行政院及所屬各機關出國報告

（出國類別：研究）

風力發電設備製造及維修技術研習

服務機關：台灣電力公司
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出國地區：歐洲

出國日期：91.7.9~91.9.15
報告日期：91.11.15

行政院及所屬各機關出國報告提要

出國報告名稱：風力發電設備製造及維修技術研習

頁數 80 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

邱文寶/台灣電力公司/電力修護處/機械工程師/02-27853199 轉 216

出國類別：□1 考察□2 進修■3 研究□4 實習□5 其他

出國期間：91.7.9~91.9.15　　出國地區：歐洲

報告日期：91.11.15

分類號/目

關鍵詞：風力發電

內容摘要：

風力發電是本公司近年來持續發展的方向，本公司計畫未來裝置 200 部或 30 萬 KW 之風力發電機組，現已在澎湖安裝四部機組，即將面臨的保養及維護將成為極重要的課題:

1. 全球十年前風力發電開始突破技術，蓬勃發展，五年前開始大量裝機。其中以丹麥及德國之風力發電技術較為成熟，此兩國之裝機數也較多，全球前三大風力發電機製造商均在此三國。
2. 風力發電之運轉維護方式與水火力電廠方式大不相同，風力發電機不需大修，但須定期維修，維修人員須開維修車至風力發電機現場維護保養。
3. 運轉模式:風力發電機是相當高度自動化之機組，平時不需人員巡視或現場值班，在監控中心之值班員經操作電腦即可。
4. 因本公司未來採購風力發電機，無法預測其廠牌及來源自何公司，故須於裝機時就參與，並於保固期間就與原廠密切配合，進而習得該機組相關技術。

壹.國外公務之內容與過程

本次出國至丹麥及德國共四家風力發電機製造公司，從事風力發電機之製造、運轉及維護修理之研究，該四家公司分別為丹麥之 VESTAS、NEG.MICON 以及德國之 ENERCON、NORDEX 公司。主要研究方式如下:

一.至風力發電機上實際從事維護工作。

二.至生產及組裝工廠實際從事製造加工組裝工作。

三.收集風力發電相關資料。

四.與技術人員討論風力發電技術。

貳.國外公務之心得與感想

一、風力發電機簡介:

1. 全球十年前風力發電開始突破技術，蓬勃發展，五年前開始大量裝機。其中以丹麥及德國之風力發電技術較為成熟，此兩國之裝機數也較多，全球前三大風力發電機製造商均在此三國，即丹麥之 VESTAS 公司及 NEG.MICON 公司，以及德國之 ENERCON 公司，丹麥之技術成熟且裝機量也多，自有其天然條件，因丹麥全國無山，土地皆是平原，風量充足且穩定。
2. 風力發電機之設計有日趨大型化之趨勢，由早期之 300KW，一直到 600KW，然後 900KW，現在之主流機種為 1.5~2.0MW.
3. 以下是丹麥之風力發電農場(WIND FARM 約 100 部機):

4. 廠家介紹:

A. 風力發電廠家，國外廠家甚多，但較具規模有以下之廠家:

a. VESTAS(丹麥)*(有齒輪箱)

b. ENERCON(德國)*（無齒輪箱）

c. NEG.MICON（丹麥)*（有齒輪箱）

d. NORDEX（德國)*(有齒輪箱)

e. BONUS（丹麥）

f. REPOWER（德國）

g. GE(ENRON)(美國)

h. GAMASA(西班牙)

B. 本次共至四家廠家從事研究分述如後:

a. VESTAS(丹麥)

- 全球最大風力發電製造公司。
- 設備極大部分均自行製造。
- 有非常強大的研發團隊。
- Off shore 風力發電最大製造商。
- 已在台塑麥寮裝置四部。
- 天龍紡織廠購買兩部並在測試運轉中

b. ENERCON(德國)

- 歐洲唯一無齒輪箱設計且商品化之公司
- 無齒輪箱但有大發電機
- 目前安裝於澎湖共四部,運轉極佳
- 以電氣設備代替機械設備
- CUT IN SPEED 最低 2.5m/sec(其他公司約 4 m/sec)
- 可發電率較高

c. NEG. MICON (丹麥)

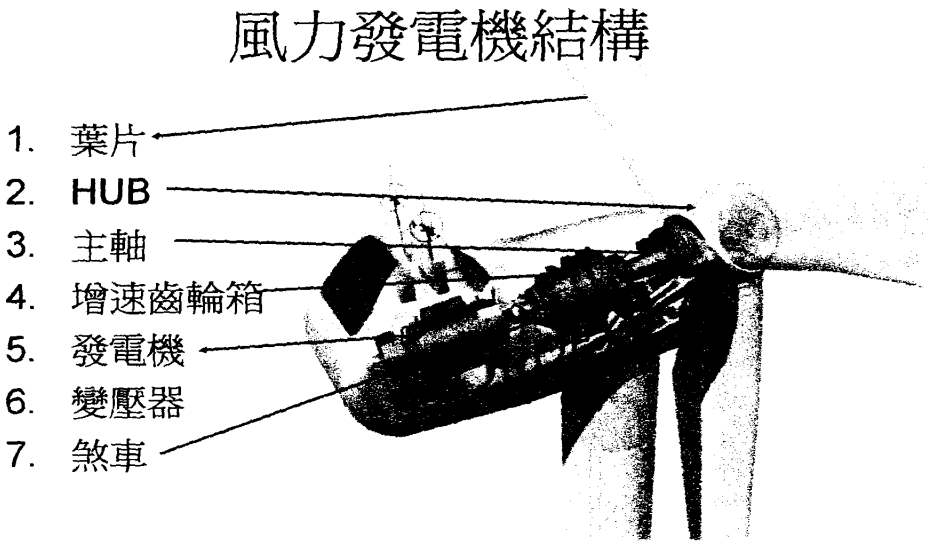
- 有齒輪箱
- PLC, DAMCONTROL
- 維護較簡單。
- 小機組(KW)用 TIPCONTROL 控制轉子起停，STALL TYPE。
- 大機組用(MW)PITCH CONTROL 控制轉子起停。
- 需爬至機鼻檢查壓力,並檢查其他配件。

d. NORDEX (德國)

- 有齒輪箱,公司規模較小。
- 本處人員受訓後,可直接接管運轉及維護。
- 設備都自行設計再委託外界製作,再自行組裝。
- PLC 控制

5. 風力發電機

A. 風力發電機結構



B. 風力發電機系統:

a. 迎風控制系統: YAW GEAR system，使葉片始終面向風來之方向。

b. 葉片旋角系統: Pitch system，控制葉片旋轉角度，以達轉子起停目的。

c. 避雷系統:一般均在葉片末端裝設金屬以接收電擊，並送至地下。

d. 微處理器(PLC)控制系統: 控制整部機組之運轉。

e. 發電及傳輸系統:含變壓器或整流器等。

C.風力發電機之種類:

a. 有齒輪箱:

● .優點:

*齒輪箱及發電機均為量產品,易於取得更換。

*設備簡單易於保養,性能較穩定。

●.. 缺點:

*CUT IN speed 較高(4m/sec)

*需保養齒輪箱及齒輪油

*保養時需爬至機鼻外

b. 無齒輪箱:

● 優點:

*聯電網較佳

*.CUT IN speed 較低(2.5m/sec)

*.保養時不需爬至機鼻外

● 缺點

*.發電機太大(E66,發電機直徑5米),且為開放式,須較細心照顧。

*.維修次數較多,每3各月保養1次。

二. 歐洲風力發電運轉維護方式

1. 風力發電公司本身不負責運轉及保養.

2. 風力發電公司裝機後, 即與維護公司簽訂維護合約, 維護公司則保證其可用率.

3. 維護公司定期用電腦檢查可用率及發電量並列印報表.

4. 一般運轉及保養維護均由修護公司負責.

5. 修護公司均設有遙控中心(service center)負責所有風力發電機之運轉及保養維護修理工作.

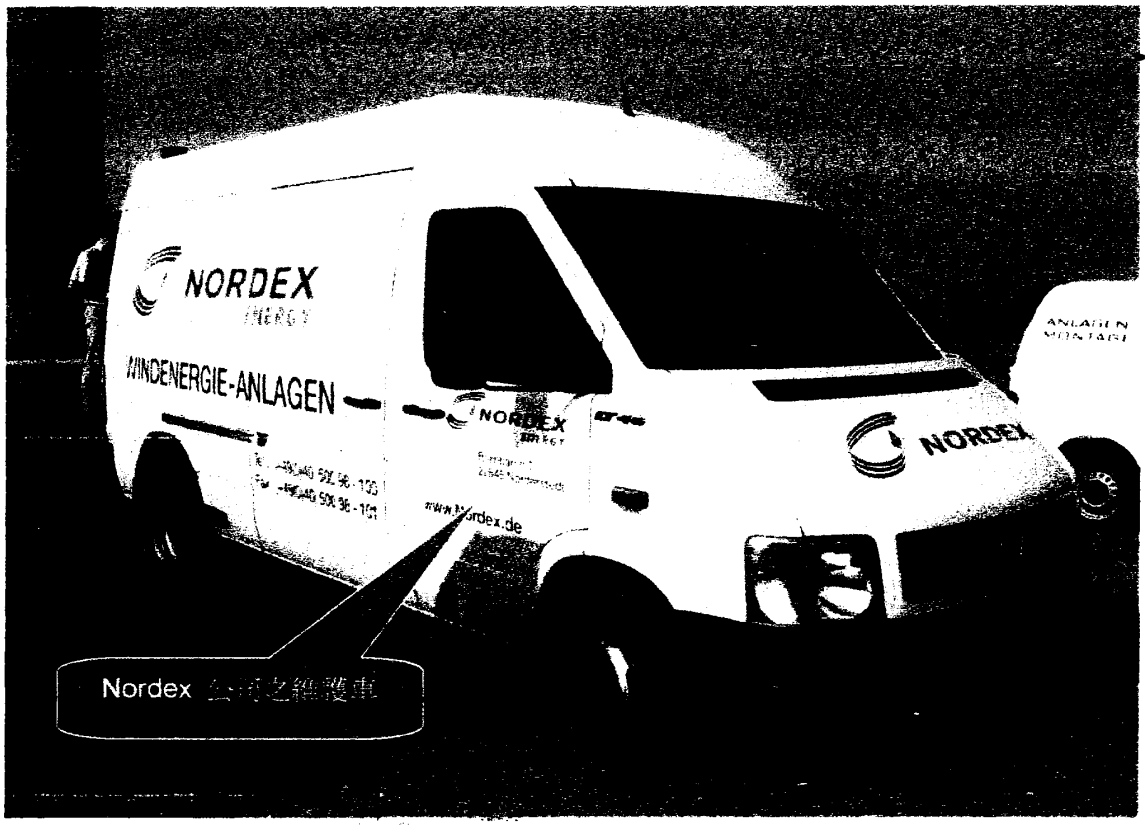
6. 下圖係德國 Nordex 公司之 service center, 共負責 2000 部風力發電機, 人員約 2 至 4 人, 電腦約 12 部.

7. 一般係以一部車及兩個人員共組一個 TEAM, 約 20 部至 40 部機需要一個 TEAM.

8. 修護公司決不負責別家公司之維護工作.

9. 各廠家之產品差異極大, 尤以 ENERCON 公司之差異更大.

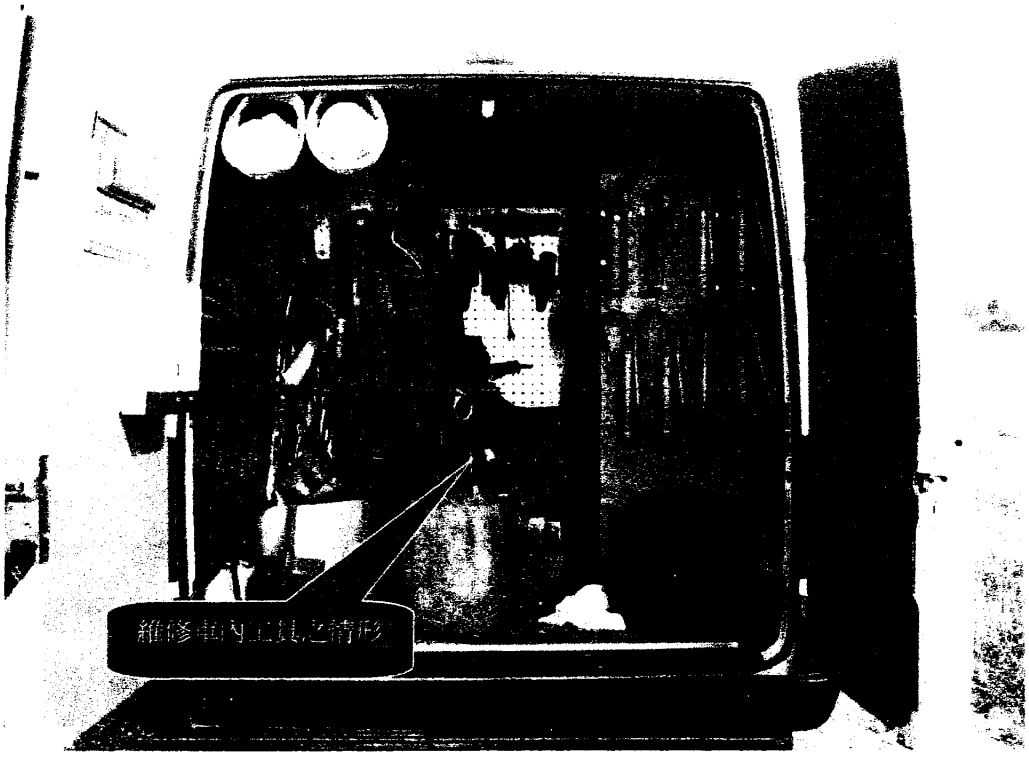
10. 以下是 Nordex 公司之維護車.



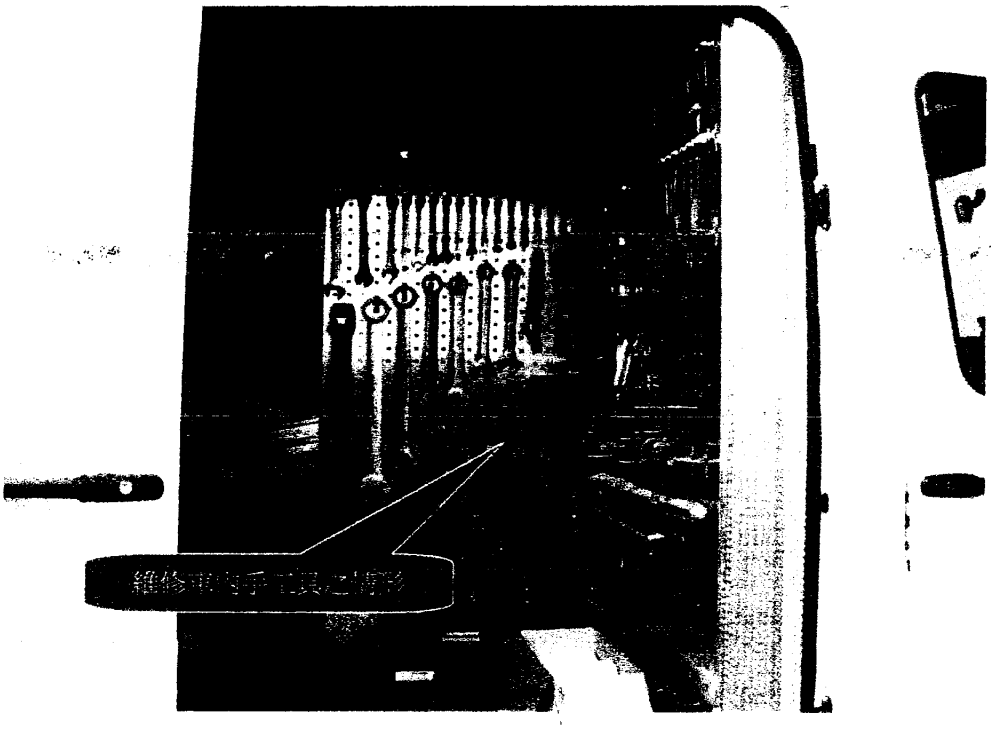
11. Micon 公司之維修車:

12. 每部車均附 NOTEBOOK:

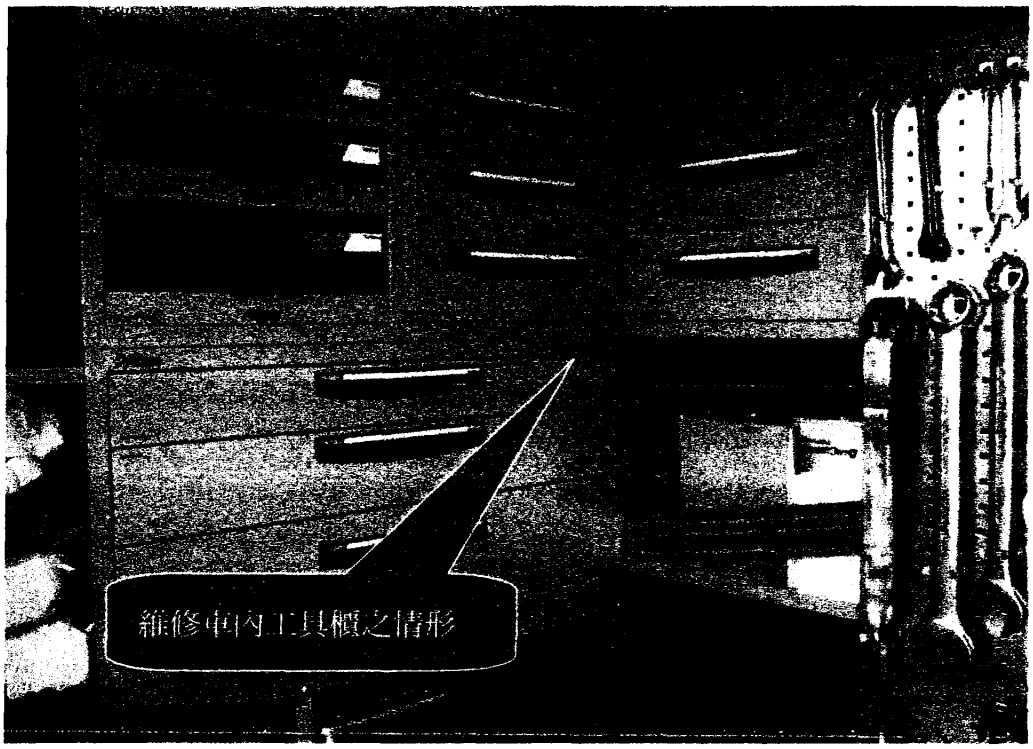
13. 維修車內工具之情形:



