Marsh

Marsh Specialty

Sohar3 Independent Power Project

Deep Dive Report Feb 2023

Shinas Generating Company SAOC, Oman

Prepared by: Kanchan Shere
kanchan.shere@marsh.com
Marsh (Bahrain) Company WLL - Bahrain

Following: A Deep Dive session of the Plant on 22nd Feb 2023 and discussions with the site personnel

Revision History

Revision	Date	Comments
1.0	February 2021	First issue following February 2021 survey
2.0	December 2021	Second issue following December 2021 survey
3.0	Feb 2023	Third issue following February 2023 Deep Dive session

Sohar3 IPP

Contents

Section One

Introduction

This report has been prepared following a one day physical deep dive session of the site and discussions with site management and technical specialists on 22nd February 2023. This was the third Deep Dive session by a Marsh engineer. The report provides an overall update of the organisation's operations and maintenance activities and should be read in conjunction with the latest full underwriting report (ACWA.SGC.OSR.REV.6.0).

The report provides a description of the project arrangements surveyed, and gives our opinions of the risk quality on a worldwide industry basis.

Objectives and Acknowledgements

The purpose of this report is to provide information for the client, insurers and reinsurers who may be interested in underwriting the following insurance covers for:

- Material Damage.
- Business Interruption.

Information contained in this report was to an agenda sent to the plant prior to the visit, structured meetings with the Management, Operations and Maintenance personnel together with records checks followed by a site tour. Observations made during a tour of the plant provided more information of site operations.

There was no physical testing of systems carried out at the time of this visit.

Kanchan Shere of Marsh (Bahrain) Company WLL conducted the survey. The following team accompanied the survey.

Edward Lim	- Sr. Risk Engineer	- CV Starr, Singapore
Kok Wei Cheah	- Risk Engineer	- CV Starr, Singapore
Eric The	- Sr. Risk Engineer	- HDI, Singapore

We gratefully acknowledge the contribution of everyone involved in the survey and in particular the following personnel.

Abdullah Al Nofli	- Chief Executive Officer	- Shinas Generating Company, Oman
Justin Humphrey	- Chief Operating Officer	- Shinas Generating Company, Oman
Saif Al Dhuhli	- Operation Manager	- NOMAC, Oman
Abuthahir Jahaya	- Maintenance Manager	- NOMAC, Oman
Saif Al Abri	- Shift Charge Engineer	- NOMAC, Oman
Rajesh Srinivasan	- Operation Director	- NOMAC, Oman
Aisha Al Abri	- Planning Engineer	- NOMAC, Oman

Section Two

Executive Summary

Deep Dive Overview

Avoidable expensive losses in the power generation industry are quite often caused by “failure on demand” of safety relevant equipment. Such failures may be caused by design issues, component failures, human factors, etc.

The emphasis of this Deep Dive will be to go in details on the topic of “Asset Integrity Management – Rotating Equipment” and look for any possible gaps within Operation and Maintenance departments.

The current portfolio within Power industry sees many losses centred around Machinery Breakdown of large Rotating Equipment. Large Rotating Equipment contains massive amounts of energy when in operation, hence when failures occur they are usually catastrophic due to the loss of control / loss of integrity of the machine and of that energy. Therefore, the topic of “Asset Integrity Management – Rotating Equipment” is a vital part of the healthy operation of the plant and is crucial from the Insurance point of view.

This Deep Dive review of Shinas Generating Company SAOC will be conducted by the risk engineers from Marsh and accompanied by markets engineers.

Background

The owner of the plant is Shinas Generating Company SAOC, a company registered in Muscat, Oman, with the following shareholders:

- ACWA Power International 44.9%.
- Mitsui & Co Ltd 50.1%.
- Dhofar International Development & Investment Holding Company SAOG 5%.

The project Scheduled Commercial Operation Date (SCOD) was scheduled to be 01 January 2019 but impediments encountered during the construction and commissioning phase delayed the Commercial Operation Date to May 4, 2019. The delays were largely due to HV transmission line installation and availability of Natural Gas connection. The Generator has notified Oman Power & Water Procurement Company (OPWP) that a Buyer Risk Event exists due to the delayed access and availability of Oman Electricity Transmission Company (OETC) facility required for the transportation of Electrical Energy from the Electrical Delivery Point. SGC and OPWP are engaged in concluding the determination of these Buyer Risk Events and Gas Operation Failure.

Shinas Generating Company has a 15 year Power Purchase Agreement with Oman Power and Water Procurement Company (OPWP) commencing from COD date, 4th May 2019, with payments received for capacity, and fuel cost is passed through at the guaranteed annual Heat Rate.

The Guaranteed Contract Power Capacity is 1,710MW on Natural Gas.

Fuel is natural gas is sourced from Ministry of Gas (MOG) and provided to SGC as per Natural Gas Supply Agreement (NGSA).

The “EPC Contract” is a combination of three separate contracts amalgamated under a Bridging Agreement with entities like SEPCO III of China, Power China and TIEJUN, who are parties in one or more of the three Contracts.

The Operations and Maintenance Contractor is NOMAC Oman.

Project Description

Location

The plant is located within the Sohar Industrial Port Complex, Oman.

The site is 500m long and 300m wide.

The grid coordinates for the sites are:

Co-ordinates:	Longitude	Latitude
Sohar 3 IPP	56.6400 East	24.4659 North

The size and layout of the site provides good spatial separation.

There is a regional airport located at Sohar but not yet in high demands. The nearest commercial airport is at Muscat, which is the main airport for the region and situated 240km from the power station. There was no indication of flight paths over the site during the survey.

There is good access to the site by road. The seaport at Sohar is 2km from the site.

Plant

There are two Power Blocks in the Project to produce the Power Purchase Agreement contracted net output of 1710 MW with each Block comprising:

- Two Ansaldo Energia Gas Turbines.
- Two Heat Recovery Steam Generators.
- One Steam Turbine.
- Three Generators.
- Three Step Up Transformers.
- One Seawater Cooled Condenser.

The Gas Turbines are GT26 B2.2 (2006) MXL2 version supplied by Ansaldo Energia (formerly supplied by Alstom).

The Heat Recovery Steam Generators are triple-pressure; single reheat supplied by GE (formerly Alstom) and is ASME stamped.

The Steam Turbines are single reheat condensing type turbines supplied by GE (formerly Alstom) – ND33 model.

The Generators are supplied by GE (formerly Alstom) – the generators for the steam turbines are 50WT21H-120 model and are hydrogen cooled – the generators for the Gas Turbines are 50WY23Z-124 model and air cooled.

The six Generator Step Transformers and the Gas Turbine Auxiliary transformers are manufactured in China. These were supplied by Xi'an XD Transformer Co., Ltd.

The Cooling Towers are supplied from India and are manufactured by Mundra using Fibre Reinforced Plastic. They do not have automatic fire protection installed.

The Distributed Control System is supplied by Emerson Process Controls Ltd.

There is a dedicated fire water tank supplying the firewater pumps with a capacity of 880m^3 whereas the requirement of the volume of water for two hours supply is 877m^3.

There are no shared facilities at this site. All facilities are dedicated for this plant.

The plant is designed to be able to run on back up fuel, which is fuel oil. The design includes bypass stacks to allow the GTs operate in open cycle mode if necessary.

Fuel is natural gas is sourced from the Ministry of Oil and Gas and provided to SGC as per NGSA Diesel Oil is the back-up fuel.

There is a 15 year Power Purchase Agreement (PPA) with the Oman Power and Water Procurement Company S.O.A.C (OPWP), with payments being received for capacity, and fuel cost is passed through at the guaranteed annual Heat Rate.

The planned construction duration of the project was 34 months from project effective date. A delay of 123 Days meant that the construction duration extended to 38 months and the Commercial Operation Date occurred on 4th May 2019.

Asset Integrity Management – Rotating Equipment

This Deep Dive topic of “Asset Integrity Management – Rotating Equipment” covers Gas and Steam Turbines, their Generators (rotating aspects), Large Motors, Compressors or similar such equipment.

Asset Integrity Management ensures you have the business processes, systems, tools, competence and resources you need to ensure integrity throughout the asset lifecycle. Design, operational, and technical integrity must all be managed effectively to control costs and mitigate risks. As the focus on process plant safety increases, stricter regulations and safety awareness demand better solutions for Asset Integrity Management. In addition to full compliance, operators are also expected to look for practical systems that can cater to their day-to-day needs and overcome practical issues.

