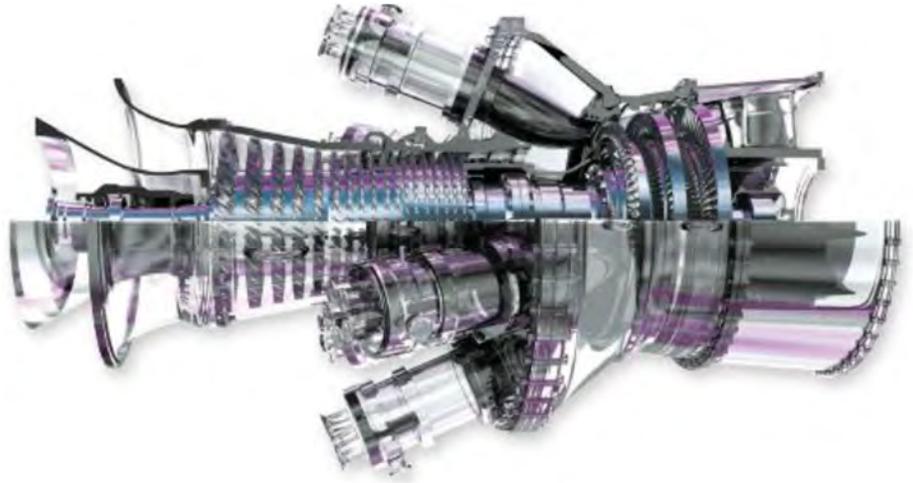


GAS TURBINE INSPECTION REPORT

For

Combustion Inspection



Gas Turbine Model: GE 6FA.03, MNQC
Unit: GTG2 (Serial Number: 875123)
Plant: Nghi Son Refinery and Petrochemical, LLC

Prepared by:

UNEW | Dilip Majumder – TFA

UNEW | Prakash Periyasamy - Controls TA

Report Date: July, 2025



PART 1 COMBUSTION INSPECTION REPORT



INSPECTION REPORT



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INSPECTION REPORT



INSPECTION SUMMARY

Customer:	Nghi Son Refinery and Petrochemical, LLC
Station:	Nghi Son, Thanh Hoa, Vietnam
Unit No:	2

Turbine Serial #:	875123
Service Year:	2025
Generation Equipment Model:	Generator GE/TEWAC 717043
GT Frame Size:	MS6001FA 6FA.03, MNQC
GT Model:	
Load Gear Box Make &Type:	RENK/ TA 73XT
Service Type:	Contract Maint.
Technical Field Advisor:	Dilip Majumder
Job Start Date:	28-June-2025
Job Type:	Combustion
Work Scope:	[N] Fuel Nozzle <input checked="" type="checkbox"/> Combustion [N] Hot Gas Path [N] Major [N] Other
Last Inspection:	June-2024
Next Inspection:	June-2026
Rating:	81 MW(ISO)
Control System:	Mark VIe
Fuel Type:	Gas and Distillate
Load Gear Box S/N:	3056043
Mechanical Completion Date:	07-July-2025
Start Up Date:	12-July-2025
Last Job Type:	Combustion
Next Job Type:	HGP Inspection

	Total Fired Hours	Gas Fuel Fired Hours	Liquide Fuel Fired Hours	Manual Initiated Starts	Total Starts	Emergency Trips	Fired Starts
Current:	59834.5	24699.50	35135.4	450	457	116	174
Last:	51277.7	17507.6	33770.5	355	363	112	171
Interval:	8556.8	7191.9	1364.9	95	94	04	03



INSPECTION REPORT



INSPECTION SUMMARY

UNEW Key Site Personnel:

Name	Responsibility
Mr. Nguyen Duc Cuong	General Manager
Mr. Tran The Hung	Site Manager
Mr. Dilip Majumder	Mechanical Expert
Mr. Vaikuntha Rao	Mechanical Supervisor
Mr. Prakash Periyasamy	Controls Expert

NSRP Site Personnel:

Name	Responsibility
Mr. Nguyen Van Nam	
Mr. Doan Nhat Bang	
Mr. Nguyen Van Sau	
Mr. Nguyen Le Phi Long	
Mr. Le Nguyen Hao	
Mr. Pham Ngoc Sang	
Mr. Le Quang Hai	



INSPECTION SUMMARY

This is a report on the Combustion Inspection (CI) carried out on Fr-FA.03, MNQC Gas Turbine unit#2 (S/N # 875122) at Nghi Son Refinery and Petrochemical, Vietnam. The Refinery has installed 2x Fr 6FA gas turbines as part of captive power to the refinery.

The unit can run on both Gas and liquid fuel. It has accumulated 59,834.5 total fired hours till this inspection. Since then, unit operates on both Gas and distillate fuel the calculated equivalent / factored fired hours is 77, 402.5 FFH. Prior to this another combustion inspection was carried out during June 2024 @ 51,277.7 FH / 68,163.3 FFH.

The purpose of Combustion Inspection is to examine all of the internal rotating and stationary components in the combustion path. This includes the inspection of fuel nozzles, liners, cross fire tubes & retainers, flow sleeves, combustion chambers, transition pieces, spark plugs and flame detectors etc. The work scope also involves visual inspection of accessible hot gas path components like Stage- 1 through 3 Buckets, shrouds and nozzles as Turbine casing upper halve need to be opened as a part of combustion inspection scope. Bottom casing HGP parts and Compressor R1 and S1 also inspected through bore scope instrument provided by NSRP. In this opportunity inlet guide vans were inspected after proper cleaning and DPT, IGV clearances also checked and recorded accordingly.

The combustion inspection was a planned outage, scheduled and commenced on 28th July 2025. All major jobs related to combustion inspection mechanical scope were completed by 07th July 2025. Unit was put on turning gear on 10th July 2025 after completion of pre-start up checks and peripheral jobs taken up by NSRP. Water wash was carried out on 11th July'25 and further start up on 12th July'25. Unit was synchronized and loaded gradually to 60 MW on both Liquid and Gas fuel by 13th July 2025. Water injection and tuning was also performed for both Liquid and gas fuel, Nox found to be within acceptable limit. All other operating parameters were observed normal and within limits. Pre-start up and start up details are given separately in the C&I report part.

For this Combustion Inspection, UNEW has provided Technical Advisory Service along with required skilled manpower, tools and tackles, consumables etc. UNEW puts on record its appreciation for round the clock support extended by NSRP team for successful **on time** completion of the job.



INSPECTION REPORT



INSPECTION SUMMARY

Section	Clocked F/hrs.	Description	Remarks
Inlet Plenum			
Assembly	59834.5	Visual Inspection	Inspected and Cleaned
Fuel Nozzle			
Assembly	8556.8	Visual Inspection	Replaced with Refurbished set
Combustion Liner			
Assembly	8556.8	Visual Inspection	Replaced with Refurbished set
Crossfire Tube	8556.8	Visual Inspection	Replaced with New
Retainer - Crossfire Tube	8556.8	Visual Inspection	Replaced with New
Flow Sleeve, Combustion			
Assembly	59834.5	Visual Inspection	Inspected and Re-Used
Transition Piece, Combustion			
Assembly	8556.8	Visual Inspection	Replaced With refurbished Set
Inlet Guide Vane			
Assembly	59834.5	Non-Destructive Test	Inspected, kept in service
Bucket, 1st Stage			
Assembly	xxxxx	Visual Inspection and BI	Kept in service
Bucket, 2nd Stage			
Assembly	xxxxx	Visual inspection and BI	Kept in service
Bucket, 3rd Stage			
Assembly	xxxxx	Visual inspection and BI	Kept in service
Nozzle Arrangement, Stage 1			
Assembly	xxxx	Visual Inspection and BI	Kept in service
Assembly	xxxx	Non-Destructive Test for upper segments, BI for bottom segments	Kept in service
Nozzle Arrangement, Stage 3			
Assembly	xxxx	Visual inspection and BI	Kept in service
Shroud, Stage 1 Turbine			
Assembly	xxxx	Visual Inspection and BI	Kept in service
Shroud, Stage 2 Turbine			
Assembly	xxxx	Visual Inspection and BI	Kept in service
Shroud, Stage 3 Turbine			
Assembly	xxxx	Visual Inspection and BI	Kept in Service



INSPECTION REPORT



Unit Inspection History

INSPECTION HISTORY																		
Customer		Nghì Son Refinery and Petrochemical			Total Fired Hours		59834.5			Date as On		28-Jun-25						
Location		Nghì Son, Thanh Hoa, Vietnam			Gas Fired Hours		24699.5			Primary Fuel		Distillate						
Frame/ Unit		Fr 6 FA, MNQC/ #2			Dist. Fired Hours		35135.4			Secondary Fuel		Gas						
Turbine S/N		875123			Emergency Trip		116											
Year	Month	Type of Inspection	FH during Inspection	Inspection Interval	Agency for Inspection	Capital Parts replaced during the Inspection												REMARKS
						S1B	S2B	S3B	S1N	S2N	S3N	S1S	S2S	S3S	CL	TP	FN	
2025	July	CI	59834.5	8556.8	UNEW	-	-	-	-	-	-	-	-	-	X	X	X	Cross fire tubes, retainers and CI hard ware and gasket replaced
2024	June	CI	51277.7															
2023																		
2022																		

PARTS INFORMATION						
Customer	NSRP		Outage Period		June-July 2025	
Location	Nghi Son, Thanh Hoa, Vietnam		Outage type		CI	
Frame/ Unit	Fr 6 FA, MNQC/ #2		Turbine S/N		875123	
Component	REMOVED PARTS			INSTALLED PARTS		
	Drawing No./ Part No.	Installed On (new/refurbished)	FH During Inspection	Drawing No./ Part No.	Total FH During the Outage and Number of repair(If refurbished)	Reused/ New/ Refurbished
Stage-1 Bucket	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-2 Bucket	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-3 Bucket	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-1 Nozzle	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-2 Nozzle	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-3 Nozzle	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-1 Shroud	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-2 Shroud	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Stage-3 Shroud	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service
Transition Piece	119E9674G002 Rev.00	CI in June 2024(New)	8556.8	BTSA 631601 Rev-00	NSRP to Provide	Refurbished
Combustion Liner	119E9620G001, Rev.A	CI in June 2024(New)	8556.8	119E9620G001	NSRP to Provide	Refurbished
Fuel Nozzle	119E9942G033	CI in June 2024 (Refurbished)	NSRP to Provide	119E9942G033	NSRP to Provide	Refurbished
Crossfire Tube (M)	118D9471G001	CI in June 2024(New)	8556.8	118D9471G001	0	New
Crossfire Tube (F)	118D9471G002	CI in June 2024(New)	8556.8	118D9471G002	0	New
Flow Sleeve	110E1194 G004	Since commissioning	Continue	110E1194 G004	59834.5 (77402.5 FFH)	Reused
Combustion Chamber	129E8465G003, 004,011,012 & 013	Since commissioning	Continue	129E8465G003, 004,011,012 & 013	59834.5 (77402.5 FFH)	Reused
IGV	-	NSRP to provide	Continue	-	NSRP to Provide	Kept in service



INSPECTION REPORT



EXCERPTS INSPECTION

- Turbine compartment Roof top Vent fan motors and vent ducts removed. Cleaned and installed back with replacement of necessary gaskets. Silicon sealant applied on joints.
- Turbine compartment roof panels removed as required to facilitate EOT crane access for removal of Roof structural beam, Turbine casing top half, combustion casings, and pipes etc. as required. Roof structure beams cleaned and painted by NSRP before installation back. Roof panels installed back after cleaning and replacement of gaskets.
- Liquide fuel and water injection Header, Gas fuel and Atomizing air flexible hose pipes, liquid fuel and water injection tubing including purge tubing removed after proper marking. All the removed pipes and tubes were cleaned and installed back per the marking and unit orientation. All flange bolts tightened as per prescribed torque, tube joints tightness also ensured and recorded in jointly signed respective check sheets. Before installation, all flexible hoses were pressure tested by NSRP to ensure no leakages.
- NSRP team removed the Spark plugs and flame scanners with associated connections, conduits and tubing. Same installed back after necessary testing and mechanical assembly completion.
- Liquide fuel check valves and other associated purge valves properly marked and removed. All the valves taken by NSRP and tested before handing over for fixing back. All the check valves flow direction was jointly checked and ensure proper installation, respective check sheets also jointly signed accordingly.
- Fuel nozzle cum end covers removed. Refurbished set installed back after necessary checking and cleaning.
- Retainers and cross fire tube (Male and female) removed. Both replaced with new set.
- Combustion liners removed and replaced with refurbished set.
- Outer cross-fire tubes removed along with fixing adapter flange. Same installed back after proper cleaning and with new packing ring gaskets.
- Combustion casing with flow sleeves removed. Same is returned back to service after proper cleaning and checking.
- Necessary cooling and sealing air pipes were removed after proper marking. Same assembled back after necessary cleaning with new gaskets, bolts, nuts and washers as required.
- Casing support jacks were installed beneath the turbine casing joints before opening of casing bolts. Same removed after installation of turbine casing back.

- Turbine casing top half removed after removal of all bolts of Vertical and Horizontal plan bolts, Body bound bolts first. The casing installed back after replacement of transition pieces and clearances check, clearances recorded and respective check sheets jointly signed. All the casing bolts tightened with respective torque value. Torque value with bolt sizes were recorded and jointly signed in the respective check sheets. Before installation of casing back all HGP components were visually inspected also BI conducted on bottom casing to ensure no foreign object remain inside.
- VIGV was cleaned, NDT carried out. IGV clearances recorded in the respective check sheet and jointly signed, kept in service.
- Instruments tubing connected to CPD, Fuel Gas and Atomizing headers removed and installed back after flashed cleaning. It's recommended keep few quantities of Straight connectors, tubing and ferrules with nut for future replacement as the joints are being opened and fixed several times since commissioning. The probabilities of leakage through the ferrule joints expected to increase due to multiple opening and fittings.
- NSRP replaced inlet filters and cleaned the filter house.
- NSRP inspected the exhaust tunnel, Bearing # 2 housing area.
- GCV, SRV, IGV and Liquid fuel by pass valve stroke check was carried out by NSRP with C&I expert.
- Servicing of Compressor Bleed valves, Inlet Bleed Heating valve, Exhaust blowers done by NSRP team.

RECOMMENDATIONS

- It's recommended to carry out all the scheduled inspections as per OEM recommended interval considering fuel used for operation.
- With the available information on unit inspection, next scheduled inspection should be HGP Inspection and expected to be in June 2026, considering 8000 fired hours of operation with Gas Fuel.
- It's strongly advised to keep record of operating hours (Factored fired hours/ FFH) of all the Capital parts including refurbishment history of the parts. This will help to ascertain residual life of the parts with respect to OEM prescribed expected design life. This data also to be considered before further repair consideration. NSRP can follow the OEM latest guide line given in GER3620P (Heavy-Duty Gas Turbine Operating and Maintenance Considerations), respective page attached.

6F.03

	Repair Interval	Replace Interval (Hours)	Replace Interval (Starts)
Combustion Liners	CI	2 (CI)	2 (CI)
Caps	CI	3 (CI)	2 (CI)
Transition Pieces	CI	3 (CI)	2 (CI)
Fuel Nozzles	CI	2 (CI)	2 (CI)
Crossfire Tubes	CI	1 (CI)	1 (CI)
Crossfire Tube Retaining Clips	CI	1 (CI)	1 (CI)
End Covers	CI	4 (CI)	2 (CI)
Stage 1 Nozzles	HGPI	3 (HGPI)	3 (HGPI)
Stage 2 Nozzles	HGPI	3 (HGPI)	3 (HGPI)
Stage 3 Nozzles	HGPI	3 (HGPI)	3 (HGPI)
Stage 1 Shrouds	HGPI	3 (HGPI)	3 (HGPI)
Stage 2 Shrouds	HGPI	3 (HGPI)	3 (HGPI)
Stage 3 Shrouds	HGPI	3 (HGPI)	3 (HGPI)
Stage 1 Buckets	HGPI	3 (HGPI)	2 (HGPI)
Stage 2 Buckets	HGPI	2 (HGPI)	3 (HGPI)
Stage 3 Buckets	HGPI	3 (HGPI)	3 (HGPI)

Note: Repair/replace intervals reflect current production (6F.03 DLN 2.6) hardware, unless otherwise noted, and operation in accordance with manufacturer specifications. They represent initial recommended intervals in the absence of operating and condition experience. For factored hours and starts of the repair intervals, refer to *Figure 36*.

CI = Combustion Inspection Interval
 HGPI = Hot Gas Path Inspection Interval

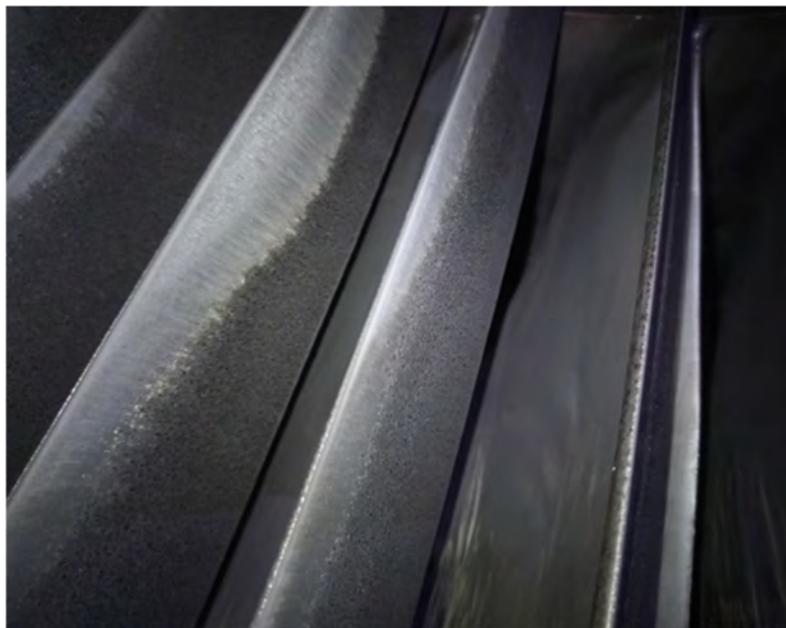
Figure D-4. Estimated repair and replacement intervals

- NSRP to arrange parts required in advance to avoid any last-minute surprise. Capital parts like Stage-1, 2 & 3 Nozzle, bucket and shrouds with installation hardware, Transition piece with installation hard ware, Combustion liner, Fuel nozzle cum end cover, cross fire tubes, retainers etc. In addition, HGPI consumable also to be procured.
- During this CI inspection there was some issue faced with few tube connectors. It's recommended to keep required SS Tube with connectors, union, T-union, ferules with nut. It seems the tubes are being in service since long and several times opened and re-installed. Due prolonged uses probability of leakages through those tube joints likely to increase.

INLET SYSTEM

Inlet Plenum and IGV Assembly

The inlet plenum area was accessed through a designated manhole. A light sooty deposit was visible on the plenum, bell mouth, as well as on IGV and compressor R1 blades. IGVs were cleaned, and no damages such as FOD or cracks were noticed on any vane. The whole plenum and VIGV was cleaned, and clearances of VIGV were recorded. It is advisable to keep the VIGV area clean. VIGVs were checked through the dye penetrant test, no abnormalities were revealed in the DP test. All clearances recorded and attached in jointly signed check sheets. During this opportunity condition of the water wash nozzles was also checked for integrity and any blockage, found to be in good condition. Compressor R1 and S1 blades were also inspected through the Bore scope for damage as corrosion, cracks, dents, bent, etc., no indication found except a light sooty deposit. BI images are available in the BI kit provided by NSRP.



Condition of IGV before Cleaning



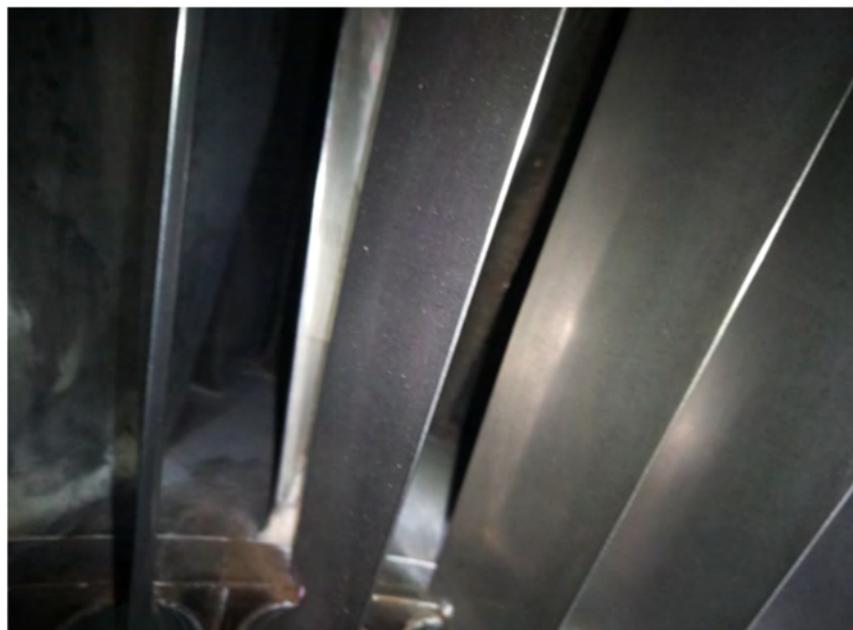
Condition of Plenum Bottom and Bell mouth



Condition of Water wash Nozzle



Dye Penetrant Test on VIGVs



VIGVs after Final Cleaning

COMBUSTION SECTION

Fuel Nozzle Cum End Cover Combustion Can

Assembly

All fuel nozzles cum end covers of combustion cans were removed and inspected visually. Light to medium carbon deposits were observed on all the fuel nozzles. Minor to medium wear on a few of the AA cones, and fuel Gas tips were also observed. The Fuel Nozzle Set was installed during combustion inspection carried out in June 2024 at 51,277.7 fired hours (68,163.4 FFH), and so far, it has clocked 8556.8 FH (9239.3 FFH) since last installation. The set of Fuel nozzles was replaced with another refurbished set. Details of both removed and installed are recorded in jointly signed check sheets. The fuel nozzle cum end covers were installed with new gaskets, bolts tightened with the prescribed torque value, and recorded in respective jointly signed check sheets. Before installation of the refurbished fuel nozzles, the water injection distributor inlet connector was fitted from the old one and welded (due to non-availability of a suitable new connector and O-ring). NDT was also carried out on the weld joints; no indication was found. In addition, the connector for the Liquide fuel distributor drain line was also replaced from old nozzle set with new O-rings, tightness of bolts and tubing's also ensured before installation.

The removed set can be considered for further refurbishment for future use, subject to the following OEM latest guideline mentioned in GER3620P. NSRP to provide the Total FFH and previous repair history of the removed fuel nozzle set to finalize refurbishment possibilities.

Remover Component Part/ Dwg. No.: 119E9942G033

Installed Components Part/ Dwg. No.: 119E9942G033

IMAGES

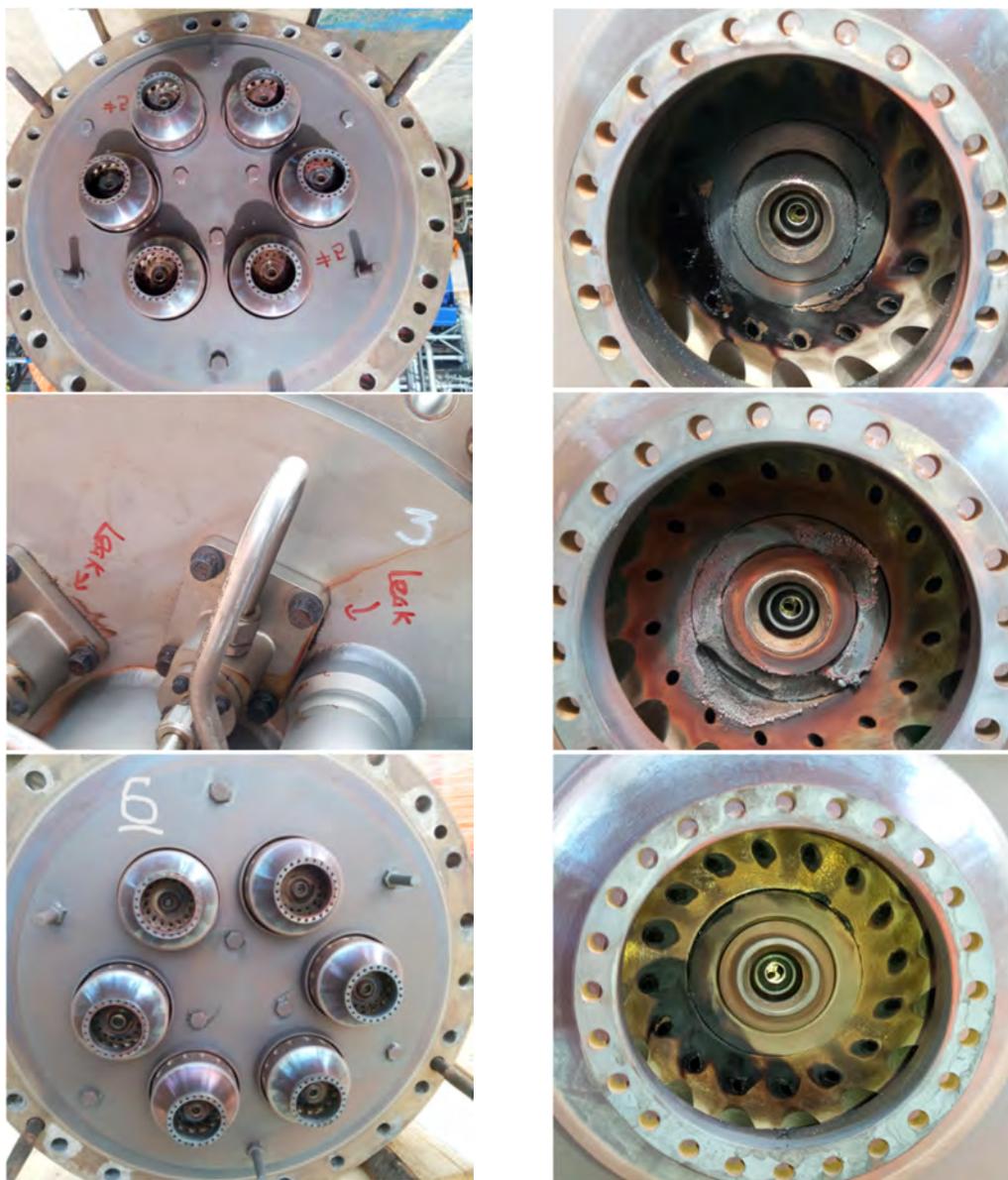


Figure 06: Removed Fuel Nozzles



Figure 07: Installed Refurbished Fuel Nozzles

Combustion Liner

Assembly

The combustion liners were removed from position and inspected. The combustion liners are found with TBC coating loss. Hot corrosion as well as radial and axial cracks of 5mm to 30mm length were also observed on the liner body; no noticeable damage noticed on the cap cowl. Normal wear and compression marks were noticed on the Hula seal. The removed liner set was in service since last CI executed during June 2024 and so far, clocked 8556.8 fired hours (FH)/ 9239.3 factored fired hours (FFH). The set replaced with a refurbished set provided by NSRP. The set total FFH and refurbishment history to be provided by NSRP for better parts management. Details recorded in jointly signed respective Check Sheet. The Removed set can be sent for refurbishment facility after assessing the total uses (FFH), previous repair history and expected residual designed life as per OEM latest guide line provided in GER3620P.

Drawing/ Part No. Out:

Drawing/ Part No. In:

LINERS IMAGES



Figure 08: Removed Liners



Figure 09: Removed Liners



Figure 10: Installed Refurbished Liners

Combustion Cans, Combustion

Assembly

All the combustion cans were removed, cleaned and inspected. Mostly found in good condition except normal light hot corrosion. NDT carried out on weld joints of the Liner

stoppers except normal light hot corrosion. NDT carried out on weld joints of the Liner stoppers and retaining ring holders, no indication found. No cracks or other abnormalities noticed. The chambers installed back with new gaskets, bolts were tightened with prescribed torque value, details recorded in jointly signed respective check sheet. Drawing/ Part No. Out and In: 129E8465G003—1 no, G004—1 no, G011—2 no, G012—1 no And G013---1 no. The set is in use since commissioning of the unit and clocked 59834.4 FH/77402.5 FFH.



Figure 11: Removed and Installed Combustion chambers

Flow Sleeve, Combustion

Assembly

All the flow sleeves were cleaned and inspected visually. All weld joints were DP tested and found in good condition. The fixing screws were checked for tightness and integrity, Floating ring seal checked for freeness and integrity, both found in order. All were returned in service after proper cleaning. Details recorded in the jointly signed respective check sheet. The set of flow sleeve is in use since commissioning of the unit and clocked 59834.4 FH/ 77402.5 FFH. Drawing / Part No. Out and In: 110E1194G004



Figure 12: Removed and Installed Flow sleeves

Outer Crossfire Tube

Combustion Assembly

During combustion dis-assembly process, outer crossfire tubes were also removed. The outer tubes were cleaned and inspected, no mentionable damages noticed. Same were returned to service along with the fixing flanges with new packing rings (2 no at each side of the combustion chambers). Respective flange bolts were tightened such to maintain equal gap of 2.03 +/- 0.38 mm. Details recorded in jointly signed check sheets.



Figure 13: Removed and Installed Outer Cross-Fire Tubes

Crossfire Tube (Male & Female)

All the male and female cross-fire tubes were removed and inspected. All most all the cross- fire tubes (sets) were observed with minor wear and hot spot, hence replaced with new set for reliable service till next scheduled inspection. The removed set was in service since last installation during CI of June 2024 and clocked 8556.8 FH/ 9239.3 FFH and to be retired from service.

Drawing/ Part No. of Cross-fire Tube (Male) Out: 118D9471G001

Drawing/ Part No. of Cross-fire Tube (Female) Out: 118D9471G002

Drawing/ Part No. of Cross-fire Tube (Male) In: 118D9471G001

Drawing/ Part No. of Cross-fire Tube (Female) In: 118D9471G002

Retainer - Crossfire Tube

All the retainers were removed and inspected; no visual defects noticed except deterioration in spring action. The replaced with new set for reliable service till next scheduled inspection. The removed set was in service since last installation during CI of June 2024 and clocked 8556.8 FH/ 9239.3 FFH and to be retired from service. Drawing/ Part No. of Retainer Out: 230C3238P003

Drawing/ Part No. of Retainer In: 230C3238P003



Figure 14: Removed and installed Cross-fire tubes and retainers

Transition Piece, Combustion

Assembly

The transition pieces were removed and inspected. Minor wear was observed at picture frame and floating seal and slots. Light dis-coloration and hotspot on Cooling jacket and Inside TBC coating. No crack or major defects noticed. The TP set was replaced with refurbished set provided by NSRP. The total FFH and refurbishment history to be provided by NSRP for proper spares parts management. As per OEM lates guide line per GER3620P the TP repair interval is 1 CI and replacement interval is 3 CI. All fixing hardware was replaced with new.

The removed set of TPs was in service since last installation in June 2024 CI and so far, clocked 8556.8 FH/ 9239.3 FFH. No previous repair mark found on the body. The set can

be sent for refurbishment for future use.
Drawing / Part No. Out: 119E9674G002 Rev.00
Drawing/Part No. In: BTSA 631601 Rev. No.

Bull Horn, Transition Piece

Arrangement

All the bull horns / TP forward supports were inspected in situ. No wear, crack or other defects noticed. Same Kept in service till next scheduled inspection.

Drawing/Part No. IN and Out: 188D9456G001



Figure 15: Removed Transition Pieces



Figure 16: Bull Horns/ TP Forward Support



Figure 17: Installed Transition Pieces with New Hardware

TURBINE SECTION

Bucket, 1st Stage

Assembly

The Stage-1 buckets were inspected in situ. All buckets were found with minor tip rub, discoloration on both pressure and suction side. Cooling holes seems free from any blockage; no damages noticed on bucket platform and axial seals except normal hot corrosion. The coating found to be in good shape. Kept in service till next inspection. NSRP to provide total FFH and Repair history of the bucket kit for future parts management including repair prospect.



