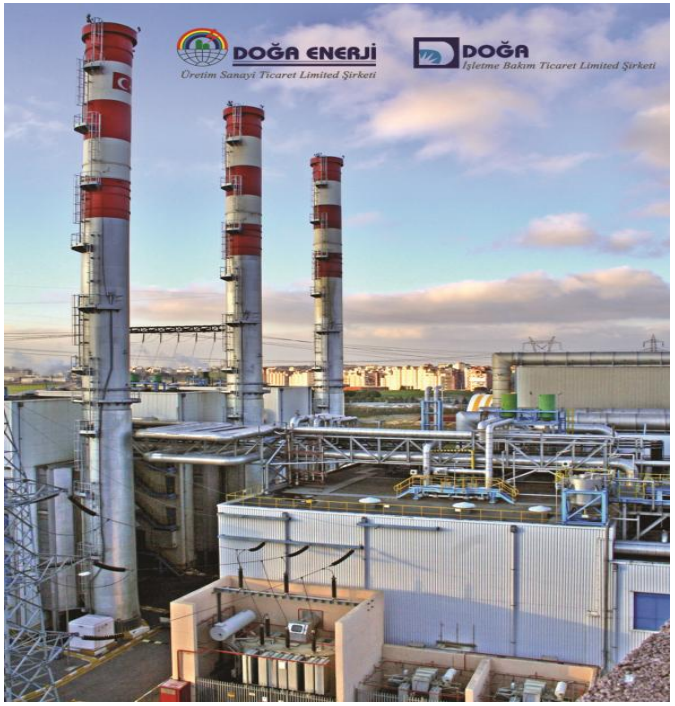
DOGA
Operation & Maintenance

DOGA Power Plant



ACC Users Group Presentation

October 8, 2018

Colorado Springs

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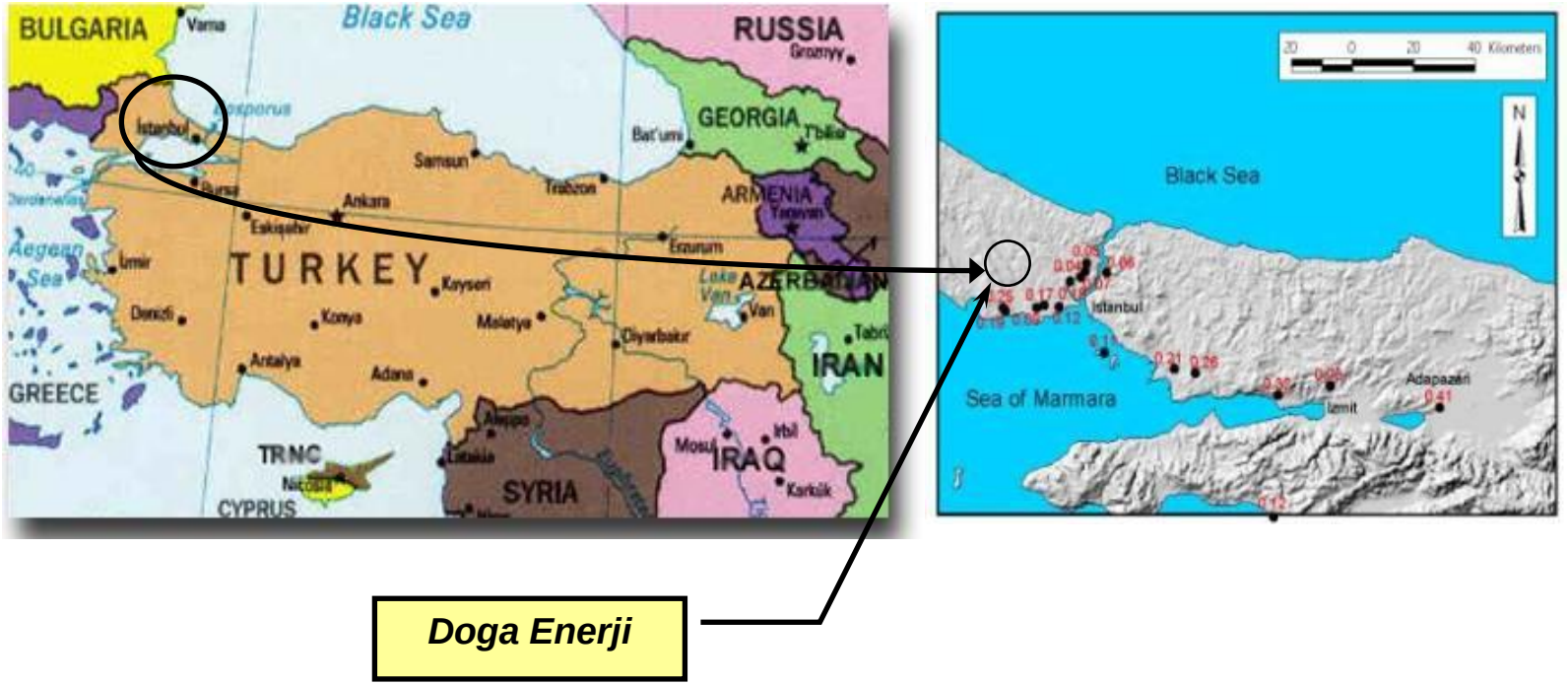
Operation & Maintenance

Plant Location :



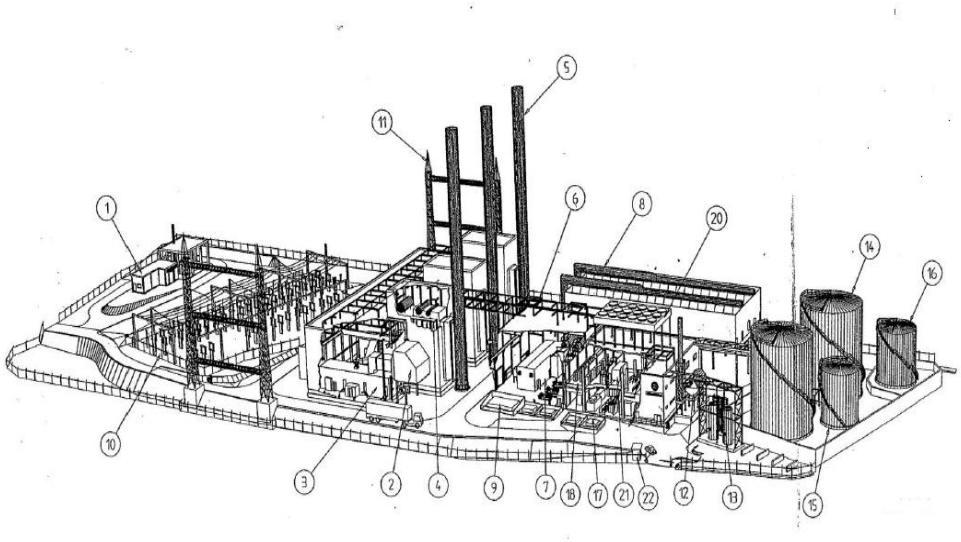
Doga Enerji is the owner of a 180 MW CCGT cogeneration project located on the outskirts of Istanbul, Turkey. Doga Enerji is a joint venture project, with NRG owning 80 % of the project and the remaining 20 % owned by a local Turkish company, Doga Enerji Yatirim ve Ticaret Ltd.