The main idea behind conducting the Deep Dive session on the topic, Asset Integrity Management (AIM) offers for a complete plan-do-check-act approach for managing risk quantitatively and qualitatively.

The methodology followed to identify the gaps was based on the factors that can cause failures of these systems can be caused by the following but not limited to, factors such as:

- Component issues:
  - mechanical/electrical/physically or chemically induced failures
  - external influences like fire, flooding, explosion
  - operator/maintenance deficiencies
  - corrosion and other deterioration effects
- Latent issues:
  - Improper design

  - Inappropriate application
  - Failure to consider operating environment
  - Incompatibilities within systems
- In-Service issues:
  - Improper or inappropriate operation
  - Lack of training and competency
  - Improper or inappropriate maintenance
  - Human error
  - Wilful damage
  - Sustained overloading

Section Three

Risk Improvement Recommendations

Prioritisation

The criteria used to prioritise the recommendations are summarised in the following Table.

Code	Description
Critical	Extreme Risk; should be brought to the attention of plant management and immediately progressed.
A	High Priority; requires attention of senior management and an action plan developed as a priority
B	Moderate Risk; requires action at the earliest opportunity
C	Low Risk; Opportunity for industry best practice initiatives providing long term benefits

Recommendations Overview

Four new recommendations are raised that highlight potential areas of improvement and risk reduction. New recommendations have been well received by the management team. These recommendations are different to those ones raised as part of regular survey and are covered under the report, ACWA.SGC.OSR.REV.6.0.

Out of 18 recommendations raised during previous Deep Dive sessions, 11 are closed and on the remaining seven, there is a good progress to complete them.

New Recommendations Summary

Description	Category	Reference DDR #
GT22 Air Intake Structure Integrity	B	DDR # 2023/02/01
Cooling Tower Fire Fighting System	A	DDR # 2023/02/02
Protection Alarms Assessment	A	DDR # 2023/02/03
RCA & Control Mitigations related to CV15	A	DDR # 2023/02/04

Previous Recommendations Summary

Description	Category	Reference DDR #	Status
UPS Reliability at Offtaker premises	B	DDR # 2021/12/01	In Progress
EDG Tank Level	B	DDR # 2021/12/02	In Progress
EDG Corrosion	B	DDR # 2021/12/04	In Progress
Condition Monitoring of Electrical Systems	B	DDR # 2021/12/06	In Progress
DC Lube Oil Pump Hardwired Pressure Switch Testing	B	DDR # 2021/02/01	In Progress
Feasibility Study For DC Lube Oil Pump Starting Push Button In CCR	B	DDR # 2021/02/06	In Progress

Description	Category	Reference DDR #	Status
ST Main CV/ESV Monthly Stroking	B	DDR # 2021/02/10	In Progress

Completed Recommendations Summary

Description	Category	Reference RIR #	Status/Year
EDG Fire System Manual Activation	B	DDR # 2021/12/03	Completed (2023)
Emergency Scenarios Hard Copies	C	DDR # 2021/12/05	Completed (2023)
Checklists To Include Condition Measures	C	DDR # 2021/02/02	Completed (2021)
Checklists Reviewed By Section	C	DDR # 2021/02/03	Completed (2021)
Fuel Gas ESD Valve Testing	B	DDR # 2021/02/04	Completed (2021)
Emergency Push Buttons Testing	A	DDR # 2021/02/05	Completed (2021)
Emergency Scenarios Staff Actions Elaboration	C	DDR # 2021/02/07	Completed (2021)
Emergency Scenarios Staff Competency Assessment	B	DDR # 2021/02/08	Completed (2021)
Document Management	C	DDR # 2021/02/09	Completed (2021)
ST Main CV/ESV Tightness Testing	B	DDR # 2021/02/11	Completed (2021)
Competency Assessment Of Third Party Contractors	C	DDR # 2021/02/12	Completed (2021)

New Recommendations Details

GT22 Air Intake Structure Integrity	**Category B**	**DDR # 2023/02/01**
Date Raised / Revised	February 2023	
Risk Exposure	Machinery Breakdown	
Description	GT22 Air Intake Structure particularly the roof is exposed directly to the draft from the cooling tower. Looking from some of the other structure where it has affected, the roof could be corroded. This will lead to entry of the dirty air bypassing the first stage air intake filters.	
Recommendation	Carry out the detailed assessment and control mitigation action plan for the Air Intake structure corrosion. Include these structures in the corrosion management program and implement actions as early as possible.	
Client Response	**Feb 2023:** GT22 Intake assessment including roof are planned in unit outage, Cooling tower drift control and repair works are in progress Periodical inspection on opportunity will be performed as the task has been uploaded in SAP	

Status	**Feb 2023:** **New**

Cooling Tower Fire Fighting System	**Category A**	**DDR # 2023/02/02**
Date Raised / Revised	February 2023	
Risk Exposure	Fire	
Description	It was noted during site walk that Cooling Tower does not have any Fire Fighting system installed. The fins, Fan blade, etc are made of flammable material. Any ignition source could catch fire on the system.	
Recommendation	It is recommended to implement stringent controls for the management of Cooling Tower works: 1. Avoid any hot works on the Cooling Tower. 2. Consider installing CCTV around fan motors, to keep a close eye on any fire ignition and immediate actions taken. 3. Place Fire Extinguishers around Cooling Tower deck for easy access in case of emergency. 4. Install Fire hydrants around fan motors.	
Client Response	**Feb 2023:** Although this has been defended by SGC in previous review it is understood that the current works could cause additional risks. NOMAC have undertaken specific tool box talks and the use of powered tools is not permitted where sparks and or heat are possible. For such works requiring these, NOMAC will include specific measures for a very short duration and include a fire watch for a period of one hour after the work is completed. Additional fire extinguishers are located around the job area as additional precaution. A fire risk review and assessment will be undertaken by NOMAC corporate regarding the assessment on Cooling Towers in particular.	
Status	**Feb 2023:** **New**	

Protection Alarms Assessment	**Category A**	**DDR # 2023/02/03**
Date Raised / Revised	February 2023	
Risk Exposure	Machinery Breakdown	
Description	It was noted that during the discussion related to GT #12 CV15 incident in Nov 2022, that detailed assessment of the issue was not carried out before the unit was declared commercially available.	
Recommendation	It is recommended to conduct training session for the operations team to consider going through the O&M manuals followed by detailed assessment before declaring any unit commercially available particularly after the trip due to protection alarms. It is imperative to conduct such an assessment for the reliability of the machine.	

Client Response	**Feb 2023:** A training session for the Operations team will be undertaken which will reiterate the importance of a full and comprehensive understanding for the reasons of the trip and the possible risk areas to be investigated before the unit is declared available. This will include conformation with Ansaldo for higher risk trips of irregular occurrence.
Status	**Feb 2023:** **New**

RCA & Control Mitigations related to CV15	**Category A**	**DDR # 2023/02/04**
Date Raised / Revised	February 2023	
Risk Exposure	Machinery Breakdown	
Description	It was noted that the phenomenon of GT #12 CV15 failure seems to be possibly similar to earlier CV16 failures. If it is so, then the possibility of this happening on the other Gas Turbines needs to be risk assessed.	
Recommendation	It is recommended to conduct the RCA, carry out risk assessment of the potential similar impact on other Gas Turbines. Ansaldo to be consulted for any conditions implied on GT #12 operation without any restriction or additional operational inspections, if any. It is also to be considered to consult with Ansaldo if similar failure can happen on the other machines.	
Client Response	**Feb 2023:** At this point SGC do not wish to speculate on CV15 causes until the RCA is concluded. One in progress and is a combination of RINA and Ansaldo on behalf of SGC. SGC will actively engage with all recommendations and mitigations as identified and ensure these are followed and will engage with Marsh and the Insurers	
Status	**Feb 2023:** **New**	

Previous Recommendations Details

UPS Reliability at Offtaker premises	**Category B**	**DDR # 2021/12/01**
Date Raised / Revised	December 2021	
Risk Exposure	Machinery Breakdown	
Description	It was noted that UPS system installed at the OETC's premises monitors plant main circuit breaker position feedback and feeds that information back to plant control system for protection circuit for normal and emergency operations. The SCADA system at the OETC is fed from the UPS system and healthiness of the UPS system is extremely crucial for reliable plant operations.	
Recommendation	As part of lessons learnt from the loss incident, it is important to ensure the reliability of the UPS system. Plant needs to get in touch with OETC to understand the maintenance and operational routine testing carried out on the UPS system. If feasible/allowed, witness the routine operational testing of their UPS system.	

