

國外公差報告

中山科學研究院

國 外 公 差 心 得 報 告

| 批 示 | | | | | |
|----------|----------------------|--------------|-----|-----|-----|
| | | | | | |
| 公年 差度 | 九 一 | 所屬單位 各級主管 | 計品會 | 政戰部 | 企劃處 |
| 單 位 | 第二研究所 工程發展組 | | | | |
| 級 職 | 簡聘技監 上尉技士 荐聘技士 | | | | |
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國外公差人員返國報告主官（管）審查意見表

輕軌車的測試和認證為當前軌道車輛計畫重要的執行目標之一，為開發 1435 標準軌距輕軌車，本次派遣林英才等三員前往德國及瑞士兩國，拜訪 KIEPE、IRTC、GHH、PROSE、WINPRO 等 5 家軌道車輛專業公司，分別就軌道車輛整車系統測試、另組件測試、轉向架組銲製程、出廠前檢測等項目和標準軌距輪軸規格及推進系統控制元件等相關技術與製造廠工程師進行研討並參觀其工廠設施，實際所接觸的技術層面相當具體而深入，特別是能親身體驗國際一流標準測試廠與轉向架製造廠的運作狀況，實效更是良好，對提昇本院軌道車輛研發能力、繼續推動計畫之執行及未來國內輕軌車計劃之發展有極大的幫助。

| 報 告 資 料 頁 | | | |
|--|------|------------------------------|---------------------------|
| 1. 報告編號： CSIPW-92B-F0002 | | 2. 出國類別： 考 察 | 3. 完成日期： 92 年 1 月 16 日 |
| | | | 4. 總頁數： 54 頁 |
| 5. 報告名稱： <u>德國</u> 、 <u>瑞士</u> 軌道車輛技術研討暨資料蒐集 | | | |
| 6. 核准 文號 | 人令文號 | 91 銓鑑字第 7322 號 | |
| | 部令文號 | | |
| 7. 經 費 | | 新台幣： 421,152 元 | |
| 8. 出(返)國日期 | | 91 年 10 月 29 至 91 年 11 月 7 日 | |
| 9. 公 差 地 點 | | <u>德國杜塞道夫</u> 、 <u>瑞士蘇黎克</u> | |
| 10. 公 差 機 構 | | KIEPE、IRTC、GHH、PROSE、WINPRO | |
| 11. 附 記 | | | |

封面格式

行政院及所屬各機關出國報告
(出國類別：考察)

(裝
釘
線)

德國、瑞士軌道車輛技術研討暨資料蒐集

服務機關：中山科學研究院

出國人職稱：聘用技監 上尉技士 聘用技士
姓名：林英才 洪興漢 周亞屏

出國地區：歐洲

出國期間：911029~911107

報告日期：920120

行政院及所屬各機關出國報告提要

出國報告名稱：德國、瑞士軌道車輛技術研討暨資料蒐集

頁數 54 含附件：☒ 是 ☐ 否

出國計畫主辦機關/聯絡人/電話

出國人員姓名/服務機關/單位/職稱/電話

林英才等三人/中科院第二研究所/工程發展組/簡聘技監/03-4456622

出國類別：☒ 1 考察 ☐ 2 進修 ☐ 3 研究 ☐ 4 實習 ☐ 5 其他

出國期間：911029~1107 出國地區：

報告日期：920116 德國杜塞道夫
瑞士蘇黎克

分類號/目

關鍵詞：軌道車輛、輕軌車，轉向架

內容摘要：

輕軌車計畫赴歐洲德國、瑞士等國，拜訪 KIEPE、ITRC、GHH，PROSE、WINPRO 等公司，分別就馬達驅動系統、軌道車輛測試及規劃和輪軸剎車系統進行研討，並參觀各組裝、製造和測試現場，以增加軌道專業技術及實務經驗。

主要研討項目是為配合台灣標準軌距輕軌車開發計畫需求，其中馬達驅動系統部份主要著重在電子驅動元件如變頻器 啟動剎車電阻的規格介面及應用；軌道車輛測試則著重在全新系統檢測、零組件測試及與噪音震動的量測；輪軸剎車系統則著重於標準軌距輪軸規格研討。經由本次參觀與研討所獲得之寶貴經驗，將對未來標準軌距輕軌車之測試計畫和轉向架的開發，有極大的幫助。

本文電子檔已上傳至出國報告資訊網（<http://report.gsn.gov.tw/work>）

附件三

行政院及所屬各機關出國報告審核表

| | |
|-------------------------------------|---|
| 出國報告名稱：德國、瑞士軌道車輛技術研討暨資料蒐集 | |
| 出國計畫主辦機關名稱：中山科學研究院 | |
| 出國人姓名/職稱/服務單位：林英才等 3 人/簡聘技監/中山科學研究院 | |
| 出國計畫主辦機關審核意見 | <input type="checkbox"/> 1. 依限繳交出國報告 <input type="checkbox"/> 2. 格式完整 <input type="checkbox"/> 3. 內容充實完備 <input type="checkbox"/> 4. 建議具參考價值 <input type="checkbox"/> 5. 送本機關參考或研辦 <input type="checkbox"/> 6. 送上級機關參考 <input type="checkbox"/> 7. 退回補正，原因： <input type="checkbox"/> ①不符原核定出國計畫 <input type="checkbox"/> ②以外文撰寫或僅以所蒐集外文資料為內容 <input type="checkbox"/> ③內容空洞簡略 <input type="checkbox"/> ④未依行政院所屬各機關出國報告規格辦理 <input type="checkbox"/> ⑤未於資訊網登錄提要資料及傳送出國報告電子檔 <input type="checkbox"/> 8. 其他處理意見： |
| 層轉機關審核意見 | <input type="checkbox"/> 同意主辦機關審核意見 <input type="checkbox"/> 全部 <input type="checkbox"/> 部分_____（填寫審核意見編號） <input type="checkbox"/> 退回補正，原因：_____（填寫審核意見編號） <input type="checkbox"/> 其他處理意見： |

說明：

- 一、出國計畫主辦機關即層轉機關時，不需填寫「層轉機關審核意見」。
- 二、各機關可依需要自行增列審核項目內容，出國報告審核完畢本表請自行保存。
- 三、審核作業應於出國報告提出後二個月內完成。

德國、瑞士軌道車輛技術研討暨資料蒐集

壹、出國目的及緣由

中山科學研究院第二研究所執行經濟部科技研究發展專案計畫「機械業關鍵系統技術研究發展第二期三年計畫（3/3）之九十一年度科技專案”軌道車輛系統”」，本年度計畫目標是建立輕軌電車系統測試能量，完成輕軌電車測試場規劃及完成輕軌原型車系統測試，現正積極進行中。

由於輕軌電車採共用路權，不需徵收土地，建造費用較捷運系統低廉，在歐洲許各大城市早已普遍存在，成為當地的特殊景觀。發展輕軌電車以解決台灣都市地區大眾運輸需求，改善環境品質，創新都市景觀，已逐漸在國內形成共識，並成為台北市市長候選人及地方民意代表之參選政見，預期未來各縣市政府都將會列為重要市政建設，輕軌電車市場潛力已被看好。

配合科專計畫軌道車輛系統的計畫進度，參訪國外軌道工業專業廠，了解軌道工業發展的先進技術，一直是年度計畫重要工作項目之一，目的在培養參與研發設計人員的軌道專業知識與實務經驗，使能更了解系統特性以掌握設計方向。

透過參與輕軌車計畫之零組件廠協調，得以派員前往德國、瑞士兩國軌道零組件製造廠及系統測試場，拜訪 KIEPE、IRTC、GHH，PROSE、WINPRO 等公司，就馬達驅動系統、軌道車輛系統測試、規劃和輪軸剎車系統等技術領域進行觀摩研討，並順道參觀各項組裝、製造和測試現場，了解實際工作狀況，其中 IRTC 與 WINPRO 兩公司原本不在本次列出之參訪行程中，因參訪地點相距不遠，且在軌道車輛測試和轉向架製造方面有非常專業的經營模式，透過 KIEPE、PROSE 公司的合作關係，額外安排前往參觀，收獲超過預期。

貳、公差心得

KIEPE 公司參訪心得

這次公差第一站，是位於德國杜塞道夫的 KIEPE 公司，KIEPE 公司提供整套的軌道車輛電子設備，包括推進技術、車輛控制系統、空調系統以及自行開發生產供軌道車輛用電源供應靜態變流器。台灣輕軌電車原型車的牽引馬達電源供應變頻器、起動剎車電阻和速度及位移檢知器等多項控制設備即是使用 KIEPE 公司產品，詳見附圖 2-1~2-5。



圖 2-1 Direct DC Inverter; 3-phase output



圖 2-2 Direct DC Converter



圖 2-3 Starting and Braking Resistor



圖 2-4 Speed Transmitter



圖 2-5 Displacement Transducer

KIEPE 產品已普遍應用於德國、英國和奧地利幾個大城市的電車系統上，如科隆、杜塞道夫、漢堡、斯圖加特、倫敦和維也納等電車系統，技術已極為成熟，台灣輕軌車推進系統在引進該公司系統後，未來運轉使用時，必有良好品質。

KIEPE 公司推進控制系統電車均在鄰近 IRTC 測試中心進行測試，KIEPE 公司在該處設有測試部門，長期駐有工作人員。本次拜訪 KIEPE 公司有另一項重要目的，就是透過 KIEPE 公司安排，參觀歐洲最現代化、測試設備最完整的 IRTC 測試中心。

IRTC 公司參訪心得

IRTC 正式名稱是國際軌道技術中心(International Rail Technology Center)，地點在 Wegberg-Wildenrath，原為德國的空軍基地，位於阿赫恩（Aachen）/ 杜塞道夫/ 科隆（Cologne）三區域中間(詳見附圖 2-6)，直接與荷、比、盧相鄰，連接人口稠密的 Rheinschiene 和 Ruhrgebiet 兩區，因位置獨特，在北萊因邦(State of North Rhine Westphalia, NRW)的積極開發下，成功地將其轉變為德國及歐洲最重要的軌道測試技術中心和兼具理論與實務的研發重鎮。該區鐵路路網綿密總長約 8300 公里，依據邦政府及德鐵公司估計，該區於 2003 年將有約 150 部機車頭 600 輛客車廂、210 輛電車及 300 輛柴力車的需求量。

