CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

Petition No. 8/MP/2019

Subject : Petition for relaxation/modification of the provisions of the Indian Electricity Grid Code (Fourth Amendment) Regulations, 2016 and the Central Electricity Regulatory Commission (Deviation and Settlement Mechanism and related matters) (Fourth Amendment) Regulations, 2018 in respect of the schedule for operation of the Ratnagiri Gas Power Station.

Date of Hearing : 10.1.2019

Coram : Shri P. K. Pujari, Chairperson
Dr. M. K. Iyer, Member

Petitioner : Ratnagiri Gas and Power Private Limited (RGPPL)

Respondents : Power System Operation Corporation Limited and Others

Parties present : Shri M.G.Ramachandran, Advocate, RGPPL
Ms. Poorva Saigal, Advocate, RGPPL

Record of Proceeding

Learned counsel for the Petitioner submitted that the present Petition has been filed for seeking modification of technical minimum loading of the gas turbines of the Petitioner at 65% to 67% of the MCR/capacity in place of 55% provided in the Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Fourth Amendment) Regulations, 2016. Learned counsel further submitted that when load is reduced below 120 MW, the combustion mode changes from the Premix Steady State to Piloted Premix mode and NOx levels in the Piloted Premix mode of combustion are more than 160 PPM (corrected) which is much higher than the permissible limit under the Air (Prevention and Control of Pollution) Act, 1981. Learned counsel requested the Commission to pass ad-interim ex-parte order to allow the Petitioner to operate the gas turbine at a level not lower than 65% to 67% till the decision in the petition.

2. After hearing the learned counsel for the Petitioner, the Commission admitted the Petition and directed to issue notices to the respondents.

3. The Commission directed the respondents to file their replies by 4.2.2019, with an advance copy to the Petitioner, who may file its rejoinders, if any, by 22.2.2019. The Commission directed that due date of filing the replies and rejoinder should be strictly complied with. No extension shall be granted on that account.

4. The Commission directed the staff to refer the matter to CEA and obtain its expert opinion in the matter.

5. The Petition shall be listed for hearing in due course for which separate notices will be issued.

By order of the Commission

SD/-
(T. Rout)
Chief (Law)

भारत सरकार / Government of India
विद्युत मंत्रालय / Ministry of Power
केंद्रिय विद्युत प्राधिकरण / Central Electricity Authority
तापीय यांत्रिकी एवं अभियांत्रिकी विकास प्रभाग
Thermal Engineering & Technology Development Division

संख्या: CEA/TETD-TT/2019/N-15/449-451 दिनांक : 14.06.2019

सेवा में

सचिव,
केंद्रीय विधुत विनियामक आयोग,
तीसरी और चौथी मंजिल,
चंद्रलोक बिल्डिंग, 36, जनपथ,
नई दिल्ली - 110 001

विषय: Request for CEA's expert opinion on upward revision of the Technical minimum from 55% to 65-67% with respect to loading of the Gas Turbines of M/s Ratnagiri Gas and Power Private Limited (RGPPL) - के बारे में।

संदर्भ: CERC पत्र संख्या Nil दिनांक 12th February, 2019.

महोदय,

Please refer to CERC letter cited above enclosing Record of Proceedings (RoP) of Petition No. 8/MP/2019 filed by M/s RGPPL before Hon'ble Central Electricity Regulatory Commission requesting upward revision of technical minimum from 55% to 65-67% of RGPPL Combined cycle power plant at Dabhol. M/s RGPPL has submitted that its six gas turbines are advanced 9 FA Class Machine with DLN-2+ (Dry Low NOx) combustors. Further, they have submitted that when the gas turbines are operated at a load less than 120 MW, the combustion mode changes from Premix Steady State to Piloted Premix mode and the NOx emissions in the Piloted Premix mode are much higher than the norms stipulated by the Maharashtra Pollution Control Board (MPCB). Hon'ble CERC has requested CEA to examine the issue and furnish suitable recommendation on the subject issue/ matter.

In above respect, it is to mention that CEA (TE&TD Division) had written to M/s RGPPL to provide various relevant documents to facilitate in examining the subject matter. In response, RGPPL has furnished the documents to CEA as available with them. Further, in order to have an insight into the design, construction and operational aspects of Dry Low NOx (DLN) combustors, interactions were held with GE personnel/ engineers. A team of CEA engineers also made a visit to RGPPL's power plant from 19th to 22nd May 2019 with demonstration done on operating Block- 3 CCGT on 20th & 21st May, 2019.

The above issue of technical minimum load has been examined in CEA and our observations on the same are indicated as below:

i) As per Records of Proceedings (RoP), the Block-I of the generating station was established by Dabhol Power Company Limited in the year 1999 and the works on Block-II & III and LNG terminal was in progress. The Dabhol Power Project was closed down in May, 2001 and the assets of Dabhol Power Company were placed under the control of a Receiver appointed by the Hon'ble High Court of Bombay. M/s RGPPL took over the Dabhol Power Project including the integrated LNG Terminal and associated infrastructural facilities from Court Receiver on 6th October, 2005. ROP indicates that at the time of takeover of the project, equipment of the generating station were amongst the first few advanced class machines and their repair, revival and operation & maintenance were unpredictable with no guarantee or warranty from the OEM.

ii) The Petitioner (M/s RGPPL) after revival and undertaking Renovations & refurbishment is indicated to be operating and maintaining the CCGT station with the following capacity:

Blocks	Capacity (MW)	COD
Block – I	640 (2x 205 MW GTs + 1x 230 MW ST)	19.05.2009
Block – II	663.54 (2x 213 MW GTs + 1x 237.54 MW ST)	01.09.2007
Block – III	663.54 (2x 213 MW GTs + 1x 237.54 MW ST)	21.11.2007
Total	1967.08 MW	

iii) MPCB's letter dated 11.7.2017 on renewal of consent to operate indicates capacity of Block- 1 as 670 MW, Block- 2 & 3 as 668.54 MW each totaling to 2007.08 MW. The schedule- II of this letter regarding terms and conditions for compliance of air pollution control indicate NOx emission not to exceed 27 ppm (v/v at 15% oxygen) with natural Gas firing. There is no reference of relaxed NOx emission at part loading of the plant/ module.

iv) The DLN 2+ combustion system operates in three modes of operation viz. Diffusion mode, Piloted Premix mode (PPM) and Premix Steady State (PMSS) mode. Out of these modes Diffusion and Piloted Premix Modes are used during transient modes like Startup/ Shutdown or operation at low load. The NOx emissions are high during diffusion and piloted premix modes of combustion. The literature available on internet also indicate that due to the flame instability limitations of the DLN combustor below approximately 50 percent of rated load, the turbine is typically operated in a conventional diffusion flame mode until the load reaches approximately 50 percent. As a result, NOx levels rise when operating under low load conditions.

In above respect, it is to mention that referring to M/s GE's document No. GER-3568G titled, "Dry Low NOx combustion system for GE heavy- duty gas turbines" available on internet, the Fig. 16 indicates that DLN- 2 combustion system operates in primary mode & lean- lean mode upto 50% GT load and in premix mode above 50% GT load. The Fig. 18 indicates that NOx emission is minimum in premix mode (load range >50% GT load) and sharply increases at load below 50% GT load. The extract of M/s GE's document is enclosed as **Annexure- 1**.

v) As per GE documents, the reference for changeover of combustion mode from piloted premix to premix and vice versa, in terms of combustor mode sequencing and fuel split scheduling, is a calculated temperature called combustion reference temperature (TTRF1). M/s GE's document No. GEK 106939 titled, "Dry Low NOx 2.0⁺ System Operation" defines TTRF1 as a function of the median exhaust temperature, compressor discharge pressure and inlet bell mouth temperature. Premix mode combustion is indicated as occurring above 2270 deg F during loading and 2220 deg F during unloading. The extract of M/s GE's document No. GEK 106939 is enclosed as **Annexure- 2**.

vi) M/s GE's document No. GER- 3620N (10/17) on heavy- duty gas turbine operating and maintenance considerations mentions that DLN $2/2^{+}$ use diffusion combustion (non- Premix) mode at part load before reaching low emission combustion (Premix) mode. The general recommendation indicated for continuous mode operation with guaranteed emission is premixed combustion mode (PM), also ensuring expected hardware life. The use of non- Premix combustion mode is indicated to affect the factored maintenance interval of combustion hardware and for DLN $2/2^{+}$ the extended piloted premixed operation is indicated to result in a high maintenance factor of 10. The extract of M/s GE's document (page- 16, 17) is enclosed as **Annexure- 3**.

vii) The variation of NOx emissions at different loadings of gas turbine as provided in the ROP is indicated at **Annexure- 4**. It is seen from this annexure that when GT load is at 120 MW or below, the combustion mode changes from Premix Steady State (PMSS) to Piloted Premix mode and NOx emission is more than 160 ppm (corrected) which is much higher than MPCB's permissible limit of 27 ppm (v/v at 15% oxygen).

viii) The para 27(c) of the RoP indicates that RGPPL is required to sustain the operation of the gas power units in a manner consistent with the technical requirements of 9 FA gas turbines and those provided in the Long term service agreement (LTSA) with GE Energy (OEM) failing which the RGPPL would not have the technical support for operating the generating station.

ix) As per CREC regulation, technical minimum load for operation of thermal power plants (coal, lignite and gas/ liquid fuel based stations) is 55% of rated load. It is understood that this has been set as per normal capability of existing coal based stations without requiring any major modification in plant equipment/ systems. It is to mention that in case of coal/ lignite based stations, the flame stability is the constraint for achieving a lower minimum load of the unit. However, in case of DLN combustor based gas/ liquid fuel based stations, there is no such constraint, but the limitation comes from sharply increased NOx emission below a preset load of GT as per change of combustion mode from premix mode to piloted premix mode which is governed by a calculated combustion reference temperature. M/s GE's technical document No. GER- 3568G indicates this change over load for DLN $2/2^{+}$ combustion system as 50% GT load, below which the NOx emission is indicated to sharply increase from level of 25 ppm to about 100 ppm. As such, the reference for consideration of technical minimum load for DLN $2/2^{+}$ combustion based plants (maintaining NOx emission level without requirement of major plant modifications) should be the changeover load (50% GT load), and to provide for some operational margin the same should be set as 52% GT load with corresponding CCGT/ plant loading taken as 62% (vis- a- vis technical minimum load of 55% for coal based stations).

x) The **Annexure- 5** indicates the components of GT & ST outputs at part loading as furnished by RGPPL for a module and corresponding % loading values worked out by CEA. It is seen that due to relatively high part load heat rate deterioration of GT, the CCGT module loading of 65.22% (minimum value of 431.44 MW) corresponds to average GT loading of 56.8% (average 119.77 MW).

As per results of site demonstration test carried out on 663.54 MW rating Block- 3 [discussed in para (xiii) below alongwith **Annexure- 7**], for average GT load of 108.4 MW (50.9% loading), the corresponding CCGT load amounts to 402.65 MW (60.7% CCGT loading).

M/s GE were also requested to furnish the similar data indicating the components of GT & ST outputs at part loading upto 50% CCGT loading. As per generic data received from M/s GE and analysis carried out at our end (**Annexure- 6**), for CCGT loading of 55%, the individual GT loading amounts to 43.7% which is much below the minimum GT loading of 50% for premix/ premix steady state (PMSS) mode required for NOx emission within stipulated limit. For GT loading of 49.5%, the CCGT loading corresponds to 60%. Thus, for keeping individual GT loading at 50% or above, the CCGT loading needs to be kept above 60%.

xi) In the discussions held with M/s GE on the issue, it was intimated that that GTs in Block- 1 are provided with DLN 2 combustion system and in Block- 2 & 3 with DLN 2^{+} combustion system and that NOx emission can be restricted within stipulated base load emission value above about 55% GT load (about 118 MW). It was clarified by M/s GE that with DLN $2/2^{+}$ combustion system, stipulated NOx emission limit is difficult to be maintained for plant operation below this GT load.

xii) RGPPL's CCGT plant at Dhabol has three modules, each in configuration of 2GT + ST. The modules have not been provided with GT bypass stack, as such, the plant/ module(s) cannot be operated with GT in open cycle mode and needs to be operated in CCGT mode only.

xiii) A visit to RGPPL's CCGT power plant at Dhabol was made to get apprised about the issue involved and to have demonstration of the NOx emission problem being experienced at part load in an operating module. The demonstration was made on CCGT Block- 3 in afternoon on 20th & around noon on 21st May 2019 and for this RGPPL had taken reduced DC for three time blocks from 11:30 to 12:15 Hrs. on 21.5.2019.

The results of the demonstration test carried out at plant site are indicated in **Annexure- 7**. The tabulated data indicates performance parameters of Block- 3 CCGT module in terms of load of GTs, ST & CCGT, reference combustion temperature (TTRF1), combustion mode (Premix/ Piloted Premix) and NOx emission values, covering range of individual GT load from about 208 MW to about 80 MW. Some reference screen shots are also enclosed as **Annexure- 8**.

In the above annexures, the maximum load of the Block- 3 is seen to be about 648 MW with GT3A at about 208 MW, GT3B at about 207 MW and STG at about 233 MW, and DLN combustion system in each GT operating in Premix mode with NOx emission for GT3A as -0.47 ppm (low value due to effect of purging air/ instrument error) and for GT3B as 16.67 ppm. For operation at higher part loads also, the NOx emission was seen to be well below 20 ppm with GT3A value less than GT3B value. It was also observed that for low NOx combustion, the stack emission is colourless. For site demonstration, the load of each GT was planned to be reduced from maximum operating to about 80 MW (about 40% of full load).

The analysis of screen shots taken during the demonstration test and trend data subsequently furnished by RGPPL indicates that for GT3A load upto about 118 MW, the gas combustion is in premix mode with combustion reference firing temperature (TTRF1) about 1236 deg C and NOx emission values well below 20 ppm level (screen shot, time 11:41:41 Hrs). Based on DAS data furnished by RGPPL, with reducing load, the initiation for transfer of combustion mode from premix to piloted premix in case of GT3A is understood to have started at TTRF1 of about 2247 deg F (1230.6 deg C) and load about 115 MW (trend data time 11:45:10 Hrs.) M/s RGPPL have indicated that, after initiation, completion of combustion mode transfer process takes about 7- 8 seconds and onset of piloted premix mode is indicated subsequently. The extract of trend data from DAS for GT3A is enclosed as **Annexure- 9**. From trend data, GT load is also seen to increase during combustion mode changeover process. The NOx emission value in piloted premix regime was seen to rapidly increase to a high value of about 80 ppm. In case of GT3B, the initiation for transfer of combustion mode from premix to piloted premix is understood to have started at TTRF1 of about 2253 deg F (1233.9 deg C) with corresponding 3GTB load about 111 MW. The NOx emission value in piloted premix regime was seen to be about 100 ppm. As GT3A/ GT3B load was reduced further, the TTRF1 value was also seen to follow a general reducing trend with NOx emission in higher range upto 125 ppm. In low load regime, the colour of chimney emission was seen to turn to yellowish due to increased quantum of NOx emission. From site demonstration as above and data collected, it is observed that for NOx emission compliant operation (Premix mode combustion), the individual GT load needs to be kept above about 115 MW with corresponding CCGT load about 420MW. This amounts to about 63 % of CCGT Block- 3 rated load of 663.54 MW.