Figure 18: Stage-1 Bucket condition

Bucket, 2nd Stage

Assembly

The Stage #2 buckets were visually inspected in situ. High to medium dis-coloration and corrosion noticed on both suction and pressure side of the bucket, same also noticed on platform and tip, light deposit also observed. No cracks, FOD, missing metal

visualized. Cooling holes found to be clear from any blockage. Bottom buckets also inspected through bore scope provided by NSR, images captured and kept on the instrument. Set kept in service till next scheduled inspection, HGPI due with in nex 8000 FFH. Recommended to replace.

NSRP to keep 1 set ready for next HGPI outage. Regarding repair possibility, NSRP to provide total FFH of the set along with previous repair history.



Figure 19: Condition of Stage-2 Buckets

Bucket, 3rd Stage

Assembly

Stage #3 buckets were cleaned and inspected visually in situ. No remarkable defects noticed except minor and normal hot corrosion. Buckets were observed free from any nicks & dents. Shrouded tip seal and Z- lock observed in good condition. The set kep in service till next scheduled inspection.

NSRP to keep I set ready for upcoming HGPI due within next 8000 FFH. Regarding repair possibility, NSRP to provide total FFH of the set along with previous repair history.



Figure 20: Condition of Stage-3 Buckets

Nozzle Arrangement, Stage 1

Assembly

The first stage nozzle visually inspected in situ. In general; condition seems to be good. No cracks, FOD, missing metal observed. Black sooty deposit on the leading edge and suction side noticed in addition to normal hot corrosion, minor coating crack noticed on inner and outer walls of few segments. The cooling holes found to be clear from any blockage. The set is in operation since last replacement and kept in service till next scheduled outage, supposed to be HGPI. As per OEM latest guide line (GER3620P) the Stg-1 nozzle repair cycle is 1-HGPI and Replacement is 3 HGPI.

NSRP to provide the total FFH of the nozzle set along with previous refurbishment history to finalize future repair possibilities and proper spare parts management.

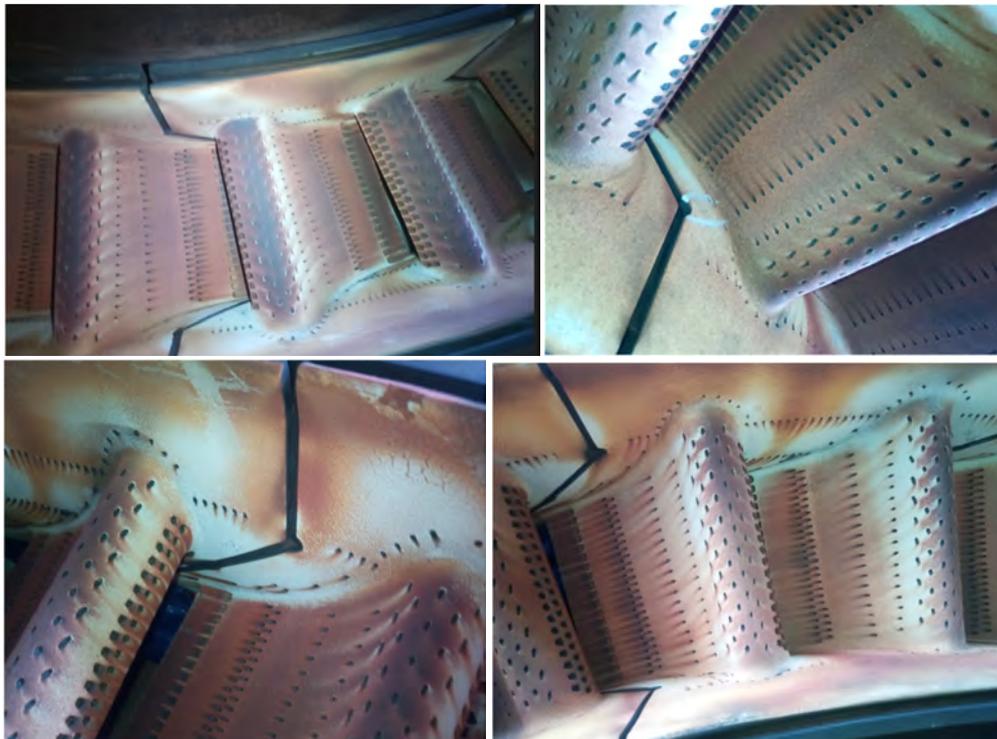


Figure 21: Stage-1 Nozzle Condition

Nozzle Arrangement, Stage 2

Assembly

The second stage nozzle segments visual checked in situ on top casing and through bore scope on bottom casing. Medium to heavy corrosion and oxidation noticed on the nozzle leading and trailing edges including inner and outer walls. Single line hair crack noticed on almost all the vanes airfoil fillet area both leading and trailing edge. No open crack observed. After joint discussion it was decided keep the set in service till next scheduled inspection, HGPI will be due within next 8000 FFH. Considering the unit efficient and safe operation, it's advised to have a Bore scope inspection of the Stage-2 nozzle within next 4000 FFH to monitor the condition of the crack. If cracks open up, it will impact proper cooling of the nozzle as well as respective wheel space area. No damages noticed on Diaphragm, except hot corrosion.

NSRP to provide total FFH and refurbishment history of the nozzle set to finalize further repair and usability. NSRP to keep another set of Stage-2 nozzle along with fixing hardware for upcoming HGPI.



Figure 22: Condition of Stage-2 Nozzle

Nozzle Arrangement, Stage 3

Assembly

The third stage nozzles were visual checked in situ. No cracks, FOD or missing meta noticed. Light to medium hot corrosion and light oxidation noticed. The set kept in service till next scheduled outage, HGPI. As per OEM guide line repair interval is 1 HGPI and Replacement is 3 HGPI. NSRP to provide total FFH of the set along with refurbishment history to finalize further repairability and use.



Figure 23: Condition of Stage-3 Nozzle

Shroud, Stage 1 Turbine

Assembly

Stage - 1 shroud were visually inspected in situ. No remarkable damages visualized except minor discoloration and coating losses on few segments. Shroud segment 1 & 2 found with minor rub marks. The shroud set retained in service.

As per OEM latest guide line Stage-1 shroud repair interval is 1 HGPI and replacement-3 HGPI. NSRP to keep 1 set Stage-1 shroud along with fixing hardware for upcoming HGPI. Also to provide total FFH and refurbishment history of the shroud set to finalize future repair and use accordingly.



Figure 24: Condition of Stage-1 Shroud

Shroud, Stage 2 Turbine

Assembly

Stage #2 shrouds were inspected visually in situ. Medium to Heavy corrosion and oxidation noticed on all the segments. Loss of honey comb also found in few segments. The shroud set should be replaced in upcoming HGP inspection. NSRP to keep one set of stage-2 shroud in stock along with hard ware for upcoming HGP inspection. NSRP also to provide total FFH and refurbishment history of the existing set to finalize future repair and use possibilities. This will help better spare management.



Figure 25: Condition of Stage-2 Shroud

Shroud, Stage 3 Turbine

Assembly

Stage #3 shrouds were inspected visually in situ. No remarkable defects noticed except normal hot corrosion and bucket rail groove on honeycomb face. The shroud set kept in service till upcoming HGP Inspection.

NSRP to keep one set of Stage-3 shroud set in stock for upcoming HGPI along with fixing hardware. Also to provide total FFH and refurbishment history of the existing set to finalize repair prospect for future use accordingly.



Figure 26: Condition of Stage-3 Shroud

Casing Turbine, Case

Arrangement Turbine

Top half of turbine casing removed to facilitate Transition piece removal and replacement.

During this opportunity all HGP parts also inspected and details recorded.

In addition, turbine clearances of accessible points measured and recorded in respective check sheets and jointly signed. The casing was cleaned and checked for any cracks or damages, no indication. The casing returned back to service after proper cleaning and polishing of vertical and horizontal parting plans. Also, all the pipe fixing flange faces and bolt holes Polished. Before fixing the top casing, the bottom casing was inspected through Bore scope (provided by NSRP), no issue found, images captured. Casing bolts were tightened as per prescribed torque value, same is recorded in respective check sheets and jointly signed.



STARTUP COMMENTS

All major jobs related to combustion inspection mechanical scope were completed by 07th July 2025. Unit was put on turning gear on 10th July 2025 after completion of pre-start up checks and peripheral jobs taken up by NSRP. Water wash was carried out on 11th July'25 and further start up on 12th July'25. Unit was synchronized and loaded gradually to 60 MW on both Liquid and Gas fuel by 13th July 2025. Water injection and tuning was also performed for both Liquid and gas fuel, Nox found to be within acceptable limit. All other operating parameters were observed normal and within limits. Pre-start up and start up details are given separately in the C&I report part along with the screen shots.



PART 2 COMBUSTION INSPECTION MARK VIe/VIeS CONTROL REPORT

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1. UNIT INFORMATION DETAILS

UNIT TYPE	GT
MODEL DESIGNATION	6F.03
INSPECTION TYPE	Combustion
FUEL CONFIGURATION	LPG / Liquid Fuel
NO _x CONFIGURATION	MNQC
INJECTION TYPE	WI
CONTROL SYSTEM	Mark VIe / Mark VIeS
TOTAL FIRED TIME	59834.50
TOTAL UNIT FIRED GAS FUEL	24699.50
TOTAL UNIT FIRED LIQUID FUEL	35135.40
MANUAL INITIATED STARTS	450
FIRED STARTS	174
TOTAL STARTS	457
FAST LOAD STARTS	0
EMERGENCY TRIPS	116
LOAD TYPE	Generator
LOAD MODEL	TEWAC
RPM	5200
KVA	98000

2. JOB SCOPE/SUMMARY

2.1 Introduction

This report covers the work performed on Turbine Control Systems of GE 6FA.03 Gas Turbine **GTG2** at Nghi Son Refinery and Petrochemical LLC – Nghi Son, Thanh Hoa, Vietnam by Turbine Controls and Startup **Technical Advisor (TA) – Prakash Periyasamy**.

The gas turbine GTG2 was shut down for scheduled Combustion Inspection (CI) in **July-2025**. The existing turbine combustion parts were replaced by refurbished ones. During the CI, auxiliary field devices, controls valves, and field instruments were disassembled for inspection by customer and other contractors.

The work scope of Controls TA **was to commission, re-start GTG2** after the CI. In addition, to provide technical support, assistance to plant personnel and customer instrument contractors to do function test all associated **pneumatic & hydraulic** valves, sensors, and pressure transmitters to ensure a reliable machine is turned over to the customer in a timely manner throughout Cold and Hot Commissioning phases.

2.2 Cold Commissioning

The cold commissioning during the Combustion Inspection was to ensure that all transmitters and associated control loops are working properly, to calibrate the IGV, SRV, GCV, stroke and troubleshooting the IBH, CBVs, WI Control Valve, and LCV, also, to check spark plugs, flame detectors and to support customer and instrument contractors to conduct functional checks to all devices associated with the machine those connect to the GTG2 Mark VIe / VIeS Control System. The cold commissioning activities are performed before the unit startup, included check/ replacement IO Pack of Mark VIe / VIeS System (if any).

2.3 Hot Commissioning

The hot commissioning was to monitor the gas turbine machine from startup to FSNL, synchronize, and then baseload of the unit.

Control TA to monitor the steps of the start-up process to log events and ensure values conform to the manufacturer's standards during the machine's start-up and operation.

Whenever a technical error causes the machine to stop or the specifications exceed the manufacturer's criteria during the start-up process, Control TA determined the cause and suggests appropriate technical solutions to comprehensively address the problem and immediately return the machine to stable operation.

Performed water injection tuning on DO, Base Load test on DO, transfer fuel from DO to LPG and perform water injection tuning on LPG and Base Load test on LPG.

3. ELECTRICAL OVERSPEED TRIP TEST

An electrical overspeed test was successfully performed on Gas Turbine **GTG2 on July 17 at 21:12 hrs** Nghi Son Refinery and Petrochemical LLC – Nghi Son, Thanh Hoa, Vietnam by Turbine Controls and Startup **Technical Advisor (TA) – Prakash Periyasamy** to verify the integrity of the overspeed protection system.

The turbine was accelerated under controlled conditions, and the overspeed trip was initiated at the expected setpoint. All protective devices responded within acceptable limits, and the turbine shutdown sequence was completed without anomalies. The system meets operational and safety requirements.

4. FINDINGS AND CORRECTIVE ACTIONS

During Cold and Hot Commissioning phases, there had been numbers of issues happened with field devices that have caused delays of the startup and commissioning progress. Such as,

4.1 Fuel Gas Skid Pneumatic Valves Unresponsiveness

- During nitrogen purging, fuel gas skid's pneumatic valves did not respond to control signals.
- During nitrogen purging, pneumatic valves did not actuate.
- Found 125 VDC power supply incomplete—positive leg measured 0 VDC at the terminal.
- Confirmed valve control signal from the turbine controller; performed master reset and diagnostic reset on the control panel; valves returned to normal operation.

4.2 Seismic Velocity Transducer (39V-1A) Defective

- Erratic and zero vibration readings observed during no-load and load-ramp tests.
- Secure Diagnostic checks confirmed an open-circuit fault within the sensor element, Defective transducer isolated and replaced with a calibrated spare unit.

4.3 Phoenix Contact Power Supply Unit Failure

- Complete loss of 24 V DC output detected under normal load conditions; status LED remained off.
- Visual inspection revealed a blown internal fuse and no response to reset attempts, Failed PSU swapped out, 24 V DC rail restored, and panel functions verified.

4.4 Turbine Compartment Vent Flap Malfunction

- Vent flap actuator failed to reach full open/close positions, triggering a safety-controller trip on high-vibration interlock, Mechanical inspection uncovered binding in the actuator linkage and misaligned limit stops on the mounting bracket.

- Flap assembly realigned, linkage lubricated, then function-tested through multiple cycles without alarm.

4.5 Bellmouth Pressure Transducer (96BD-1) Instability

- Pressure Readings oscillated during study-state condition.
- Loop checks and wiring inspections revealed loose terminations, recalibrated zero/span, tightened terminations, and re-ran loop verification to ensure stable output.

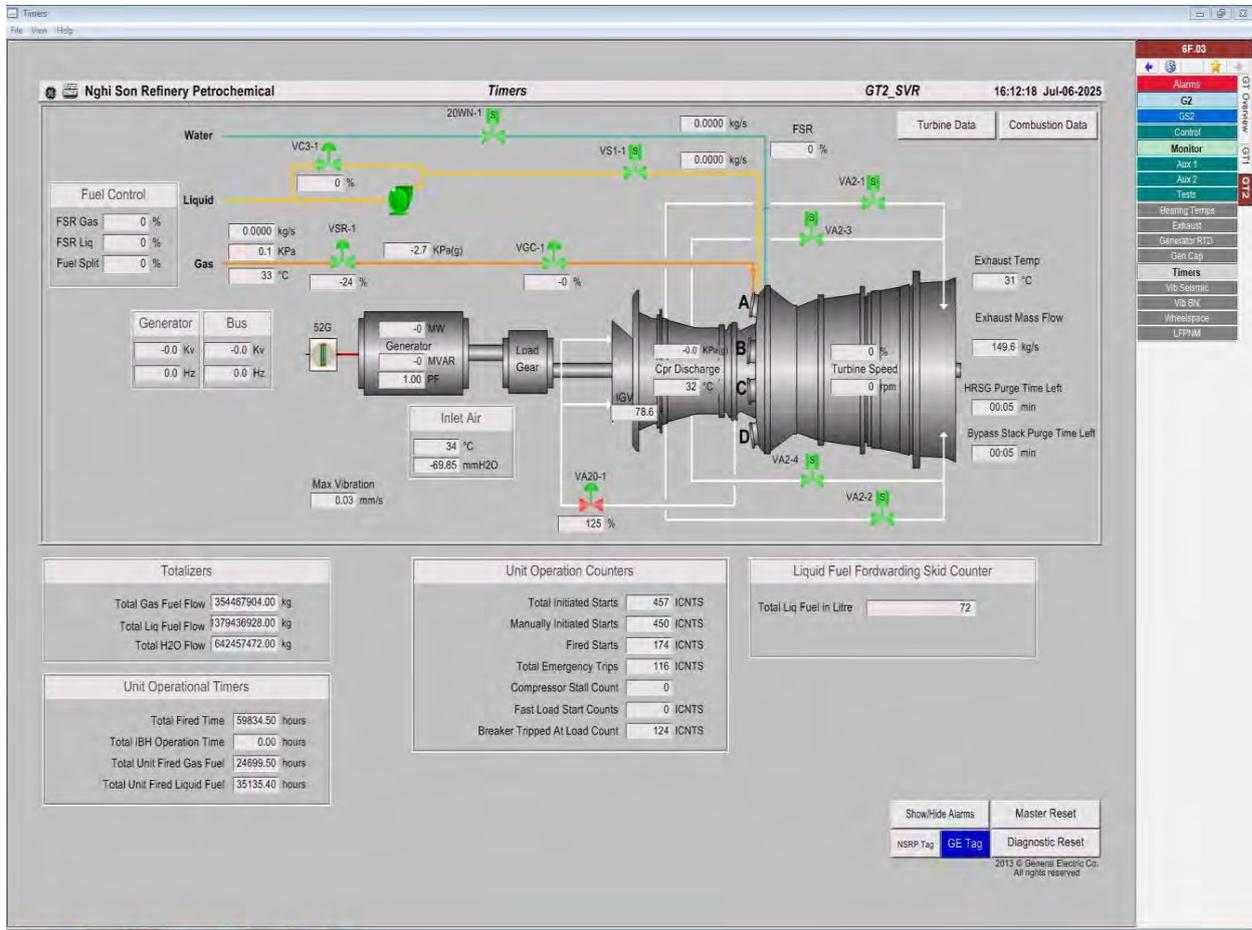
5. STARTUP COMMENTS

Controls TA support the customers to determine the root cause of each problems mentioned above and provided appropriate recommendation to customers to comprehensively address the problem accordingly and immediately return the unit to normalize the system and/or stable operation in timely manner.

On 12-July-2025 after customer resolved the all issues, the unit was Started at 00:18Hrs and Fired at 00:33Hrs, unit reached Full Speed No Load at 00:38Hrs, and synchronized to grid at 00:51Hrs. Unit was gradually loaded to Base Load of 60 MW. Water injection tuning for the GTG2 on both Liquid Fuel up to 60MW (12-July-2025) and Gas Fuel up to 60MW (13-July-2025) was completed with accepted NO_x range and customer witnesses. The unit was then turned over to operations, declared and returned to services as customer schedule, fully complied with EHS and quality control.

Documentation of the CI mechanical inspection is included in separate reports. Documentation of control valves and field instruments inspections those under customer and/or other contractor are in separate reports.

6. TIMERS AND COUNTERS INFORMATION

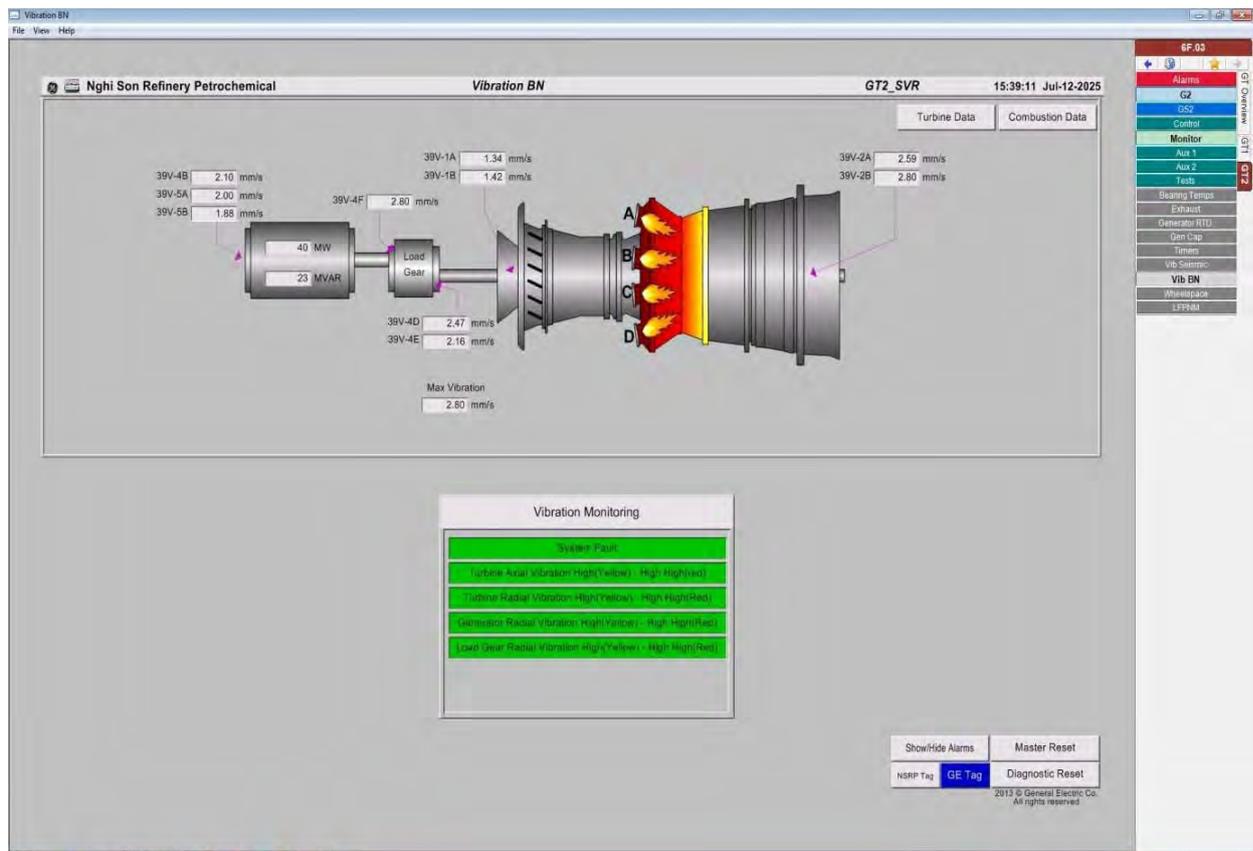


7. RECOMMENDATIONS

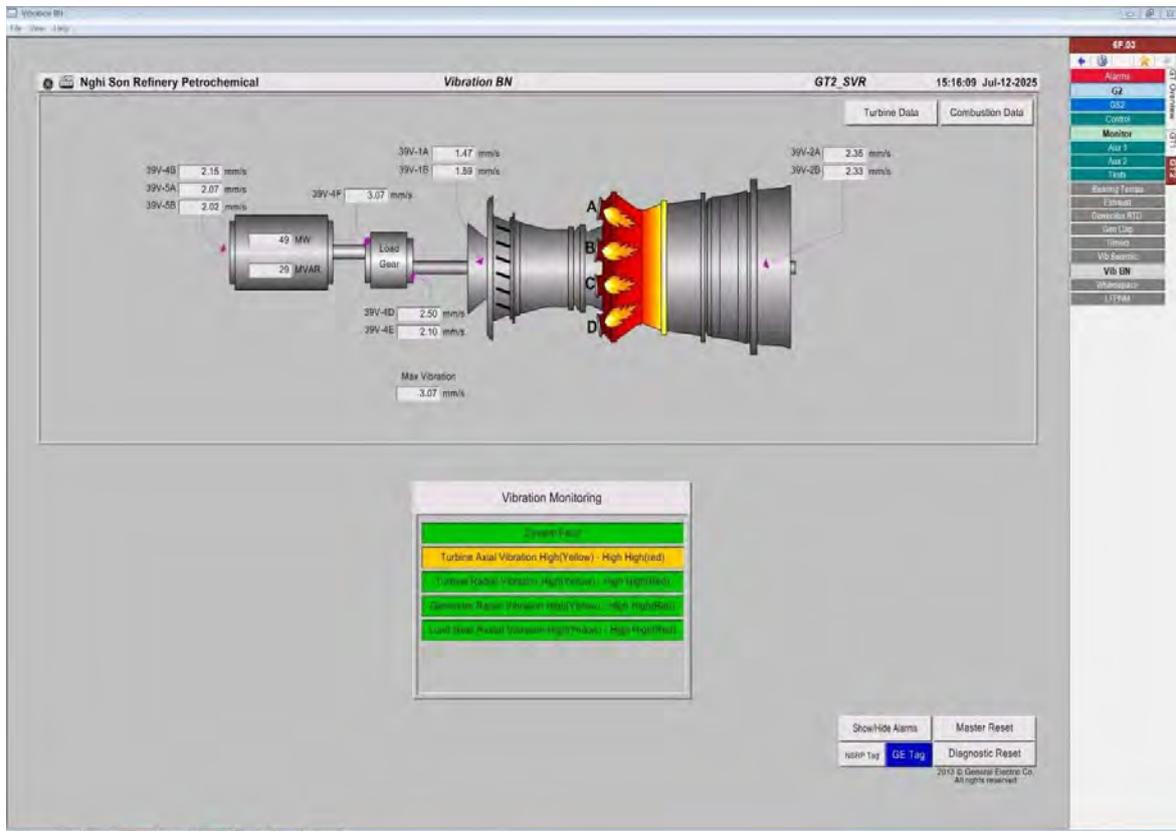
7.1 Turbine axial (BN) vibration high

- Turbine axial (BN) vibration high during load transfer from 40 MW to 50 MW.
- Investigate root cause—check rotor balance, bearing clearances, shaft alignment, and damping system—and implement corrective actions during the next Major Overhaul.

The unit axial vibration (BN) monitoring screenshot



40 MW Screenshot



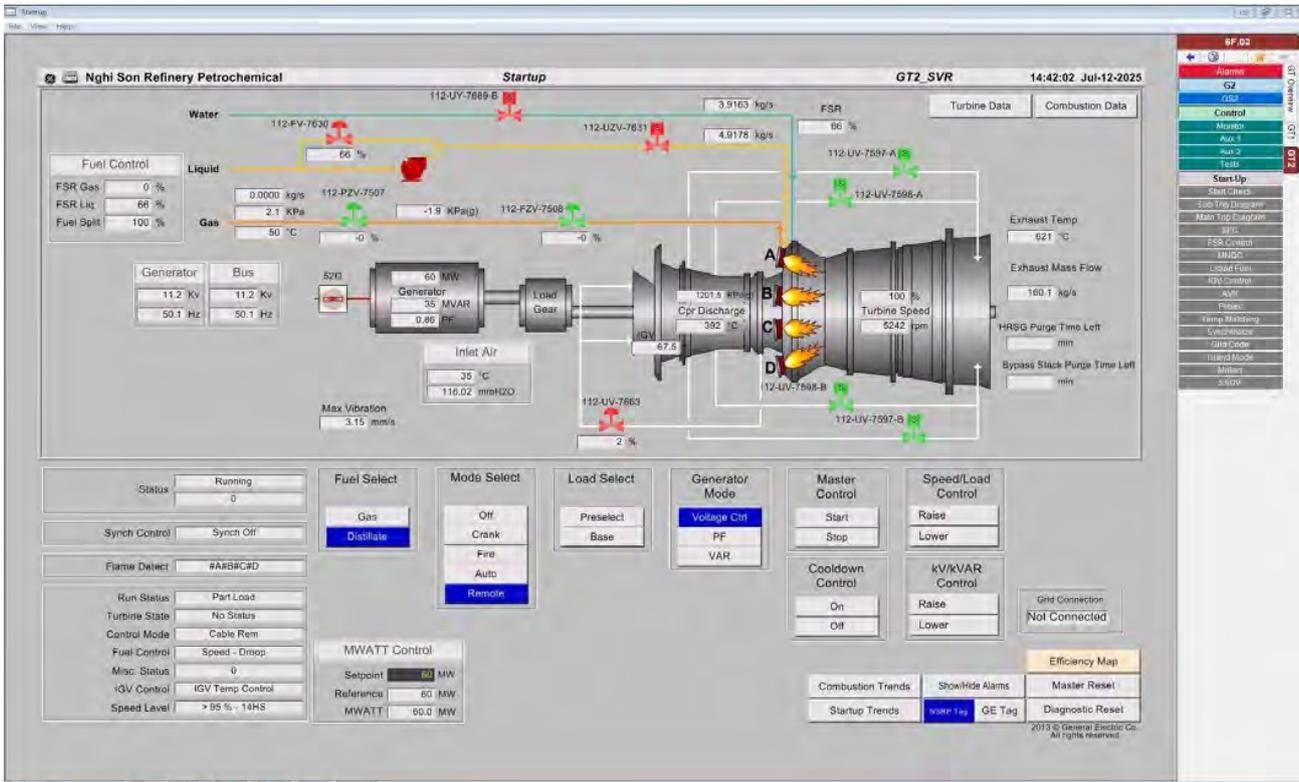
50 MW Screenshot

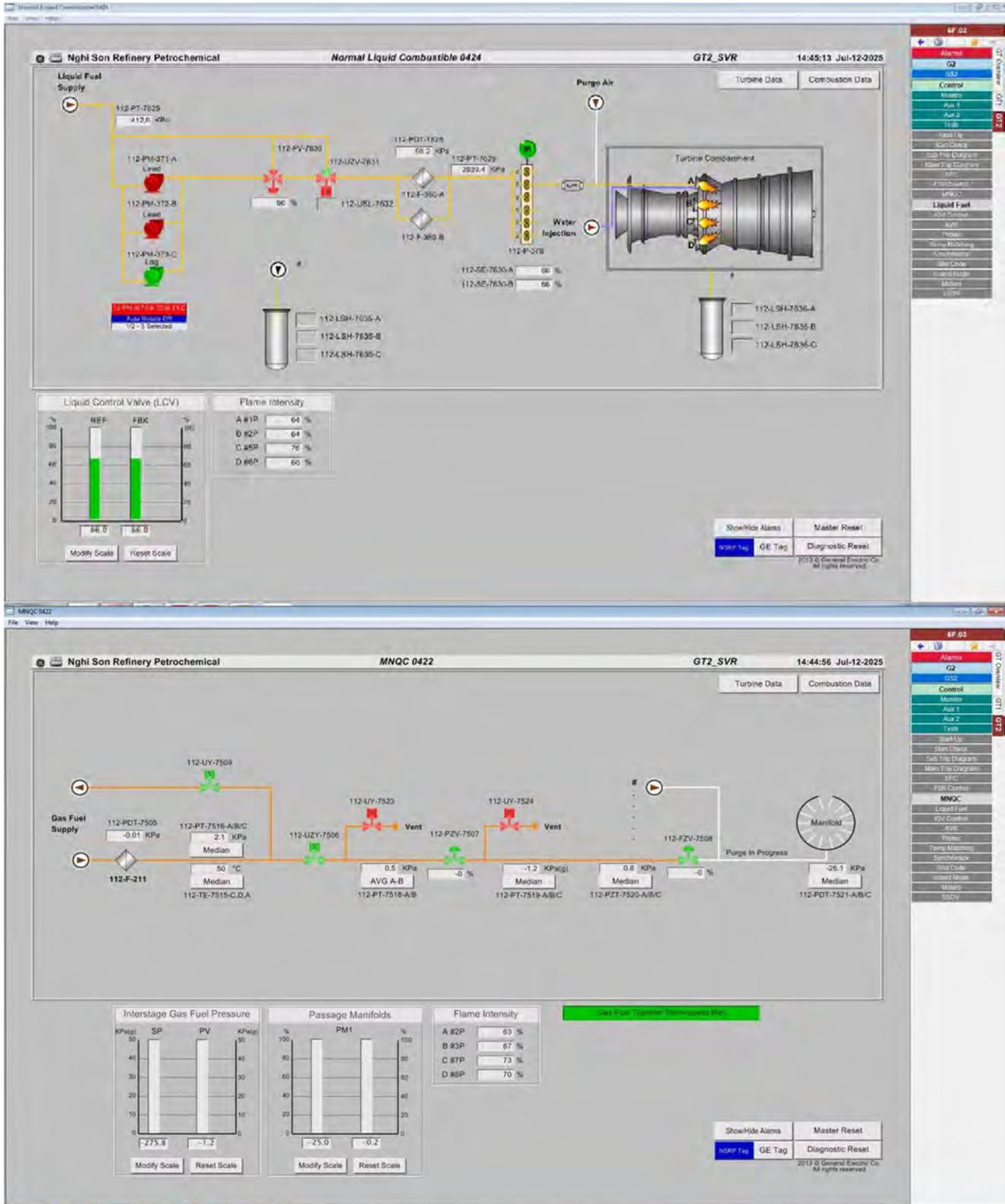
7.2 Local Control room environmental conditions (LCR)

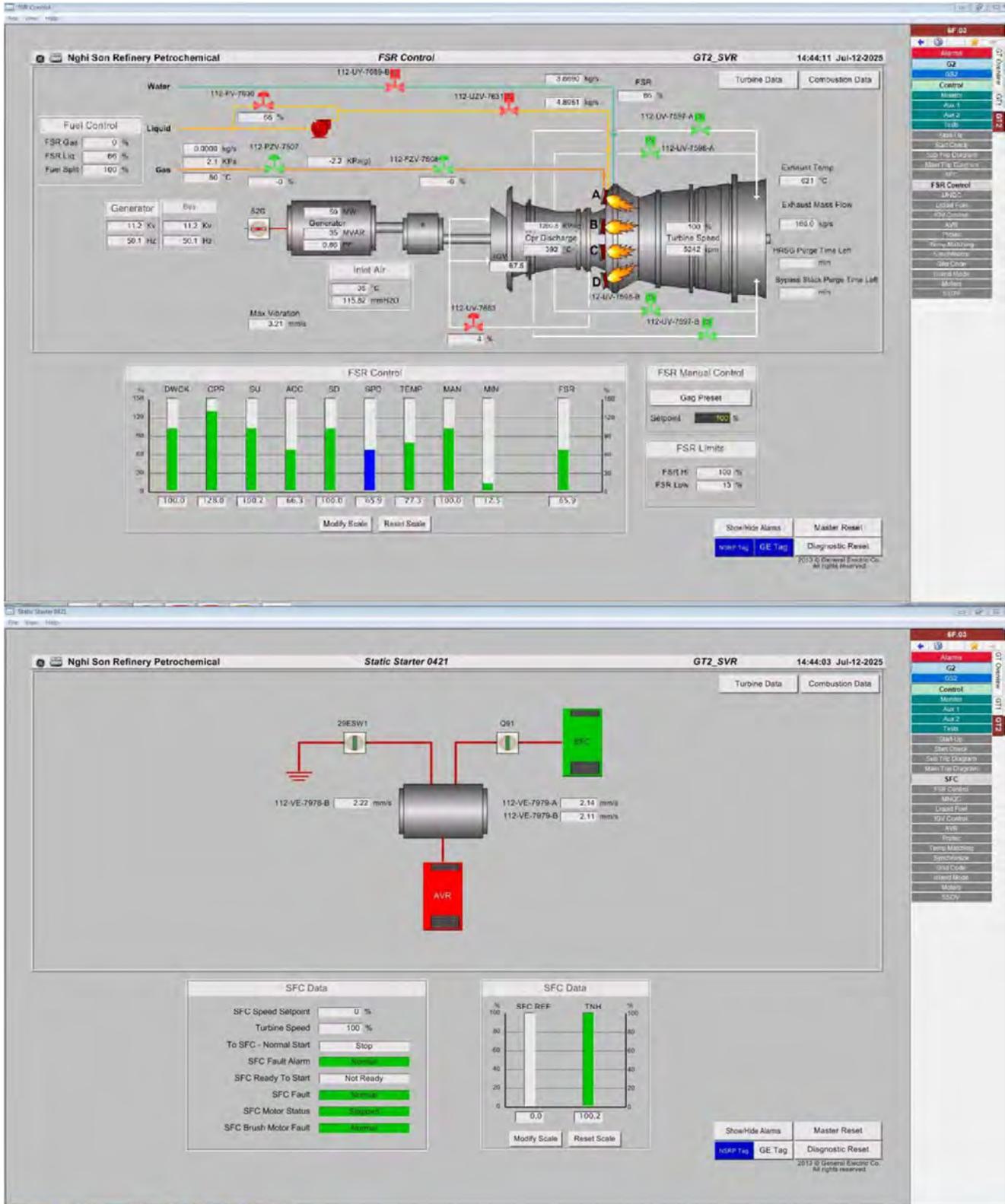
- Install and commission a dedicated air-conditioning system for the local control room, with a focus on the turbine control-panels area. Maintain ambient temperature within the manufacturer’s specified range (typically 18 °C to 27 °C) to ensure reliable operation and extend the service life of electronic components.