Client Response	**Dec 2021:** Site will engage with OETC and seek their approval for attendance during testing and understanding of their current operational and maintenance routines. **Feb 2023:** The discussions with LDC/OPWP/OETC are ongoing for receiving the reports of the tests conducted.
Status	**Dec 2021:** New **Feb 2023:** **In Progress**

EDG Tank Level	**Category B**	**DDR # 2021/12/02**
Date Raised / Revised	December 2021	
Risk Exposure	Fire	
Description	It was noted during site visit at EDG that the single diesel tank for eleven Emergency Diesel Generators was filled half of tank capacity whereas tank should never be below two-third of tank level.	
Recommendation	It is recommended that means other than sight tubes for continuous indicating of the amount of fuel in storage tank shall be provided as such that the level indicator shall activate the two-thirds tank level as stated in NFPA. It should be established that two-thirds tank level provides a minimum 2hr running capacity	
Client Response	**Dec 2021:** Tank level is maintained. The switch recommendation is under review. The tank site level indication is at fault and is being replaced by the EPC contractor. A dip check has verified the tank level is 2/3rds full. The design documents will be checked to verify the 2 hour running capacity. **Feb 2023:** Discussions are ongoing with OEM.	
Status	**Dec 2021:** New **Feb 2023:** **In Progress**	

EDG Corrosion	**Category B**	**DDR # 2021/12/04**
Date Raised / Revised	December 2021	
Risk Exposure	Machinery Breakdown	
Description	Considering the short age of the plant since COD, the amount of corrosion on all the EDGs seems to be excessive. There were metal flakes falling down from one of the EDG units. It was noted that this was due to the Cooling Tower mist causing this excessive corrosion.	

Recommendation	It is recommended to address the excessive corrosion of all EDGs at such a short span of the plant. Develop and formalise planning for corrosion rehabilitation and prevention at the site. The site should consider prevention and risk as guidance for prioritisation of effort and expense.
Client Response	**Dec 2021:** The rate of corrosion is higher in some localised areas even though the plant was designed for a coastal area. The corrosion predominates in some areas where the prevailing wind direction carries the cooling tower plume. Site is in discussions with the EPC to improve the performance of the Cooling Tower and this will be the primary focus for the root cause remedy. The EDG manufacturer will be contacted to identify additional measures that can be taken to improve the corrosion resistance of the existing installation through protective coatings or other means as part of an early intervention of this issue developing further. **Feb 2023:** The work is in progress. One EDG set exhaust hood and stack is painted followed by treatment and lamination that can withstand temperature upto 600°C. Currently, it is under test and once concluded the other EDG tests will follow the same.

Status	**Dec 2021:** New **Feb 2023:** **In Progress**

Condition Monitoring of Electrical Systems	**Category B**	**DDR # 2021/12/06**
Date Raised / Revised	December 2021	
Risk Exposure	Machinery Breakdown	
Description	Currently the scope of thermography is limited to equipment which are exposed and can be reached. The thermography is not performed for the enclosed equipment whose terminals are not accessible.	
Recommendation	By considering the current difficulty in extending the scope of infrared survey program to switchgear, transformer, etc while energised, the purchase of ultrasonic listening equipment should be considered. Example: Ultraprob equipment (ACWA SWEC plant is using Ultraprobe 1500 successfully for monitoring switchgears, transformers, transformer bushing, etc.)	
Client Response	**Dec 2021:** Site will review the equipment for monitoring of live electrical equipment including the example vendor mentioned above. **Feb 2023:** Equipment ordered, expected to be delivered by end of March 2023.	
Status	**Dec 2021:** New **Feb 2023:** **In Progress**	

DC Lube Oil Pump Hardwired Pressure Switch Testing	**Category B**	**DDR # 2021/02/01**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	Current ST DC Lube Oil Pump connection from DCS testing is carried out on annual basis during scheduled outage. For DC pump to start automatically in case of emergency while DCS is not available, it is imperative to ensure integrity of the hardwired connection.	
Recommendation	The hardwired connection should be tested for its functionality during annual outage period and the type of pressure switch should be confirmed to be fail-safe contact (NC contact). The soft-wired trip should be disabled during this test to ensure the trip has been initiated by the hard-wired trip.	

Client Response	**Feb 2021:** Feasibility will be checked in consultation with OEM Nomac would propose local start from panel for testing **Dec 2021:** Request is sent to OEM, GE is expected to reply by end of Dec 2021. **Feb 2023:** Reminders have been sent to GE from both NOMAC and SGC
Status	**Feb 2021:** New **Feb 2023:** **In Progress**

Feasibility Study For DC Lube Oil Pump Starting Push Button In CCR	**Category B**	**DDR # 2021/02/06**

Date Raised / Revised	February 2021
Risk Exposure	Machinery Breakdown
Description	Failure of the DC Lube Oil pump to start, or start in a timely manner when needed, has resulted in numerous cases of substantial loss. One such scenario is the loss of the DCS system in a trip situation, where a start signal to the DC pump isn't initiated. In that instance, critical time can be lost, before a start is initiated from the local control/MCC. For this reason, it is beneficial to have a remote (in the CCR) hard-wired connection to the pump start/MCC allowing immediate response.
Recommendation	It is recommended site to undertake a feasibility study into the installation of a hard-wired, independent and fast acting connection for starting the DC L.O pump from the CCR
Client Response	**Feb 2021:** Please refer DDR # 2021/02/01 **Dec 2021:** Same feedback as DDR # 2021/02/01 **Feb 2023:** Pushing GE for the feedback from both NOMAC and SGC.
Status	**Feb 2021:** New **Feb 2023:** **In Progress**

ST Main CV/ESV Monthly Stroking	**Category B**	**DDR # 2021/02/10**

Date Raised / Revised	February 2021
Risk Exposure	Machinery Breakdown
Description	It was noted that Steam Turbine Control and Stop valves are not tested for freedom test as part of the routine tests. If the Steam Turbine is in continuous operation, the valves might be in the same position for a long time and hence testing of these valve for their freedom of movement is critical.

Recommendation	Include testing of the Steam Turbine control and stop valves for the freedom of their movement as part of the monthly test. Include these in SAP as notification for tracking purposes.
Client Response	**Feb 2021:** Stop valve freedom test is in follow up with EPC as warranty Control valves are always in movement, as per operating philosophy **Dec 2021:** There are issues identified in completing the valve freedom test. This has been referred with OEM and waiting for the answer. **Feb 2023:** No progress so far.
Status	**Feb 2021:** New **Feb 2023:** **In Progress**

Completed Recommendations Details

EDG Fire System Manual Activation	**Category B**	**DDR # 2021/12/03**
Date Raised / Revised	December 2021	
Risk Exposure	Fire	
Description	It was noted that EDG Diesel tank is provided with fire system manual activation by means of manual operating call points located just adjutant to the diesel tank. In the inadvertent event of fire, it will not be safe for anyone to approach close to the manual operation call point to activate the sprinkler system. Hence it is important to locate the manual call point at a safe location.	
Recommendation	It is recommended that a feasibility study be carried out on EDG Diesel tank fire system manual operating call points and if feasible, they should be relocated to give safe access to manual operating call point in the inadvertent case of EDG Diesel tank fire.	
Client Response	**Dec 2021:** The manual call point is accessible although noted that in the advent of a fire it would be unsafe for normal operational personnel to activate in all scenarios. A feasibility study will be carried on the manual operating call points for relocation or for an additional point of activation. **Feb 2023:** Two manual call points are provided for safe activation in case of emergency.	
Status	**Dec 2021:** New **Feb 2023:** **Completed**	

Emergency Scenarios Hard Copies	**Category C**	**DDR # 2021/12/05**
Date Raised / Revised	December 2021	
Risk Exposure	Machinery Breakdown	

Description	All the Operational and Maintenance procedures are stored electronically on the server under the Document Management System. However, during the event when the server is not accessible, the procedures will also not be available and the access to Emergency scenario procedures will be restricted.
Recommendation	For better access to Emergency scenario procedures during emergency situations when the access to Document Management Server is restricted, the procedures should be easily accessible. Hence, it is recommended to store a hard copy of only Emergency scenarios in the Control Room. The desktop exercises should be conducted for people to be aware of the access and appropriate use of them. Hard copies should include last review date and forecast next review dates so that everyone knows they are using the most current version.
Client Response	**Dec 2021:** Following the Deep Dive Survey, the latest hard copy was printed and put into the CCR and the team made aware of the same.
Status	**Dec 2021:** **Completed**