It is to mention that minimum GT load of about 115 MW is as per combustion reference temperature set point observed to be about 2250 deg F. However, as per M/s GE's document No. GEK 106939 as referred at para (v) above, the TTRF1 for change of combustion mode from premix to piloted premix mode during unloading in case of DLN 2^{+} machines is 2220 deg F. M/s RGPPL have also confirmed that TTRF1 for change of combustion mode from premix to piloted premix (during unloading) is presently set in their machines by OEM (M/s GE) as 2250 deg F. M/s RGPPL are mentioned to have written to M/s GE asking for reason of setting TTRF1 set point at 2250 deg F instead of 2220 deg F indicated in GE document. Subsequently, M/s GE's reply forwarded by RGPPL, it has been mentioned that GE document GEK 106939 (as referred above) has been superseded by GEK 110846a and that a combustion reference temperature (FXKTM) value of 2310 deg F has been set for RGPPL's 9FA machines based on field fleet operation. It has been further mentioned that on unit by unit basis reduction in transfer point can be attempted during DLN tuning at site.

From above, a margin of 30 deg F seems to be available for lowering of combustion reference temperature (TTRF1/ FXKTM) set point. From the data collected during site demonstration test, two graphs have been plotted: one for variation of average TTRF1 with average GT load & other for variation of average TTRF1 with corresponding CCGT load during unloading in premix mode and same are indicated in **Annexure- 10.** From this, it is observed that as GT/ CCGT load reduces, the TTRF1 also reduces. At GT load about 120 MW, the slope of the curve indicates that TTRF1 reduces by about 1.9 deg F per one MW reduction in GT load. As such, for every 10 deg F reduction in existing set point of TTRF1 (or FXKTM), the expected reduction in minimum load of individual GT can be taken as about 5 MW. With reference to CCGT load, TTRF1 is seen to reduce by about 0.9 deg F per one MW reduction in CCGT load. For every 10 deg F reduction in existing set point of TTRF1 (or FXKTM), the expected reduction in minimum load of CCGT (2GT+1ST) can be taken as about 10 MW which amounts to about 1.5% of CCGT Block- 3 rated load of 663.54 MW.

xiv) During the plant visit, RGPPL furnished the extract of load profile of the plant for specific days when there was –ve RRAS during the period May, 2018 to February, 2019. The perusal of the data revealed that there were large number of instances when schedule given was less than 400 MW (mostly about 378 MW) but corresponding actual generation was more than 400 MW (mostly about 410 MW). M/s RGPPL indicated that excess generation over the given schedule due to technical limitation on NOx emission has resulted in huge penalty to them as per applicable CERC regulations.

The **Annexure- 11** indicates the generation details for time blocks with –ve RRAS in two months of July & August 2018 (excluding time block 14 on 20.8.2018 for which scheduled generation was more than 400 MW). It may be seen that for DC of 540 MW for the indicted 147 time blocks, the generation schedule given to RGPPL is in the range 371.68 MW to 379.39 MW with average schedule as 378.30 MW. The actual generation of the plant/ module in the corresponding period is in the range 406.2 MW to 427.78 MW with average generation as 413.57 MW. The actual generation is more than the schedule in the range 27.96 MW to 49.69 MW with average excess generation as 35.27 MW. This may be considered as reflection of technical difficulty being experienced by RGPPL for module operation below about 410 MW (61.8% of Block- 3 module rating of 663.54 MW) with NOx emission to be maintained within stipulated limit.

xv) In the discussion held with M/s GE, they were asked about available options to restrict NOx emission from 9FA machines fitted with DLN2/2$^+$ combustion system below the CCGT load of about 65%. It was emphasised by M/s GE that change of combustion hardware system from DLN 2/2$^+$ to the latest advanced DLN 2.6$^+$ will be essentially required to extend the regime of NOx emission control down upto 40% GT load without use of their proprietary OpFlex turndown software and upto 35% GT load with use of OpFlex turndown software. The key features of Dry Low NOx (DLN) 2.6$^+$ combustion system was indicated that it provides low NOx level emissions, increased emissions compliant turndown capability, and longer combustion inspection intervals.

xvi) During plant visit, M/s RGPPL were also asked about options available to them for control of NOx emission at part load operation. It was apprised that M/s GE have given upgradation offer for GTs costing about Rs. 250 crore for each GT. This amounts to about Rs. 500 crore for one CCGT block i.e. about Rs. 0.75 crore/MW of installed capacity.

xvii) As regards feasibility of installing post combustion SCR system in HRSG of 9FA machines with DLN 2/2+ combustion system, M/s GE have indicated that this requires huge space in HRSG and additionally huge investment if existing HRSG doesn't have the requisite space. With installation of SCR, high additional operating expenses shall be involved for consumption of DeNOx reagent. Further, as module at low load shall be operating in PPM mode, the maintenance factor shall be huge at about 10. M/s GE as OEM are indicated as not offering SCR system for their 9F machines.

Based on consideration of various factors as given, our recommendations are as below:

1. **The technical minimum load of RGPPL's CCGT plant/ modules at Dhabol, having GE make 9FA machines provided with DLN 2/2+ combustion system, for MPCB stipulated NOx emission compliant operation without making major modification in the combustion system, should be set at 62% of CCGT rated load (corresponding to about 52% GT loading).**

2. **The technical minimum load of individual CCGT module can be reduced below the 62% value @ 1.5%age point for every 10 deg F reduction in set point of combustion reference temperature if achieved by GE during DLN tuning of RGPPL's 9FA machines at Dhabol in near future.**

3. **If major modifications are carried out in a module in terms of complete replacement of combustion hardware from present DLN 2/2+ to DLN 2.6+, the module can be operated below the level of 60% CCGT load with NOx emission within the stipulated limit.**

This issues with the approval of Chairperson, CEA.

संलग्नक: यथोपरी।

भवदीय,

(एच.आर.अरोड़ा)

निदेशक

कृते मुख्य अभियंता टी.ई.टी.डी.

Copy for kind information to: i) SA to अध्यक्ष, के.वि.प्रा.

ii) SA to सदस्य (तापीय), के.वि.प्रा.

ANNEXURE-1

GER-3568G

GE Power Systems

Dry Low NO_x Combustion Systems for GE Heavy-Duty Gas Turbines

L.B. Davis
S.H. Black
GE Power Systems
Schenectady, NY

premixed operation is set by the combustion reference temperature and IGV position. It typically ranges from 50% with inlet bleed heat on to 65% with inlet bleed heat off. Mode transition from premix to piloted premix or piloted premix to premix, can occur whenever the combustion reference temperature is greater than 2200 F/1204 C. Optimum emissions are generated in premix mode.

Tertiary Full Speed No Load (FSNL)

Initiated upon a breaker open event from any load > 12.5%. Fuel is directed to the tertiary nozzle only and the unit operates in secondary FSNL mode for a minimum of 20 seconds, then transfers to lean-lean mode.

Figure 16 illustrates the fuel flow scheduling associated with DLN-2 operation. Fuel staging depends on combustion reference temperature and IGV temperature control operation mode.

DLN-2 Controls and Accessories

The DLN-2 control system regulates the fuel distribution to the primary, secondary, tertiary and quaternary fuel system. The fuel flow distribution to each combustion fuel system is a function of combustion reference temperature and IGV temperature control mode. Diffusion, piloted premix and premix flame are established by changing the distribution of fuel flow in the combustor. The gas fuel system (*Figure 17*) consists of the gas fuel stop-ratio valve, primary gas control valve, secondary gas control valve premix splitter valve and quaternary gas control valve. The stop-ratio valve is designed to maintain a predetermined pressure at the control-valve inlet.

The primary, secondary and quaternary gas control valves regulate the desired gas fuel flow delivered to the turbine in response to the fuel command from the SPEEDTRONIC™ controls.

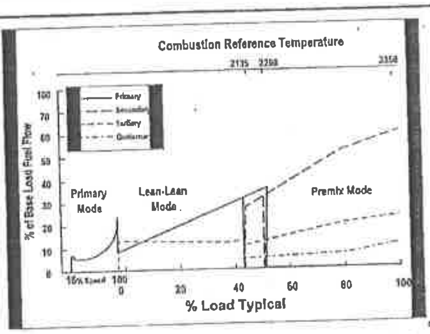


Figure 16. Typical DLN-2 gas fuel split schedule

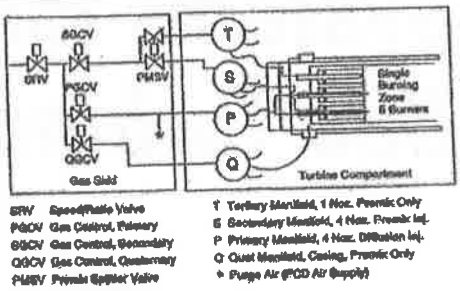


Figure 17. DLN-2 gas fuel system

The premix splitter valve controls the fuel flow split between the secondary and tertiary fuel system.

DLN-2 Emissions Performance

Figures 18 and 19 show the emissions performance for a DLN-2-equipped 7FA/9FA for gas fuel and for oil fuel with water injection.

DLN-2 Experience

The first DLN-2 systems were placed in service at Florida Power and Light's Martin Station with commissioning beginning in September 1993, and the first two (of four) 7FA units entered commercial service in February 1994. During commissioning, quaternary fuel was added and other combustor modifications were made to control dynamic pressure oscillations in the combustor.

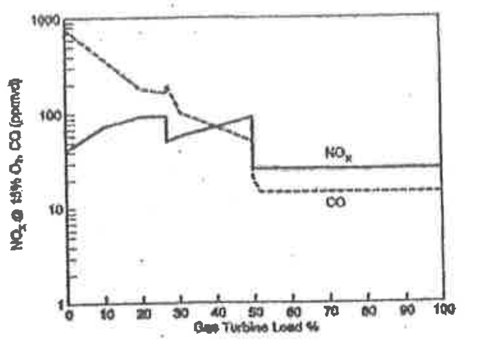


Figure 18. Gas fuel emissions in diffusion and premixed

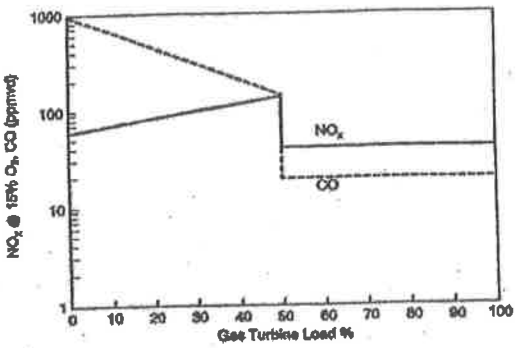


Figure 19. Distillate oil emissions with water injection above 50% load

After the 7FA DLN-2 entered commercial service the 9FA DLN-2 was introduced. Subsequent fleet experience indicated that to achieve adequate operational robustness against the entire range of site specific events, an improvement in premixer flashback resistance was needed. Under certain transient conditions flashback can occur where flame "holds" or is supported in the recirculation zone downstream of the premixed gas pegs. This region is not designed to withstand the abnormally high temperatures resulting from the presence of a flame. In the event of a flashback, the metal temperatures increase to unacceptable levels and hardware damage occurs. In some cases, these events have caused forced outages and adversely impacted availability. The solution chosen was to install full "fairings" on the downstream side of the cylindrical fuel injection pegs. Laboratory testing and subsequent fleet experience has demonstrated that full fairings are highly effective in reducing the probability of fuel nozzle flash-back. The fairings improve the peg aerodynamics in order to reduce the size of the recirculation zone downstream of the pegs. The result is to significantly reduce the probability of flame holding or attachment to the premixed pegs. *Figure 20* shows the original DLN-2 fuel nozzle while *Figure 21* illustrates the same nozzle with the addition of the fuel-peg fairings.

As of May 1999 there were 8 6FA, 26 7FA and 38 9FA units equipped with DLN-2 in commercial service. They have accumulated more than 1.1 million hours of operation.

DLN-2.6 Evolution

Regulatory pressures in the U.S. market in the early 1990s led to the need to develop a 9 ppm combustion system for the Frame 7FA. The result of this development is the DLN-2.6, which was first placed into service in March 1996 at Public Service of Colorado.

Reduction of NO_x levels from the DLN-2 at 25 ppm to 9 ppm required that approximately 6%

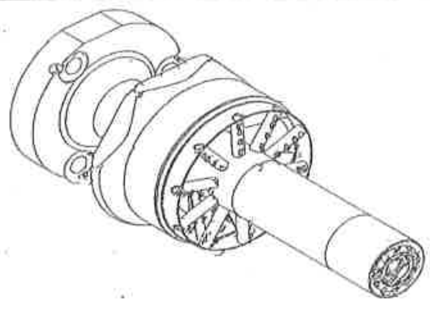


Figure 20. Un-faired DLN-2 fuel nozzle

ANNEXURE-2

GEK 106939
April 1998

GE Power Systems
Gas Turbine

Dry Low NOx 2.0+ System Operation

I. GENERAL

The dry low 2.0+ (DLN–2.0+) control system regulates the distribution of fuel delivered to a multi-nozzle combustor arrangement. The fuel flow distribution to each combustion chamber fuel nozzle assembly is a function of combustion reference temperature (TTRF1) and IGV temperature control mode. Diffusion, piloted premix, and premix flame are established by changing the fuel flow distribution in the combustor. By a combination of fuel staging and shifting of burning modes from diffusion at ignition through full pre-mix at high load, dramatically lower NOx emissions can be achieved above firing temperatures of 2,270°F.

II. GAS FUEL SYSTEM

The gas fuel system consists of the gas fuel auxiliary stop valve, gas fuel stop/ratio valve, diffusion gas control valve, PM4 gas control valve, and PM1 gas control valve. (Refer to Figure 1.)

The stop/ratio valve (SRV) is designed to maintain a predetermined pressure (P2) at the control valve inlet. The diffusion, PM4, and PM1 gas control valves (GCVs) regulate the desired gas fuel flow delivered to the turbine in response to the command signal FSR from the SPEEDTRONIC™ panel. The dry low NOx mode of operation will determine how the control valves stage fuel to the multi-nozzle combustion system. The auxiliary stop valve is used to provide class 6 sealing when heated fuels are used.

The stop ratio valve and gas control valves are monitored for their ability to track the command setpoint. If the valve command setpoint differs from the actual valve position by a prescribed amount for a period of time, an alarm will annunciate to warn the operator. If the condition persists for an extended amount of time, the turbine will be tripped and another alarm will annunciate the trip.

