specification, the Seller shall, before the Contract, inform the Buyer of the deviation by documents for the Buyer's acceptance. After the Contract, no deviation is accepted.

Appendix A

The Owner's Specification 23 EFS Volume 2.2 WP 01.12 Clause 5.12

The suspension system of the vehicle shall ensure that the maximum vertical gap between the train floor (or threshold) and platform, specified above, is not exceeded whatever the loading condition of the train.

Failure of a suspension shall not result in a condition that allows damage to the trains, electrical system, or guideway, or present a hazard to passengers. In this case the train shall still be able to run until the nearest safe location controlled by the ATC.

5.11 • Train end fittings

The ends of each train shall be designed to enable replacement of damaged parts without having to do any work on the main structure, if it is not damaged.

The lower parts shall be designed so that they can be easily replaced at the level of the horizontal bumper and the coupling level.

No roughness or sharp angles shall be tolerated.

Audio and lighting appliances can be integrated.

The straps or grab handles for accompanying staff shall be integrated to the vehicle end if required.

5.12 • Material and Workmanship

5.12.1 General

All equipment shall be constructed in a sufficiently robust manner, and arranged so as not to suffer deterioration, wear, or damage due to vibration or shock loads encountered in operation.

The components shall be arranged into groups of equipment as far as possible. The components of specific item of equipment shall be mounted on a common frame or equivalent, including wiring, piping, etc.

External equipment shall be protected from high pressure water jets and shall comply with a minimum of IP66 as described in EN 60529 standard or equivalent recognized standard.

The workmanship and material specified for the rolling stock and goes in complement to the ones specified in 9 EFS Volume 2.1 Part 6 Applicable Standards and Technical Requirements

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5.12.2 Mechanical requirements

5.12.2.1 Mechanical Components

5.12.2.1.1 General

All materials and workmanship for furnishing and installation of mechanical products and associated work shall be accomplished utilizing international railway approved methods, regulations and engineering standards. Such material and equipment shall be designed, manufactured, installed, and tested in accordance with the latest editions of applicable standards, codes, and recommended guidelines of the relevant ASCE, EN, UIC or equivalent standards, in effect at the contract "Notice To Proceed" signature date.

The Contractor shall propose standards that will be met for construction and testing of this construction. The Contractor shall provide the technical characteristics of the mechanical components which will be used for the rolling stock.

This applies to the following components, but not limited to :

- Pressure vessels, piping and fittings,
- Air conditioning system piping and fittings,
- Fasteners,
- Locking devices,
- Rivets,
- Bearings,
- Sleeve bearings and bushings.

5.12.2.1.2 Materials

The Contractor shall provide the technical characteristics of the materials which will be used for the construction of the rolling stock.

This applies to the followings, but not limited to:

- Steel,
- Stainless steel,
- Castings,
- Low-alloy, high-tensile steel,
- Aluminium,
- Galvanizing,
- Isolation coatings,

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- Permanent protective finishes,
- Dissimilar materials: Connection of different materials shall be permitted only at permanent connections and with suitable electrochemical isolation. All such isolation treatments shall be permanent and shall not require maintenance or replacement. Dissimilar materials shall not be permitted at electrical connections, or at connections requiring disassembly for maintenance or for removal and replacement of equipment,
- Panels in composite materials (not allowed for structural parts of the rolling stock),
- Fibreglass-reinforced plastic (not allowed for structural parts of the rolling stock),
- Insulation materials:
  - o Sound damping materials,
  - o Elastomer,
  - o Glass,
  - o Filters,
  - o Lubricants,
  - o Marking films,
  - o Sealing,
  - o Paint and painting (application process for each type of paint to be detailed).

Soft metals subject to creep (aluminium, zinc, etc.), shall not be used in applications requiring them to carry current, stress or operate in high temperatures. In exceptional cases, such applications shall be submitted to the Employer for approval.

All non-metallic materials, as well as electrical cables, cable trays, glues and sealing shall comply with the flammability and smoke emission requirements specified in section 6.3.3 *"Fire protection and safety, flammability and smoke emission"* of this document.

Natural rubber shall not be used for any components exposed to sunlight or lubricants during operation or maintenance.

5.12.2.1.3 Prohibited Materials

The following materials are prohibited for use in construction, except where specifically permitted:

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- Asbestos,
- Lead,
- Urethane foam,

- Aluminium threaded fasteners.

5.12.2.2 Welding and Brazing

The Contractor shall be responsible for the quality of all welding and brazing, of rolling stock elements, including that performed by suppliers.