14. 維修車內手工具之情形:



15. 維修車內工具櫃之情形:



16. 維修車內工具櫃內之情形:

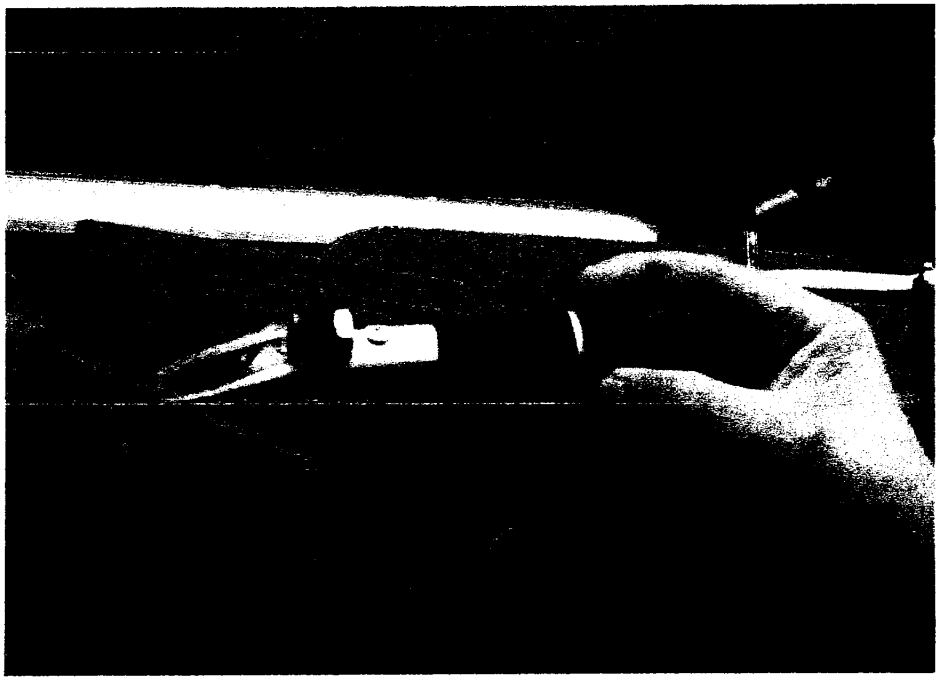
17. 安全護具

三.風力發電維護作業:

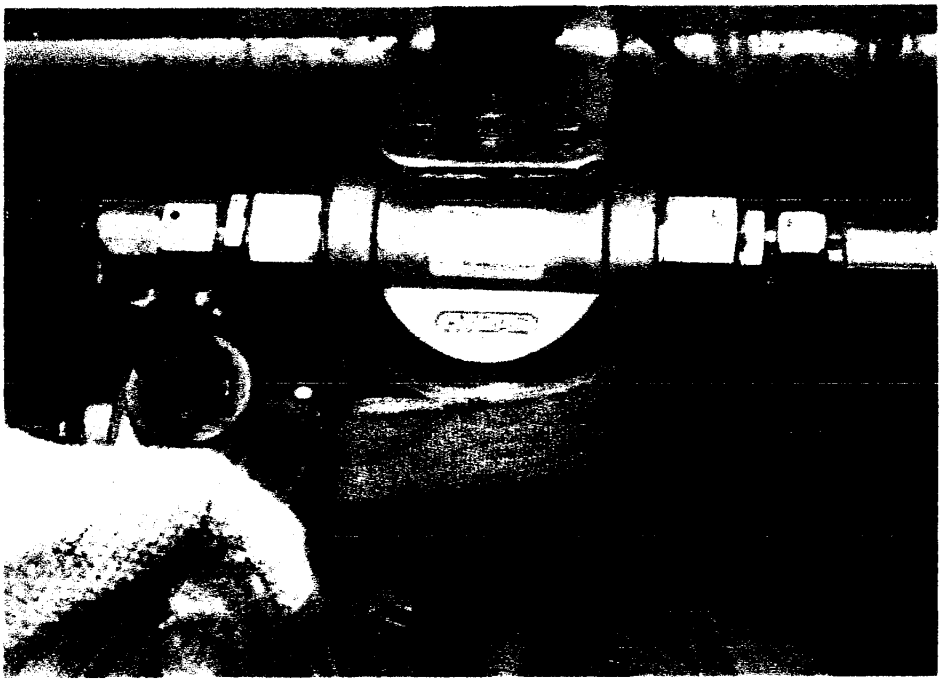
以有 GEAR BOX 之 VESTAS 公司之產品 V66 1.75MW 之風力發電機為例:

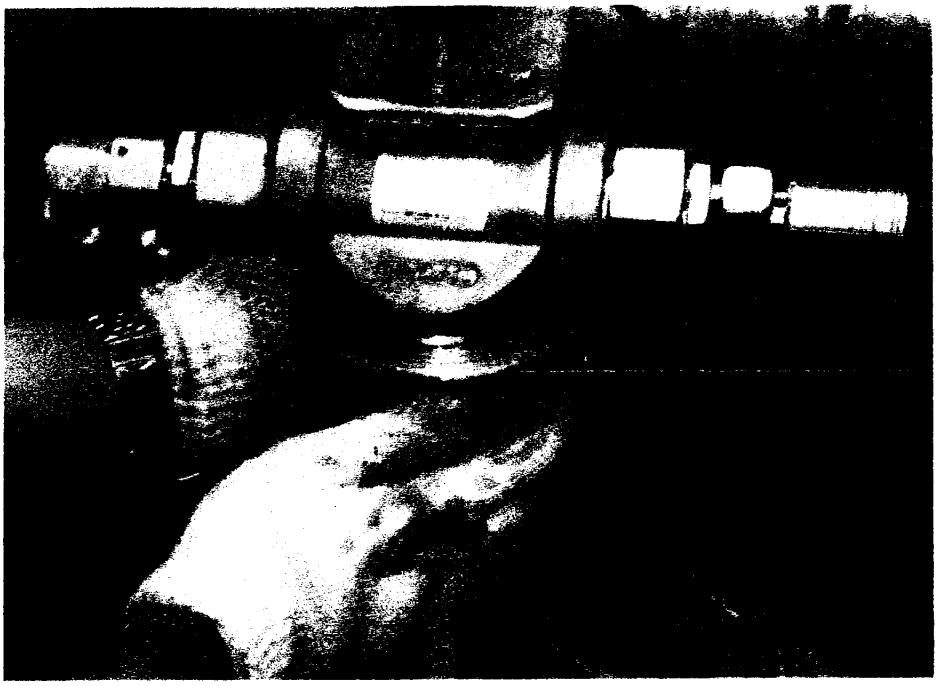
機械設備之檢查維修主要工作如下:

1. 檢查冷卻器之防凍液:



