行政院及所屬各機關出國報告

(出國類別：開會/實習)

火力發電機組性能監診中心運作技術研究

服務機關：台灣電力公司

出國人職稱：機械工程師

姓　　名：李亦堅

出國地區：德國

出國日期：105 年 5 月 29 日至 6 月 7 日

報告日期：105 年 8 月 2 日

出國報告審核表

出國報告名稱：火力發電機組性能監診中心運作技術研究		
出國人姓名（2人以上，以1人為代表）	職稱	服務單位
李亦堅	機械工程師	台灣電力公司
出國類別	☐ 考察 ☐進修 ☐研究 ■實習 ☐ 其他＿＿＿＿＿（例如國際會議、國際比賽、業務接洽）	
出國期間：105 年 5 月 29 日至 105 年 6 月 7 日	報告繳交日期：105 年 8 月 1 日	

出國人員自我審核	計畫主辦機關審核	審 核 項 目
■	☑	1.依限繳交出國報告
■	☑	2.格式完整（本文必須具備「目地」、「過程」、「心得及建議事項」）
■	☑	3.無抄襲相關資料
■	☑	4.內容充實完備.
■	☑	5..建議具參考價值
☐	☐	6..送本機關參考或研辦
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☐	☐	8..退回補正，原因：
☐	☐	（1）不符原核定出國計畫
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☐	☐	（5）引用相關資料未註明資料來源
☐	☐	（6）電子檔案未依格式辦理
☐	☐	（7）未於資訊網登錄提要資料及傳送出國報告電子檔
☐	☐	9..本報告除上傳至出國報告資訊網外，將採行之公開發表：
☐	☐	（1）辦理本機關出國報告座談會（說明會），與同人進行知識分享。
☐	☐	（2）於本機關業務會報提出報告
☐	☐	（3）.其他
☐	☐	10.其他處理意見及方式：

報告人：李亦堅　　單位主管：鍾年勉　　主管處主管：　　總經理／副總經理：副大（章）

說明：

一、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。

二、審核作業應於報告提出後二個月內完成，以不影響出國人員上傳出國報告至「公務報告資訊網為原則」。

行政院及所屬各機關出國報告提要

出國報告名稱：火力發電機組性能監診中心運作技術研究

頁數 40 含附件：■是□否

出國計畫主辦機關/聯絡人/電話：

台灣電力公司/陳德隆/2366-7685

出國人員姓名/服務機關/單位/職稱/電話：

李亦堅/台灣電力公司/綜合研究所/資深研究專員/8078-2293

出國類別：□1 考察□2 進修□3 研究■4 實習□5 其他(開會)

出國期間：105.5.29~105.6.7　　出國地區：德國

報告日期：105.8.1

分類/號目：

關鍵詞：火力發電機組（Fossil Power Plant)、複循環發電機組（Combined Cycle Power Plant)、監測（Monitoring)、診斷（Diagnosis)、性能（Performance）

內容摘要：(二百至三百字)

本研究計畫自 100 年既已長期規劃氣渦輪機組效能提升，陸續完成氣渦輪機組燃燒調校技術及機組性能監控分析系統，103 年著手研究與建置複循環機組性能監測與分析系統，並完成自行設計開發部分氣渦輪機組性能監測與分析系統建置於電廠。104 年完成第一部複循環發電機組效能即時監診技術與系統開發應用。105 年擬將發展擴大至傳統汽力機組之監診技術與系統規劃與開發，並配合本年度研究計畫進行之大林 5 號燃氣鍋爐降低 NOx 排放燃燒調校、金門塔山柴油發電機組性能監診系統建置、大潭電廠複循環機組性能監診系統建置、

南二機氣渦輪機更新延壽之複循環機組性能分析研究…等研究開發案。今年擬將過去7年餘研究成果與技術整併建立複循環發電機組性能監診中心。為擴大性能監診中心實際效益，擬併入燃煤火力機組之性能監診運轉模式，將一併赴本公司火力發電機組製造商- SIEMENS 實習火力發電機組性能監診中心運作技術實務經驗與理論。

目前複循環發電機組電廠與綜合研究所積極合作推動機組性能監診技術，以期使機組運最佳狀態，並擴展至各機組性能調配成最佳運轉組合，其中建立電廠性能監診中心及運作理論技術建立為本計畫負責核心技術之建立與運作。若將複循環機組運作理論技術推展至燃煤機組，使公司全部火力機組皆納入性能監診中心運作，將可提升公司整體發電效率、降低發電成本。但是目前國內並無相關單位與組織進行實際發電機組性能監診中心運作，為期公司能引進該項應用性能監診中心技術，並因應未來高發電效率、低發電成本發展趨勢，學習機組性能監診中心運作技術，有其必要性。

本次出國實習工作內容為：

- 學習火力發電機組性能監診中心建置架構:其公司火力發電機組性能監診中心之應用已運行多年，熟悉其架構可為由複循環機組性能監診推廣至未來擬建置之火力發電機組性能監診中心，可達到事半功倍效益。

- 學習火力發電機組性能監診中心建置功能與案例:其公司利用監診技術配合其發展之性能調校技術為客戶服務，此應用技術SIEMENS已使用多年，目前綜合研究所在氣渦輪機監診技術研發中已有多項成果，通霄及南部電廠已陸續自行開發即時監測與預警系統，赴國外實習建置功能相關技術與案例討論,相互觀摩與學習對實質之性能監診中心建置助益甚大。

實習心得總結報告為

本次實習複火力發電機組性能監診中心建置技術,藉由實地監診中心之觀摩實習及與技術人員技術之交流,可充分了解與學習建置發電機組性能監診中心之架構、技術，由實習過程中所獲得之心得，評估目前公司如何將複循環機組性能監診技術推展至火力發電機組性能監診，以目前從事多年之複循環機組運轉狀態監測、性能分析診斷與改善所累積之經驗、監測系統、分析工具與技術，已可以規劃建置功能性之機組性能監診中心。經與西門子專業團隊討論與經驗交流後，應整合目前已有技術建置機組性能監診中心，推廣至整個火力機組，對於機組事故之肇因分析與改善措施、機組運轉性能劣化之早期預警、機組重要組件更新案之機組性能影響整體評估等具有實質之貢獻。

本次出國實習複循環機組性能監診中心建置之建議：

為維護先進複循環機組高效率、 高可用率及低污染排放之性能，建議公司可規劃建置各電廠火力發電機組性能監診中心，其功能：

- 機組性能及重要關建設備進行追蹤與記錄
- 機組發電成本影響因素量化
- 機組性能提升及電能安全

本文電子檔已傳至出國報告資訊網（http://open.nat.gov.tw/reportwork）

實習火力發電機組性能監診中心運作技術研究

目　　錄

圖表目錄

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附件

壹、實習目的與行程

1.1 緣起與目的

目前研究工作中，主要為協助公司所屬複循環機組電廠之氣渦輪機（Gas Turbine）燃燒穩定性調校、事故肇因分析與改善建議、機組性能分析與技術諮詢工作，研究過程中建置分析改善之工具為必要之程序。獲得機組運轉數據訊號、重要參數計算分析皆為研究之過程，經多年研究經驗與成果建立出氣渦輪機效能分析與改善核心技術，完成了多項即時線上運轉數據截取系統、遠端數據傳輸系統、性能分析計算軟體、以及即時線上機組性能衰退預警系統。如何整合相關技術為目前技術開發重點，因此本次出國實習「火力發電機組性能監診中心運作技術」為擴展目前核心技術之應用。