8. APPENDIX

8.1 Appendix A – GTG2 Post CI at 60MW OnLoad (Liquid Fuel Operation) Screenshots







Start Checks

Nghi Son Refinery Petrochemical GT2_SVR 14:43:32 Jul-12-2025

Start Check 0

- Final Guide Valve Position Sensor Trouble
- Continuous Regeneration
- Diagnose Purge Parameters
- Block Control Mode
- Flow at F-Stop 1
- Flow Regeneration Start Parameters
- OSP Ready to Start**
- Control System Circuit Fault
- Control System Transmittance Diagnostic
- Control System Fault - Stop Level
- Exhaust Gas Pressure Transmitter Failure
- No Response Outside Plant to Start

Start Check 1

- Line Up Pressure Tests Passed
- Flame Detector Trouble
- OT Block Sensing
- Pressure Transmitter Trouble
- Generator Breaker Not Closed
- Control System Locking Signal Trip
- Control System Control
- Control System Control Trip - Generator Break
- Control System Valve Control Post Lockout

Start Check 2

- Gas Control Valve at XCV Post Lockout
- Time Delay Loss of Master Protective
- Master Protective Startup Lockout
- Control System Locking Signal Trip
- Self-Check Airblast Temp TO Trouble

Start Check 4

- Block Air Compressor Start Check
- Start Check for SSOV System
- Gas Purge System OK
- Start Check for Liquid Fuel Purge System
- Block Start Level Low

Start Check Logic

- Generator Breaker Close/Open Status Input
- Auxiliary Check Failure
- 12M KV Delta Unbalance Protection OK
- Low KV Phase Start Delay Transmittance Settings
- VA17-1 Open Position
- Protective VPOD Card Trip
- Control System Fault Effect Safety Controller

Not Ready to Start

Start Check 3

- Master Protective Trip
- Minimum Startup Failure
- Minimum Firing Speed Signal
- DC Supply A1 Control Fault
- DC Supply B2 Control Fault
- DC Supply B1 Control Fault
- Lubrication Discharge Pressure Fault Alarm
- Control System Fault Trip
- SSOV Ignition Test in Progress
- Block Start Level
- SSOV at correct location for start

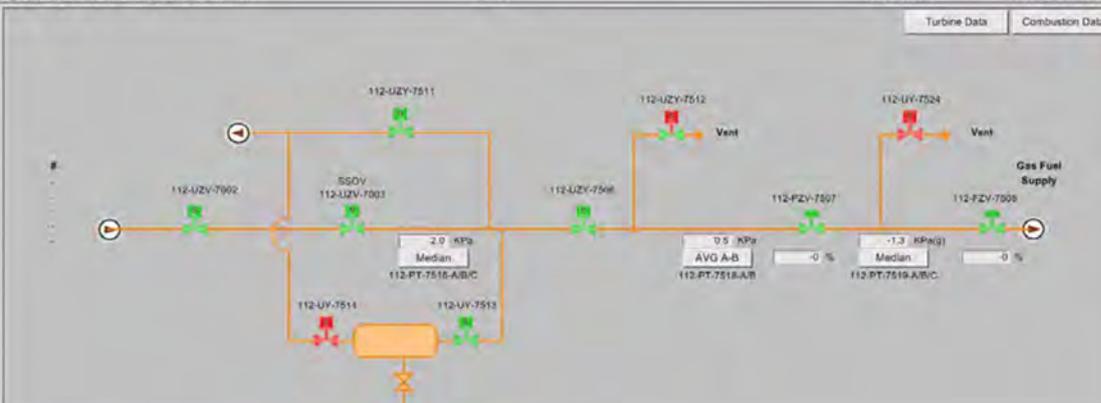
Signals in the proper state to permit a start are shown in GREEN.
Therefore, a green signal is required to start the unit.
Signals which are RED
inhibit start requests.

Show/Hide Alarms Master Reset
 Show/Hide GE Tag Diagnostic Reset

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SSOV

Nghi Son Refinery Petrochemical GT2_SVR 14:46:44 Jul-12-2025



SSOV Closure Permissives

- Line Closed
- Off Mode Selected
- No Speed

Close SSOV

Use this button to close SSOV and vent gas line.
SSOV closure is required only for maintenance purposes.
In case of emergency use E-stop pushbutton.

Open SSOV

Use this command to start gas-compartment ventilation and open SSOV.

SSOV Operating Permissives

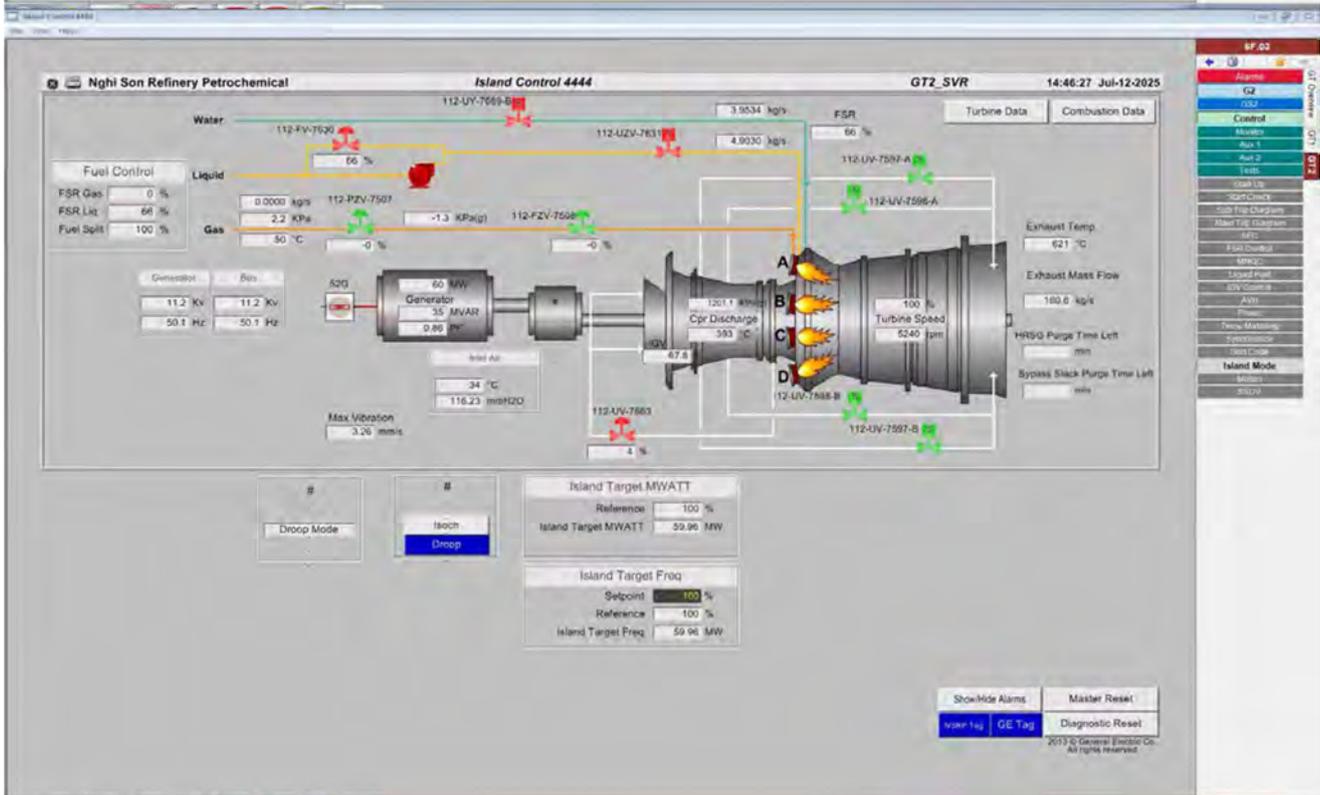
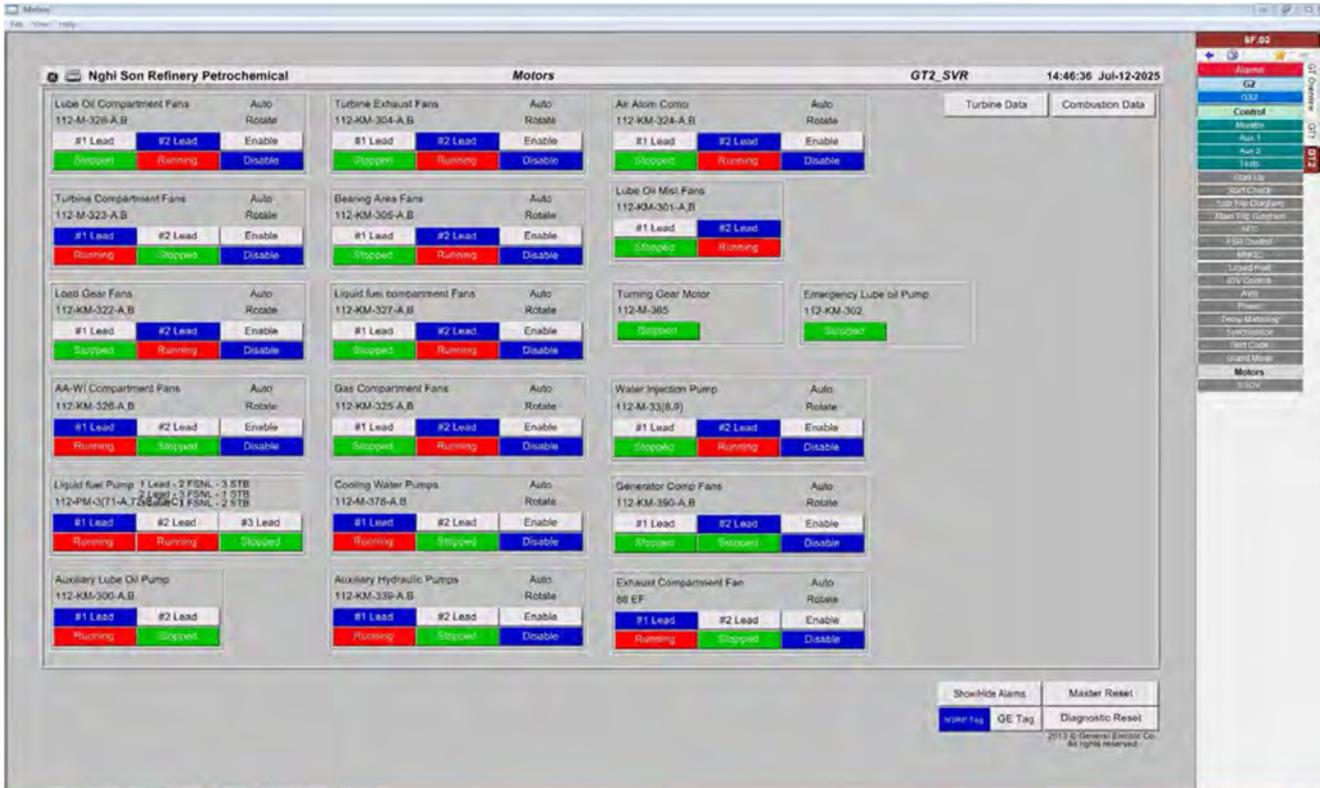
- Line Closed
- Off Mode
- Control System

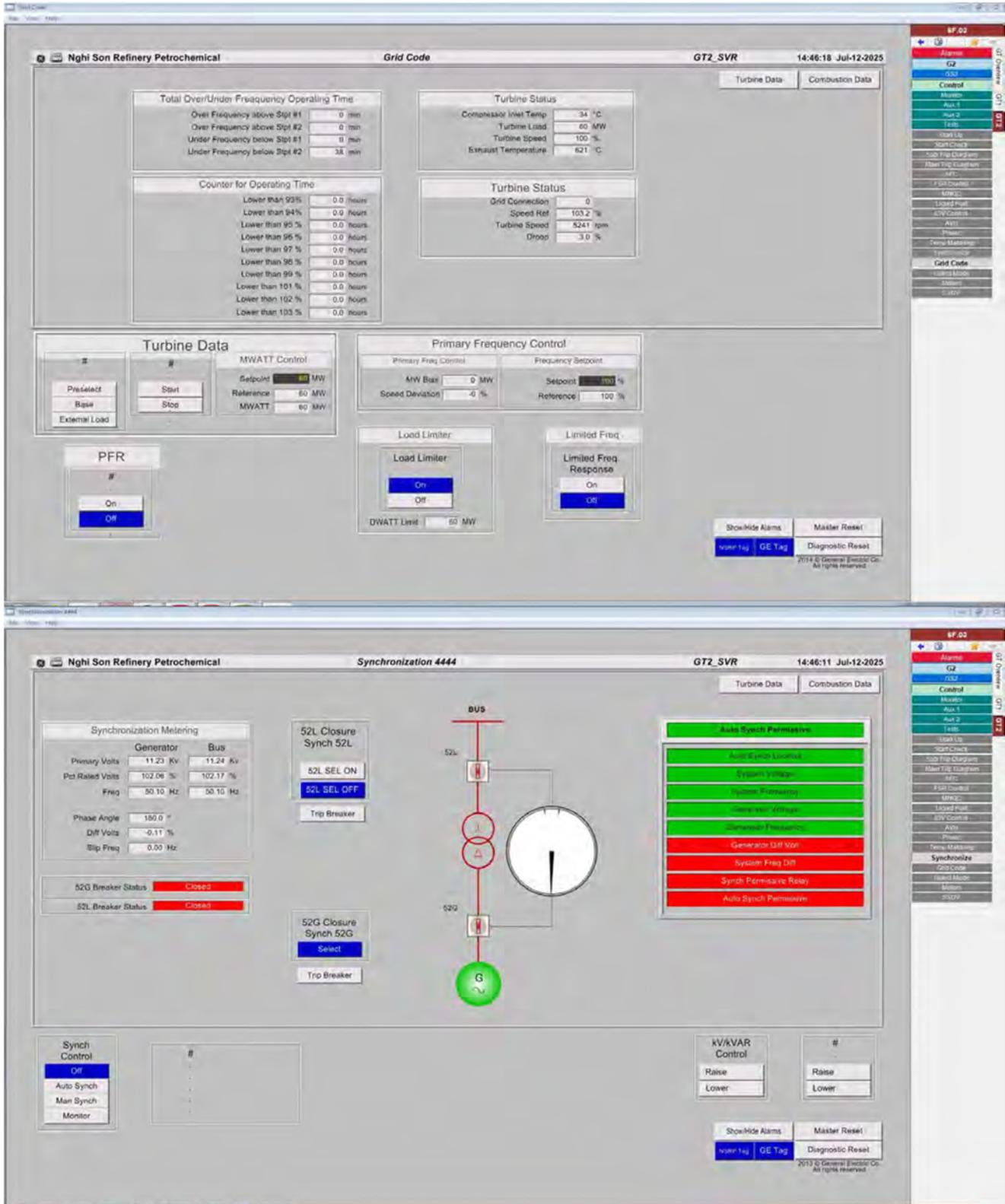
Gas Comp. Timer

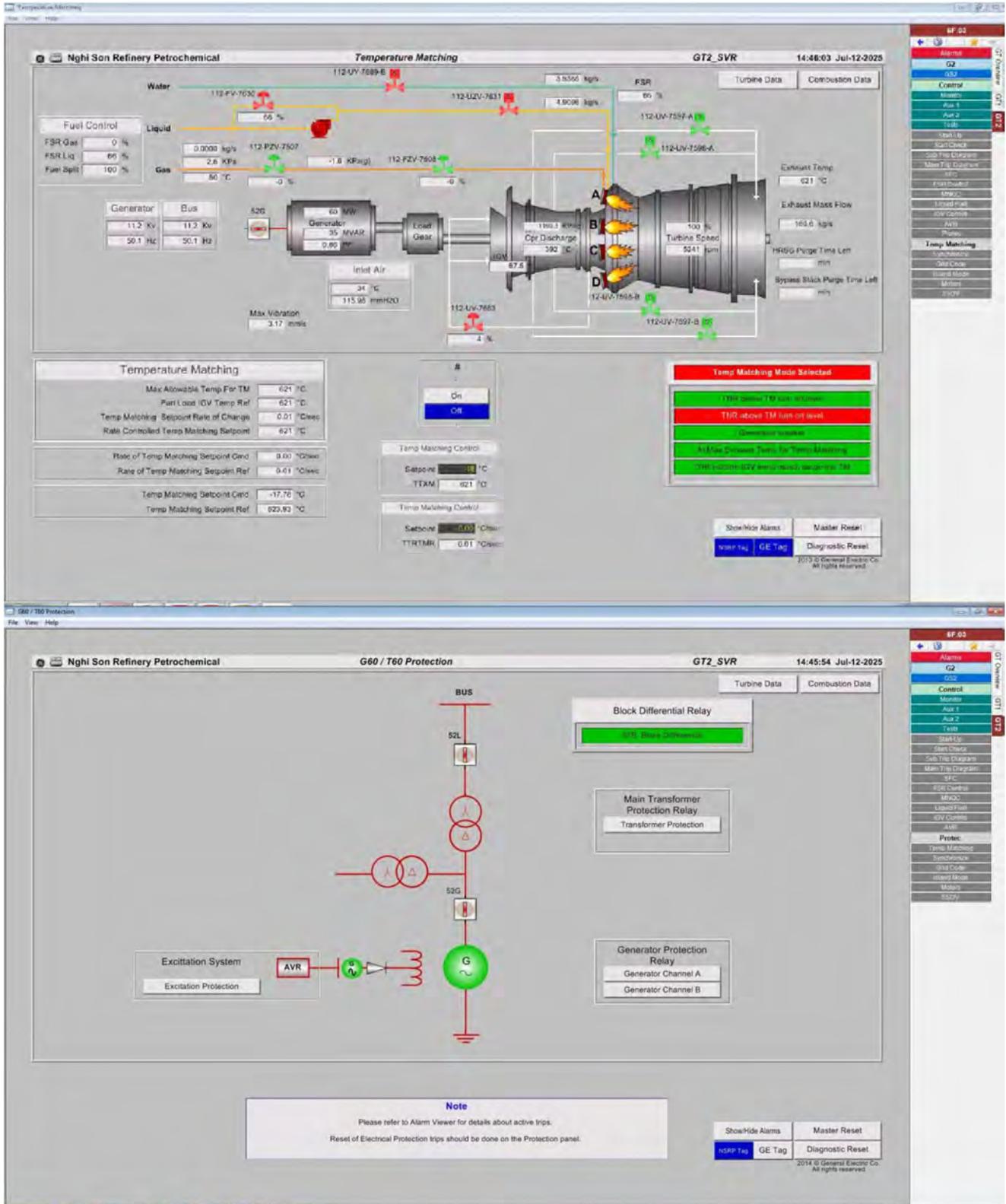
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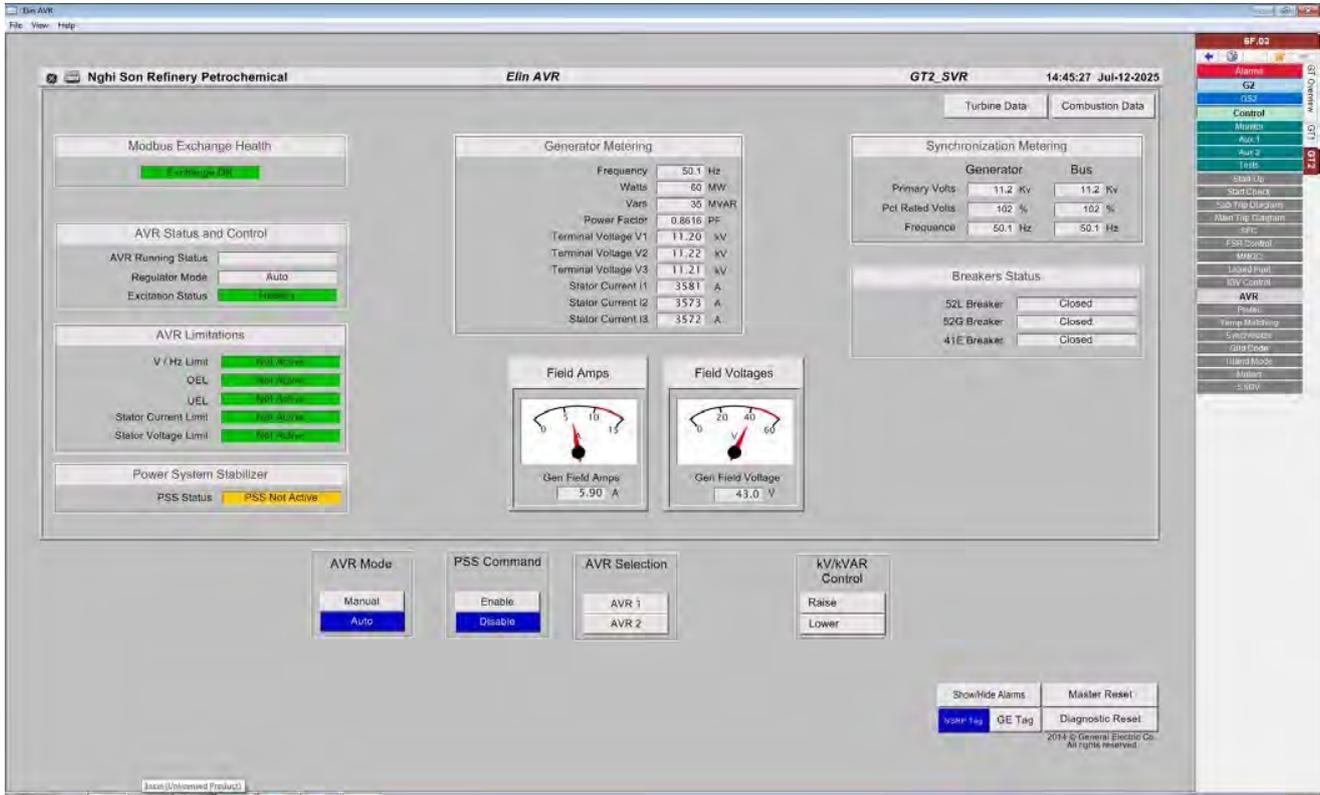
Show/Hide Alarms Master Reset
 Show/Hide GE Tag Diagnostic Reset

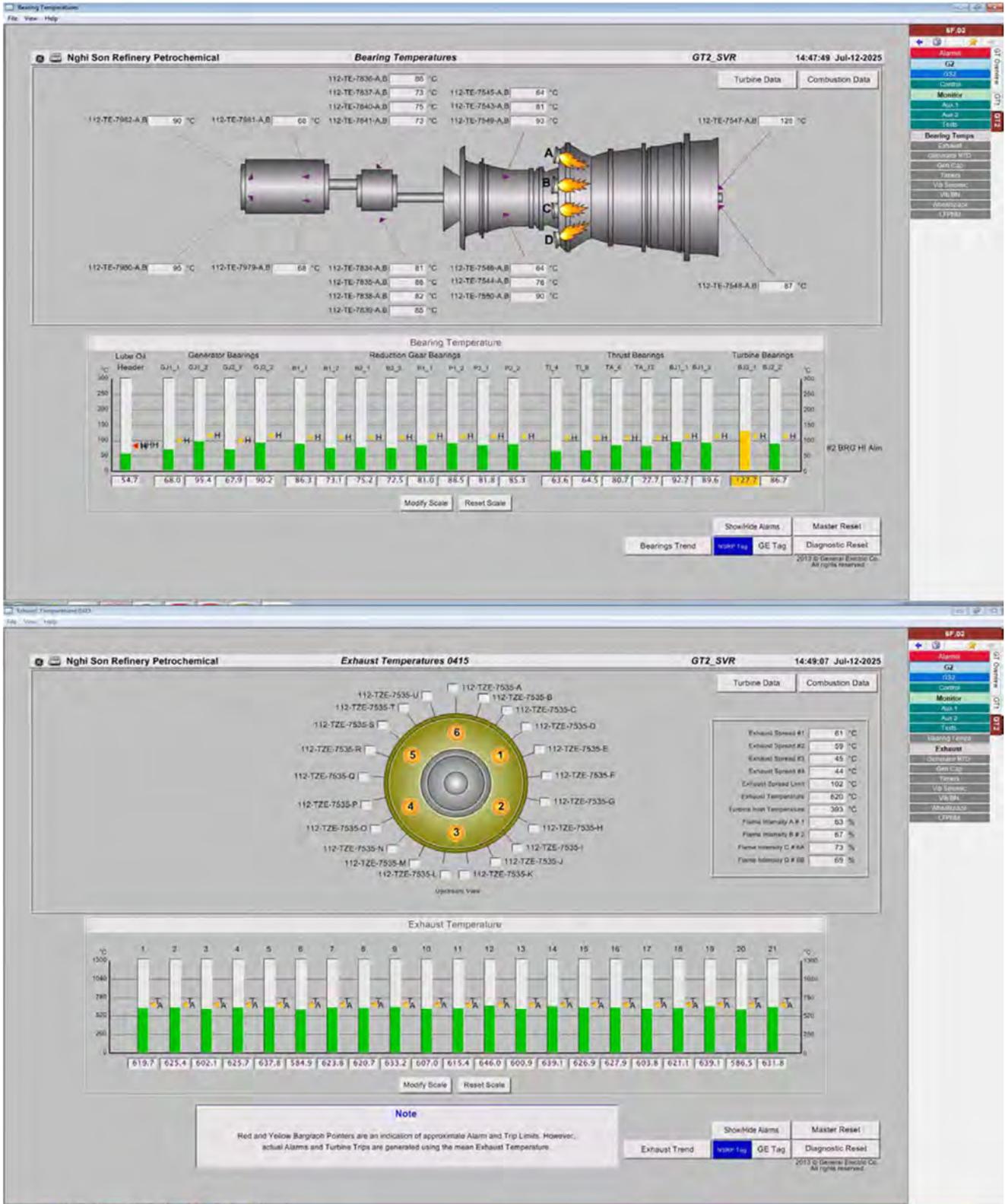
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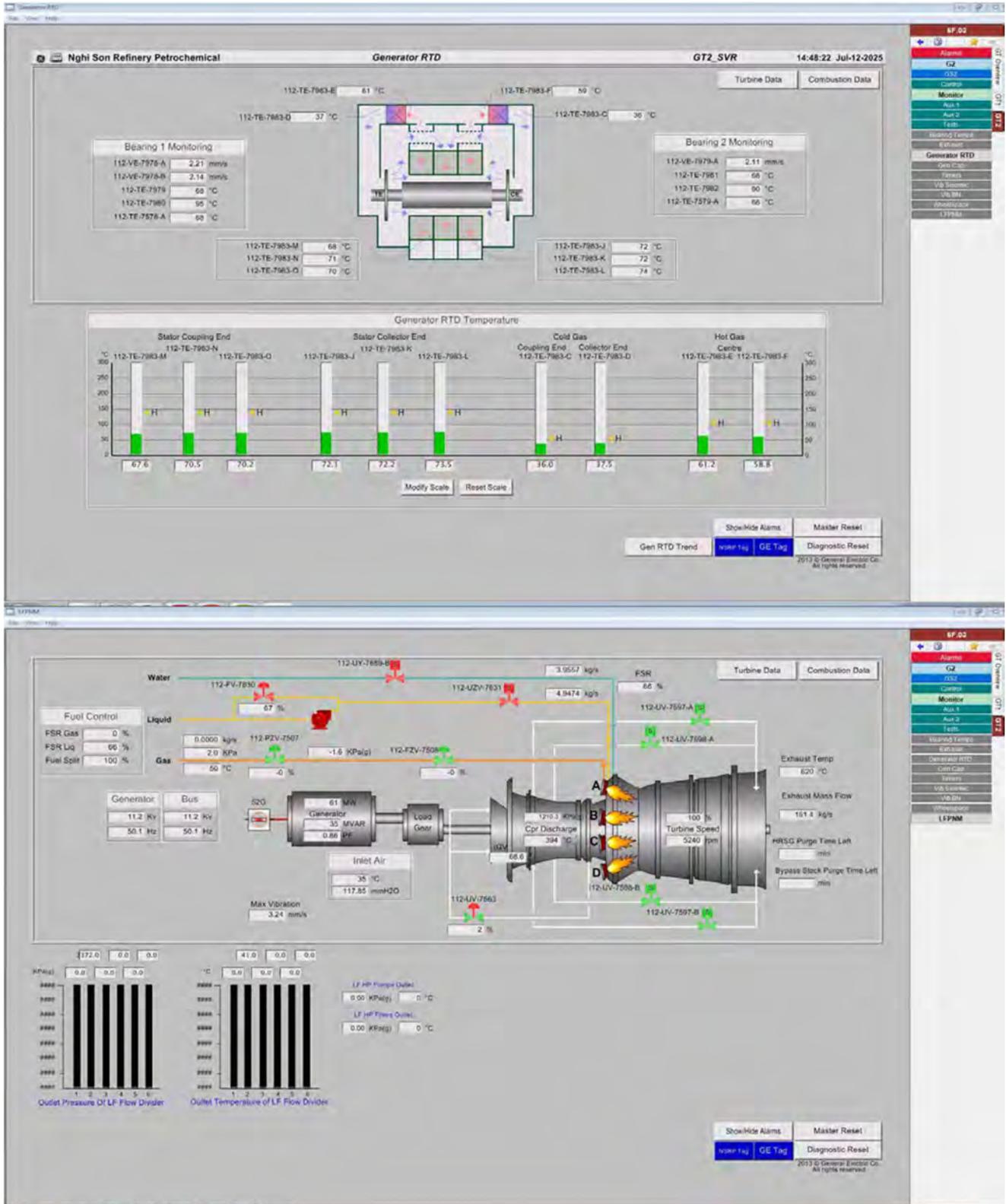