Plant Overview

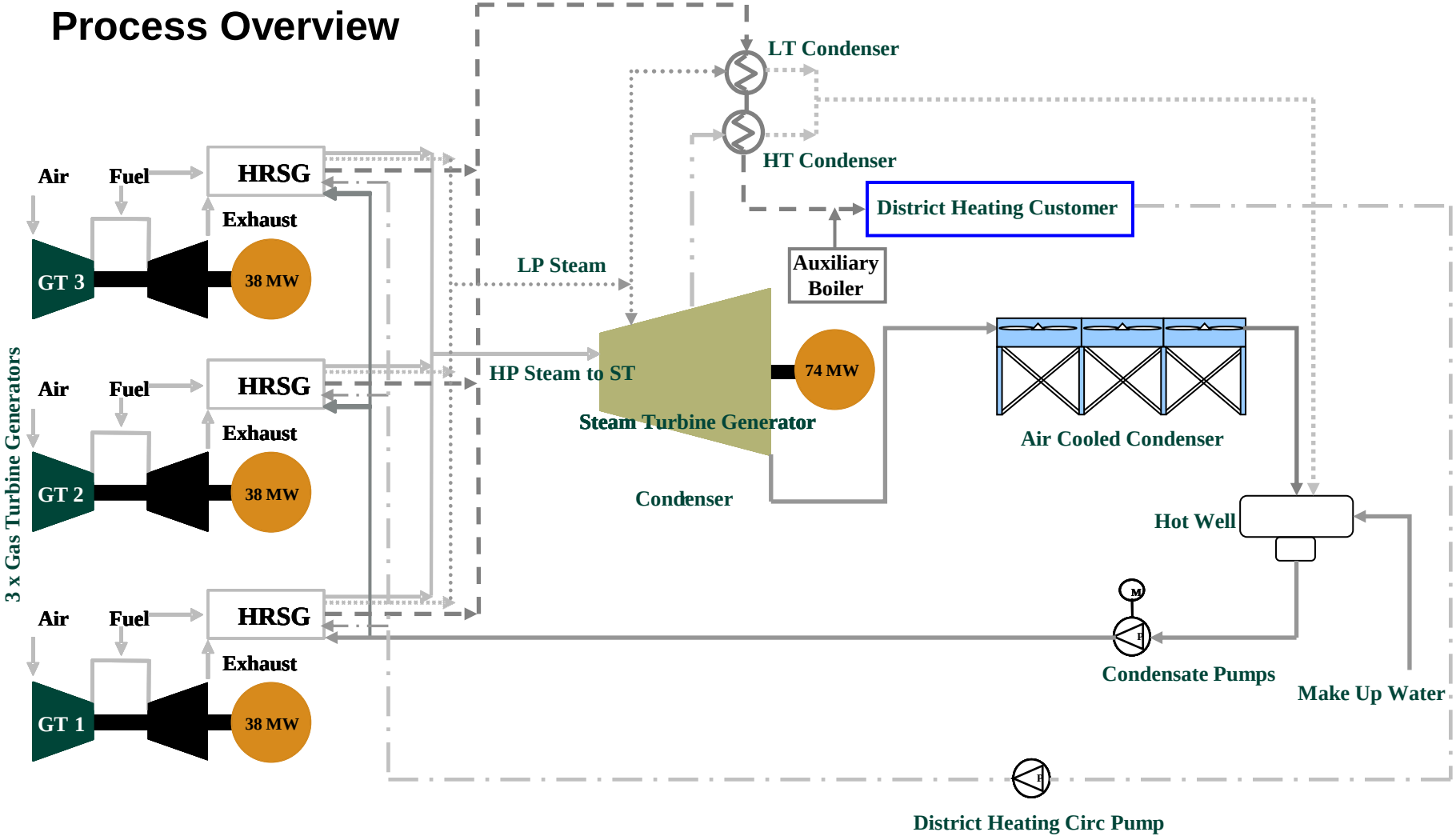
Plant Site

Plant Overview :

- Three GE-designed, Thomassen-built Frame 6 GTs, 38 MW
- Three Schelde-designed HRSGs
- One GE designed, Thomassen-built Steam Turbine, 74 MW
- On-site storage of diesel oil, 10000 m3
- Demin Unit
- Air-cooled condensers
- District Heating
- Auxiliary boiler



Process Overview



Historical Production / Performance Data

Historical Production / Performance Data :

Performance Indicator	2010	2011	2012	2013	2014	2015	2016	2017
Electrical Generation (MWh)	1.375.766	1.363.048	1.444.608	1.439.093	1.423.405	1.430.187	1.411.407	1.343.831
District Heating Delivered (MWh)	131.208	157.472	133.246	123.523	111.718	119.870	113.868	122.560
EAF (%)	98,08	90,16	96,26	97,89	95,52	96,55	97,95	92,78
EFOR (%)	0,55	0,52	0,81	1,59	1,64	1,53	1,47	0,60
Heat Rate (kj/kWh)	9.007	9.161	9.197	9.192	9.190	9.184	9.244	9.291

Plant Water Chemistry

Plant Water Chemistry:

Demin Plant Treatment

Demin plant produces high purity water from the city water to feed all systems .

Feedwater Treatment

Amine blend is used for Condensate/ Feedwater chemical treatment and injected into condensate pump discharge.

Boiler Water Treatment

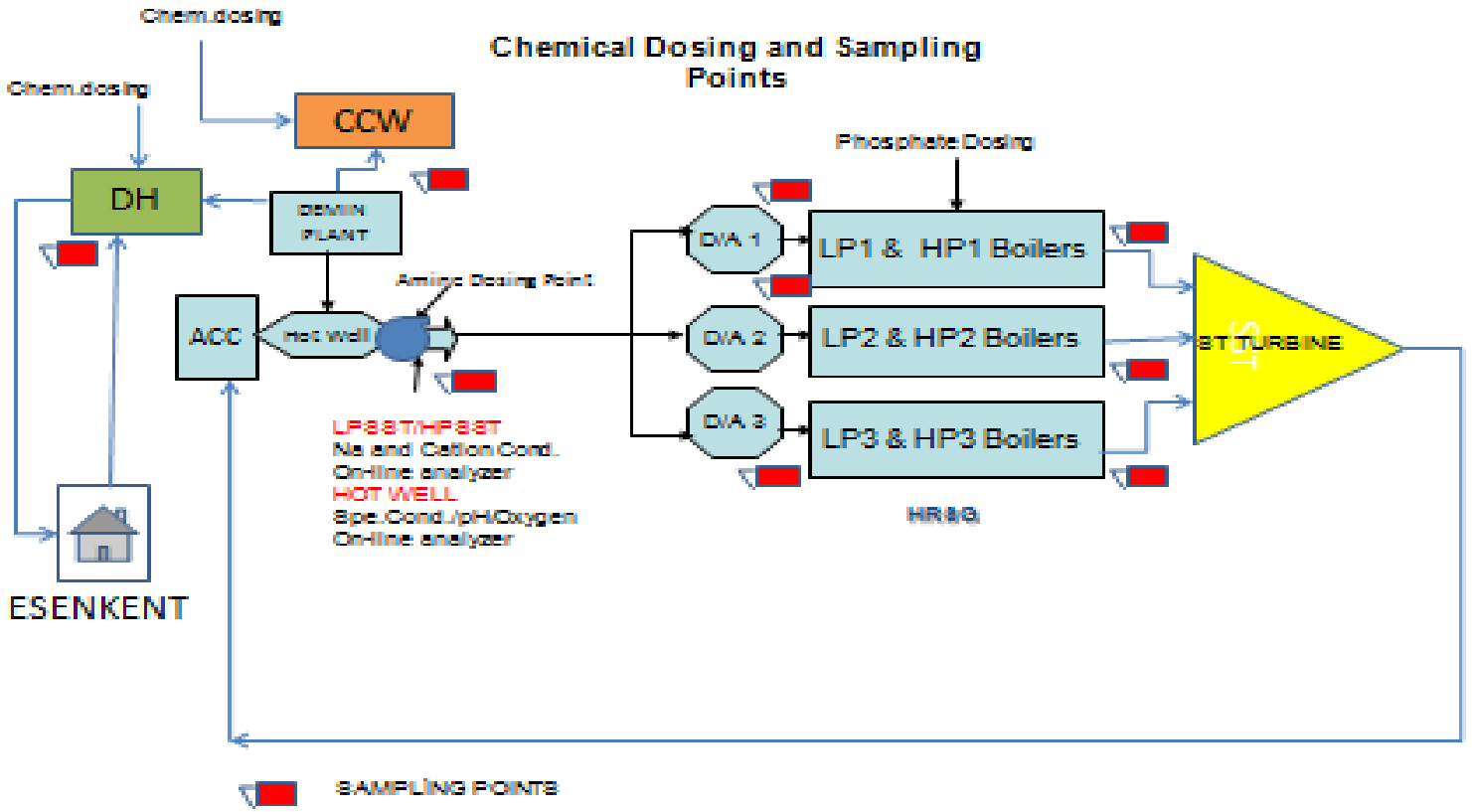
DE uses a phosphate blend for the application of “Coordinated Phosphate Treatment” control. .