本次出國實習 SIEMENS 公司如何規劃建置火力發電機組性能監診中心運作技術，其公司利用監診技術配合其發展之性能調校技術為客戶服務，此應用技術在國外之氣渦輪機已使用多年，目前綜合研究所在複循環機組中已有多項技術研發成果，在通霄及南部電廠已陸續自行開發即時監測、分析與預警系統，赴國外實習相關技術,相互觀摩與學習對實質之機組性能監診中心建置能力助益甚大。

實習氣渦輪機組效能提升核心技術之主要規劃：

（100年度）：氣渦輪機組燃燒效能改善技術。

主要對氣渦輪機組燃燒控制與調校技術學習與燃燒調校方法之提升。

成果：建立公司電廠人員對氣渦輪機組燃燒控制理論與調校技術認知。

（101年度）：氣渦輪機組燃燒效能監測診斷技術。

主要對氣渦輪機組燃燒效能監測系統之建置與監測診斷技術學習與提升。

成果：建立通霄與南部電廠氣渦輪機燃燒效能監測系統。

（102年度）：氣渦輪機組早期預警技術技術。

主要對氣渦輪機組燃燒效能監測系統之遠端監測診斷功能之建置與遠端監測診斷技術學習與提升。

成果：建立通霄氣渦輪機組之遠端效能監測系統。

（103年度）：氣渦輪機組燃燒效能調校技術。

主要對如何氣渦輪機組燃燒效能調校,進行補強目前核心技術之應用。

目標：針對氣渦輪機組燃燒效能調校分析技術，補強目前核心技術之架構與分析功能。

成果：完成南部電廠3號機燃燒穩定度與排氣NOx濃度最佳化調校。

(104年度)：複循環機組性能監診中心建置技術。

主要對目前在複循環機組中已有多項技術研發成果,如何整合目前核心技術，進行如何建置複循環機組性能監診中心之應用，如圖1所示。

目標：實習複循環機組性能監診中心之建置技術。

成果：完成通霄電廠4號機(GT41、GT42、GT43)、5號機(GT51、GT52、GT53)(如圖2所示)及南部電廠1號機(GT11、GT12、ST10) (如圖3所示)…等共9部氣渦輪機及汽渦輪機性能監診，模擬建置虛擬之複循環機組性能監診中心。

(105年度)： 實習火力發電機組性能監診中心運作技術研究***（本次出國實習之目的）***。

目前複循環發電機組電廠與綜合研究所積極合作推動機組性能監診技術，以期使機組運最佳狀態，並擴展至各機組性能調配成最佳運轉組合，其中建立性能監診中心及運作理論技術建立為本計畫負責核心技術之建立與運作。若將複循環機組運作理論技術推展至燃煤或柴油發電機組，使公司全部火力機組皆納入性能監診中心運作，將可提升公司整體發電效率、降低發電成本。。

目標：實習火力機組性能監診中心之建置技術。

1.2 行程與內容

1.2.1 行程

日期	地點	拜訪公司討論內容
5/29	去程	
5/30~6/2	西門子 Power Diagnostic Center	實習複循環機組性能監診運作技術，以整合目前研究成果。
6/3~6/5（含2日例假）	西門子 Power Generation Division	實習火力發電機組性能監診中心運作技術，作為未來發展公司性能監診中心運作基礎
6/6~6/7	返程	

1.2.2 行前規劃及實習內容

1.2.2.1 行前規劃實習主題

此次依出國任務之主題聯繫本公司火力發電機組製造商-SIEMENS,出國前規劃相關實習內容並與實習公司聯絡相關細節，其主要內容如下：

1. 提出實習拜訪之需求

Dear Mr. Julian,

On the 7th April, we had a meeting with Mr. Vinod Philip, CTO of SIEMENS at our office. After that, I have interest in your new technology and service, especially on the power diagnostics technology. In Taiwan, Taiwan Power Company may be not the only one electric producer in the future of Taiwan power electricity market. The impact of electricity liberalization will lead to another consideration for higher performance and availability on our power plants. After that conversation, I think that SIEMENS's technology could have a good support and reference on our new unit established and exist unit reliability.

Could I have a visit to your Power and Gas Division in Berlin. I would be grateful if you could arrange this invitation trip between late May and early June.

Sincerely Yours truly,

I-Chien Lee, Ph.D.

李亦堅

Researcher

Energy Research Laboratory, TPC

84, Ta-an Rd., Shulin

New Taipei, Taiwan 23847

R.O.C.

Email: u630727@taipower.com.tw

Phone: 886-2-8078-2293 (Office)

2. 本次拜訪實習經西門子同意後之內容

SIEMENS

Siemens Ltd. Seoul, Seoul Square 12th Floor, 416, Hangang-daero, Jung-gu, Seoul 04639, Korea

Taiwan Power Company
Dr. I-Chien Lee
Power Research Institute
84, Ta-An Road, Shu-Lin
New Taipei City 23847, Taiwan R.O.C.

Name	Christine Herbst
Department	PG S ASP LGP
Telephone	+82 (2) 3287-4867
Fax	+82 (2) 3287-4491
Mobile	+82 (10) 4697-6870
E-mail	Christine.herbst@siemens.com
Date	April 29, 2016

Letter of Invitation

Dear Dr. I-Chien Lee,

After the fruitful dialogue with our CTO of Power & Gas Division Vinod Philip on the 7th of April, we would like to reiterate our invitation to visit our Power & Gas Division and gas manufacturing factory in Berlin.

We would like to take this opportunity presenting you the latest updates on diagnostic technologies, new developments of gas turbines and combined cycle power plants, market and technology outlook for small gas turbines, Big Data and 3-D printing/ simulation, improvements on combined cycle power plants' (gas turbines') availability and reliability relevantly and respectively.

The aforementioned business trip may be planned in May 2016.

Please do not hesitate to contact with us for any questions you may have.

Sincerely Yours,

Thomas Hagedorn

Executive Vice President
Head of PG S ASP

Restricted

Siemens Ltd. Seoul
Management: JongKsp Kim

Seoul Square building 12th Floor,
416, Hangang-daero, Jung-gu,
Seoul 04639, Korea

Tel.: +82 (2) 3450-0000
Fax: +82 (2) 3450-0000
http://www.siemens.co.kr/energysolutions/

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貳、實習項目與心得

本次實習主要瞭解西門子性能監診中心（Power Diagnostics Center）功能與效益，尤其針對火力發電機組性能監診技術、監診內容、分析技術(大數據技術投入應用)、技術整合...等等進行實習，其次,在實習過程中由西門子各專業領域之專家講授、討論與現場設備、系統之參觀，以獲得更多之應用技術與專業知識。在本次實習內容之時程上，首先與西門子監診中心技術人員進行技術研討與交流，再赴現場實際觀摩，最後再拜會氣渦輪機性能監診設計人員學習其設計應用理念與經驗。由於本次出國時習之目的是為未來規劃公司之火力發電機組性能監診中心而準備。

由於台電公司為西門子發電事業部之重要客戶，此次實習西門子公司欲提供使用者進一步之服務與說明其能力與實績，由西門子能源部門與性能監診部門提供之重要文件（基於承諾部分文件基於製造商同業間敏感性，不宜公開，報告文件以簡略圖表顯示，其文件如附件1)。