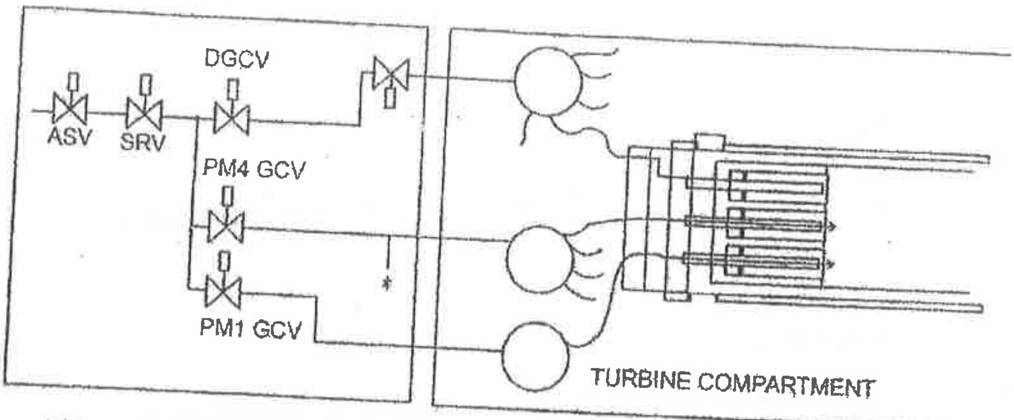
III. GAS FUEL OPERATION

There are three basic modes of distributing gas fuel to the DLN–2.0+ combustor. These modes are described below:

A. Diffusion Mode

In this mode, all the gas fuel directed to the 5 diffusion tips in each of the combustors. At this time, the pre–mix passages PM1 and PM4 are purged with compressor discharge (CPD) air.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes the matter should be referred to the GE Company.



ASV Aux. Stop Valve
SRV Speed/Ratio Valve
DGCV GCV Gas Control, Diffusion
PM4 GCV Gas Control, Pre–Mix 4
PM1 GCV Gas Control, Pre–Mix 1

PM1 Manifold, 1 Noz. Pre–Mix Only
PM4 Manifold, 4 Noz. Pre–Mix Inj.
Diffusion Manifold, Noz. Diffusion Inj.

* Purge Air (CPD Air Supply)

Figure 1. DLN–2.0+ Gas Fuel System

Diffusion is in the normal mode of operation from ignition to a combustion reference temperature of 2,000°F loading and unloading from 1,950°F till flame out.

B. Piloted Pre–Mix

In this mode, the fuel is split between the three gas control valves. To fire an even pre–mix split, the split between PM1 GCV and PM4 GCV, which feed the PM1 and PM4 manifolds respectively, should be 20/80. It is normal to run the pre–mix burners slightly off even split to optimize combustion dynamics at the expense of emissions.

Piloted pre–mix is the combustion mode between combustion reference temperature 2,000°F and 2,270°F loading and 2,220°F unloading.

C. Pre–Mix

In pre–mix, all the fuel is directed to the PM1 and PM4 GCVs which feed the pre–mix nozzles. Pre–mix mode combustion occurs above 2,270°F loading and 2,220°F unloading.

The diagrams in Figures 2 and 3 show how fuel flow is controlled while transferring between the various combustion modes.

IV. CHAMBER ARRANGEMENT

The 9FA+ employs 18 similar combustors. For each machine there are two spark plugs and four flame detectors in selected chambers with crossfire tubes connecting adjacent combustors. Each combustor consists of a five nozzle/cover assembly, forward and aft combustion casings, flow sleeve assembly, multi-nozzle cap assembly, liner assembly, and transition piece assembly.

V. COMBUSTION REFERENCE TEMPERATURE

The combustion reference temperature signal (TTRF1) is generated by a calculation in the DLN–2.0+ control software. This equation calculates TTRF1 as a function of the median exhaust temperature (TTXM), the compressor discharge pressure (CPD), and the inlet bell mouth temperature (CTIM). This calculated temperature represents a reference for combustor mode sequencing and fuel split scheduling and is not a true indication of actual machine firing temperature. A careful checkout of the combustion reference temperature during start-up is required. The initial loading of the turbine should be performed with "pilot premix base" selected on and samples of the combustion reference temperature calculation should be compared to values listed in the control specifications. The combustion reference temperature should match the control specification numbers within 20°F. Differences greater than 20°F may indicate an error in the calculation.

VI. DLN–2.0+ INLET GUIDE VANE OPERATION

The DLN–2.0+ combustor emission performance is sensitive to changes in fuel to air ratio. The combustor was designed according to the airflow regulation scheme used with inlet guide vane (IGV) temperature control. Optimal combustor operation is crucially dependent upon proper operation along the predetermined temperature control scheme. Controlled fuel scheduling will be dependent upon the state of IGV temperature control. IGV temperature control on can also be referred to as combined cycle operation while IGV temperature control off is referred to as simple cycle operation.

VII. DLN–2.0+ INLET BLEED HEAT

Operation of the gas turbine with reduced minimum IGV settings can be used to extend the Premix operating region. Reducing the minimum IGV angle allows the combustor to operate at a firing temperature high enough to support premix operation.

Inlet bleed heating (IBH), through the use of recirculated compressor discharge airflow, is necessary when operating with reduced IGV angles. Inlet heating protects the compressor from stall by relieving the discharge pressure and by increasing the inlet air stream temperature. Other benefits include anti-icing protection due to increased pressure drop across the IGVs.

The inlet bleed heat system regulates compressor discharge bleed flow through a control valve and into a manifold located in the compressor inlet air stream. The control valve varies the inlet heating air flow as a function of IGV angle. At minimum IGV angles the inlet bleed flow is controlled to a maximum of 5.0% of the total compressor discharge flow. As the IGVs are opened at higher loads, the inlet bleed flow will proportionally decrease until shut off.

The IBH control valve is monitored for its ability to track the command setpoint. If the valve command setpoint differs from the actual valve position by a prescribed amount for a period of time, an alarm will annunciate to warn the operator. If the condition persists for an extended amount of time, the inlet bleed heat system will be tripped and the IGV's minimum reference will be raised to the default value.

ANNEXURE-3

GE Power

Heavy-Duty Gas Turbine Operating and Maintenance Considerations

GER-3620N (10/17)

Justin Eggart

Christopher E. Thompson

Jerry Sasser

Mardy Merine

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Atlanta, GA

Combustion Parts

From hardware configuration standpoint, GE combustion hardware configuration include transition pieces, combustion liners, flow sleeves, head-end assemblies containing fuel nozzles and cartridges, end caps and end covers, and assorted other hardware parts including cross-fire tubes, spark plugs and flame detectors. In addition, there are various fuel and air delivery components such as purge or check valves and flexible hoses.

GE offers several types of combustion systems configurations: Standard combustors, Multi-Nozzle Quiet Combustors (MNQC), Integrated Gasification Combined Cycle (IGCC) combustors, and Dry Low NO_x (DLN) combustors. Each of the combustion configurations mentioned above, has specific gas or liquid fuel operating characteristics that affect differently combustion hardware factored maintenance intervals and refurbishment requirements.

Gas turbines fitted with DLN combustion systems operate in incremental combustion modes to reach to base load operation. A combustion mode constitutes a range of turbine load where fuel delivery in combustion cans is performed via certain combination of fuel nozzles or fuel circuits within the fuel nozzles. For example, for DLN 2.6 combustion systems, mode 3 refers to the load range when fuel is being delivered to PM 1 (Premix 1) and PM 2 (Premix 2) fuel nozzles through gas control valves PM 1 and PM 2.

Combustion modes change when turbine load, and consequently combustion reference temperature value (TTRF1 or CRT) crosses threshold values defining the initiation of next combustion mode.

- **Continuous mode operation** mentioned in this section refers to intentional turbine operation in a certain combustion mode for longer than what typically takes during normal startup/shutdown.
- **Extended mode operation** mentioned in this sections is possible in DLN1 or 1+ and DLN2 or 2+ combustion configuration only, where the controls logics can be forced to extend a Lean-Lean Mode or Piloted Premixed Mode beyond the turbine load corresponding to a normal combustion mode transfer (as defined via TTRF1 or CRT values).

From operational standpoint, earlier DLN combustion configurations such as DLN1/1+, DLN2/2+ use diffusion combustion (non-Premix) at part load before reaching the low emissions combustion mode (Premix). These combustion modes nomenclatures are referred to as Lean-Lean, extended Lean-Lean, sub-Piloted Premix and Piloted Premix Modes. General recommendation for continuous mode operation is in the combustion mode that provides guaranteed emissions, which is the premixed combustion mode (PM). This combustion mode is also the most beneficial operation mode for ensuring expected hardware life.

Continuous and extended mode operation in non-PM combustion modes is not recommended due to reduction in combustion hardware life as shown in *Figure 24.*

With the introduction of full Premix combustion systems, such as 2.6, 2.6+ the risks for reduction in hardware durability when running in non-emissions compliance modes are diminished (with exception of Mode 3, as shown in *Figure 24*).

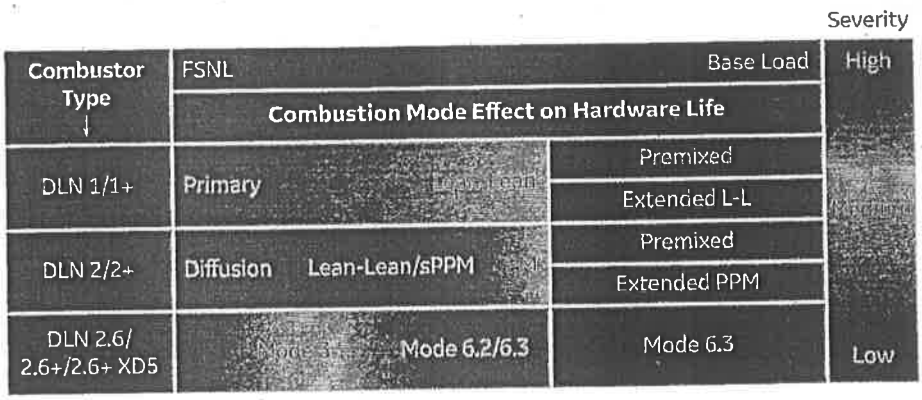


Figure 24: DLN combustion mode effect on combustion hardware

The use of non-Premix combustion modes affects the factored maintenance intervals of combustion hardware as shown below:

- DLN-1/DLN-1+ extended lean-lean operation results in a maintenance factor of 10 (excluding Frame 5 units where MF=2). Nimonic 263 will have a maintenance factor of 4.
- DLN 2.0/DLN 2+ extended piloted premixed operation results in a maintenance factor of 10.
- Continuous mode operation in Lean-Lean (L-L), sub-Piloted Premixed (sPPM), or Piloted Premixed (PPM) modes is not recommended as it will accelerate combustion hardware degradation.
- In addition, cyclic operation between piloted premixed and premixed modes leads to thermal loads on the combustion liner and transition piece similar to the loads encountered during the startup/shutdown cycle.

Continuous mode operation of DLN 2.6/DLN 2.6+ combustors will not accelerate combustion hardware degradation.

Another factor that can affect combustion system maintenance is acoustic dynamics. Acoustic dynamics are pressure oscillations generated by the combustion process within the combustion chambers, which when are present at high levels can lead to significant wear of combustion or hot gas path components. Common GE practice is to tune the combustion system to levels of acoustic dynamics deemed low enough not to affect life of gas turbine hardware. In addition, GE encourages monitoring of combustion dynamics during turbine operation throughout the full range of ambient temperatures and loads.

Combustion disassembly is performed, during scheduled combustion inspections (CI). Inspection interval guidelines are included in *Figure 36*. It is expected, and recommended, that intervals be modified based on specific experience. Replacement intervals are usually defined by a recommended number of combustion (or repair) intervals and are usually combustion component specific. In general, the replacement interval as a function of the number of combustion inspection intervals is reduced if the combustion inspection interval is extended. For example, a component having an 8,000-hour CI interval, and a six CI replacement interval, would have a replacement interval of four CI intervals if the inspection intervals were increased to 12,000 hours (to maintain a 48,000-hour replacement interval).

For combustion parts, the baseline operating conditions that result in a maintenance factor of one are fired startup and shutdown to base load on natural gas fuel without steam or water injection. Factors that increase the hours-based maintenance factor include peak load operation, distillate or heavy fuels, and steam or water injection. Factors that increase starts-based maintenance factor include peak load start/stop cycles, distillate or heavy fuels, steam or water injection, trips, and peaking-fast starts.

Casing Parts

Most GE gas turbines have inlet, compressor, compressor discharge, and turbine cases in addition to exhaust frames. Inner barrels are typically attached to the compressor discharge case. These cases provide the primary support for the bearings, rotor, and gas path hardware.

The exterior of all casings should be visually inspected for cracking, loose hardware, and casing slippage at each combustion, hot gas path, and major outage. The interior of all casings should be inspected whenever possible. The level of the outage determines which casing interiors are accessible for visual inspection. Borescope inspections are recommended for the inlet cases, compressor cases, and compressor discharge cases during gas path borescope inspections. All interior case surfaces should be inspected visually, digitally, or by borescope during a major outage.

Key inspection areas for casings are listed below.

- Bolt holes
- Shroud pin and borescope holes in the turbine shell (case)
- Compressor stator hooks
- Turbine shell shroud hooks
- Compressor discharge case struts
- Inner barrel and inner barrel bolts
- Inlet case bearing surfaces and hooks
- Inlet case and exhaust frame gibs and trunions
- Extraction manifolds (for foreign objects)

Annexure- 4

Variation of NOx emission at different loadings of gas turbine for 9FA machine as furnished by M/s RGPPL:

Load (MW)	O_2 (%)	NOx (ppm)	Corrected NOx (ppm)	Mode of Combustion
60	15.5	59	64.5	Diffusion
80	14.8	111	107.4	Piloted PM
90	14.7	126	119.9	Piloted PM
100	14.6	147	1347.7	Piloted PM
100	14.7	150	142.7	Piloted PM
120	14.4	178	161.6	Piloted PM
130	14.3	16	14.3	PMSS
140	14.2	24	21.1	PMSS
141	14.2	22	19.1	PMSS
149	14.2	20	17.6	PMSS
160	14.2	19	16.7	PMSS
180	14.1	22	19.1	PMSS
200	14.0	38	32.5	PMSS
200	13.9	26	21.9	PMSS
200	13.9	27	22.8	PMSS
215	13.8	28	23.3	PMSS

Piloted PM – Piloted Premix mode; PMSS – Premix Steady State mode

Annexure- 5

Components of GT & ST outputs at part loading for a module as per data furnished by M/s RGPPL						
GTs load				STG load (MW)	CCGT load (MW)	% loading of CCGT w.r.t. its full load
GT-1 load (MW)	GT-2 load (MW)	Average load of GT-1/ GT-2 (MW)	Average loading of GTs w.r.t. full load of GTs (%)			
211.05	210.64	**210.85**	**100.00**	239.82	**661.51**	**100.00**
205.81	207.60	206.71	98.04	246.93	660.34	99.82
200.53	210.13	205.33	97.38	241.44	652.1	98.58
209.55	199.38	204.47	96.97	240.55	649.48	98.18
203.82	199.70	201.76	95.69	243.59	647.11	97.82
204.36	200.44	202.40	95.99	242.18	646.98	97.80
200.04	200.31	200.18	94.94	236.82	637.17	96.32
185.19	145.12	165.16	78.33	214.59	544.9	82.37
163.69	154.58	159.14	75.47	210.52	528.79	79.94
159.84	160.76	160.30	76.03	205.95	526.55	79.60
154.00	155.86	154.93	73.48	209.69	519.55	78.54
153.26	155.83	154.55	73.30	208.47	517.56	78.24
159.58	150.00	154.79	73.41	207.77	517.35	78.21
153.74	154.18	153.96	73.02	204.97	512.89	77.53
154.45	150.15	152.30	72.23	205.62	510.22	77.13
150.70	149.94	150.32	71.29	208.92	509.56	77.03
150.85	148.50	149.68	70.99	205.62	504.97	76.34
144.88	144.88	144.88	68.71	206.38	496.14	75.00
144.79	145.15	144.97	68.76	203.42	493.36	74.58
145.36	145.36	145.36	68.94	202.04	492.76	74.49
140.07	139.89	139.98	66.39	207.7	487.66	73.72
139.94	144.12	142.03	67.36	203.03	487.09	73.63
139.95	144.09	142.02	67.36	202.17	486.21	73.50
140.26	139.65	139.96	66.38	204.28	484.19	73.19
129.87	121.82	125.85	59.69	193.74	445.43	67.34
128.86	119.64	124.25	58.93	193.76	442.26	66.86
120.69	120.00	120.35	57.08	197.52	438.21	66.24
120.22	119.02	119.62	56.73	192.54	431.78	65.27
120.72	118.99	119.86	56.85	191.93	431.64	65.25
119.73	119.81	119.77	56.80	191.90	431.44	65.22