中心現有超過 450 家軌道相關之廠家進駐，包括軌道系統供應商、技術公司和學術研究機構，約 6 萬人在此區工作，(重要

的研究機構如：Professorship and institute for rail vehicles and conveyor technique、Professorship and institute for control engineering、Professorship and institute for power converter technology and electric drives、Professorship and institute for construction techniques in machine building、Professorship and institute for drives and controls based on fluid technology、Institute for transport sciences and professorship for railway systems and transport economics)



圖 2-6 IRTC 位置圖

IRTC 測試中心主要是由西門子公司 (Siemens AG) 主導興建, 合作團隊包括 Institute of Railway Technology Ltd、TUV Inter Traffic Ltd.、TUV Automotive Ltd. and Studiengesellschaft fur Unterirdische Verkehrsanlagen / STUVA , 為軌道車輛的標準測試場, 並獲產官界 (如德國軌道工業協會 / Association of Railway Industry in Germany、德國都會運輸營運協會 / Association of Urban Transport Operators in Germany、德鐵公司 / Deutsche Bahn、德國經濟部 / Ministry of Economic Affairs 及北萊茵邦政府) 的支持, 資本額為 182,000 歐元, 並於 1997 年 1 月獲得德國聯邦鐵道部門 (Federal Railway Office EBA) 認可成為官方的軌道測試場, 可進行: 研發車輛測試、車輛型態測試(依據 IEC 1133 / EN 50 215) 全新系統檢測、軌道設備檢測、例行檢查、量產車輛測試、允收試驗、乘客舒適測試、噪音隔音量測、震動

量測、推進電力測試、集電弓測試、煞車性能測試、耗能量測與電磁匹配性動態量測等不同車種及零組件的測試，以期有效的加速研發進程和原型車的上市前置時間，在最短時間內進行量產車輛的品質提昇及在交給客戶之前確定軌道零組件及系統的品質，降低因錯誤所需的修正及自行投資測試設備的成本，以最佳測試週期與縮短整體的交期，並計畫發展專門用於零組件測試的試驗車及量測噪音與震動的測試軌道。

測試中心的人員具有軌道車輛多種領域的動態測試與品保經驗，亦接受運輸營運公司再製、再修車輛或零組件的測試需求及性能規格驗證，以減低回原製造廠的測試工作及時間，提高維修效率。



圖 2-7 IRTC 測試場鳥瞰圖



圖 2-8 IRTC 測試場區域放大圖

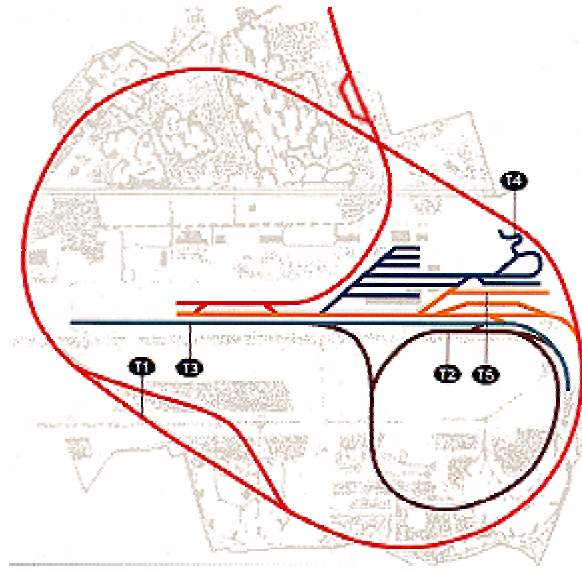


圖 2-9 IRTC 測試區配置圖

整個 IRTC 測試場區是由 T1~T5 五個測試區(詳見附圖 2-7&2-9)和佔地面積達 11,000 平方公尺,作為受測車輛整備和靜態測試的兩棟大型建築廠區(詳見附圖 2-8)組成。

各測試區有不同的測試環境和條件,列表分述 (詳見附表 2-1) 如后,在測試軌道的起點和終點兩側還有數條待測區支線。

- T1 區為長度 6,082m 大橢圓形測試軌道,作為最高車速 160km/h 的標準軌距(1435mm)車輛測試。本區另外包括一段 350m 長的 S 形曲線,有不同的曲度變化和軌道超高度。
- T2 區為長度 2,485m 小圓形測試軌道,可作為最高車速 100km/h 的標準軌和米軌(1000mm)車輛測試。
- T3 區為長度 1,400m 水平直線測試軌道,具標準軌、米軌和寬軌三種軌距。
- T4 區具標準軌、米軌之急轉曲線和多種曲度變化的測試軌道
- T5 區具標準軌和米軌之小曲線半徑和極度軌道超高測試軌道。

在 IRTC 完善的設備和完全不受干擾的獨立測試環境下,可以取得相當可靠的測試數據,這是在一般實際運轉條件下所無法測得的,而且量測速度相當快,節省人力、時間和動力的消耗,可及早改善維修度,提高國際競爭力。

表 2-1 各測試區不同的測試環境和條件

| Test area | Test track T1 | Test track T2 | Test track T3 | Test track T4 | Test track T5 | Train formation shed TFS1 | Train formation shed TFS2 |
|-------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------------------|---------------------------|
| Characteristics | | | | | | | |
| Max. speed (kph) | 160 | 100 | 100 | 25 | 25 | 5 | 5 |
| Length (m) | 6083 | 2485 | 1400 | 553 | 410 | 9 x 220 | 3 x 75 |
| Min. radius (m) | 700 | 300 | – | 15 | – | – | – |
| Max. grade (%) | 3.8 | 6 | 0 | 0 | 40/70 | 0 | 0 |
| Superelevation (mm) | maximum 150 | | | | | | |
| Structure clearance | 1 SM/DR | | | | | | |
| Track gauge 1435 mm | | | | | | | |
| 1000 mm | | | | | | | |
| Axle load 22.5 t | | | | | | | |
| 26 t | | | | | | | |
| Conductor line | | | | | | | |
| Conductor rail | *) | | | | | | |
| Traction power supply alternatively | | | | | | | |
| 15 kV 16 2/3 Hz | | | | | | | |
| 25 kV 50 Hz | | | | | | | |
| 12 kV 25 Hz | | | | | | | |
| 25 kV 60 Hz | | | | | | | |
| ± 750 V | | | | | | | |
| ± 400 – 2000 V | | | | | | | |
| ± 2000 – 4000 V | | | | | | | |

*) conductor rail of British standard

IRTC 測試中心的服務項目：

1. 設備提供(詳見附圖 2-10~2-15)：

動靜態測試設備（如負重機構、傾斜測試平台及轉向架升降機構等）、停車軌道、廠房及量測工具、簡報會議室和市場營運及動靜態分析專業操作人員。

2. 測試及準備工作：

測試程序準備、測試車輛整備、型態測試、壽限測試、車輛與驅動電力的介面測試、舒適度測試（如噪音、電磁干擾、震動及環境）與新系統的檢驗，並由通過認證的專家負責執行。

2.1 動態測試能量

煞車性能測試

運動性能及安全性測試

擺動測試

動態推進測試

噪音及震動量測

暫態及系統變化程序測試

車輛導引系統測試（含車輛打滑保護測試）

2.2 靜態測試能量

車輛幾何外形測試

建立傾斜係數

負載及軸承測試

氣壓及結構源噪音測試

靜態隔熱量測

防漏測試

電磁相容性量測

安全及資訊系統測試

3. 工程服務：

支援報告準備、量測結果的評估及建議、測試計劃的安排、檢查與協調、特殊測試的開發與安排、監督其他營運軌道的測試活動及發展客製化的測試。

4. 顧問服務：測試設備技術需求的建議、規範標準的合作、軌道車輛系統與零組件測試能量的市場分析、特殊測試（如環境氣候測試及滾轉測試）的效益與條件資訊提供、實務導向的教育訓練（RWTH-Aachen 大學及 TU-Berlin 大學）。

此外，為配合北萊茵邦政府在此地區建立一個結合理論與實務的研發中心，該測試中心更進一步提供一般訓練課程、職訓課程及研發創新工作，其相關內容如下：

1. 鐵道駕駛及工作管理訓練課程
2. 新型軌道車輛交車前的個人訓練課程
3. 以模擬器學習道路駕駛
4. 緊急情況下救援處置訓練課程
5. 跨產業的軌道專業人員認證
6. 暑期進修學院、會議及研討會
7. 軌道多元技術整合實務研討會

測試場重要設備：

1. 負重機構：量測車輪及車軸的負荷、扭曲量測

全長：52 m

重力計：8 個，間距可調

最大受力：30 噸（每對輪軸組）

軸負荷量測範圍：1 到 300 KN

資料解析度：100 N

軌距：1435 / 1000 mm

2. 靜態及傾斜測試平台：間隙測試、轉向架滾轉阻力量測

全長：6.6 m

軌距：1435 / 1000 mm

滾轉角度（Z 軸）： $\pm 15^\circ$

滾轉速度： $0.25^\circ / \text{sec}$

滾轉角度（Y 軸）： 4.5°



圖 2-10 靜態測試平台



圖 2-11 靜態測試平台機構



圖 2-12 車輛及轉向架升降機購



圖 2-13 雨淋模擬廠房



圖 2-13 標準軌與米軌複軌系統



圖 2-14 測試中的 ICE 高鐵



圖 2-15 測試中的通勤電車

GHH 公司參訪心得

GHH 公司位於 OBERHAUSEN，與杜塞道夫相鄰，距離杜塞道夫北方約 22 公里，現為專業的軌道車輛輪軸製造廠，追溯其建廠歷史極為悠久，自 1782 年開始，即於現址成立熔鑄生鐵的鼓風爐廠，之後逐漸擴充，增加鑄造加工、蒸汽機製造、採礦輸送機器製造和鐵軌鑄造等產品，1811 年開始生產礦坑車輛用鑄鐵輪，1845 年第一條生產工業輪軸的組裝生產線成立，1994 年公司重整，成為 Thyssen Guß AG 旗下的輪軸專業製造部門，1997 年母公司與 SAB WABCO 合併，SAB WABCO 公司從事各式軌道車輛剎車系統及輔助設備的發展已有 120 多年，產品品質良好，合併後彼此相得益彰如虎添翼。

