

**BEFORE THE NATIONAL GREEN TRIBUNAL (SZ), SITTING
AT CHENNAI**

O.A No.229/2020

BETWEEN:

Tribunal on its own Motion

... **APPLICANT**

AND

Ministry of Environment & Forest

and Ors.

... **RESPONDENTS**

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Place: Bangalore

Date:09/03/2021


Advocate for the Respondent No.4^{TS}

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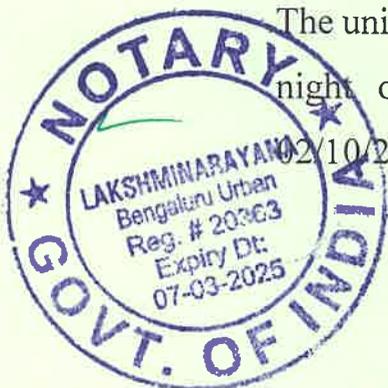
AFFIDAVIT FILED ON BEHALF OF RESPONDENT NO. 4th

I, Mr. D.R.Kabade aged 50 years, S/o R.Y Kabade, working as Assistant General Manager (Law), Office of the Head (Legal Services) and authorised signatory of Karnataka Power Corporation Limited, having office at Shakthi Bhavan, Race Course Road, Bangalore- 560 001, do swear and state on oath as under:

1. I am the Assistant General Manager (Law) of Karnataka Power Corporation Ltd., the 4th Respondent in the present proceedings, and as such I am well aware of the facts of the case and competent to swear to this affidavit.

2. At the very outset, the Respondent No. 4th would like to state that there has been no "Gas Turbine Explosion" as claimed by the Article in The New Indian Express Newspaper, E-paper Edition dated 3rd October, 2020. It is submitted that a fire incident occurred at the Plant while the gas turbine was being commissioned jointly by the officials of BHEL, GE and the Respondent No. 4th. The Gas Turbine was under the process of commissioning since last week of September 2020. Various pre commissioning activities had already been completed by 01/10/2020.

The unit was being run at full speed no load (FSNL) in the intervening night of 01/10/2020 and 02/10/2020. At around 2:52 AM on 02/10/2020, a fire broke out in the Gas Turbine resulting in damage to



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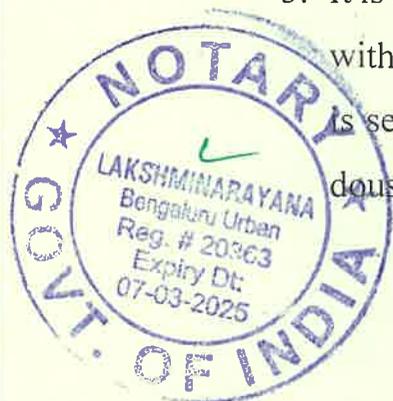
the Gas Turbine and injuries to few personnel standing close to the Gas Turbine. However, there has been no damage, whatsoever outside the gas turbine enclosure and no other areas of the Plant is affected.

3. Thereafter, on 08/10/2020, a Cross functional team comprising of representatives from BHEL, GE and the Respondent No.4¹³, under the chairmanship of a former Member (Thermal) of the Central Electricity Authority (CEA) was constituted by BHEL to analyse the root cause of the Fire Incident and to suggest remedial measures to be taken up to avoid such fire related incidents in future.
4. The Committee observed that the Fire Incident was caused due to two distinct events :

- Leakage of oil from Bearing No.2 of the Gas Turbine.
- Deflagration near the exhaust compartment doors causing injuries to personnel.

Based on available evidence, the root cause of the oil leak from Bearing No.2 was due to the non-removal of mesh from the oil drain line by BHEL commissioning team after completion of oil flushing activity. The mesh had got choked during oil flushing and its continued presence in the oil drain line resulted in developing back pressure in the oil drain line, causing oil level to raise in the Bearing housing No.2 and subsequently leading to overflow into the gas turbine tunnel and further into the Turbine and Exhaust compartments. The overflowing oil passing through the hot gas path picked enough heat to catch fire within the Gas Turbine. The fire was, however, confined to the Turbine and Exhaust Compartments.