					Annexure- 6
Components of GT & ST outputs at part loading for a CCGT module as per generic data furnished by M/s GE					
% CCGT load	Load contribution			Average contribution of GT-1/ GT-2 (%)	Average GT loading as % of its full load capacity
	GT-1 load contriburion (%)	GT-2 load contriburion (%)	SGT load contriburion (%)		
100	32	32	36	32	100
95	30.8	30.8	38.4	30.80	91.44
90	30.5	30.5	39.10	30.50	85.78
85	30	30	40.00	30.00	79.69
80	29.5	29.5	41.10	29.50	73.75
75	28.9	28.90	42.30	28.90	67.73
70	28.3	28.3	43.80	28.30	61.91
65	27.6	27.6	44.80	27.60	56.06
60	26.4	26.4	47.20	26.40	49.50
55	25.4	25.5	49.30	25.45	43.74
50	24.3	24.3	51.50	24.30	37.97

Annexure- 7

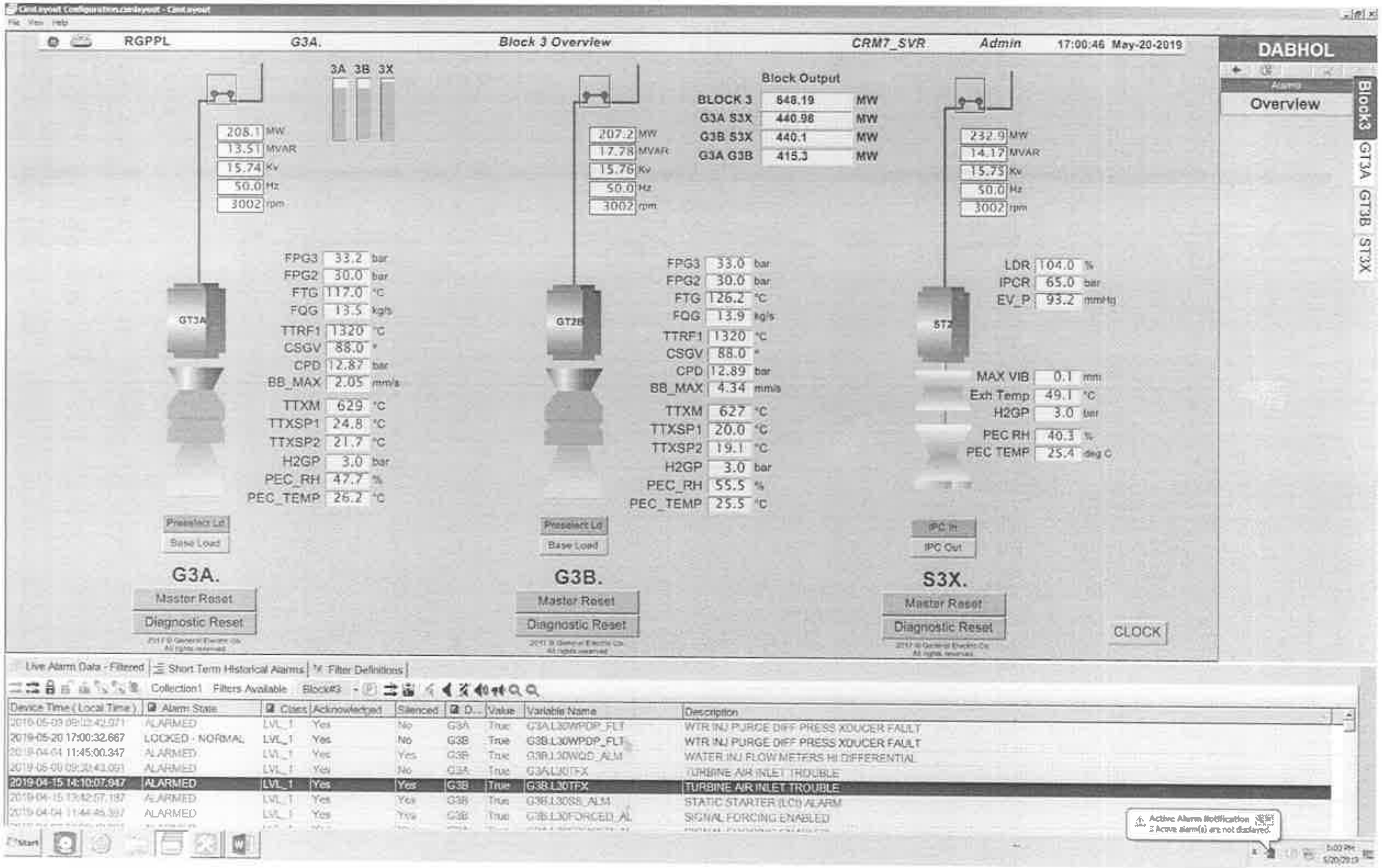
Results of site demonstration test on CCGT Block- 3

Rated GT load (MW) 213 Rated CCGT load (MW) 663.54

Date/ Time	GT3A				GT3B				Average GT load	STG (MW)	CCGT (MW)
	MW	TTRF1 (°C)	Mode	NOx (ppm)	MW	TTRF1 (°C)	Mode	NOx (ppm)			
20.5.19											
16:04:36	199.1	1300	Premix		200.1	1303	Premix		199.6	229.8	629.56
16:17:18	207.2	1320	Premix		207.1	1320	Premix		207.2	233.5	647.8
16:29:32	169	1283	Premix	1.96	169.8	1287	Premix	10.39	169.4	215.6	554.36
16:43:26	169.8	1284	Premix	6.11	170.4	1287	Premix	9.45	170.1	209.6	549.76
17:00:46	208.1	1320	Premix	-0.47	207.2	1320	Premix	16.67	207.7	232.9	648.19
17:12:55	207.2	1320	Premix		198.6	1302	Premix		202.9	233.7	639.47
21.5.19											
11:18:39	184.6	1293	Premix		183.8	1296	Premix		184.2	220.3	588.69
11:25:20	169.3	1283	Premix	5.57	168.6	1287	Premix	11.41	169.0	215.3	553.23
11:30:33	158.4	1275	Premix	4.13	158.7	1280	Premix	9.62	158.6	209.5	526.53
11:34:59	148.1	1268	Premix	5.01	148.4	1273	Premix	9.75	148.3	204.6	501.08
11:39:09	134.1	1255	Premix	2.55	135.1	1263	Premix	9.05	134.6	199.8	469.02
11:41:41	118.1	1236	Premix		118	1242	Premix		118.1	196.7	432.92
11:43:08	120.5	1238	Premix	-0.16	118.4	1243	Premix	6.07	119.5	194.8	433.7
11:45:37	108.5	1218	Piloted Premix	74.32	117.6	1243	Premix	6.04	113.1	190.9	417.02
11:46:31	116.1	1235	Piloted Premix	81.61	119	1242	Premix	6.02	117.6	190.0	425.06
11:48:27	99.6	1214	Piloted Premix	103.6	118.2	1244	Premix	5.89	108.9	186.6	404.39
11:49:16	98.8	1213	Piloted Premix	113.3	118	1243	Premix	5.84	108.4	185.9	402.65
11:51:56	98.5	1213	Piloted Premix	86.78	110.2	1230	Piloted Premix	85.46	104.4	181.6	390.3
11:54:42	97.9	1213	Piloted Premix	88.32	110.7	1237	Piloted Premix	123.6	104.3	177.7	386.38
11:56:53	98.7	1213	Piloted Premix	88.13	99.2	1222	Piloted Premix	125.3	99.0	173.1	371.05
11:59:12	98.5	1212	Piloted Premix	88.29	98.3	1219	Piloted Premix	101.6	98.4	168	364.71
11:59:38	98.9	1214	Piloted Premix	88.54	98.7	1220	Piloted Premix	110.3	98.8	167.3	364.89
12:03:58	79.2	1188	Piloted Premix	88.01	80.4	1198	Piloted Premix	106	79.8	167.9	327.54
12:07:41	80.3	1185	Piloted Premix	61.24	79.8	1192	Piloted Premix	81.96	80.1	167.2	327.26
12:09:12	80.4	1186	Piloted Premix	61.51	80.1	1193	Piloted Premix	76.25	80.3	165.2	325.73
12:26:22	205.9	1320	Premix	10.95	205.7	1320	Premix	21.42	205.8	215.7	627.4
12:29:51	205.56	1319	Premix	13.04	205.1	1320	Premix	19.82	205.3	226.2	636.92

NOx emission values are as per screen shots taken from another OWS at slightly different time than that indicated above.