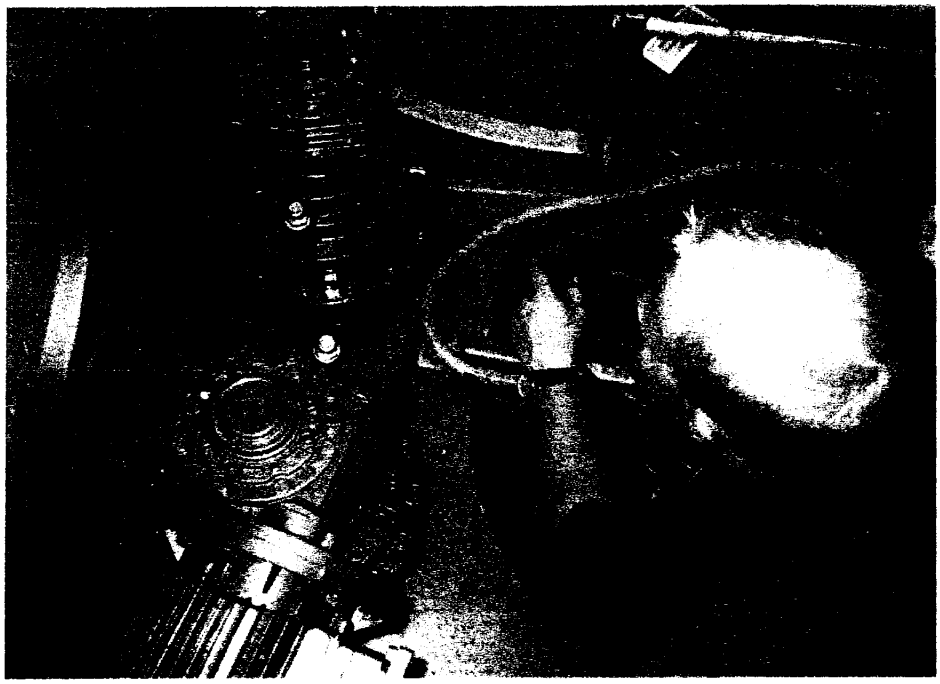
2. 更換齒輪箱之濾網，並取齒輪油之樣品送化驗。

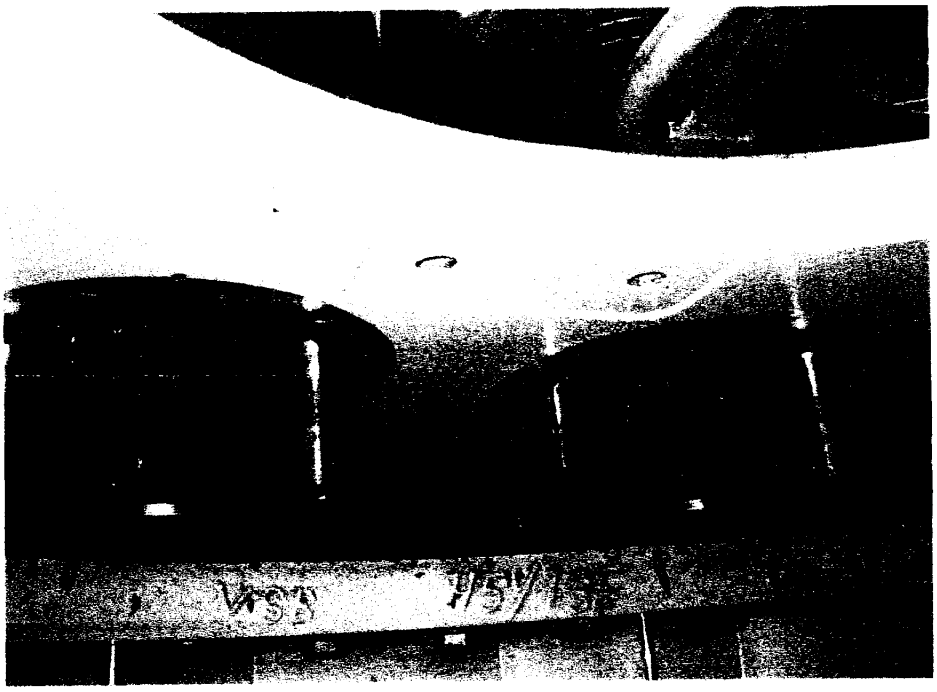


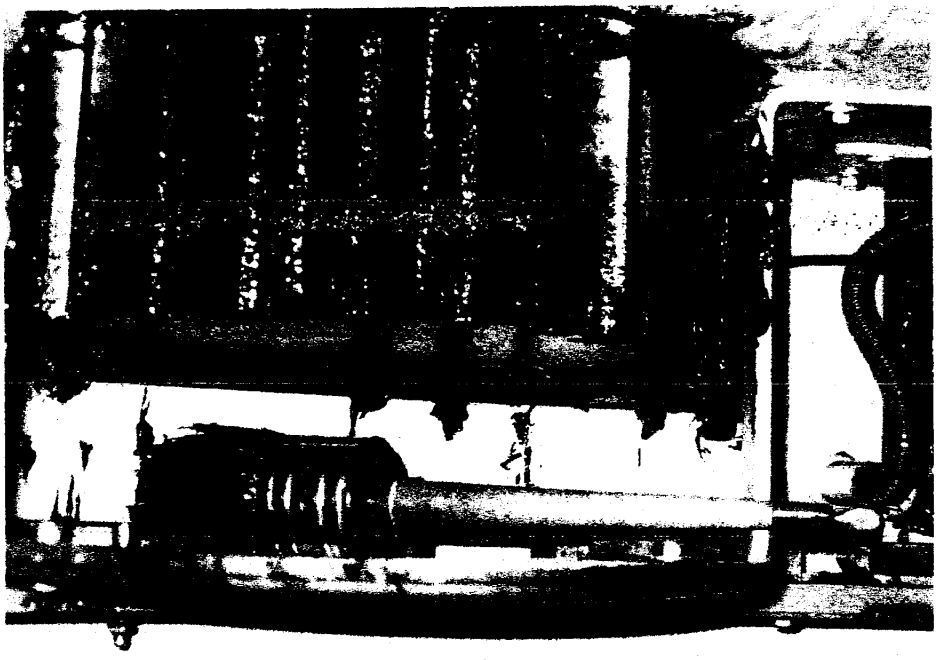


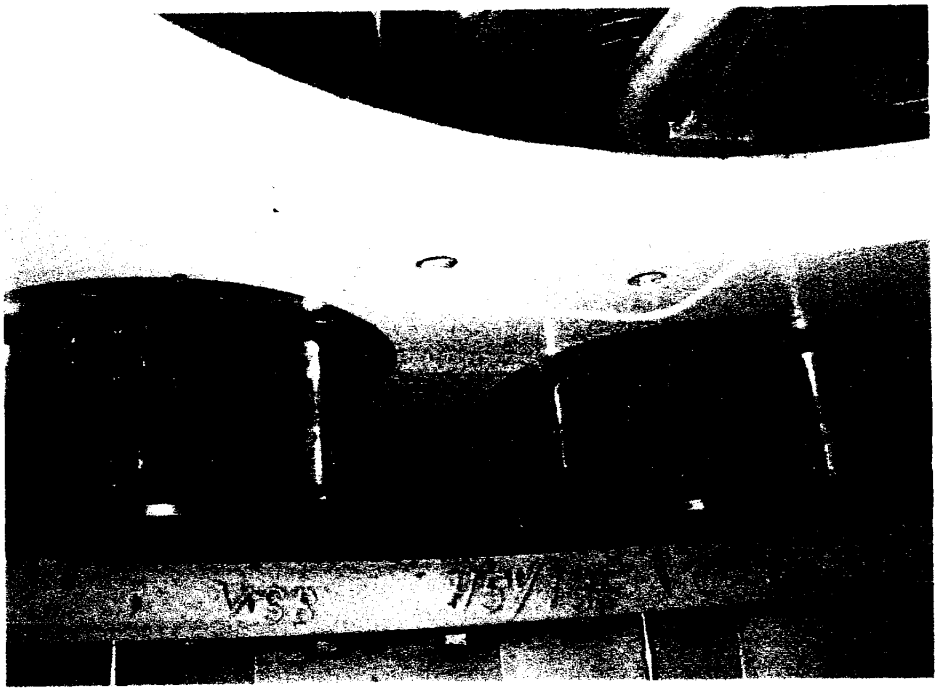
3. 於各軸承添加潤滑油脂。

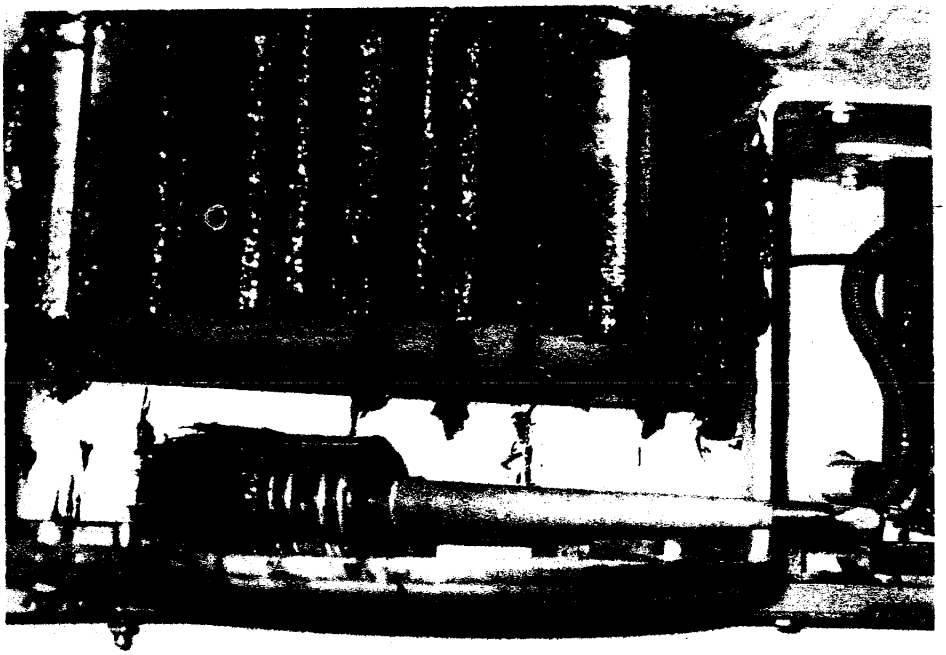
4. 迎風系統齒輪加牛油。



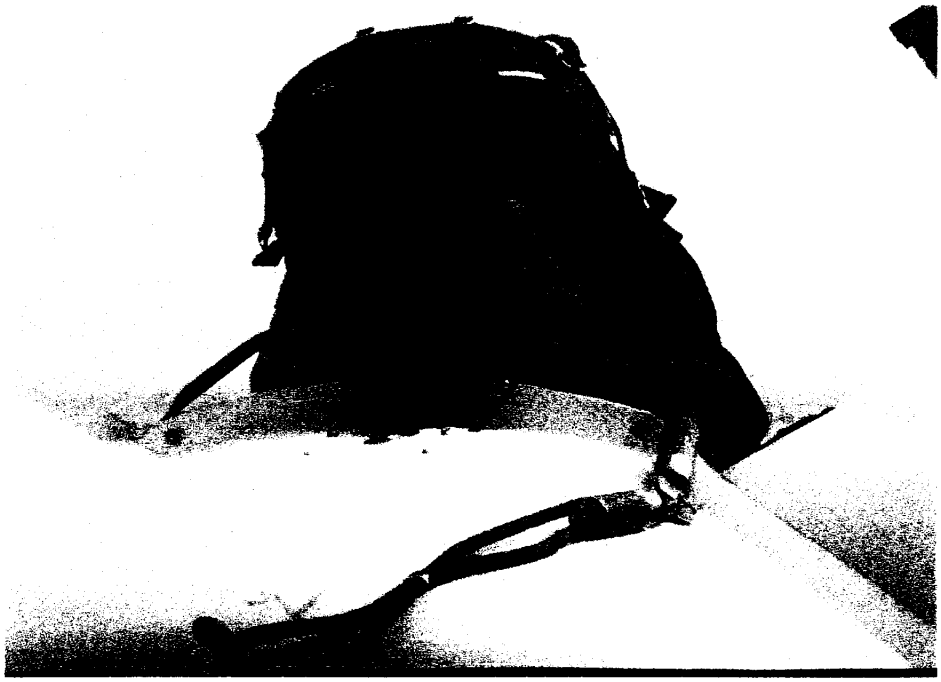


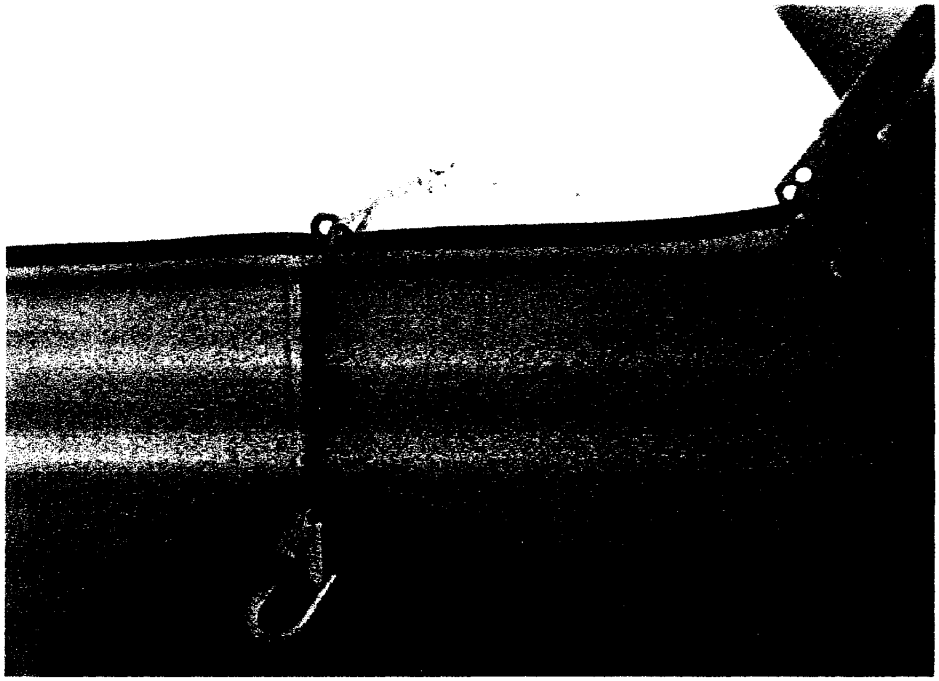


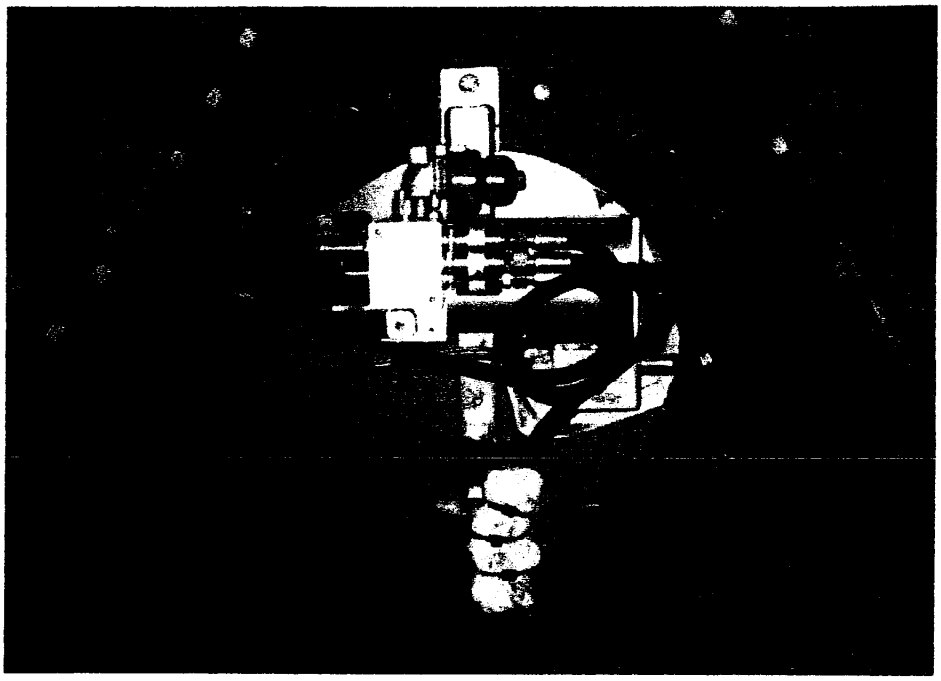


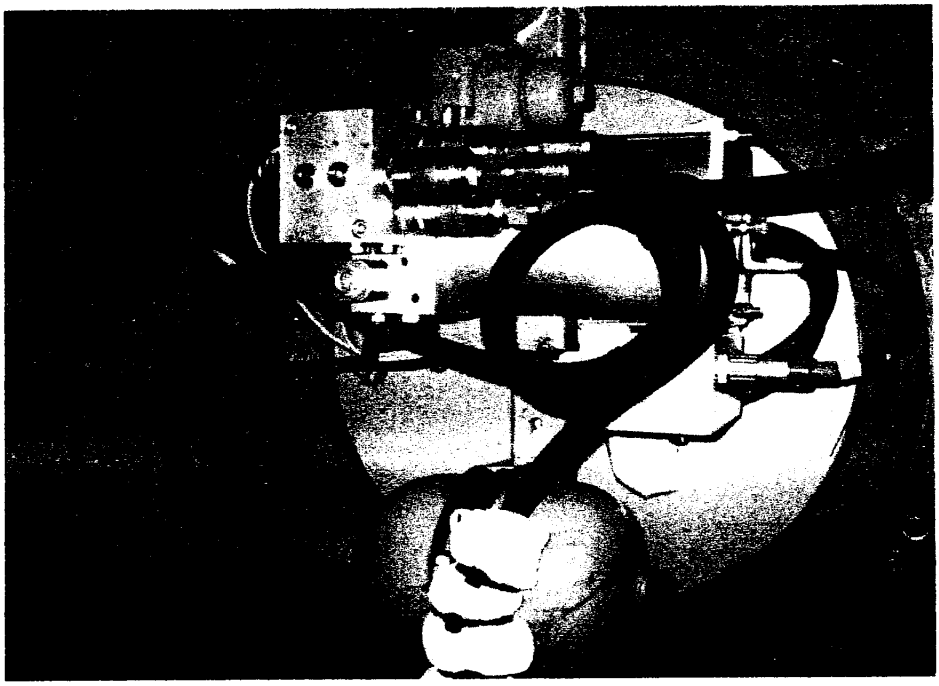


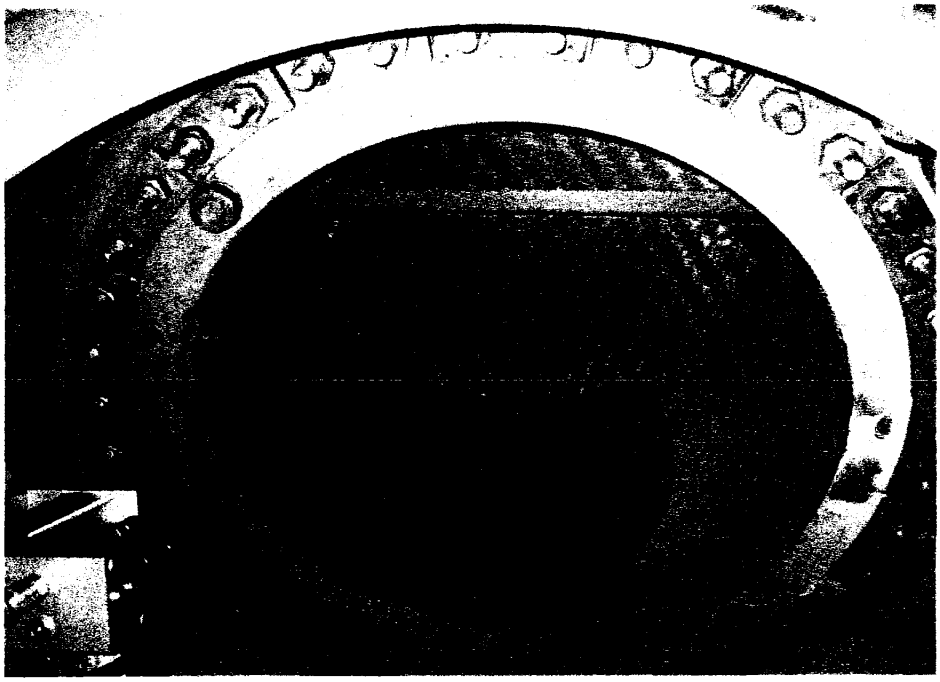
4. 檢查蓄壓器壓力



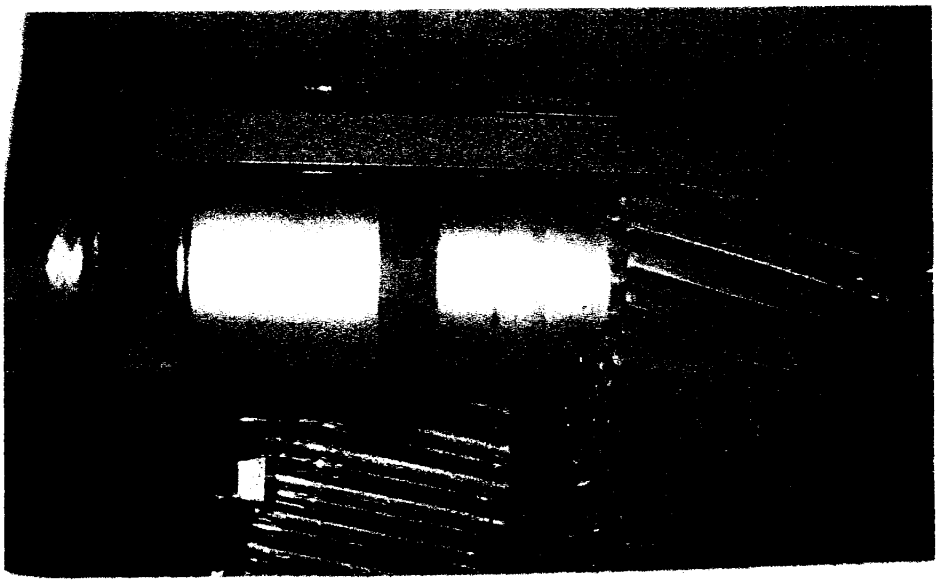


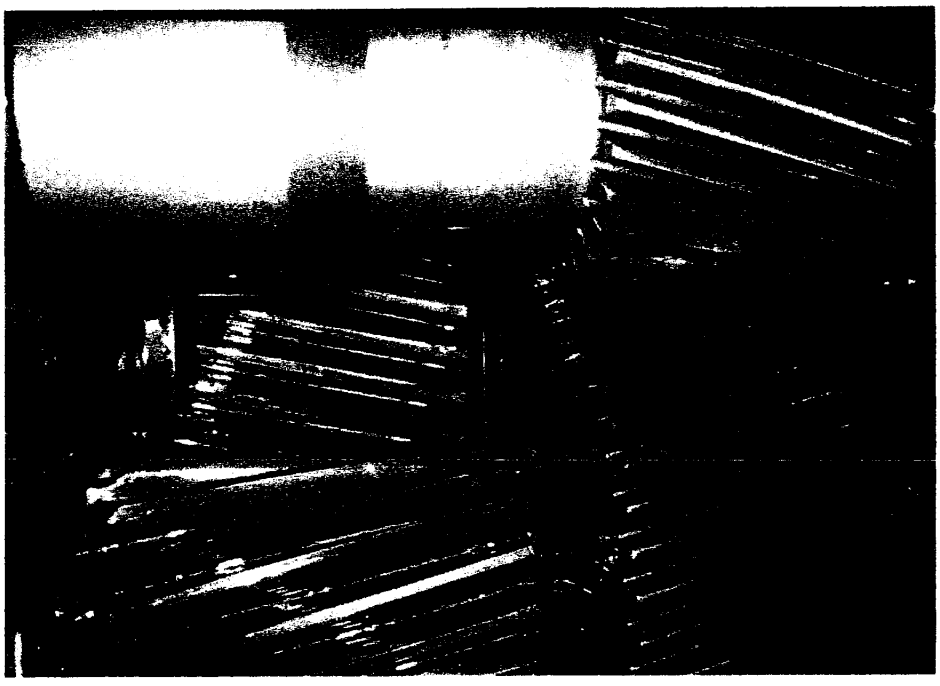




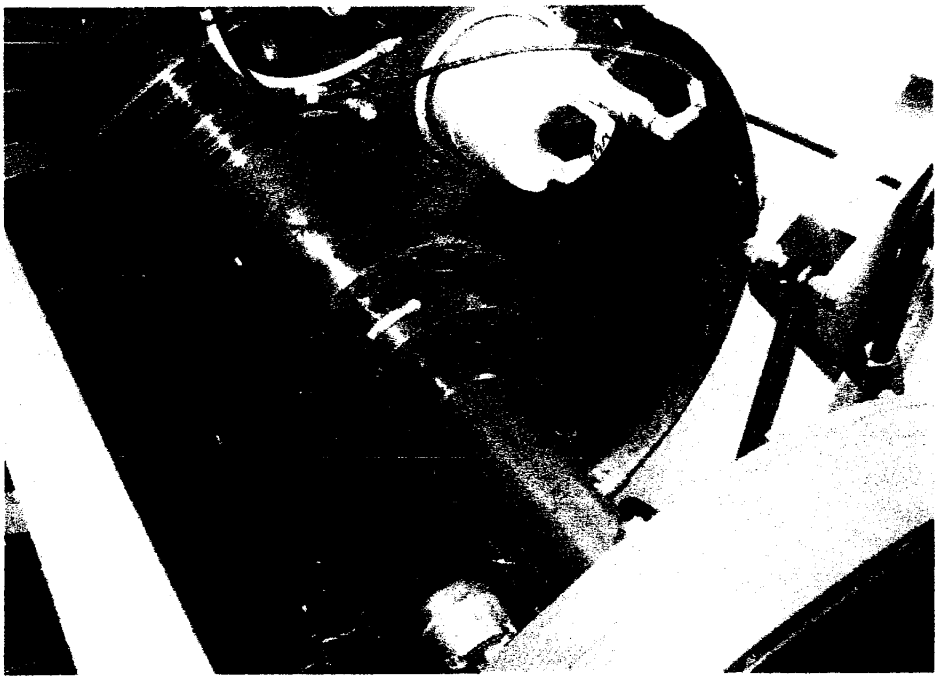


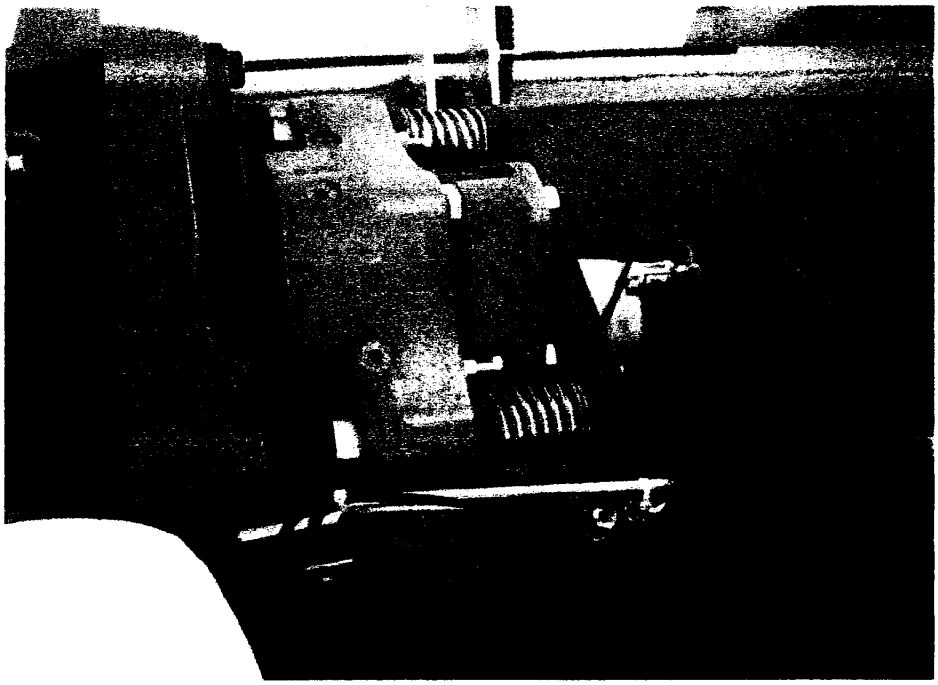
6.檢查齒輪箱

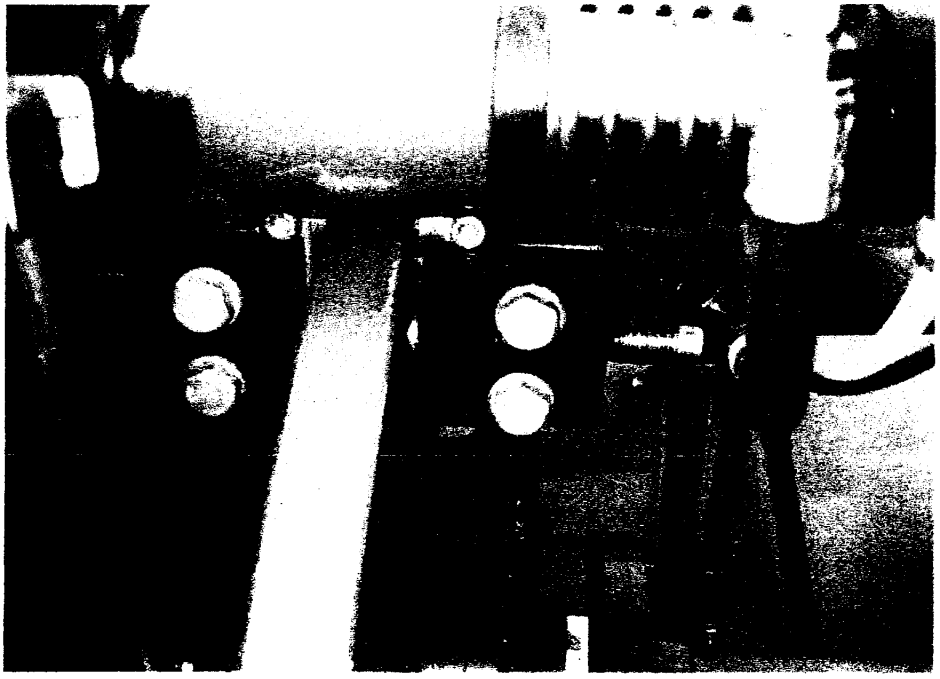




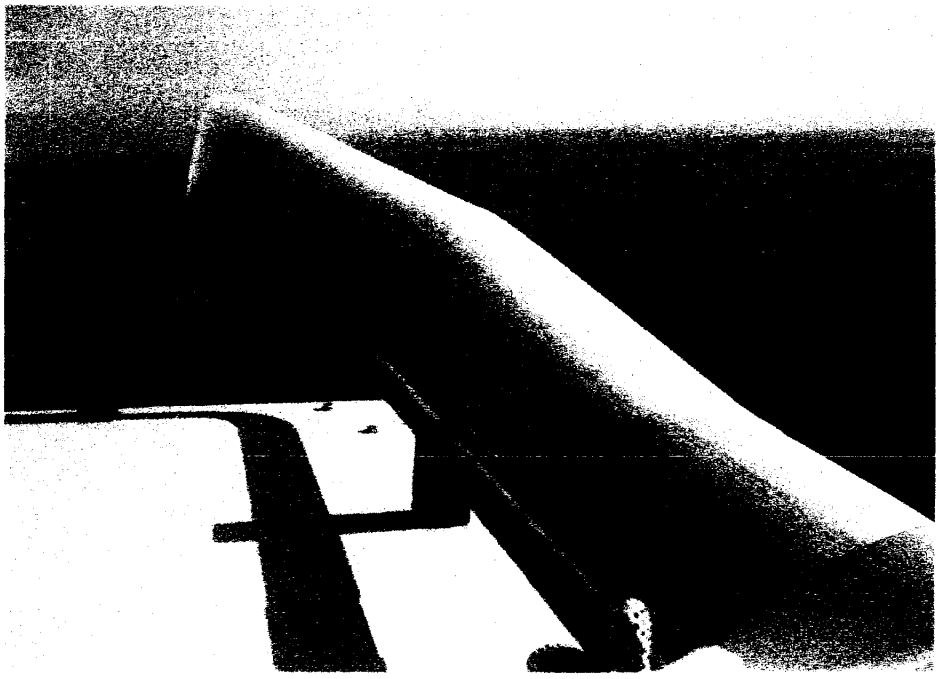
7. 檢查煞車



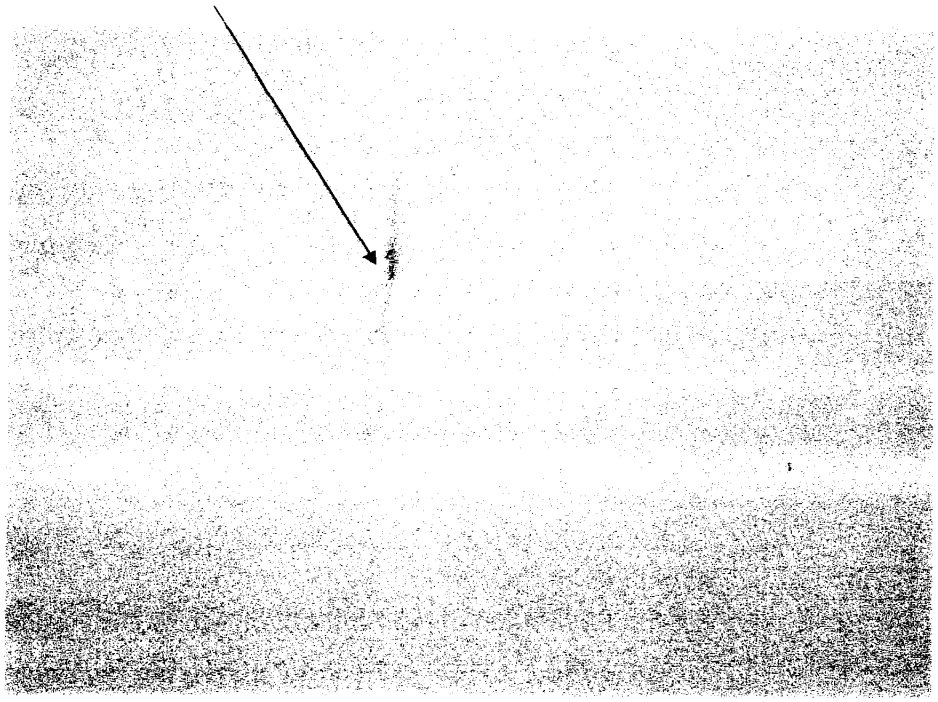




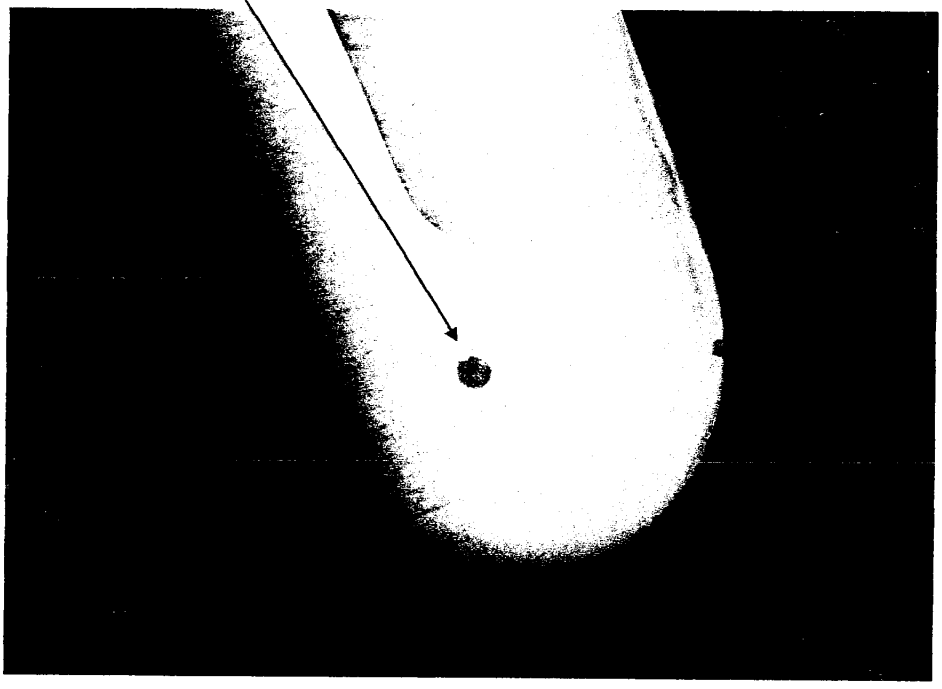
8. 葉片檢查



葉片破損案例:

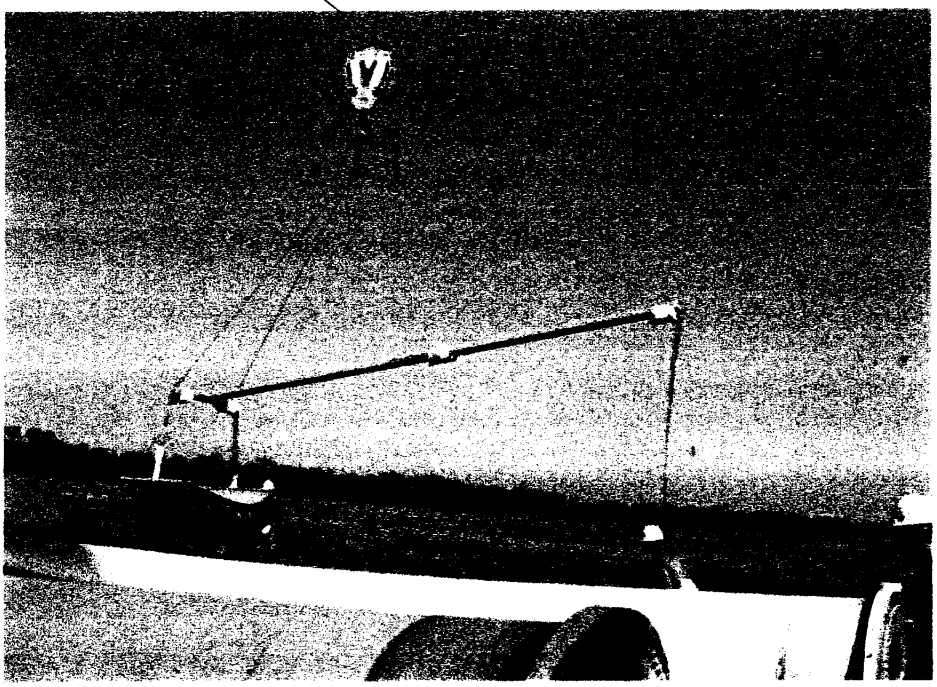


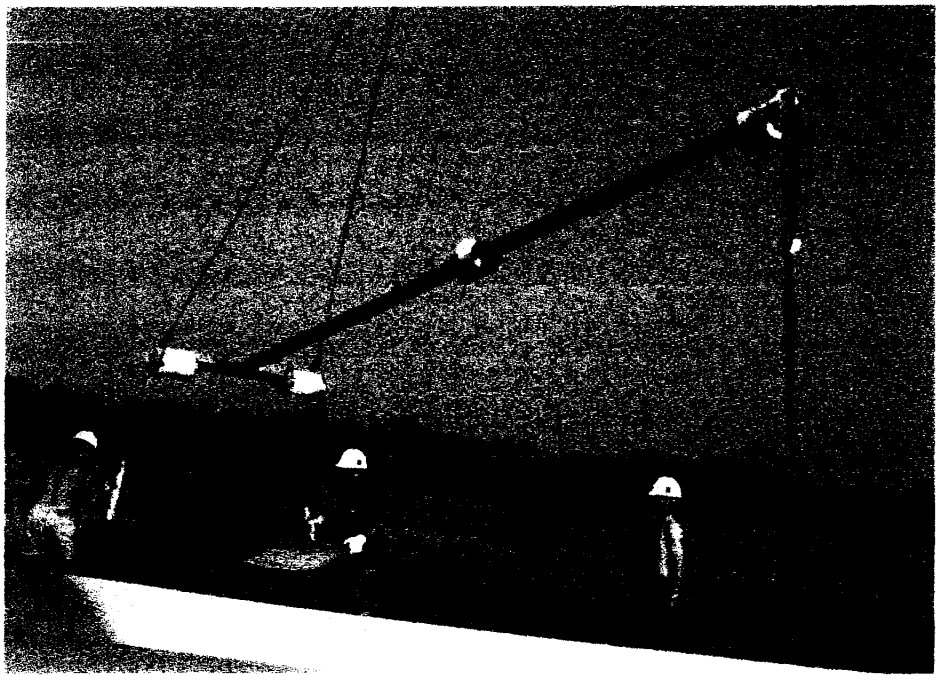
雷擊接收金屬

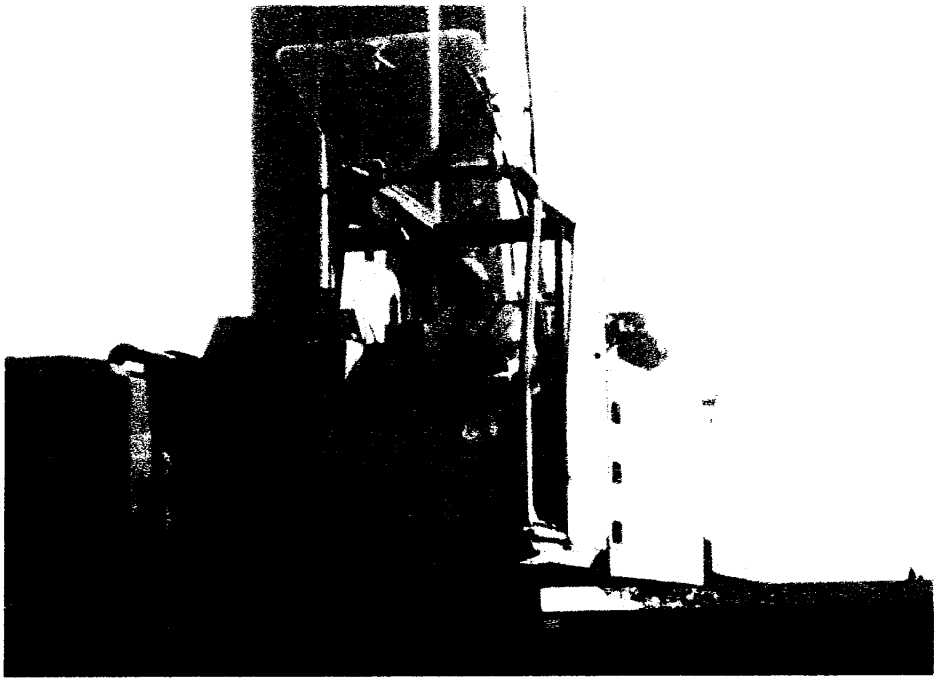


9. 其他:

葉片更換作業