GHH 的輪軸組與 SAB WABCO 的剎車系統兩項產品，組裝製程交互重疊，公司合併後介面簡化、產品品質與完工時程更容易掌控，成本降低，產品採購也比較容易，目前台灣輕軌車計畫所用的輪軸剎車系統即是向 SAB WABCO 採購。

GHH 生產電力車、柴油車用各式軌道車輛動力及無動力輪軸總成(詳見附圖 2-16~2-18)，在輪軸組裝技術方面，大多採用壓入配合，輪軸加工及組裝精度要求相當高，並且在壓入過程中，以電腦全程掌握受力變化，繪製圖表作為合格與否的驗收研判依據，品質要求非常嚴格，充分表現其專業形象。

本次前往 GHH 主要是配合未來發展趨勢，討論標準軌距輪軸規格、介面，並參觀輪軸製造、組裝、檢驗等製程與技術(詳見附圖 2-19~2-22)，以便開發新型轉向架。

圖 2-16 GHH 輪軸成品

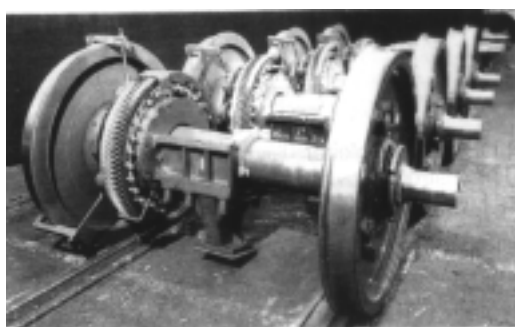


圖 2-17 GHH 輪軸成品

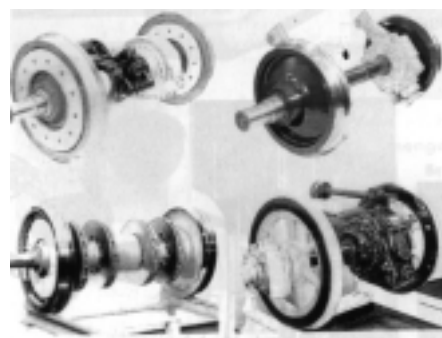




圖 2-18 輪軸成品



圖 2-19 輪軸與軸承箱組裝



圖 2-20 車輪車削中心



圖 2-21 剎車盤壓入輪軸過程



圖 2-22 輪軸組裝前檢驗

PROSE 公司參訪心得

PROSE 公司(詳見附圖 2-35)位於瑞士北部 WINTERTHUR 市，距蘇黎克約 25 公里，是一個由資深專業技術人員組成的年輕公司，早期以軌道運輸工具和訊號系統的開發設計及諮詢為主，後來增加軌道車輛的量測和認證，已通過 ISO9001:2000 認證，並獲得德國聯邦鐵道部(EBA)認可，對下列之軌道車輛測試項目具有認證資格：

1. 車體靜態結構測試_ 依據 DIN 12633、UIC566 和 UIC 577
2. 行車動態測試_ 依據 UIC 518
3. 脫軌安全係數評估_依據 OREB55/Rp8
4. 剎車系統測試_依據 UIC 54Q UIC 541、UIC 544-2 UIC 546 和 UIC 547
5. 空氣噪音和車體產生噪音量測_ UIC 651

PROSE 公司的「工程和諮詢部門」主要執行項目有

車輛工程：包括整車觀念設計、車體設計、轉向架設計、動態分析和模擬、結構分析及元件設計

車輛諮詢：軌道車輛技術移轉、車輛技術和商業化評估

操作諮詢：軌道車輛操作和維修訓練

計畫管理諮詢：複雜設計發展計畫之管理

標準化委員會諮詢：參與歐洲標準化活動有關轉向架剎車部份以及噪音規範的研擬

測試工作台技術諮詢：測試工作台設計諮詢(詳見附圖 2-23~2-25)



圖 2-23 螺旋彈簧靜態測試台
精密量測軌道車輛轉向
架螺旋彈簧垂向特性值
以及受力偏向



圖 2-24 多功能轉向架測試台

可量測參數：

二次懸吊負載

一次和二次懸吊系統彈性係數

單一輪負荷量測

輪位置量測(x-y 位置)

垂向尺寸量測(z 方向)



圖 2-25 簡易型全自動轉向架測試台

可量測下列參數：

二次懸吊負載

單一輪負荷量測

輪位置量測(x-y 位置)

輪重量測系統：詳見附圖 2-26~2-30



圖 2-26 靜態輪重量測系統(SWWS)

靜態或時速 5 公里下，輪負荷連續量測，可直接安裝在現有軌道上。

量測精度 0.5%



圖 2-27 靜態輪重量測系統(SWWS)

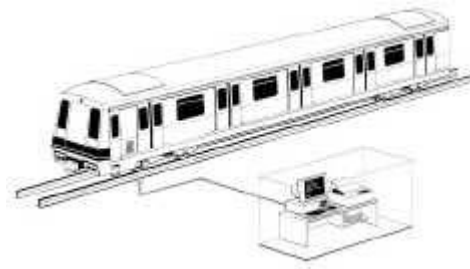


圖 2-28 輪重量測系統示意圖

直接顯示於電腦螢幕並自動儲存
數值資料



圖 2-29 輪重量測系統(WWS)應用

線上監督防治貨車出軌及量
測全車重量



圖 2-30 輪重量測特殊設備(WWF)

量測各種軌道扭曲狀況下的
靜態輪軸負荷

PROSE 公司的「檢測部門」主要執行項目有

車輛的認證(詳見附圖 2-31)

行車動態和舒適度檢測(詳見附圖 2-32)

噪音檢測(詳見附圖 2-33)

剎車系統檢測

全面結構檢測(詳見附圖 2-34)

驅動系統振動檢測

檢測專用車箱

其他指定項目檢測

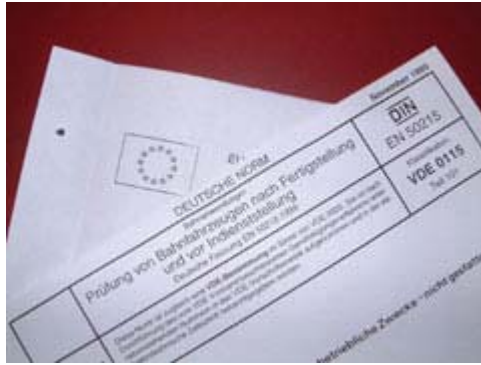


圖 2-31 合格認證文件
出具檢測合格證明



圖 2-32 行車動態和舒適度檢測
依據 UIC518 規範檢測動態行為、
安全、軌道疲勞和行車狀態
依據 UIC513 規範檢測舒適度



圖 2-33 噪音檢測
依據 prEN ISO 3095 和 3381 規範檢
測行車狀態下車箱內外噪音



圖 2-34 結構完整性檢測
依據 UIC 規範驗證設計負荷於驅
動系統、轉向架骨架、車體和接合
介面上的作用力
可連續記錄受力及應力數據以推
斷疲勞負荷及車輛受限



圖 2-35 PROSE 公司



圖 2-36 WINPRO 公司

在 WINTERTHUR 的第二天行程由 PROSE 公司老闆 HUBER 先生安排，前往參觀 WINPRO 公司，本項參訪亦非原排定行程，為此行額外收穫。

WINPRO 公司(詳見附圖 2-36)與 PROSE 公司位於同一工廠區，彼此對門而立，廠區面積達 22,000m²，僱有員工 160 人，是一家

完全符合標準的轉向架製造廠，除專業從事轉向架製造、組裝與維修外，還少量製作車體和彈性製造驅動齒輪及齒輪箱組(詳見附圖 2-37)，與 PROSE 公司關係密切，有多項檢測設備即是彼此合作建立，亦接受 PROSE 公司委託製造與檢驗。

WINPRO 為轉向架及其零件之代工製造廠，2001 年年營業額 2,100 萬歐元，主要客戶為 Bombardier、Alastom、Siemens 等大型軌道車輛公司。廠內自另件加工、銲接構件組立焊接、總成件加工到元件檢驗、轉向架系統組裝、總成檢測和負載測試，整個製造流程規劃完整順暢，並完全符合 ISO9001 品保規範，尤其在銲接品質方面，獲有 DIN6700 EN729-2 合格證書和德鐵合格證明。

以下是參訪現場拍攝的照片(詳見附圖 2-38~2-51)，由照片中可明顯看出，雖然是機械工廠，但廠內外環境整齊清潔，各工作區物件安置井然有序，加工製程有條不紊，人員衣著整齊工作服，非常敬業的工作，很自然的將該公司良好品質形象表現出來。