The whole welding process shall be in accordance with EN 15085 parts 1 to 5 "Welding of railway vehicles and components" or equivalent recognised standard. If different, the Contractor shall provide for approval the standard that is proposed for welding construction and testing.

The Contractor shall provide the technical characteristics of the materials and methodology which will be used for all welding and brazing.

5.12.2.2.1 Welder Qualifications

Welders, brazers employed in the making of structures or products specified under these technical provisions shall make only those welds, brazes, or soldered joints for which they have been previously qualified to a standard that the Contractor will propose. Certificates shall be made available upon request.

5.12.2.2.2 Welding Process

Current, voltage, distance, flame, and other variables shall be controlled to give a smooth weld, free of

gas pockets, oxide inclusions, and variations in the width and thickness of the weld, as well as wandering and spattering.

Arc welding shall be performed by the MIG process and in all cases complete and adequate fusion with the base material shall be ensured.

The Contractor shall provide details of all preparatory and post-welding procedures to be undertaken during the process of spot welding. Spot welding of components which carry structural loads shall be performed using equipment fitted with time, current and pressure control.

The contractor shall be capable of providing the welding procedure applied on Employer request.

5.12.2.2.3 Test Welds

The Contractor shall propose for approval requirements and recommendations to be followed in test welds.

These requirements and recommendations shall also apply to brazed or soldered joints.

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5.12.2.2.4 Heat Treatment

Where appropriate for the material and welding methods used, parts rotating at high speed, parts subject to shock and vibration and other critically stressed parts shall be heat treated after welding for stress relief or approved strength attainment. Such stress relief shall comply with the recommendations of the supplier of the material.

5.12.2.2.5 Special Welding

The welding of stainless steel to galvanized steel and the brazing of stainless steel shall be prohibited in rolling stock elements. Procedures for structural welding of stainless steel to other combinations of metals or conditions shall be submitted by the Contractor for review.

5.12.2.2.6 Weld Inspection

The Contractor shall inspect all structural welds. In addition to visual inspections required by the relevant welding standards, non-destructive surface inspection (dye penetrant or magnetic particle methods, as appropriate) shall be used to inspect all first-production welds. The Contractor shall specify additional non-destructive inspection requirements for subsequent welds. In no case shall the length of weld non-destructively inspected be less than one percent of the total weld length.

Full-penetration welds shall be non-destructively, volumetrically inspected (using either ultrasonic or radiographic methods).

Welding shall be inspected under the supervision of a certified welding inspector, and shall be conducted in accordance with the latest applicable standards requirements.

5.12.2.2.7 Brazing and Soldering

All pipe or tubing connections shall be leak-free. The inner surfaces of air conditioning tubing and piping shall be protected from oxidizing contaminants during and after brazing or soldering operations. Any soldering of stainless steel lap joints shall have a smooth, uniform appearance and shall be leak-free.

5.12.2.2.8 Toughness of Welded Assemblies

The Contractor shall verify and must be capable of proving that all safety-related welded structures have sufficient toughness for the expected environmental exposure. Specifically, the weld heat affected zone and base metal shall resist service impact loads expected in normal service at the expected operating temperature.

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5.12.2.3 Housing and Enclosure

Each housing and enclosure shall be appropriately protected against the ingress of dust, water and the accumulation of moisture due to condensation.

The material of the housing and enclosure for the outdoor equipment shall be stainless steel. The cable entry shall be of the clamped type.

The Contractor shall provide all equipment in suitable enclosures providing ease of access for maintenance purpose. This shall be achieved with lockable doors/lids, or screwed lid for small boxes, on safety related equipment.

5.12.2.4 Cables Fastening

Cable ties shall be made from corrosive resistant, flame retardant and ultra violet resistant materials. At locations where cables are installed above tracks or in areas subjected to significant and constant vibration, cable ties shall be of metal or plastic construction type and coated with corrosive resistant flame retardant materials.

5.12.2.5 Connectors

The design shall minimise the different sizes and types of electrical connectors. All connections shall be in accordance with a recognised railway international standard. All connectors shall be identified by number or colour. Where connectors could be mistaken with one another, they shall be dissimilar or polarized so that mistake is avoided.

Unless otherwise approved by the Employer, connectors shall have recessed pins and designed so that there is no dangerous touch voltage on exposed pins when disconnected. Connector cables shall be provided with enough slack to permit withdrawal of assemblies for test.

Unless otherwise approved by the Employer, all connectors provided in vital and non-vital circuits shall have a surface leakage distance according to recognised railway international standards.