Closed Cooling Water (CCW) and District Heating (DH) System Treatment

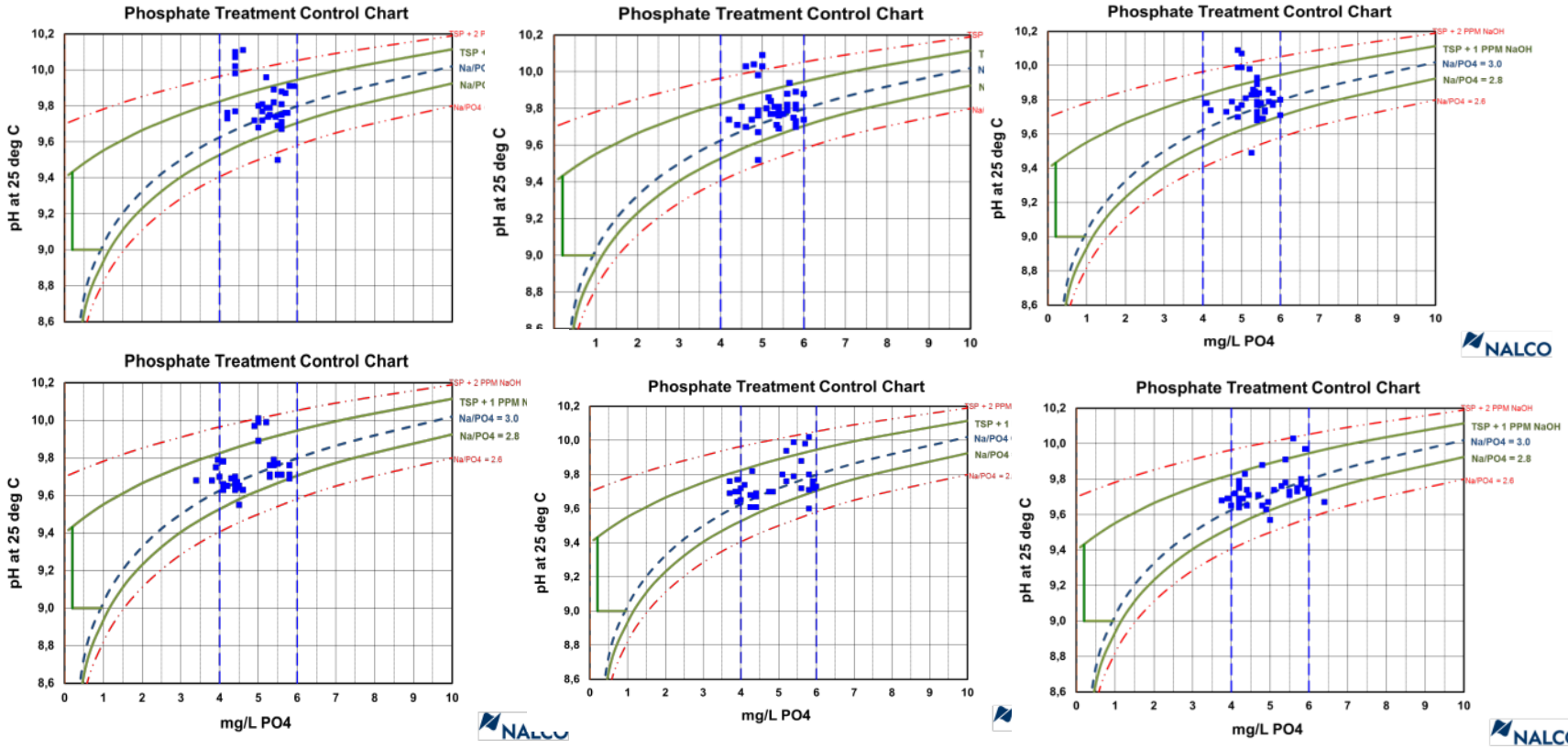
Nitrite and biocide chemicals are used for the CCW .

Corrosion inhibitor and oxygen scavenger chemicals are injected into the DH System.

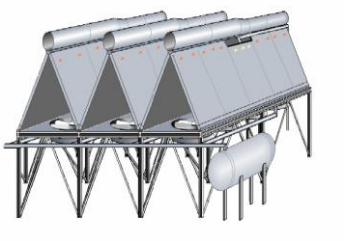
Plant Water Chemistry:



Water Chemistry Review LP/ HP drums



ACC System



DESCRIPTION / OPERATION

ACC System is used to condense The Steam Turbine exhaust steam and/or Bypass Station Exhaust steam.

The ambient air drawn by ACC fans helps the steam inside the ACC bundles to condense.

Condensed water returns to the HOTWELL for reusing in HRSG as the feed water. The air removes the energy unused in the steam and allows it to condense.

Additionally, ACC provides low backpressure to meet steam turbine capacity and requirements.

ACC Air Side

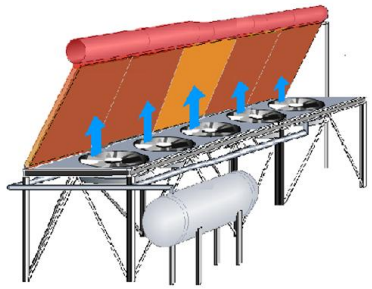
ACC airside consists of 3 rows of finned tube bundles and 15 air fans. 5 fans are for each row.

The central of the 5 fans in each row supplies cooling air to the reflux module.

Non- condensable gases is sucked from reflux module by air ejector and vented to the atmosphere.