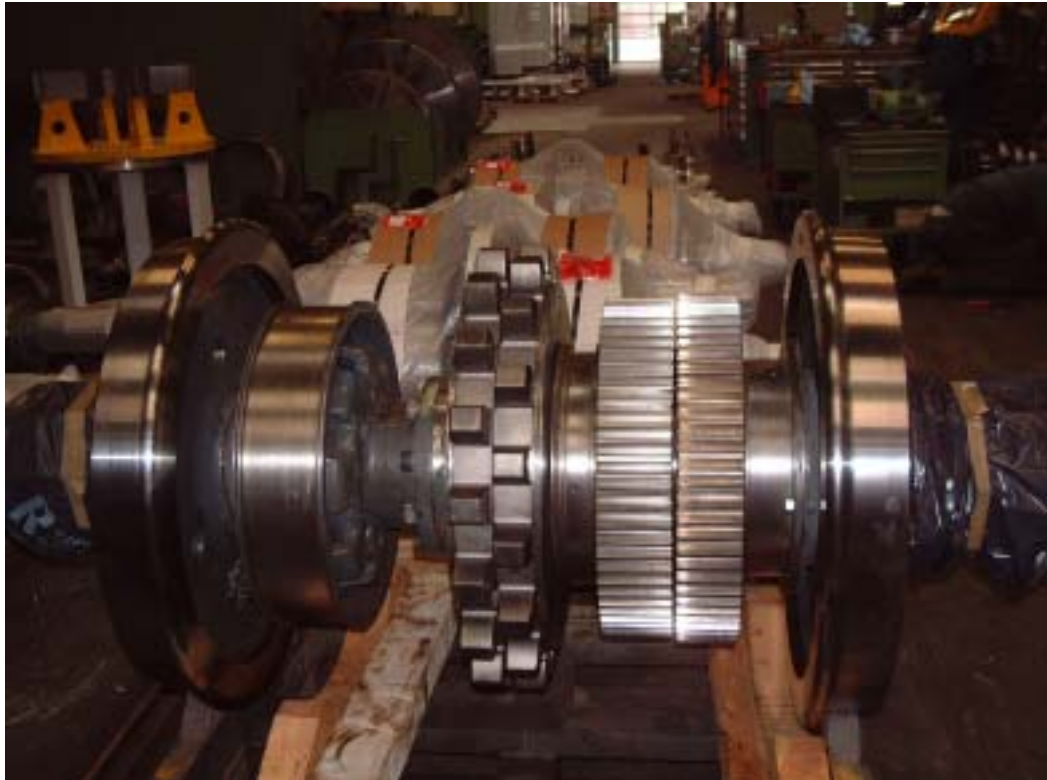


圖 2-37 瑞士登山火車驅動輪軸組

中央部份為登山齒輪直接與軌道中央齒條契合



圖 2-38 轉向架骨架中間橫樑焊接組立



圖 2-39 轉向架骨架測樑焊接組立



圖 2-40 組銲完成的轉向架骨架



圖 2-41 轉向架骨架吊裝作業



圖 2-42 轉向架表處前處理

人員著標準工作服與護具施工，品質與安全要求一絲不苟



圖 2-43 轉向架管線安裝



圖 2-44 轉向架承樑組裝現場工作狀況



圖 2-45 轉向架組裝量測工作台



圖 2-46 轉向架組裝量測工作台總成件上架情形



圖 2-47 轉向架總成輪軸滾轉測試台及工作溝

左上角為安放再滾轉檯上測試的轉向架



圖 2-48 轉向架總成靜負載檢驗



圖 2-49 轉向架總成靜負載檢驗

施加 8 噸負荷下量測懸吊系統受力後變化



圖 2-50 單軸式轉向架成品



圖 2-51 軌道車輛輪軸定期維修

參、效益分析

歐洲軌道工業進步，許多技術與觀念值得我們學習與倣效，尤其是德國和瑞士兩國，工業基礎紮實，一般員工工作態度嚴謹踏實，對工作上的每一個環節都中規中矩一絲不苟。其產品品質能在國際間建立良好信譽，都是一步一腳印逐步落實的成果，絕不是平空獲得的，在參訪過程中已能充分體認。

輕軌電車開發雖已陸續完成展示車和原型車的研製而進入整車測試階段，但是如果想要讓軌道工業能真正在國內生根，成為本土化產業，就必須確實作好工程管理與建立標準化觀念，目前國內最迫切需要的是建立一套完整的輕軌車研發機制，不論另組件規格、設計、製造與測試，都應符合各項國際標準規範，切實執行，而不是為求速效只強調硬體成果。

就軌道車輛來說，經歐洲各國官方鐵道部門和業界多年來為確保行車安全所作的研究和努力，建立軌道工業標準化規格，一些細部設計規範早已不再視為廠商的私有技術，而是人人都可以輕易取得(大部份可上網郵購)，且符合鐵路交通舒適安全基本要求的共同遵循標準，使鐵路交通的安全性和舒適性大為提高。如何在正確的指引下直接切入目標，將適合的規範標準引進國內，快速提昇軌道產業的技術能力和品質與世界共軌，

就需要借助與歐美專業人員的技術交流來累積經驗，是此行最主要目的。

本次參訪的 KIEPE、IRTC、GHH、PROSE 和 WINPRO 各公司都具有相當規模與制度，並已在軌道車輛市場建立良好的品質形象，所生產之產品已廣泛應用在世界各地的鐵道車輛上，能現場參觀整套加工製程與品質管理技術，並對相關技術問題進行討論，對於國內剛起步的軌道工業技術，具有實質上意義。

彙整各公司參訪技術性研討內容及具體效益如後：

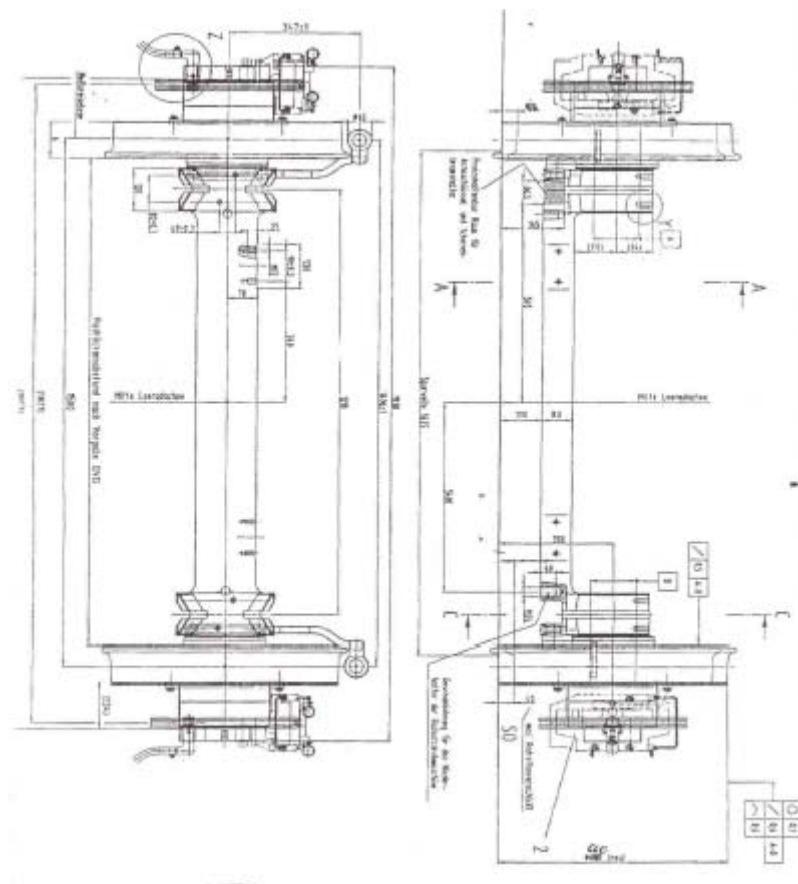


圖 3.1 標準軌距無動力轉向架輪軸組參考圖

與 KIEPE 公司討論主題及具體效益

| | |
|----------------|--|
| 馬達驅動系統 | 泛指車輛推進系統，包括高電壓系統、輔助系統、控制系統、偵測系統、驅動程式和牽引馬達等部分， |
| 研討項目 | <ol style="list-style-type: none"> 1. 電子動力系統，變頻器驅動力和煞車力的控制 2. 設備箱的安裝、電磁干擾防治與維修安全。 3. 牽引馬達的電器絕緣與變流器頻率的機械共振 4. 推進控制概念、車輪打滑與空轉之控制。 |
| 具體效益 (研討建議) | <ol style="list-style-type: none"> 1. 變頻器部分，建議採用最先進的 GTO(Gate Turn Off) 變流器並加入輸入保護和監控裝置，變流器需允許車輛在蠕行之及低電壓下運作。 2. 建議設備箱的安裝腳需安裝適當的彈性元件以免將振動傳至車體。 3. 注意！開關元件及載有脈衝電流的導線及電感導線，需僅可能的縮短並加以隔離，以避免強磁場外洩影響車內其他設備。 導線安裝需符合無線電波頻率的干擾需求， 另外輸入濾波器共振頻率需夠低以避免電話干擾。 4. 需加裝電容器電流放電或警告裝置以避免開啟設備箱蓋後，對維修人員可能造成的危害。 |

| | |
|--|-------------------------|
| | 5. 牽引馬達至少需符合 H 級的電氣器絕緣。 |
|--|-------------------------|

與 PROSE 公司討論主題及具體效益

| | |
|--------|--|
| 軌道車輛測試 | 主要是指全車運轉測試，包括各分項總成的功能檢驗，噪音、無線電波干擾測試、動態穩定性測試、時速 40 公里和 65 公里測試、摩擦煞車性能測試、混合煞車性能測試、緊急煞車性能測試、加減速時車輪防滑及防滾保護測試、行車電力間斷測試、行車最大速限及超速保護測試。 |
| 研討項目 | <ol style="list-style-type: none"> 1. 測試計劃、項目及測試程序 2. 測試元件、儀器設備及量測點安排 3. 車體結構強度改善及車體最佳化設計 |
| 具體效益 | <ol style="list-style-type: none"> 1. 了解測試要點及程序並規劃輕軌車測試計劃 2. 對輕軌車認證預作準備 4. 最佳化車體設計，可作為商用輕軌車車體設計參考。 5. 廠商提供軌道車輛測試項目及相關測試規範參考資料(如附件 3.1) 6. 廠商提供軌道車輛技術規格標準規範參考資料(如附件 3.2) |

與 SAB WABCO 公司 GHH 廠討論主題及具體效益

| | |
|--------|--|
| 輪軸煞車系統 | <p>為開發 1435 標準軌距輕軌車轉向架，就計劃規格需求與 GHH 廠工程師進行討論，希望能由該廠現有已驗證使用的產品中找出適用輪軸組件，以降低新車型的開發成本。</p> |
| 研討項目 | <ol style="list-style-type: none"> 1. 標準軌距無動力轉向架曲軸輪軸介面規格 車輪踏面、車輪寬度、輪中心直徑、輪背距、一次懸吊方式及介面規格、軸負載 2. 將目前 1067 軌距動力轉向架輪軸，延長為 1435 軌距，變更設計可行性研究及對軸負載之影響 |
| 具體效益 | <ol style="list-style-type: none"> 1. 廠商提供無動力轉向架適用之參考組件圖(如圖 3.1) 2. 了解軌道車輪軸加工製造過程及品質檢驗標準 |