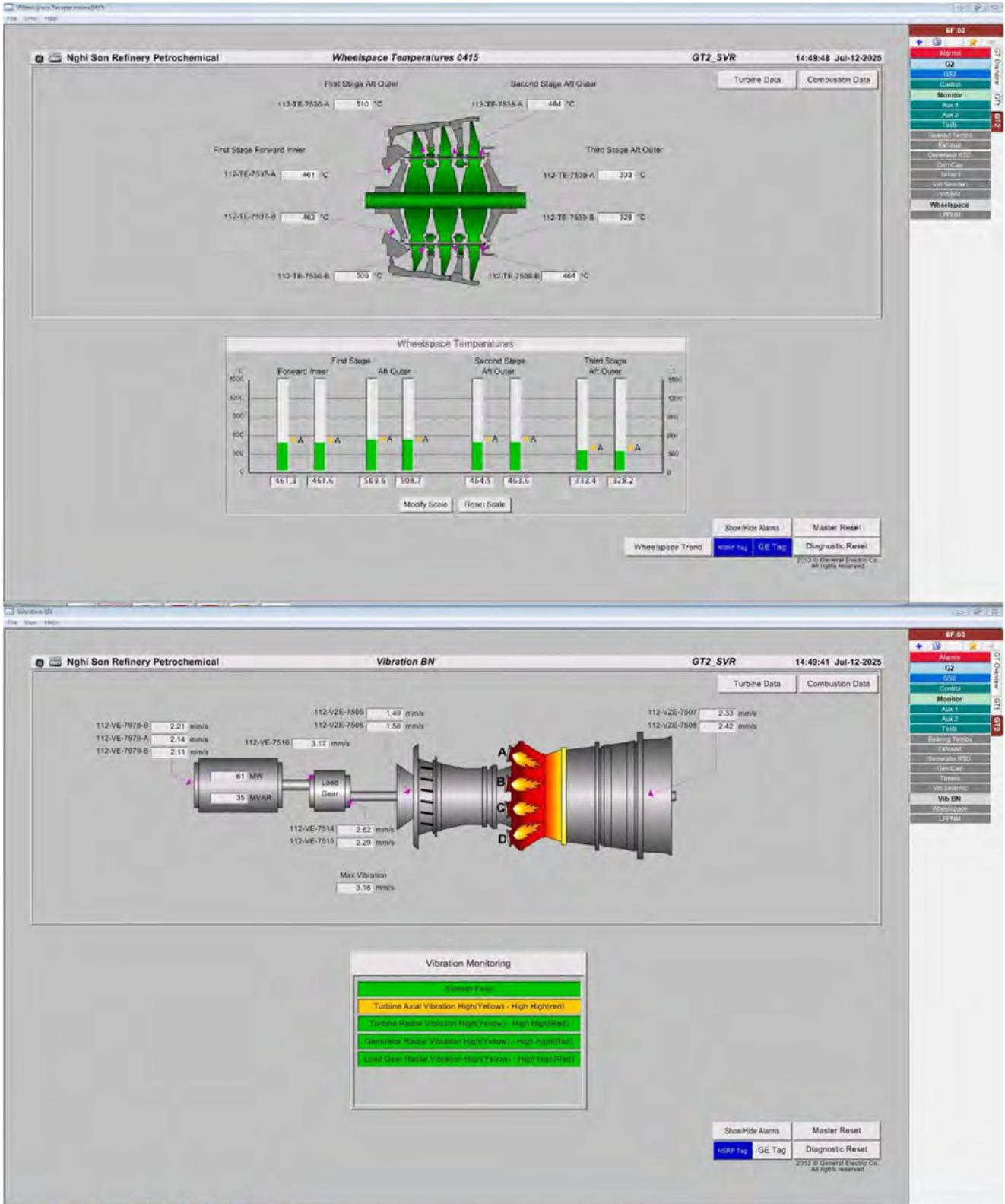


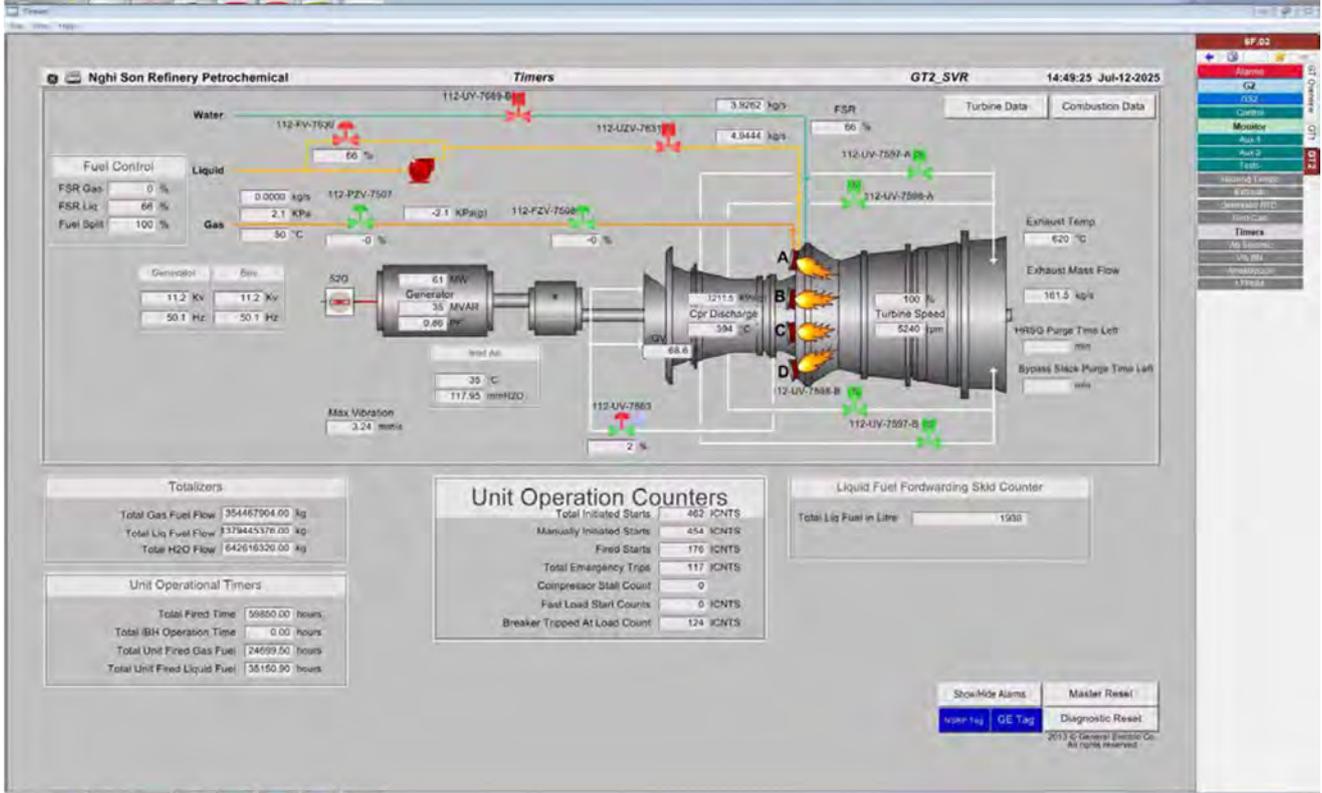
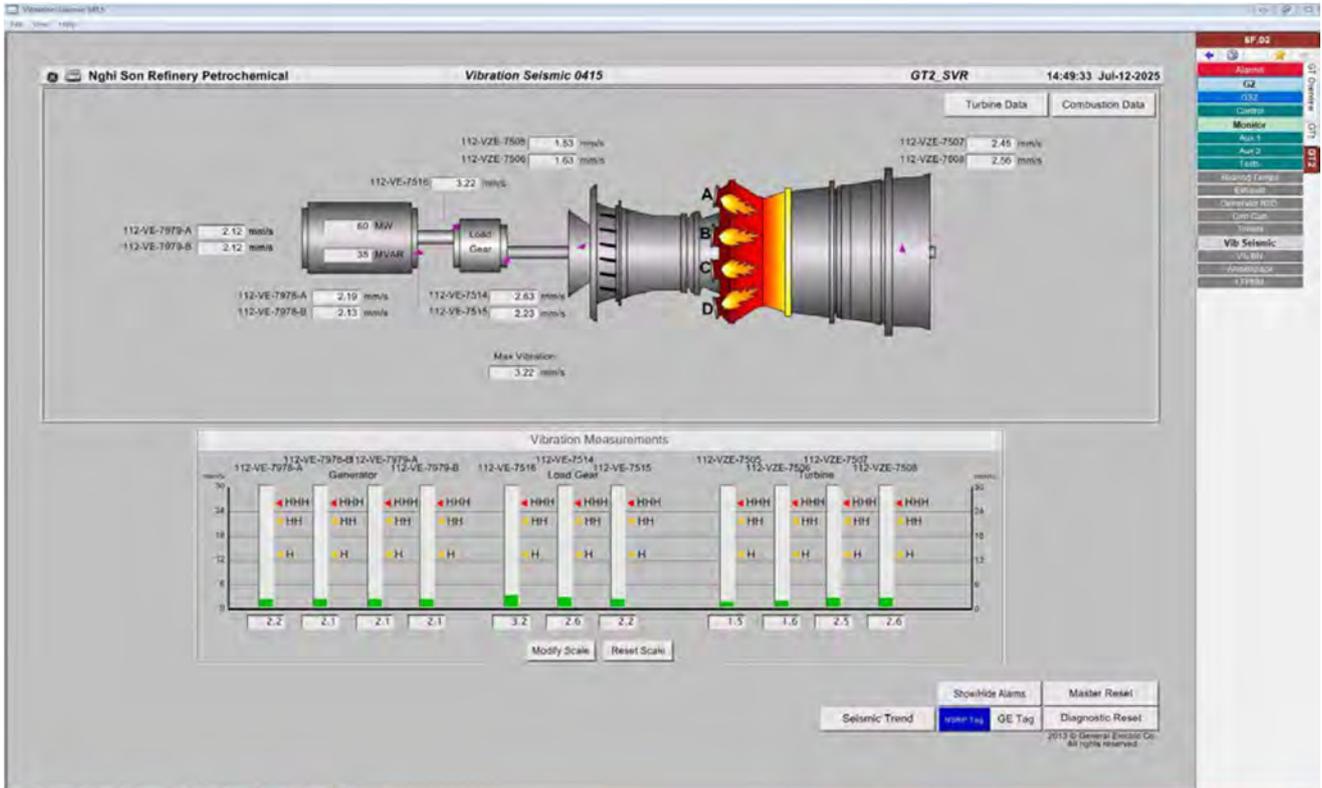


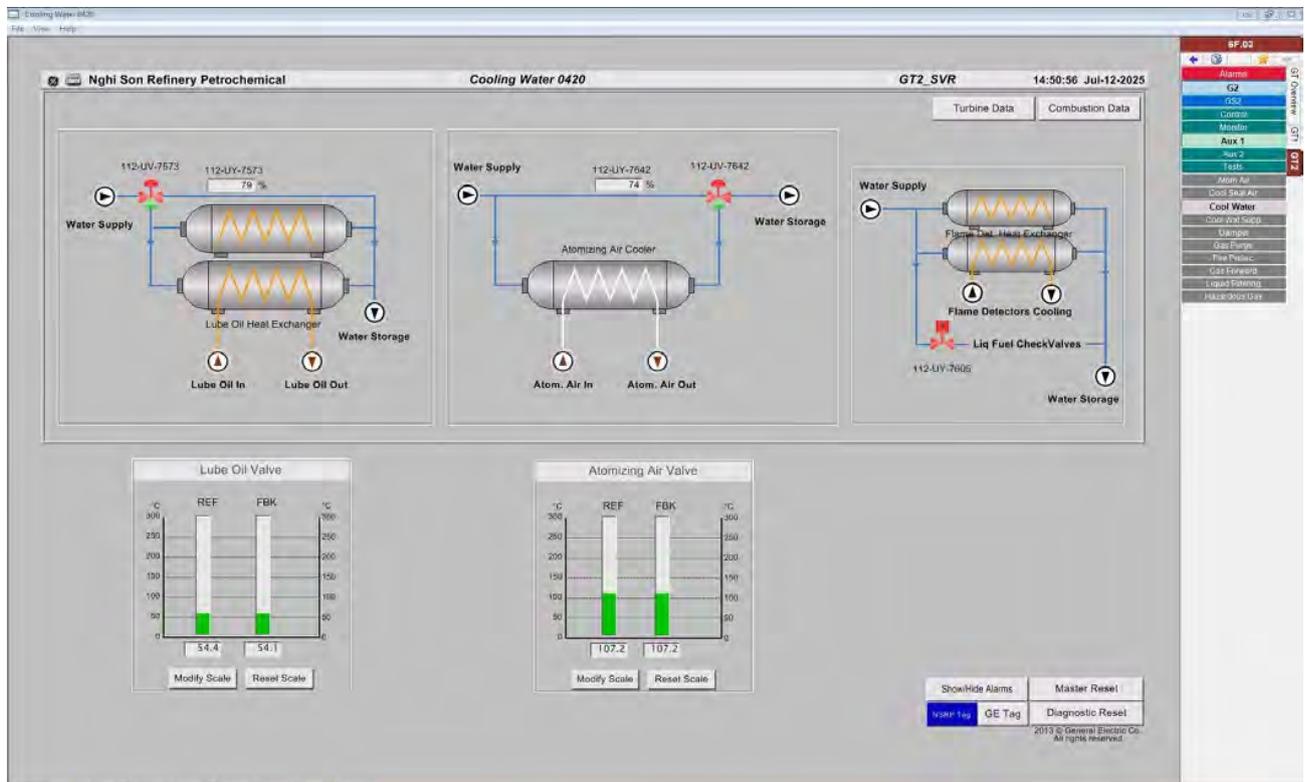
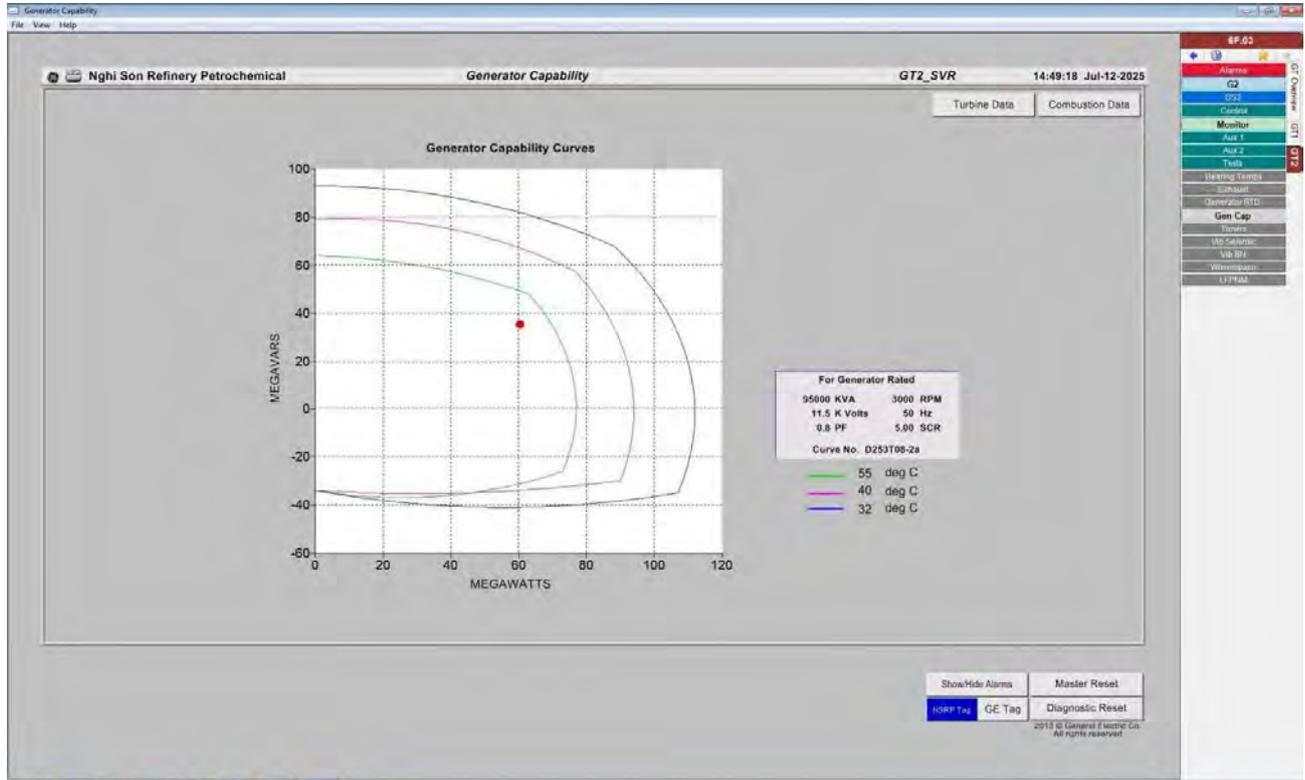


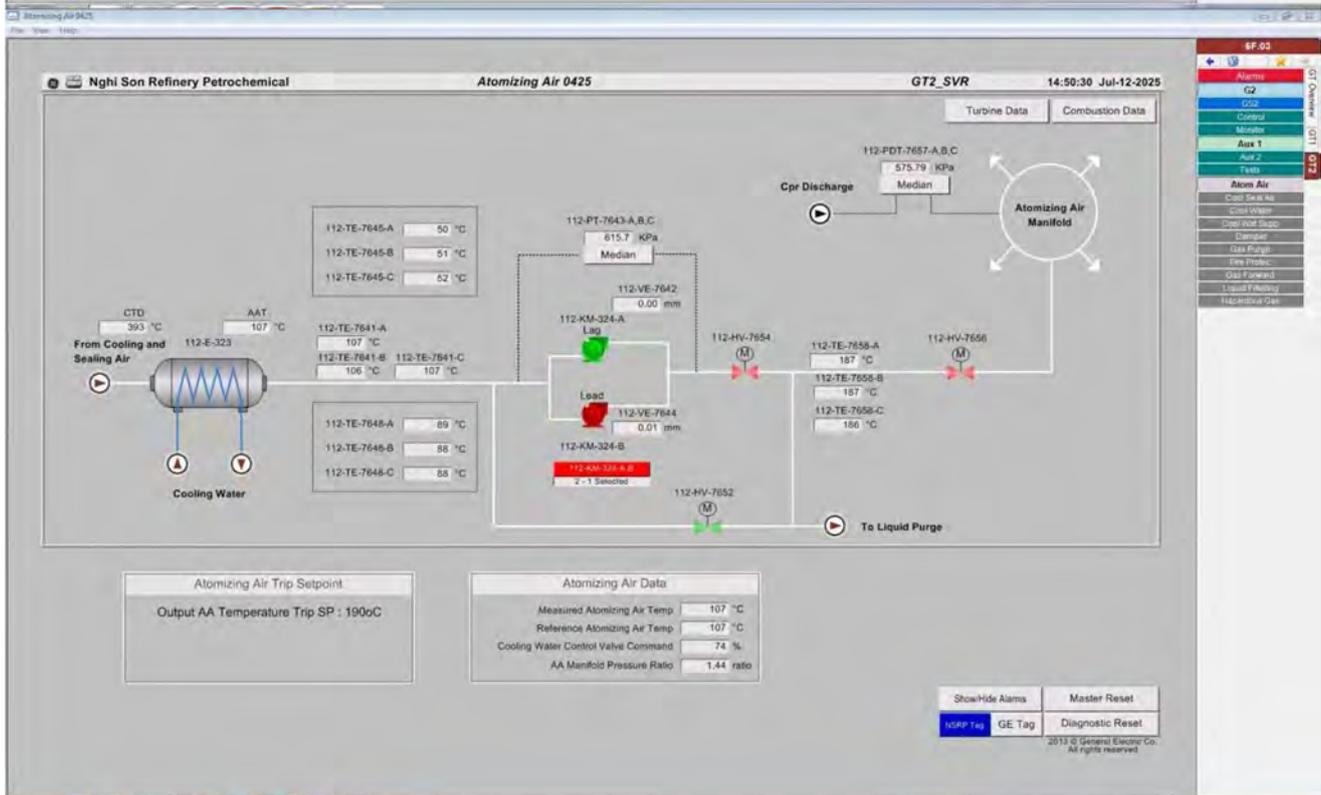
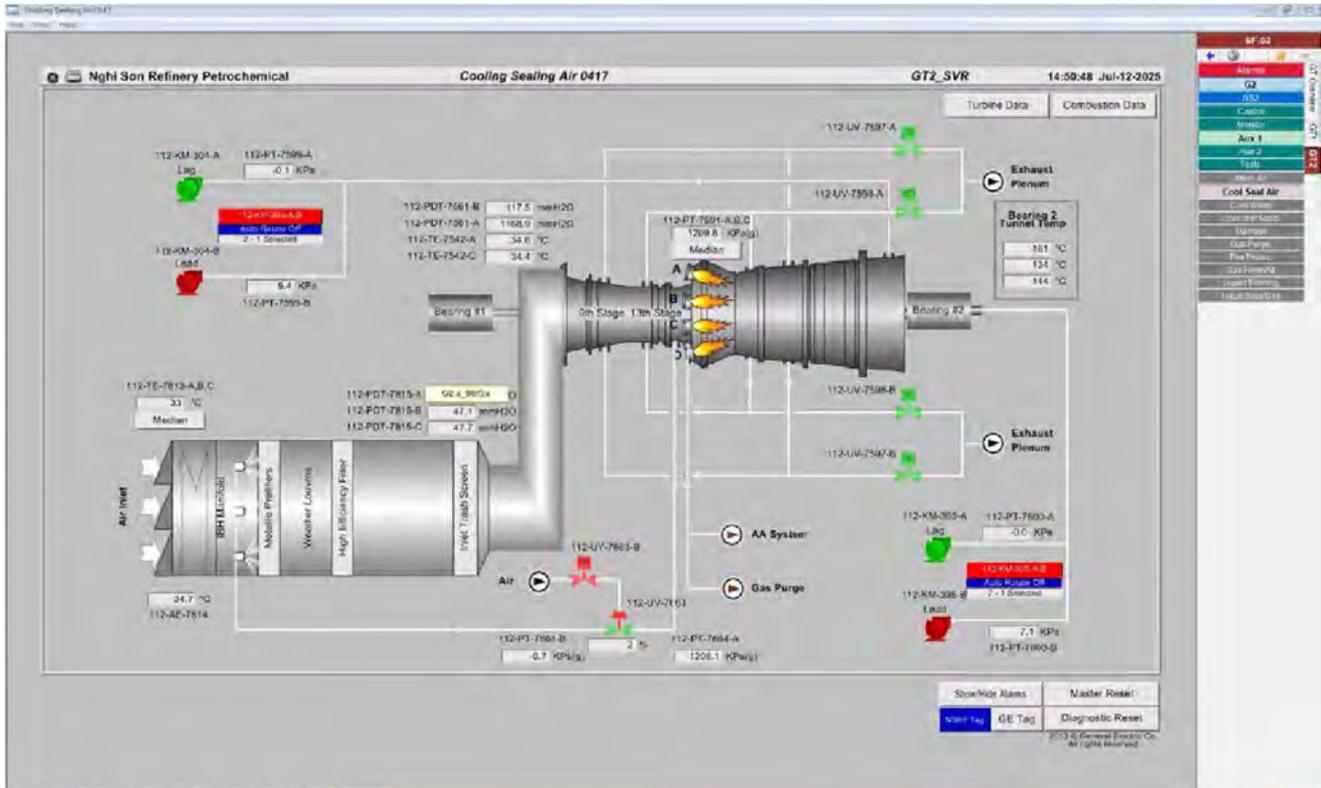


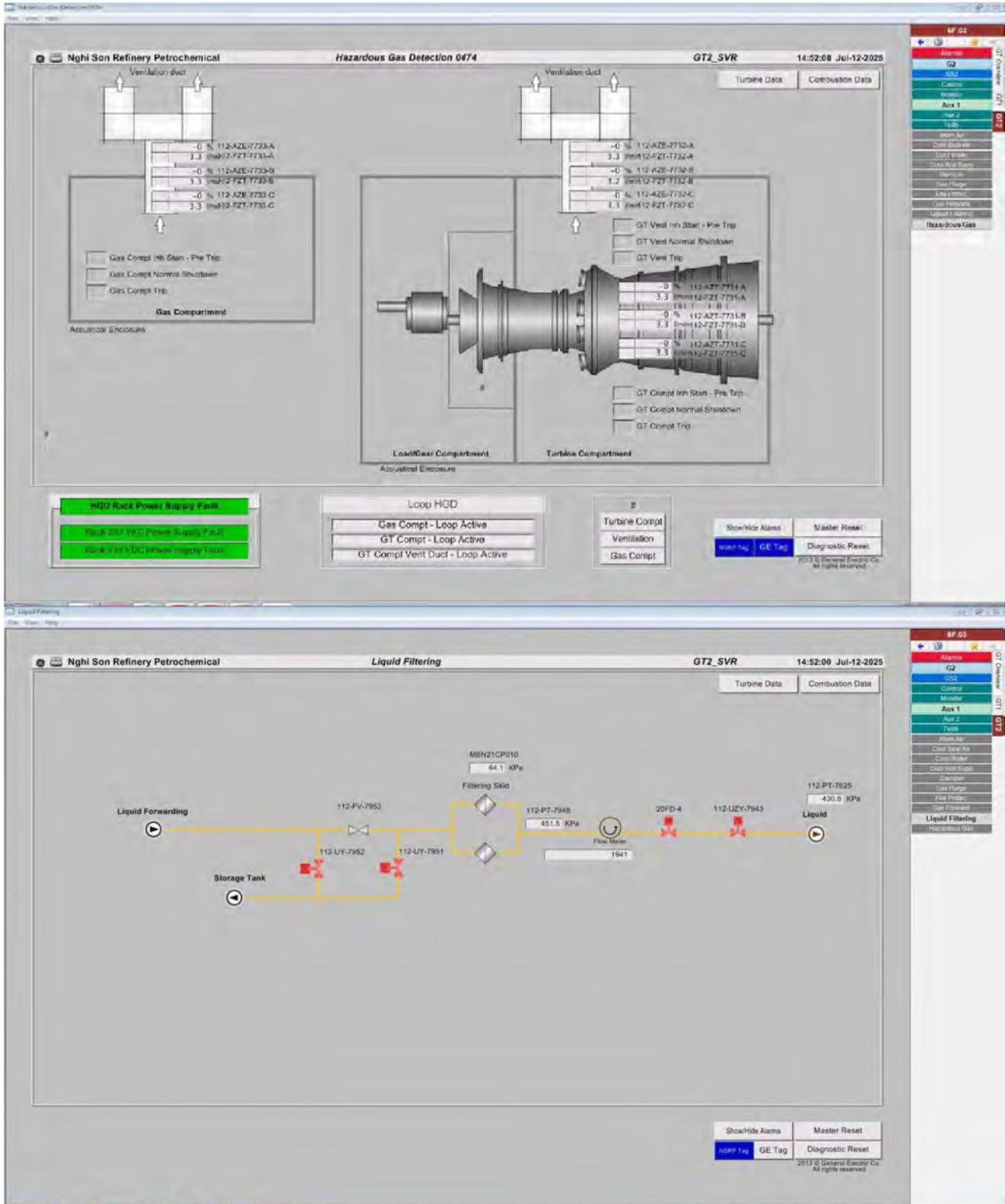


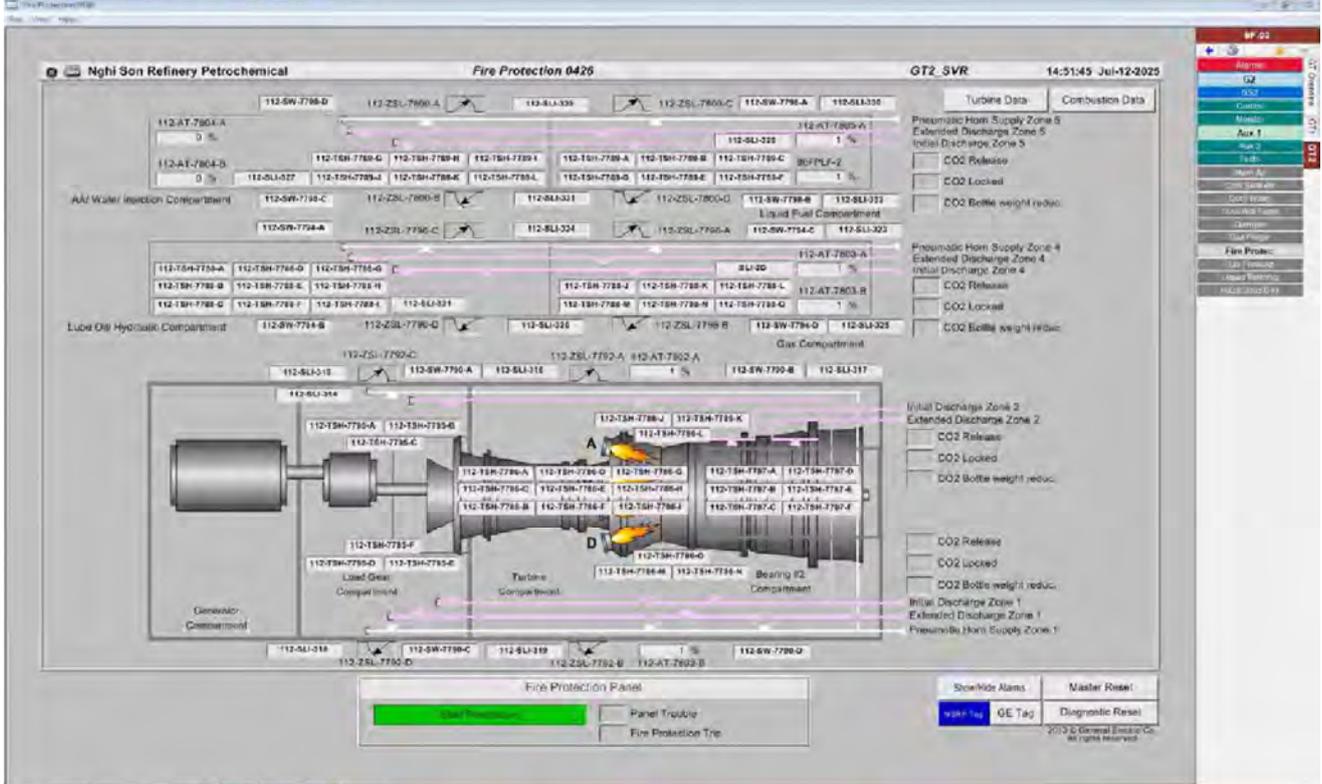
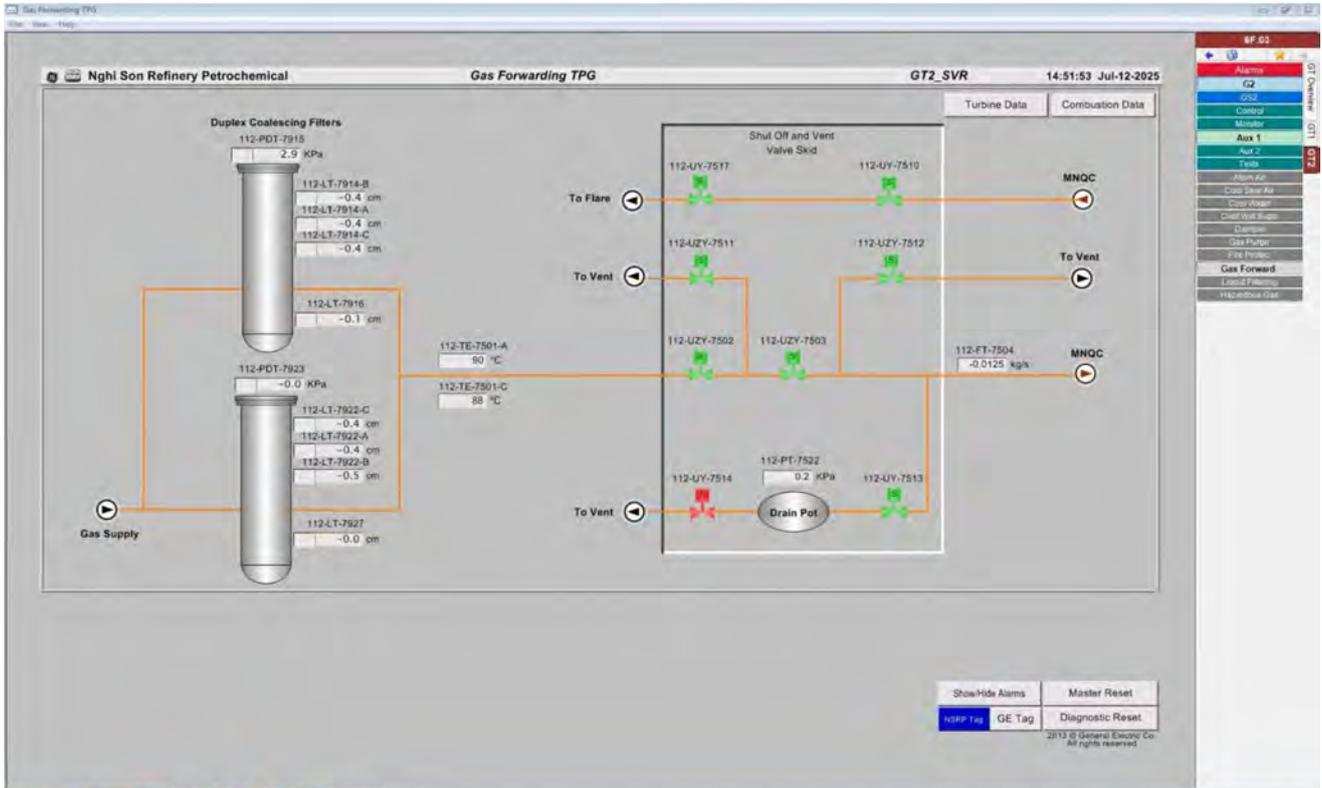