5.12.2.6 Corrosion

Protection of materials against all types of corrosion shall be appropriate for the environment of Macau and the operating conditions of the rolling stock.

The Contractor shall submit corrosion protection methods for metallic components and equipment cases (tropicalisation plan). Such corrosion protection measures shall not require to be repeated throughout the life of the rolling stock.

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5.12.2.7 Fasteners

Nuts and bolts for the installation of any equipment shall conform to the requirements of ISO 272, and be galvanized to ISO 1459, 1460 and 1461 as appropriate. If different, the Contractor shall provide for approval the standard that is proposed for fasteners.

Screw threads shall be of ISO metric sizes.

ISO Metric fine threads shall be used in applications where the fastener is subjected to alternating transverse loads. In other cases, the coarse series of threads shall generally be used, except where precluded by size. The use of studs shall be avoided as far as possible.

Screw threads smaller than M5 size shall be avoided as far as possible. Screw and bolt heads shall be of hexagonal form on all M5 and larger screws. Screws smaller than M10 shall be of high tensile material.

Fixings shall be locked adequately to prevent loosening in service. Fixings shall withstand any shock loads the equipment is likely to encounter.

In critical areas the locking of all nuts, bolts and fixings shall be of a positive form, which prevents mechanical rotation of the nut relative to the bolt, irrespective of source of vibration.

Stainless steel parts shall be attached by stainless steel screws or fasteners.

Tapped holes shall be drilled and tapped to the full thickness of the material. Blind holes shall be used only where this is unavoidable. All such blind holes shall provide at least 3mm clearance between the end of the screw and the bottom of the tapped hole.

Tapped holes shall be provided with suitable thread inserts where necessary, and shall always be used in aluminium or copper.

Fixings for covers which may have to be removed for maintenance, shall be captive.

All steel fasteners used in electrical equipment shall be either galvanised, sherardised or cadmium plated.

5.12.2.8 Labels

All equipment shall be labelled with a rating plate including but not limited to :

- the manufacturer's name
- the manufacturer's logo,
- the identifying name of the equipment,
- the serial number of the equipment,
- the nedeed information allowing the traceability and update of the equipment (revision number...)
- the date of manufacture of the equipment.

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Rotating machines or equipment shall carry a rating plate indicating current and voltage ratings and speed at rated current, and maximum speed. In addition a connection diagram shall be provided inside or adjacent to the terminal box wherever provided.

Unidirectional rotating machines or equipment shall carry an arrow showing the correct direction of rotation.

The labels shall be clearly stamped, cast or engraved and securely attached to the equipment. Where appropriate, equipment shall be labelled with warnings of high temperature and electric shock risk. Warning labels shall be written in English at least.

All cables and busbars shall be provided with durable and legible cable identification markers at each end, corresponding exactly with those on circuit diagrams provided by the Contractor.

5.12.2.9 Painting

All painting processes shall be in accordance with a railway recognised international standard.

The entire underside of the vehicle, including equipment boxes made of steel, and bogies shall be covered with primer and finishing paint. All steel parts which will be hidden and unaccessible, except stainless steel, shall be covered with primer and corrosion protection before being concealed. The type of painting used shall be easily cleanable.

The painted areas that are in direct contact with passengers should be minimized. In case the passengers can come easily into contact with painted surfaces, the paint of these surfaces shall be resistant and without danger for health. In general way epoxy painting shall be preferred.

5.12.3 Electrical requirements

5.12.3.1 Electrical constructive measures

The design and construction of all electrical and electronic equipment shall prevent conducted electromagnetic interference from interfering with system performance. The electrical equipment shall comply with IEC 62 236 or EN 50 121 or equivalent recognized standards.

The Contractor shall submit documentation that the designs, materials, equipment, installation, and testing furnished in accordance with these provisions conform to the applicable referenced standards and requirements.

Where other standards are proposed by the Contractor, the Contractor shall submit, for Employer review, documentation that the proposed procedures or standards are the equivalent of the foregoing standards and specifications. Proposed substitute specifications shall be submitted in English at least.

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All electrical and electronic components shall be supplied with ample thermal margins that provide no less than 15 years of service life in application, and shall have over-current, over-temperature, and over-voltage protection provided.

Each appliance of the electrical installation shall be fully interchangeable without the need of modification or adjustments (plug & play type).

All electrical equipment and cable installation shall include a provision of 15% extra (quantity, length, space etc...) at the start of the revenue service in order to cope with upgrading of the system without the need to replace the equipment.