Annexure- 8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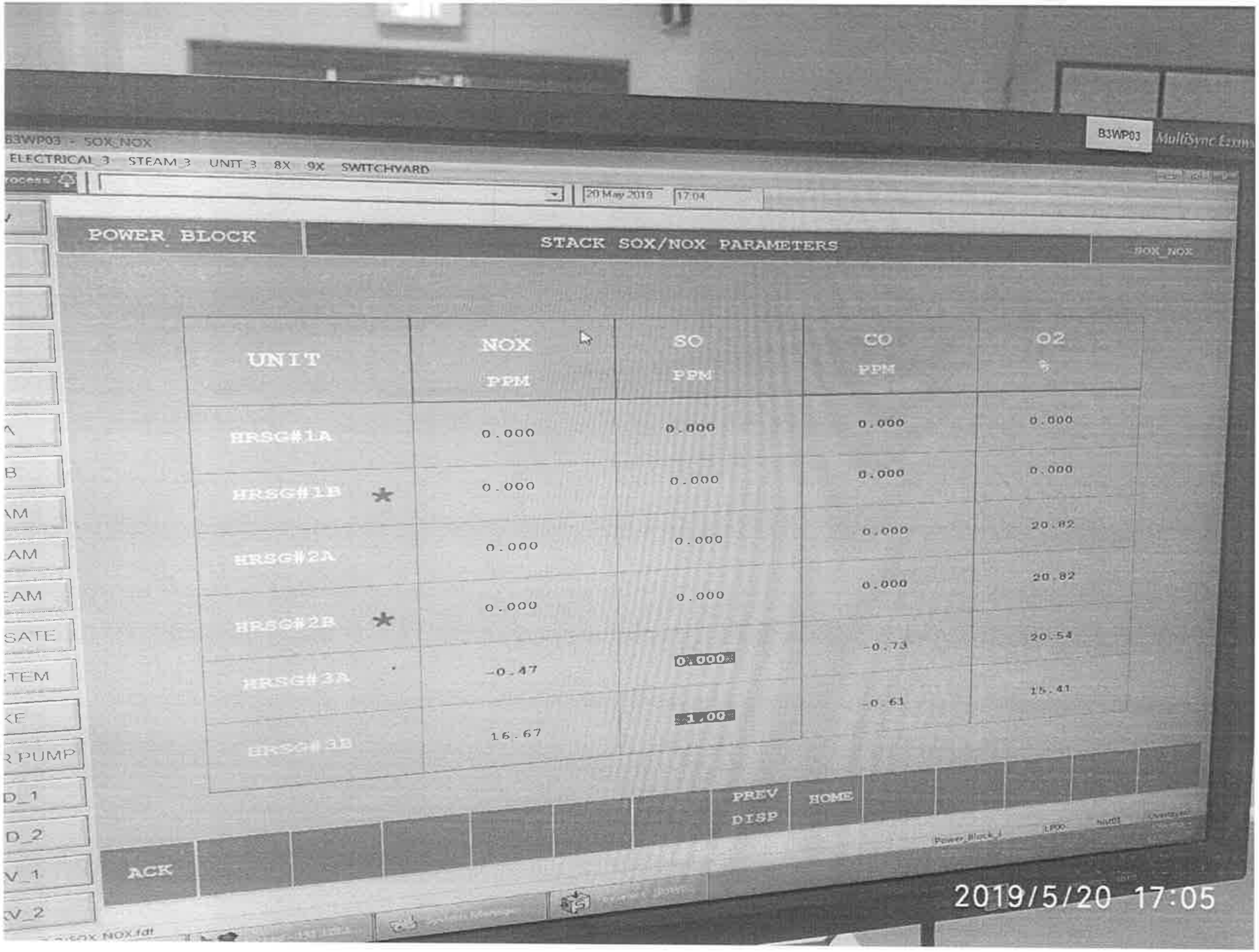
G3A.
Block 3 Overview
CRM7_SVR
Admin
17:00:46 May-20-2019
DABHOL
Overview
Block3
GT3A
GT3B
ST3X
3A 3B 3X
Block Output
BLOCK 3 648.19 MW
G3A S3X 440.98 MW
G3B S3X 440.1 MW
G3A G3B 415.3 MW
208.1 MW
13.51 MVAR
15.74 Kv
50.0 Hz
3002 rpm
FPG3 33.2 bar
FPG2 30.0 bar
FTG 117.0 °C
FQG 13.5 kg/s
TTRF1 1320 °C
CSGV 88.0 °
CPD 12.87 bar
BB_MAX 2.05 mm/s
TTXM 629 °C
TTXSP1 24.8 °C
TTXSP2 21.7 °C
H2GP 3.0 bar
PEC_RH 47.7 %
PEC_TEMP 26.2 °C
Preselect Ld
Base Load
G3A.
Master Reset
Diagnostic Reset
207.2 MW
17.78 MVAR
15.76 Kv
50.0 Hz
3002 rpm
FPG3 33.0 bar
FPG2 30.0 bar
FTG 126.2 °C
FQG 13.9 kg/s
TTRF1 1320 °C
CSGV 88.0 °
CPD 12.89 bar
BB_MAX 4.34 mm/s
TTXM 627 °C
TTXSP1 20.0 °C
TTXSP2 19.1 °C
H2GP 3.0 bar
PEC_RH 55.5 %
PEC_TEMP 25.5 °C
Preselect Ld
Base Load
G3B.
Master Reset
Diagnostic Reset
232.9 MW
14.17 MVAR
15.73 Kv
50.0 Hz
3002 rpm
LDR 104.0 %
IPCR 65.0 bar
EV_P 93.2 mmHg
MAX VIB 0.1 mm
Exh Temp 49.1 °C
H2GP 3.0 bar
PEC RH 40.3 %
PEC TEMP 25.4 deg C
IPC In
IPC Out
S3X.
Master Reset
Diagnostic Reset
CLOCK
Live Alarm Data - Filtered
Short Term Historical Alarms
Filter Definitions
Collection1 Filters Available Block#3
Device Time (Local Time) | Alarm State | Class | Acknowledged | Silenced | D... | Value | Variable Name | Description
2019-05-20 17:00:32.667 | LOCKED - NORMAL | LVL_1 | Yes | No | G3B | True | G3B.L30WPDP_FLT | WTR INJ PURGE DIFF PRESS XDUCER FAULT
2019-04-04 11:45:00.347 | ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30WQD_ALM | WATER INJ FLOW METERS HI DIFFERENTIAL
2019-04-15 14:10:07.947 | ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30TFX | TURBINE AIR INLET TROUBLE
ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30SS_ALM | STATIC STARTER (LCI) ALARM
ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30FORCED_AL | SIGNAL FORCING ENABLED
Active Alarm Notification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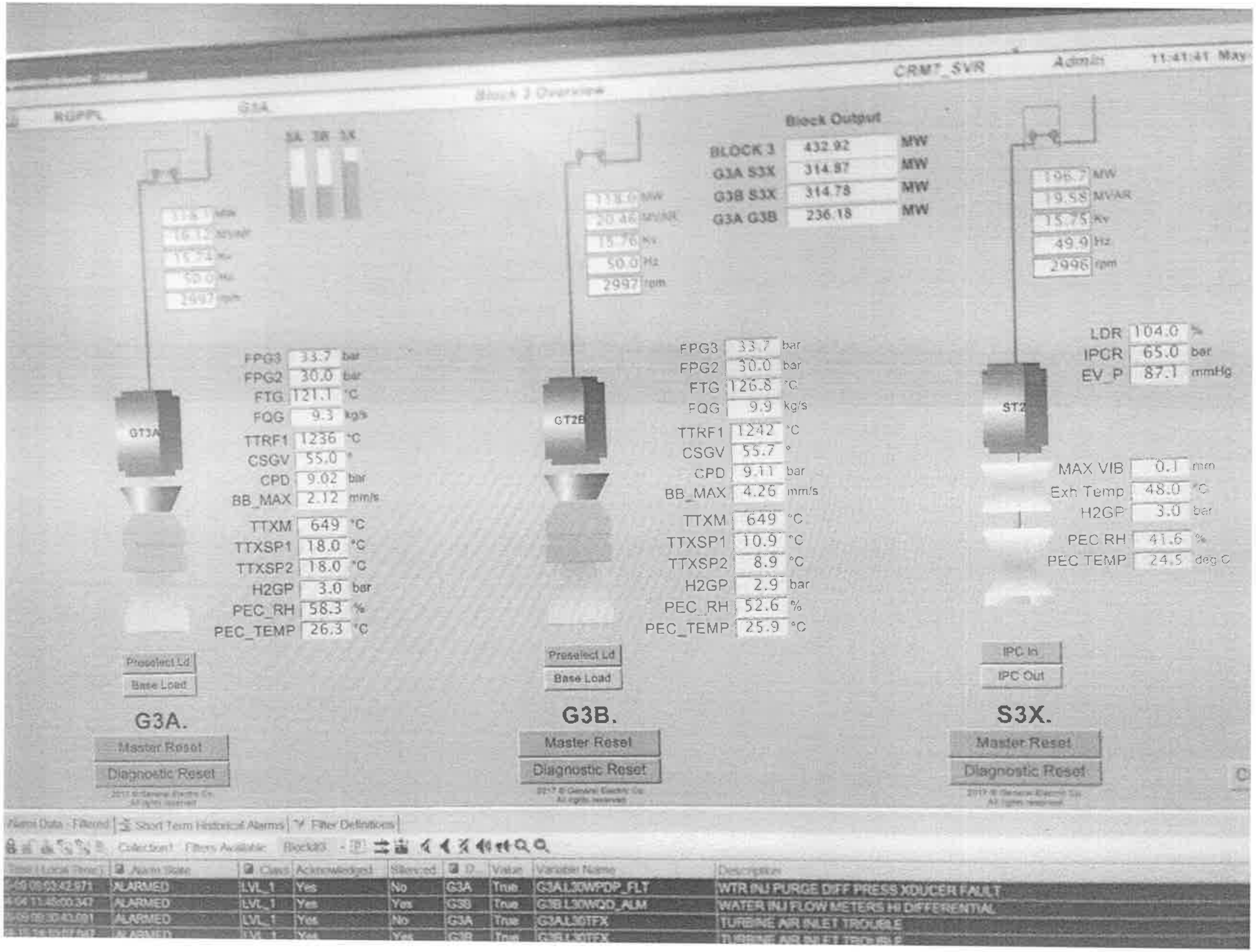
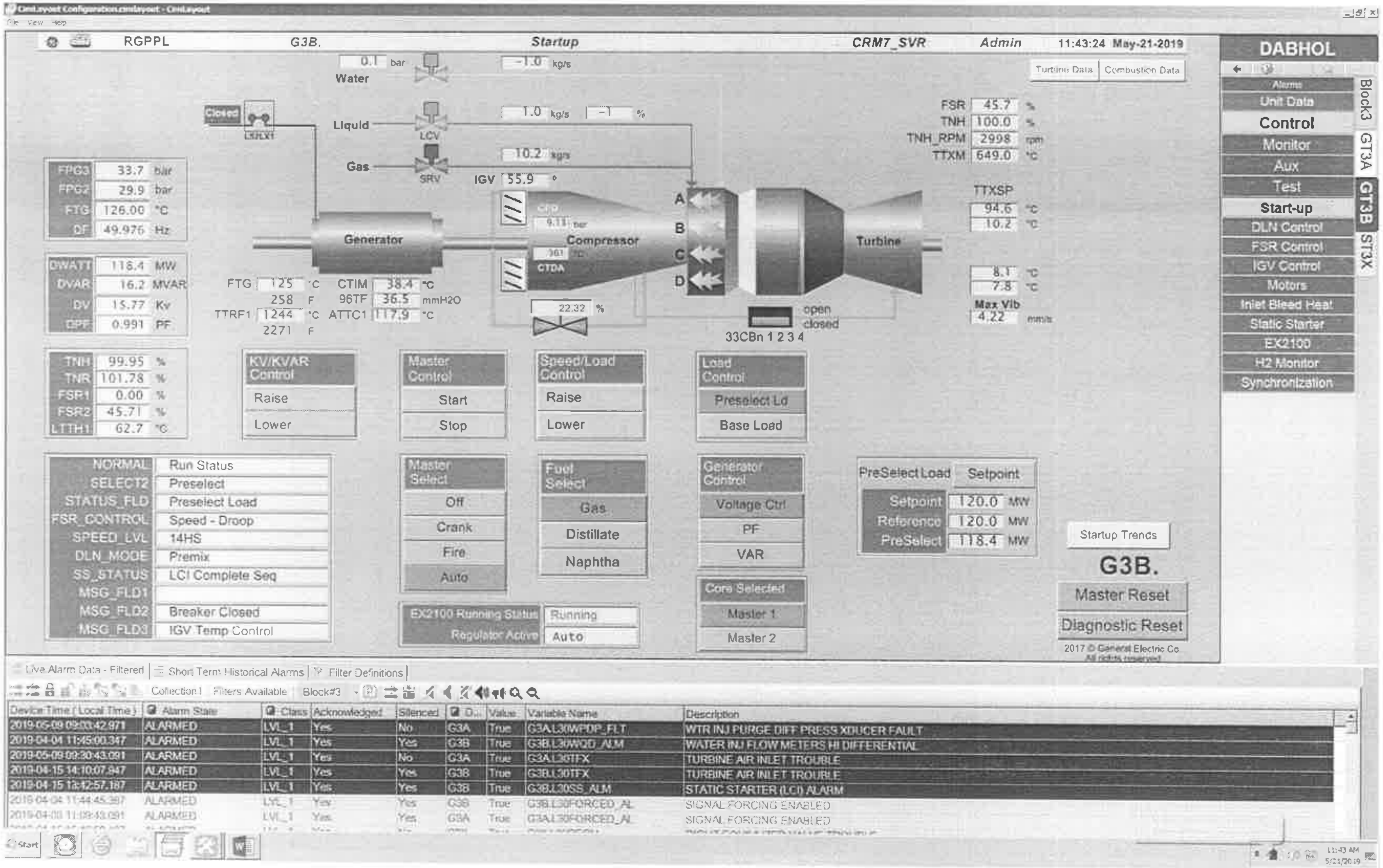
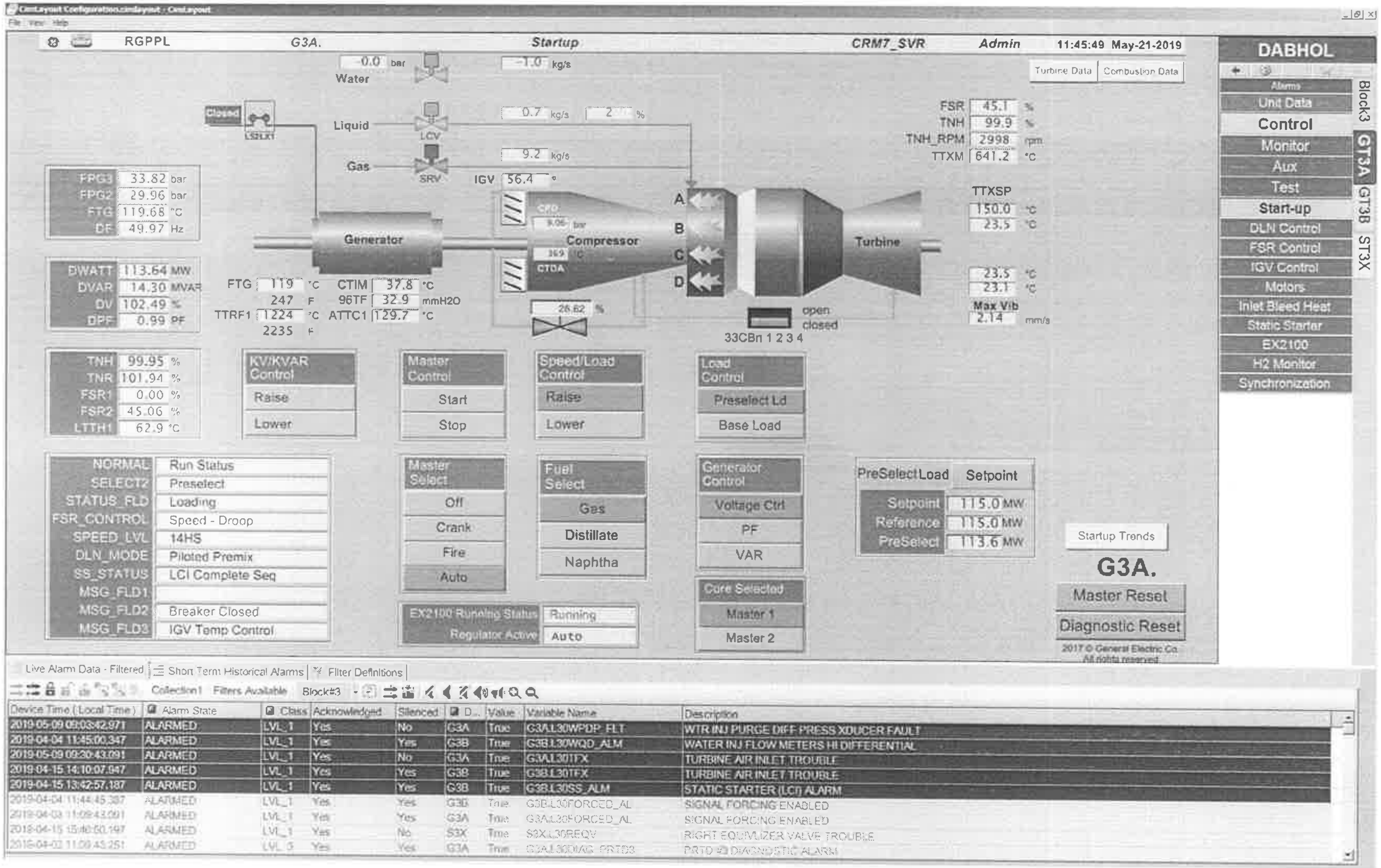
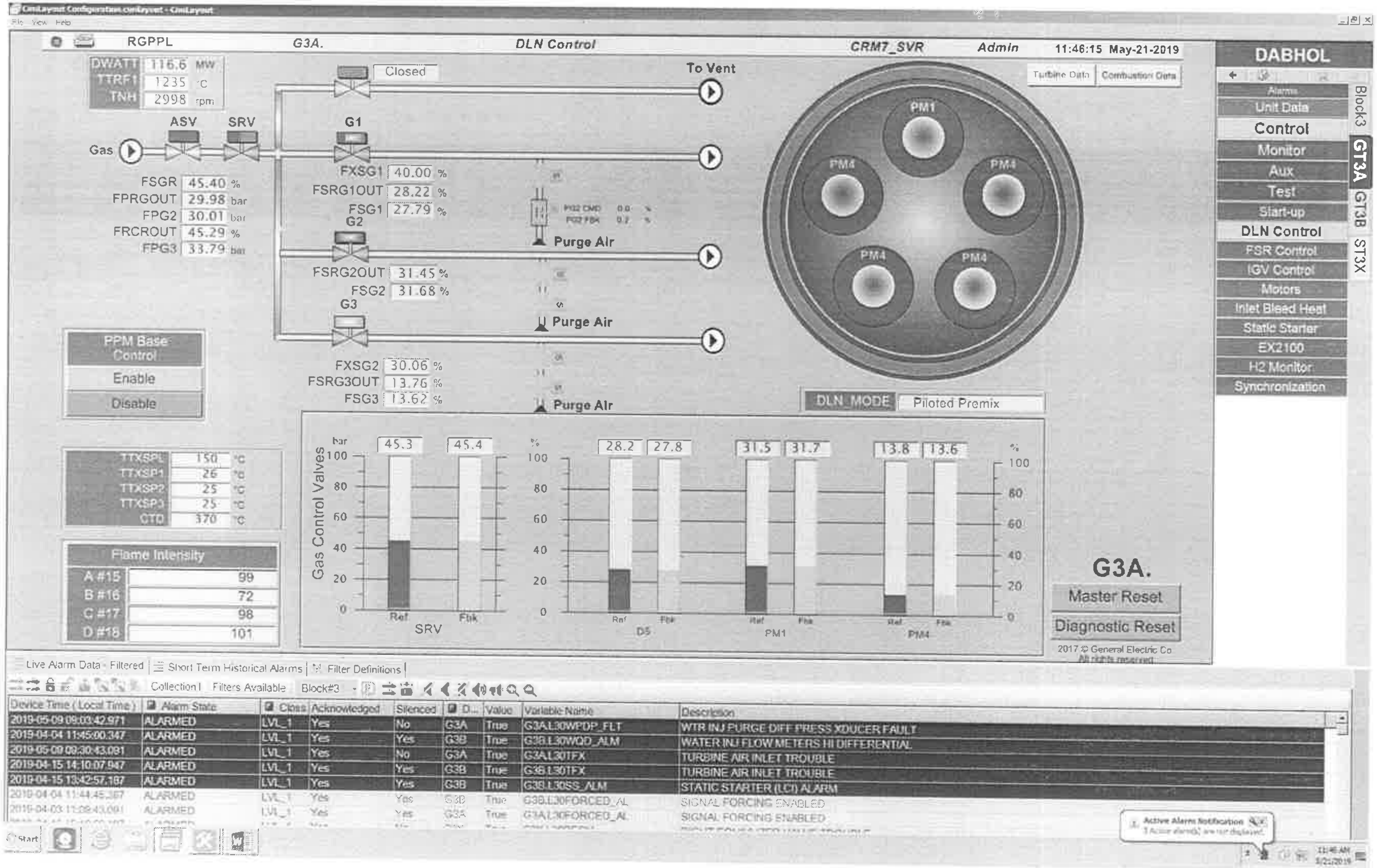
20 May 2019 17:04
POWER BLOCK
STACK SOX/NOX PARAMETERS
SOX_NOX
UNIT
NOX PPM
SO PPM
CO PPM
O2 %
HRSG#1A 0.000 0.000 0.000 0.000
HRSG#1B * 0.000 0.000 0.000 0.000
HRSG#2A 0.000 0.000 0.000 20.82
HRSG#2B * 0.000 0.000 0.000 20.82
HRSG#3A -0.47 0.000 -0.73 20.54
HRSG#3B 16.67 1.00 -0.61 15.41
PREV DISP
HOME
ACK
B3WP03
2019/5/20 17:05