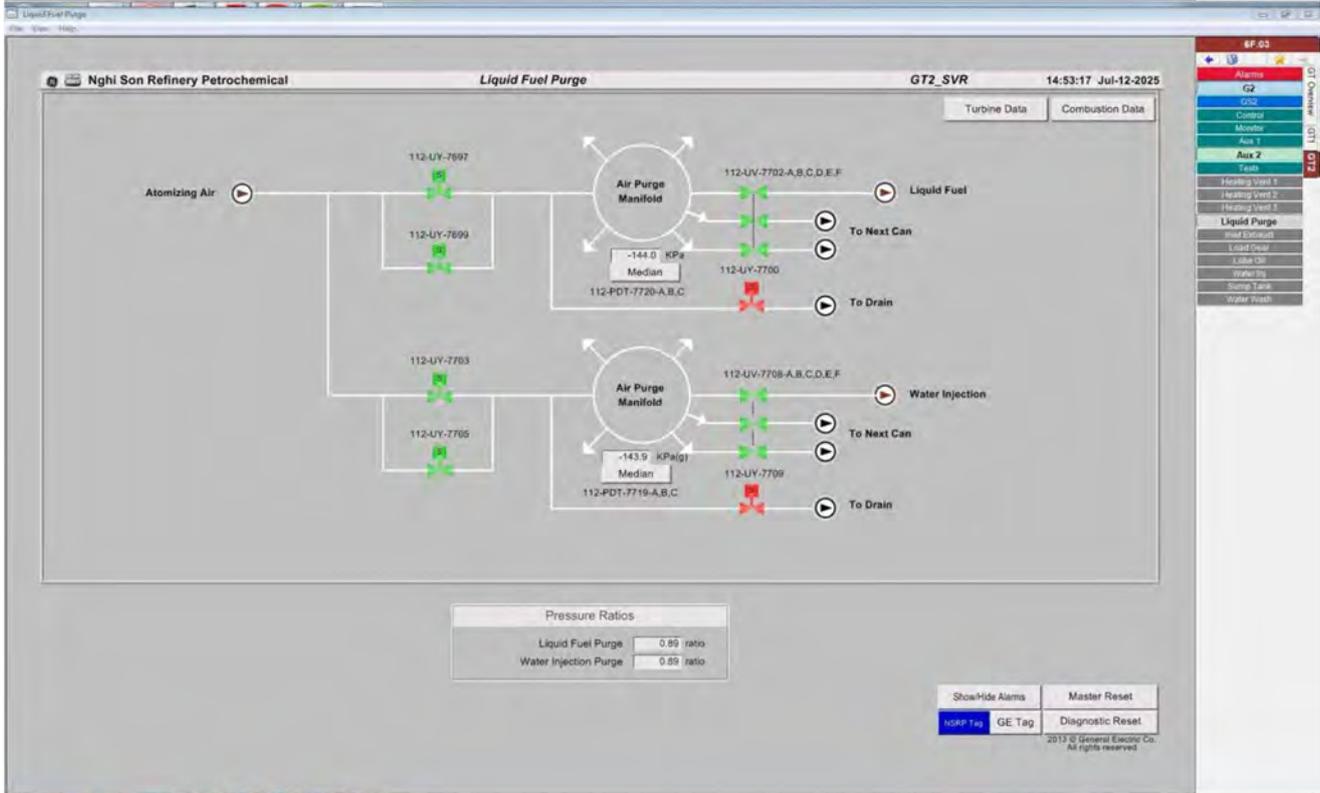
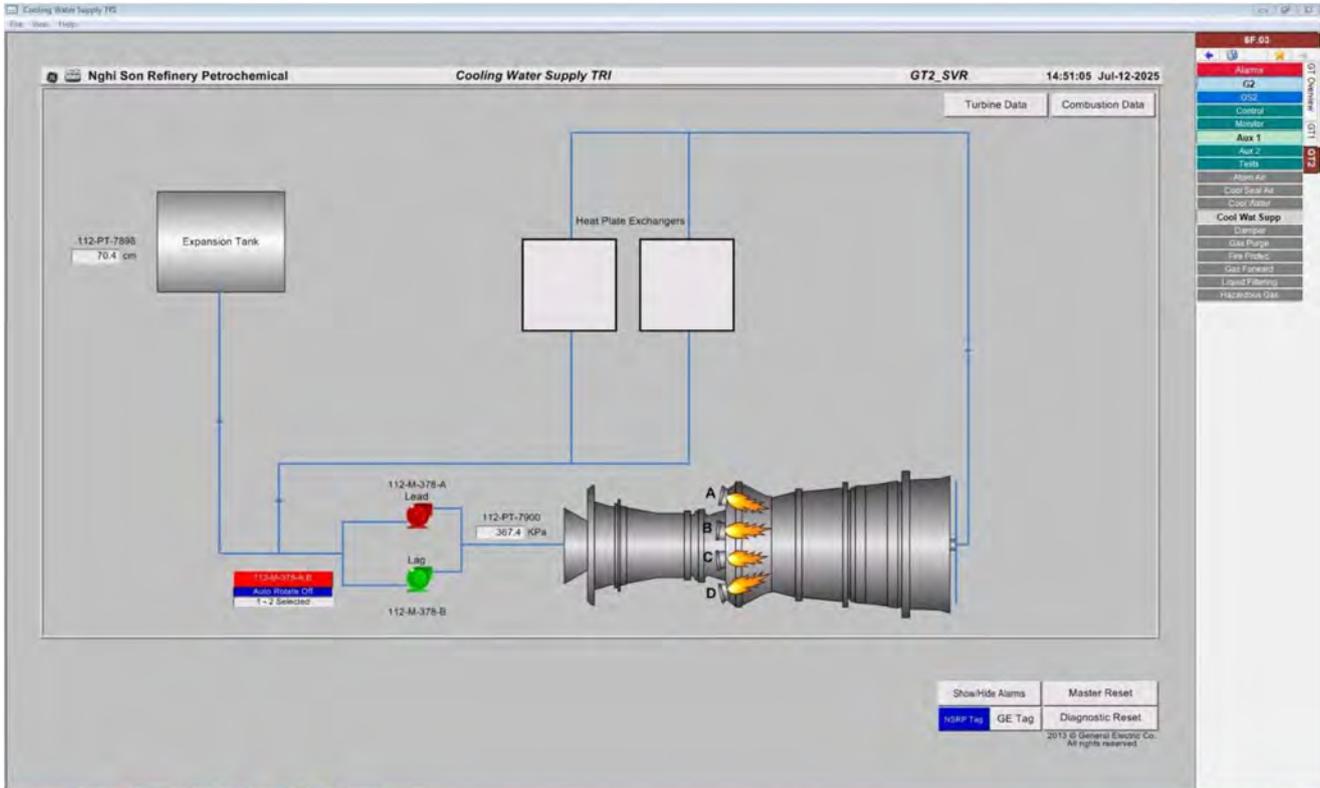


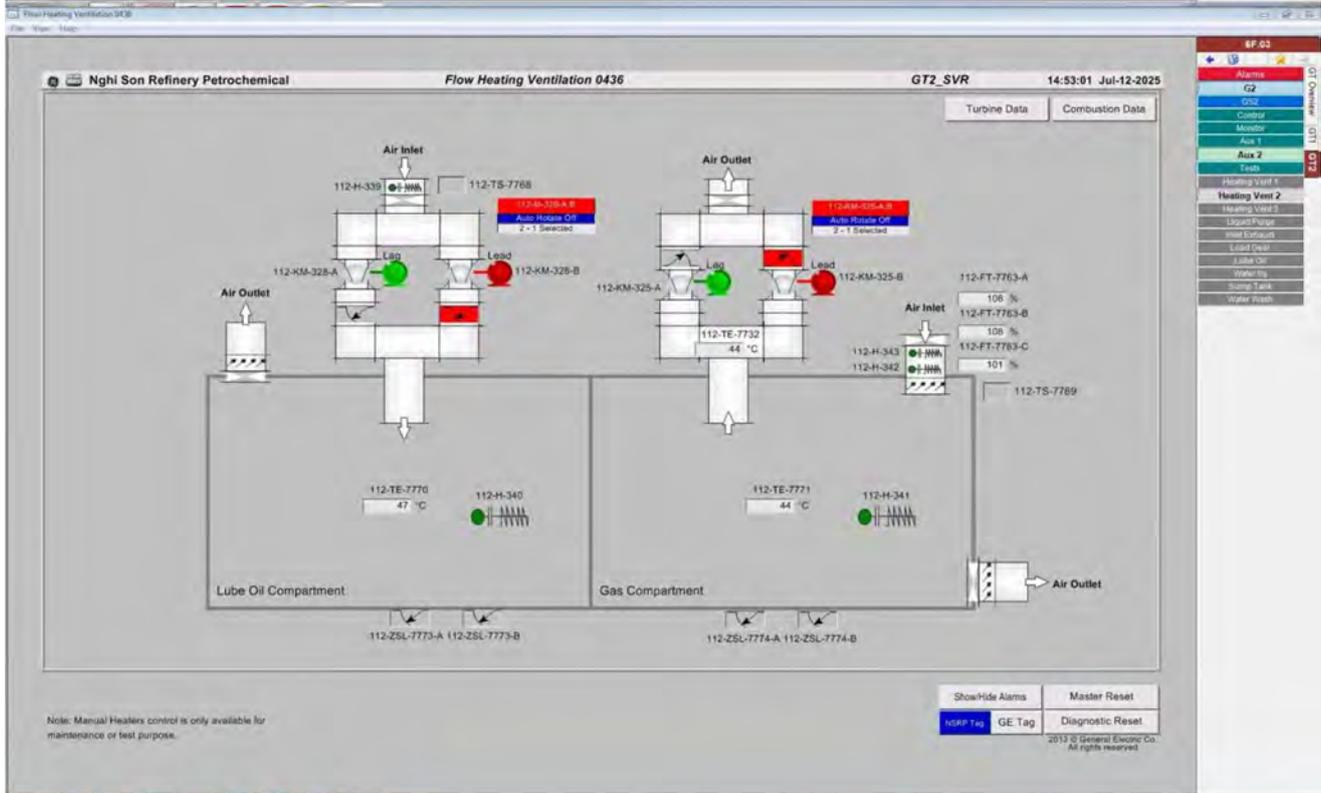
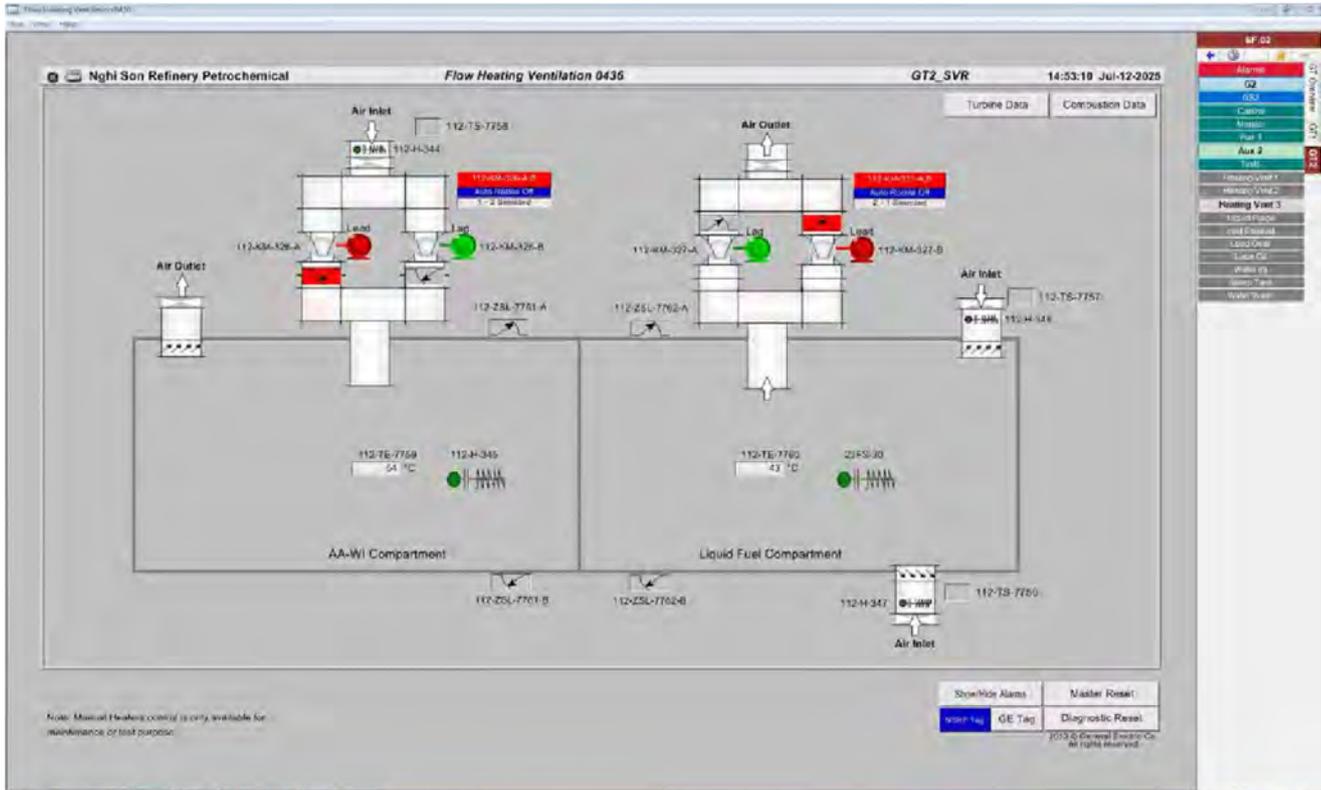


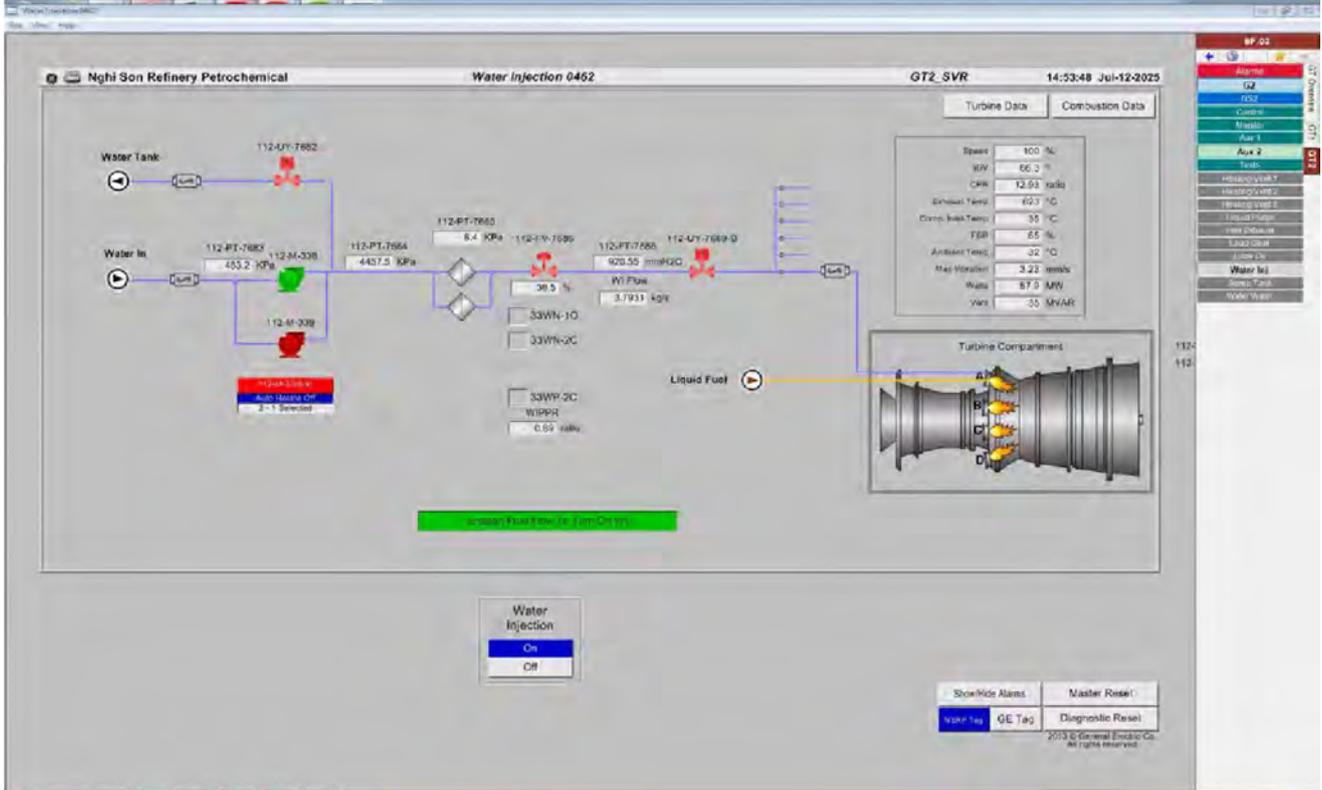
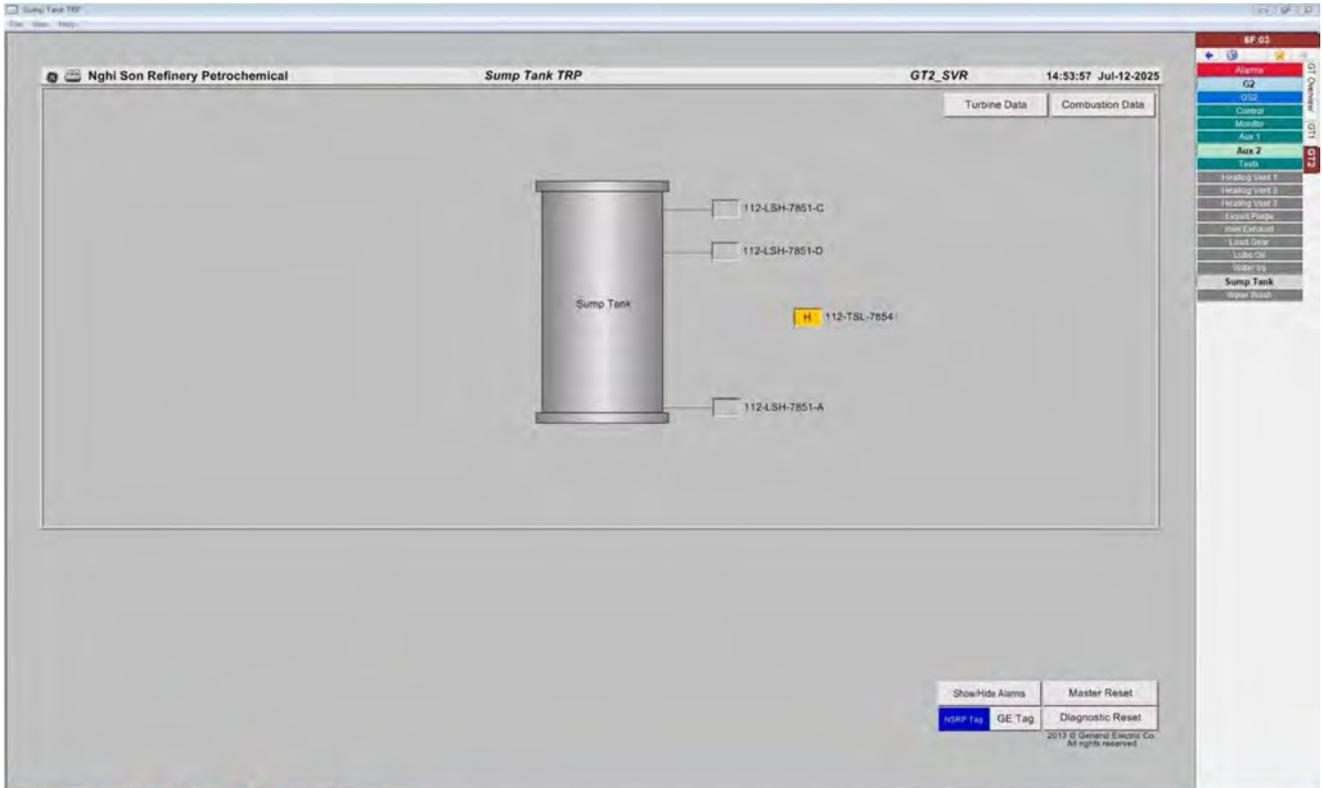


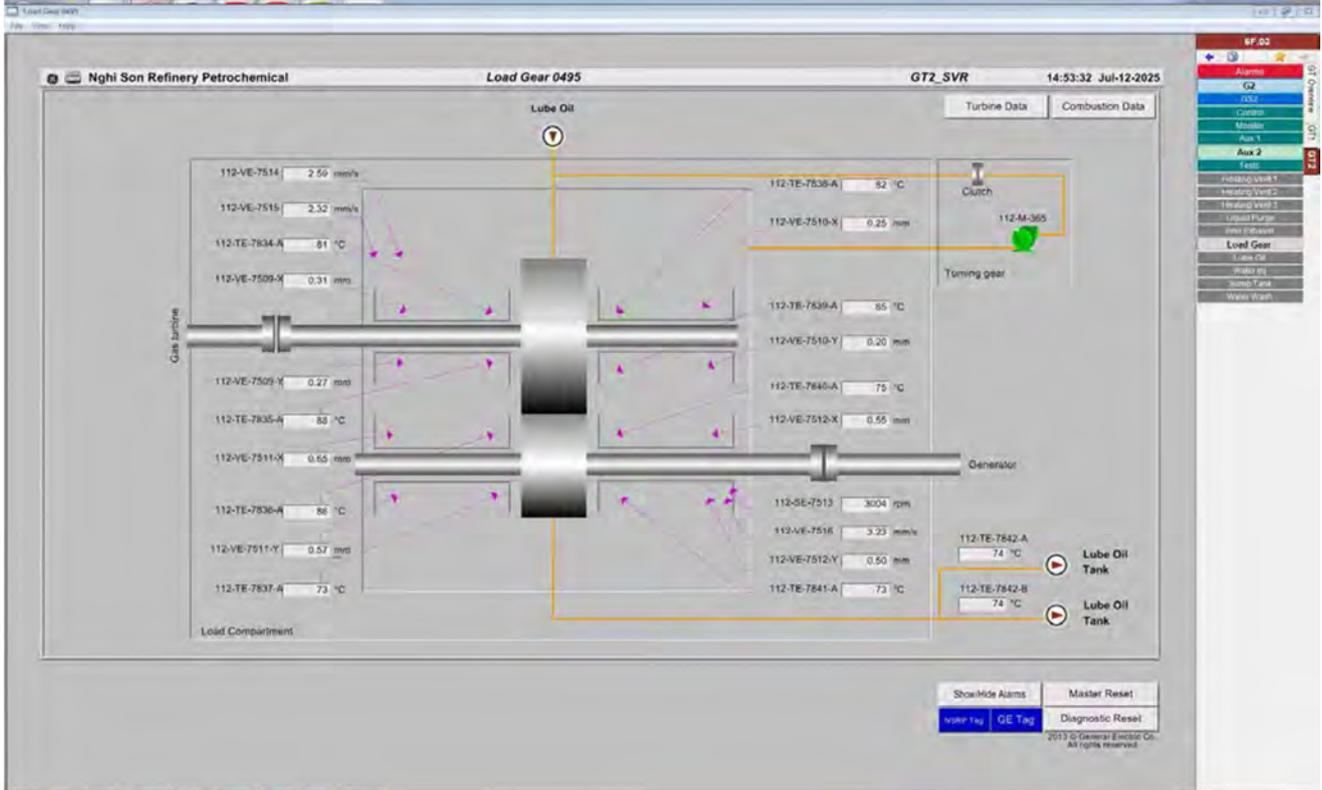
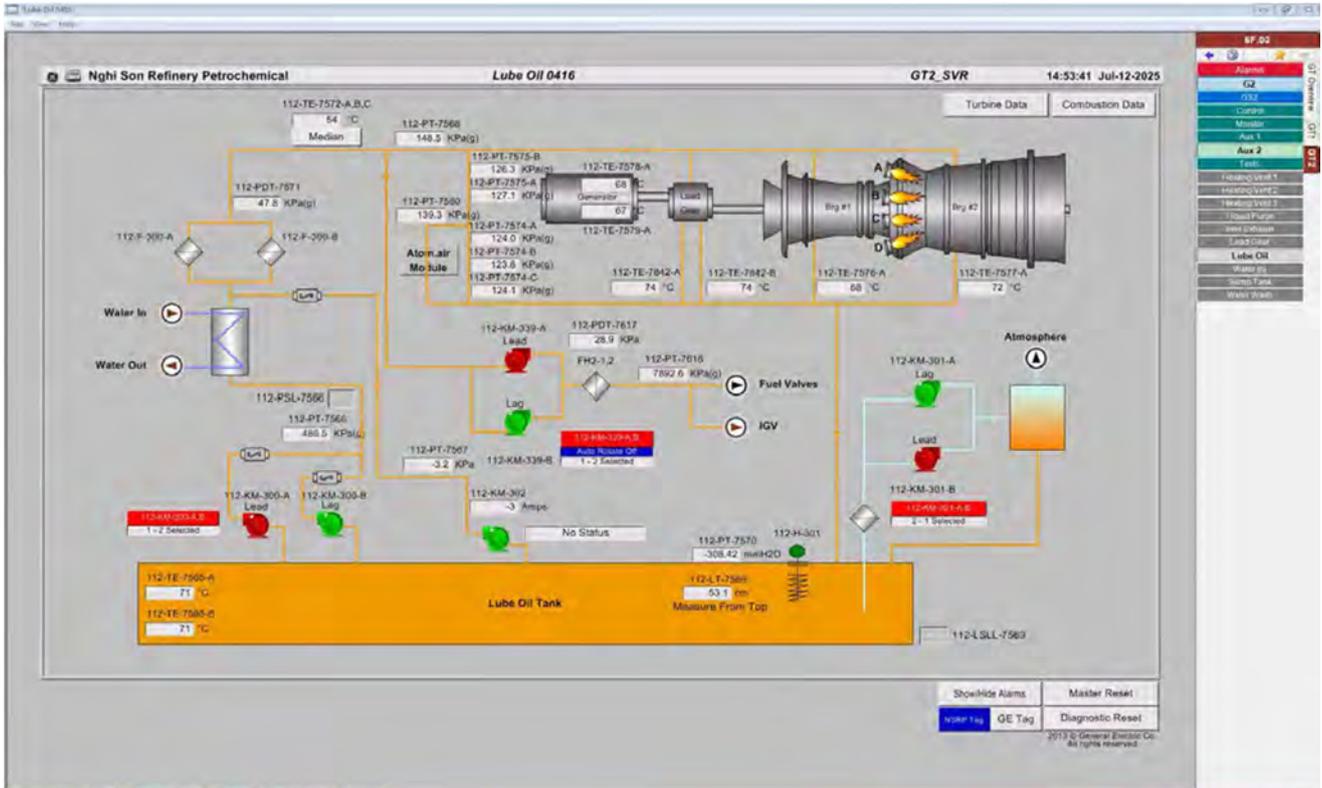