火力發電機組性能監診中心的功能主要為針對系統整體效能與大型重要組件性能進行性能監測及診斷，目前我們已完成燃氣輪機，蒸汽輪機，餘熱回收鍋爐和發電機等電廠主要設備性能之資料擷取、資料儲存、初步統計分析、機組性能分析，上述重要組件性能分析、電廠端結果回饋、改善建議與追蹤。實習中發現針對火力機組尚有些重要設備需監測與診斷，依西門子提供之資訊有泵系統(pump system)、

冷凝器(condenser system) 、冷卻水系統(cooling water system)、潤滑油系統(lube oil system)…等等。實習中針對各項之說明討論與案例說明(如附件 1 文件)重點摘錄如下:

火力機組主要監診架構主要分為下列主要類型與案例說明

1. Unit Operation Performance Overview

機組整體運轉性能顯示，實習中提供許多關鍵性能指標(Key Performance Index) ，值得未來放入建置中監診畫面。

2. 鍋爐飼水泵系統 Boiler Feed water pump (BFWP) system

- Boiler Feed water pump (BFWP) system Monitoring
- Boiler Feed water pump (BFWP) performance monitoring
- Boiler Feed water pump (BFWP) Bearing Temperature Trends
- Boiler Feed water pump (BFWP) Motor Winding temperature trends

鍋爐飼水泵系統為一重要性能監診目標,依原廠設計理論及觀點，如何分析性能指標為此項實習重點,基於此在開發建置監診系統時才具有正確性。

3.Condensate Extraction pump (CEP) system Monitoring

- Condensate Extraction pump (CEP) system Monitoring

- Condensate Extraction pump (CEP) performance monitoring
- Condensate Extraction pump (CEP) Bearing Vibration Trends
- Condensate Extraction pump (CEP) Bearing Temperature Trends

冷凝器為影響系統效率與負載重要設備, 如何保持真空度為重要指標，相關 CEP 泵為重要監診目標，如何分析相關運轉指標為此項實習重點，基於此在開發建置監診系統時才具有正確性。

-

4.Sea Water Intake Pump (PAC) system

- Sea Water Intake Pump (PAC) system Monitoring
- Sea Water Intake Pump (PAC) Bearing Temperature Trends
- Sea Water Intake Pump (PAC) Motor Winding temperature trends

海水冷卻系統亦為影響系統效率與負載重要設備, 如何保持足夠熱交換量為重要指標，相關泵為重要監診目標，如何分析相關運轉指標為此項實習重點，基於此在開發建置監診系統時才具有正確性。

5.Closed cooling water (PGB) system Monitoring

6.Closed cooling water Heat Exchanger Performance Monitoring

7.Generator cooler (PGB side) Performance Monitoring

8.Generator Seal Oil cooler (PGB side) Performance Monitoring

9.Lube Oil cooler (PGB side) Performance Monitoring

10.GT Auxiliary System Performance Monitoring

11.GT Enclosure Temperature Monitoring

12.MBX Compressor system Monitoring

13.Lube Oil Tank Monitoring

14.Lube Oil Tank Oil Vapor Exhaust system Performance Monitoring

以上5至14項為影響系統效率與可用率之設備, 為開發監診系統次要目標，如何分析有關運轉參數為此項實習重點，基於此在開發建置監診系統時才具有完整性。

本次實習另一重要心得 -「大數據之應用」，此部分一直是目前最新技術，在工程研究領域上其實就是擴大了分析範圍與資訊來源，學術領域上是著重專精，工程研究領域上是著重廣與應用。目前國內發展大數據理論者不乏其人，但對工程研究領域上之應用乏善可陳，主要原因為無實際之標的物可進行研究與開發，目前本團隊進行之發電廠火力機組性能監診與效能提升研究，為一應用大數據技術開發火力機組性能監診與預警絕佳應用開發工具，104 年團隊以應用機械學習(Machine Learning)(大數據理論) 開發出通霄電廠4、5號機氣渦輪機空氣壓縮機性能衰退預警系統，此次赴西門子實習如何應用大數據理論建置預測模組使用在火力機組性能監診，整體應用架構如圖

所示，相關建模理論、分析資訊項目、應用範圍…等皆有實質收穫，對於目前研究開發具有關鍵性幫助。

參、綜合結論與建議

● 本次出國實習火力發電機組性能監診中心運作技術研究之結論：

實習心得總結報告為

本次實習火力發電機組性能監診中心運作技術研究，藉由實地監診中心之觀摩實習及與技術人員技術之交流，可充分了解與學習規劃火力發電機組之架構、技術，由實習過程中所獲得之心得，比較目前已經建立之複循環機組性能監診技術尚欠缺之架構與技術(如圖　應用於火力機組效能即時顯示圖之人機介面及圖　應用於火力機組空氣壓縮機性能衰退即時預警顯示圖所示)，以目前從事多年之複循環機組運轉狀態監測、性能分析診斷與改善所累積之經驗、監測系統、分析工具與技術，可規劃如圖 5 所示之火力發電機組性能監診系統規劃開發架構，及如圖 6 所示之火力發電機組性能監診系統規劃應用架構。經與西門子專業團隊討論與經驗交流後，深感目前在公司機組建置之性能監診技術皆有機組性能監診功能，實績上但皆屬局部性功能，一樣的研究改善工作卻無法達到全面之機組效能改善與提升效益，僅能服務於即時之機組事故肇因分析、防範與改善，研究工作之技術提升與在公司之效益與機組可用率應多投入研究開發比例。

本次出國實習火力發電機組性能監診中心運作技術研究之建議：

經複西門子實習複循環機組性能監診中心後，比較目前公司已有技術與實績，建議規劃火力發電機組性能監診中心之運作技術研究，其對公司產生之效益為：

1. 對火力發電性能進行追蹤與記錄為能有效提升機組效能、評

估機組維護改善工程必要性。對於機組事故之肇因分析與改善措施、機組運轉性能劣化之早期預警、機組重要組件更新案之機組性能影響整體評估等具有實質之貢獻。

2. 機組發電成本影響因素量化:有效量化燃料使用成本中以上各項佔有比例，此為提升機組性能、電廠發電競價計算、或經濟性調度重要指標。

3. 有系統建置與整合各機組效能，掌握關鍵性發電技術及機組特性，可提高機組安全運轉可靠度，確保系統供電穩定，提升公司企業形象。

肆、參考文獻

Digital Services and Power Diagnostics for Power and Gas, SIEMENS

Plant diagnostics [R] Monthly Report, Energy Sector, SIEMENS AG,

Website:” http://www.siemens.com/entry/cc/en/ ”