Checklists To Include Condition Measures	**Category C**	**DDR # 2021/02/02**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	Plant checklists often require a simple “tick” that the check was made. This foregoes the opportunity to gather critical information as to the state of the aspect (heat, pressure, level, flow etc.) being measured. Operational parameters measured will have safe operating ranges and it is critical to observe and record where within that safe operating range the current condition is sitting. Recording and trending of such conditions allows prediction of faults, likewise indicators to those observing the condition whether action is required.	
Recommendation	It is recommended that plant review and amend where necessary, plant check lists to include: • Parameter Range • Record of parameter state (measurement of heat, pressure, level, flow etc.) • Recording of parameter OK / NOT OK Plant check records should be filled, trended, analysed and recorded.	
Client Response	**Feb 2021:** Will be reviewed and modified on feasible check lists **Dec 2021:** Most of the checklists are updated however fine tuning as found will be carried out.	
Status	**Feb 2021:** New **Dec 2021:** **Completed**	

Checklists Reviewed By Section	**Category C**	**DDR # 2021/02/03**

Date Raised / Revised	February 2021
Risk Exposure	Machinery Breakdown
Description	The Plant Checklist of the operational routines are included with a section as "Reviewed By" which was left blank in many checklists submitted.
Recommendation	The purpose of the "Reviewed By" is to someone on the supervisory level to oversee the field readings to compare them with the normal operating limits. If this can be certified by the person who takes reading, the procedure needs to be amended accordingly or training to be arranged for staffs to review the checklist and sign the documents.
Client Response	**Feb 2021:** The same is followed and signed off, local checks will be carried out to comply **Dec 2021:** All checklists are reviewed and signed by respective section heads.
Status	**Feb 2021:** New **Dec 2021:** **Completed**

Fuel Gas ESD Valve Testing	**Category B**	**DDR # 2021/02/04**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	The ESD installed on the incoming single stream gas supply line can only be tested during complete plant shutdown. The last time this valve was tested was during commissioning time. It is very essential to test the reliability of this valve for its appropriate functioning when required during emergency.	
Recommendation	It is recommended to develop the testing plan for the ESD during annual planned outage or at appropriate frequency in line with O&M philosophy.	
Client Response	**Feb 2021:** The activity is scheduled in SAP and available in outage plan **Dec 2021:** Activity is already planned for upcoming complete plant outage and is available in SAP for automatic workorder notification.	
Status	**Feb 2021:** New **Dec 2021:** **Completed**	

Emergency Push Buttons Testing	**Category A**	**DDR # 2021/02/05**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	There are a number of emergency push buttons installed in the plant. All of them should be tested during scheduled annual outage. There are some Hybrid push buttons that includes hard and soft signals to trip the Gas Turbine unit and these should be tested for their respective loop.	

Recommendation	Develop annual testing plan for the Emergency push buttons during outage including the Hybrid push buttons installed in the Gas Turbine enclosure that connects through DCS as a soft loop and there is a hard wired connection connecting to the controller tripped the unit. All such push buttons should be inventoried and tested during annual outage of the respective unit. There should be notifications available is SAP for these.
Client Response	**Feb 2021:** The same is exercised and protocol will be developed, list to be prepared and SAP notification in annual outage to be raised. **Dec 2021:** Push buttons are tested for GT22 during outage and SAP automatic workorders are set for other units as per outage schedule.
Status	**Feb 2021:** New **Dec 2021:** **Completed**

Emergency Scenarios Staff Actions Elaboration	**Category C**	**DDR # 2021/02/07**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	Emergency scenarios are captured as part of Emergency Response Plan however they could be further improved with clear guidance of the operators actions during such emergencies. Once captured they need to be tested by conducting desktop exercises.	
Recommendation	Capture all possible technical scenarios as part of the Emergency Response Plan with listing specific actions by the operators during such emergencies. The examples of such technical scenarios could be, Lube oil spillage and fire, emergency lubrication system failure, GCB not opening, EDG not starting, freeze-up of control system, stuck steam admission valves, contamination of water steam cycle with chemicals from the water treatment plant, etc. Conduct desktop exercises with records of doing so.	
Client Response	**Feb 2021:** Available scenarios will be shared and with staff actions **Dec 2021:** 18 emergency scenarios including technical scenarios are developed with specific concerned staff action points.	
Status	**Feb 2021:** New **Dec 2021:** **Completed**	

Emergency Scenarios Staff Competency Assessment	**Category B**	**DDR # 2021/02/08**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	

Description	In the previous recommendation, emphasis has been placed on the importance of procedures. Equally so is the importance that people are trained and competent to fulfil their duties correctly in emergencies, as outlined in those procedures.
Recommendation	It is recommended that site include actions listed in various emergency scenarios as part of the position competency assessment carried out on annual basis.
Client Response	**Feb 2021:** Qual book and interview assessment shall be shared **Dec 2021:** Assessment is included as part of permit to work assessment carried out every two years. Emergency scenarios knowledge assessment is part of these assessments that include written test and personal interview process.
Status	**Feb 2021:** New **Dec 2021:** **Completed**

Document Management	**Category C**	**DDR # 2021/02/09**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	It was noted during discussions that some old procedures are still in use while the latest version procedures were already released. The document management needs to be controlled as such the access to old documents is disabled followed by communication to all staff that new documents are released.	
Recommendation	Establish a robust document management system wherein version control and staffs communication is managed in such a way that old documents should not be available to staff and they are aware of the release of the new versions.	
Client Response	**Feb 2021:** Will be reviewed and updated, and document list will be shared with update. **Dec 2021:** Process is in place to review all O&M procedures every two years as part of IMS auditing requirement. Procedure is pre maturely reviewed if there are any changes made. All such changes are communicated to all staffs as part of automatic mail generated with acknowledgement. There is a dedicated person overlooking and managing the document management system.	
Status	**Feb 2021:** New **Dec 2021:** **Completed**	

ST Main CV/ESV Tightness Testing	**Category B**	**DDR # 2021/02/11**
Date Raised / Revised	February 2021	

Risk Exposure	Machinery Breakdown
Description	It was noted that the Steam Turbine control and stop valve tightness test were performed during commissioning but since then the tightness test has not been performed. It is very important to ensure the tightness of these valves during ST shutdown or trip to ensure tightness of these valves to avoid any passing resulting in turbine overspeeding.
Recommendation	Include testing of the Steam Turbine control and stop valves tightness at the time of start-up of the Steam Turbine post any outage and at least with the frequency of once in a year. Include these in SAP as notification for tracking purposes.
Client Response	**Feb 2021:** Feature available and exercised before startup SAP notification will be implemented on annual basis **Dec 2021:** Tests on both units are completed during scheduled outage and are successfully completed.
Status	**Feb 2021:** New **Dec 2021:** **Completed**

Competency Assessment Of Third Party Contractors	**Category C**	**DDR # 2021/02/12**
Date Raised / Revised	February 2021	
Risk Exposure	Machinery Breakdown	
Description	The current process for competency assessment of third party contractors engaged in carrying out works at site involves assessment of the company records but not the particular individuals who would be engaged in carrying out the job at site.	
Recommendation	It is recommended to assess the competency of third party contractors (individual staff members) to capture competency of individual personnel undertaking the jobs at site and formalize the feedback.	
Client Response	**Feb 2021:** Process in place, will be shared in co-ordination with Supply chain **Dec 2021:** Process is in place for departmental review of the competency assessment and also ensuring that same person is undertaking the job as part of the CV provided during initial discussion. A feedback mechanism is also in place to consider it for further jobs on site.	
Status	**Feb 2021:** New **Dec 2021:** **Completed**	

Section Four

Process Description

Overview

The plant configuration is designed in two blocks for a total power generation capacity at reference conditions delivering 1,710 MW of electrical output. The two Power blocks in the project with each block comprising of the following:

- Two Ansaldo Energia Gas Turbines.
- Two Heat Recovery Steam.
- One Steam Turbine.
- Three Generators.
- Three Step Up Transformers.
- One Seawater Cooled Condenser.