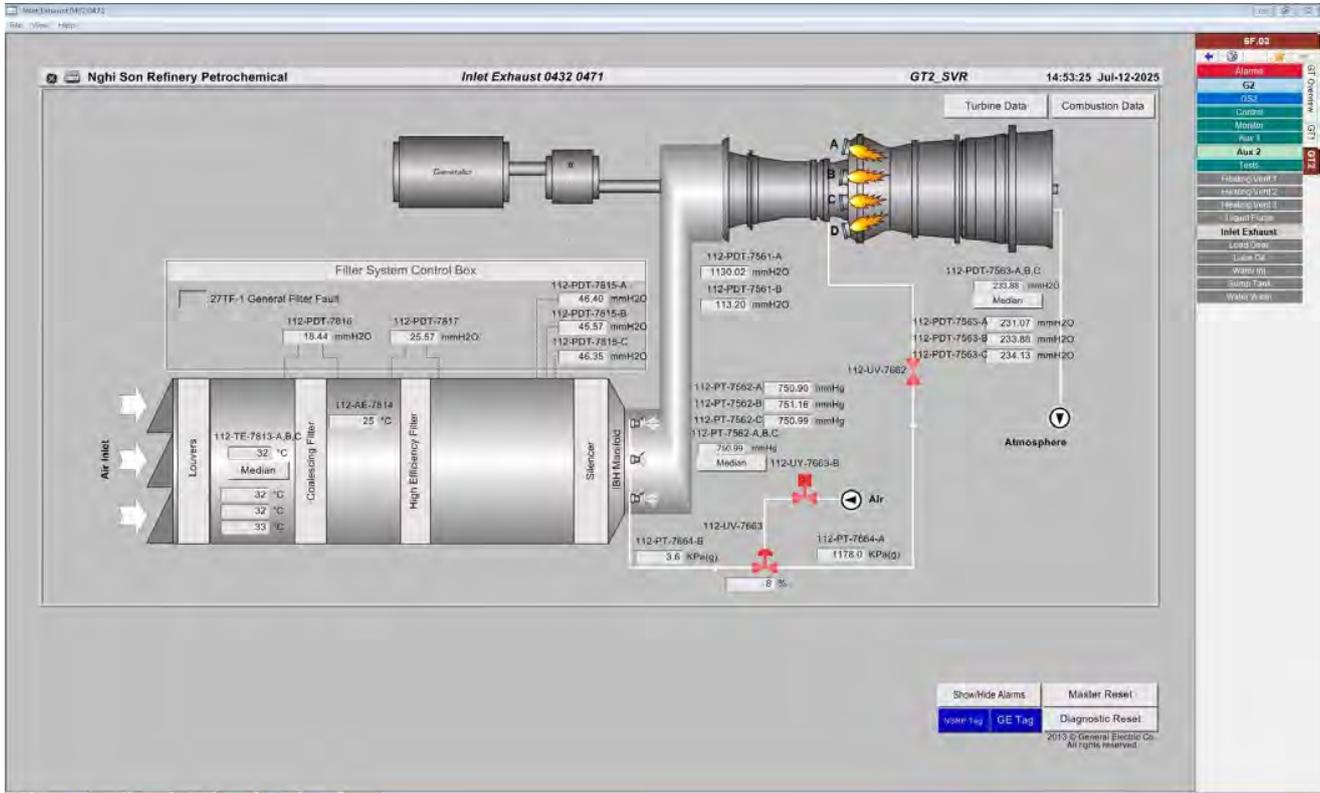




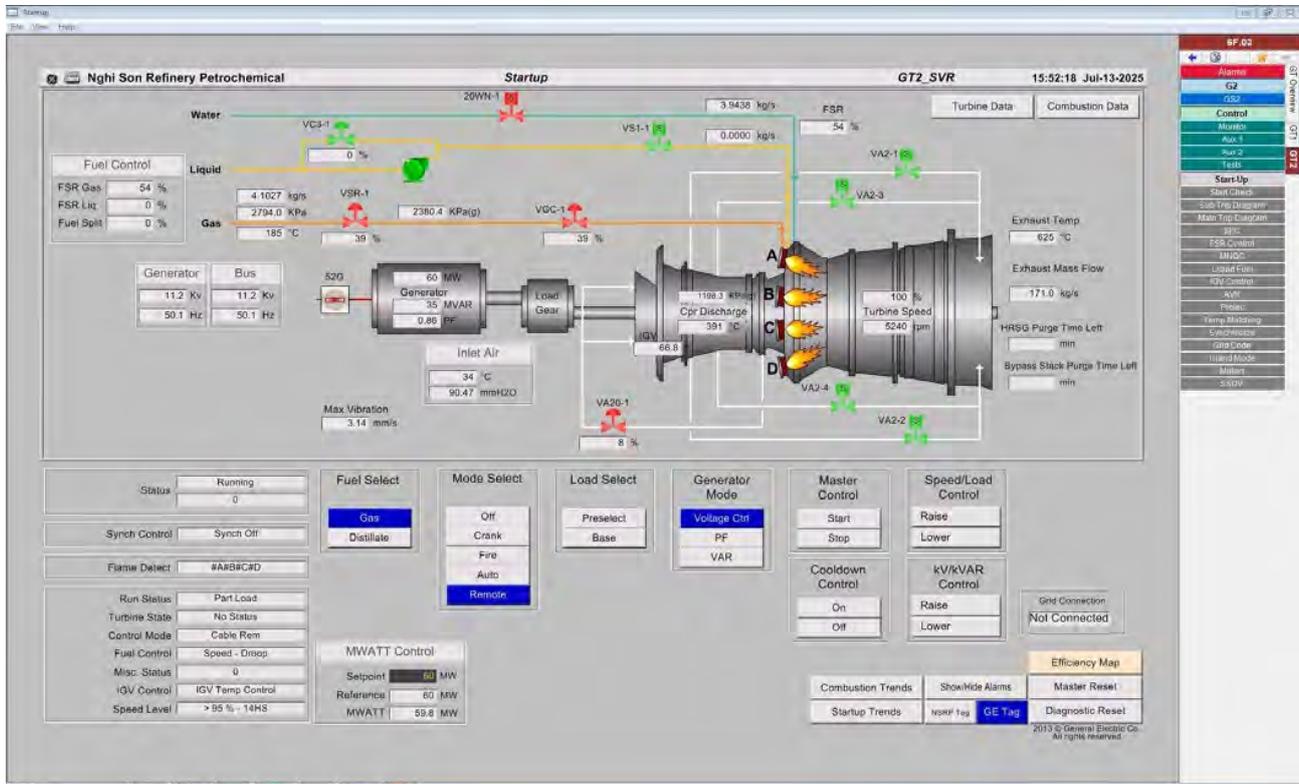


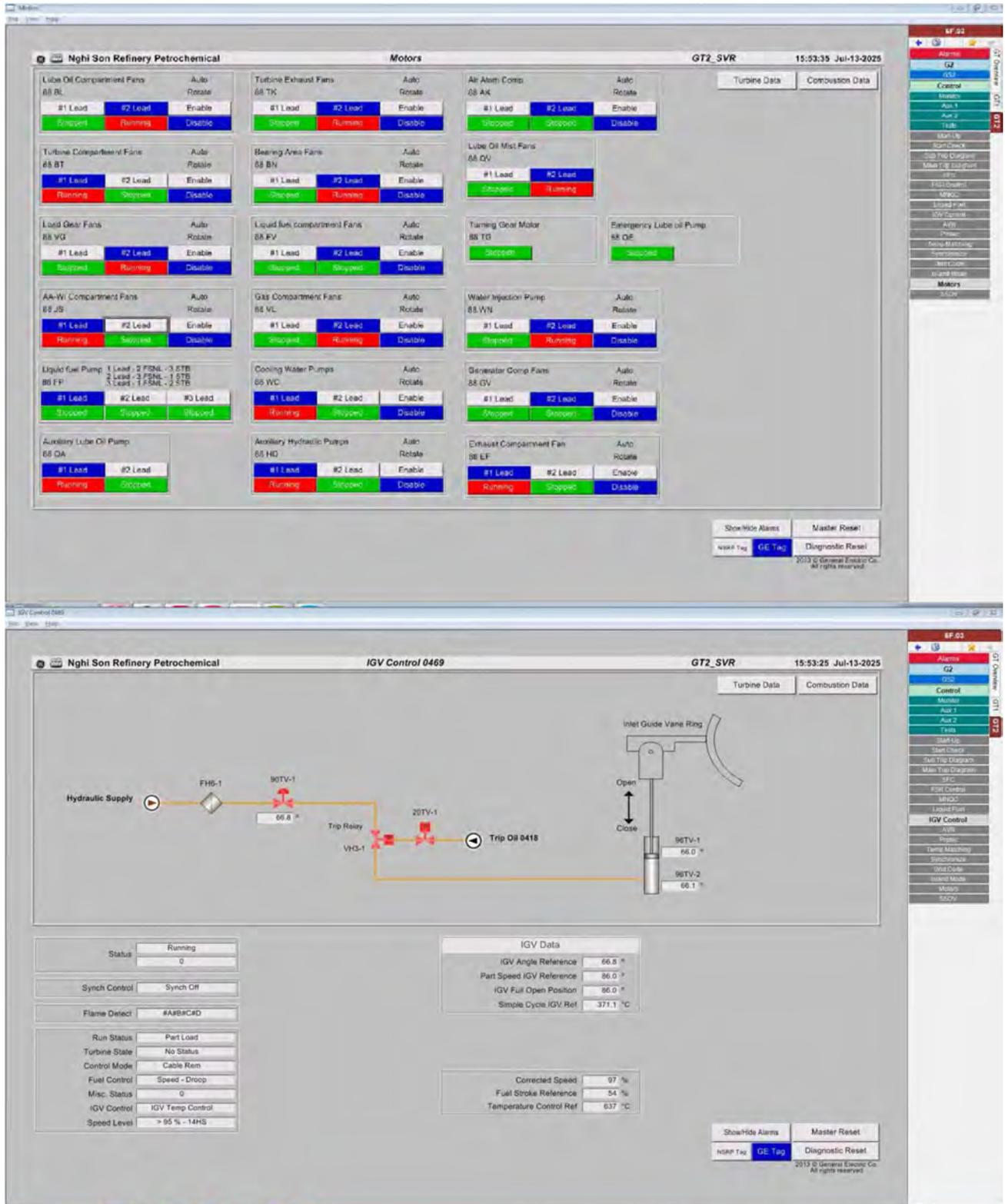


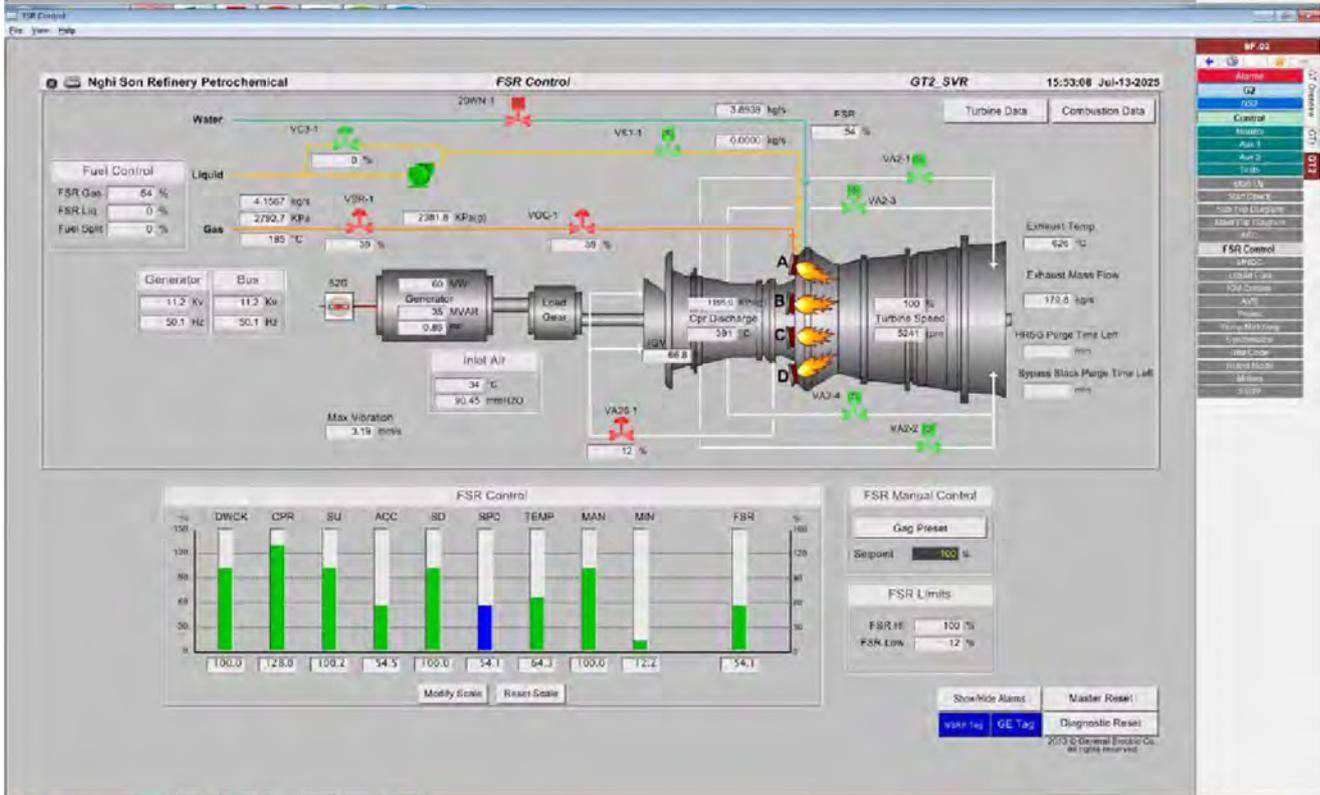
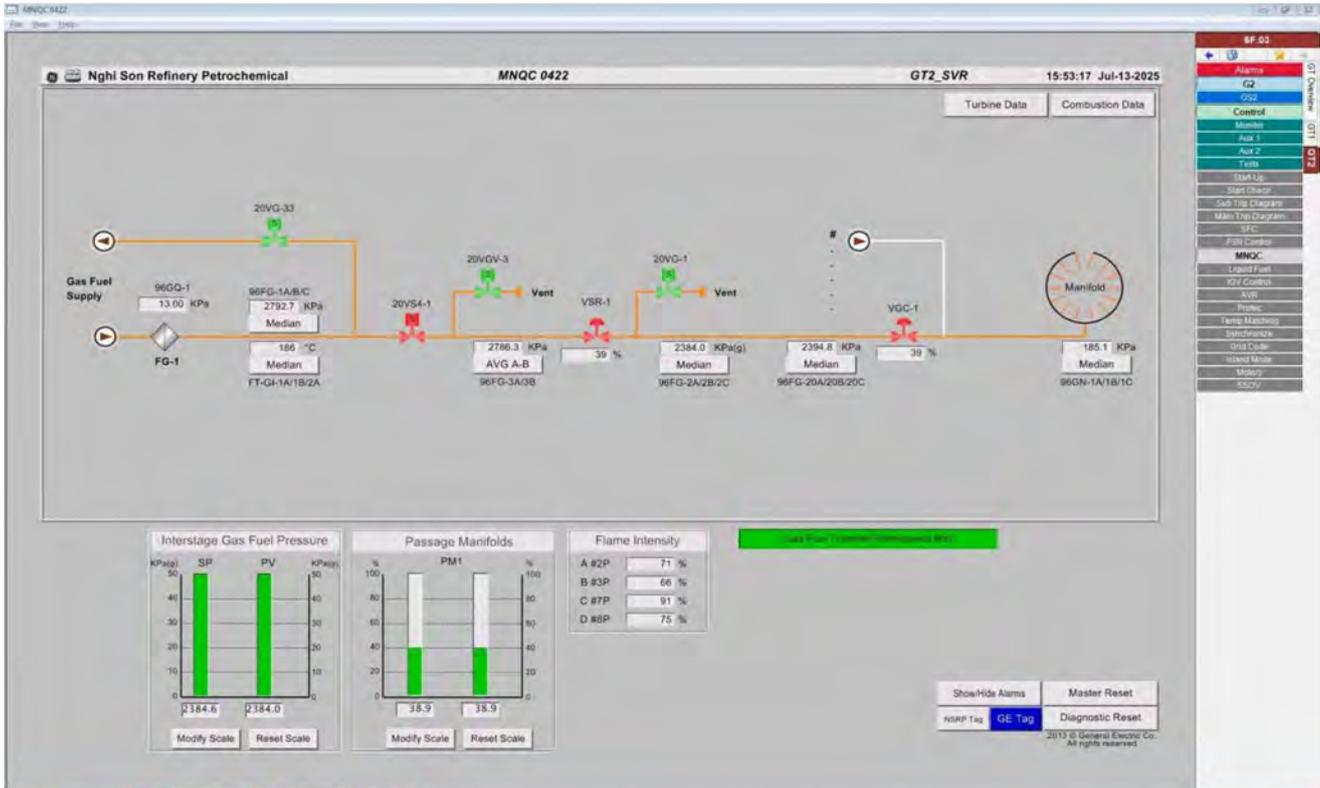


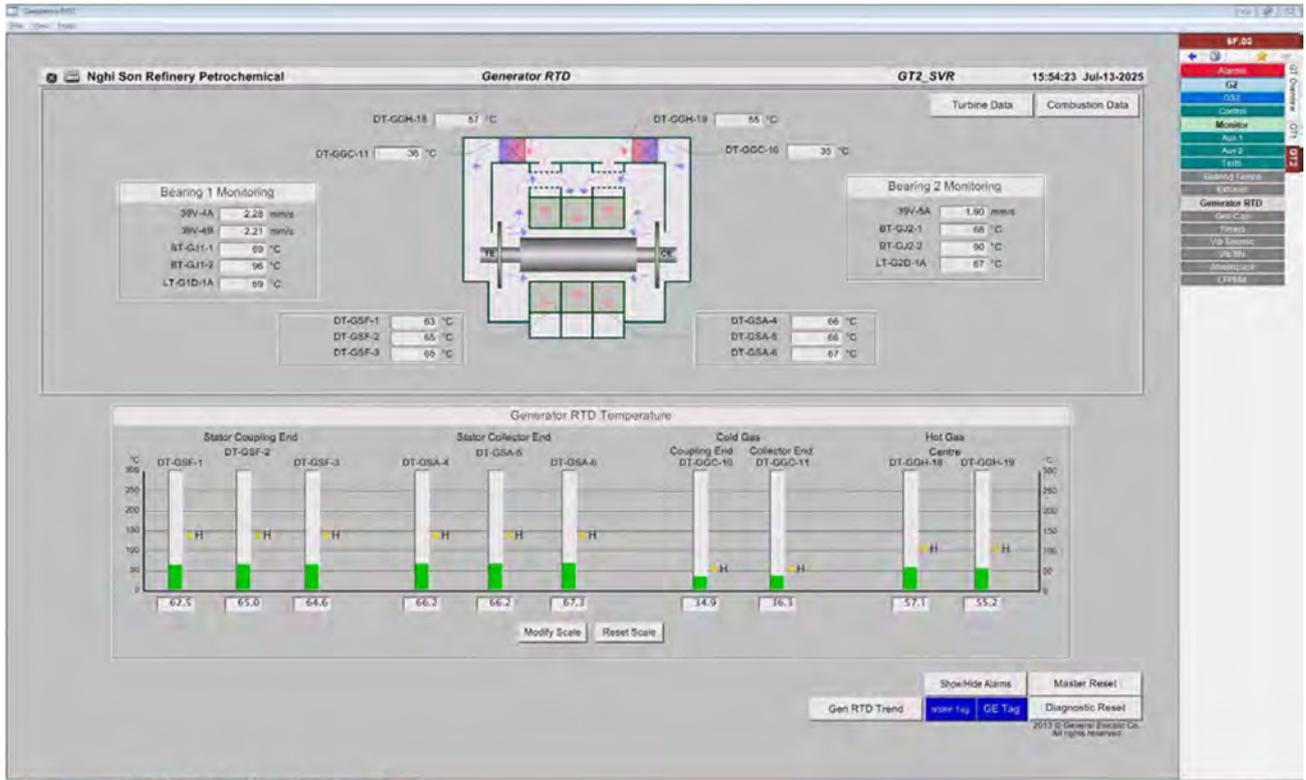


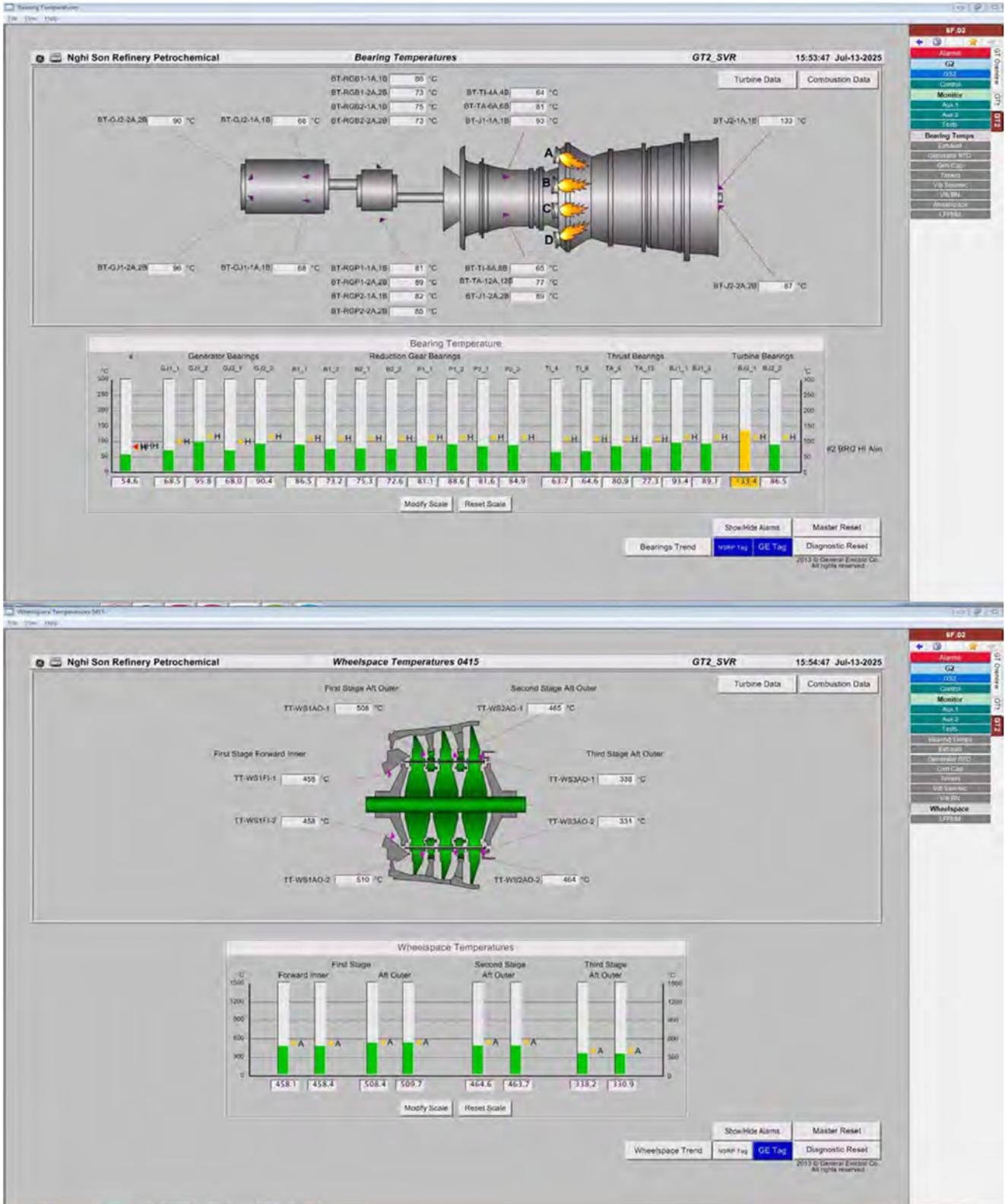
8.2 Appendix B – GTG2 Post CI at 60MW OnLoad (Gas Fuel Operation) Screenshots

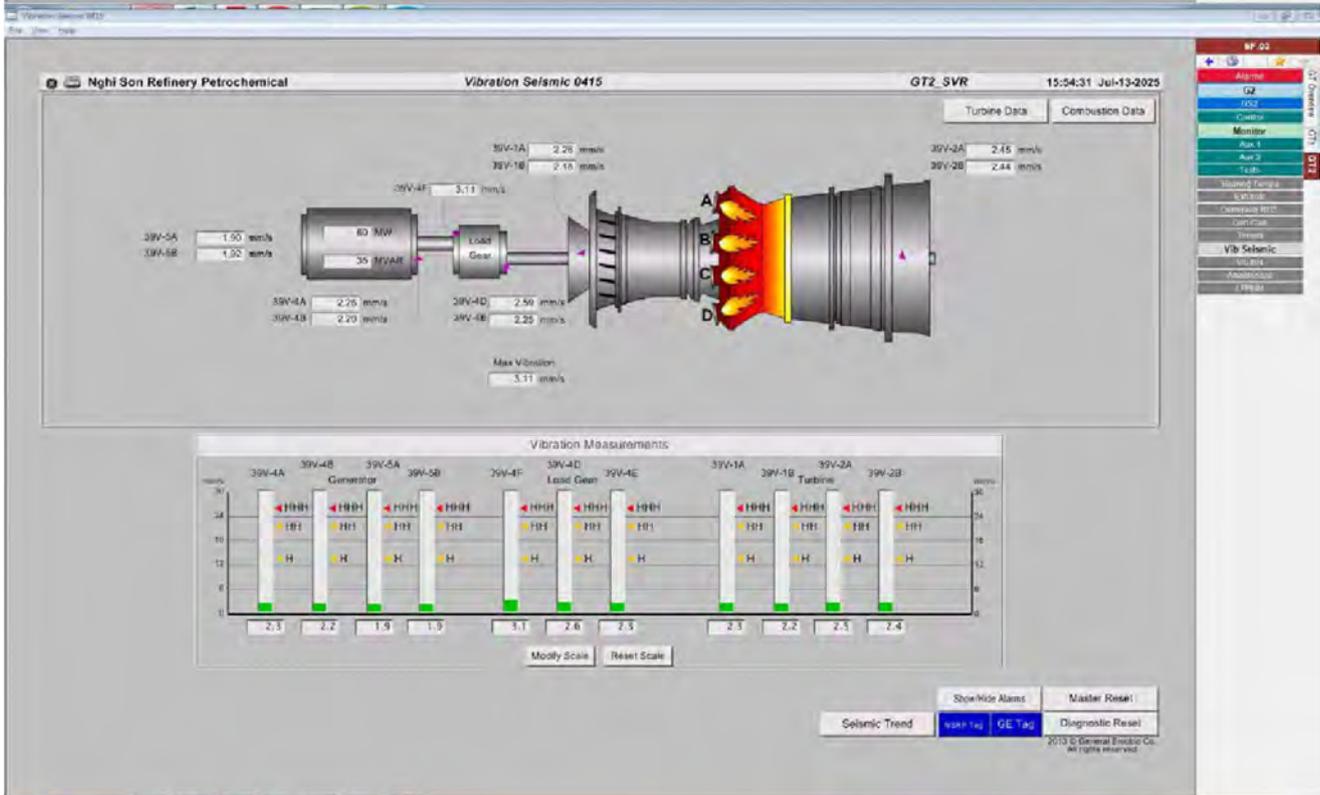
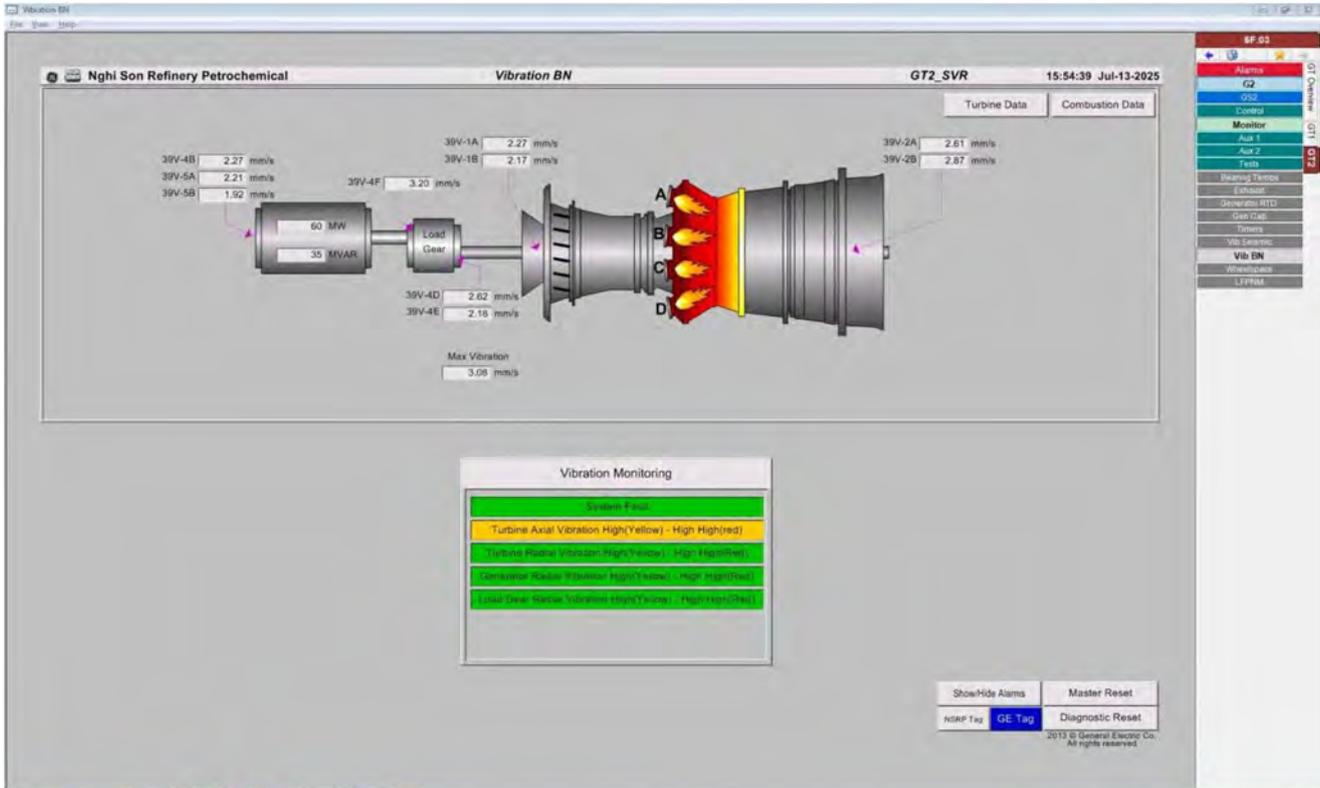