功能測試:


7 8 9
4 5 6
1 2 3
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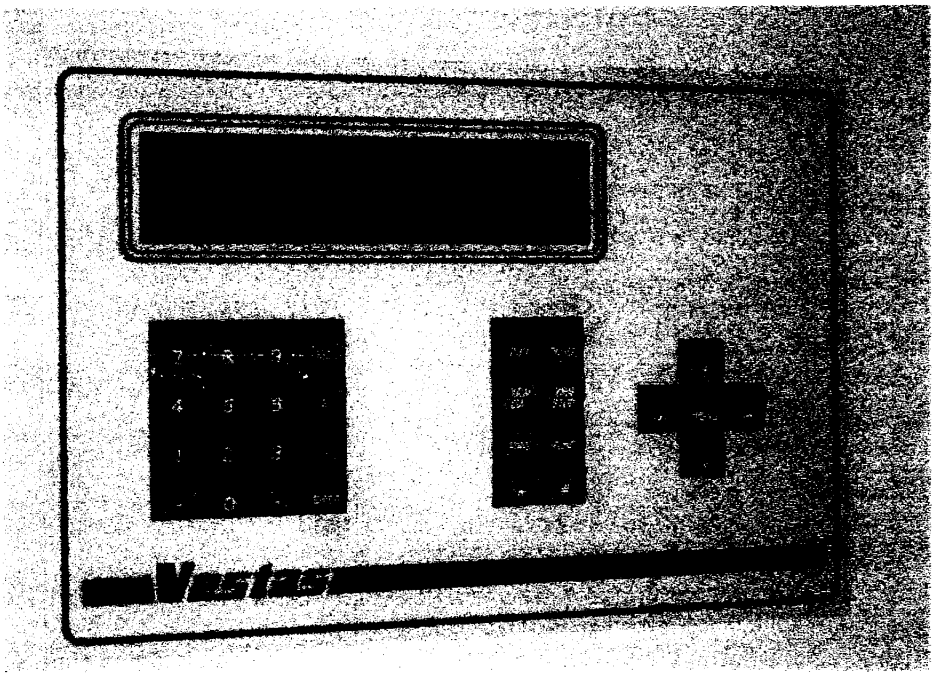


四.維護作業程序:

1.機械設備維護如附件一

2.儀控設備維護如附件二

參.出國期間所遭遇之困難與特殊事項

本次國研究因適逢國外研究差旅費大幅降低,日用費(含吃住室內交通費)每日約1000元台幣，故本人本次出國約需倒貼25萬元台幣。

肆.對本公司之具體建議

一、請恢復原出國研究差旅費規定。

二、將來吊車租用一定相當頻繁,有必要建立一套吊車租用機制。

三、可考慮向中興電工挖角或榮福人員搭配從事維護工作。

四、於維護工作中可逐步收集資料,某些備品可直接在台灣取得。

五、持續向營建處要求減少風車種類,以利維護。

六、對本處風力發電運轉維護建議及計畫如後:

電力修護處風力發電運轉維護計劃書

編寫人:邱文寶

目錄:

壹. 前言:

配合電業法修訂及再生能源條例，本公司計劃至 2011 年共裝置 30 萬 KW 或 200 部之風力發電機，依總經理核定之 91.9.25 風力發電運轉維護分工會議記錄，風力發電機之運轉、維護由修護處負責辦理。依國外風力發電運轉維護模式及本公司現況，日後風力發電應採運轉維護一元化之方式，以收事權統一集中管理之效，並可降低人事成本及管理費用。

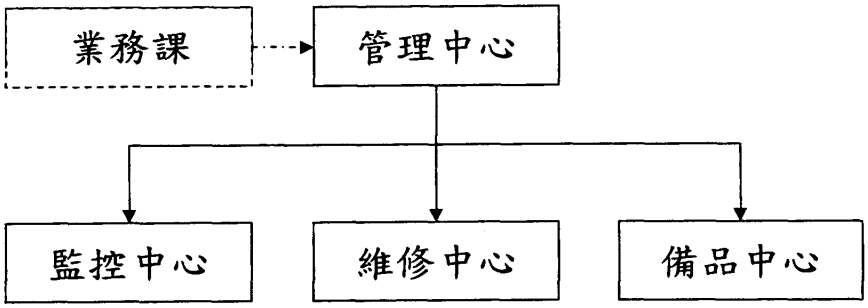
貳. 風力發電運轉模式及特性:

一、 運轉模式:風力發電機是相當高度自動化之機組，機組現場平時不需人員巡視或值班，利用監控中心之值班員經操作電腦即可遙控操作全台所有風力發電機(透過 Modem 或 ADSL)，並可包括離島之遙控。

二、 運轉維護特性:

1. 風力發電機正常狀況不需拆解檢修，但須定期保養維修，維修人員須開維修車至風力發電機現場維護保養，ENERCON 公司之產品三個月保養一次，其餘公司均為半年保養一次(每次約一天至兩天)。
2. 維修人員從事現場工作屬高空作業，人員應以年輕健康無懼高症者為原則。
3. 風力發電機之維修尤應注意工作安全，尤其是氣候影響極大，如雷擊、地震、強風、豪雨均無法實施維修工作。

4. 本處風力發電運轉維護各部門之架構可依下圖方式逐漸成立：



備註：1. 業務課為本處原編制單位.