肆、國外工作日程表

| 中山科學研究院出國人員工作計畫表 | | | | | | | | | | 姓 名 | 日期 星期 | | 行 程 | 公 差 地 點 | 工 作 項 目 | 備 考 |
|------------------|--------------------------------|------------------|------------------------------|------|------|-------------------|---|---|------------------|-------------|----------|--|--------|------------------|------------------|--------|
| 四 | 三 | 二 | 一 | 日 | 六 | 五 | 四 | 三 | 二 | | | | 出 發 | 抵 達 | | |
| 法蘭克福 | 蘇黎克 | | | | 杜塞道夫 | | | | 桃園 | 林英才、洪興漢、周亞屏 | | | | | | |
| 桃園 | 法蘭克福 | | | | 蘇黎克 | | | 杜塞道夫 | | | | | | | | |
| | 德國 | 瑞士 | 瑞士 | 瑞士 | 瑞士 | 德國 | 德國 | 德國 | | | 國名 | | | | | |
| | | | | | | | | | | | (州)省 | | | | | |
| | 法蘭克福 | Winter-thur | Winter-thur | 蘇黎克 | 蘇黎克 | Ober-hausen | 杜塞道夫 | 杜塞道夫 | | | 城鎮 | | | | | |
| 返抵桃園中正機場 | 由瑞士搭火車返回德國，由德國法蘭克福機場出發直飛桃園中正機場 | PROSE 公司車體結構設計研討 | PROSE 公司測試場參觀 輕軌車測試規劃技術研討 | 資料整理 | 資料整理 | 標準軌低地板轉向架輪軸規格技術研討 | 與KEPE 公司軌道車輛馬達變頻器技術研討，之後前往杜塞道夫市政府系統測試場參觀 至GHH 公司輪、軸製造廠參觀 | 下午至 KEPE 公司馬達驅動控制測試場參觀 抵達法蘭克福機場轉搭火車至杜塞道夫 | 自桃園中正機場出發，直飛法蘭克福 | | | | | | | |
| | 宿飛機上 | 宿蘇黎克 | 宿蘇黎克 | 宿蘇黎克 | 宿蘇黎克 | 宿杜塞道夫 | 宿杜塞道夫 | 宿杜塞道夫 | 宿飛機上 | | | | | | | |

伍、社交活動

歐洲鐵路交通運輸便捷舒適

歐陸密實的鐵路網與先進的軌道技術，使歐鐵系統獨步全球，幾乎取代航空業在歐陸的地位，時速 160 到 280 公里的火車已普遍奔馳在歐洲大陸，例如由英國通達法國、比利時行車時間將縮短為 40 分鐘。

歐洲火車種類繁多，依照行駛區域、速度、時段，可分為國際列車 EC (EuroCity)及 ICE(InterCity Express)、境內長途特快列 IC (InterCity)、區間快車 IR (InterRegio)和國際特快夜快車 EN (EuroNight)等，其中 IC 以行駛各國境內為主，路線網涵蓋相當廣，與 EC、ICE 結合可行遍全歐。

歐鐵專為優惠歐洲以外國家旅客，特別提供歐洲聯營火車票 (Europass)，對計畫到歐洲兩國以上旅行旅客，可在兩個月有效期限內選擇 5 天到 15 天不同天數「無限制」使用，所謂無限制表示不限車種(含所有國營和大部份民營火車及市區輕軌車)、里程和搭乘次數，唯一缺點是不保證有座位，如果要劃位需另付劃位費(一般列車每人約 3 歐元，ICE 列車每人約 15 歐元)。

本次行程安排在抵達德國法蘭克福機場後，其他歐陸行程都搭乘鐵路交通，對往返公差地點、住宿地點和機場極為方便。

以實際搭乘經驗，歐洲車站完全採開放式月台，進出不需檢查車票，但是長途列車車上查票非常嚴，每停一站後車掌都會全車巡一遍，但若是同一個車掌，對已查驗過的旅客都不會再度打擾。至於市區輕軌車，上下車都不用亮票，也沒有查票。長途火車，同一列車有不同艙等的車箱，按車票艙等上車不可越級進入車箱，平常日子通常空位很多不需劃位，只要不是掛有保留字牌的位子都可以坐，可省劃位費，車上有餐車，餐飲價格與市區餐廳一樣。

開放式的歐洲國界

目前適用歐洲申根簽證的國家已達十七國，進出歐洲各國已不需一一辦理簽證，只要向其中任一國家辦理簽證，即可通行無阻進出歐洲各國，極為方便。搭乘跨國長途火車穿越國界時，邊界警察也只是隨車查看一下護照，頂多問一下行程，護照也不用蓋印，國界幾乎已不存在，只有在聽見月台播音系統更換不同語言廣播，或由上車旅客的語言變化，才知道已經進入另一個國家。

歐洲的鐘塔建築

鐘塔是歐洲另項特殊的地區景觀，每個城鎮都可看到百年以上的大型鐘塔，定時發出鐘響，成為市民生活作息共同指標，

也是維繫每一位居民心靈的橋樑。

陸、建議事項

遵循標準規範建立輕軌車輛設計與製造機制

參觀德國及瑞士大型設計製造廠給人印象最深的是，他們每一項作業都中規中矩決不馬虎，上自設計部門下至現場作業，甚至工作環境，每一環節都嚴格的遵循標準規範執行，很自然的養成習慣並形成制度，反觀國內推行標準制度多年，確流於形式，標準規範大概只是放在架子上，沒有真正落實其精神與確實執行，品質無法達到國際標準。因此國內在開發輕軌車輛的同時，也必須引進軌道標準規範並認真遵循，才能面對國際競爭。

建立輕軌車輛的認證制度

國內是否需要建立標準軌道車輛測試廠，必須考量市場需求與能否帶動軌道工業的發展，因為建立軌道車輛檢測設備(包括拆、組裝場地及機具)和環形測試軌道，費用極為昂貴，還需要許多量測分析專業人員，在成本和專業分工因素的考量下，歐洲各國對軌道車輛新系統及更改後系統的性能和舒適性評估工作，已由早先買方和使用單位自行驗證，逐漸轉變為交由經官

方認可的專業認證公司執行。至於檢測項目標準，除了買方特別提出的舒適和性能需求外，主要標準需求，都是由獨立的鐵路公用事業和軌道專業機構設定，認證單位完全依據檢測標準檢驗，最後出具檢測報告，交予買賣雙方，以評估是否符合規格需求，非常客觀公正並可以達到統一的行車安全標準。

台灣幅員狹小，內需量有限，不足以維持一個標準測試廠的營運規模，對自行研製的輕軌系統或後續可能開發的其他軌道系統，送往國外測試是最經濟可行而且能夠最快速開拓國際市場的唯一途徑，但是有必要建立類似 IRTC T2 區小圓形測試軌道和 WINPRO 公司轉向架靜負荷量測等基本量測設備。

建立培養國民新的輕軌交通觀念

輕軌交通系統採開放式路權，與汽、機車共同行駛於市區街道，特別是在較為狹窄的街道上，必定會遇到紅綠燈與路邊停靠上下乘客等狀況，民眾若沒有養成良好行車紀律與習慣，很容易引起交通事故與糾紛，應事先加強宣導國民新的輕軌交通觀念，才不會引起社會反彈，影響未來新系統的推行。

歐洲輕軌交通早已成為當地的特殊景觀，就瑞士蘇黎克所見輕軌系統行車狀況，不論行人車輛都非常有秩序，雖然繁忙卻不顯得雜亂，特別是汽、機車駕駛人，遇到輕軌車路邊停靠上下乘客

時，都能耐心等候，絕對不會超越停在前面的輕軌車，行車紀律非常好(詳見附圖 6-1~6-2)，這點可能是在國內推行最困難的一項。



圖 6-1 蘇黎克輕軌路線之行車狀況



圖 6-2 蘇黎克輕軌路線之行車狀況
輕軌車到站停車開門上下乘客，後面車輛耐心等候不會從左側車道超越

附件 3.1 軌道車輛測試項目及相關規範

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Appendix 1

3.3.4 SUMMARY OF TESTS

The tests to be performed are summarised in the following list, which shall be amended as necessary during the detail design of the vehicle. The meaning of the test-code shall be as follows:

T; Type test **R**: Routine test **C**: Test certificate

A COMPONENTS AND SUBSYSTEMS

A1 Mechanical equipment

| | | | |
|--------------|----------------------------|-------------|--------------------|
| A1.1 | Structural material | C | |
| A1.2 | Suspension springs | R | |
| A1.3 | Air springs | R | |
| A1.4 | Hydraulic dampers | R | |
| A1.5 | Windshield | T, R | UIC 617-4 |
| A1.6 | Doors system | T, | |
| A1.7 | Door actuators | T, R | |
| A1.8 | Brake actuators | T, R | |
| A1.9 | Wheels and axles | R.C | DIN 50049 |
| A1.10 | Running gear frame | T, R | UIC 515 |
| A1.11 | Carbody | T, R | VOV 6.030.3 |

| | |
|-----------------------------|-------------|
| A1.12 Couplers | T, R |
| A1.13 Passenger seat | T |

A2 Electrical equipment

| | | |
|--------------------------------------|----------------|----------------------------|
| A2.1 Pantograph | T, R | IEC 165/13.1 |
| A2.2 Main circuit breaker | T, R, C | IEC 77/21 |
| A2.3 Traction motor | T, R, C | IEC 349, Spec 9.1.7 |
| A2.4 Gearbox | T, R | Spec 8.12.4 |
| A2.5 Inverter | T, R | IEC 411 |
| A2.6 Brake resistors | T, R | VDE 0660/2 |
| A2.7 Line capacitor | R | VDE 0660/5 |
| A2.8 Inductivity | T, R | VDE 0535 |
| A2.9 Master controller | T, R | VDE 0660/49 |
| A2.10 Electronic control unit | T, R | IEC 571 |
| A2.11 Fault monitoring system | T, R | IEC 571 |
| A2.12 Contactors | C | VDE 0660, |
| A2.13 Operator control desk | T, R | IEC 77 |
| A2.14 Installation material | C | IEC 77, IP 65 IEC |
| A2.15 Equipment boxes | R,C | 77, IP 65 |
| A2.16 Magnetic track brake | T,C | Par. 3.3.2.8 |
| A2.17 Propulsion system | T | Par.. 3.3.2.10 |
| A2.18 Air-comfort system test | T, R | Par. 3.3.2.11 |