CRMT_SVR
Admin
Block Output
BLOCK 3 432.92 MW
G3A S3X 314.87 MW
G3B S3X 314.78 MW
G3A G3B 236.18 MW
FPG3 33.7 bar
FPG2 30.0 bar
FTG 121.1 °C
FQG 9.3 kg/s
TTRF1 1236 °C
CSGV 55.0 °
CPD 9.02 bar
BB_MAX 2.12 mm/s
TTXM 649 °C
TTXSP1 18.0 °C
TTXSP2 18.0 °C
H2GP 3.0 bar
PEC_RH 58.3 %
PEC_TEMP 26.3 °C
118.6 MW
20.46 MVAR
15.76 Kv
50.0 Hz
2997 rpm
FPG3 33.7 bar
FPG2 30.0 bar
FTG 126.8 °C
FQG 9.9 kg/s
TTRF1 1242 °C
CSGV 55.7 °
CPD 9.11 bar
BB_MAX 4.26 mm/s
TTXM 649 °C
TTXSP1 10.9 °C
TTXSP2 8.9 °C
H2GP 2.9 bar
PEC_RH 52.6 %
PEC_TEMP 25.9 °C
196.7 MW
19.58 MVAR
15.75 Kv
49.9 Hz
2996 rpm
LDR 104.0 %
IPCR 65.0 bar
EV_P 87.1 mmHg
MAX VIB 0.1 mm
Exh Temp 48.0 °C
H2GP 3.0 bar
PEC RH 41.6 %
PEC TEMP 24.5 deg C
Preselect Ld
Base Load
G3A.
Master Reset
Diagnostic Reset
Preselect Ld
Base Load
G3B.
Master Reset
Diagnostic Reset
IPC In
IPC Out
S3X.
Master Reset
Diagnostic Reset
ALARMED LVL_1 Yes No G3A True G3AL30WPDP_FLT WTR INJ PURGE DIFF PRESS XDUCER FAULT
ALARMED LVL_1 Yes Yes G3B True G3BL30WQD_ALM WATER INJ FLOW METERS HI DIFFERENTIAL
ALARMED LVL_1 Yes No G3A True G3AL30TFX TURBINE AIR INLET TROUBLE

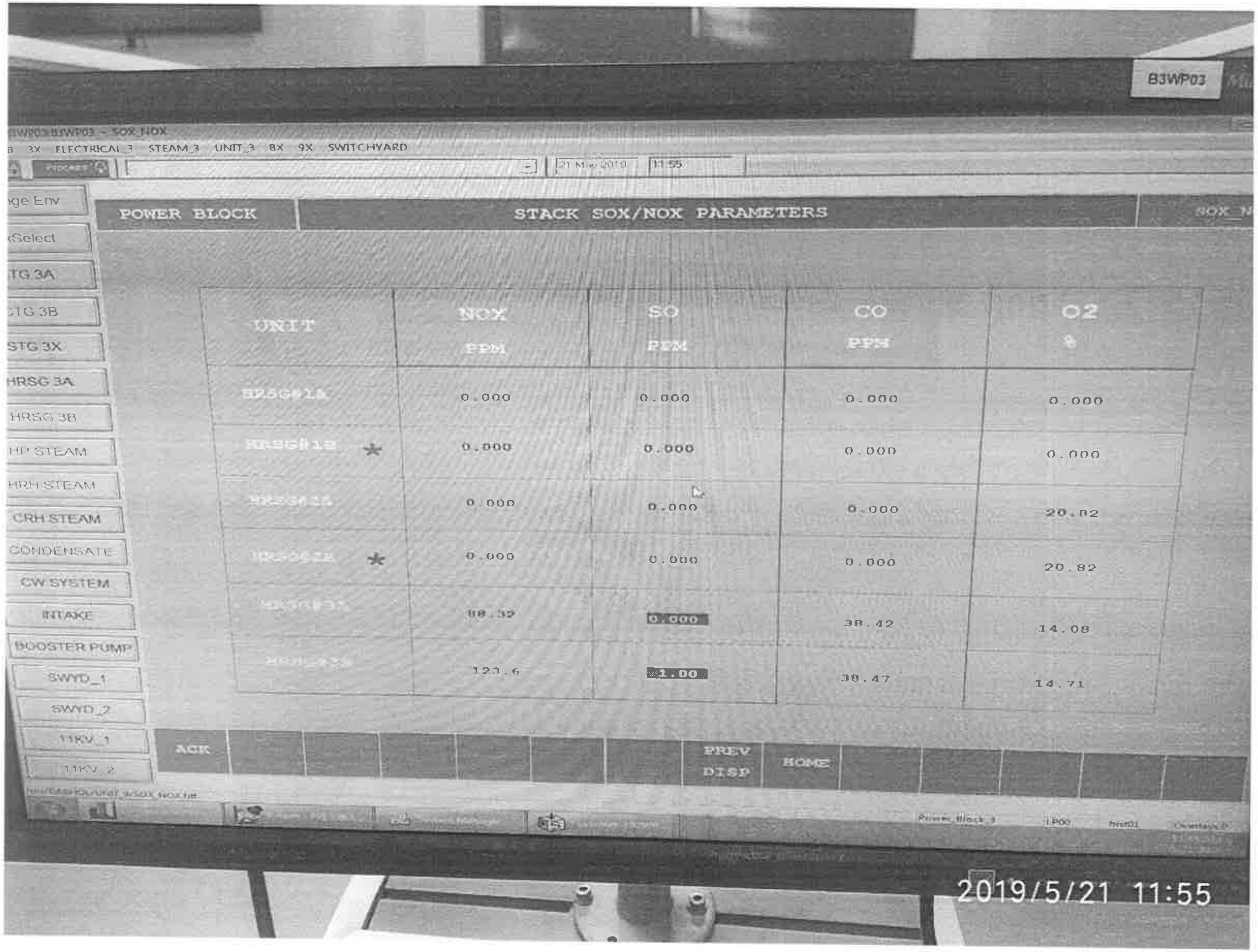


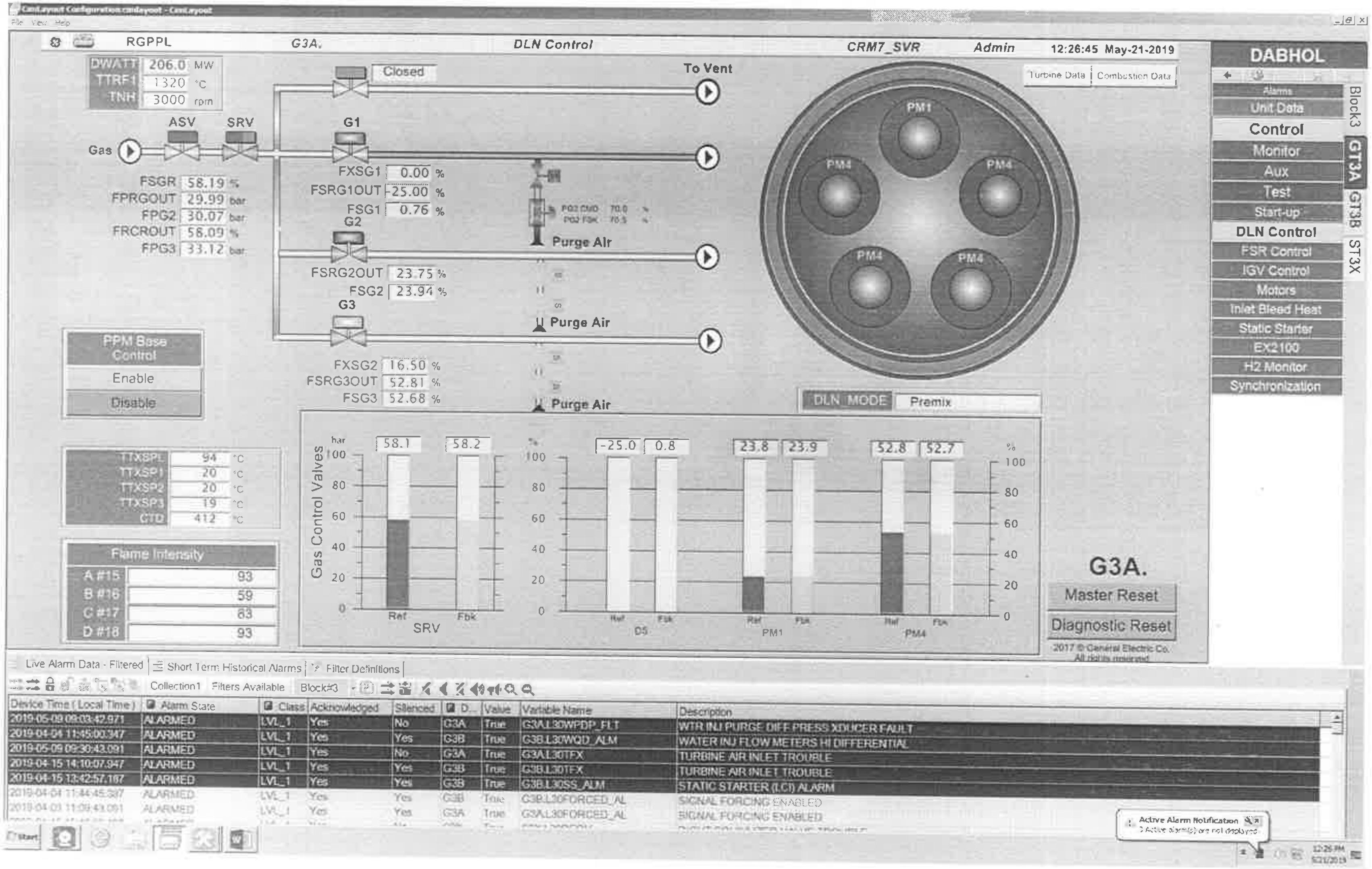
Device Time (Local Time)	Alarm State	Class	Acknowledged	Silenced	D...	Value	Variable Name	Description
2019-05-09 09:03:42.971	ALARMED	LVL_1	Yes	No	G3A	True	G3A.L30WPDP_FLT	WTR INJ PURGE DIFF PRESS XDUCER FAULT
2019-04-04 11:45:00.347	ALARMED	LVL_1	Yes	Yes	G3B	True	G3B.L30WQD_ALM	WATER INJ FLOW METERS HI DIFFERENTIAL
2019-05-09 09:30:43.091	ALARMED	LVL_1	Yes	No	G3A	True	G3A.L30TFX	TURBINE AIR INLET TROUBLE
2019-04-15 14:10:07.947	ALARMED	LVL_1	Yes	Yes	G3B	True	G3B.L30TFX	TURBINE AIR INLET TROUBLE
2019-04-15 13:42:57.187	ALARMED	LVL_1	Yes	Yes	G3B	True	G3B.L30SS_ALM	STATIC STARTER (LCI) ALARM
2019-04-04 11:44:45.387	ALARMED	LVL_1	Yes	Yes	G3B	True	G3B.L30FORCED_AL	SIGNAL FORCING ENABLED
2019-04-03 11:09:43.091	ALARMED	LVL_1	Yes	Yes	G3A	True	G3A.L30FORCED_AL	SIGNAL FORCING ENABLED


RGPPL
G3A.
Startup
CRM7_SVR
Admin
11:45:49 May-21-2019
DABHOL
Turbine Data
Combustion Data
Water
Liquid
Gas
LCV
SRV
IGV 56.4
FPG3 33.82 bar
FPG2 29.96 bar
FTG 119.68 °C
DF 49.97 Hz
DWATT 113.64 MW
DVAR 14.30 MVAR
DV 102.49 %
DPF 0.99 PF
TNH 99.95 %
TNR 101.94 %
FSR1 0.00 %
FSR2 45.06 %
LTTH1 62.9 °C
Generator
Compressor
Turbine
FSR 45.1 %
TNH 99.9 %
TNH_RPM 2998 rpm
TTXM 641.2 °C
TTXSP
150.0 °C
23.5 °C
Max Vib 2.14 mm/s
FTG 119 °C
247 F
TTRF1 1224 °C
2235 F
CTIM 37.8 °C
96TF 32.9 mmH2O
ATTC1 129.7 °C
33CBn 1 2 3 4
open
closed
KV/KVAR Control
Raise
Lower
Master Control
Start
Stop
Speed/Load Control
Raise
Lower
Load Control
Preselect Ld
Base Load
NORMAL Run Status
SELECT2 Preselect
STATUS_FLD Loading
FSR_CONTROL Speed - Droop
SPEED_LVL 14HS
DLN_MODE Piloted Premix
SS_STATUS LCI Complete Seq
MSG_FLD1
MSG_FLD2 Breaker Closed
MSG_FLD3 IGV Temp Control
Master Select
Off
Crank
Fire
Auto
Fuel Select
Gas
Distillate
Naphtha
Generator Control
Voltage Ctrl
PF
VAR
Core Selected
Master 1
Master 2
EX2100 Running Status Running
Regulator Active Auto
PreSelect Load
Setpoint
Setpoint 115.0 MW
Reference 115.0 MW
PreSelect 113.6 MW
Startup Trends
G3A.
Master Reset
Diagnostic Reset
Unit Data
Control
Monitor
Aux
Test
Start-up
DLN Control
FSR Control
IGV Control
Motors
Inlet Bleed Heat
Static Starter
EX2100
H2 Monitor
Synchronization
Block3
GT3A
GT3B
ST3X
Live Alarm Data - Filtered
Short Term Historical Alarms
Filter Definitions
Device Time (Local Time) | Alarm State | Class | Acknowledged | Silenced | D... | Value | Variable Name | Description
2019-05-09 09:03:42.971 ALARMED LVL_1 Yes No G3A True G3A.L30WPDP_FLT WTR INJ PURGE DIFF PRESS XDUCER FAULT
2019-04-04 11:45:00.347 ALARMED LVL_1 Yes Yes G3B True G3B.L30WQD_ALM WATER INJ FLOW METERS HI DIFFERENTIAL
2019-05-09 09:30:43.091 ALARMED LVL_1 Yes No G3A True G3A.L30TFX TURBINE AIR INLET TROUBLE
2019-04-15 14:10:07.947 ALARMED LVL_1 Yes Yes G3B True G3B.L30TFX TURBINE AIR INLET TROUBLE
2019-04-15 13:42:57.187 ALARMED LVL_1 Yes Yes G3B True G3B.L30SS_ALM STATIC STARTER (LCI) ALARM
SIGNAL FORCING ENABLED
SIGNAL FORCING ENABLED
RIGHT EQUALIZER VALVE TROUBLE