2. 管理中心總管所有風力發電運轉維護之責。

3. 管理中心下轄監控中心、維修中心及備品中心。

參. 各部門執掌及分工:

一. 管理中心:

風力發電管理中心設立於機械課，負責管理所有風力發電機組之運轉維護保養修理之管理工作，主要工作內容如下:

1. 負監控中心、維修中心及備品中心三中心之管理及督導之責。
2. 安排維修工作時程，及維修中心之維修車及人員之派遣，與故障處理之聯絡及諮詢。
3. 與監控中心人員保持聯繫，及線上故障排除之諮詢。
4. 接收監控中心之報表,並予以分析並歸檔。
5. 與原國外廠家技術方面之聯繫。
6. 負責安排所有人員之訓練及技術認證工作。
7. 協助業務課簽訂相關合約，並傳送整理後之相關報表至業務課。

二. 監控中心設於機械課之獨立辦公室，監視控管所有風力發電機，每日上班時間(含例假日)派人值班。

1. 值班人員 1 人並視機組廠牌多寡而增加,並安排預備人員 1 員負責例假日輪值及平時替換。
2. 監視風速風向及發電產量。
3. 線上處理風力發電機問題。
4. 線上分析提前發現風力發電機問題。
5. 線上無法處理之問題或分析有問題徵兆時通知管理中心。
6. 列印報表送管理中心。
7. 電腦軟硬體維護及儀控之問題請儀電課支援。

三. 維修中心:

1. 現場機組維修工作由三隊負責執行。
2. 每部維修車配人員兩員，一人兼駕駛，另一人須操作筆記型電腦，可監控風機及撰寫報告。
3. 車輛及人員由管理中心統一調派,以收事權統一及管理一元化之效。
4. 中南部視需要設一處分中心。
5. 約 20 部至 40 部機組需要一部維修車(同廠牌)，並需考慮機組至維修中心車程距離。若以 200 部風力發電機作計算基礎,約需 5~10 部車(會依廠牌數變化)。
6. 車輛之保養及維修所需之吊車由工務課支援辦理。
7. 車輛之筆記型電腦軟硬體及無線網路儀電設備請儀電股支援辦理。

四. 備品中心

1. 供應課成立風力發電備品管理倉庫,專責備品採購、編號、管理及運送(配合工務課)工作。
2. 風力發電備品管理倉庫需獨立於本處其他系統。
3. 電腦化管理，維修車於當日於車上發 e-mail 要求備品，備品中心須於當天準備妥當置於維修車上,以利維修車第二天一早即可開車前往現場工作。

五. 業務課:

1. 負責本處所有風力發電對電廠簽約及相關事宜。
2. 與原廠聯繫及簽約事宜。
3. 對總公司連絡,傳送報表。
4. 對公司外之相關事宜。

六. 其他支援單位:

1. 工務課負責車輛維修及吊車支援.
2. 儀電股負責電腦軟硬體維護，管理監控中心儀控部分之支援，並逐步建立本處之風力通訊及網路系統。
3. 電機工場,變壓器工場,機械工場,儀電課、品檢工場及其他部門負責修理時必要之支援工作。

肆. 風力發電機維護所需之設備:

一、 監控中心需設於獨立房間,每增加一種廠牌之風力發電機即須配備一套電腦系統(需儀電股協助安裝)。

二、 同一種廠牌之機組每20~40部機即需一部維修車(附無線網路筆記型電腦),並需考慮機組至維修中心車程距離,再決定所需維修車數量。

三、 維修車內需配備無線網路筆記型電腦、工具、備品及安全護具。

四、 同一種廠牌之機組每種型式即需有一套面盤設於管理中心,以利管理中心與現場溝通之用。

五、 以上三項設備須於營建處採購時一並購買。

六、 保養初期備品應足夠,但慢慢地需要採購或補充新工具及備品,因廠牌機組差別甚大,工具及備品可於保固期間陸續收集相關資訊。

伍. 人員訓練及認證:

一. 人員訓練:

1. 於機組採購時依約派員前往原廠受訓。
2. 與營建處保持聯繫，於機組裝機時即派員參與。
3. 機組到達一定數量後即可於本處設訓練課程，並自行培訓講師。

二. 人員認證:

1. 初期須經由原廠作人員認證。
2. 機組到達一定數量及累積一定經驗後即可由本處作人員認證。
3. 若認證人員達一定數量後即可接公司外之維修工作，同時運轉同一廠牌機組達經濟規模時，亦可接公司外之維修工作。

陸.近程、中程、及遠程計畫:

本處風力發電運轉維護推行計畫須配合電源開發處之風力發電計畫，該計畫內容如下:

時間	計畫期別	裝置機組數	裝置地點
89~91 年	澎湖計畫	600KW x 8 台	澎湖
92~94 年	第一期計畫	600KWx6 台 1800KWx54 台	電廠廠內: 核一、核三、台中及大潭電廠。 電廠廠外: 桃園大員觀音 台中港 彰濱工業區
94~96 年	第二期計畫	60 台	電廠廠外: 台中港 彰濱工業區 新竹縣市沿海
96~98 年	第三期計畫	台數未知	彰化、雲林、嘉義沿海防風林及海堤
98~100 年	第四期計畫	台數未知	朝離岸式發展

一、 近程計畫:

1. 初期只有澎湖四部機作維護,且尚在保固期內，為儘速接收維護技術,本處可於定期維護期間，利用現有人力派員與德國技師及中興電工人員一起作維護工作。

A. 每次維修需紀錄並持續收集資料。

B. 與營建處保持聯繫，並提供意見及規範。

2. 配合第一期計畫之廠內第一批 20 部本島風力發電機組約在 92

年 3 月招標，年底裝機，本處將參與裝機，裝機前本處須逐步成立四中心並著手營運，裝機後即可步上軌道開始營運。開始成立人員可較精簡，隨機組數增加再逐步增加人員。

3. 配合第一期計畫廠外籍廠內完成 60 部機之運轉規劃如下:

A. 目標:完成管理、監控中心、維修中心之設置，並能運轉維護 60 部風力發電機。

B. 人員配置:

a. 管理中心:

課長:負風力發電運轉維護督導之責。

股長: 執行風力發電運轉維護督導之任務。

工程師:一員; 執行並聯繫風力發電機之運轉維護。

技術員: 一員，協助工程師及支援監控中心或維修中心。

b. 監控中心:

技術員 2 員(會依廠牌數變化)，於上班時間輪流值班，包括例假日。

c. 維修中心:

約需 2~3 部車(會依廠牌數變化)，故技術員需 4~6 人。

d. 備品中心:供應課材料股兼任。

二. 中程計畫(民國 96 年):

1. 目標: 完成增設備品中心，並能運轉維護 120 部風力發電機。

2. 人員配置:增加以下人力:

A. 管理中心: 工程師一員，技術員一員。

B. 監控中心: 技術員 1 員。

C. 維修中心: 約需 2~3 部車(會依廠牌數變化)，故技術員需 4~6 人。

D. 備品中心:成立備品中心，增設技術員一員。

三. 遠程計畫(民國 100 年):

1. 目標:完成管理、監控、維修、備品中心之設置，並能運轉維護 200 部風力發電機。

2. 人員配置:增加以下人力:

A. 管理中心: 工程師一員，技術員一員。

B. 監控中心: 技術員 1 員。

C. 維修中心: 約需 2~3 部車(會依廠牌數變化)，故技術員需 4~6 人。

D. 備品中心:成立備品中心，增設工程師一員。

柒.前景、未來挑戰及總結:

一、 前景:

1. 風力發電運轉維護係本處新的業務，經驗不如水火力發電，但其實在國外原廠家除丹麥之 Vestas 公司外，其他歐美日之風力發電製造廠家經驗也不多，頂多也是僅 5 年之運轉經驗，有運轉維護風力發電超過 10 年之機組之公司更是少之又少。
2. 本公司預計在 10 年內裝置 200 部或 30 萬 KW 之風力發電機，這是頗具經濟規模之機組數量，在本處成立專責單位相當具有經濟性。
3. 以二十餘人去運轉維護 30 萬 KW 之風力發電機組，以每人之產值來算非常高，所以此業務將來對本處會變得相當重要。
4. 日後可雇用及訓練榮福人員更可降低成本。
5. 日後可接公司外之運轉維護工作。

二、 未來挑戰:

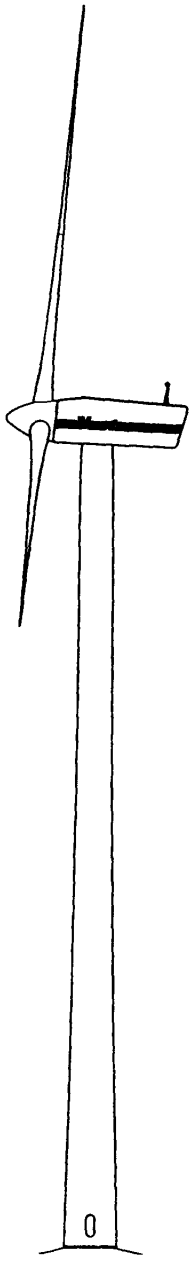
1. 日後挑戰將來自公司外，因本公司計畫未來 10 年裝置 30 萬 KW，但民間公司也計畫於未來裝置 20 萬 KW，預估將有數家風力發電維護公司將成立，但該維護公司將僅維護某一家廠牌之風力機組，並須已達經濟規模。
2. 本處應持續注意民間公司裝機及相關動向，並於必要時採取因應對策。
3. 積極研發備品自製降低維修成本，並自行研發小型風機設計製造技術，以提升本處設計製造運轉維修能力。

三、 總結:

1. 風力發電運轉維護係本處新的業務，因相對產值高，將成為本處相當重要之業務，且前景相當看好。
2. 本處須與營建處加強聯繫，以期本公司能採購有利於本處日後運轉維護之機組。
3. 持續收集風力發電相關資料，並注意國內裝機動態。

附件一

Check, Mechanical Part



Vestas V66-1.75 MW
50Hz/ Wind Turbine

Item no.: 944815.R2

(6b)

V66-1.75 MW Check, Mechanical Part

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History of this document

Changes in this revision:

Item no.:	Date:	Description of change
944815.R2	11 Sept. 2001	Safety rules: Composite coupling – point added
		5.7: Lubrication of Blade Bearing: quantity deleted, 10-20 changed to 20
		6.9: "Dismount the rubber sleeves in both ends" changed to "Dismount both ends of the rubber sleeve of the hydraulic cylinder"
		7.5: Check of Main Bearings: Instruction added concerning play in blade bearing
		9.3: Extraction of Oil Sample: Reference to Work Instruciton 959406
		11.1: Connecting Tube and 11.2: Composite Discs: Text added
		13.3: Addition concerning automatic lubricator
		13.5: Rotating Contacts: First sentence changed
		13.8: New point: Check fan for slip ring
		15.1: Check of Oil Level: Text added
		15.5 and 15.6: "rotating unit" changed to "rotating union"
		15.9: Check of pressure relief valve: Stabilisation pressure changed
		15.11: Pressure in Brake System and 15.12 Pre-charge pressure in Brake Accumulator: Different pressure for 50 and 60 Hz turbines
		15.11: "19.5" changed to "test nipple 19.5"
		15.16: Pre-charge Pressure in Pitch Accumulator: pressure specified
		15.18: Pre-charge Pressure in Bursting Disc Accumulator: new point
		15.20: Change of Pressure Line Filters in Hub: Reference to lubrication chart
		16.3: Check of Bearings, Leakage: check gear/foundation added
		24.1: "the first tools" changed to "a load of about 100 kg"
		24.8: Oil type corrected to "Texaco White Oil Pharmaceutical"
		Throughout document: Torque wrench settings deleted and replaced by reference to item no. 943648/Work Instruction 920098 or inspection record form
		Language revision

Points written in Italic font are for first check only, 3 months after turbine start-up.

General Rules at Service Check

Tightening Torque

Bolts tightened at turbine erection must be carefully checked at the first 3 months service. Every 3rd of the bolts tightened at erection must be checked with 100% of nominal tightening torque unless otherwise stated.

If a bolt in a bolt connection can be retightened, retighten every bolt in this connection. If a bolt is loose, it must be replaced with a new one.

Play and Wear in Bushings and Bearings

Check this more carefully, when the turbine gets older, if it has had a large production, or if it is situated on a site with very turbulent winds.

Safety Rules

Locking of Rotor/Blades

Locking of Rotor

Set the turbine in PAUSE, and apply the parking brake by pressing an EMERGENCY STOP button or via picture 11.7.

By means of the parking brake, align the lock holes in the rotor lock disc with the locking pins and mesh the locking pins with the holes by activating the manual hydraulic pump.

Then set the pump handle in "Locking"-position.

When to lock the Rotor

When working in the blade hub

When working on transmission line components in the nacelle

The rotor locking system will tolerate all wind loads with the blades fully pitched, BUT IT IS RECOMMENDED THAT THE WIND SITUATION IS CAREFULLY CONSIDERED BEFORE WORKING IN THE BLADE HUB.

This is especially important when running pitch tests!

When not to lock the Rotor

During normal operation when not working in the blade hub or on transmission line components in the nacelle.

When each individual blade is locked in an 87°-pitch angle (see below).

Locking of a Blade

Each individual blade can be "locked" in 4 pitch angle positions between 0° and 87°.

Locking is done by guiding the blade locking block to the position desired, loosening the counter nut and screwing the M30 bolt into the bottom of the groove. Retighten the counter nut.

When to Lock a Blade

When working on the mechanical or the hydraulic part of the pitch system, both in the hub and the nacelle.

When the turbine is left without connection to the power grid for more than a short period. In this situation the blades must be locked in an 87°-pitch angle.

		Pitch system. Main gear, brake. Transmission shafts, rotating parts of generators.
	Noise	When staying in the nacelle during operation, use ear protection, if it is not to check for gear and generator noise. Use ear protection as often as possible when working in the nacelle.
	Composite Coupling	Check the composite coupling between gear and generator for damages before operating a manned nacelle.

1. Fall Protection Device

1.1	**Anchor Point for Wire in Top and Bottom**	Check the mountings for yellow markings, cracks and deformation. Check all bolt connections.
1.2	**Wire, Shackle and Shackle Lock**	Check wire, shackle and shackle lock. Examine the wire for broken threads and deformation. If the wire is corroded it must be replaced (note it in the service report). Check wire thimbles and wire lock for cracks. Check shackles and lock for cracks and deformation.
1.3	**Wire Guides on Ladder**	Check the wire guides on the ladder. Check that the wire guides are attached properly and hold the wire in place. Check all bolt connections.

2. Safety Equipment for Turbine Owner

2.1	**H-Belt/Belts**	Check the 2 H-belts/straps according to the instruction. Note the serial number and mark for OK. If the belt cannot be approved take it back to the service department (make a note in the service report).
2.2	**Long Lanyards**	Check the two long lanyards plus fall damper device, if any, according to the instruction. Check the strands plus the splicing. Note the serial number and mark for OK. Measure the diameter of the straps with a sliding gauge and note the diameter. If the belt can not be approved take it back to the service department (make a note in the service report).
2.3	**Shortening Lanyards**	Check the two shortening lanyards plus fall damper device, if any, according to the instruction. Check the strands plus the splicing. Note the serial number and mark for OK. Measure the diameter of the straps with a sliding gauge and note

		the diameter. If the belt cannot be approved take it back to the service department (make a note in the service report.
2.4	**Safety Helmet**	Check safety helmets for cracks. Check sweatband for cracks and wear.
2.5	**Sliding Stop Lock**	Perform a functional test of the sliding stop lock. Test the lock on the wire. Check the claws of the wire lock. Check the opening and closing mechanism of the lock.

3. Nose Cone

3.1	***Bolts at Nose Cone Support***	*Check torque level of 1 bolt between nose cone support and blade hub.*
3.2	**Bolts in Fibreglass**	Check for loose bolts where fittings are attached to fibreglass.
3.3	**Cracks in Fibreglass**	Check the nose cone for cracks in fibreglass around the bolt connections.
3.4	**Cracks in Support**	Check the front nose cone support for cracks around the welds.
3.5	**3.5 Movable Lightning Current Transfer Units**	**Only on turbines with lightning conductor bands on the blades** Check current transfer units for loose bolts. Check all parts incl. conductor cable on the units for burns after lightning. Replace the mechanical parts if they have major damages. Replace the cable if there are any visible damages to the insulation. Check that the aluminium discs have not got loose. Replace the bolt through the wheel fork if it has got loose and check wheel + aluminium discs for wear in the axle hole. Torque wrench setting: See item no. 943648 Torque Settings or inspection record form. Check that the rubber wheel can turn freely and check for play in wheel bearings. Replace wheel if there is play, which is not due to a loose bolt.
	IMPORTANT!	A turbine must **never** be left without earth connection to all three blades. If a current transfer unit is not fully repaired or if it is removed completely, a 50mm^2 jumper (768745) MUST be applied inside the blade. The jumper is mounted between the bolt connection at the lightning conductor band and the stiffening plate. The jumper **must** be removed when the current transfer unit is fully mounted and functioning correctly.

3.6	**Replacement of Transfer Unit Parts**	Note in the inspection record form, if any parts have been replaced on the current transfer units.

4. Blades

4.1	***Bolts connecting Blade and Blade Bearing***	*Check every 3rd of the 80 blade bolts for each blade. Torque wrench setting: See item no. 943648 or inspection record form..*
4.2	**Bolts connecting Blade and Blade Bearing**	Check every 10th of the 80 blade bolts for each blade. Torque wrench setting: See item no. 943648 or inspection record form.
4.3	**Cracks in Blades**	Check if there are any cracks along the blade edges.
4.4	**Marking of Cracks**	If possible, mark the ends of any cracks to see if they are growing. Write date for the mark on the blade. Note any observations in the inspection record form under "Remarks".
4.5	**Existing Marks**	Check all existing marks to see if any cracks have grown longer.
4.6	**Blades Repaired?**	Note if any repair has been carried out on the blades, and note blade and serial number.
4.7	**Lightning conductor bands**	**Only on turbines with lightning current transfer units** Check that the lightning conductor bands have not become detached from the blade surfaces. Check the conductor bands for exaggerated wear and scraping marks. Check the conductor bands for burns after lightning. Replace the band if the surface has larger damages.
4.8	**Replacement of parts for conductor bands?**	Note in the inspection record form, if a lightning conductor band or a bolt has been replaced.