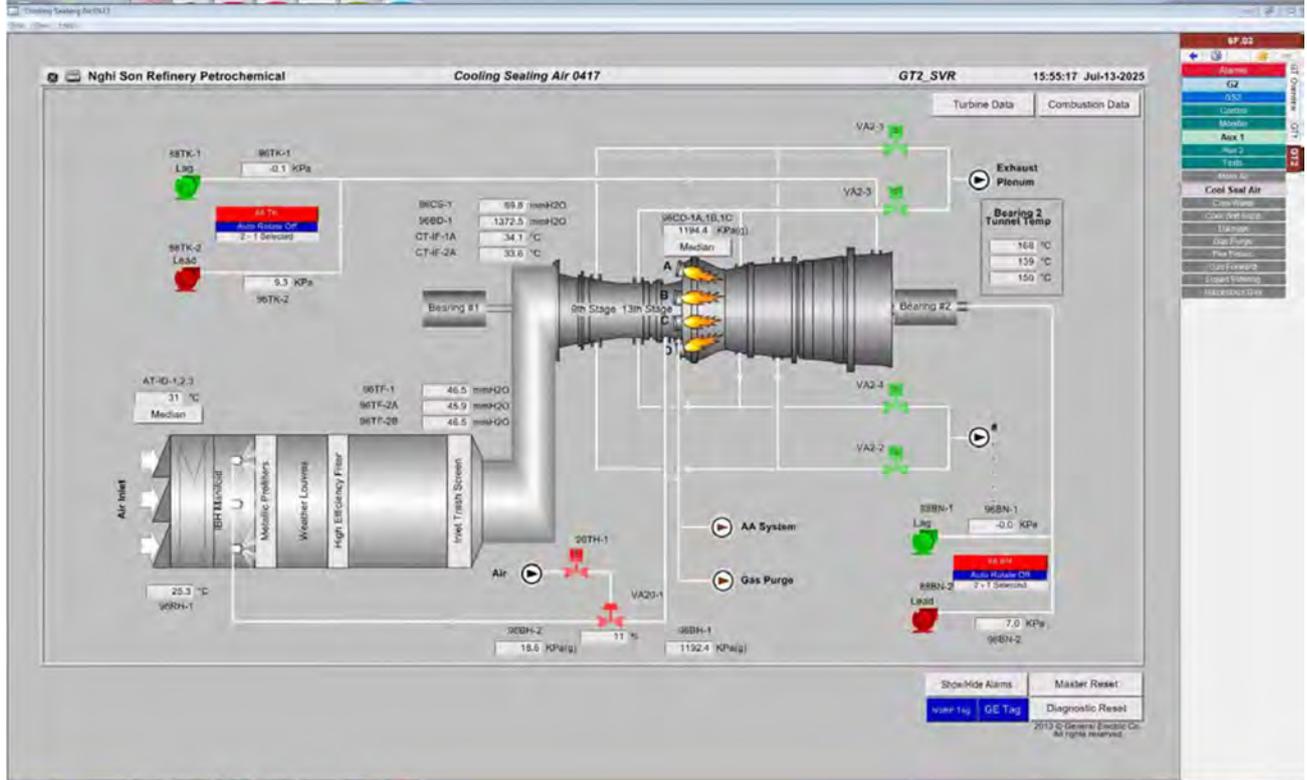
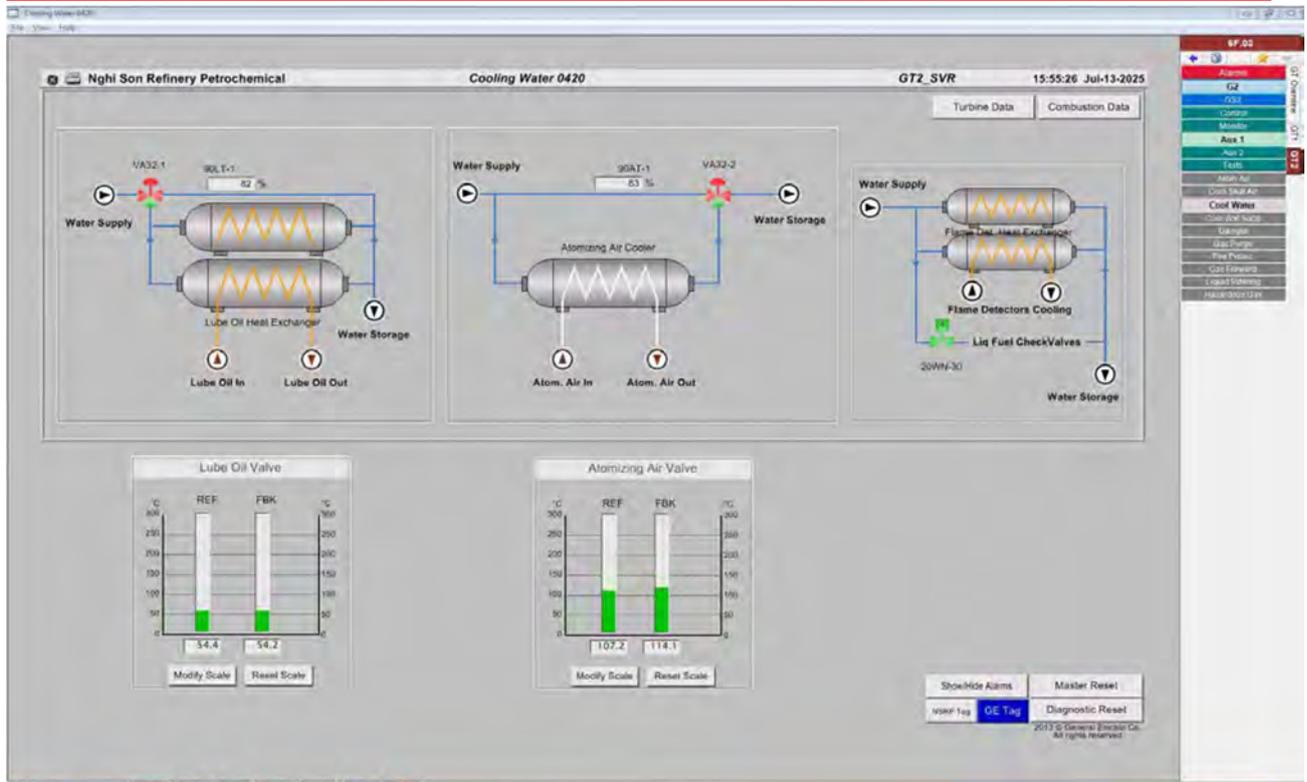


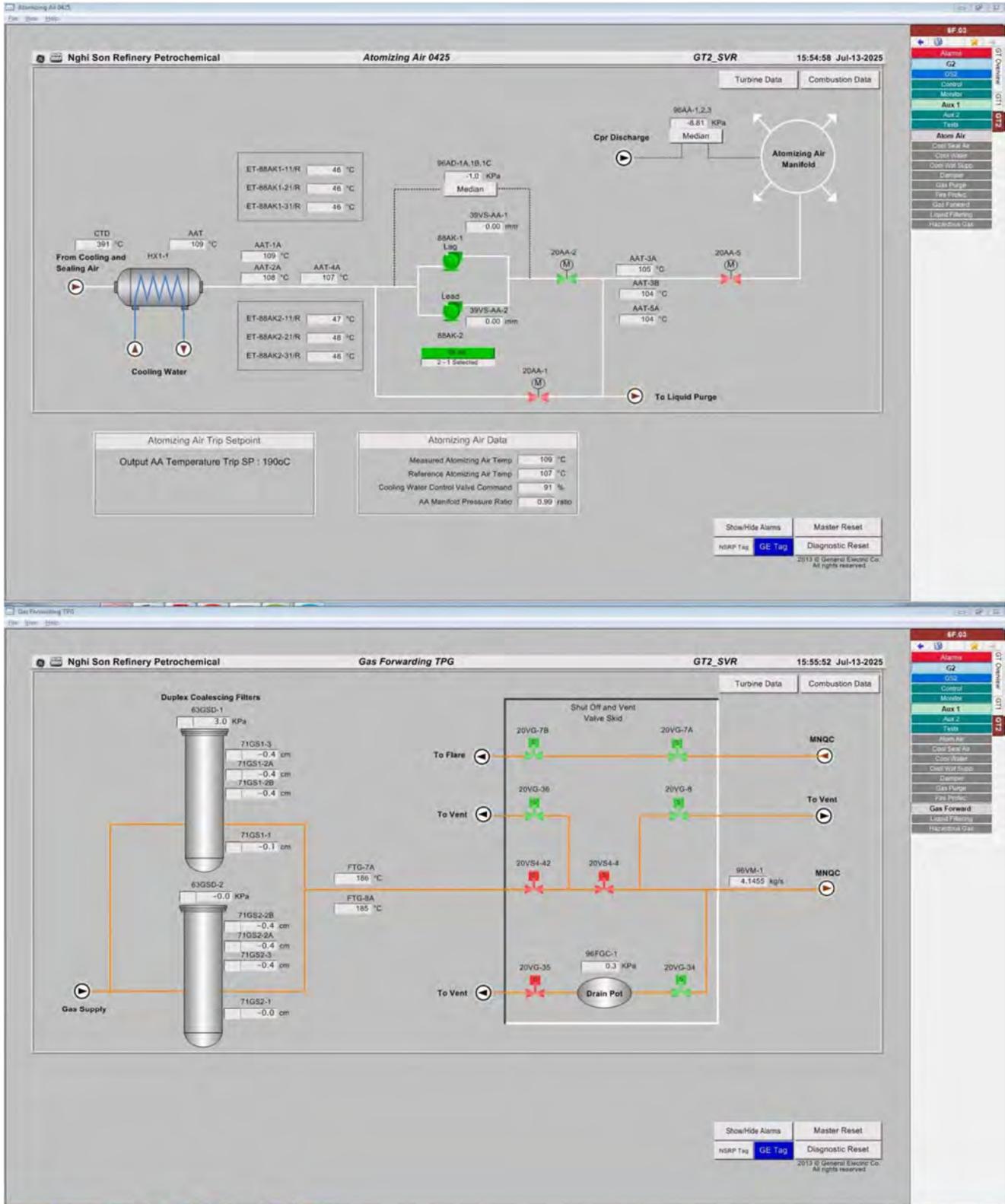


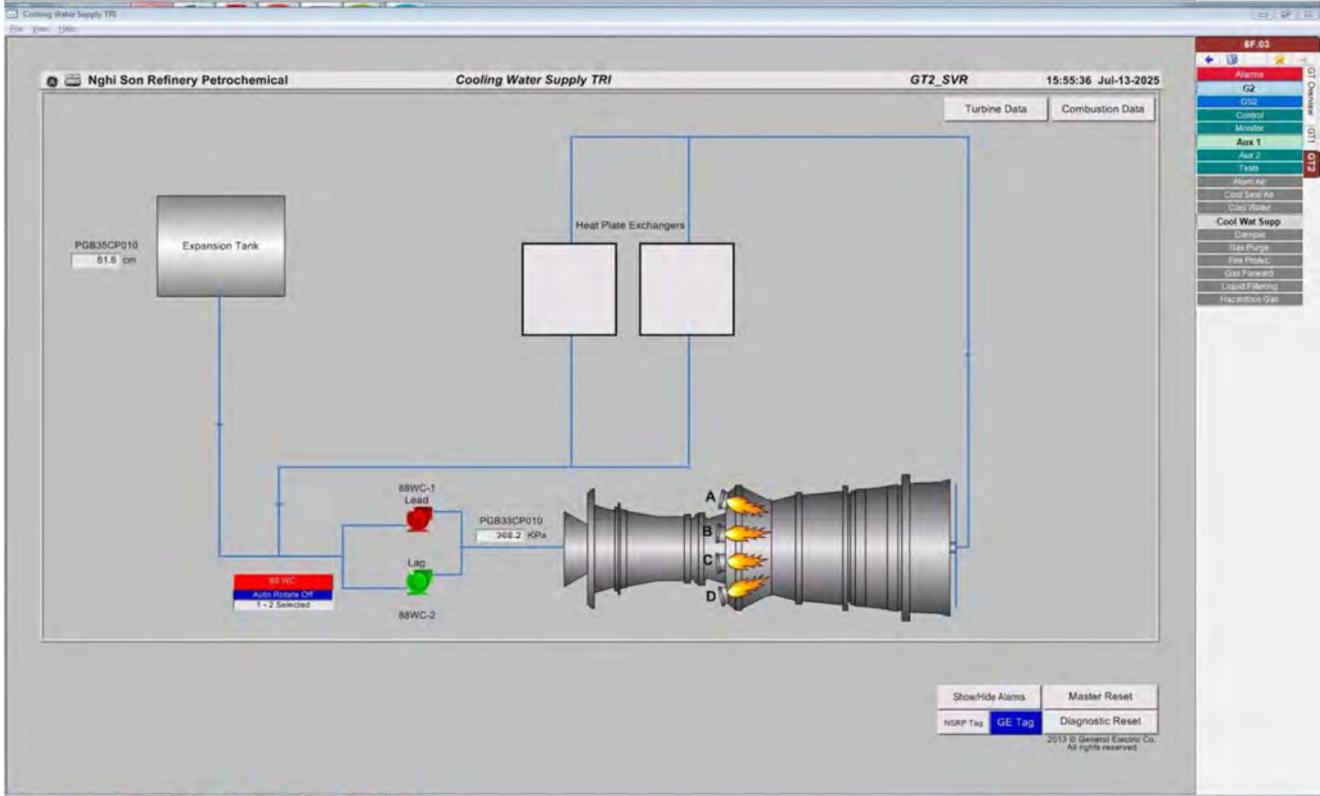
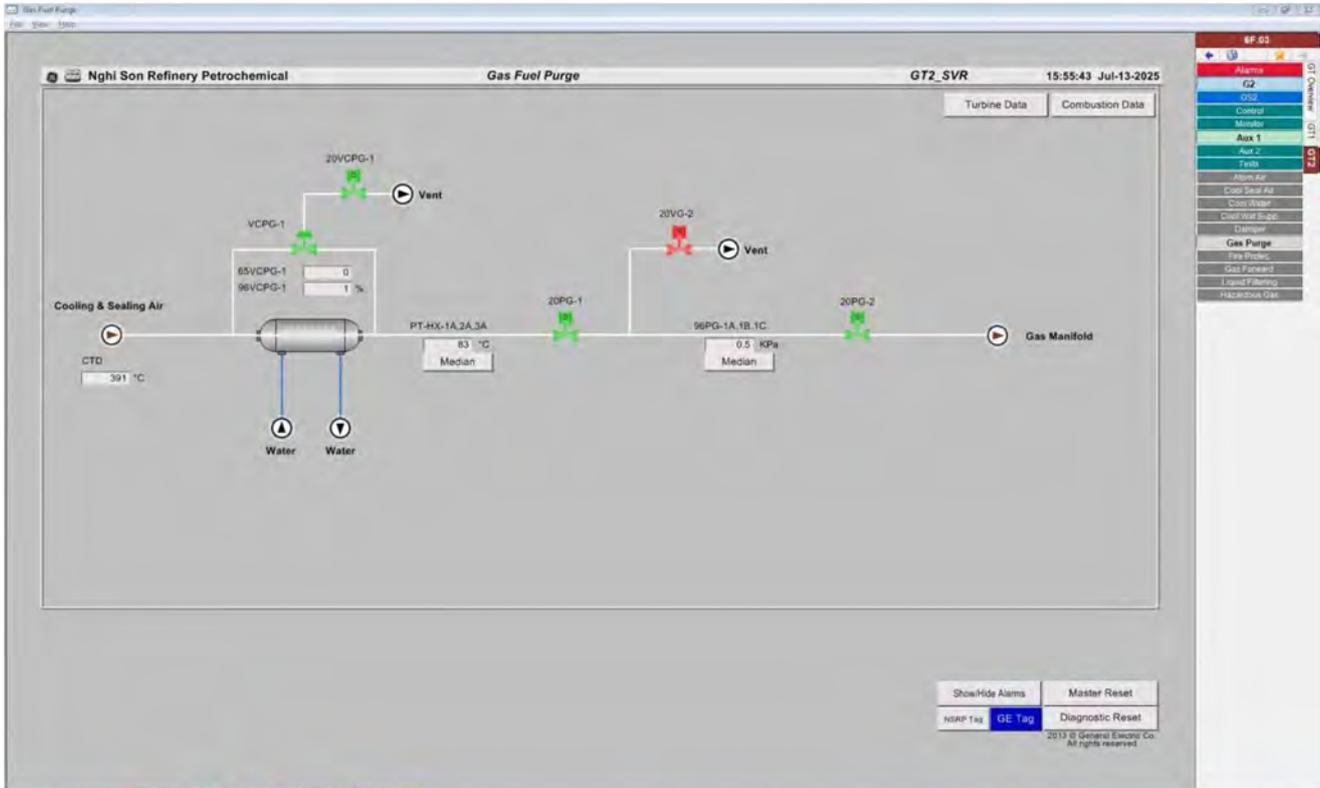


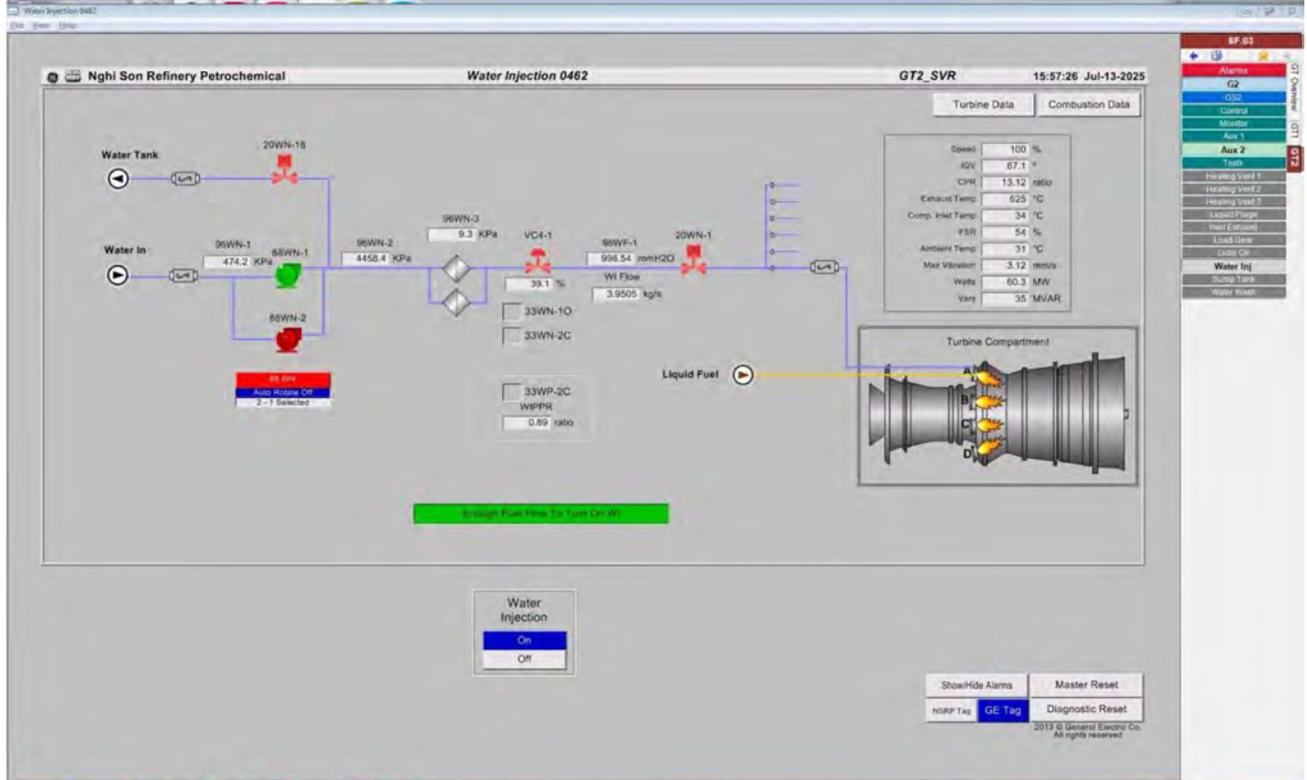
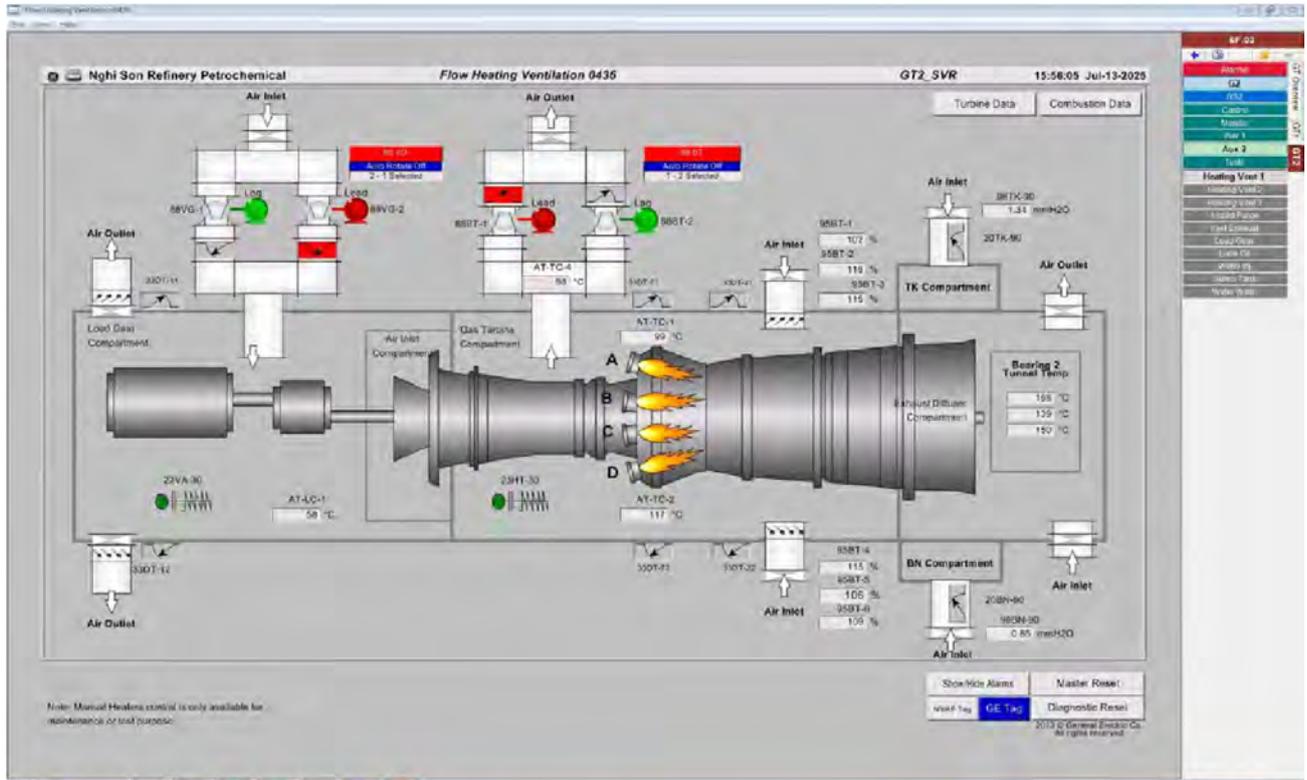


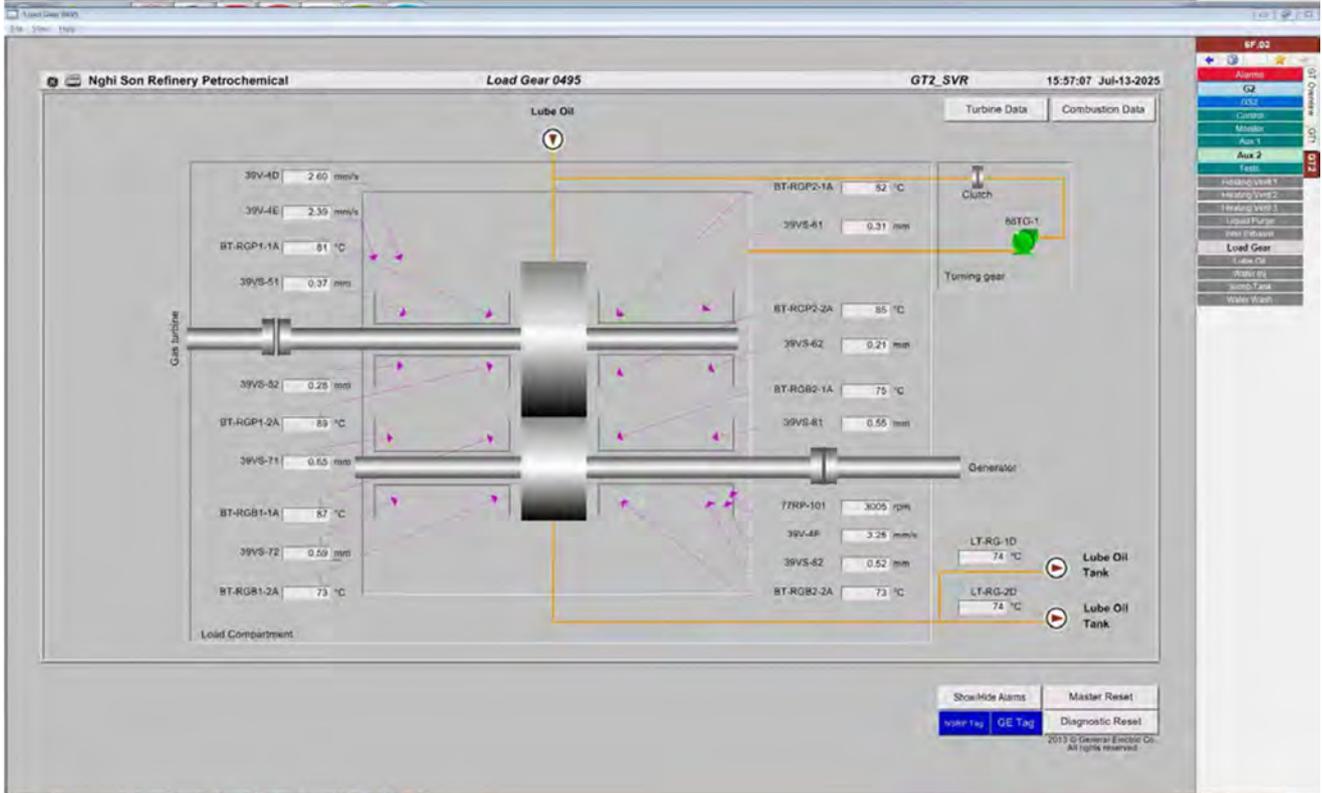
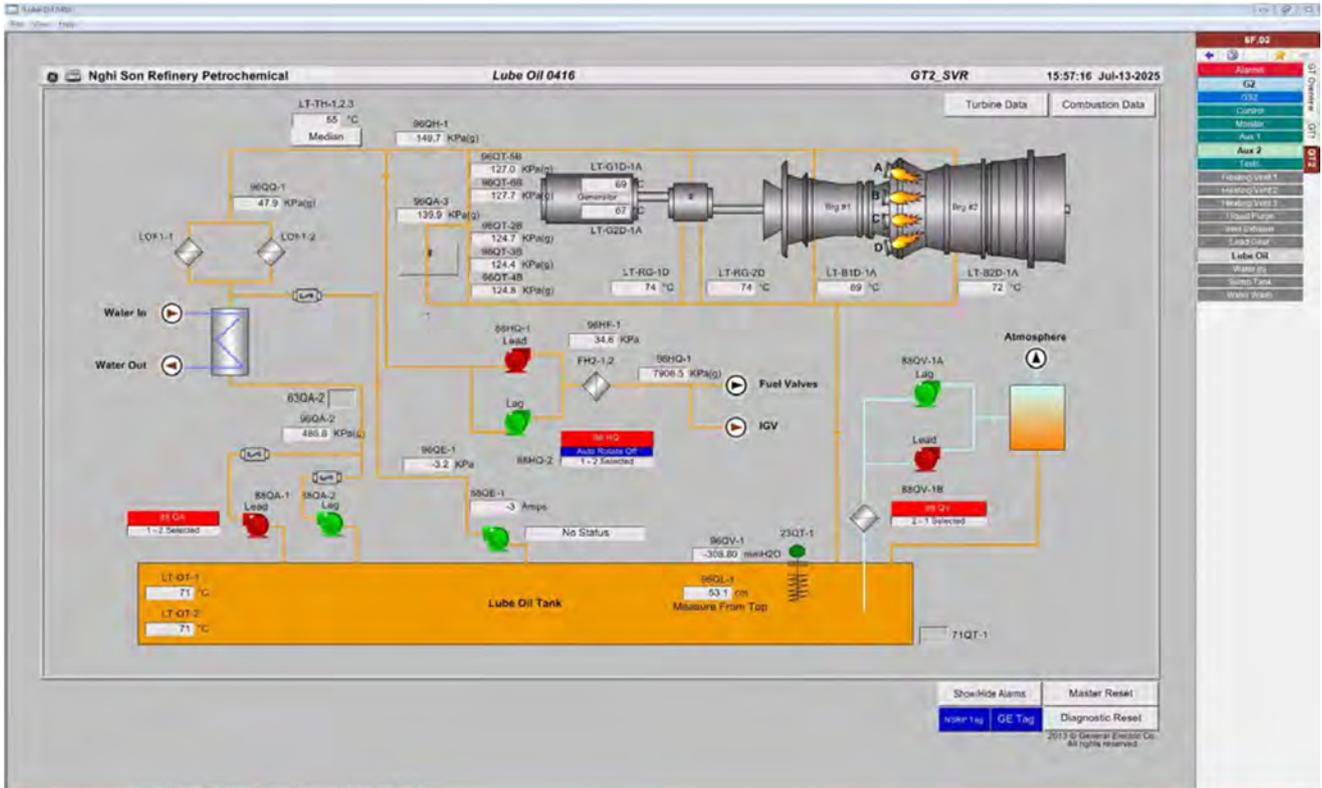


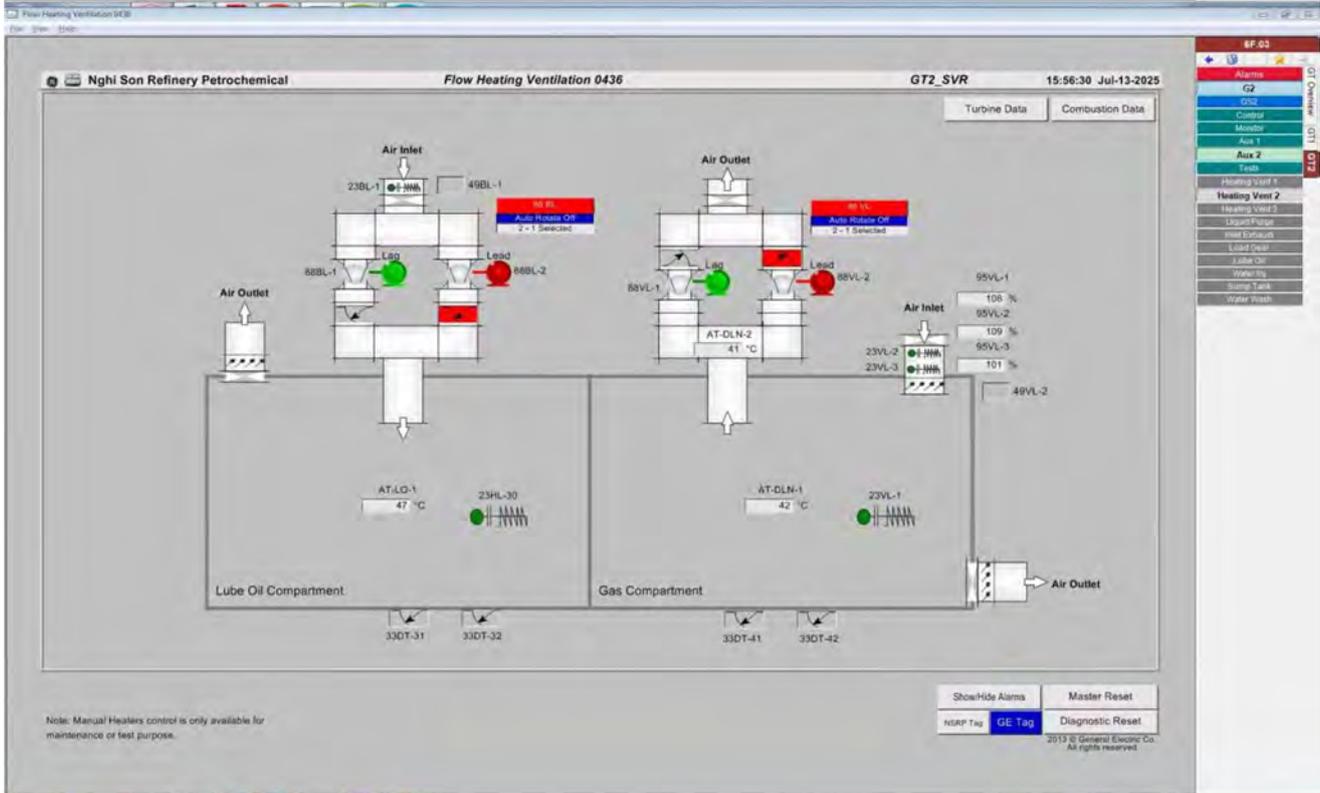
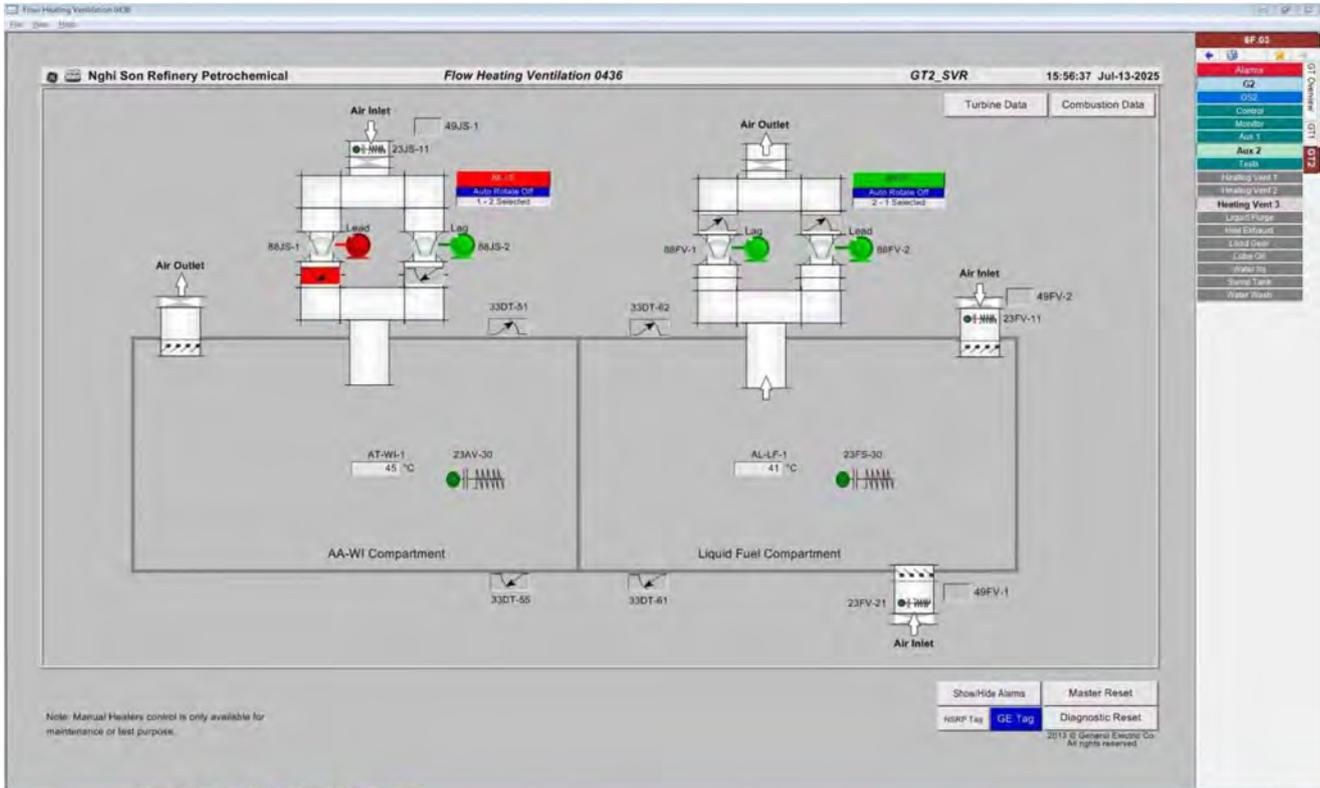