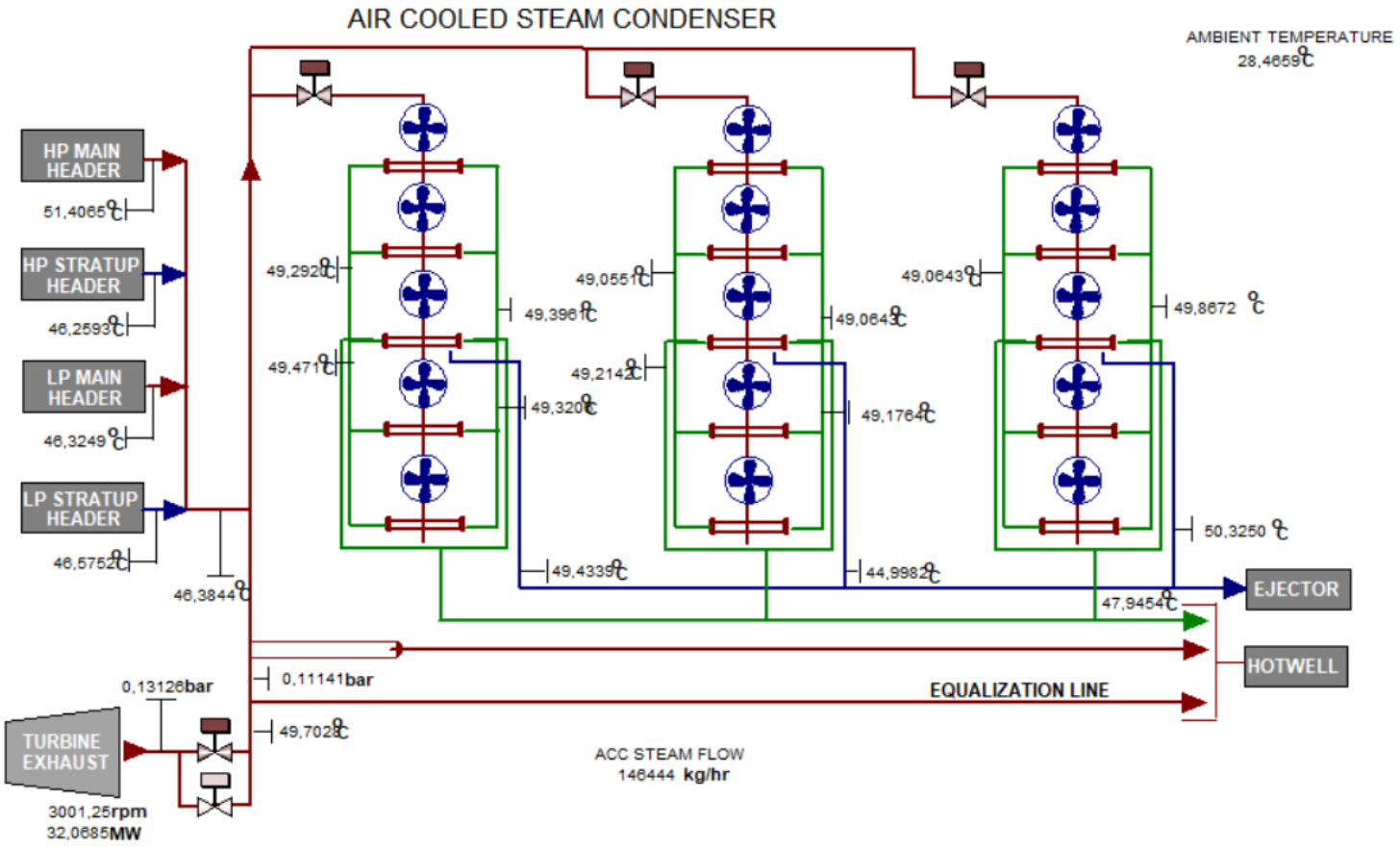
On the original ACC, the motor speed is reduced to 109 and 54 rpm by the gearbox.

On the row that was added ACC, the motor speed is reduced to 175 and 88 rpm by the gearbox.



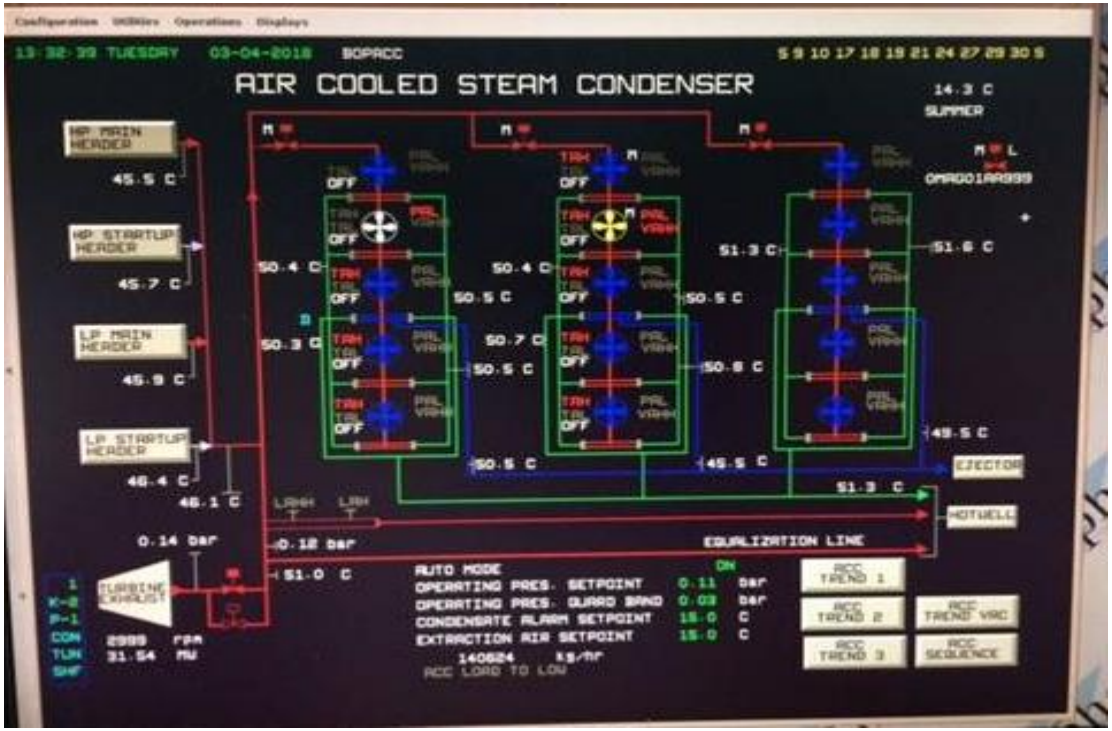
Air Removing System

Ejector system composed of three groups of ejectors. These are Start-up ejector (hogging ejector), older ACC Main ejector, new ACC main ejector. Ejectors are supplied LP steam (5barg) from LP main header.


AIR COOLED STEAM CONDENSER
AMBIENT TEMPERATURE
28,4659℃
HP MAIN HEADER
51,4065℃
HP STRATUP HEADER
46,2593℃
LP MAIN HEADER
46,3249℃
LP STRATUP HEADER
46,5752℃
46,3844℃
49,292℃
49,396℃
49,471℃
49,320℃
49,055℃
49,0643℃
49,214℃
49,1764℃
49,0643℃
49,8672 ℃
50,3250 ℃
49,4339℃
44,9982℃
47,9454℃
EJECTOR
HOTWELL
EQUALIZATION LINE
0,11141bar
0,13126bar
49,702℃
TURBINE EXHAUST
3001,25rpm
32,0685MW
ACC STEAM FLOW
146444 kg/hr

DCS Screens at the Control Room

The on-line monitoring of the ACC shows control and performance of the ACC.