5. Hub, Blade Bearing

5.1	***Bolts at Lifting Tool***	*Check 3 bolts in each side between blade bearing and hub where the lifting tool was mounted. Torque wrench setting: See item no. 943648 or inspection record form.*
5.2	***Bolts connecting Blade Bearing and Hub***	*Check every 3rd of the 71 bolts between each blade bearing and hub. Torque wrench setting: See item no. 943648 or inspection record form.*
5.3	**Bolts connecting Blade Bearing and Hub**	Check every 10th of the 71 bolts between each blade bearing and hub. Torque wrench setting: See item no. 943648 or inspection record form.

5.4	**Outer Lip Seals**	Check the lip seals for leakage. Replace them if necessary.
5.5	**Inner Lip Seals**	Check the lip seals for leakage.
5.6	**Function of Blade Bearings, Measurement of Play**	Check the blade bearings for uneven running and play.
5.7	**Lubrication of Blade Bearing**	Dismount the six blanking caps from the grease drain nipples. Please note that the O-ring must stay in the cap. Mount plastic bags on the grease drain nipples. Set the controller to pitch 0° - 90° - 0° in sine test mode. Lubricate the bearing alternately through the 6 grease nipples, while the blades pitch back and forth. Grease each bearing. Let the blades pitch 20 times after terminated greasing, before dismounting the plastic bags.
	Lubricant:	See lubrication chart.
	Mount threaded caps	Mount the threaded caps. Check that the O-ring is in the cap before mounting it. Tighten the cap slightly by hand.

6. Pitch System

6.1	***Cylinder Holder***	*Check 2 of 7 M20 bolts in each half of the cylinder holder. Torque wrench setting: See Work Instruction 920098 or inspection record form.*
6.2	**Cylinder Holder**	Check 1 of 7 M20 bolts in each half of the cylinder holder. Torque wrench setting: See Work Instruction 920098 or inspection record form.
6.3	***Crank Arm***	*Check 2 of 9 bolts in each crank arm. Torque wrench setting: See Work Instruction 920098 or inspection record form.*
6.4	**Crank Arm**	Check 1 of 9 bolts in each crank arm. Torque wrench setting: See Work Instruction 920098 or inspection record form.
6.5	***Locking Bolt in Shaft End***	*Dismount the floor plate on the torque arm plate making access to the inner of the blade. Check that the M24 lock nut and the bolt on the back of the stiffening plate are not loose. Do not tighten to specified torque level.*
6.6	***Bolts in Plain Bearing Housing***	*Check all 3 x 2 M20 locking bolts in the plain bearing housings. Torque wrench setting: See Work Instruction 920098 or inspection record form.*
6.7	**Holder for Cylinder. Check of Play in Carbon Fibre Slide Bearings**	Lock the blade in an 87° pitch angle, making it unable to pitch. Mount a dial meter on the hub, fixing the sensor on the machined surface inside the hub towards the blade bearing and set the dial to measure on the end of the elbow connection on the hydraulic cylinder. Activate the hydraulic cylinder by +strokes and –strokes

by means of hydraulic pressure and measure the axial play in the holder for the cylinder.
If the clearance exceeds 1.0 mm (0.040"), replace the holder for the cylinder. See Figure 1.

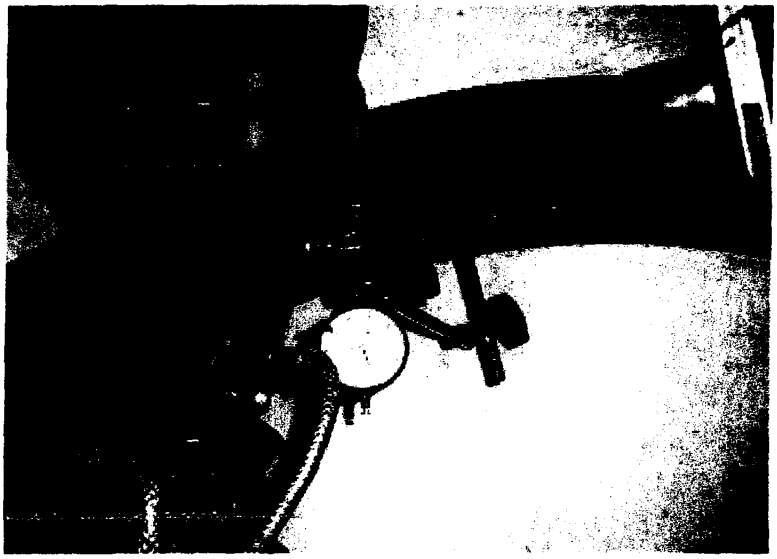

Figure 1

6.8 Plain Bearing between Torque Arm Shaft and Hydraulic Cylinder

Lock the blade in an 87° pitch angle by means of the locking bolt, disabling it to pitch. Dismount the cover plate of the plain bearing housing and clean off the Tectyl at the end of the torque arm shaft. Mount a dial meter, fixing the sensor on the end of the torque arm shaft. Set the dial meter to measure on the cylindrical outside of the plain bearing housing inline with the hydraulic cylinder. Activate the hydraulic cylinder by +strokes and –strokes by means of hydraulic pressure and measure the radial play in the plain bearing. If the clearance exceeds 0.3 mm (0.012"), replace the plain bearing. Remember to apply Tectyl CGV127 to the torque arm before re-mounting the cover. See Figure 2.

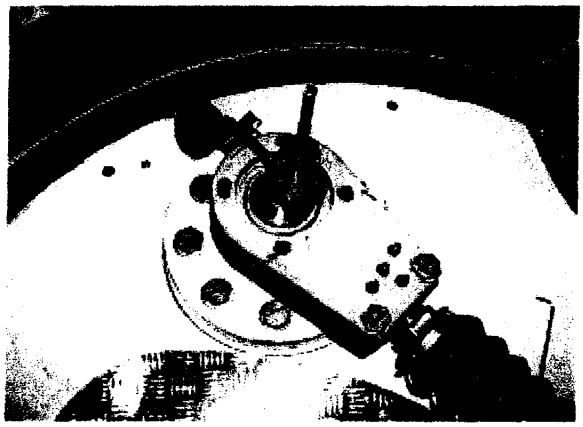

Figure 2

6.9 Check of Hydraulic Cylinder Piston Rod

Dismount both ends of the rubber sleeve of the hydraulic cylinder and check the piston rod for scratches or any sign of wear or damaged packing boxes. If any marks/signs are found, check if there is oil in the hoses to the leakage oil container. If oil is found, the cylinder must be replaced. If leakages have been detected previously, there may be oil remnants in the hoses. Dismount the cylinder hose, pitch the blade a few times. Replace the cylinder if hydraulic oil is leaking from the cylinder.

6.10 Rubber Sleeves and Leakage

Check the rubber sleeves for damages.
Check the hydraulic system for leakage.

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7. Main Shaft Arrangement

7.1 Bolts connecting Blade Hub and Main Shaft

Check every 3rd of the 48 M33 bolts.
Torque wrench setting: See item no. 943648 or inspection record form.

7.2 Bolts connecting Blade Hub and Main Shaft

Check every 10th of the 48 M33 bolts.
Torque wrench setting: See item no. 943648 or inspection record form.

7.3 Bolts in Main Bearing Housing

Check 2 M42 bolts in each side of front and rear main bearing housing, 8 bolts in all.
Torque wrench setting: See Work Instruction 920098 or inspection record form.

7.4 Bolts in Main Bearing Housing

Check 1 M42 bolt in each side of front and rear main bearing housing, 4 bolts in all.
Torque wrench setting: See item no. 943648 or inspection record form.

7.5 Check of Main Bearings

Listen for bearing noise or vibrations in the bearing housing, while the rotor is rotating slowly.
In case of abnormal noise or uneven rotation of the main shaft, try the following to find the clearance in the main bearings.

		Let the rotor rotate slowly, stop the turbine and look for movements between the main shaft and the bearing housing covers. Try to mount a dial meter on the bearing housing covers with the sensor on the main shaft and do the same test as mentioned above. If the play exceeds 0.3 mm, contact Vestas' R&D department. Report the results of the test to Vestas.
7.6	**Lubrication of Main Bearings**	Dismount the lower 1/4" plug of the bearing cover. Let the rotor rotate slowly to distribute the grease. Lubricate until 1200 g is used or fresh grease is being pressed out through the hole in the cover. Stop lubricating and increase the rotation to approx. 2/3 of nominal rpm and keep it there until almost no more grease is pressed through the hole. Mount the cap to the grease nipple and the 1/4" plug.
	Lubricant:	See lubrication chart.
7.7	**Rotor Locking Pins**	Check the rotor locking pins for damage. Lubricate the pins through the grease nipple at the end of the pin. The pins must be fully drawn back before lubrication.
	Lubricant:	See lubrication chart.

8. Torque Arm System

8.1	***Bolts connecting Torque Arm and Nacelle Bed Plate***	*Check 3 bolt connections between each torque arm and nacelle bed plate at both sides. Torque wrench setting: See Work Instruction 920098 or inspection record form.*
8.2	**Bolts connecting Torque Arm and Nacelle Bed Plate**	Check 1 bolt connection between each torque arm and nacelle bed plate. Torque wrench setting: See Work Instruction 920098 or inspection record form.
8.3	***Bolts connecting Torque Arm and Gear Connection***	Check 3 of 15 bolts in torque arm – gear connection. Torque wrench setting: See Work Instruction 920098 or inspection record form.
8.4	**Bolts connecting Torque Arm and Gear**	Check 3 of 15 bolts in torque arm – gear connection. Torque wrench setting: See Work Instruction 920098 or inspection record form.
8.5	**Check Play**	Check if there is play in the rubber spring package. If so adjust the package as described in the Mechanical O & M Manual (947450), chapter 947457 Torque Arm System.

9. Gearbox

9.1 Check of Oil Level

Check the oil level in the gearbox when it has been at rest for at least **ten minutes**. On gearboxes with oil dipstick this determines the oil level. Otherwise the level is indicated on the sightglass.

In case of L+S gear pull out the oil dipstick and wipe it off. Screw it back in and pull it out to make the correct reading.

Variation in oil level

Notice that the oil level varies with the oil temperature and the amount of air bubbles in the oil. On a warm gearbox, the oil level should be close to the upper indication.

9.2 Check for Leakages

Check joints, seals and covers for leakage.

9.3 Extraction of Oil Sample

Stop the turbine and extract an oil sample in a special sample bottle. Fill in the bottle label and attach it to the bottle.

Oil samples must be extracted at every 3, 6 and 12 months' check. See Work Instruction 959406 Extraction of Oil Samples on Gearboxes.

9.4 Lubrication, Oil Change

Change gear oil according to the oil sample analyses. Any oil change will appear from the service report.

Drain off the oil

Switch off the gear oil heater by selecting "O Off".in Picture 11.26. Drain off the oil through the drain valve located in the bottom of the helical gearbox and through the bolt hole/drain tap in the bottom of the ring gear flange (L+S fear).

Check for residual oil. Oil in "pockets" must be removed by sucking or wiping up.

Cleaning of gearbox

Remove the top cover and check visually for contamination. If necessary, wash and clean the gearbox inside with "Dry cleaner". If any contamination is detected during the draining of the ring gear flange, flush the planetary gear with "Dry cleaner" via the inspection cover on the large front cover until no more contaminants can be detected. Due to the tilt of the helical gear a certain amount of residual oil will be left. Drain off the residual oil from the drain tap. Do not leave more than 1 litre of "cleaner" in the gearbox after cleaning.

Note: If contaminants are found in the gear, contact Vestas.

9.5 Inspection of Gearbox

Check the gearbox inside; look for metal chips in the oil and on the inside surfaces. Look for sludge, damages on the tooth flanks and coloured areas indicating high temperatures. Check for play where possible.

If it is considered necessary to let the gearwheels rotate to inspect them, make sure that the pitch system and the braking system work correctly. Take care when working between the gearwheels. If possible, yaw the turbine to backwind.

	Report any damage in the gearbox to Vestas. Item no 923453 can be used for inspection of the gearbox.
Oil filling	Close the drain valve. Mount new air breather filter. Top up with oil until the stated level. Type of oil and approx. amount are stated on the sign on the gearbox. If oil type is changed without cleaning, maximum 1 % of the "old" oil must be left in the gearbox and only if the new type is compatible with the former. If the oils are incompatible, the gearbox must be washed with "Dry-cleaner" or with the new oil type. The new oil type must appear from the sign at the side of the gearbox and must be approved by Vestas prior to filling. Check the seal at the top cover for damage and remount the cover. Switch on the gear oil heater by selecting "Auto" in Picture 11.26.
Running condition	Listen for abnormal noise or vibrations from the gearbox.

10. Brake

10.1	**Check of Brake Lining**	Measure the thickness of the lining. Minimum lining thickness = 3 mm, 1/8".
10.2	**Check of Brake Calibres**	Check for leakage. Check for worn rubber sleeves. In case of leakages or worn rubber sleeves, change the calibre. Check that the pistons are easily moved.
10.3	**Check of Brake Disc**	Check for axial runout. Maximum deflection = 0.2 mm, 0.008". Check for cracks in the brake disc surface. Check for damage in the brake disc surface. Check for deep grooves in the brake disc surface. Check for severe corrosion in the brake disc surface. Check that the brake disc is not loose. Check that the nacelle is not vibrating when the brake is activated. Check the brake disc for wear. Minimum thickness = 20 mm.
10.4	**Bleeding of Brake System**	Mount the rotor locking system. Press <EMERGENCY STOP> or apply the brake by way of picture 11.7. Dismount the cover over the brake disc and the protection caps on the bleeder screws. Connect a hose with one of the bleeder screws on the upper calibre. Put the other end of the hose into a bottle. Open the bleeder screw carefully and bleed oil/air until pure oil comes out. Do not pour the oil back on the system after the bleeding operation. Tighten the bleeder screw again and mount the protection cap.

Repeat the procedure for the other bleeder screw on the upper calibre.

11. Composite Coupling

11.1 Connecting Tube Check the connecting tube for cracks around the milled contour of the flanges and at the welding between flange and tube. If any cracks are found the turbine must be stopped and Vestas must be informed.

11.2 Composite Discs Check for cracks around the steel bushings. Serious "resin cracks" around which the fibreglass is lighter than usual are unacceptable. Check for cracks in the outer edge around the steel bushings. See work instruction 945578.

11.3 Bolts *Check the tightening of the M10 bolts.*
Torque wrench setting: see item no. 943648 or inspection record form.

11.4 Bolts Check the tightening of the M10 bolts.
Torque wrench setting: see item no. 943648 or inspection record form.

12. Gear Oil System

After each service on the gear oil system, spills and drops under fittings and valves must be wiped off in order to ease the location of leakages at the next service.

12.1 Gear Oil Filter Change gear oil filter every 6 months or:

- at oil change
- when the turbine controller reports too high pressure (exceeding 2.2 bar) at the filter.

An electronic indicator S425, which brings a signal to the controller, surveys the filter. The signal is considered only when the gear oil temperature is above 35°. When both conditions are fulfilled, the controller will return a "Run Error" (Oil Filter Failure).

When changing the filter element the oil from the filter must not be poured back into the gearbox. Always check the oil level after changing the gear oil filter, as approx. 3 l of oil is removed with the filter.

12.2 Check of Flow / Pressure Monitoring Connect a digital pressure gauge to the test nipple Pos. 12
Let the gearbox rotate at a higher rotation speed until "Flow S412" in Picture 14G changes "+". This condition should occur before 1200 rpm, as the surveillance goes active at that stage during normal operation.
Slowly reduce the gearbox rpm until "Flow S412" changes to "-".
Check that "Flow S412" changes to "-" within the range 0.4 - 0.6

		bar. If necessary, adjust the pressure switch by using a 5mm Allen key after dismounting the cover.
12.3	**Check for Leakage**	Check all fittings, components on the manifold block and the pumps for leakage.
12.4	**Check for Contamination of Oil Cooler**	Check if the cooling ribs of the gear oil coolers are clogging up because of dirt outside. If so, they must be cleaned. This can be done by means of a vacuum cleaner. If necessary, turn the fan direction of the motor at the same time. Take care not to damage the cooling ribs.
12.5	**Filter, gear airing**	Replace filter and clean filter housing
12.6	**Check off-line filter**	Check that the filter motor starts at 40° C gear oil temperature. Test the pump manually, if the gear oil temperature is below 40°. The pump is started in menu 11.36. Check pump and components for leakages. Check that pressure arises in the green area of the pressure gauge.
12.7	**Change of filter in off-line filter unit**	Change the filter every 12 months. It is important that the filter container is completely emptied and remaining oil is sucked or wiped up. Use the packing from the new filter for the replaced filter. Remember to bleed the filter housing by means of the blanking plug on top of the filter housing.

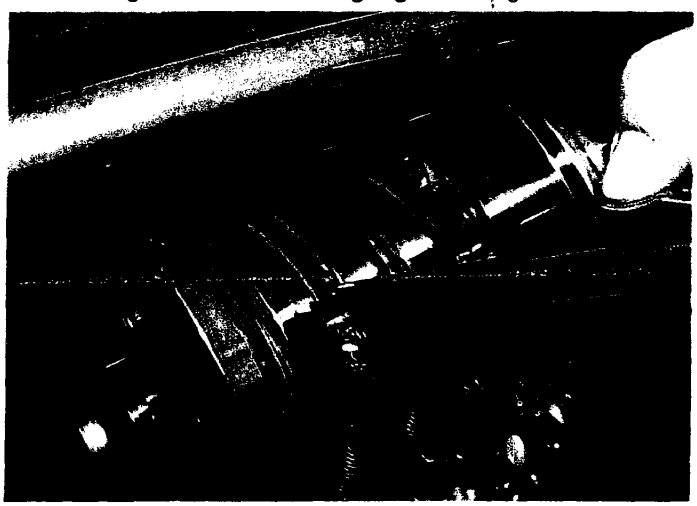
13. Generator

13.1	**Cables in Generator Terminal Box**	Disconnect the generator circuit breaker (Q8) in the board arrangement. Lock the circuit breaker in position "off" with a padlock and take the key with you. Check that the cable connections are properly tightened in the generator terminal box and that they are undamaged. Torque wrench settings: see the inspection record form.
13.2	**Check of Bearings**	Start the turbine to listen for abnormal noise in the bearings. If noise is detected, check if it disappears when bearings are lubricated.
13.3	**Lubrication: Front Bearing**	Lubricate the front/rear generator bearing. Let the generator rotate slowly while lubricating. (300 rpm) Lubricant: See lubrication chart. Note: If automatic lubricator is mounted, check that it is adjusted correctly in accordance with Work Instruction 959400. Do not lubricate manually if lubricator is mounted.
13.4	**Check of Lubricator Tightness**	Check fittings and hoses for grease leakages.