B VEHICLE SYSTEM TESTS

B1 General and mechanical tests

| | | |
|---|-------------|---------------------|
| 81.1 Gauge test (stationary vehicle) | T, R | IEC165CL3 |
| B1.2 Weighing | T, R | IEC 165 CL 4 |
| B1.3 Stationary braking tests | T, R | IEC165CL6.1 |
| B 1.4 Car water tightness test | R | IEC 165/7 |
| B 1.5 Checks for accident prevention | T | IEC 165/8 |
| B1.6 8 hour cycling test | R | |
| B1.7 Auxiliary equipment functional test | T, R | |
| B1.8 Endurance test | T | IEC 165/2.2 |

B2 Electrical Tests

| | | |
|--|------------|-------------------|
| B2.1 Dielectric test | T,R | IEC165/16 |
| B2.2 Continuity check of return circuit | T,R | IEC165/17 |
| B2.3 Running test on aux. Machines | T,R | IEC165/18 |
| B2.4 Impulse voltage withstand test | T,C | IEC 165/25 |

| | | | |
|--------------|--|------|------------|
| B2.5 | Switchgear operating test | T, R | |
| B2.6 | Auxiliary circuits check | R | |
| B2.7 | Control circuit checks | R | |
| B2.8 | System check of propulsion controls | R | |
| B2.9 | Functional check of fault monitoring system | R | |
| B2.10 | Starting and acceleration test | T | IEC 165/20 |
| B2.11 | Check of battery charger | T | IEC 165/26 |
| B2.12 | Line short-circuit test | T | IEC 165/22 |

C LINE TESTS

| | | | |
|-------------|--|------|--------------------|
| C1 | Functional test | T, R | |
| C2 | Running tests on curved track /over humps | T | IEC 165/9 |
| C3 | Starting and acceleration tests | T.R | IEC 165/20 |
| C4 | Towing of a dead car test | T | Spec 7.1 |
| C5 | Checks on working conditions and amenities | T, R | IEC 165/10 |
| C6 | Test on safety equipment | T, R | IEC 165/11 |
| C7 | Test for safety of running | T | IEC 165/12, UIC 51 |
| C8 | Current collector test | T.R | IEC 165/13 |
| C9 | Test for resistance of motion | T | IEC 165/14 |
| C10 | Interruption and voltage jump test | T | IEC 165/21 |
| C11 | Short-circuit and overload tests on the vehicle | T | IEC 165/23 |
| C12 | Check of level of internal overvoltages | T | IEC 165/24 |
| C13 | Check of vehicle generated ripple voltage | T | Spec 3.3 |
| C 14 | Check of magnetic interference | T | Spec 3.4 |
| C15 | Noise level tests | T | DIN 45637/45638 |
| C 16 | Ride comfort test | T | Spec 3.7 |
| C 17 | Tractive capacity test | T | IEC 165/19 |
| C18 | Electric braking test | T.R | IEC 165/28 |
| C19 | Friction brake test | T, R | |
| C20 | Magnetic track brake test | T, R | |
| C21 | Energy consumption test | T | IEC 165/29 |
| C22 | Checks on typical running schedule | T | IEC 165/30 |
| C23 | Interference test for radio and track side signal and control equipment | T | Spec 3.4 |

D COMMISSIONING TEST

附件 3.2 軌道車輛技術規格標準規範

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Appendix 3

3 TAIWAN STANDARDS

3.1 General Norms and Standards

To be added by

3.2 Meteorology

The Contractors attention is specially drawn to the specific climatic conditions in Taiwan.
The climatic conditions are as follows:

| | Maximum | Average | Minimum |
|--------------------------------|---------|---------|---------|
| Average temperature (February) | | | |
| Extreme temperature (February) | | | |
| Average temperature (July) | | | |
| Extreme temperature (July) | | | |
| Relative humidity | | | |
| Wind speed | | | m/s |
| Daily precipitation | | | |

4 INTERNATIONAL NORMS AND STANDARDS

4.1 General

The Engineer will recognise the proposals and recommendations made in the following national and international standards as evidence of good practice in respect to the Work. Subject to the Conditions of Contract, the Contractor shall submit, within 21days of the date of the Notice of Acceptance, a list of the particular standards he proposes to use in the design and execution of the vehicles for the approval of the Engineer. The list shall give titles, dates and reference numbers of each standard which he intends to apply. If required by the Engineer, the Contractor shall promptly furnish him for his examination and for his use with two copies of any such standard, together with up-to-date amendments thereto, and, if required by the Engineer, shall ensure that he is furnished thereafter with

all further amendments, and with any standard and amendment thereto that may supersede any standard submitted beforehand.

| | | |
|--------|--|-------------|
| i. | International Standards Organisation | (ISO) |
| ii. | International Electrotechnical Commission | (IEC) |
| iii. | European | (CEN) |
| iv. | European | (CENELEC) |
| v. | International Telephone and Telegraph Consulting Committee | (CCITT) |
| vi. | Standards of the Subdivision "Radio" of the CCITT | (CCIR) |
| vii. | International Association of Railways | (UIC) |
| viii. | British Standards | (BS) |
| ix. | American Iron and Steel Institute | (AIS) |
| x. | American National Standards Institute | (ANSI) |
| xi. | American Society of Mechanical Engineers | (ASME) |
| xii. | American Society for Testing and Materials | (ASTM) |
| xiii. | American Welding Society | (AWS) |
| xiv. | Institute of Electrical and Electronic Engineers | (IEEE) |
| xv. | National Electrical Manufacturer's Association | (NEMA) |
| xvi. | United States of America Standards Institute | (USAS) |
| xvii. | Standards Association of Australia | (AS) |
| xviii. | Swedish Standards Institute | (SIS) |
| xix. | Deutsches Institut fuer Normung | (DIN) |
| xx. | Verein Deutscher Elektroingenieure | (VDE) |
| xxi. | Verein Deutscher Ingenieure | (VDI) |
| xxii. | Verband Oeffentlicher Verkehrsbetriebe | (V6V / VDV) |

4.2 ISO Standards

The following ISO standards have been considered when preparing the Technical Specification:

3095 Acoustics - Measurement of noise emitted by railbound vehicles

4.3 IEC Standards

The following IEC standards have been considered when preparing the Technical Specification:

- 77 Rules for electric traction equipment
- 113 Equipment designation and preparation of diagrams
- 123 Recommendations for noise-level measurements
- 165 Rules for testing of electric rolling stock on completion of construction and before entry into revenue service

- 310 Rules for traction transformers and reactors**
- 322 Rules for Ohmic resistors used in power circuits of electrically powered vehicles**
- 341-1 Push buttons**
- 349 Rules for rotating electric machines on rail vehicles**
- 494 Rules for pantographs on electric rolling stock**
- 563 Admissible temperature ranges for the electric traction equipment**
- 571 Rules for electronic equipment of rail vehicles**
- 50(30) International electrotechnical vocabulary**
- 631 Characteristics and tests of electrodynamic and electromagnetic braking systems**
- 638 Criteria for assessing and coding of the commutation of rotating electrical machines for traction**

4.4 UIC Standards

The following UIC Codes and Standards have been used when preparing the Technical Specification:

- 505 Structure gauge**
- 512 Conditions for rail vehicles in order to avoid disturbances of rail-loops and rail contacts**
- 533 Earthing of metallic parts**
- 541-3 Brake linings (disc brakes)**
- 544-2 Conditions to be fulfilled by the electrodynamic braking system**
- 560 Doors, windows, steps and handholds on vehicles**
- 564-1 Safety glass on passenger cars**
- 613 Symbols for electrical traction**
- 614 Definitions for the nominal power of electric powered rail vehicles**
- 616 Rules for the electrical equipment on self propelled vehicles**
- 617-1 Prescriptions for the fire-fighting on electrically powered rail vehicles**
- 617-3 Rules for the installation, the types and the operational characteristics of the main handling elements for the control of electric vehicles**
- 617-4 Windshields and windows on driver compartments**
- 671-5 Specific rules for the safety of the personnel in the drivers cabs of electric power cars**
- 617-6 Rules for the design of drivers cabs of electric power cars**
- 619 Rules for rotating electric machines on railway and street vehicles**
- 800-00 Rules for the application of the SI-units**
- 803-10 List for the selection of tubes made from steel, stainless steel and copper**
- 810-1 Technical requirements for wheel-treads**
- 811 Technical requirements for axles**
- 812-1 Technical requirements for wheel-bodies**
- 842-1/6 Technical requirements for the painting, corrosion protection as well as the**

- relative quality control on new rail vehicles
- 842-12 Technical conditions for two-component painting systems and fillers for exterior application on rail vehicles
- 844-3 Preliminary technical specification for phenol-resin bonded and protected plywood
- 844-4 Preliminary technical specification for pressed plastic interior linings
- 895 Technical specification for the delivery of electric cables with rubber or polyvinylchloride insulation
- 897-11 Technical conditions for the approval of welders for the construction and repair of rail vehicles

4.5 ORE Reports

The following ORE report have been considered:

B55 Safety against derailment of freight cars on twisted track

4.6 DIN Standards

- 4066 Information signs for fire defence
- 5035 Artificial lighting; terminology and general requirements
- 5510 Preventive fire protection on rail vehicles (draft)
- 5512 Materials for rail vehicles; steel
- 5513 Materials for rail vehicles; aluminium
- 5514 Materials for rail vehicles; synthetics
- 5566 Railway Vehicles - Driver cabs
 - Part 1: Common requirements
 - Part 2: Additional requirements for local traffic vehicles
- 5588 Compressed-air systems for rail vehicles
- 5591 Symbols on pneumatic diagrams for rail vehicles
- 18025 Part 1: Accessible dwellings; dwellings for wheelchair users, design principles
- 25002 Numbering systematic for rail vehicles (WBS)
- 25008 Basic rules for determination of vehicle weight
- 25100 Streetcars; vehicle cross-sections
- 25101 Streetcars; dimensions and seat arrangement
- 25105 Streetcars; seats
- 25107 Streetcars; coupler installation
- 25108 Streetcars; track-brake installation
- 25109 Streetcars; journal bearings
- 25110 Streetcars; axle mounted discs
- 32983 Lifts installed on vehicles for wheelchair users and for people restricted in their

| | |
|--------|---|
| | mobility; Safety requirements and testing |
| 43000 | Brushes for electric machines |
| 43021 | Brushes for electric machines on rail vehicles |
| 43051 | Brush holder |
| 43101 | Electric rail vehicles, definitions |
| 43102 | Traction motors and auxiliary motors; definitions |
| 43169 | Insulators |
| 43174 | Pantographs |
| 43200 | Cylindrical roller bearings on machines in rail vehicles |
| 43203 | Maintenance of electric motors and gears |
| 43234 | Circuit breakers |
| 43236 | Cables and insulated conductors |
| 43237 | Cam-controllers |
| 43240 | Conductors for pantographs; dimensions |
| 43264 | Conductors for pantographs; carbon contact strip |
| 43267 | Pantographs; clearance requirements |
| 43268 | Pantographs; definitions |
| 43320 | Rules for electrodynamic and magnetic brakes |
| 43321 | Rules for electronic equipment |
| 43602 | Operation conditions and installation of operating elements |
| 43635 | Measurement of airborne noise emitted by machines |
| 45637 | Measurement of exterior noise of rail vehicles |
| 45638 | Measurement of interior noise of rail vehicles |
| 54341 | Testing of seats for rail vehicles |
| 57266 | Halogen-free cables |
| 57580d | Electromagnetic apparatus |
| 57831 | Electric signalling systems for railways |
| 57875 | Prevention of electromagnetic interference from electric machines and equipment |

4.7 VDV Recommendations

The following VDV recommendations have been taken into account when preparing the Technical Specification (* available in English translation):

| | |
|-----|--|
| 150 | Recommendation of Type - Light Rail Vehicle |
| 152 | Structural requirements to rail vehicles for the public mass transit in accordance with BOStrab * |
| 153 | Recommendations regarding the preparation of technical specifications for light rail vehicles and for metros |
| 154 | Basic requirements to the electrical equipment in light rail vehicles and metro vehicles (was V6V 6.030.5) |

| | |
|-----------|---|
| 155 | Compressed air tanks on vehicles in accordance with BOStrab |
| 160 | Traction control - recommendation of type for vehicle controls of electrically powered trains and trailer cars with electronic calculation components |
| 162 | System to record, register and notify errors (PERM) on rail guided vehicles for the public mass transit * |
| 180/1 | Heating and ventilation systems in passenger compartments in rail-guided vehicles for the public mass transit |
| 180/2 | Heating and ventilation systems in the driver's cab in rail-guided vehicles for the public mass transit |
| 343 | Switch control in areas operated on sight |
| 401 | Technical requirements to digital public address systems (DAG) |
| 700 | Electronic ticket printers in vehicles |
| 704 | Mobile ticket vending machines (machines on vehicles) |
| 04.05.4 | Integrated on-board information system (IBIS) (01/92) * |
| 04.06.1 | Technical requirements of automatic stop announcements |
| 06.22.1 | Requirements to the monitoring of powered doors and steps in line buses and tram vehicles |
| 06.90.1 | Rules for the noise emission of Streetcars |
| 07.3.1 | Rules for the prevention of fire on rail veh. |
| 6.325.1 | Control electronics |
| 6.325.2 | Recommendations for the design of propulsion systems, based on semiconductors, for electric passenger vehicles |
| 6.411.1/2 | Power electronics |
| 8.23.1 | Requirements to automatically working, powered doors in line buses and tram vehicles |

4.8 VDE Standards

The following VDE standards have been considered in the Technical Specification:

| | |
|---------|---|
| 0100 T | Electric power systems up to 1000V |
| 0115 T | General safety and installation conditions for rail vehicles |
| 0150 | Stray currents from DC systems, corrosion protect. |
| 0288 T | Influence on communication systems by high power electric systems |
| 0510 | Batteries |
| 0535 T1 | Transformers and inductivities on rail vehicles |
| 0558 T3 | DC-Choppers |
| 0873 T3 | Measures against radio frequency interference by high power electric supply systems and electric railways |
| 0875 | Prevention of radio frequency interference of electric machines and equipment |

4.9 VDI Standards

The following VDI standards have been considered in the Technical Specification:

2717 Noise situation on Light Rail Transit Systems

4.10 DB Standards

The following publications of the German Federal Railways have been considered in the Technical Specification:

TL, Technical delivery conditions

918 199 Synthetic material for seats and linings

918 174 Installation of compressed air systems

918 179 Brake callipers and shoes

918 300/6 Painting of rail vehicles

DS, General Publications

952 Prescription for the welding of metallic materials

4.11 Various Standards

**Requirements for European Buses Dutch specification Wegenverkehrswet,
Uitvoeringsvoorschriften (CIII-F-Z)**

| | |
|-----------|---|
| 155 | Compressed air tanks on vehicles in accordance with BOStrab |
| 160 | Traction control - recommendation of type for vehicle controls of electrically powered trains and trailer cars with electronic calculation components |
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| 0558 T3 | DC-Choppers |
| 0873 T3 | Measures against radio frequency interference by high power electric supply systems and electric railways |
| 0875 | Prevention of radio frequency interference of electric machines and equipment |

| | |
|--------|---|
| | mobility; Safety requirements and testing |
| 43000 | Brushes for electric machines |
| 43021 | Brushes for electric machines on rail vehicles |
| 43051 | Brush holder |
| 43101 | Electric rail vehicles, definitions |
| 43102 | Traction motors and auxiliary motors; definitions |
| 43169 | Insulators |
| 43174 | Pantographs |
| 43200 | Cylindrical roller bearings on machines in rail vehicles |
| 43203 | Maintenance of electric motors and gears |
| 43234 | Circuit breakers |
| 43236 | Cables and insulated conductors |
| 43237 | Cam-controllers |
| 43240 | Conductors for pantographs; dimensions |
| 43264 | Conductors for pantographs; carbon contact strip |
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- relative quality control on new rail vehicles
- 842-12 Technical conditions for two-component painting systems and fillers for exterior application on rail vehicles
- 844-3 Preliminary technical specification for phenol-resin bonded and protected plywood
- 844-4 Preliminary technical specification for pressed plastic interior linings
- 895 Technical specification for the delivery of electric cables with rubber or polyvinylchloride insulation
- 897-11 Technical conditions for the approval of welders for the construction and repair of rail vehicles

4.5 ORE Reports

The following ORE report have been considered:

B55 Safety against derailment of freight cars on twisted track

4.6 DIN Standards

- 4066 Information signs for fire defence
- 5035 Artificial lighting; terminology and general requirements
- 5510 Preventive fire protection on rail vehicles (draft)
- 5512 Materials for rail vehicles; steel
- 5513 Materials for rail vehicles; aluminium
- 5514 Materials for rail vehicles; synthetics
- 5566 Railway Vehicles - Driver cabs
 - Part 1: Common requirements
 - Part 2: Additional requirements for local traffic vehicles
- 5588 Compressed-air systems for rail vehicles
- 5591 Symbols on pneumatic diagrams for rail vehicles
- 18025 Part 1: Accessible dwellings; dwellings for wheelchair users, design principles
- 25002 Numbering systematic for rail vehicles (WBS)
- 25008 Basic rules for determination of vehicle weight
- 25100 Streetcars; vehicle cross-sections
- 25101 Streetcars; dimensions and seat arrangement
- 25105 Streetcars; seats
- 25107 Streetcars; coupler installation
- 25108 Streetcars; track-brake installation
- 25109 Streetcars; journal bearings
- 25110 Streetcars; axle mounted discs
- 32983 Lifts installed on vehicles for wheelchair users and for people restricted in their

| | |
|--------|---|
| 310 | Rules for traction transformers and reactors |
| 322 | Rules for Ohmic resistors used in power circuits of electrically powered vehicles |
| 341-1 | Push buttons |
| 349 | Rules for rotating electric machines on rail vehicles |
| 494 | Rules for pantographs on electric rolling stock |
| 563 | Admissible temperature ranges for the electric traction equipment |
| 571 | Rules for electronic equipment of rail vehicles |
| 50(30) | International electrotechnical vocabulary |
| 631 | Characteristics and tests of electrodynamic and electromagnetic braking systems |
| 638 | Criteria for assessing and coding of the commutation of rotating electrical machines for traction |

4.4 UIC Standards

The following UIC Codes and Standards have been used when preparing the Technical Specification:

| | |
|------------|--|
| 505 | Structure gauge |
| 512 | Conditions for rail vehicles in order to avoid disturbances of rail-loops and rail contacts |
| 533 | Earthing of metallic parts |
| 541-3 | Brake linings (disc brakes) |
| 544-2 | Conditions to be fulfilled by the electrodynamic braking system |
| 560 | Doors, windows, steps and handholds on vehicles |
| 564-1 | Safety glass on passenger cars |
| 613 | Symbols for electrical traction |
| 614 | Definitions for the nominal power of electric powered rail vehicles |
| 616 | Rules for the electrical equipment on self propelled vehicles |
| 617-1 | Prescriptions for the fire-fighting on electrically powered rail vehicles |
| 617-3 | Rules for the installation, the types and the operational characteristics of the main handling elements for the control of electric vehicles |
| 617-4 | Windshields and windows on driver compartments |
| 671-5 | Specific rules for the safety of the personnel in the drivers cabs of electric power cars |
| 617-6 | Rules for the design of drivers cabs of electric power cars |
| 619 | Rules for rotating electric machines on railway and street vehicles |
| 800-00 | Rules for the application of the SI-units |
| 803-10 | List for the selection of tubes made from steel, stainless steel and copper |
| 810-1 | Technical requirements for wheel-treads |
| 811 | Technical requirements for axles |
| 812-1 | Technical requirements for wheel-bodies |
| 842-1/6 | Technical requirements for the painting, corrosion protection as well as the |

all further amendments, and with any standard and amendment thereto that may supersede any standard submitted beforehand.