DCS Screens at the Control Room

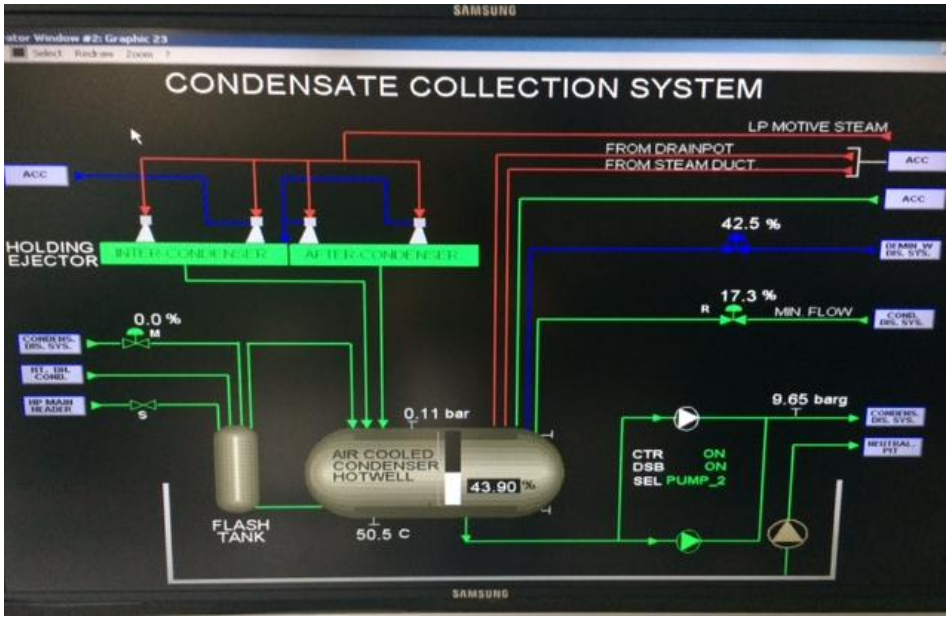
Each fan unit is equipped with vibration switch, low lube oil pressure switch, over current protection relay to provide alarm and trip functions to DCS to protect the fan unit against high vibration, low lube oil and over current.

A running fan can trip due to the reasons listed below:

- Busbar under voltage
- Gear box low lube oil pressure
- High vibration
- Fan motor electrical protection
- Faulty operation.

Condansate Collection Tank (Hotwell)

Hotwell is used to collect all condensate returning from ACC and the other systems such as steam traps and steam turbine drains etc.



ACC Design Shortcomings

ACC DESIGN SHORTCOMINGS

1.Our ACC system consist of two rows, with 10 cells constructed during plant construction and 5 additional cells added two years after commisioning.

Thus, the cooling capacity of the upgraded Air Cooled Condenser by 44 % helped limit summer season generation restrictions.

The new ACC design conditions increased the total steam cooling capacity from 177000 kg /hr to 255000 kg /hr.

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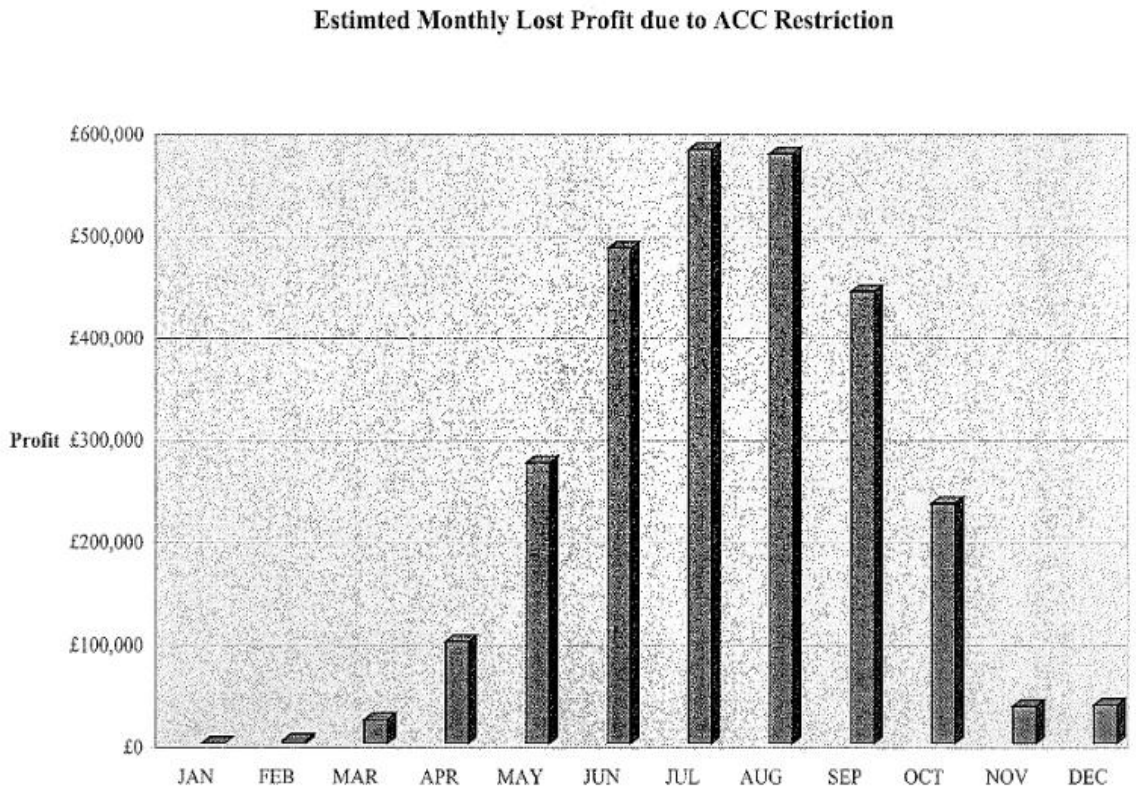


ACC DESIGN SHORTCOMINGS

2.Old ACC intake area, blocked by containers . We removed the containers in 2013.

ACC DESIGN SHORTCOMINGS

3.Neutralization pit is under the Old ACC intake area and leads to corrosion at cell number 8 fan blade.We have no chance to relocate that pit and it must be open to atmosphere for cooling the plant waste water.

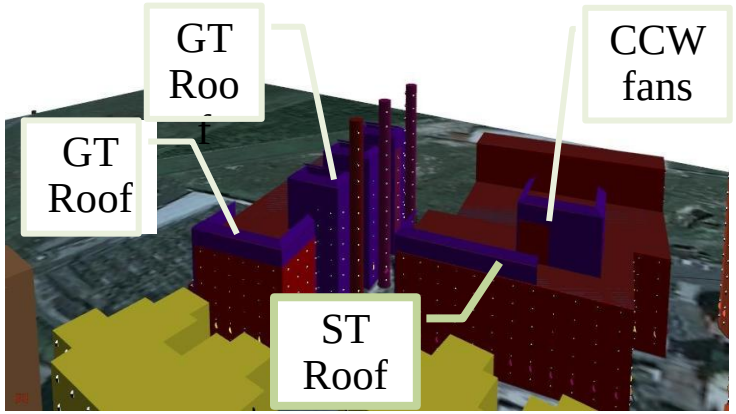
ACC DESIGN SHORTCOMINGS

ACC DESIGN SHORTCOMINGS

Noise issues

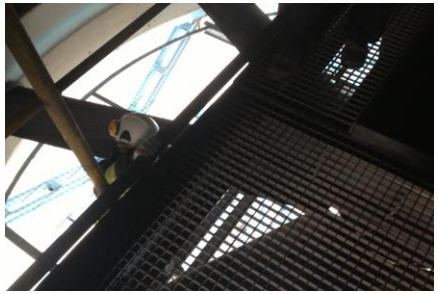
4.We're under pressure from the urban neighbourhood because of the high noise emission the plant produces.