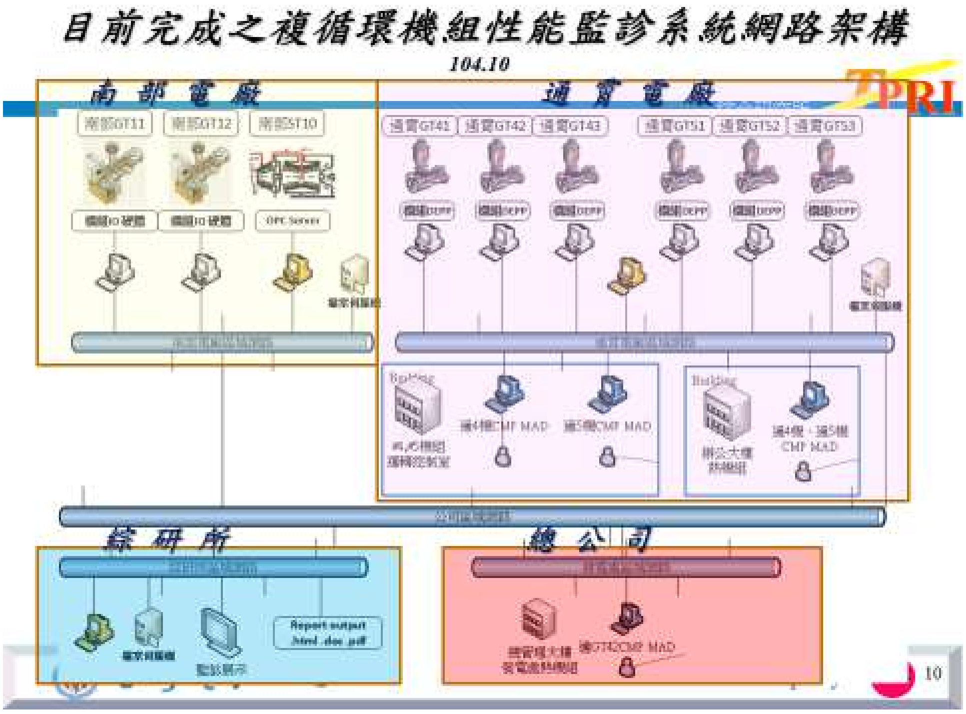


圖 1 目前完成之複循環機組性能監診系統網路架構示意圖

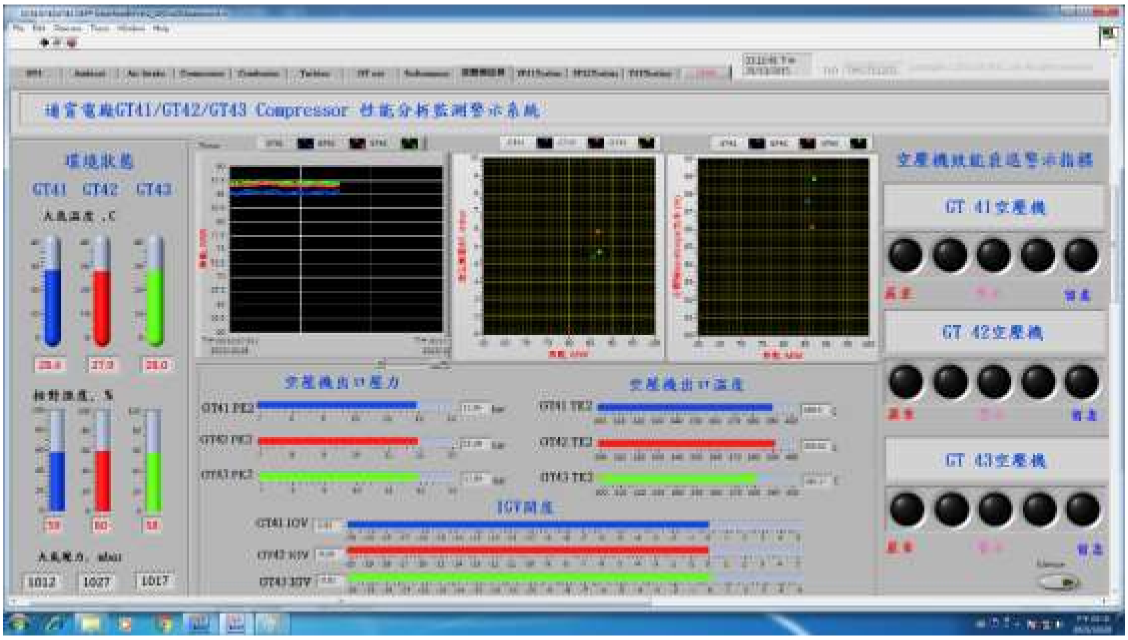


圖 2 應用於火力機組空氣壓縮機性能衰退即時預警顯示圖

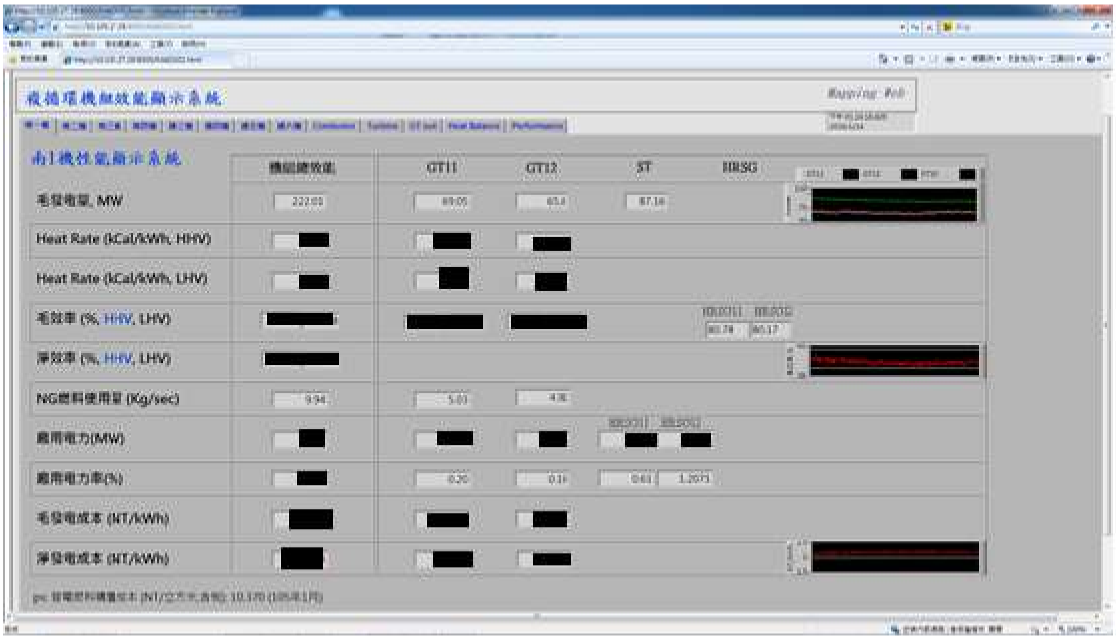


圖 3 應用於火力機組效能即時顯示圖之人機介面

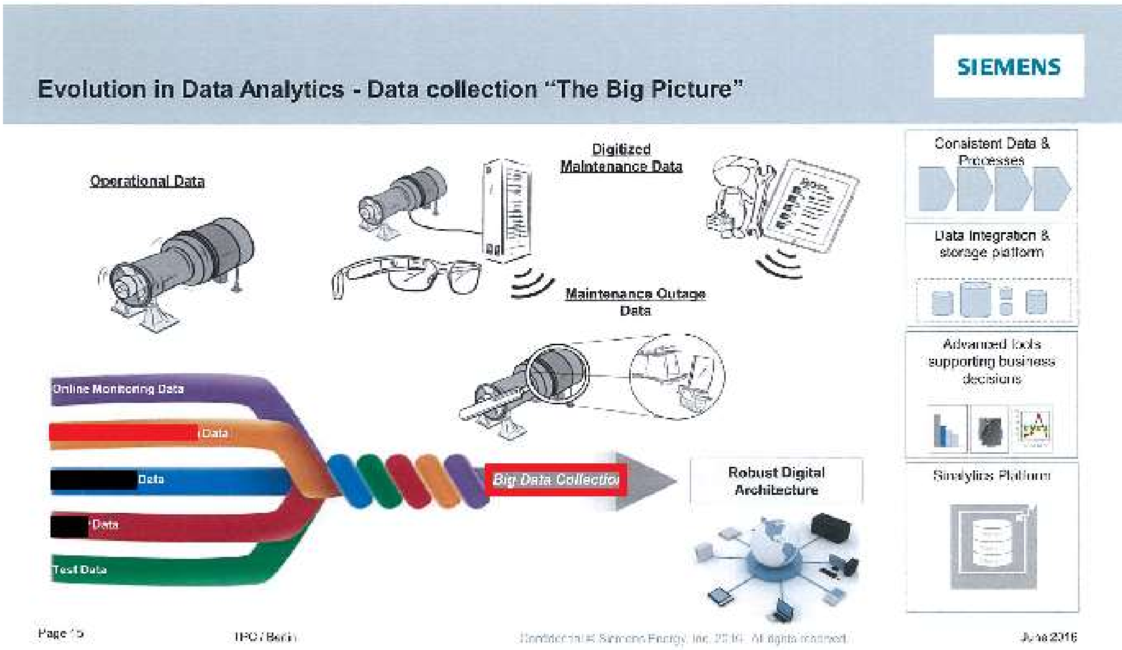


圖 4 西門子公司之應用大數據分析模組架構示意圖

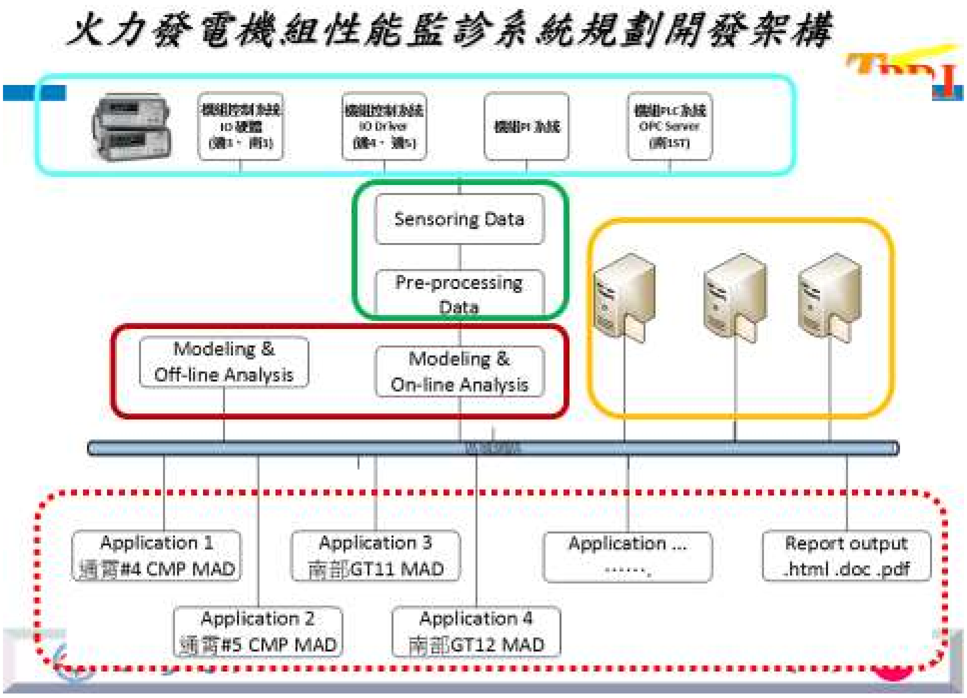


圖 5 火力發電機組性能監診系統規劃開發架構圖

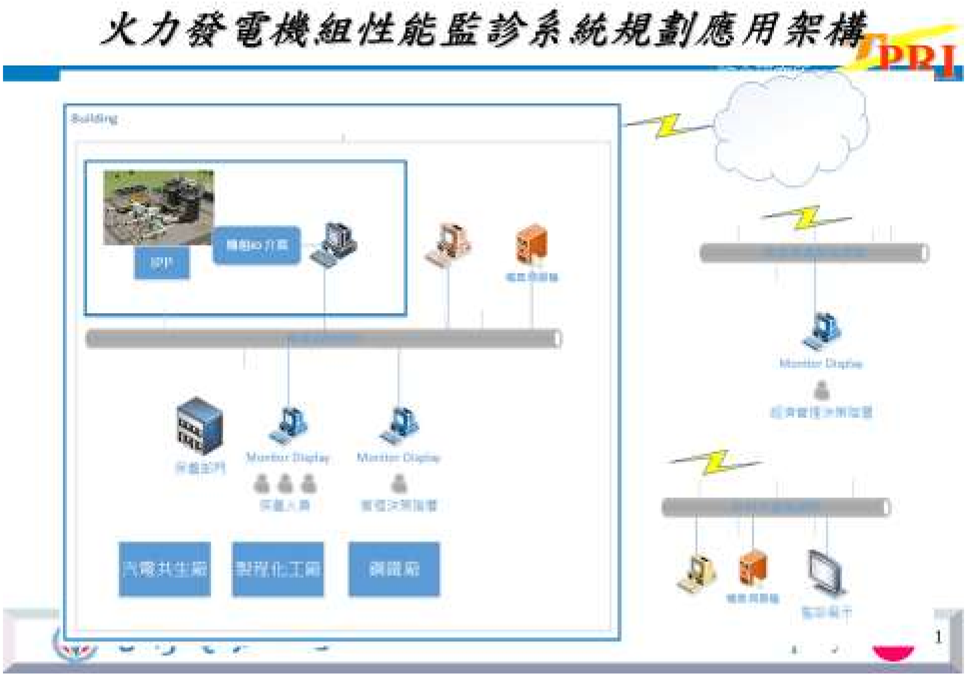


圖 6 火力發電機組性能監診系統規劃應用架構圖

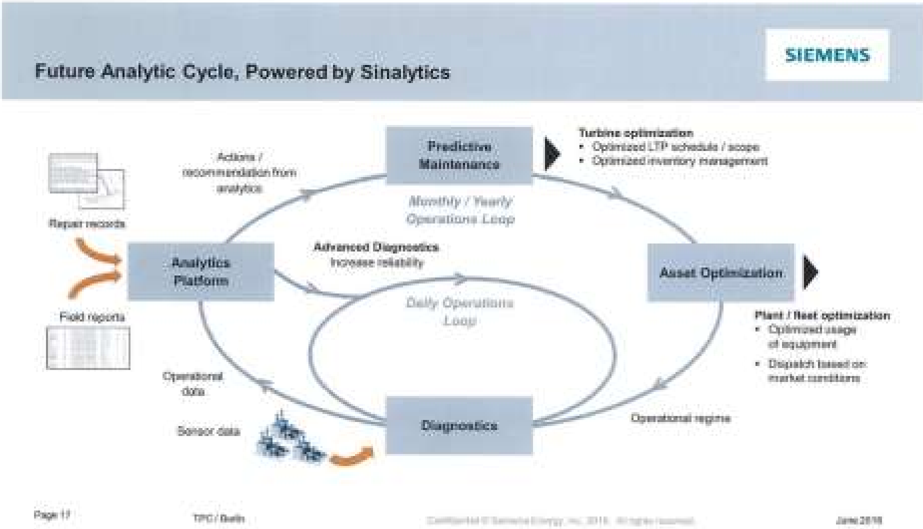


圖 7 火力發電機組性能監診分析架構圖

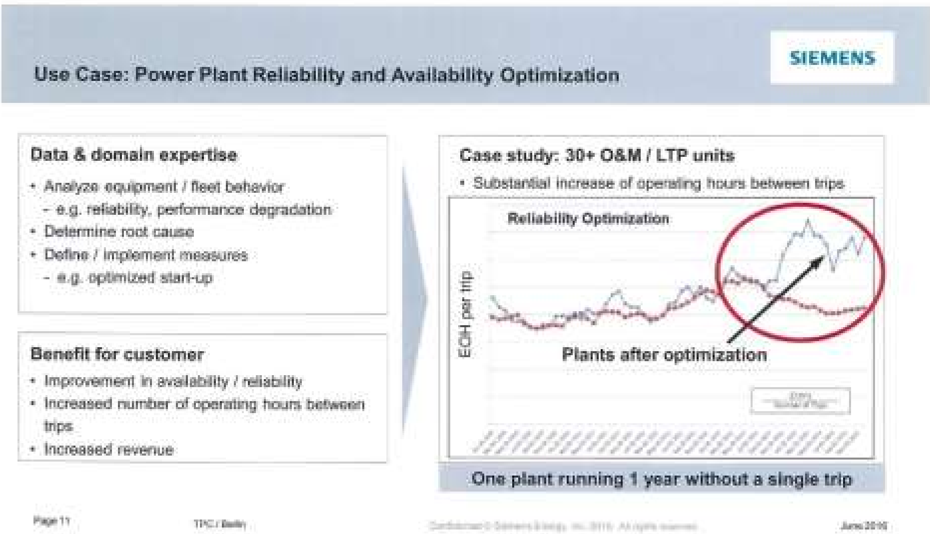


圖 8 西門子對火力發電機組性能監診之可用率效益顯示圖

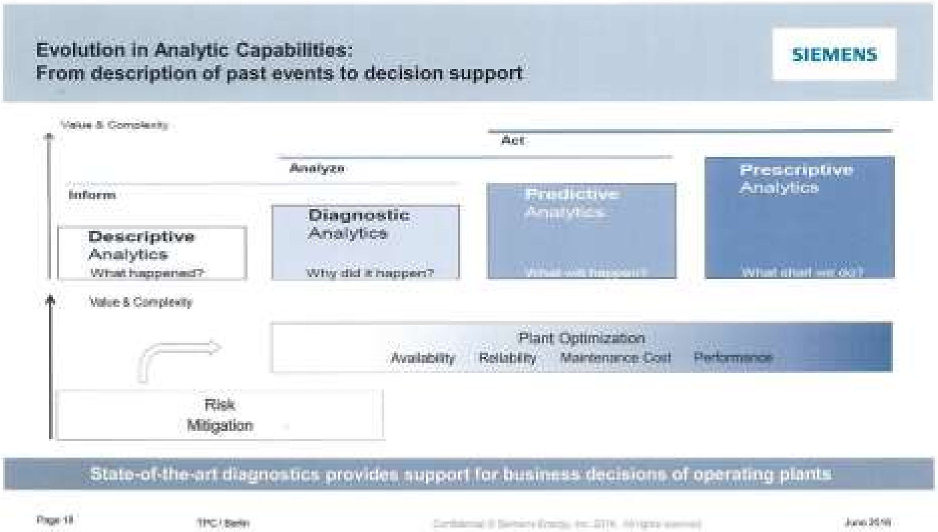


圖 9 西門子對火力發電機組性能監診之技術建立流程示意圖

附件 1 火力機組主要監診架構與案例

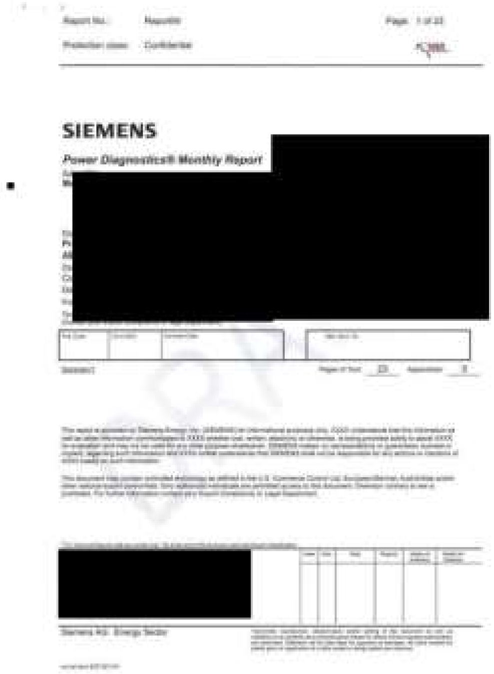


Table of contents

1 General

Consecutively the PDC BOP monthly report will show how the unit was operated over the month. It gives an overview over the various BOP and Auxiliary systems operating ranges (e.g. bearing vibration and temperatures). In case of any observed abnormality, it will be highlighted below the responding chart.