| | |
|---|-------------|
| i. International Standards Organisation | (ISO) |
| ii. International Electrotechnical Commission | (IEC) |
| iii. European | (CEN) |
| iv. European | (CENELEC) |
| v. International Telephone and Telegraph Consulting Committee | (CCITT) |
| vi. Standards of the Subdivision "Radio" of the CCITT | (CCIR) |
| vii. International Association of Railways | (UIC) |
| viii. British Standards | (BS) |
| ix. American Iron and Steel Institute | (AISI) |
| x. American National Standards Institute | (ANSI) |
| xi. American Society of Mechanical Engineers | (ASME) |
| xii. American Society for Testing and Materials | (ASTM) |
| xiii. American Welding Society | (AWS) |
| xiv. Institute of Electrical and Electronic Engineers | (IEEE) |
| xv. National Electrical Manufacturer's Association | (NEMA) |
| xvi. United States of America Standards Institute | (USAS) |
| xvii. Standards Association of Australia | (AS) |
| xviii. Swedish Standards Institute | (SIS) |
| xix. Deutsches Institut fuer Normung | (DIN) |
| xx. Verein Deutscher Elektroingenieure | (VDE) |
| xxi. Verein Deutscher Ingenieure | (VDI) |
| xxii. Verband Oeffentlicher Verkehrsbetriebe | (V6V / VDV) |

4.2 ISO Standards

The following ISO standards have been considered when preparing the Technical Specification:

3095 Acoustics - Measurement of noise emitted by railbound vehicles

4.3 IEC Standards

The following IEC standards have been considered when preparing the Technical Specification:

| | |
|-----|---|
| 77 | Rules for electric traction equipment |
| 113 | Equipment designation and preparation of diagrams |
| 123 | Recommendations for noise-level measurements |
| 165 | Rules for testing of electric rolling stock on completion of construction and before entry into revenue service |

3 TAIWAN STANDARDS

3.1 General Norms and Standards

To be added by

3.2 Meteorology

The Contractors attention is specially drawn to the specific climatic conditions in Tawan. The climatic conditions are as follows:

| | Maximum | Average | Minimum |
|--------------------------------|---------|---------|---------|
| Average temperature (February) | | | |
| Extreme temperature (February) | | | |
| Average temperature (July) | | | |
| Extreme temperature (July) | | | |
| Relative humidity | | | |
| Wind speed | | | m/s |
| Daily percipitation | | | |

4 INTERNATIONAL NORMS AND STANDARDS

4.1 General

The Engineer will recognise the proposals and recommendations made in the following national and international standards as evidence of good practice in respect to the Work. Subject to the Conditions of Contract, the Contractor shall submit, within 21 days of the date of the Notice of Acceptance, a list of the particular standards he proposes to use in the design and execution of the vehicles for the approval of the Engineer. The list shall give titles, dates and reference numbers of each standard which he intends to apply. If required by the Engineer, the Contractor shall promptly furnish him for his examination and for his use with two copies of any such standard, together with up-to-date amendments thereto, and, if required by the Engineer, shall ensure that he is furnished thereafter with

| | | | |
|-------|---|------|------------|
| B2.5 | Switchgear operating test | T, R | |
| B2.6 | Auxiliary circuits check | R | |
| B2.7 | Control circuit checks | R | |
| B2.8 | System check of propulsion controls | R | |
| B2.9 | Functional check of fault monitoring system | R | |
| B2.10 | Starting and acceleration test | T | IEC 165/20 |
| B2.11 | Check of battery charger | T | IEC 165/26 |
| B2.12 | Line short-circuit test | T | IEC 165/22 |

C LINE TESTS

| | | | |
|------|--|------|--------------------|
| C1 | Functional test | T,R | |
| C2 | Running tests on curved track /over humps | T | IEC 165/9 |
| C3 | Starting and acceleration tests | T,R | IEC 165/20 |
| C4 | Towing of a dead car test | T | Spec 7.1 |
| C5 | Checks on working conditions and amenities | T,R | IEC 165/10 |
| C6 | Test on safety equipment | T,R | IEC 165/11 |
| C7 | Test for safety of running | T | IEC 165/12, UIC 51 |
| C8 | Current collector test | T,R | IEC 165/13 |
| C9 | Test for resistance of motion | T | IEC 165/14 |
| C10 | Interruption and voltage jump test | T | IEC 165/21 |
| C11 | Short-circuit and overload tests on the vehicle | T | IEC 165/23 |
| C12 | Check of level of internal overvoltages | T | IEC 165/24 |
| C13 | Check of vehicle generated ripple voltage | T | Spec 3.3 |
| C 14 | Check of magnetic interference | T | Spec 3.4 |
| C15 | Noise level tests | T | DIN 45637/45638 |
| C 16 | Ride comfort test | T | Spec 3.7 |
| C 17 | Tractive capacity test | T | IEC 165/19 |
| C18 | Electric braking test | T,R | IEC 165/28 |
| C19 | Friction brake test | T,R | |
| C20 | Magnetic track brake test | T, R | |
| C21 | Energy consumption test | T | IEC 165/29 |
| C22 | Checks on typical running schedule | T | IEC 165/30 |
| C23 | Interference test for radio and track side signal and control equipment | T | Spec 3.4 |

D COMMISSIONING TEST

| | | |
|-----------------------|---|---------------|
| D1 Commissioning test | R | Par.. 3.3.3.7 |
|-----------------------|---|---------------|

Appendix 1

Draft Specification
Low Floor Light Rail Vehicle

A1.12 Couplers A1.13
Passenger seat

T,R
T

A2 Electrical equipment

A2.1 Pantograph
A2.2 Main circuit breaker
A2.3 Traction motor
A2.4 Gearbox
A2.5 Inverter
A2.6 Brake resistors
A2.7 Line capacitor
A2.8 Inductivity
A2.9 Master controller
A2.10 Electronic control unit
A2.11 Fault monitoring system
A2.12 Contactors
A2.13 Operator control desk
A2.14 Installation material
A2.15 Equipment boxes
A2.16 Magnetic track brake
A2.17 Propulsion system
A2.18 Air-comfort system test

T, R IEC 165/13.1
T, R, C IEC 77/21
T, R, C IEC 349, Spec 9.1.7
T, R Spec 8.12.4
T, R IEC 411
T, R VDE 0660/2
R VDE 0660/5
T, R VDE 0535
T, R VDE 0660/49
T, R IEC 571
T, R IEC 571
C VDE 0660,
T, R IEC 77
C IEC 77, IP 65 IEC
R,C 77, IP 65
T,C Par. 3.3.2.8
T Par.. 3.3.2.10
T, R Par. 3.3.2.11

B VEHICLE SYSTEM TESTS**B1 General and mechanical tests**

81.1 Gauge test (stationary vehicle)
B1.2 Weighing
B1.3 Stationary braking tests
B 1.4 Car water tightness test
B 1.5 Checks for accident prevention
B1.6 8 hour cycling test
B1.7 Auxiliary equipment functional test
B1.8 Endurance test

T ,R IEC165CL3
T,R IEC 165 CL 4
T,R IEC165CL6.1
R IEC 165/7
T IEC 165/8
R
T, R
T IEC 165/2.2

B2 Electrical Tests

B2.1 Dielectric test
B2.2 Continuity check of return circuit B2.3
Running test on aux. Machines B2.4
Impulse voltage withstand test

T,R IEC165/16
T,R IEC165/17
T,R IEC165/18
T,C IEC 165/25

附件 3.1 軌道車輛測試項目及相關規範

condition. In addition to the performance test, an endurance test of a minimum of 30,000km shall be performed, with a subsequent comprehensive check of the entire vehicle and its subsystems. This test can be performed as part of the initial drivers instruction and trial operation.

3.3.3.4 Commissioning Test

Upon arrival of each vehicle in Taipei a stationary and low speed running test shall be performed in order to establish, that all systems are operating correctly. Due to the limited availability of track on the streetcar system, it is essential, that the maximum amount of testing is carried out at or near the suppliers works. The tests to be carried out in Taipei will be confined to a series of tests designed to verify that the results of the tests as set out in paragraph 3.3.3.3 and the routine line tests are applicable to conditions in Taipei and that no deterioration in performance has taken place during the shipping.

3.3.3.5 Trouble Free Running

Each vehicle has to undergo continuous trouble free running in revenue service for 400km before final acceptance.

3.3.4 SUMMARY OF TESTS

The tests to be performed are summarised in the following list, which shall be amended as necessary during the detail design of the vehicle. The meaning of the test-code shall be as follows:

T; Type test R: Routine test C: Test certificate

A COMPONENTS AND SUBSYSTEMS

A1 Mechanical equipment

| | | |
|--------------------------|-------|-------------|
| A1.1 Structural material | C | |
| A1.2 Suspension springs | R | |
| A1.3 Air springs | R | |
| A1.4 Hydraulic dampers | R | |
| A1.5 Windshield | R | |
| A1.6 Doors system | T,R | UIC617-4 |
| A1.7 Door actuators | T | |
| A1.8 Brake actuators | T, R, | |
| A1.9 Wheels and axles | T, R | DIN 50049 |
| A1.10 Running gear frame | R, C | UIC515 |
| A1.11 Carbody | T, R | VOV 6.030.3 |

4.9 VDI Standards

The following VDI standards have been considered in the Technical Specification:

2717 Noise situation on Light Rail Transit Systems

4.10 DB Standards

The following publications of the German Federal Railways have been considered in the Technical Specification:

TL, Technical delivery conditions

918 199 Synthetic material for seats and linings

918 174 Installation of compressed air systems

918 179 Brake callipers and shoes

918 300/6 Painting of rail vehicles

DS, General Publications

952 Prescription for the welding of metallic materials

4.11 Various Standards

Requirements for European Buses Dutch specification [Wegenverkehrswet, Uitvoeringsvoorschriften \(CIII-F-Z\)](#)