Gas Turbines

Four units of dual fuel Gas Turbines from Alstom of type GT26 (2006) are installed having 22 compressor stages, 3 variable guide vane rows, 5 turbine stages, 2 combustion chambers with 24 fuel nozzles per combustor. The GTs have capability of automatic changeover from gaseous fuel to Fuel oil at base load. The GT technology selected to fulfil these requirements is based on components and concepts well-proven throughout Alstom's gas turbine product line:

- Robust welded rotor design
- Low NOX EV burner
- Compact annular combustor
- State-of-the-art Gas Turbine controls
- Proven mechanical and electrical auxiliary systems

The GT26 gas turbine is specifically developed for combined cycle applications, with above 58% efficiency; it is designed to burn natural gas as a primary fuel and diesel (No. 2 oil) as backup fuel.

Highly-efficient compressor
The development of the GT26 compressor is the result of an evolutionary process with a gradual increase in the pressure ratio to over 30 bar. The GT26 employs controlled diffusion airfoil (CDA) blading, where each compressor stage is individually optimised according to specific requirements and boundary layer conditions. This leads to high overall compressor efficiency while retaining a high surge margin. In addition, three rows of variable guide vanes are used to optimise the operation concept at every load. Two fully annular combustion chambers distribute the circumferential temperature evenly. This simple design does not require cross-firing tubes or transition pieces. EV (Environmental) burner technology, operating successfully for several millions of hours throughout the Alstom gas turbine fleet, gives long burner life, no maintenance between hot gas path inspections and low emissions. The EV burner gives the benefit of dry low NOx combustion for operation with different natural gases, with the option to run with liquid fuel as an alternative.

EV combustor
The EV combustor has an annular burner arrangement. The GT26 is fitted with 24 retractable EV burners. Each operates over the whole load range. Compared to other combustor arrangements, the annular combustor distributes the hot gas, circumferentially, at a much more uniform temperature. Radial temperature uniformity is

accomplished by pre-mixing virtually all incoming compressor air with the fuel in the EV burner, and by the absence of film cooling in the convection-cooled combustor walls. This produces a single, uniform flame ring in the free space of the EV combustion zone. A key benefit is that the flame has no contact with the walls of the burner. These design features distinguish the EV combustor significantly from other combustion systems.

SEV combustor

In the annular SEV combustor, the combustion process is repeated as in the EV: vortex generation, fuel injection, pre-mixing and flame stabilisation in a vortex. The SEV combustor consists of 24 burners distributed in a ring, followed by an annular combustion zone surrounded by convection-cooled walls. Exhaust gas from the EV = Environmental

Turbine

The sequential combustion concept results in a gas turbine exhibiting extremely high power density resulting in the smaller blade dimensions of the GT26 machines. The five rows of turbine blades (1 stage in the high pressure turbine, 4 stages in the low pressure turbine) are anchored in fir tree slots. Air from the compressor cools the high-pressure turbine stage and the first three low-pressure turbine stages utilizing a combination of film and convection cooling techniques. Axial exhaust system The exhaust diffuser directs the exhaust gases into the exhaust duct. It also
recovers pressure energy from the kinetic energy of the exhaust stream, therefore improving the efficiency of the gas turbine.

Combustion System

EV burner

For enabling lowest NOx emissions from the EV burner and to maximize operational reliability, the GT26 is equipped with an internally staged premix burner concept. The injection of fuel gas is divided between the burner air slots and the centre of the burner cone. Both stages are in operation over the entire operation range, from ignition to base load.

SEV burner

In the SEV burner, where the incoming hot gas has considerably lower oxygen content than normal air, less oxygen is available for NOx formation. Furthermore, because the SEV air is at a temperature considerably higher than conventional combustion air, it requires less heating to reach flame temperature. Both of these NOx mitigation phenomena are known from other combustion technologies that employ exhaust gas recirculation. Although a large amount of the total fuel is burnt in the SEV combustor, the very low NOx formation means that emissions remain
similar across the SEV combustor. The combination of the two combustion systems – EV and SEV– result in low NOx emissions without additional water injection or Selective Catalytic Reactors (SCR), and low CO emissions.

Gas turbine details are shown in the following Table.

Combustion Turbine	**GT11, GT12, GT21, GT22**
Manufacturer	Ansaldo Energia
Type	GT26
Model	GT26 B2.2 (2006) MXL2
Country	Switzerland
Serial number	G2698/G2699/G26100/G26101
Year of manufacture	2014
Speed (rpm)	3,000
Rated capacity (MW)	293.08

Combustion Turbine	**GT11, GT12, GT21, GT22**
Compressor stages	22
Compressor pressure ratio	1:32
Combustor	2
Combustor type	Annular
Nozzles	EV (24) / SEV (24)
Fuel	Natural Gas and Fuel Oil
Turbine stages	1 HPT and 4 LPT
Starting	Static Frequency Converter, 1 per Block
Service	Base and Part Load operation
Control	ControGas
Spacing	40m (centre line)
Exhaust mass flow (kg/s)	599.164
Exhaust Temperature (°C)	645.7

Notes:

1. Maximum Continuous Rating on Gas with Evaporative Cooling and High Fogging On with ambient conditions 0.976 bar, 50°C and 30% relative humidity.

Vibration Alarm and Trip settings for the GTs are 7.5 mm/s and 11.8 mm/s.

The two Steam Turbines are from Alstom of type STF30C with sliding pressure mode of operation at loads above 50% otherwise fixed. The ST comprises of one single flow HP and IP Turbine and one double flow LP Turbine.

The three-cylinder steam turbine consists of standardized inlet- and exhaust modules. The modules are members of the ALSTOM range of steam turbine components, which can be combined, to adapt to a wide range of steam conditions, rated power and configurations. The main features of the proposed steam turbine concept are as follows:

- Double shell design for all cylinders
- Reaction type blading
- Precision forged last stage rotating blades
- Monobloc HP-rotor and welded (build-up) IP- and LP- rotor
- Integral expansion sleeve coupling

Maintaining control of differential expansion between rotating and static components is achieved by careful selection of fixed points. The axial fix points for the turbine casings are at the exhaust end of the IP- turbine for the HP- and IP turbine and at the LP- turbine. The expansion of the IP- turbine is transmitted to the HP- turbine via the sliding radial /thrust bearing pedestal arranged between the two casings. The HP-casing rests on sliding supports on the fixed front bearing. The fixed point of the shaft line is located at the thrust bearing between HP- and IP turbine. The advantage of this design is to minimize differential expansion between static and rotating elements.

The condenser is water cooled surface type.

STEAM TURBINE - General Specifications

Designation	ST10 and ST20
Spacing	Separate Buildings

GENERAL	Single Reheat Condensing type
Service Status	Base Load and Partial Load
Number of units	2
TURBINE	
Designer	GE (formerly Alstom)
Type & N° of cylinders & reheat	DKYZZ3-2N41
Manufacturer / Year	2016
Model #	D652-41
Rating (MW)[1]	326
Speed (RPM)	3,000
LP R0 Size and Material	1,164 mm; ST11TNIE
LUBRICATING OIL/SEAL OIL	
Type	Sinopec 46/Total Preclia 68 ISO VG 32/46
Piping	Welded – single walled, SS
Containment	Enclosed Room
Reservoir location	ST Building basement
HP / IP / LP STEAM	
Flow (kg/s)	173.985 / 201.32 / 16.596
Pressure (Mpa)	162.35 / 35.663 / 5.298
Temperature (°C)	584.5 / 584.5 / 289.9

Heat Recovery Steam Generators

Four triple pressure HRSG units for outdoor installation are of horizontal configuration, OCC Module assembly (natural circulation) and include the following main features:

- Triple pressure horizontal natural circulation heat recovery steam generator
- Outdoor installation
- ‘Cold casing’ design
- High degree of standardization
- Serrated finned tube design
- Large steam drums
- Top supported/suspended heat surfaces

These triple pressure horizontal natural circulation heat recovery steam generator for outdoor installation is installed to generate the steam for the steam turbine set, utilizing the waste heat from the gas turbine (GT) exhaust.