RGPPL
G3A.
DLN Control
CRM7_SVR
Admin
11:46:15 May-21-2019
DWATT 116.6 MW
TTRF1 1235 °C
TNH 2998 rpm
Closed
To Vent
ASV
SRV
G1
Gas
FXSG1 40.00 %
FSRG1OUT 28.22 %
FSG1 27.79 %
FSGR 45.40 %
FPRGOUT 29.98 bar
FPG2 30.01 bar
FRCROUT 45.29 %
FPG3 33.79 bar
G2
Purge Air
FSRG2OUT 31.45 %
FSG2 31.68 %
G3
Purge Air
FXSG2 30.06 %
FSRG3OUT 13.76 %
FSG3 13.62 %
Purge Air
PM1
PM4
PM4
PM4
PM4
Turbine Data
Combustion Data
DLN_MODE
Piloted Premix
PPM Base Control
Enable
Disable
TTXSPL 150 °C
TTXSP1 26 °C
TTXSP2 25 °C
TTXSP3 25 °C
CTD 370 °C
Flame Intensity
A #15 99
B #16 72
C #17 98
D #18 101
Gas Control Valves
45.3
45.4
28.2
27.8
31.5
31.7
13.8
13.6
Ref
Fbk
SRV
D5
PM1
PM4
G3A.
Master Reset
Diagnostic Reset
2017 © General Electric Co.
DABHOL
Alarms
Unit Data
Control
Monitor
Aux
Test
Start-up
DLN Control
FSR Control
IGV Control
Motors
Inlet Bleed Heat
Static Starter
EX2100
H2 Monitor
Synchronization
Block3
GT3A
GT3B
ST3X
Live Alarm Data - Filtered
Short Term Historical Alarms
Filter Definitions
Collection
Filters Available
Block#3
Device Time (Local Time)
Alarm State
Class
Acknowledged
Silenced
Value
Variable Name
Description
2019-05-09 09:03:42.971 ALARMED LVL_1 Yes No G3A True G3A.L30WPDP_FLT WTR INJ PURGE DIFF PRESS XDUCER FAULT
2019-04-04 11:45:00.347 ALARMED LVL_1 Yes Yes G3B True G3B.L30WQD_ALM WATER INJ FLOW METERS HI DIFFERENTIAL
2019-05-09 08:30:43.091 ALARMED LVL_1 Yes No G3A True G3A.L30TFX TURBINE AIR INLET TROUBLE
2019-04-15 14:10:07.947 ALARMED LVL_1 Yes Yes G3B True G3B.L30TFX TURBINE AIR INLET TROUBLE
2019-04-15 13:42:57.187 ALARMED LVL_1 Yes Yes G3B True G3B.L30SS_ALM STATIC STARTER (LCI) ALARM
ALARMED LVL_1 Yes Yes G3B True G3B.L30FORCED_AL SIGNAL FORCING ENABLED
ALARMED LVL_1 Yes Yes G3A True G3A.L30FORCED_AL SIGNAL FORCING ENABLED
Active Alarm Notification
Start


B3WP03
SOX_NOX
3X ELECTRICAL_3 STEAM 3 UNIT_3 8X 9X SWITCHYARD
21 May 2019
11:55
POWER BLOCK
STACK SOX/NOX PARAMETERS
UNIT
NOX PPM
SO PPM
CO PPM
O2 %
0.000
0.000
0.000
0.000
0.000
0.000
0.000
0.000
0.000
0.000
0.000
0.000
20.82
0.000
0.000
0.000
20.82
88.32
0.000
38.42
14.08
123.6
1.00
38.47
14.71
Select
TG 3A
TG 3B
STG 3X
HRSG 3A
HRSG 3B
HP STEAM
HRH STEAM
CRH STEAM
CONDENSATE
CW SYSTEM
INTAKE
BOOSTER PUMP
SWYD_1
SWYD_2
11KV_1
11KV_2
ACK
PREV DISP
HOME
2019/5/21 11:55


RGPPL
G3A.
DLN Control
CRM7_SVR
Admin
12:26:45 May-21-2019
DABHOL
DWATT 206.0 MW
TTRF1 1320 °C
TNH 3000 rpm
Closed
To Vent
Turbine Data
Combustion Data
ASV
SRV
G1
Gas
FSGR 58.19 %
FPRGOUT 29.99 bar
FPG2 30.07 bar
FRCROUT 58.09 %
FPG3 33.12 bar
FXSG1 0.00 %
FSRG1OUT -25.00 %
FSG1 0.76 %
G2
Purge Air
FSRG2OUT 23.75 %
FSG2 23.94 %
G3
Purge Air
FXSG2 16.50 %
FSRG3OUT 52.81 %
FSG3 52.68 %
Purge Air
PM1
PM4
PM4
PM4
PM4
DLN MODE
Premix
PPM Base Control
Enable
Disable
TTXSPL 94 °C
TTXSP1 20 °C
TTXSP2 20 °C
TTXSP3 19 °C
CTD 412 °C
Flame Intensity
A #15 93
B #16 59
C #17 83
D #18 93
Gas Control Valves
58.1
58.2
-25.0
0.8
23.8
23.9
52.8
52.7
Ref
Fbk
SRV
D5
PM1
PM4
G3A.
Master Reset
Diagnostic Reset
2017 © General Electric Co.
Alarms
Unit Data
Control
Monitor
Aux
Test
Start-up
DLN Control
FSR Control
IGV Control
Motors
Inlet Bleed Heat
Static Starter
EX2100
H2 Monitor
Synchronization
Block3
GT3A
GT3B
ST3X
Live Alarm Data - Filtered
Short Term Historical Alarms
Filter Definitions
Collection1
Filters Available
Block#3
Device Time (Local Time) | Alarm State | Class | Acknowledged | Silenced | D... | Value | Variable Name | Description
2019-05-09 09:03:42.971 | ALARMED | LVL_1 | Yes | No | G3A | True | G3A.L30WPDP_FLT | WTR INJ PURGE DIFF PRESS XDUCER FAULT
2019-04-04 11:45:00.347 | ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30WQD_ALM | WATER INJ FLOW METERS HI DIFFERENTIAL
2019-05-09 09:30:43.091 | ALARMED | LVL_1 | Yes | No | G3A | True | G3A.L30TFX | TURBINE AIR INLET TROUBLE
2019-04-15 14:10:07.947 | ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30TFX | TURBINE AIR INLET TROUBLE
2019-04-15 13:42:57.187 | ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30SS_ALM | STATIC STARTER (LCI) ALARM
ALARMED | LVL_1 | Yes | Yes | G3B | True | G3B.L30FORCED_AL | SIGNAL FORCING ENABLED
ALARMED | LVL_1 | Yes | Yes | G3A | True | G3A.L30FORCED_AL | SIGNAL FORCING ENABLED
Active Alarm Notification
Start

Annexure- 9

Extract of DAS data pertaining to initiation and completion of changeover from Premix mode to Piloted Premix mode for gas turbine GT3A

Date of demonstration test: 21.5.2019

Time duration of data indicated: 11:45:00 Hrs to 11:45:30 Hrs.

Original DAS data interval: 40 milli second

Time	DWATT (MW)	DF	DLN MODE	TTRF1 (deg F)	TTXM	FQG	
44:59.5	115.004	49.974	3	2251.259	1200.755	20.2897	
45:00.5	114.782	49.975	3	2251.023	1200.471	20.1101	
45:01.5	114.461	49.974	3	2251.296	1200.312	20.0005	
45:02.5	114.781	49.974	3	2252.677	1200.276	19.7160	
45:03.5	114.954	49.974	3	2250.262	1200.160	20.0976	
45:04.5	114.903	49.975	3	2252.674	1200.190	20.0055	
45:05.5	114.995	49.974	3	2251.151	1200.111	19.4058	
45:06.5	114.507	49.975	3	2251.634	1200.269	20.3247	
45:07.5	114.779	49.974	3	2251.691	1200.214	20.4094	
45:08.5	113.818	49.975	3	2249.979	1199.236	21.8393	
45:09.5	114.138	49.976	3	2246.795	1197.622	22.0884	
45:09.8	114.804	49.976	3	2247.734	1197.360	21.8496	
45:09.9	114.902	49.977	3	2247.159	1197.406	21.9586	
45:09.9	115.026	49.977	3	2246.799	1197.351	21.8826	**Changeover is initiated**
45:10.5	117.616	49.976	3	2250.031	1198.283	21.6659	
45:11.5	123.609	49.979	3	2266.260	1204.151	21.9624	
45:12.5	124.768	49.977	3	2294.355	1213.604	21.7789	
45:13.5	127.432	49.978	3	2309.970	1215.547	21.8808	
45:14.5	128.368	49.978	3	2305.823	1212.328	21.8829	
45:15.5	128.196	49.978	3	2295.120	1210.518	21.1673	
45:16.5	125.656	49.978	3	2291.712	1212.474	21.4219	
45:17.0	125.656	49.976	2	2292.224	1213.779	21.4952	**Changeover Completed**
45:17.1	125.508	49.976	2	2292.633	1213.829	21.9776	
45:17.1	125.261	49.976	2	2291.791	1213.886	21.1937	
45:17.5	125.286	49.982	2	2293.343	1214.843	21.5529	
45:18.5	127.579	49.977	2	2302.427	1220.130	21.5867	
45:19.5	126.396	49.978	2	2308.498	1223.463	21.3561	
45:20.5	125.576	49.980	2	2305.372	1222.531	21.3956	
45:21.5	123.461	49.977	2	2297.604	1220.937	21.0644	
45:22.5	119.048	49.975	2	2287.768	1220.439	20.3355	
45:23.5	115.192	49.976	2	2275.083	1218.597	20.1381	
45:24.5	110.540	49.976	2	2262.840	1216.414	19.8246	
45:25.5	106.779	49.979	2	2253.060	1214.204	19.3764	
45:26.5	102.033	49.976	2	2241.755	1211.978	19.0413	
45:27.5	99.419	49.978	2	2230.636	1206.911	18.7003	
45:28.5	100.257	49.981	2	2218.270	1201.907	18.8738	
45:29.5	99.986	49.981	2	2219.177	1201.740	18.3973	

TTRF1: Combustion reference temperature (deg F)

DWATT: GT load (MW)

DLN Mode 3: Premix DLN Mode 2: Piloted Premix

Note: The indicated reference time for initiation & completion of changeover is as per information/ data furnished by RGPPL.

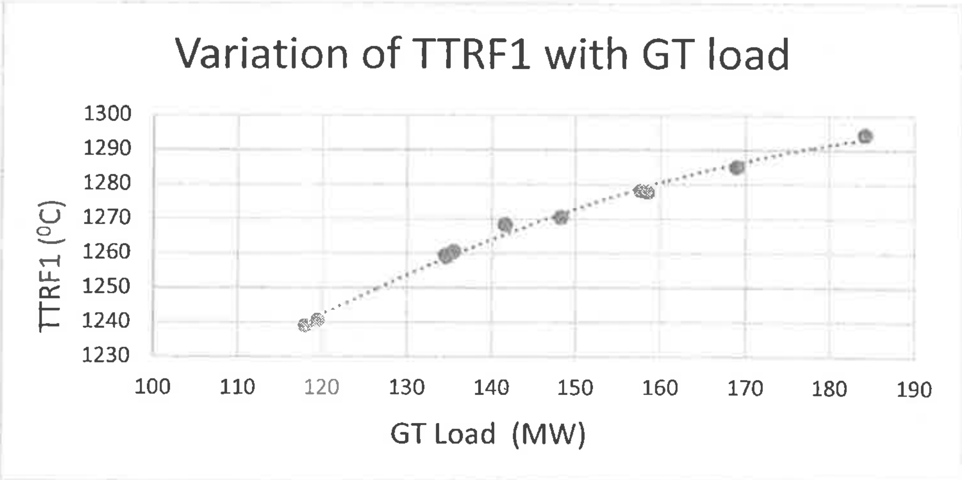
Annexure- 10

Variation of combustion reference temperature (TTRF1) with GT load & CCGT load for Block- 3

Date of site demonstration test: 21.5.2019

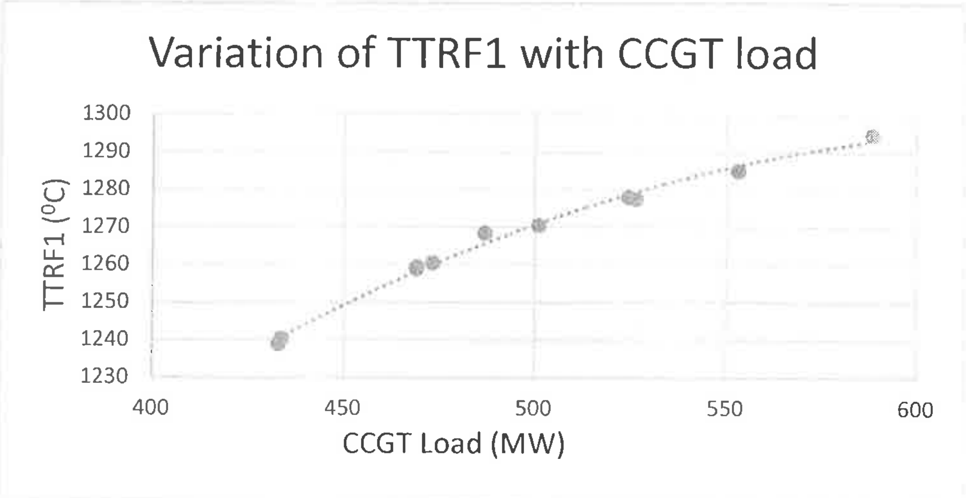
Time (Hrs.)	GT3A		GT3B		Avg. GT load	Avg. TTRF1	STG (MW)	CCGT (MW)
	MW	TTRF1 (^0C)	MW	TTRF1 (^0C)				
11:18:39	184.6	1293	183.8	1296	184.2	1294.5	220.3	588.69
11:25:20	169.3	1283	168.6	1287	169.0	1285.0	215.3	553.23
11:30:33	158.4	1275	158.7	1280	158.6	1277.5	209.5	526.53
11:31:36	158.6	1276	156.8	1280	157.7	1278.0	209.1	524.54
11:34:59	148.1	1268	148.4	1273	148.3	1270.5	204.6	501.08
11:35:50	142.3	1267	140.9	1270	141.6	1268.5	203.8	486.96
11:37:10	134.4	1257	136.5	1264	135.5	1260.5	202.4	473.29
11:38:48	134	1256	135.1	1263	134.6	1259.5	200	469.08
11:39:09	134.1	1255	135.1	1263	134.6	1259.0	199.8	469.02
11:41:41	118.1	1236	118	1242	118.1	1239.0	196.7	432.92
11:43:08	120.5	1238	118.5	1243	119.5	1240.5	194.8	433.7