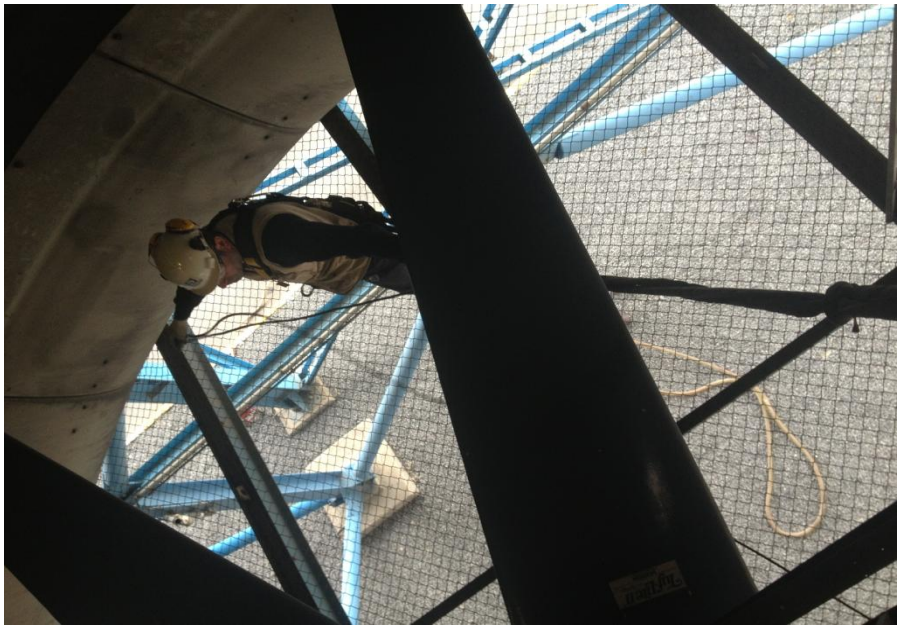
Low noise fans had to be installed.



ACC DESIGN SHORTCOMINGS

5.On the fans the safety guard material is weak wire mesh, making any maintenance work on the fan blades difficult and dangerous.





ACC DESIGN SHORTCOMINGS

6.Dissolved Oxygen in the Condansate

Our oxygen level of the Hotwell tank is about 150-200 ppb. The dissolved oxygen content mostly comes from the make-up water, being an atmospheric storage tank. It doesn't give accurate oxygen data from the condensate since it gets into contact and mixed with make-up water near the point of sample withdrawal.

If we had a seperate sampling line that did not reflect the oxygen in the make-up water, we could get suitable results.

ACC CLEANING DEVICE

7.Two cleaning devices were not properly designed by our maintenance team.

Two accidents happened due to lack of compliance with safety precautions.

Old ACC

New ACC

ACC CLEANING DEVICE

Working environment is not proper to work long time due to high noise, vibration and hot environments in this area.

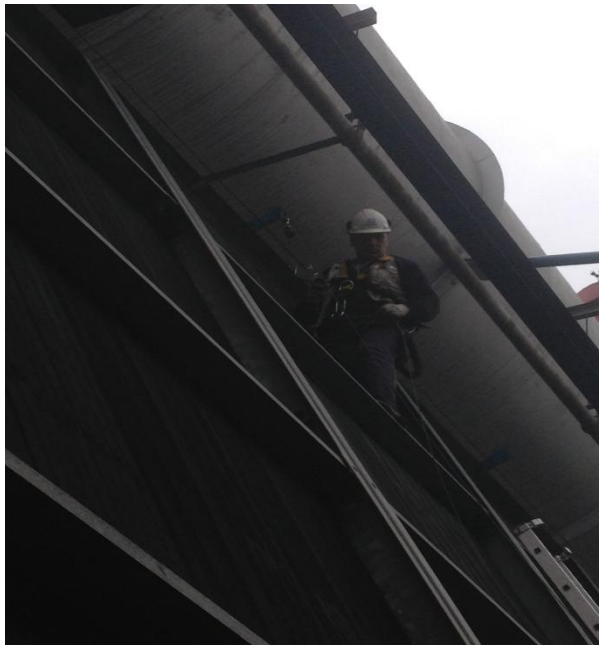
The outside door handling is also dangerous.

Old ACC

New ACC

ACC CLEANING DEVICE

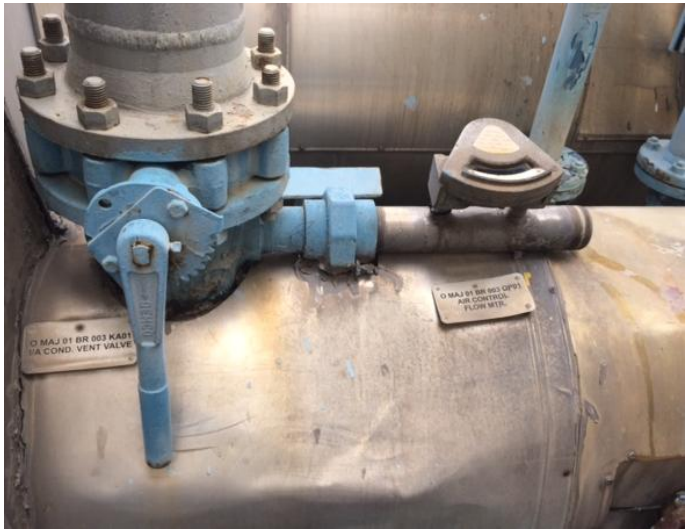
There are safety risks to fix ACC cleaning device or maintenance activities on the ACC bundles by the maintenance team.



Regular Controls

Regular Controls for ACC

- Controlling of vibration switchs, yearly.
- Sending the oil samples from the gear box, monthly.
- Air pressure control from the ejector outlet, weekly.
- ACC fan motors temperature control, weekly.



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Operation & Maintenance

Mobil Serv™ Lubricant Analysis

Normal

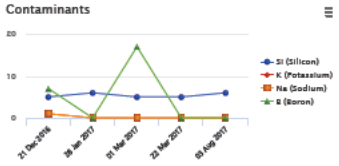
Unit ID: DOĞA ENERJİ — Asset ID: 4008

Description: ACC GEAR BOX1

Account Information	Sample Information	Equipment Information
ID: 326324 Name: Özyilmaz Petrol / DOGA ENERJI Address: İkitelli Dolapdere Sanayi Sitesi, 5. Ada No:10 İkitelli OSB, Istanbul, 34306 TR Parent Account: Özyilmaz Petrol	Sample ID: 17216637110 Service Level: Essential Bottle ID: a005975781 Tested Lubricant: MOBIL GLYGOYLE 320	Asset Class: Gear Drive Manufacturer: FLENDER (SIEMENS) Model: ACC GEAR BOX1 Lubricant: MOBIL GLYGOYLE 320