HRSG - General Specifications

Designation	HRSG11, HRSG12, HRSG21 and HRSG22
Service Status	
Bypass Stack	Yes – Diverter damper Hangzhou
Spacing	25m
GENERAL	Triple Pressure Boiler
Number of units	4

Designer	Nooter Eriksen
Manufacturer / Year	2018
Serial#	160700/1
Type	Horizontal Duct and Vertical tube boiler, Natural circulation
Steam flow (t/h) SH / RH	308.324/346.271
Steam pressure (MPa) SH / RH	16.586/3.649
Steam temperature (°C) SH / RH	587.0/587.3
Boiler Fuels	Exhaust Flue Gas from GT
N° of burners & type	NA
Burner Interlocks & Controls	Available
Boiler interlocks (level, temp, press)	Yes
BOILER FEED PUMPS	3
Driver & redundancy	Yes
MISCELLANEOUS Deaerator, Preheater pumps, CEMS	
Water Chemistry Testing/Controls	Yes (SWAS, LAB/Chemicals, Blowdown)

Generators

Four air-cooled gas turbine generator units are provided and two H2-cooled generators for the steam turbines are provided.

GT Generator Main Features

- General
  - Two pole turbo generator
  - Design according to the latest IEC recommendations
- Stator and Rotor
  - Micadur® insulation system patented by Alstom (vacuum pressure insulation, VPI)
  - Roebel® type winding design patented by Alstom
  - Class F insulation for stator and rotor winding
  - Rotor equipped with a wedge based damper winding
  - Insulated bearings in combination with shaft grounding
- Cooling System
  - Closed circuit air cooling with air/water heat exchangers (TEWAC design)
  - Open air cooling circuit independent from generator cooling system for the slipring housing.
- Excitation
  - Static excitation

ST Generator Main Features

- General
  - Non-salient, two pole turbo generator
  - Design according to IEEE/IEC recommendations
  - Terminal location three on top and three on bottom of generator housing
- Stator and Rotor
  - Micadur® insulation system patented by ALSTOM
  - Roebel® type winding design patented by ALSTOM

  - Class F insulation for stator and rotor winding
  - Rotor equipped with a wedge based damper winding
- Bearings
  - Insulated bearings in combination with shaft grounding system
  - Bearings separated from the generator housing and decoupled from shaft seals
- Cooling System
  - Closed circuit H2 cooling with H2/water heat exchangers incorporated in the housing
  - Very effective self-ventilated H2-cooling system for stator and rotor
  - Minimised fouling of cooling paths inside the generator, thus providing constant performance over the entire generator lifetime.
- Excitation
  - Static excitation

Generator	**ST**	**GT**
Manufacturer	GE	GE
Type	50WT21H-120	50WY23Z-124
Rated Voltage (kV)	20	21
Rated MVA	440	380
Speed (rpm)	3000	3000
Year of manufacture	2017	2017
Rotor Cooling	Hydrogen	Air
Stator Cooling	Hydrogen	Air
LUBRICATING/SEAL OIL	Yes/Yes	Yes/No
Type	ISO VG 32/46	ISO VG 32/46
Tank Volume (US Gallons)	4649.4281	8453.5057

Vibration Alarm and Trip settings for the Generators are 165 µm and 240 µm.

Hydrogen is not manufactured on site and is delivered and stored in bottles on site.

Emergency Diesel Generator (4 Nos)	
Supplier	Shandong Supperwatt Power Equipment
Engine	Perkins
Rated Output (kW)	1800 kW
Speed (RPM)	1500 rpm

Black Start Diesel Generator (8 Nos)	
Supplier	Shandong Supperwatt Power Equipment
Engine	Perkins
Rated Output (kW)	2330 kW
Speed (RPM)	1500 rpm

Transformers / Switchyard

Transformers

Designation	GTs	STs
Number	11,12,21,22 BAT10	18BAT10

Manufacturer/Country	XIAN XD Transformer co. LTD / China	XIAN XD Transformer co. LTD / China
Year Manufactured	2017	2017
Type	SFZ-410000/400	SFZ-450000/400
Serial #	2017020182/ 183/184/185	2017020186 /187
Rating (MVA)	228/410	270/450
Serial Voltage (kV)	400/21	400/20
# Phases	3	3
Frequency (Hz)	50	50
Cooling	ONAN/ONAF	ONAN/ONAF
Vector Group	YNd11	YNd11
Oil type	DIALA S4	DIALA S4
Oil Capacity (kg)	90000	95000
Total Weight (kg)	430000	472000
Drainage/Containment	YES	YES
Separation	External	External
Blast wall to NFPA 850	Yes	Yes
Oil filled Condenser type Bushings	High Voltage: Trench High Voltage Products, Model: ETG 420/120 Low Voltage: Nanjing Zhida Electric Co Ltd, Model: BFW-24/16000-4 Neutral: Nanjing Zhida Electric Co Ltd, Model: BRDLW-126/1250-4	
OLTC	UCLRN650/900A/W	UCLRN650/900A/W
Protection Relays	Yes	YES

The factory acceptance tests of the power transformer have been carried out according to the requirements of IEC 60076.I-2011, IEC 60076.2-2011 IEC 60076.3-2013, IEC 60076.10-2001.

All power transformers for four GTs and two STs were tested on site before putting them in service. Tests such as Insulation Resistance, Winding Resistance, Polarity, LV/HV Bushing, Dielectric & Capacitance, functional checks for protections,

The mineral oil used has been certified to meet DIN 51353, ASTM 1275B and IEC 62535 for Corrosive Sulphur.

The step up transformers have on line Dissolved Gas Monitors installed which are supplied by Totus and the model is TTM. Monitoring of DGA, PD and bushing is included. Each fault gas is monitored and displayed on a monitor in the control room. https://www.camlingroup.com/product/totus

All medium voltage cables were specified to comply with the non-flame propagation and non-fire propagation (category C) tests as per IEC 60332-1-1 and IEC 60332-3-24 respectively.

All main six transformers are connected with substation through underground Cu/XLPE/AWA 1200mm^2 cables. The plant battery limit lies up switchgear GIS isolator terminals. The cable lengths vary between 120-220m as per the distance between the transformer and substation.

UPS / DC Power Supplies

The Uninterruptible Power Supply (UPS) for the safe 220V AC Distribution Boards (with normally open sectionaliser) are supplied through two static inverters from the 220V DC Distribution Boards (with normally open

sectionaliser). There is a bypass switch on each inverter. The system is supplied by Emerson Network Power/Vertiv.

The 220V DC distribution system is directly fed from the batteries. Critical loads with two off 100% redundancy are supplied from both DC systems.

All DC loads necessary for a safe shut-down of the plant in case of an AC failure are supplied from the DC distribution systems. The most important of these loads include the emergency lube oil pump; the emergency seal oil pump, the UPS inverter, the dc converters, and solenoid valves.

The batteries are supplied by Hoppecke.

Both battery modules are in the same closed room which is provided with adequate safety signals, fire detection, air ventilation and eye-washing device. Electrical installation is Ex-type.

Section Five

Deep Dive Findings

Findings

The findings below result from discussions and observations during the Deep Dive survey. The intention is that the narrative in the findings provides context for the recommendations and ratings given.

Systems

NOMAC is contracted to operate and maintain the Sohar3 IPP. NOMAC is a mature organisation that has long provided Power Generation O&M services within various GCC countries. The site is largely equipped with systems and procedures developed by NOMAC. These appear adequate for routine operations and maintenance activities. NOMAC has introduced the SynergiLife platform, and it was advised that some site processes are shifting to this platform, *e.g.* the Trip investigation and the Management of Change process. The site uses SAP as its Computerised Maintenance Management System (CMMS) and uses this application extensively. SAP has the facility to categorise work orders and preventative maintenance routines and has assigned appropriate priority to Safety Critical Devices when maintenance is required. NOMAC also uses guidelines from EPRI for implementing the PM plans whichever is stringent. Therefore, PM plans are implemented not only in line with OEM but also with EPRI recommendations. Single point of failure study has been carried out.

Procedures

The site has adequate procedures for routine Operations and Maintenance. These are procedures based on the NOMAC templates based on OEM manuals and are revised as per EPRI standards. As mentioned, existing procedures are for routine and mainstream activities. All EPC submitted documents are stored under SharePoint where the access is given to all staffs to access latest documentation. As per IMS requirements, all procedures are reviewed every two years and any change in document revision is automatically intimated to all staffs with detailing the change.

During the Deep Dive session in 2023, a new risk improvement recommendation was raised about protection alarms needs to be assessed thoroughly before releasing the unit for commercial operation after tripping due to protection alarms.