13.5 Rotating Contacts

Disconnect the generator circuit breaker (Q8 and Q7) in the board arrangement. Lock the circuit breaker in the switched-off position with a padlock and take the key with you.
This switches off the power to the generator, but wait for another 5 minutes before removing the side covers. Check with a voltmeter that the unit is unpowered, and check that the heater and the fan are switched off. Remove dust on the contact unit and in the housing with a brush and a vacuum cleaner. Graphite dust can be removed from insulation and cables with a cloth moistened with white spirit.

Check the brush height with a slide gauge and note it in the inspection record form. It is important to measure radially to the contact ring and that the slide gauge rests against the brush arm.



The brush height from upper corner of brush arm to the contact ring is measured at the upper one of the phase and ground brushes. The brush closest to the generator is named "1", right side is indexed "SB" and left side is indexed "P".

Compare with the inspection record from the previous inspection (see inspection record form) and estimate if brush replacement is necessary, as the brush wear is considered proportional to the number of operating hours. If the height is less than 20mm, replace the brush.

Check the surface of the contact rings.

13.6 Inlet Filter, Fan for Rotating Contacts

Dismount the filter (when the generator is stopped) for check and visual inspection. If the filter surface seems covered with dust and dirt, replace or wash it. See cleansing instruction for filter.

13.7 Outlet Filter, Rotating Contacts

Dismount the filter (when the generator is stopped) through the opening at the side of the filter housing. Clean it with a brush and a vacuum cleaner. Also remove dust or dirt in the flexible hose between the contact housing and the filter. Remount the filter and close the cover.

13.8 Check Fan for Slip Ring

Check that fan M542 starts in picture 11.35 "slip rin cooler and heater". Remember to reset the fan to AUTO.

14. Water Cooling

14.1 Cooler

Switch off Q8 and Q7 and wait minimum 5 minutes before opening the control cabinets. Check seals and gaskets.

Check hoses for marks and cracks.

14.2 Pumps and Valves

Check that all cables are dry.

Check that all ball valves are open.

14.3 Pipes and Hoses

Check hoses from VCS section to pump. Check seals.

Check hoses from pump to cooler. Check seals.

14.4 Expansion Tank

Check hoses to and from the expansion tank.

Check that there is cooling liquid (18 litres) 1 cm below max. indicator on the expansion tank.

15. Hydraulics

15.1 Check of Oil Level

With all the accumulators blown off and with the turbine in EMERGENCY STOP or PAUSE, the oil must always be visible above the minimum indication of the sight glass. If necessary, top up with oil:
Oil type: See lubrication chart.

15.2 Change of oil

With the turbine in EMERGENCY STOP blow the accumulators by opening needle valves 27 and 34 on the hydraulic unit and needle valve 85 on each pitch cylinder manifold block.
Connect a hose to the ¾" drain valve and drain the oil.

Replace the filters on the hydraulic unit and on the manifold block in the hub. Empty the filter bowl for oil.
Screw off the air filter cap and remove the air breather filter element.
Top up with fresh oil through the air filter hole.
Mount a new air breather filter (109113).

Start the pump and let it run for 15 seconds with both needle valves open. Close the needle valves 27 and 34 on the hydraulic unit and let the pump run for 1 minute further. Close needle valve 85 on all three pitch cylinder manifold blocks and pitch three double strokes with each pitch cylinder in order to let out the air of the system.
Check the oil level and top up if necessary.
Oil type: See lubrication chart.

15.3 Change of Pressure Line Filter on Power Unit

Change the pressure line filter element every 6 months and in case of oil change.

15.4 Contamination of the Pressure Line Filter on Power Unit

Open needle valve 27 fully. Switch the pump ON and measure the pressure between test nipples 19.2 and 19.3.
Replace the filter every six months.

Do not pour back the oil on the system.

Switch the pump into AUTO.

15.5 Leakage in the Nacelle

Check if there is any leakage from the hydraulic system in the nacelle. If there are visible drops of oil, try tightening the connections. If a leakage of more than a few drops from the rotating union can be spotted, replace it.

15.6 Leakage in the Main Shaft

Dismount the cover of the rotating union. Stop the turbine. The ¼" plug in the adapter for the rotating union must be pointing downwards. Dismount the plug and drain leak oil, if any.
Find out whether the oil is gear oil or hydraulic oil.
In case of an oil leakage of more than a few drops, dismount the rotating union and the adapter in order to locate the leakage and repair the damage. Retighten the fittings.

15.7 Pressure Digital Pressure Gauge / Service Panel

Set the hydraulic pump in AUTO. After 30 seconds press <EMERGENCY STOP>.
Compare the pressure displayed on the digital pressure gauge connected to test nipple 19.3 with the pressure displayed on the service panel.
Maximum deviation is 5 bar.
List two values observed simultaneously.

15.8 Check of Pump

Start the hydraulic pump (AUTO) and open needle valve 34 a little.
Check in the controller display that the pump starts correctly at a pressure of 180 bar and stops at 200 bar.
Close needle valve 34.

15.9 Check of Pressure Relief Valve

Switch the pump ON.
Check that the pressure rises and stabilises at 250 bar +0/-2.5 bar.
If the pressure does not stabilise within this range, adjust the pressure relief valve pos. 25

15.10 Pre-charge Pressure in Pitch Accumulator on Hydraulic Power Unit

Press <EMERGENCY STOP> and slowly relieve the pressure from the pitch accumulator by opening needle valve 27.
Connect the nitrogen filling device to pitch accumulator 26 and check the pre-charge pressure min. 5 minutes after the pressure relief.
The pre-charge pressure must be 143 bar +0/-5 bar, at a temperature of 20°C.

The temperature of the accumulator is estimated by reading the nacelle temperature and the temperature of the hydraulic oil in the control panel. At other temperatures, see AI 941918.
List the observed value before and after any filling up.

15.11 Pressure in Brake System

Connect the digital pressure gauge to test nipple 19.5.
Check the pressure in the brake system min. 5 minutes after the turbine is set in PAUSE. Correct pressure is 18.5±1 bar.
List the observed value.

15.12 Pre-charge Pressure in Brake Accumulator

Press <EMERGENCY STOP> and slowly relieve the pressure from the brake accumulator by opening needle valves 27 and 34.
Connect the nitrogen filling device to brake accumulator 36 (the small accumulator on the hydraulic unit) and check the pre-charge pressure min. 5 minutes after the pressure relief.
The pre-charge pressure must be 11±1 bar at a temperature of 20°C. At other temperatures, see Work Instruction 941918.
List the observed value before and after any refilling.

15.13 Brake Pressure Switch

Bring the turbine in PAUSE mode. Set the pump to OFF in menu 11.4.
Connect a digital pressure gauge to pos. 19.6.
Set the brake Y211 ON in menu 13 "Digital Output". Y211 changes to "+". Check in menu 12 that S208 is in position "-".

The needle valve 34 opens slowly, the pressure drops and at 10 ±2 bar S208 goes from "–" to "+".

In menu 13 return "Digital Output" Y211 to "-". Set the pump back to AUTO in menu 11.4.

Reset EMERGENCY STOP and press <PAUSE>.

List the observed value.

Dismount the digital pressure gauge and close the needle valves fully.

15.14 Leakage in Hub

Lock the rotor in service position, i.e. with blade "A" pointing vertically downwards. Press <EMERGENCY STOP> and open needle valve 27. In case of leak oil retighten the connections and wipe up the oil.

15.15 Leak Oil Tank

Dismount the drain plug and drain the tank of oil. If more than a few drops of oil are left in the tank, check if the leak comes from a damaged bursting disc cartridge (140 bar) in the distributor manifold block. Otherwise it comes from one of the pitch cylinders, refer to point 6.9.

15.16 Pre-charge Pressure in Pitch Accumulator

Connect the nitrogen filling device to pitch accumulator 74 (located next to the leak oil tank) and check the pre-charge pressure min 5 minutes after releasing the oil pressure.
The pre-charge pressure must be 143 bar +0 / -5 bar at a temperature of 20°C.

15.17 Pre-charge Pressure in Emergency Pitch Accumulators

Mount test hose on pos. 19.4 on the hydraulic power unit for the air filter/waste tray or on pos. 72.2 in the hub to drain off the remaining 5 bar in the return line.
Open needle valve 85 on each pitch cylinder manifold block to drain the three emergency pitch accumulators Pos. 87.
Check the pre-charge pressure in each emergency pitch accumulator min. 5 minutes after draining the accumulator.
The pre-charge pressure must be 73 bar +0/-5 bar, at a temperature of 20°C. At other temperatures, see Work Instruction 941918.
List the observed value (digital pressure gauge).

15.18 Pre-charge Pressure in Bursting Disc Accumulator

Drain pos. 73. Check the pre-charge pressure, pos. 79, by means of a nitrogen-filling device.

The pre-charge pressure must be 10 bar +/-1 at 20°C.

15.19 Pre-charge Pressure in Return Line Damping Accumulators

NOTE: During check of all six 0.075 l accumulators and all other work on emergency pitch valves and the proportional valve, the pressure must be fully relieved. This is done by opening needle valves 27 and 34 on the hydraulic power unit and needle valve 85 on each pitch block.

Check the pre-charge pressure by means of nitrogen filling device in damping accumulator Pos. 93. The pre-charge pressure must be 20 bar ±1 bar at 20°C. In damping accumulator Pos. 94 the pressure must be 30bar ±1 bar at 20°C. At other temperatures refer to Work Instruction 941918.

15.20 Change of Pressure Line Filters in Hub

See lubrication chart.

15.21 Contamination of the High Pressure Filter

Reset <EMERGENCY STOP> and press <PAUSE>. Switch the pump ON and measure the pressure between 72.1 and 72.3 on the distributor manifold block in the blade hub.
Change the filter if the pressure difference exceeds the below-mentioned values.

Hydraulic oil temperature	Difference in pressure
20°C	3.0 bar
25°C	2.5 bar
30°C	2.0 bar
35°C	1.7 bar
40°C	1.3 bar
45°C	1.1 bar
50°C	0.8 bar
55°C	0.7 bar
60°C	0.5 bar

Check the pressure difference at one of the temperatures only

15.22 Emergency Pitch Pressure Switches

Bring the turbine in PAUSE mode. Set the pump OFF in menu 11.4. Check in menu 12 that S209 shows "+". Connect the digital pressure gauge to test nipple 86.1 on the pitch cylinder valve block A. Open the needle valve 85 on blade A slowly, and the pressure will drop. Check that S209 changes from "+" to "–" at 170± 2 bar.

If the pressure switch pos. 91 does not change at the correct pressure, adjust the Allen screw at the end of the pressure switch. The screw is located under a protection cap.

Close needle valve 85 and set the pump ON in menu 11.4. Reset the error in menu 1, and the turbine is back in PAUSE-mode.

Move the digital pressure gauge to 86.1 on pitch cylinder manifold blocks B and C and repeat the measurement for each of these.

Set the pump to AUTO mode in menu 11.4.

15.23 Extract Oil Sample

Extract an oil sample into a sample bottle every 12 months.

Label the sample bottle with turbine number, date and hours of operation.

Open needle valve 27. Connect the test hose to test nipple 19.2 in front of the filter. Unscrew the air breather filter, start the pump and flush the hose through the air breather filter by slowly closing the needle valve. After flushing a couple of litres through the hose, fill the sample bottle.

Remount the components and set the hydraulic power station back in normal operation.

The service department handles the analysis of the oil sample.

16. Yaw Gear Drives

16.1 Check of Bolts

Check every 3rd of the 12 M16 bolts on the yaw gear drive. Torque wrench settings: See Work Instruction 920098 or inspection record form.

16.2 Check of Bolts

Check every 3rd of the 12 M16 bolts on the yaw gear drive. Torque wrench settings: See Work Instruction 920098 or inspection record form.

16.3 Check of Bearings, Leakage

Check bearing play on the output shaft.
While the turbine is yawing, listen for bearing noise or vibrations in the bearing housing.
If you suspect wear on the output shaft bearings, check it with a dial meter.
Report the results to Vestas.

Also check that the gear is attached to the foundation.

16.4 Leakage

Check the lower lip seals for leakage.

16.5 Lubrication Worm Gear

Change oil on the worm gear (every 8 years).
The worm gear has oil drain through the side and oil filling on top.

Lubricant:

See lubrication chart

16.6 Lubrication, Planetary Gear

Change oil on planetary gear (every 8 years). Planetary gear oil drain is on the side and refill at the top. The output bearing is lubricated for life (maintenance free).

Lubricant:

See lubrication chart

17. Yaw Bearing System

17.1 Check of Bolts connecting Yaw Top and Tower

Check every 3rd of the 90 bolts connecting yaw top and tower. Torque wrench setting: See Work Instruction 920098 or inspection record form.

17.2	**Check of Bolts connecting Yaw Top and Tower**	Check every 10th of the 90 bolts connecting yaw top and tower. Torque wrench setting: See Work Instruction 920098 or inspection record form.
17.3	**End Stop for Radial Slide Blocks**	Check the M16 bolts for end-stop for radial slide plates (brass block). Torque wrench setting: See Work Instruction 920098 or inspection record form.
17.4	**End Stop for Axial Slide Plates**	Check the bolts (M16 x 1.5, ISO 8765 - 10.9, Delta) for end-stop for big slide plates. Torque wrench setting: See Work Instruction 920098 or inspection record form.
17.5	***Claw Beams***	Check 1 of 5 M33 bolts in each of the 9 claw beams. Torque wrench setting: See Work Instruction 920098 or inspection record form.
17.6	**Claw Beams**	Check 1 of 5 M33 bolts in each of the 9 claw beams. Torque wrench setting: See Work Instruction 920098 or inspection record form.
	Lubrication:	See lubrication chart
17.7	**Sliding Plates**	Lubricate via the 2 tubes in the sliding plates. Do not lubricate too much.
	Lubricant:	See lubrication chart.
17.8	**Sliding Surface on Yaw Top**	Lubricate the sliding surface of the yaw top with a very thin layer of grease. Remove the surplus grease.
	Lubricant:	See lubrication chart.
17.9	**Yaw Teeth**	Lubricate the yaw teeth by use of a brush.
	Lubricant:	See lubrication chart.

18. Ultrasonic Wind Sensor

18.1	**Attachment of Ultrasonic Wind Sensor**	Check that the ultrasonic wind sensor is tightened properly to the socket.
18.2	**Check Direction**	Judge whether the turbine is yawed precisely into the wind. If not, the cause could be a loose holder (see next checkpoint)
18.3	**Holder for Ultrasonic Wind Sensor**	Check if it is possible to turn the holder out of position by hand. If it is, the mounting procedure must be repeated (refer to erection manual). If not, re-tighten the 2 x 4 screws with a 4 mm Allen key.

19. Nacelle Cover

19.1	**Bolts, Fittings, Fibre Glass**	Check visually that all bolts are tightened. Check all fittings to the machine cover for cracks. Check the fibreglass for cracks around the fittings.
19.2	**Sound Insulation**	Check that the sound insulation is properly mounted and undamaged.
19.3	**Roof Rails, Outer**	Check the outer roof rails. Check all the bolt connections for the outer roof rail. Check the rails for cracks. Check the fibreglass very carefully for cracks at all points of attachment.
19.4	**Gutter**	**Only on turbines with lightning current transfer units** Check the inside of the gutter for excessive wear and scraping marks.

20. Fire Extinguisher (if present)

20.1	**Check Fire Extinguisher**	Check the date for inspection of the fire extinguisher. Check the fire extinguisher visually including the pressure gauge (power extinguisher) and pressure relief valve (CO_2 extinguisher). Make a note of the date for next check (if the time limit is exceeded, note it in the service report). Leave the fire extinguisher in the turbine.

21. Tubular Tower

21.1	***Bottom Flange – Foundation Section***	*Check the tightening torque of 6 bolts between bottom flange and section flange.* *Torque wrench setting: See item no. 943648 or inspection record form.*
21.2	**Bottom Flange – Foundation Section**	Check the tightening torque of 6 bolts between bottom flange and section flange. Torque wrench setting: See item no. 943648 or inspection record form.
21.3	***Connection between Sections***	*Check the tightening torque of 6 bolts in each of the section flanges.* *Torque wrench setting: See item no. 943648 or inspection record form.*
21.4	**Connection between Sections**	Check the tightening torque of 6 bolts in each of the section flanges. Torque wrench setting: See item no. 943648 or inspection record form.

21.5 Welding at Door Frame	Visually check the welding at the door frame for cracks, outside and inside.
21.6 Ladders and Landings	Spot check if there are any loose bolts on ladders and landings.
21.7 Oscillation Absorber	Check that the pendulum moves easily. Check that the oil level in the absorber reservoir is min. 200 mm above the bottom. Check chains, shackles, fittings etc. Check that the chains are fixed in the centre of the suspension. Check that the chain coverings and collars are intact – no oil leakage.

22. Service Platform

22.1 Service Platform	Check the service platform according to the Power Climber user manual. Check the hoisting gear. Check the wire system. Check the lift. Check the electrical unit.