All trend plots show data based on normal operation instrumentation, this instrumentation does not allow an exact performance calculation and is used for trend overview purposes only.

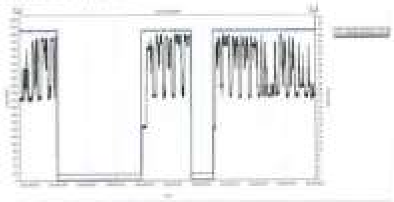
2 Combined cycle power plant details

Generic illustration of Combined cycle Power Plant (does not reflect Mechanical Design Details)

3 Monitoring results

3.1 Unit Operation Overview

This chart gives an overview of the unit operation over the month. It shows the GT power output and the speed of the gas turbine.

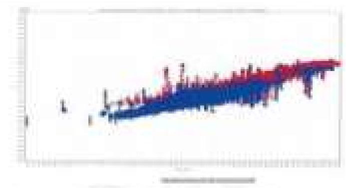


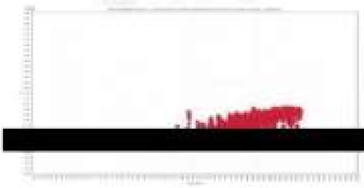
The chart shows unfiltered data.
No unusual behavior was observed.

3.2 Boiler Feed water pump (BFWP) system Monitoring

3.2.1 Boiler Feed water pump (BFWP) performance monitoring

This chart gives an overview of the BFWP total flow rate vs BFWP motor current. The first chart [redacted]





[redacted]

The chart shows comparison data for the last 3 months in blue and last month in red.

The BFWP total flow rate was filtered to steady state base load operation (CTC controller ON, IGV fully open and compressor outlet temperature change within the last hour less than 1K.)

[Increase [redacted] current consumption with reference to the same B… low rate from the last 3 [redacted] is normally a symptom for degradation BFW Pump… Kilometer.]

Slightly inc[redacted] current consumption observed with BFWP Pump… compared with the la[redacted] data.

As BFWP [redacted] 1 was in service for the last three months, the BFWP… 2 did not have the past 3 [redacted] reference data set for comparison.

3.2.2 Bo[redacted] water pump (BFWP) Bearing Temperature T…

This chart [redacted] overview of the BFW Pump and Motor Bearing Temp… nds.

These cha[redacted] overview of the bearing temperature behavior, so th… sual behavior like high ju[redacted] slowly differing trends can be detected.

The first c[redacted] the BFWP No.1 bearing temperature trends. The se… shows the BFWP No.[redacted] temperature trends.

The chart shows comparison data of Unit load, BFWP motor current and BFW pump and motor bearing temperature trends.

The data is unfiltered.

No unusual behavior was observed.