Sample Data & Trends

Sample Info	Report Status	Normal	Normal	Normal	Normal	Normal
	Sample ID	17003373101	17031857110	17061501101	17086199106	17216637110
	Service Level	Essential	Essential	Essential	Essential	Essential
	Bottle ID	a004582262	a004554183	a004553975	a005873929	a005975781
	Tested Lubricant	MOBIL GLYGOYLE 320	MOBIL GLYGOYLE 320	MOBIL GLYGOYLE 320	MOBIL GLYGOYLE 320	MOBIL GLYGOYLE 320
	Sampled	21 Dec 2016	28 Jan 2017	01 Mar 2017	22 Mar 2017	03 Aug 2017
	Reported	04 Jan 2017	02 Feb 2017	03 Mar 2017	30 Mar 2017	08 Aug 2017
	Equipment Age					
	Equipment UOM					
	Oil Age	18419	19235	19989	20661	22820
	Oil UOM	Hours	Hours	Hours	Hours	Hours
	Make-up Volume					
	Volume UOM					
	Oil Changed					
	Filter Changed					
	Reservoir Temp					
	Temperature UOM					
Lubricant	Contamination Rating	Normal	Normal	Normal	Normal	Normal
	Equipment Rating	Normal	Normal	Normal	Normal	Normal
	Oil Rating	Normal	Normal	Normal	Normal	Normal
	Visc@40C (cSt)	323.3	338.0	340.6	332.4	326.3
	TAN (mg KOH/g)	0.25	0.18	0.24	0.26	0.28
	Water (Hot Plate)	NotDetected	NotDetected	NotDetected	NotDetected	NotDetected
Wear (ppm)	Al (Aluminum)	1	0	0	0	0
	Cr (Chromium)	0	0	0	0	0
	Cu (Copper)	0	0	0	0	0
	Fe (Iron)	1	2	1	1	0
	Mo (Molybdenum)	0	0	0	0	0
	Ni (Nickel)	0	0	0	0	0
	Pb (Lead)	0	0	0	0	0
	Sn (Tin)	0	0	1	1	1
Contaminant (ppm)	K (Potassium)	1	0	0	0	0
	Na (Sodium)	1	0	0	0	0
	Si (Silicon)	5	6	5	5	6
Additive (ppm)	B (Boron)	7	0	17	0	0
	Ba (Barium)	0	0	0	0	0
	Ca (Calcium)	0	1	0	3	0
	Mg (Magnesium)	0	0	0	0	0
	P (Phosphorus)	580	562	601	582	569
	Zn (Zinc)	0	1	0	0	0



Common Failures

Common Failures

- Abrasion of the motor coupling
- Oil leakage from the seals
- Fouling of the strainer filters
- Blocking of the oil pumps under the gear box (with particles)
- Oil leakage from the tubings
- Break-up the motor bearings
- Blocking of the magnetic filters
- Abrasion of the gears in the gearbox

The Objectives of the Inspection in 2011

Thermal Performance

The thermal performance of the ACC is below the expected by 4 to 6 % because the power consumption is 6% higher than designed.

The possible reasons for this deficiency;

- Heavy fouling of the bundles
- Presence of massive air ingress in the original ACC section, causing massive subcooling in that part

A consulting company recommended to carry out a serious and substantial cleaning with proper cleaning device.

Also they addressed to reduce the fan blade angle, mostly for the original ACC section and if necessary, to increase the angle for the newer retrofit section.

Old ACC, fouled and corroded bundles



New ACC , fouled with oil



Noise

The high noise emission of the ACC is originated mostly from the blade type and the fan tip speed.

Noise level has been measured at 98 dB under the fans and 85 dB in the adjacent car park.

In practice the noise is only slightly dependent upon the blade angle.

The consulting company recommended;

- To replace the blade types
- Reduce the tip speed

Wind Effect

The frequent Southerly wind apparently trouble for the operation of the ACC

-Vibration on the fans, causing fan trips and ultimately blade damage

-Negative pressure under the ACC thus the fans are working under adverse pressure conditions.

Vacuum Decay Test

The consulting company carried out a standard vacuum decay test, at base load, with constant steam flow. We shut down the air suction to the evacuation units and also the motive steam feed to the ejectors.

During 10 minutes we recorded the change of the vacuum, then the holding ejectors were restarted, and again we recorded the pressure for 5 minutes.

The results show that we had an avarage 2.3 mbar/min pressure increase ratio during the first 10 minutes and then during the restart we had a pressure drop of 5 mbar/min average.

The pressure recovery is in line with specifications, demonstrating that the ejectors work properly.

Vacuum Pressure Problem

Vacuum Presure Problem

1.The circuit interruption occurred on the 154 kV interconnection system and the entire plant shutdown.

2.The necessary vacuum pressure couldn’t supply to ST to re-start again.

After the examinations on the system, we recognised the rupture disc of the LLP line had failed.

3.After this changing the vaccum pressure reached the acceptable level.

4.We worked low load for 7-8 days with this conditions.

Vacuum Pressure Problem

5. ST backpressure raised and distrubution rates of the ACC fan temperatures were nonuniform when we raised the electricity production.

6.Normally, one ejector is enough to keep normal vaccum pressure but we had to operate the other ejector too.

7.Operators controlled all the joints, valves and connections pipes as visually and monitor the noise changing possible places.

Vacuum Pressure Problem

8.ACC bundles checked via thermal camera and found some cold sections. To find the air ingress is very difficult because of the changing temperatures on the fans.

9.They controlled the ACC ejectors outlet and manometer was showing the air was present .

10.The system was working normally but we could not find the source of air ingress yet.

Monitoring the ACC Problem From DCS Screen

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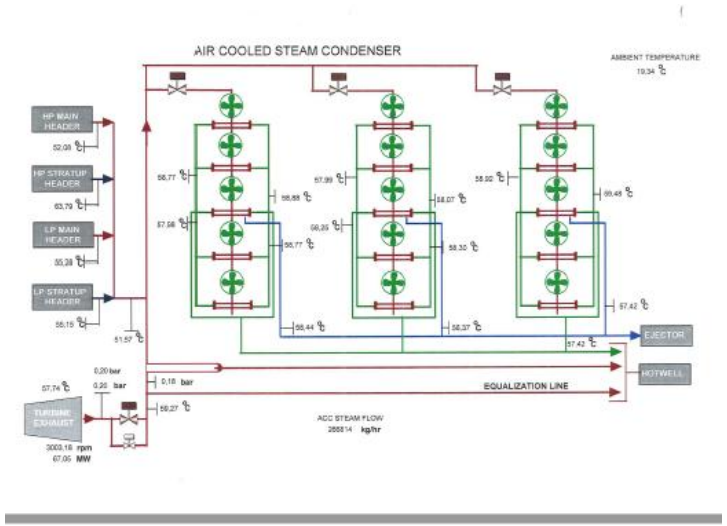