23. Surface Treatment

23.1 Turbine Surface Protection	Check all the turbine surface protection.

24. Crane

	The numbers after the titles of the check points (e.g. 8.2.4) and the numbers in the text (e.g. (12)) refer to the manual.
24.1 Check of Brake Function, 8.2.4	Check the brake function of the crane **prior to** using it. This can be done by hoisting a load of about 100 kg to a height of 2 metres and then lowering it. Apply the brake during the lowering process. Braking must be fast and without abnormal noise. At nominal load (800 kg.), the chain must stop after the length of two chain links. If it does not, adjust the brake.
24.2 Adjustment of Brake, 8.2.1/8.2.2	Press a 0.5 mm feeler gauge in between the magnet (1) and the retaining plate (2). Loosen the 3 stop screws (5) by turning them right so that the magnet is loosened. Check the brake lining. It must be replaced at a thickness of less

		than 2.5 mm. Adjust the 3 screws (4) until the gap between the magnet (1) and the retaining plate (2) is 0.5 mm. Tighten the screws in reverse order.
	Malfunction	Can occur after some time of standstill. Loosen the brake lining and adjust the brake.
24.3	**Check Sliding Clutch with Nominal Load, 8.3.1/8.3.2**	If the clutch is sliding at nominal load, loosen the lock nut (16). Tighten the compression spring (15) with the nut (14) to the point where the test load is raised. When the setting is in order, tighten the lock nut (16).
24.4	**Check for Chain Wear, 8.4.2/8.4.3**	Check at least 20 of the chain links, uniformly distributed, for wear (especially at their point of contact) and elongation, cracks and deformation. Replace the chain if: 1 The point of contact is reduced by 10% 2 The chain or links are elongated by more than 5% 3 The links are rigid.
24.5	**Suspension Hook, Crane Block and Load Hook**	Check the crane suspension (delivered by Vestas) for missing or loose bolts or lock nuts. Check the crane block in its suspension for deformations and loose bolts.
24.6	**Check of Cables**	Check the electrical cables for flaws and damages.
24.7	**General Checks**	Check all connections, bumpers, chain guide and chain rollers. Check for oil leakage. Check the chain bag and its suspension.
24.8	**Lubrication of Load Chain. 8.4.1**	Lubricate the chain with a penetrating gear oil. Oil type: Texaco White Oil Pharmaceutical.
24.9	**Crane Runway**	Check the columns for damages.
24.10	**Crane Traverse**	Check the components for damages.

25. Visual Inspection of Electric Cables

	Warning!	**The black rubber cables carry HIGH VOLTAGE.**
25.1	**Examine Cables**	Examine all the cables for damages and wear. If cables are seriously damaged, replace them. Try to prevent beginning wear from deteriorating the cables either by removing the cause of the wear or by rearranging the cables. Pay special attention to the signal cables in the cable loop and where the cables are passing landings. If there is grease or oil on the cables, remove it.
25.2	**Cable Strips**	Replace any missing cable strips. Cable strips have to be placed for every 0.3 m. Pay special attention to the cable strips in the cable loop where they are very important and placed very closely.

25.3 Grounding System Cables

Check that connections are properly tightened and that they are undamaged. Pay special attention where the cables are connected to the tower at the ground.

Disconnection from Main Grid

If it is necessary to disconnect the turbine from the main grid, the electric utility must be advised first.

26. Final Visual Check

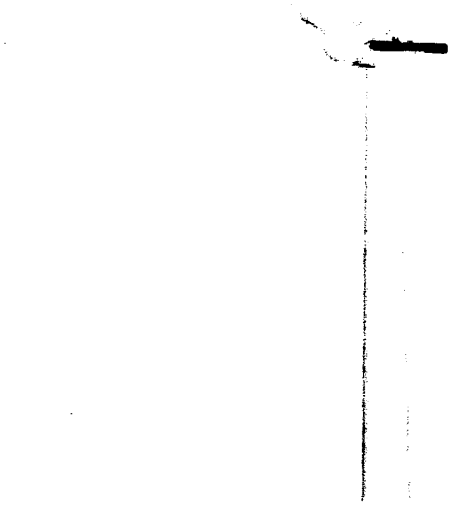
26.1 Overall Condition of the Turbine

When inspecting the nacelle always look very carefully for oil waste and loose bolts. At the covers and shaft lead-ins the gearbox can "sweat" a little. This, along with brake dust, can soil the gearbox. Clean the dirt, as otherwise it can be difficult to determine if there is a significant leak.

A significant leak is when oil drops are running down the gearbox. Such a leak means oil waste to such an extent that repair is necessary.

Loose bolts in the structure mean danger. They must be tightened immediately. See "General Rules at Service Check" on page 3.

附件二



Check, Electrical part

V66 – 1.75/2.00 MW
V80 –2.00 MW

OptiSpeed^{TM} – wind turbine

ITEM no. 944816.R2

(6c)

History of this document

Changes in this revision:

Item no.:	Date:	Description of change:
944816.R2	March 9, 2001	1.1 Security conditions – IRS no. 944808 changed to 944819 Compass stroken off the tool list 2.8 "Lock the rotor" added. 2.9 Test of emergency stop pitch system deleted – the test is performed during start-up. New point 2.9 Test of PTS5 revised. 3.11 Flow control valves added 4.1 The brake is also applied with <*>. 5.2 "Reset counters" deleted.

V66-1.75/2.00 MW OptiSpeed™
V80-2.00 MW OptiSpeed™
Check, Electrical part

Contents ..... **Page**

1. Preconditions

Personnel.

For security reasons at least two persons have to be present during the following procedure.

The work must be performed properly in accordance with "Health and Safety". This implies among other things, that personnel must be instructed and familiar with relevant parts of the Security Manual

Furthermore, personnel must be familiar with the part concerning "Substances and Materials"
Attention is especially drawn to situations where measurements and work are done in assemblies and connection boxes that can be connected to power.

1.1 Security conditions.

For security reasons please note the location of the following emergency stop buttons:

Turbine:

- S933: Main Shaft
- S934: Yaw plate
- S935: Com Controller (bottom of tower)
- S936: Nacelle Controller

When opening (activating) an emergency stop button the controller turns into "EMERGENCY STOP" that means no power to contactor solenoids and blades are full feathered and the brake is applied.

- S952: "Trip F60". Red button on Nacelle Controller

When this button is activated, high voltage (F60) is disconnected; then you have no power at all in the turbine.

Note: S952 is only available when power is connected to the controller unit. (By the circuit breakers Q15, Q16 and F35).

Elevator (Optional):

If an elevator is installed a several number of emergency stop buttons will probably be mounted. Bottom, top, cabin, roof, etc.

Note: These buttons serve only the elevator. Otherwise emergency stop buttons for the turbine do not protect the elevator.

Crane:

The crane is also equipped with an emergency stop button. This only serves the crane and otherwise the emergency stop buttons in the turbine do not protect the crane.

Tools

The following tools are necessary to carry out the check:

- Inspection Record Scheme. No. 944819
- Electrical manual, Item no. 944894.
- Transportable PC with "optical serial adapter", CT236 and relevant software.
- Service terminal CT232.
- Digital manometer, 250 bar.
- Multimeter.
- Current clamp. At least 10A.
- Tongs for retaining ring.
- Socket tool, 46 mm
- Open ended insert tool, 46 mm for torque winch, 400 Nm
- Tool no. VT730358 for adjustment of BTL5
- If available, tool no. 189553 and 190877 for adjustment of Ultrasonic wind sensor.

2. Security components

2.1 Wind speed.

Note the wind speed and check if it seems to be reasonable.

For safety reasons, it has to be below 15 m/s during the following part of the check.

2.2 Ambient temperature.

Select picture 6 a"TEMPERATURES"

Note ambient temperature and gear oil temperature. Check if they are reasonable.

2.3 Wind direction

Select picture 1C.

Check that the turbine is yawed into the wind.

2.4 Test of emergency stop buttons.

Select picture 12: "DIGITAL INPUT".

With <↑> and <↓> it is possible to look through the input signals.

S903 "Emc" is expected to be "+". If not, an emergency stop button might be opened (activated); then close it.

For all four emergency stop buttons do as follows:

Press the button and check that S903 "Emc" changes to "-".

Close the button, acknowledge the error by <*> in picture 1 and check that S903 "Emc" changes to "+".

2.5 Test of brake

Check if the brake is applied when an emergency stop button is activated.

Picture 12: "DIGITAL INPUT", S208 is expected to be "-".

Check that the brake is not released when deactivating the emergency stop button. First by acknowledging the error in picture 1.

2.6 Test of battery back-up

Switch off the power to controller (Q16). Check that the brake is not applied before 60-120 sec.

Switch the circuit breaker on again and bring the turbine in PAUSE-mode.

2.7 Test of vibration sensor.

Select picture 12: "DIGITAL INPUT"

Observe S403 "Vibr". Expectedly it is "+".

Touch the sensor (placed beneath the gear to the left in the yawing plate) and check that the signal changes to "-".

When the sensor returns to its resting position, the signal will change back to "+".

2.8 Test of pressure switches.

The work in the hub is easier, if blade A is pointing downwards.

Select test 11.4: "Enter PAUSE mode and check the hydraulic pressure."

Press <0> to set off the hydraulic pump.

Blow off the nitrogen-accumulator on the hydraulic power unit and in the hub (pos. no. 26 and 74) by opening needle valve no. 27 on the hydraulic power unit.

Lock the rotor. Enter the nose cone with a multimeter.

For each pitch system do as follows:

Measure voltage (DC) on terminals to the pressure relatively to ground, terminal 71.

Blade A: A2.X1, 44-71 and 94-71

Blade B: A2.X1, 45-71 and 95-71

Blade C: A2.X1, 46-71 and 96-71

The voltage is rectified but not smoothed out, so depending on the measuring method of your instrument you will measure something between 1 and 27 V.

Blow off each pitchacc. (pos. no. 87) by opening needle valve pos. no. 85.

Measure terminals once again and check that 94-71, 95-71 and 96-71 are dropped to 0V.

2.9 Test of PTS5

In the ground and top assembly is tested if the heating elements are turned on by the PTS5.

This is done by cooling spraying sensor R965 for ground controller and R964 for top controller.

In the hub the thermostat B347 is turned above ambient temperature.

Remember to adjust the thermostat back to its original position after the test.

2.10 Test of heating wind sensors

The heating element of the ultrasonic wind sensor is controlled by the virtual temperature measurement performed by the sensor itself.

Disturb this measurement by putting your hand in between the sensor branches; then the heating element is turned on.

Check then if every branch is heated.

2.11 Test of Trip Q8

Select picture 13 "DIGITAL OUTPUT"

Press <FUNC>, so the cursor is active on "TripGBr".

Press <1><ENTER>. Q8, Q15 and Q16 are expected to trip.

The VMP-controller is then turned off. Connect the breakers again and start up the controller.

3. Pitch system

3.1 Yaw into the wind.

The following tests must not be performed in wind speeds above 15 m/s.

To prepare the pitch test, yaw the turbine into the wind.

Leave the service mode and the turbine will automatically yaw into the wind.

3.2 Preparation of test.

The turbine is expected to be yawed into the wind.

To test and eventually adjust the entire pitch system, each system must be tested separately.

Blades that are **not** under test have to be fully feathered.

Furthermore, the test has to be done with the blade under test pointing downwards along the tower.

In weak winds it could be necessary to pitch the blades a little to turn the rotor (use test 11.7).

In weak winds the brake could probably hold the rotor. Above 6 m/s you have to use the rotor locking system.

Note: If you enter the hub for adjustment, the rotor locking system must be locked.

To release and apply the brake ***select test 11.7:"Manual pitch and brake".***

With the <*> toggle the brake and check in display as well as virtually that it is released.

3.3 Choose pitch system.

The choice of system can be done in all test pictures 11.7 to 11.13 by pressing <#>. That gives you another picture, in which you select system by pressing:

<0>: All, <1>: system A, <2>: system B, <3>: system C.

The following tests (picture 11.9 to 11.14) are now done for each system one by one.

When test 11.13 is reached, select picture 11.7 again to remove the locking system. Release the brake and let the rotor turn until the next blade points downwards.

When you have finished the tests for all three systems, select "All" and repeat test 11.13 to have an overall qualitative check of the whole pitch system.

3.4 Negative pitch

Select test 11.8: "Position transmitter voltage test".

end-stop

Press <1> "- end stop" and <2> "0°" a couple of times to check that the blades are able to pitch in both directions.
Press <1> "- end stop" and note the "Act pitch position" in the panel.
It has to be 0.040V [accepted interval: 0.020V to 0.060V].

If this value is out of range, you have to adjust the position sensor.

BTL2: The potentiometer marked with "0" in the end is adjusted.

BTL5: Adjustment is done with the tool no. VT730358 mounted on the end of the transducer.

1. Unlock for adjustment by pressing button 1 (blue) for at least 3 sec.
2. Press button 2 (grey) but **do not release button 1** for additional 3 sec.
3. Now the sensor is open for adjustment. It is locked again if no button is activated for 15 sec. or the power supply to the sensor is removed.
4. With button 1 the value is increased; with button 2 it is decreased.
5. With single presses for at least 1 sec. the value is changed 1 mV.
6. When the button is pressed, the size of steps is increased. Be aware of overshoots.
7. The sensor is locked again if no button is activated for at least 15 sec. (Timeout)
8. Note: It is only possible to adjust 12.5% in a session as described above. If it is not sufficient, another session can be performed.

3.5 Positive pitch end-stop

Select test 11.8: "Position transmitter voltage test".
Press <3> "+ end stop" and note the "Act pitch position" again.
It has to be 9.710V [accepted interval: 9.690V to 9.730V].

If this value is out of range, you have to adjust pitch position sensor.

BTL5: Adjustment is done with the tool no. VT730358 mounted on the end of the transducer.

A procedure is followed as described above; it is opened by first pressing button 2 (grey) for at least 3 sec. and then button 1 (blue) for another 3 sec.

3.6 Positive offset adjust.

Select test 11.9: "Positive offset adjust".

Press <FUNC> to start the test.

The control voltage will be 2.120 V and the controller measures the pitch velocity.

When the measuring is finished, the pitch will return to the reference 3.0°, and the pitch velocity will be displayed.

Every 10th second the controller will perform a new test.

Note the displayed pitch velocity.

It has to be 1.2°/sec. [accepted interval: 0.5 to 1.9°/sec.].

Stop the test by pressing <ESC>.

3.7 Negative offset adjust.

Select test 11.10: " Negative offset adjust".

This test is similar to test 11.9.

The contr. voltage during the test is -1.560 V. The ref. pitch angle is 12.0°.

Note the pitch velocity.

It has to be -1.2°/sec. [accepted interval: -0.7 to -2.3°/sec.].

Stop the test by pressing <ESC>.

3.8	**Positive flow test.**	***Select test 11.11: " Positive flow test".*** This test is similar to test 11.9. The contr. voltage during the test is 6.80 V. The ref. pitch angle is 3.0°. Note the pitch velocity. It has to be 10°/sec. [accepted interval: 5 to 13°/sec.]. Stop the test by pressing <ESC>.
3.9	**Negative flow test.**	***Select test 11.12: " Negative flow test".*** This test is similar to test 11.9. The contr. voltage during the test is -6.20 V. The ref. pitch angle is 81.0°. Note the pitch velocity. It has to be -10°/sec. [accepted interval: -7 to -14°/sec.] Stop the test by pressing <ESC>.
3.10	**Sine test.**	***Select test 11.13: " Sine test of pitch".*** Press <FUNC> to start the test. The pitch reference follows a sine function that will pitch the blade regularly up and down from -3.0° to 83.0° with a cycle time of 60 seconds. Check that the actual pitch (Pitch, Act) follows the reference pitch (Pitch, Ref) in the display. Check that the physical pitching of the blade is regularly and homogeneously. Press <ESC> to stop the test. In order to secure the following tests, check that pitch system "All" is selected.
3.11	**Flow control valves**	Follow the procedure described in the Service Bulletin no. 5.22, JNS, 17-04-00. Make a note of the max deviation in pitch angle during emergency pitch.

4. Rotor and generator.

4.1 Preparation of test.

Select test 11.15: "Manual pitch and brake".

With <*> apply the brake. Remove the locking system.

Release the brake with <*>.

Manually yaw the turbine upwind by leaving service mode.

For security reasons, perform the following tests from the bottom.

4.2 RPM sine-test.

Select test 11.19: "RPM test".

Press <1> to start the sine-test.

The speed reference of Gen follows a sine function from 300/360 to 1500/1800 RPM with a cycle time of 60 seconds.

Check that the actual speed (Gen.RPM, Act) follows the reference speed (Gen.RPM, Ref).

Stop the test with <ESC>.

4.3 RPM step-test.

Select test 11.19: "RPM test".

(When leaving test 11.19 the generator is regulated to 0 RPM).

Press <2> to start the step-test.

The generator speed reference moves in steps:

375-750-1125-1500-1125-750-375-750 RPM etc., 50Hz

450-900-1350-1800-1350-900-450-900 RPM etc., 60 Hz

The value will change every 30 second.

Check that the actual speed (Gen.RPM, Act) follows the reference speed (Gen.RPM, Ref). Stop the test with <ESC>.

4.4 Test of generator over speed.

This test is only performed if the wind speed is above 6.5 m/s.

Select test 11.21: "Overspeed generator".

Press <FUNC> to start the test.

The processor waits approx. 30 seconds until the generator speed has reached 750/900 RPM.

During the next minute the reference speed will increase to 1950/2350 RPM along a ramp.

When over speed is reached the generator speed is regulated back to 0 RPM.

Note the "Alarm rpm act" as displayed.

	Power	Frequency	Alarm RPM	Tolerance
V66	1.75/2.0MW	50 Hz	1945	1885-2005
V66	1.75/2.0MW	60 Hz	2350	2290-2410
V80	2.0 MW	50 Hz	1930	1870-1990
V80	2.0 MW	60 Hz	2315	2255-2375

4.5 Test of VOG.

This test is only performed if the wind speed is above 6.5 m/s.

Select test 11.22: "VOG-test".

This test is similar to 11.21.

Check that the displayed values of "Rotor RPM" and "Gen RPM" increase proportionally.

Note the "Alarm Rotor rpm", when the VOG disconnects the emergency stop circuit.

	Power	Frequency	Alarm RPM	Tolerance
V66	1.75/2.0MW	50/60 Hz	25.5	24.5-26.5
V80	2.0 MW	50/60 Hz	19.8	18.8-20.8
V80 offshore	2.0 MW	50/60 Hz	21.5	20.5-22.5

4.6 Reset of VOG-alarm

A VOG-alarm demands a hardware-reset.

Check that it is not possible to acknowledge the error by <*><PAUSE> and start up the turbine, as the VOG can only be reset by a power down.

Turn off power to the ground controller (CT291) for at least 30 seconds.

Bring the turbine in "PAUSE"-mode.

5. End of check procedure

5.1 Change batteries

Change the batteries in the top- and ground processors. The battery drawer must only be opened when the processor is mounted in the rack and is power supplied.

Warning! "Do not open when unpowered. Data loss possible".

If the battery drawer is opened, while the processor is unpowered, the RAM would be reset (production- and hour counter, all logs, calibration values and parameters).

5.2 VDF-mode

Select picture 27.1: "VDF-overview".
Check that the VDF-mode is "Full-recycle".

5.3 Start-up

Leave service-mode and bring the turbine in RUN-mode.

Check that the ***pictures 1: "Overview", 2: "Production", 3: "Hour counters"*** and ***5: "Electrical data"*** look reasonable.

Leave the turbine in ***picture 1: "Overview".***