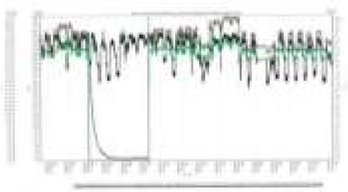
[Increase or Decrease trends of the bearing temperatures are normally a symptom for issue related to Bearing, alignment drifts and Lube Oil quality]

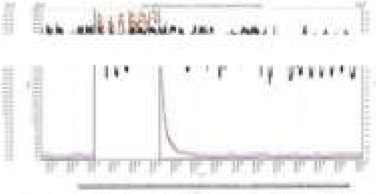
3.2.3 Boiler Feed water pump (BFWP) Motor Winding temperature trends

This chart gives an overview of the BFWP Motor winding temperature trends.

These charts give an overview of the motor winding temperature behavior, so that any unusual behavior like high jumps or slowly differing trends can be detected.

The first chart shows the BFWP No.1 motor winding temperature trends. The second chart shows the BFWP No.2 motor winding temperature trends.





The chart shows comparison data of Unit load, BFWP motor current and BFW motor winding temperature trends.

The data is unfiltered.

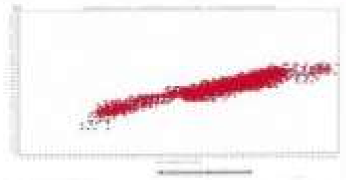
No unusual behavior was observed.

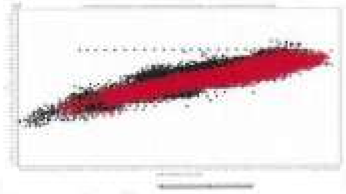
[Increase or Decrease trends of the winding temperatures are normally a symptom for issue related to motor windings]

3.3 Condensate Extraction pump (CEP) system Monitoring

3.3.1 Condensate Extraction pump (CEP) performance monitoring:

This chart gives an overview of the CEP total flow rate vs CEP motor current. The first chart

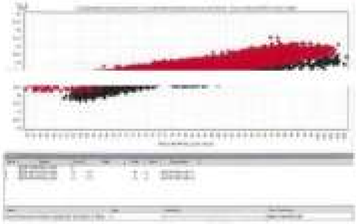




The chart shows comparison data for the last 3 months in blue and last month in red.

The CEP total flow rate was filtered to steady state base load operation (OTC controller ON, IGV fully open and compressor outlet temperature change within the last hour less than 1K.)

[Increase of the motor current consumption with reference to the same CEP total flow rate from the last 3 month data is normally a symptom for degradation CEP Pump / Motor performance.]



This chart shows comparison data of CEP Pump No.1 and CEP Pump No.2 motor current consumption for the same flow rate for the last 3 months. Data related to CEP Pump No.1 is shown in black color and data related to CEP Pump No.2 is shown in red color.

The CEP total flow rate was filtered to steady state base load operation (OTC controller ON, IGV fully open and compressor outlet temperature change within the last hour less than 1K.)

The motor current consumption of CEP Pump No.2 is higher than that of the CEP Pump No.1 for

(Increase of the motor current consumption of particular CEP Pump with reference to the same CEP total flow rate is a symptom for passing valves of that particular pump and degradation particular pump / motor performance.)

3.3.2 Condensate Extraction pump (CEP) Bearing Vibration Trends

This chart gives an overview of the CEP Pump and Motor Bearing Vibration Trends.

These charts give an overview of the bearing temperature behavior, so that any unusual behavior

CEP

No.2 bearing temperature trends.

This chart shows comparison data of CEP motor current and CEP pump motor bearing vibration trends.

(Increase or Decrease trends of the bearing vibration are normally a symptom for issue related to Bearing and alignment drifts)

3.3.2 Condensate Extraction pump (CEP) Bearing Temperature Trends

This chart gives an overview of the CEP Pump and Motor Bearing Temperature Trends.
These charts give an overview of the bearing temperature behavior, so that any unusual behavior like high jumps or slowly differing trends can be detected.

The first chart shows the CEP No 1 bearing temperature trends. The second chart shows the CEP No.2 bearing temperature trends.

The chart shows comparison data of Unit load, BFWP motor current and BFW pump and motor bearing temperature trends.

The data is unfiltered.

Unusual behavior was observed with 30LCB11CT001 of CEP Pump No 1 and 30LCB12CT071 of CEP Pump No 2. The respective sensor measuring chain links are recommended for checks.

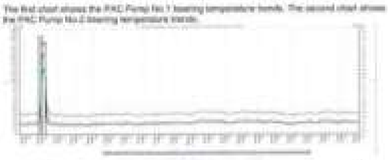
(Increase or Decrease trends of the bearing temperatures are normally a symptom for issue related to Bearing, alignment drifts and Lube Oil quality.)

3.4 Sea Water Intake Pump (PAC) system Monitoring

3.4.1 Sea Water Intake Pump (PAC) Bearing Temperature Trends

This chart gives an overview of the PAC Pump and Motor Bearing Temperature Trends.
These charts give an overview of the bearing temperature behavior, so that any unusual behavior like high jumps or slowly differing trends can be detected.

The first chart shows the PAC Pump No 1 bearing temperature trends. The second chart shows the PAC Pump No.2 bearing temperature trends.



The chart shows comparison data of PAC motor current and PAC pump and motor bearing temperature trends.

The data is unfiltered.

Minor increase of 30PAC12CT001 (thrust bearing metal temperature) was observed.

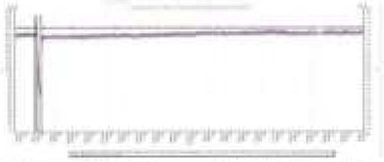
(Increase or Decrease trends of the bearing temperatures are normally a symptom for issue related to Bearing, alignment drifts and Lube Oil quality).

3.4.2 Sea Water Intake Pump (PAC) Motor Winding temperature trends

This chart gives an overview of the PAC Motor winding temperature trends.

These charts give an overview of the motor winding temperature behavior, so that any unusual behaviour like high jumps or slowly differing trends can be detected.

The first chart shows the PAC No.1 motor winding temperature trends. The second chart shows the PAC No.2 motor winding temperature trends.



The chart shows comparison data of PAC motor current and PAC motor winding temperature trends.

The data is unfiltered.

No unusual behavior was observed.

[Increase or Decrease trends of the winding temperatures are normally a symptom for issue related to motor windings].

3.5 Closed cooling water (PGB) system Monitoring

3.5.1 Closed cooling water Heat Exchanger Performance Monitoring

This chart gives an overview of the closed cooling water Heat Exchanger performance Trends. ... is deviation between the

The chart shows the trends of Unit load, PGB Cooler Inlet, outlet and Delta temperatures.

The chart shows the PGB closed cooling water heat exchanger inlet and outlet temperature trends. The cooler inlet temperature shown in blue color, outlet temperature in red color, difference

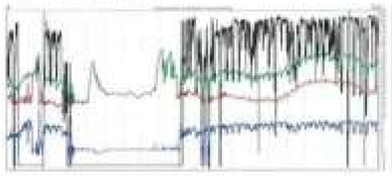
The data is unfiltered.

No unusual behavior was observed.

[Increase or Decrease of Delta temperature trends of the PGB Cooler temperature difference are normally a symptom for issue related to fouling of cooler, passing drain values and cooler leakages].

3.5.2 Generator cooler (PGB side) Performance Monitoring

This chart gives an overview of the Generator cooler (PGB Side) performance trends. So that any deviation between the cooler inlet and outlet temperature trends can be detected.



The chart shows the trends of Unit load, Generator PGB Cooler inlet, outlet and Delta temperatures.