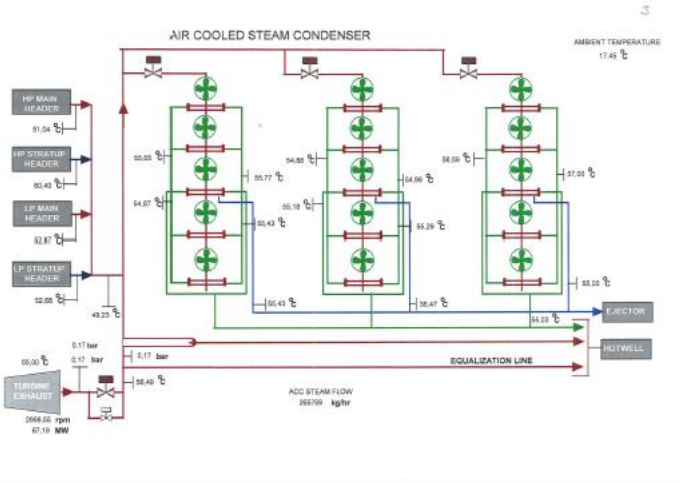

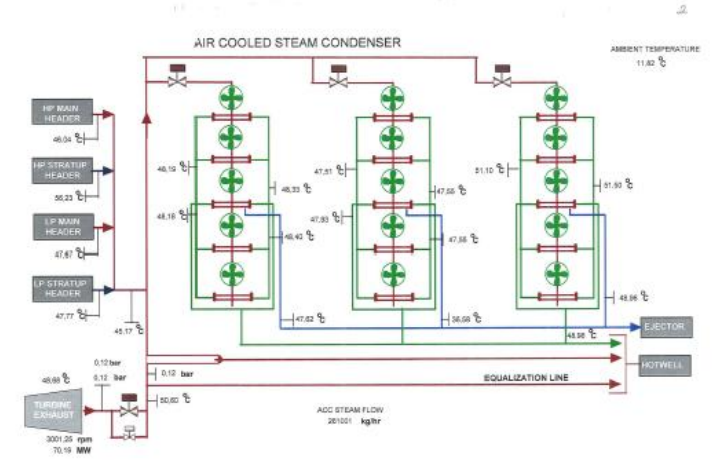

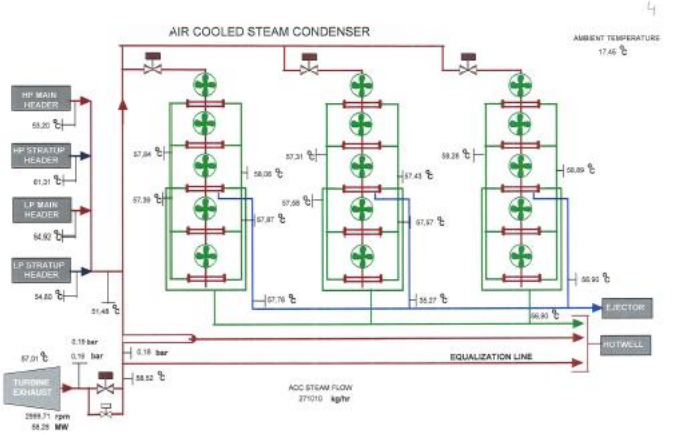

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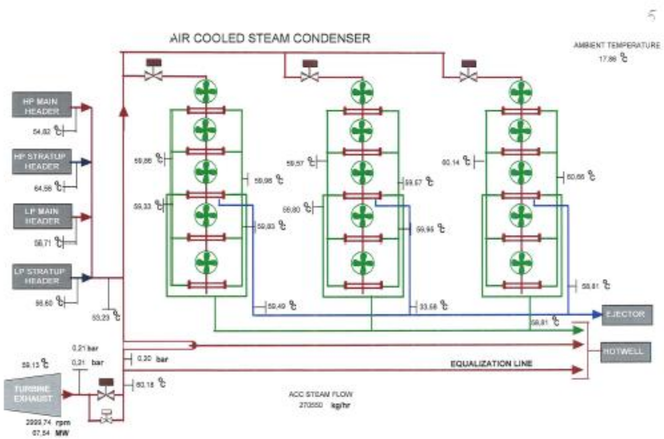
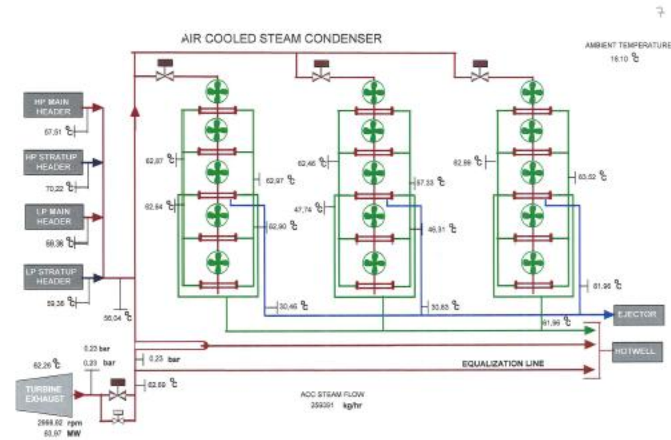
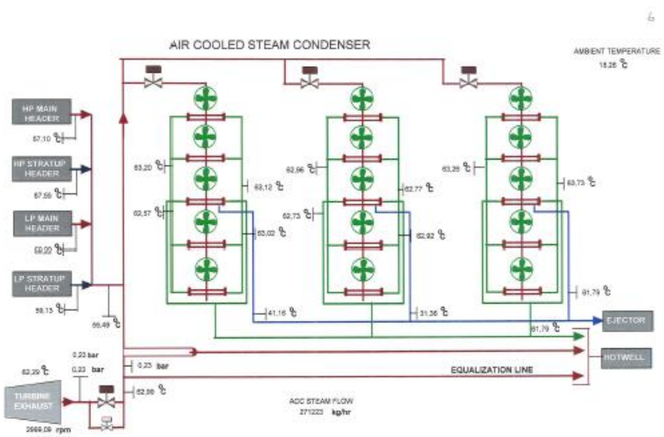
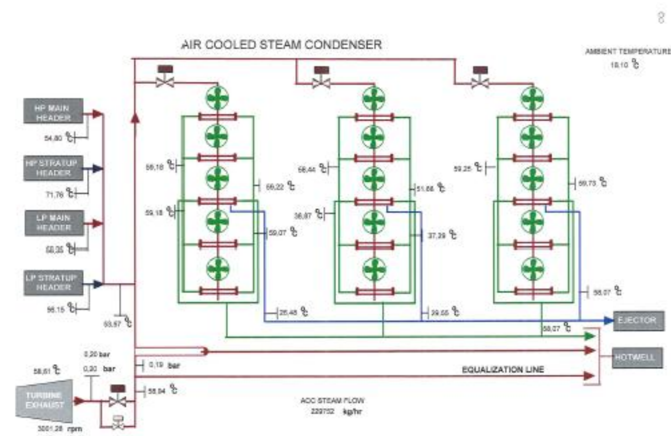
Operation & Maintenance

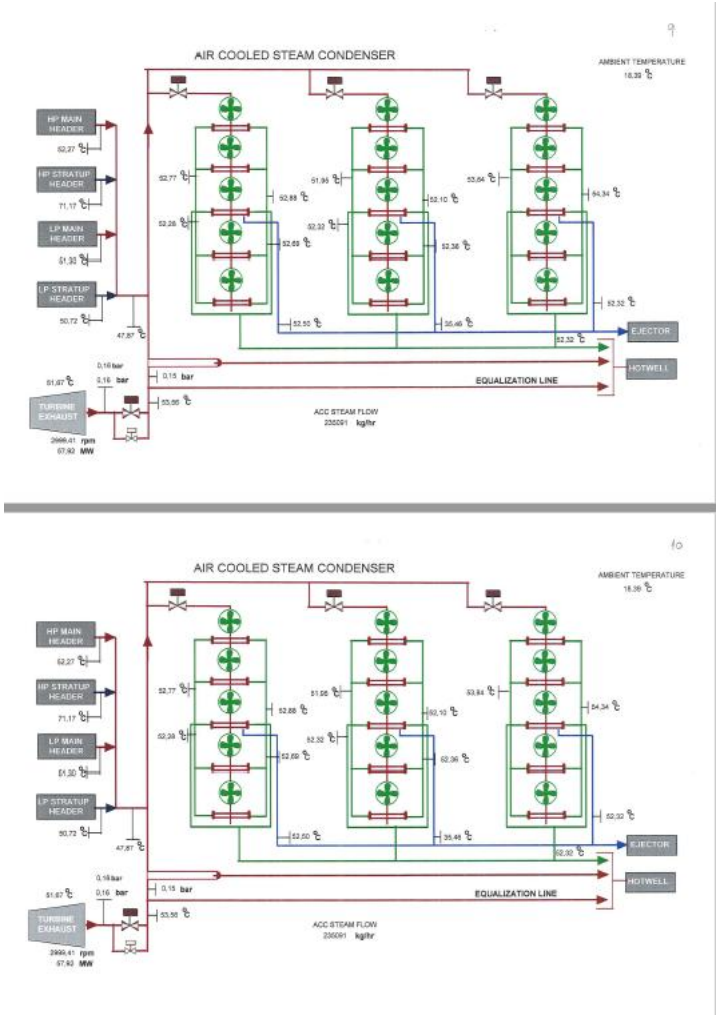








The capacity of the ejectors has been increased to 200 %.



Thank You

Deniz Çelikkantar
dcelikkantar@dogaenerji.com.tr