Implementation

The site has made good progress in establishing and implementing an emergency response procedures however, specific process related emergency procedures are being included in the emergency response plan. The suggested enhancement it to widen the scope and conduct desktop exercises for these emergency scenarios to ensure the operations staffs take immediate and accurate steps during those emergency situations. The availability of most up to date documents in the control room is the important factor to ensure that staffs refer to the correct documents. It is also important that whenever there is a change in the documents, it is immediately communicated to all staffs with revision numbers, date and detailing the change for their easy reference, and this is now followed. A dedicated person monitors the document management system and communication.

Recommendations has been raised in relation to UPS system reliability at OETC end installed panels that gives feedback of each unit circuit breaker needs to be ensured that regular PMs are followed on system is reliable.

Few more recommendations have been raised related to EDG to maintain the level upon usage and location of fire system manual activation. Excessive corrosion on all EDGs due to the mist coming from nearby cooling tower is a concern and needs immediate attention followed by long term mitigation plan.

A separate recommendation has been raised about electrical equipment condition monitoring program. Since the switchgears, transformers and bushings are enclosed, thermography techniques may not give the appropriate results and hence using ultrasonic equipment is recommended. This practice is been used within some of the other ACWA assets.

During the Deep Dive session in 2023, a new recommendation has been raised about GT #22 Air Intake structure roof assessment for accelerated corrosion due to the direct draft from the nearby cooling tower. Also another recommendation about cooling tower fire fighting system has been raised.

Review

Currently there are various points of audits, from plant side and also from corporate side and all audit points are tracked. Lessons learnt from the same technological machines are discussed and staffs are made aware and the same platform is used for corporate information used to track these lessons learnt and share among the staff.

The operations department routine checklists based on previous recommendation are included with analogue value limits and are reviewed by respective section heads.

As part of IMS external audit, all procedures are reviewed on two yearly basis and are recorded under document management system, managed by a dedicated person.

During the Deep Dive session in 2023, a new risk improvement recommendation was raised about protection alarms needs to be assessed thoroughly before releasing the unit for commercial operation after tripping due to protection alarms.

Awareness & Training

The management is in collaboration with external technical institute to train the operations and maintenance staffs.

During the ongoing Covid-19 situation, plant has implemented departmental specific online training courses that covers technical and HSE sessions using Mishkaty.

Testing of the emergency scenarios as Desktop exercises is one of the best industry practice to keep the staff aware of their expected actions in case of real emergencies to avoid potential losses and is subject to a completed recommendation raised last year.

Another completed recommendation raised last year relates to the operational department routine check sheets to include condition measures such as, normal operating range. This helps the operator taking the reading to identify the abnormal readings and take appropriate measure immediately.

Competency

Currently, the plant management follows the practice of written tests for O&M competency assessment on two year basis which is also used for permit authorization process, which is a good practice. There is also a good practice followed to conduct a Tool Box Talk about Emergency scenarios and trips to talk about the lessons learnt.

As part of the competency assessment program, same two year assessment is used to test the knowledge about emergency scenarios. This will ensure that the emergency procedures available in the control room are referred not only during the actual scenarios but on regular basis. This will ensure that staffs are aware of the actions expected from them during such emergencies. Valuable time could be saved while referring to those documents during emergencies by operators/shift charge engineers initiating actions immediately.

Documentation

The documents are managed through the centralized document management system SharePoint, with each procedure properly coded with unique number. As per the IMS guidelines, all the procedures are to be reviewed at an interval of every two years and is followed on. The document management system version control and staffs communication is managed by a dedicated person in such a way that old documents are not available to staff and they are aware of the release of the new versions. System is designed as such that automatic emails are sent to all concerned staffs.

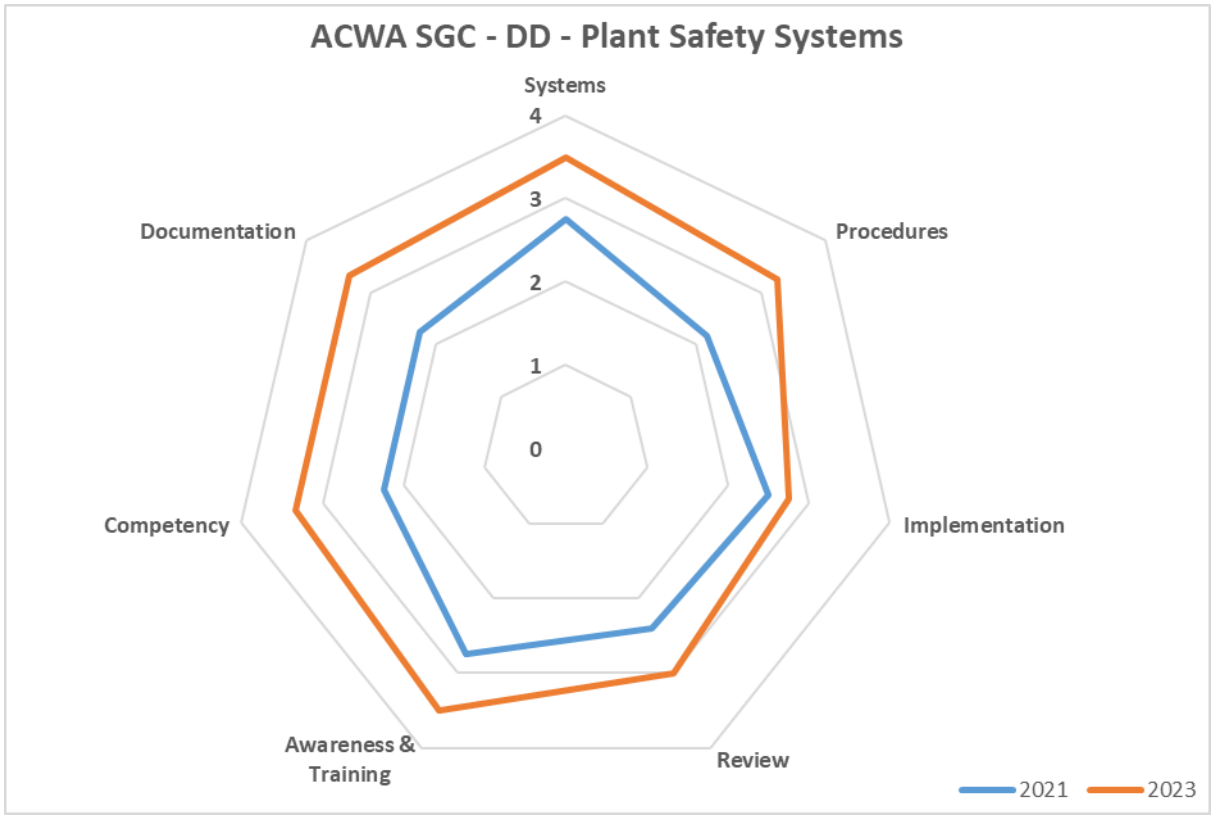
Performance Score

Based on the discussions with site management, the recommendations have been raised for further improvements in the area of Human Elements. The Radar Chart below is the reflection of the findings discussed, recommendations raised and the site Operation and Maintenance practices, measured against a standard set of seven features named, Systems, Procedures, Implementation, Review, Awareness & Training, Competency and finally Documentation.