The chart shows the Generator PGB closed cooling water heat exchanger inlet and outlet temperature trends. The cooler inlet temperature shown in red color, outlet temperature in green.

The data is unfiltered.

No unusual behavior was observed.

(Increase or Decrease of Delta temperature trends of the PGB Cooler temperature difference are normally a symptom for issue related to fouling of cooler and passing drain valves)

3.5.3 Generator Seal Oil cooler (PGB side) Performance Monitoring

This chart gives an overview of the Generator Seal Oil cooler (PGB side) performance trends, so that any unusual behavior like increasing or decreasing temperature deviation between the cooler inlet and outlet temperature trends can be detected.

The chart shows the trends of Unit load, Generator seal oil cooler (PGB side) inlet, outlet and Delta temperatures.

The chart shows the Generator seal oil cooler (PGB side) inlet and outlet temperature trends. The cooler inlet temperature shown in red color, outlet temperature in green color, difference between the cooler inlet and outlet temperature ("Delta") in blue color and unit load in black color.

The data is unfiltered.

No unusual behavior was observed.

(Increase or Decrease of Delta temperature trends of the PGB Cooler temperature difference are normally a symptom for issue related to fouling of cooler and passing drain valves)

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3.5.4 Lube Oil cooler (PGB side) Performance Monitoring

trends, so that any unusual behavior like increasing or decreasing temperature deviation between the cooler inlet and outlet temperature trends can be detected.

The chart shows the trends of Unit load, Lube oil cooler (PGB side) inlet, outlet and Delta temperatures.

The chart shows the Lube oil cooler (PGB side) inlet and outlet temperature trends. The cooler

cooler inlet and outlet temperature ("Delta T") in blue color and unit load in black color.

normally a symptom for issue related to fouling of cooler and passing drain valves)

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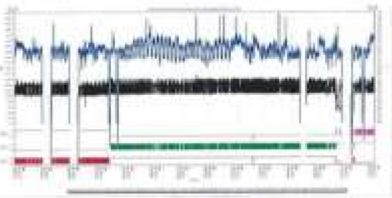
3.6 GT Auxiliary System Performance Monitoring:

3.6.1 GT Enclosure Temperature Monitoring:

This chart gives an overview of the GT Enclosure outlet temperature and SAM fan operating status trends. So that any unusual behavior like increasing or decreasing temperature can be detected.



The chart shows the trends of Unit load, GT enclosure outlet temperature trends and individual SAM fan operating status.

The GT enclosure outlet temperature shown in blue color, Unit Load in black color, SAM Fan No.1 operating status in red color, SAM Fan No.2 operating status in red color and SAM Fan no.3 operating status in purple color.

The data is filtered for RPM > 1[illegible]

No unusual behavior was observed.

(Increase or Decrease of GT enclosure temperature trends along with the number of SAM enclosure fan operating status are normally a symptom for issue related Hot gas leakage from the GT and deterioration of the GT casing insulation).

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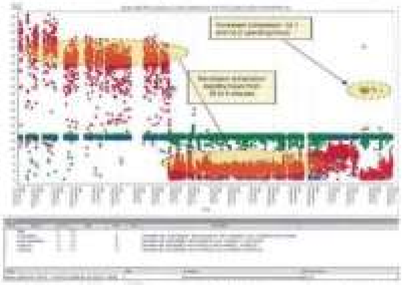
3.6.2 MBX Compressor system Monitoring:

This chart gives an overview of the GT MBX compressor no.1, compressor no.2 operating hours trends, compressor standby hours trends and parallel operation of both MBX compressor hours trends, so that any unusual behavior like increasing or decreasing MBX air compressor consumption and increasing or decreasing MBX compressor performance can be detected.



The chart shows the trends of MBX compressor no.1, MBX Compressor no.2, Parallel operation of both compressor and their standby hours trends.

The MBX compressor no.1 operating hours at single instant shown in black color. The MBX compressor no.2 operating hours at single instant shown in blue color. Parallel operation of both compressors at single instant shown in green color and compressor stand by hours at single instant shown in red color.

The data is filtered for Load > 10 MW.

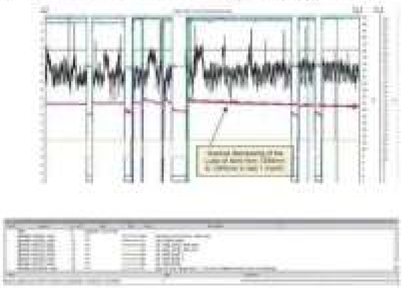
The MBX compressor standby hours decreased from average of 35minutes to 8minutes from middle of February 2014 onwards. The individual operating hours of MBX compressor no.1 and MBX compressor no.2 also observed to be increased 12minutes to about 26 minutes at many instant on July 2014. The above observations indicate either increased MBX air compressor consumption due to higher leakage or passing rate of valves in the MBX air system.

[Decreased compressor standby hours is normally symptom of Higher air consumption either due to higher leakage or passing rate of valves in the MBX air system. Increased Compressor operating hours at single instant is normally symptom of drop in that particular compressor performance]

3.6.3 Lube Oil Tank Monitoring:

This chart gives an overview of the Lube oil tank level, High and Low tank level limits, Lube oil tank temperature, GT speed and Active power output trends of last 3 months. So that any unusual behavior like increasing or decreasing lube oil tank levels due to lube oil leakage from the system

performance and potential lube oil quality issue like high foaming level by comparing the lube oil tank oil level difference between the GT operation, turning gear and stand still can be detected.



The chart shows the trends of Lube oil tank level, High and Low tank level limits, Lube oil tank temperature, GT speed and Active power output trends of last 3 months.

The Lube oil tank level summary measurement of MAV10FL001 shown in fuchsia color. lube oil

The data is unfiltered.

Gradual decr... al tank from 1209mm to 1249mm in last 1 month is observed. Detailed lube... e pipe line leakage, tank cover leakage are recommended for identifying th... tank level drop rate.

[Any unusual ... sing or decreasing Lube oil tank levels are symptom of lube oil leakage from ... ing up of water / moisture additional with the lube oil respectively.

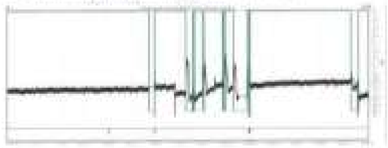
Lube oil tank ... ion are normally symptoms of Lube cooler performance deterioration ... cooler related issue.

The compari... ank level difference between the GT operations, GT Turning gear mode and G... otential symptom about the lube oil quality issue like high foaming and water in...

The higher d... vel during the turning gear operation provide potential symptom about the lea... gear pipe and heads.]

3.6.4 Lube Oil Tank Oil Vapor Exhaust system Performance Monitoring:

This chart gives an overview of the Lube Oil Tank Oil Vapor Exhaust system pressure trends, oil vapor exhaust blower operating status and GT speed trends. So that any unusual behaviors like increasing or decreasing oil vapor exhaust system pressure can be detected.



The chart shows the trends of Lube Oil Tank Oil Vapor Exhaust system pressure trends and GT speed trends.

extraction blower No.1 operating status in red color, Oil vapor extraction blower No.1 operating status in blue color and GT Operating speed in green color.

The data is unfiltered.

No unusual behavior was observed.

[Increase or Decrease of Oil Vapor Exhaust system pressure trends along with the number of oil vapor exhaust blower operating status are normally a symptom for issue related performance of oil vapor extraction system and lube oil quality]