GT MW	TTRF1
184.2	1294.5
169.0	1285.0
158.6	1277.5
157.7	1278.0
148.3	1270.5
141.6	1268.5
135.5	1260.5
134.6	1259.5
134.6	1259.0
118.1	1239.0
119.5	1240.5



Slope near 120- 130 MW load= 1.04 deg C/MW = 1.9 deg F/MW
MW load for 20 deg F= 10.65 MW

CCGT MW	TTRF1
588.7	1294.5
553.2	1285.0
526.5	1277.5
524.5	1278.0
501.1	1270.5
487.0	1268.5
473.3	1260.5
469.1	1259.5
469.0	1259.0
432.9	1239.0
433.7	1240.5



Slope near 430- 470 MW load= 0.505 deg C/MW = 0.9 deg F/MW
MW load for 20 deg F= 21.99 MW

Annexure- 11

Generation details for time blocks with –ve RRAS in July & August 2018

Sl. No.	Date	Block	DC RLNG	Railway SG	RRAS SG	Total SG	AG	AG-SG	Remark
1	1.7.2018	52	540.00	473.40	-95.00	378.40	422.03	43.64	
2	1.7.2018	53	540.00	473.60	-95.00	378.60	410.62	32.02	
3	1.7.2018	54	540.00	473.48	-95.00	378.48	410.55	32.07	
4	4.7.2018	18	540.00	486.66	-108.00	378.66	411.11	32.45	
5	4.7.2018	19	540.00	484.02	-106.00	378.02	409.37	31.36	
6	4.7.2018	20	540.00	485.45	-107.00	378.45	415.76	37.31	
7	4.7.2018	21	540.00	485.32	-107.00	378.32	418.84	40.52	
8	4.7.2018	22	540.00	480.60	-102.00	378.60	422.52	43.92	
9	4.7.2018	23	540.00	483.27	-105.00	378.27	423.98	45.71	
10	4.7.2018	24	540.00	494.47	-116.00	378.47	423.41	44.94	
11	4.7.2018	25	540.00	497.83	-119.00	378.83	424.06	45.23	
12	4.7.2018	26	540.00	498.19	-120.00	378.19	424.50	46.31	
13	4.7.2018	27	540.00	498.72	-120.00	378.72	425.16	46.44	
14	4.7.2018	28	540.00	501.77	-123.00	378.77	425.07	46.30	
15	4.7.2018	29	540.00	509.53	-131.00	378.53	424.56	46.03	
16	4.7.2018	30	540.00	511.18	-133.00	378.18	425.00	46.83	
17	4.7.2018	31	540.00	513.59	-135.00	378.59	424.87	46.28	
18	4.7.2018	32	540.00	514.12	-136.00	378.12	424.84	46.72	
19	4.7.2018	37	540.00	513.09	-135.00	378.09	427.78	49.69	
20	4.7.2018	38	540.00	512.05	-134.00	378.05	423.98	45.92	
21	14.7.2018	53	540.00	489.37	-111.00	378.37	418.69	40.32	Single Block Operation
22	21.7.2018	55	540.00	496.58	-123.00	373.58	413.44	39.87	
23	21.7.2018	56	540.00	501.17	-127.00	374.17	412.82	38.65	
24	21.7.2018	57	540.00	499.68	-128.00	371.68	412.39	40.71	
25	22.7.2018	40	540.00	504.41	-126.00	378.41	422.11	43.70	
26	22.7.2018	41	540.00	502.20	-124.00	378.20	415.61	37.41	
27	22.7.2018	42	540.00	498.48	-120.00	378.48	413.93	35.45	
28	22.7.2018	43	540.00	502.12	-124.00	378.12	413.85	35.73	
29	22.7.2018	44	540.00	500.00	-122.00	378.00	413.50	35.50	
30	22.7.2018	45	540.00	500.04	-122.00	378.04	413.70	35.66	
31	22.7.2018	46	540.00	497.82	-119.00	378.82	413.70	34.88	
32	22.7.2018	47	540.00	494.26	-116.00	378.26	413.26	35.00	
33	22.7.2018	48	540.00	490.37	-112.00	378.37	412.76	34.38	
34	22.7.2018	49	540.00	487.92	-109.00	378.92	413.14	34.22	
35	22.7.2018	50	540.00	489.63	-111.00	378.63	413.36	34.73	
36	22.7.2018	51	540.00	489.63	-111.00	378.63	413.74	35.11	
37	22.7.2018	52	540.00	489.63	-111.00	378.63	413.38	34.75	
38	22.7.2018	53	540.00	489.77	-111.00	378.77	413.55	34.78	
39	22.7.2018	54	540.00	489.77	-111.00	378.77	413.76	34.99	
40	22.7.2018	55	540.00	491.84	-113.00	378.84	413.93	35.09	
41	22.7.2018	56	540.00	492.87	-114.00	378.87	413.31	34.44	
42	22.7.2018	58	540.00	490.61	-112.00	378.61	416.02	37.41	
43	22.7.2018	59	540.00	489.58	-111.00	378.58	413.62	35.04	
44	22.7.2018	60	540.00	491.64	-113.00	378.64	414.40	35.76	
45	22.7.2018	61	540.00	491.64	-113.00	378.64	414.77	36.13	
46	22.7.2018	62	540.00	491.64	-113.00	378.64	415.34	36.69	
47	22.7.2018	65	540.00	489.44	-111.00	378.44	422.17	43.74	
48	22.7.2018	66	540.00	489.44	-111.00	378.44	412.91	34.47	

49	22.7.2018	67	540.00	489.44	-111.00	378.44	412.97	34.54	
50	22.7.2018	68	540.00	489.44	-111.00	378.44	412.51	34.07	
51	22.7.2018	69	540.00	489.44	-111.00	378.44	412.10	33.66	
52	22.7.2018	70	540.00	489.44	-111.00	378.44	412.04	33.61	
53	22.7.2018	71	540.00	489.44	-111.00	378.44	412.78	34.34	
54	22.7.2018	72	540.00	491.21	-113.00	378.21	411.66	33.45	
55	22.7.2018	73	540.00	493.92	-115.00	378.92	415.75	36.83	
56	26.7.2018	16	540.00	505.60	-127.00	378.60	413.22	34.61	
57	26.7.2018	17	540.00	507.51	-129.00	378.51	410.95	32.44	
58	26.7.2018	18	540.00	507.41	-129.00	378.41	410.06	31.65	
59	26.7.2018	19	540.00	502.74	-124.00	378.74	410.88	32.14	
60	26.7.2018	20	540.00	505.22	-127.00	378.22	410.29	32.06	
61	26.7.2018	21	540.00	507.33	-129.00	378.33	409.47	31.14	
62	26.7.2018	22	540.00	505.78	-127.00	378.78	416.43	37.64	
63	26.7.2018	36	540.00	526.01	-148.00	378.01	416.68	38.67	
64	26.7.2018	37	540.00	526.49	-148.00	378.49	409.68	31.18	
65	26.7.2018	38	540.00	524.93	-146.00	378.93	409.73	30.79	
66	26.7.2018	39	540.00	522.52	-144.00	378.52	409.72	31.20	
67	26.7.2018	40	540.00	518.97	-140.00	378.97	408.99	30.01	
68	26.7.2018	41	540.00	517.31	-139.00	378.31	410.58	32.27	
69	26.7.2018	42	540.00	516.58	-138.00	378.58	409.70	31.12	
70	26.7.2018	43	540.00	518.00	-140.00	378.00	408.96	30.96	
71	26.7.2018	44	540.00	515.73	-137.00	378.73	409.66	30.93	
72	26.7.2018	45	540.00	515.19	-137.00	378.19	409.47	31.28	
73	26.7.2018	46	540.00	514.12	-136.00	378.12	409.27	31.16	
74	26.7.2018	47	540.00	508.11	-130.00	378.11	410.02	31.91	
75	26.7.2018	48	540.00	502.56	-124.00	378.56	410.89	32.33	
76	26.7.2018	49	540.00	503.47	-125.00	378.47	411.64	33.17	
77	26.7.2018	50	540.00	497.86	-119.00	378.86	411.51	32.65	
78	26.7.2018	51	540.00	498.49	-120.00	378.49	411.35	32.86	
79	26.7.2018	52	540.00	499.11	-121.00	378.11	410.68	32.58	
80	26.7.2018	53	540.00	500.33	-122.00	378.33	410.63	32.30	
81	26.7.2018	54	540.00	497.64	-119.00	378.64	411.54	32.90	
82	26.7.2018	55	540.00	498.97	-120.00	378.97	410.64	31.67	
83	26.7.2018	56	540.00	498.58	-120.00	378.58	415.10	36.52	
84	27.7.2018	17	540.00	507.64	-129.00	378.64	421.36	42.72	Single Block Operation
85	27.7.2018	18	540.00	508.15	-130.00	378.15	410.23	32.08	
86	27.7.2018	19	540.00	504.91	-126.00	378.91	410.88	31.97	
87	27.7.2018	20	540.00	506.97	-128.00	378.97	411.80	32.82	
88	27.7.2018	21	540.00	507.93	-129.00	378.93	410.81	31.88	
89	27.7.2018	22	540.00	506.97	-128.00	378.97	410.71	31.74	
90	27.7.2018	23	540.00	509.04	-131.00	378.04	411.13	33.09	
91	27.7.2018	24	540.00	514.34	-136.00	378.34	413.04	34.70	
92	29.7.2018	44	540.00	503.26	-125.00	378.26	414.06	35.80	Single Block Operation
93	29.7.2018	45	540.00	503.31	-125.00	378.31	413.74	35.43	
94	29.7.2018	46	540.00	500.24	-122.00	378.24	413.43	35.19	
95	29.7.2018	47	540.00	497.75	-119.00	378.75	413.49	34.74	
96	29.7.2018	48	540.00	493.85	-115.00	378.85	413.23	34.38	
97	29.7.2018	49	540.00	491.39	-113.00	378.39	413.11	34.71	
98	29.7.2018	50	540.00	489.54	-111.00	378.54	414.10	35.57	
99	29.7.2018	51	540.00	489.54	-111.00	378.54	413.79	35.25	
100	29.7.2018	52	540.00	489.54	-111.00	378.54	413.06	34.52	
101	29.7.2018	53	540.00	489.68	-111.00	378.68	413.69	35.01	

102	29.7.2018	54	540.00	489.68	-111.00	378.68	413.07	34.39	
103	29.7.2018	55	540.00	491.74	-113.00	378.74	413.52	34.78	
104	29.7.2018	56	540.00	492.78	-114.00	378.78	421.69	42.92	
105	29.7.2018	61	540.00	494.84	-116.00	378.84	418.40	39.55	
106	29.7.2018	62	540.00	494.84	-116.00	378.84	412.52	33.68	
107	29.7.2018	63	540.00	494.84	-116.00	378.84	413.19	34.35	
108	29.7.2018	64	540.00	492.64	-114.00	378.64	412.50	33.86	
109	5.8.2018	54	540.00	486.29	-108.00	378.29	409.64	31.35	
110	5.8.2018	55	540.00	486.06	-108.00	378.06	409.96	31.90	
111	5.8.2018	56	540.00	485.77	-107.00	378.77	410.06	31.29	
112	5.8.2018	57	540.00	485.51	-107.00	378.51	410.35	31.84	
113	5.8.2018	58	540.00	486.62	-108.00	378.62	409.63	31.01	
114	12.8.2018	32	540.00	506.27	-128.00	378.27	426.76	48.50	
115	12.8.2018	33	540.00	506.27	-128.00	378.27	409.60	31.33	
116	13.8.2018	56	540.00	540.00	-162.00	378.00	427.34	49.34	Single Block Operation
117	13.8.2018	57	540.00	540.00	-162.00	378.00	408.73	30.73	
118	13.8.2018	58	540.00	540.00	-162.00	378.00	408.73	30.73	
119	15.8.2018	42	540.00	540.00	-162.00	378.00	419.13	41.13	
120	15.8.2018	43	540.00	540.00	-162.00	378.00	411.14	33.14	
121	15.8.2018	49	540.00	540.00	-162.00	378.00	413.65	35.65	
122	15.8.2018	50	540.00	540.00	-162.00	378.00	409.97	31.97	
123	15.8.2018	51	540.00	540.00	-162.00	378.00	410.60	32.60	
124	15.8.2018	52	540.00	540.00	-162.00	378.00	410.89	32.89	
125	15.8.2018	53	540.00	540.00	-162.00	378.00	410.30	32.30	
126	15.8.2018	54	540.00	540.00	-162.00	378.00	409.94	31.94	
127	15.8.2018	55	540.00	540.00	-162.00	378.00	410.18	32.18	
128	15.8.2018	56	540.00	540.00	-162.00	378.00	409.55	31.55	
129	15.8.2018	57	540.00	540.00	-162.00	378.00	409.97	31.97	
130	15.8.2018	59	540.00	540.00	-162.00	378.00	415.69	37.69	
131	15.8.2018	60	540.00	540.00	-162.00	378.00	407.14	29.14	
132	15.8.2018	62	540.00	540.00	-162.00	378.00	418.84	40.84	
133	15.8.2018	63	540.00	540.00	-162.00	378.00	406.20	28.20	
134	15.8.2018	64	540.00	540.00	-162.00	378.00	407.91	29.91	
135	15.8.2018	65	540.00	540.00	-162.00	378.00	410.03	32.03	
136	15.8.2018	66	540.00	540.00	-162.00	378.00	409.60	31.60	
137	15.8.2018	67	540.00	540.00	-162.00	378.00	408.95	30.95	
138	15.8.2018	68	540.00	540.00	-162.00	378.00	407.13	29.13	
139	15.8.2018	69	540.00	540.00	-162.00	378.00	408.07	30.07	
140	15.8.2018	70	540.00	540.00	-162.00	378.00	407.86	29.86	
141	15.8.2018	71	540.00	540.00	-162.00	378.00	408.30	30.30	
142	15.8.2018	72	540.00	540.00	-162.00	378.00	407.88	29.88	
143	19.8.2018	58	540.00	489.36	-111.00	378.36	414.40	36.04	
144	19.8.2018	59	540.00	488.32	-111.00	377.32	406.62	29.29	
145	19.8.2018	60	540.00	490.39	-111.00	379.39	407.35	27.96	
146	20.8.2018	13	540.00	494.89	-116.00	378.89	410.37	31.48	
147	20.8.2018	17	540.00	481.30	-103.00	378.30	412.50	34.21	
					Average	378.30	413.57	35.27	