5.12.3.2 Electric equipment

The design, construction and tests of all electrical equipment shall comply with EN 60 077 or equivalent recognized standards.

5.12.3.3 Electronic equipment

The design, construction and tests of all electronic equipment (hardware and software) shall provide high availability and safety level and shall comply with EN 50 155 or equivalent recognized standards.

Variable resistors shall be avoided wherever possible.

Electronic equipment shall not be damaged, nor shall malfunction when subjected to direct spikes and surges on the supply and indirect burst transients.

5.12.3.4 Circuit Breakers

All circuit breakers shall be with a frame size fully suitable for the service intended. They shall be the highest quality procurable.

Each input power circuit shall be protected by an individual circuit breaker. No circuit breaker shall protect more than one circuit, nor shall any one circuit be protected by more than one circuit breaker, except as otherwise specified. Circuit breaker terminals shall not be used as junction points.

All circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the minimum-size wire used for power distribution within the protected circuit.

Performance shall not be affected by ambient temperature. Circuit breaker poles may be connected in series, if necessary to achieve the stated voltage interruption requirements. Each circuit breaker pole shall be equipped with adequate means of arc extinction to prevent flashover.

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The components implemented should not be degraded according to the number of operations. The protective circuits must be able to be exchanged in the event of failure, without degrading or reforming the protected device.

5.12.3.5 Cables and wiring

5.12.3.5.1 General purpose

Rolling Stock wiring shall be unalloyed copper.

Control wiring shall be physically isolated from power wiring to prevent conducted electromagnetic interference from interfering with system performance.

Minimum wire size shall be in accordance with NFPA 130-2007, Standard for Fixed Guideway Transit and Passenger Rail System, Section 8.6.8.2; cable and wire sizes in accordance with Section 8.6.8.3; and wiring methods in accordance with Section 8.6.8.4.

The coupler cablings, inter cars cablings and carbody-bogie cablings shall be in accordance with the rules for installing cables described in the chapter 5 of EN 50343 standard or equivalent recognized standard.

Cables and wiring selection shall comply with practical method described in UTE C15-105.

5.12.3.5.2 High temperature wire and cable

At location subject to high temperature, all wire and cable shall be insulated and jacketed. This type of wire shall not be bundled together or run with any other type of cable.

The wire and cable characteristics shall comply with the chapter 8 of the EN 60077-2 or equivalent recognized standard.

5.12.3.5.3 Conduits and raceways

Design criteria for cable routing and cable containment system shall be specified at the beginning of the design stage.

Cable trays will be sorted to solid bottom type and ladder type. Solid bottom type cable tray with cover shall be used for the control and signal cables where needed as shielded cable tray to minimise the interference. Earthing of metallic cable trays is required.

Exposed PVC conduit shall not be used in the tunnel or underground areas. Metallic conduit shall be insulated from the tunnel floor by non-conducting supports. Where exposed non-metallic conduit is required, it shall be constructed of low smoke plastic or fibreglass.

All conduits shall be fabricated of rigid galvanized steel or rigid aluminium alloy, with all ends and interior seams deburred and sharp edges removed. All conduits shall be corrosion-protected and watertight, with the open ends of the conduit provided with strain relief bushings.

Vehicle wiring shall be housed in metal or plastic raceways. Plastic materials shall meet the flammability and smoke emission requirements. Open metal raceways and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall permit the sections to be mechanically and electrically coupled, while protecting the wires from abrasion. Conduit shall be designed to withstand the duty and environment in which it is applied.

Wire in conduit, ducts, and raceways shall be free of kinks, insulation abrasions, and insulation skinning.

Wire shall not be bundled if in a conduit or ducts. Each wire shall be removable for replacement without disturbing other wiring in the enclosure. Where wire is in open areas, bundling shall be permitted if this wire removal criterion is met. Any exposed wire shall be cleated, tied, or secured by other suitable means.

Pulling compound, if used, shall be non-conductive, non-hygroscopic, and non-odorous, and shall not attract vermin.

Flexible conduit shall be aluminium or steel alloy tubing with watertight compression fittings. Both inside and outside surfaces shall be protected against corrosion.

Wires connected to different sources of energy shall not be cabled together or run in the same conduit, raceway, tubing, junction box, or cable, unless such wires are insulated for the highest rated voltage in such locations. Wires connected to an electronic control apparatus shall not touch wires connected to a higher voltage source of energy than the control voltage.