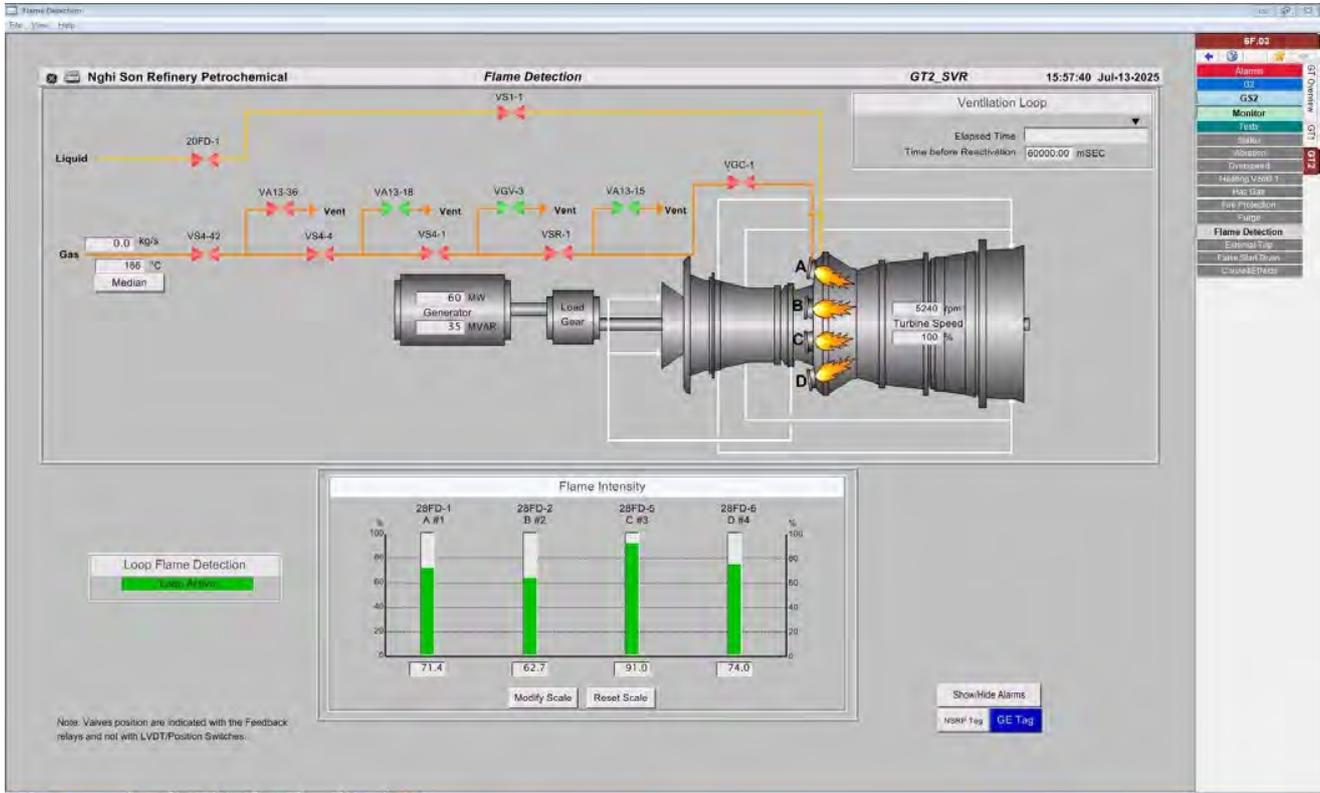




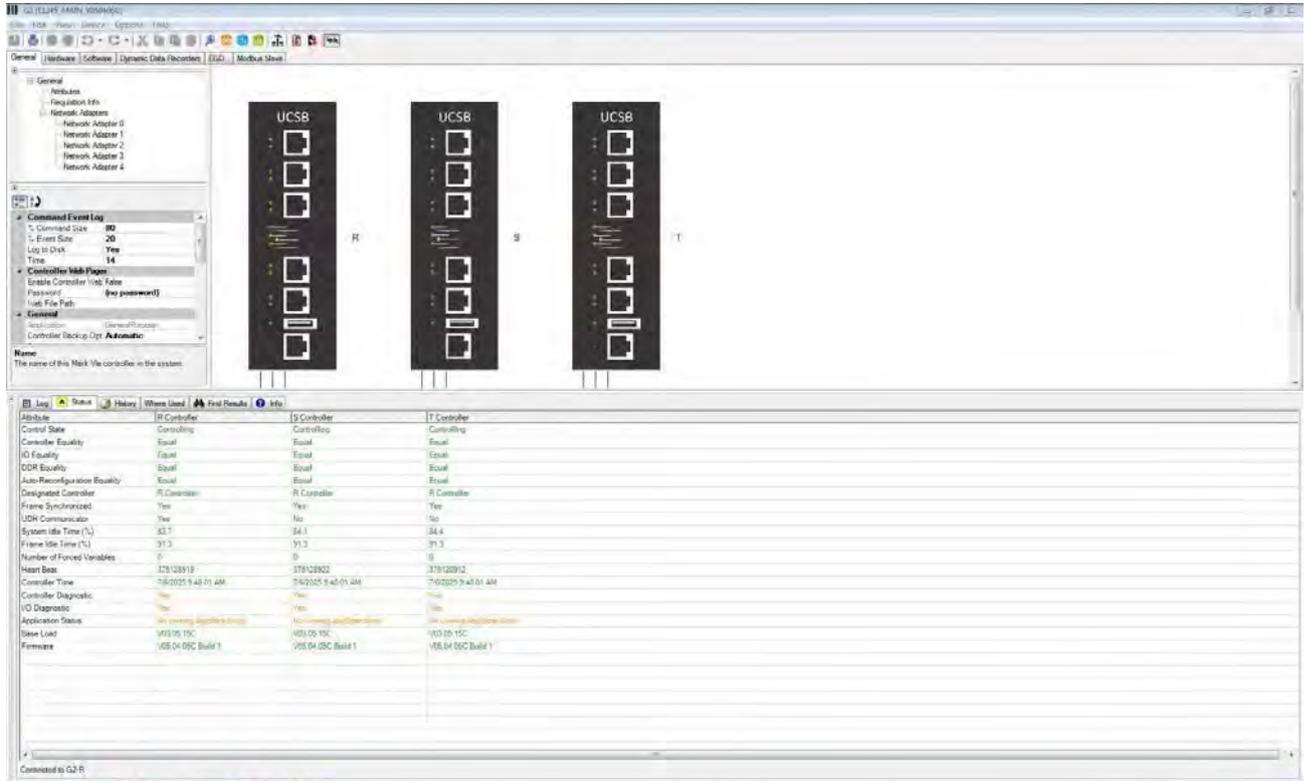








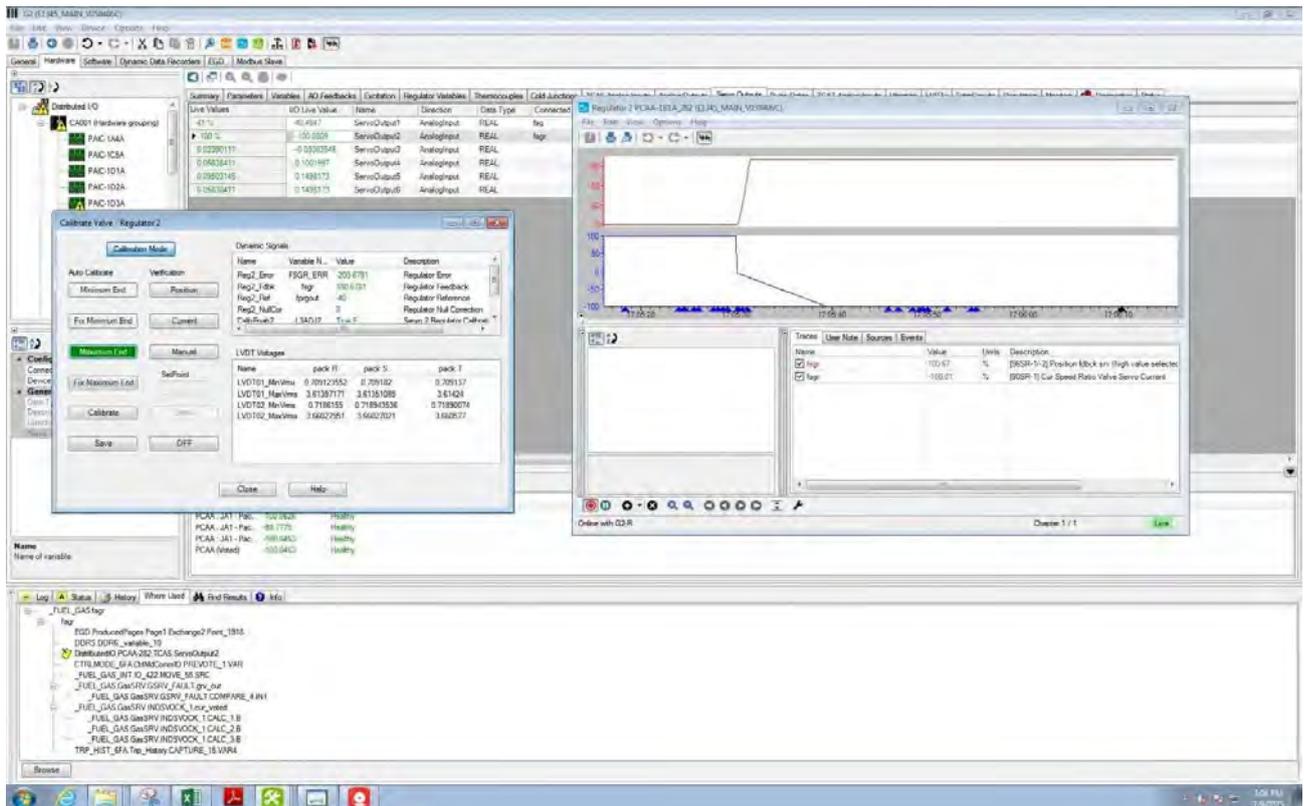
8.4 Appendix D – GTG2 CI Controls and Calibration Checks



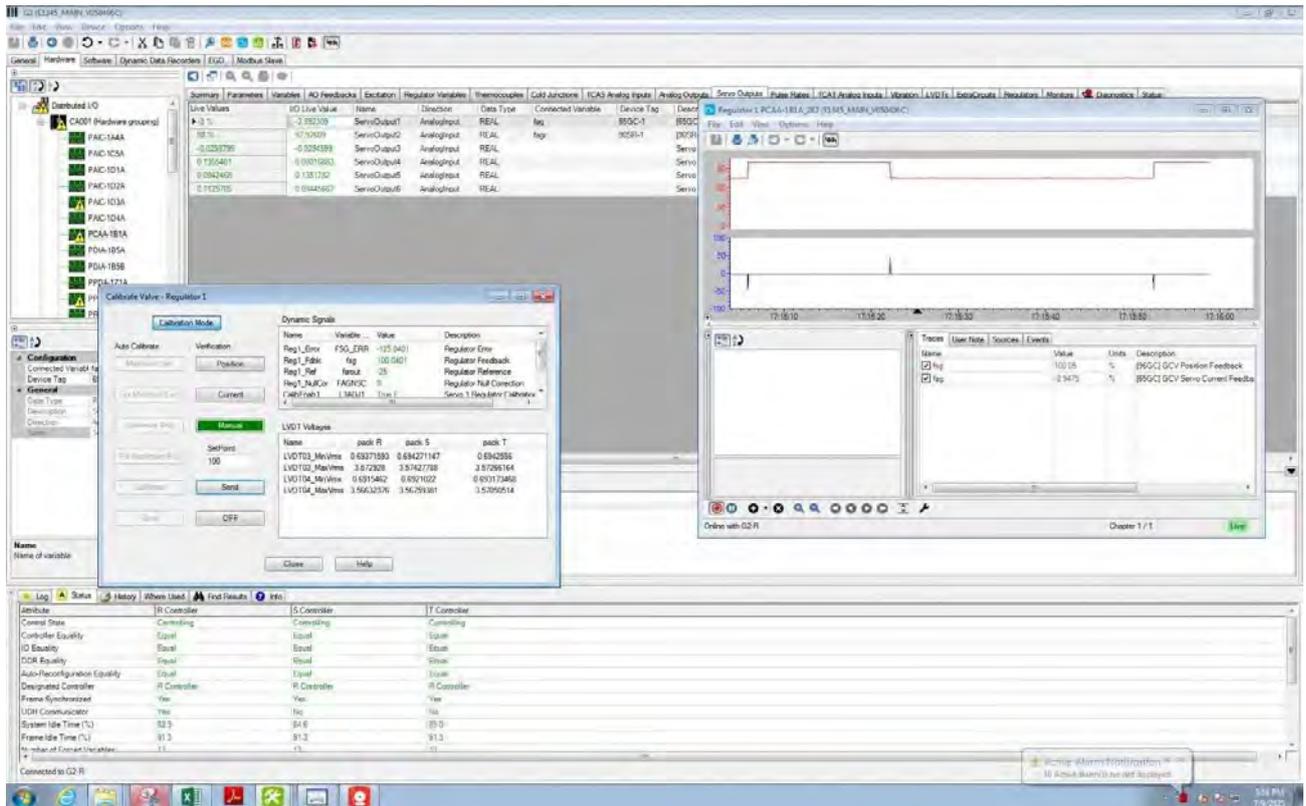
The screenshot displays a network management interface with three UCSB controllers labeled R, S, and T. Below the controllers is a table showing the status of various parameters for each controller.

Attribute	R Controller	S Controller	T Controller
Control State	Controlling	Controlling	Controlling
Controller Equality	Equal	Equal	Equal
IO Equality	Equal	Equal	Equal
DDR Equality	Equal	Equal	Equal
Auto-Reconfiguration Equality	Equal	Equal	Equal
Designated Controller	R Controller	R Controller	R Controller
Frame Synchronized	Yes	Yes	Yes
UDH Communicator	Yes	No	No
System Idle Time (%)	83.7	84.1	84.4
Frame Size (bytes)	31.3	31.3	31.3
Number of Forced Variables	0	0	0
Heart Beat	37912819	37912802	37912812
Controller Time	7/6/2025 9:48:01 AM	7/6/2025 9:48:01 AM	7/6/2025 9:48:01 AM
Controller Diagnostic	Yes	Yes	Yes
UD Diagnostic	Yes	No	No
Application Status	No warning, application OK	No warning, application OK	No warning, application OK
Base Load	103.05 15C	103.05 15C	103.05 15C
Firmware	V05.04.03C Build 1	V05.04.03C Build 1	V05.04.03C Build 1

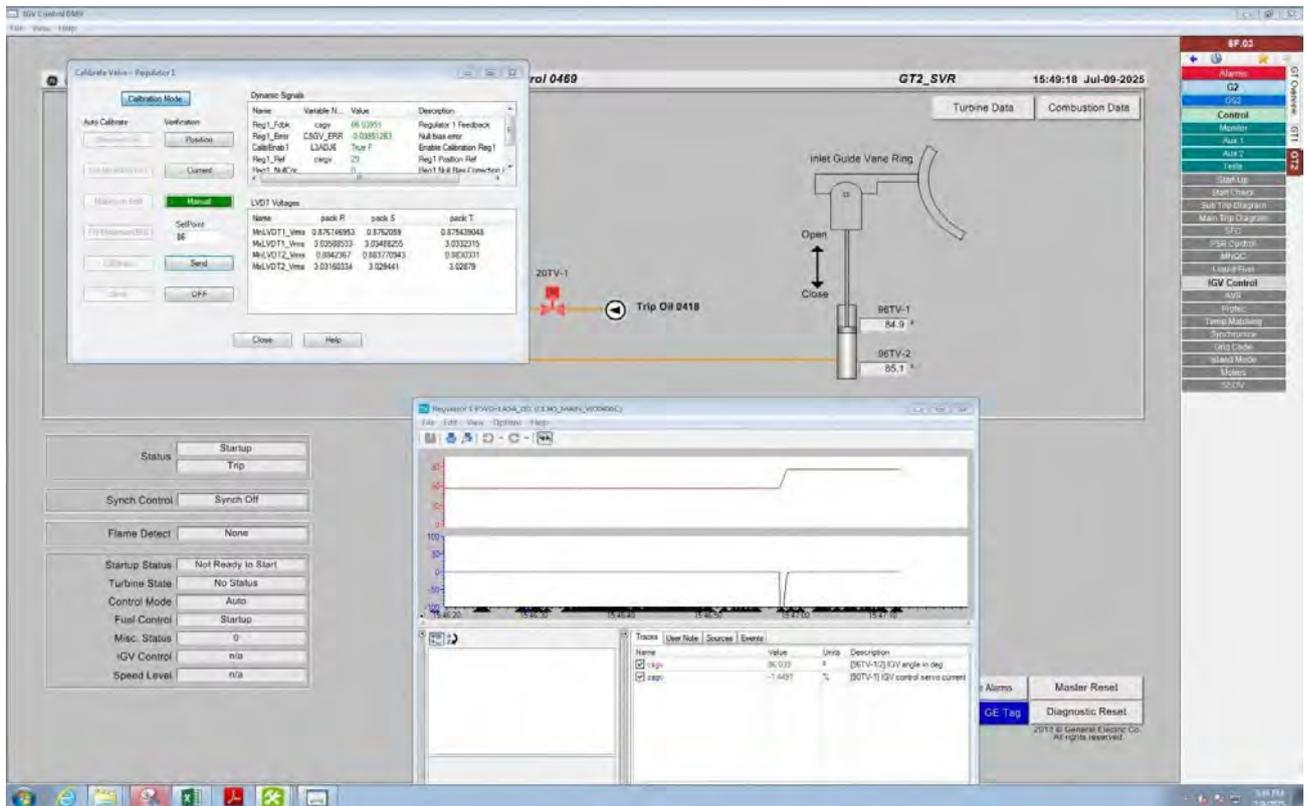
Control Status



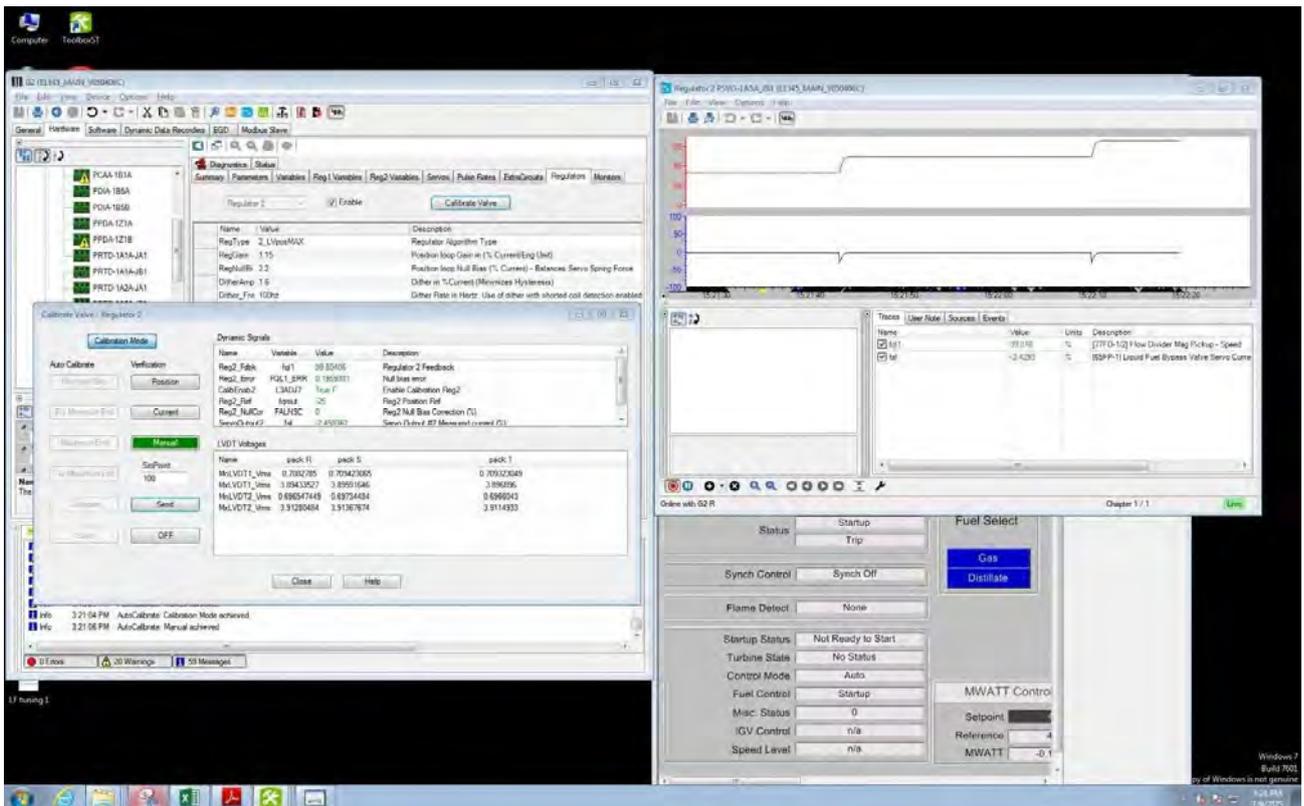
Speed Ratio Valve Calibration Checks



Gas Control Valve Stroke Checks



IGV Stroke Checks



LFBV Stroke Checks

The Combustion Inspection for GTG2, S/N #875122, was carried out from June 28 to July 13, 2025, with mechanical completion achieved between June 28 and July 7, 2025. Following completion of the instrumentation work, the unit was successfully returned to service and has been operating stably at full load. **All inspection and maintenance activities were completed as planned, stabilize after 72 hours and GTG2 is in optimal operational condition.**

I. GTG2, S/N #875122 — Load Test & Tuning Data (Full Load 60 MW)

Load (MW)	Turbine Speed (rpm)	IGV Angle (°)	Exhaust Temp Avg (°C)	Exhaust Temp Spread (°C)	CDP (psig)	TIT (°C)	Fuel Flow (kg/s)	Vib Turbine (mm/s)	Vib Generator (mm/s)	NOx (ppm)	Dynamics (psig pk-pk)	Remarks
10	5200	44	385	8	145	880	1.2	1.8	1.4	7	0.2	Stable startup load
20	5200	52	430	7	165	940	2	2.1	1.6	9	0.25	Smooth transition
30	5200	60	470	6	185	995	2.9	2.3	1.8	11	0.3	Within tuning range
40	5200	68	510	6	205	1055	3.8	2.6	2	13	0.35	Good combustion stability
50	5200	76	540	5	220	1105	4.7	2.9	2.2	15	0.4	Slight tuning for emissions
60	5200	84	565	5	235	1145	5.6	3.1	2.4	17	0.45	Full load stable operation

II. Fuel Nozzle Condition and Root Cause

During the inspection, all fuel nozzles were found to be severely worn and beyond repairable limits. The primary contributing factors include:

- Material and Design Limitations** – The current fuel nozzles are of the standard GE design, intended for generic natural gas specifications. At NSRP, the gas fuel composition contains specific constituents and contaminants that differ from the OEM design baseline, leading to accelerated erosion, thermal stress, and localized hot spots.
- Extended Dual-Fuel Operation** – The GTG has accumulated a significant number of operating hours on Distillate Oil (DO) in addition to gas operation. DO combustion produces higher particulate loading and different flame characteristics, which contribute to carbon build-up, tip erosion, and thermal cracking of the nozzle components.
- High Utilization and Operating Profile** – Continuous operation at varying loads, combined with frequent fuel transfers between DO and gas, has placed additional thermal and mechanical cycling stress on the nozzle tips and swirlers.

Recommended Solution □

1. Custom-Engineered Fuel Nozzles

Only UNEW can provide these technologies and services and will execute this solution.

- Design and manufacture fuel nozzles specifically optimized for NSRP’s gas composition and dual-fuel operation, using high-grade alloys and improved cooling passage designs.
- Implement coatings (e.g., MCrAlY or advanced thermal barrier coatings) to reduce erosion and thermal fatigue.

□ **2. Fuel Quality Monitoring Program**

- Establish routine gas and distillate oil fuel analysis to track contaminants (sulfur, vanadium, sodium, particulates) and calorific value.
 - Adjust maintenance intervals or operational limits based on measured fuel properties.
- 3. Optimized Dual-Fuel Operating Procedures**
- Minimize unnecessary fuel transfers between gas and DO to reduce thermal cycling stress on nozzles.
 - If fuel changeover is unavoidable, use gradual ramp rates to stabilize flame and avoid high thermal gradients.
- 4. Enhanced Inspection Frequency**
- Implement borescope inspections of fuel nozzle tips and swirlers at mid-cycle intervals (e.g., every 8,000–12,000 fired hours) to detect early signs of erosion or cracking.
 - Document wear patterns to refine predictive maintenance planning.
- 5. Combustion Tuning Adjustments**
- Use Mark VIe’s advanced tuning functions to optimize fuel splits and IGV scheduling, balancing NOx compliance with reduced thermal stress on the nozzles.
 - Monitor combustion dynamics trends to detect deterioration before it reaches damaging levels.

III. Combustion Liners – Cracks: Causes & Recommendations

Observed condition

Multiple cracks noted on liner hot-side surfaces (near dilution/quench holes and around weld seams), with carbon deposits present from prior DO operation.

Likely root causes

- **Thermal fatigue/hot spots:** Local overheating from non-uniform flame or blocked cooling holes causes cyclic thermal stress and cracking at dilution holes and weld HAZ.
- **Fuel composition mismatch:** Standard GE “generic gas” combustion hardware exposed to NSRP’s specific gas composition (and contaminants) can alter flame temperature/shape, creating hot streaks.
- **Extended DO operation & changeovers:** Distillate oil produces higher particulates → coke buildup → blocked cooling/film holes → hot-side metal temperature rise and tip/liner cracking. Rapid gas↔DO transfers increase thermal gradients.
- **Cooling/airflow issues:** Partial blockage/erosion of effusion holes; leakage at liner seals; improper fit-up leading to reduced purge/film effectiveness.
- **Combustion dynamics/vibration:** Elevated dynamics (pressure oscillations) and casing vibration accelerate crack initiation/propagation at geometric stress risers.
- **Coating/oxidation damage:** TBC/MCrAlY spallation and hot corrosion/oxidation reduce thermal margin and fatigue life.
- **Fit/stack-up tolerances:** Nozzle-to-liner misalignment or ovality can cause flame impingement on the liner wall.

Recommended actions (near term)

- **Disposition per damage class:**

- *Minor, isolated cracks* (no through-wall): blend/stop-drill + braze/weld repair; restore coatings.
- *Extensive cracking/through-wall or multi-site damage*: retire and replace.
- **Restore cooling effectiveness**: Drill/clear blocked effusion and dilution holes; replace worn seals; verify liner roundness and fit.
- **Retune post-repair with Mark VIe**: Optimize fuel splits/IGV; confirm exhaust TC spread and **dynamics** < **OEM limit** across 10–60 MW load points to avoid hot spots.
- **Fuel changeover procedure**: Enforce gradual, controlled ramps; complete purge; minimize unnecessary DO usage.

Upgrades (mid–long term)

- **Custom-engineered liners for NSRP fuel** (geometry, dilution pattern, and cooling tailored to site gas and dual-fuel profile).
- **Material/coating enhancements**: MCrAlY bond + advanced TBC on hot surfaces; upgraded weld procedures in high-strain regions.
- **Combustor hardware set match**: Verify nozzle swirlers and end-cover hardware match the customized liner pattern to prevent flame impingement.
- **Fuel cleanliness & QA**: Routine gas/DO analysis; tighter filtration to limit particulates that plug cooling holes.

UNEW commitment

Only UNEW can provide and will execute the **custom-engineered combustion hardware** (liners and matching fuel nozzles) with upgraded alloys, optimized cooling, and coatings tailored to NSRP’s specific fuel and dual-fuel operation, including design, manufacture, and validation.

IV. 2nd Stage Nozzles-crackes, Cause and Recommendation

During the Combustion Inspection, the 2nd stage nozzles were found to have multiple *hairline cracks* along the vane surfaces and near the trailing edges. These cracks were fine, non-penetrating, and not visibly open to the naked eye. A borescope examination confirmed their presence; however, precise crack length and depth measurements were not performed because the inspection was carried out in-situ during CI without removal of the Hot Gas Path components, and the borescope equipment cannot provide accurate dimensional readings for such fine cracks.

Likely Causes

- Thermal Fatigue: Repeated high-temperature cycles causing microstructural stress and crack initiation.
- Material Aging: Extended service hours leading to reduced alloy ductility and crack resistance.
- Fuel Composition & Operation Mode: Possible localized hot spots from dual-fuel operation, leading to uneven thermal expansion.
- Erosion & Oxidation: Long-term exposure to hot gas path conditions, accelerating material degradation.

Recommendations

1. Continue Operation with Monitoring: Keep the unit in service while closely tracking performance and vibration data to identify any abnormal trends.
2. Scheduled Detailed Assessment: Plan a comprehensive inspection and measurement of the 2nd stage nozzles during the next Hot Gas Path Inspection (HGPI) when the components will be removed.
3. Repair/Replace at HGPI:
 - If cracks remain within repairable limits at HGPI, perform weld repair with high-grade alloy filler and reapply



Clarifications and Additional Information – Final Combustion Inspection Report

- protective coatings (e.g., HVOF MCrAlY with optional partial ATB coating).
- If cracks exceed limits, replace with new or refurbished nozzles meeting OEM/UNEW specifications.
- 4. Combustion Tuning Review: Assess combustion dynamics, fuel mixing, and firing temperature profiles to reduce thermal gradients that may accelerate cracking.
- 5. Record for Lifecycle Tracking: Document this finding in the turbine's maintenance history to support lifecycle planning and spare parts procurement.