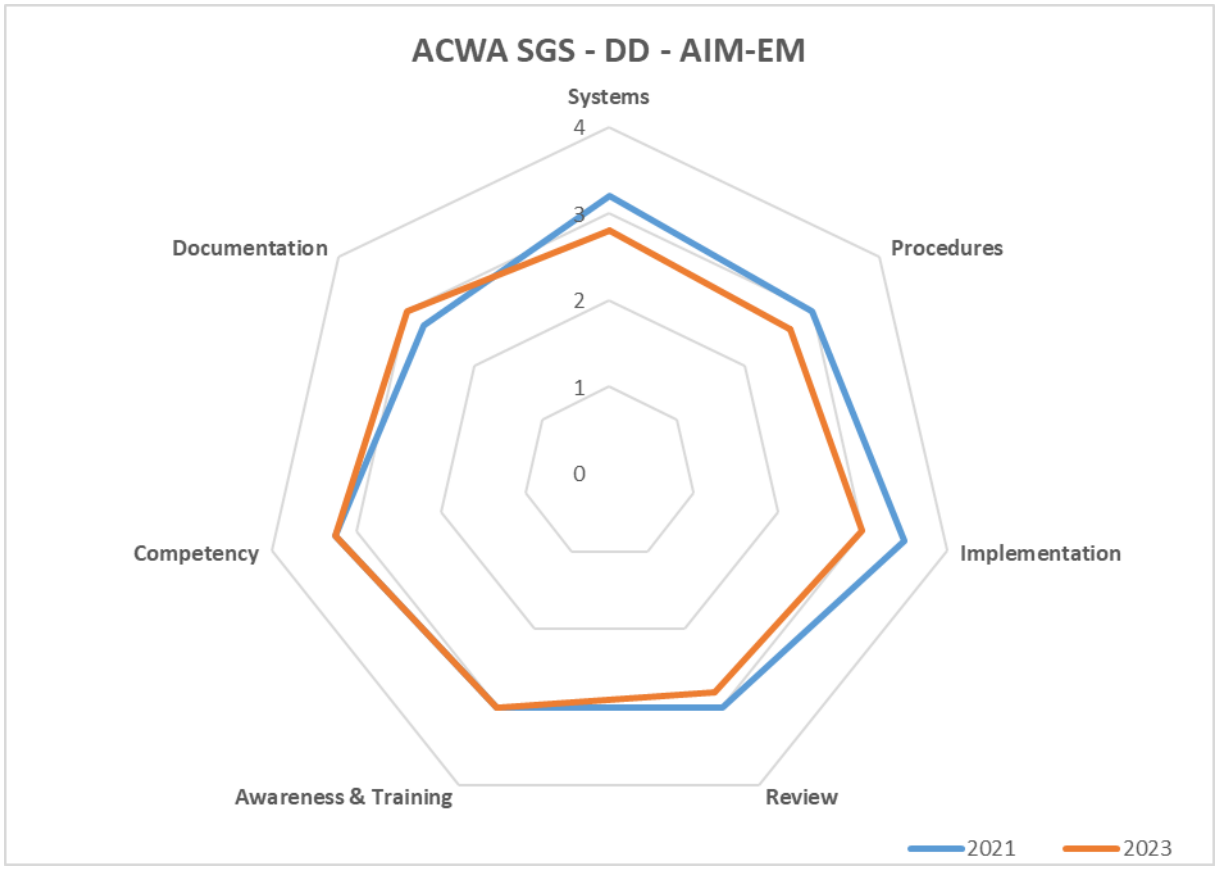
Scoring Methodology

Each parameter in the Radar chart is rated using a “system maturity” scale that considers where on the journey towards operational excellence this aspect is. In broad terms, a Zero score (least mature) means not only a lack of systems, processes and habits, but also no awareness for the need for such things. A full score (Four) indicates that systems, procedures and habits are embedded, generate certainty and constant improvement is sought (fully mature).

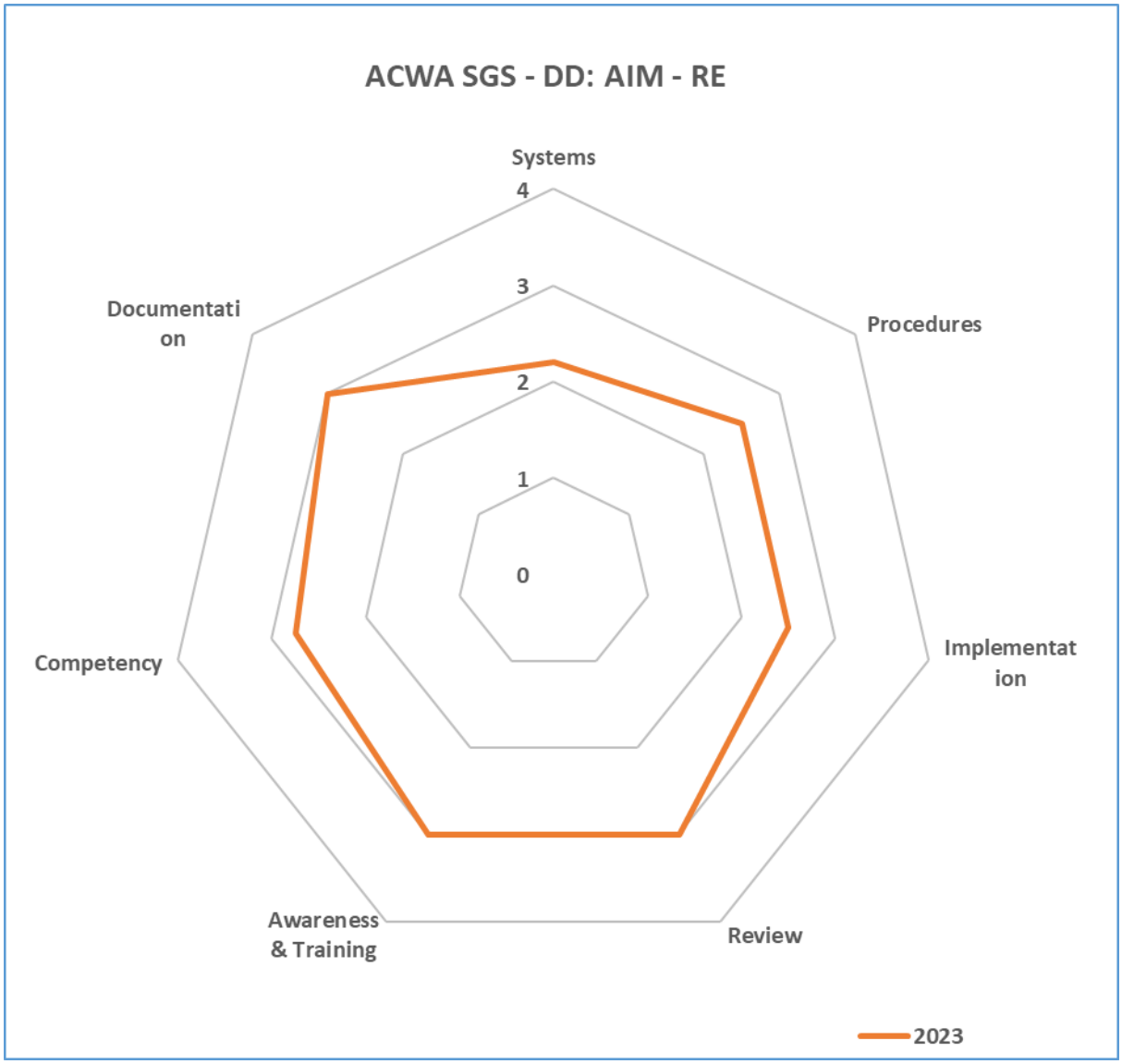
ACWA SGC Plant Safety Systems Deep Dive Assessment



ACWA SGC Plant Asset Integrity Management – Electrical Machines Deep Dive Assessment



ACWA SGC Plant Asset Integrity Management – Rotating Equipment Deep Dive Assessment



Appendix A

Requested Information

The following information is requested at least one week prior to the Deep Dive session.

Document Name	Operations Department	Maintenance Department
Asset Integrity Management – Rotating Equipment	Operations procedures, Operator training scheme, Out of limits reports	Policy and strategy definition documents
	A sample of copies of relevant procedures, evidence of use (e.g. completed associated checklists) Backlog records, deferred or delayed items completed risk assessments.	Compliance register, reference standards lists, approval to operate
	Sample of testing procedures, completion records, defect notifications where raised. Owner / Operator can explain the basis of testing, can cite reference.	Copy of risk register, Corrective Action Request (CAR) tracking and management process
	Sample copies of Rotating Equipment plant history records	Codes and standards reference lists, basis of design documents.
		Copies of Quality Management Systems (QMS) description, QMS elements relevant to AIM – Rotating Equipment, Proof of accreditations. Asset management plan.
		Copies of annual, 5 year plans, OEM recommended periods, whole of life plan, weld inspection plan, life assessment schedules.
		Copy of OEM documentation specifying maintenance intervals and scope of works.
		A sample of copies of relevant procedures, evidence of use (e.g. completed associated checklists) Backlog records, deferred or delayed items completed risk assessments.
		Sample copies of Position Qualification Requirements (PQR), sample copies of training and assessment records. Qualification database if applicable.
		Copies of previous outage reports on these equipment.
		Sample copies of MoC document pack for any MoC's related with Rotating Equipment
		Evidence of QA, inspections, Hold points of Third party inspection work
		Copy of audit plan relevant to AIM – Rotating Equipment, Corrective action tracking mechanism