Conduits, electrical metallic tubing, non-metallic ducts or tubing, and wires with their outer casings shall be extended into devices and cases, shall be rigidly secured in place by means of cleats, straps, or bushings to prevent vibration or movement, and to provide environmental protection, shall be run continuously into junction boxes or enclosing cases, and shall be securely fastened to same. Splices outside of junction boxes shall not be permitted. Connections and terminations shall provide for tightness and integrity.

Conductors and enclosures of any kind shall be protected from the environment and from mechanical damage including damage from other larger conductors.

Wire in conduit, ducts and raceways shall be free of kinks, insulation abrasions, and insulation skinning.

Except for unusual cases approved in advance by the Employer, no conduit, duct, or raceway shall contain more wires than will result in more than 40% fill.

5.12.3.5.4 junction boxes

Junction boxes shall comply with the EN 60529 standard or equivalent recognized standard. Junction boxes shall be corrosion resistant and shall be protected for a minimum of IP66.

Pull boxes, outlets, and junction boxes shall be provided specifically for the application, for all conduit and cable systems. Boxes, covers, and fittings of ferrous metal shall be hot-dip galvanized inside and outside after fabrication. Watertight boxes and fittings shall be constructed to exclude sand and rain, with all cover-securing device holes threaded and all covers gasket. Interiors of all junction boxes shall be completely painted with an insulating paint.

Exposed exterior boxes shall protect enclosed equipment against sand, water seepage, and falling or hose-directed water normally encountered in vehicle operations and cleaning.

5.12.3.5.5 Connections and connectors

Connections shall comply with the NF F61-033 and NF F 61-034 standard or equivalent international recognized standards.

Connectors shall comply with the EN60352 and NF F61-030 and NF F 61-032 standard or equivalent international recognized standards.

All connectors, for internal and external connections, shall be weather-proof, with sealing gaskets on the mating surface and on the back at cable entry. Connectors shall be metal-shelled, positive-locking, 1/4 or 1/3 turn bayonet-type lock, quick-disconnect and environmentally sealing. One piece of the connector shall be rigidly mounted.

The vehicle speed sensor connectors shall be multi-turn, fine-thread, metal-shelled, and weather-proof connectors.

Connections shall be effected through locking-type plugs or bolt-on terminal strips. Wires between terminals shall be continuous without joints.

Conductors subject to motion relative to the terminal shall be protected, to eliminate fracture of the conductor at of near the terminal.

Bolted terminal connections with overall insulating sleeves may be used to connect vehicle wiring to the propulsion motor leads and the maintenance power connection.

All connectors shall be identified by number or colour. Where connectors could be mistaken with one another, they shall be dissimilar or mechanically keyed so that mistake is avoided.

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5.12.3.5.6 Grounding

Where the maximum voltage onboard the rolling stock exceeds 48 Volts, the electrical system and carbody shall be grounded at all times by a non fused grounding circuit under all operating conditions in order to ensure the protection of people and avoid premature wear of the metallic parts of the rolling stock.

A minimum of two grounding brushes, each with sufficient current-carrying capacity to handle fault currents of the entire vehicle electrical subsystem, shall be in contact with the ground rail at all the times.

High voltage circuits and low voltage circuits should not be earthed together and separate earthing shall be arranged. All earthing pads shall be readily visible and accessible for inspection and trouble-shooting.

The carbody shall not be used to carry current for any source of power.

Electrical subsystem equipment enclosures shall be grounded with the grounding system in contact with the system ground rail at all times.

Where direct bonding is not feasible, conductors of sufficient cross section shall be used to limit the resistance across the bond to 0.0025 ohms and to carry lightning discharge current, or fault current of the equipment.

The Contractor shall provide a detailed earthing scheme. The earthing path shall prevent traction return current from passing through motor and axle bearings, gearboxes, bogie centre bearings, couplers, or any path other than the designed path.

5.12.3.5.7 Wire and terminal marking

Wiring shall be clearly marked in accordance with the rolling stock electrical schematic for ease of identification in maintenance and troubleshooting.

Electrical conductors shall be assigned circuit designations for the entire vehicle. The system of designating circuits shall be provided by the Contractor for approval.

The individual conductors within any cable shall be appropriately color-coded and numbered, with markings at ends and terminal points, complete reference to these codes shall be included in documents relating to the cables. The Contractor shall confirm that its own personnel and its Suppliers adhere to the same method of marking and coding, and that designations are consistent across equipment interconnections, regardless of their source of supply. On electrical panels or around interconnecting jumpers without a panel, the Contractor may not be required to conform to certain designated wire requirements.

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