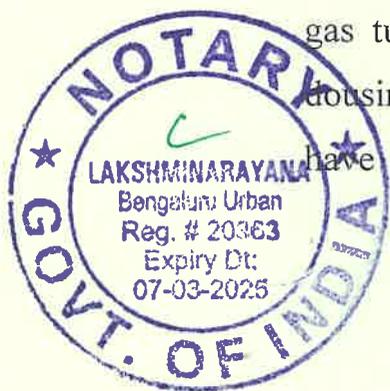
5. It is submitted that there is fire dousing system (CO2 System) installed within the Gas Turbine that gets automatically activated when the fire is sensed within the Gas turbine and this system had worked well in dousing the fire within the Gas Turbine. The Committee found that

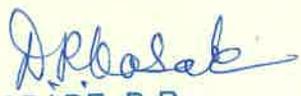


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the root cause of the deflagration near the south side of the exhaust compartment of the Gas Turbine was due to accidental opening of the compartment doors while the automatic CO2 fire protection system was in operation, thus interfering with its efficacy in limiting oxygen supply to the fire.

6. The Committee performing the Root Cause Analysis has confirmed that the design of the Gas Turbine is adequate and no modifications are required. It has opined that site installation checklists, safety protocols and procedures need revisiting and upgrading. All the three organisations (i.e. BHEL, KPCL and GE) should ensure that their employees adhere to safety requirements and instructions. It is submitted that the Respondent No. ~~4~~¹ will be strictly following the recommendations of the Committee. The Copy of the Root Cause Analysis Report is produced herewith as **Annexure R-1**.
7. It is submitted that as the incident was a fire mishap, the appropriate authority to look into the issue being the Department of Factories, Boilers, Industrial Safety and Health, Karnataka. The Deputy Director, Department of Factories, Boilers, Industrial Safety and Health, has already inspected the Plant after the fire incident and has submitted a report. A copy of the report submitted by Department of Factories, Boilers, Industrial Safety and Health is produced herewith as **Annexure R-2**.
8. It is submitted that, in total 15 employees of BHEL, GE and the Respondent No.5 have sustained injuries, out of which 3 employees have succumbed to the injuries, 2 belong to the Respondent-~~4~~¹ and 1 belong to GE. It is likely that the said officials, without suspecting the lube oil leakage, which is a rare event, might have gathered around the gas turbine enclosure for detecting the fire and take measures to dousing the fire in the exhaust compartment area. In the process, they have opened the compartment doors unknowingly, interrupting the




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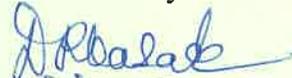
fire dousing system and thus got affected by the fire. Had these employees remained at a distance of 20 feet or more for about 10 minutes, all of them would have been at a safe distance and the flame and hot air escaping from the exhaust would have been doused using the fire tenders of the plant and none of the officials would have sustained any injuries at all. The investigations clearly indicate that it was a freak fire incident that took place during the commissioning of the Plant, however, the Respondent No. ⁷³ ~~8~~ will be taking all steps to give training to its employees to avoid any lapses in security protocols in future. Therefore, it is submitted that there has been no “blast” or “Gas turbine Explosion” as claimed by the newspaper reports. Pictures of the Plant premises immediately after the Blast is produced herewith as *Annexure R-3*, which clearly bring out the fact that there is no damage to any machine or property beyond 5-10 Mts from the exhaust compartment.

9. It is submitted that the newspaper report have been highly sensationalised and the practice of publishing such reports without proper information should be denounced by this Hon'ble Tribunal as they are likely to spread unnecessary panic and hysteria. The pictures of the area affected by the fire clearly show that there was no Fire damage outside the Turbine and Exhaust compartments and therefore, albeit there was a loud sound and some bright light caused by the fire mishap, there was no damage caused beyond the immediate area surrounding the Gas Turbine.

10. It is submitted that the following safety features and fire protection systems have already been built into the Gas Turbine and its accessories:

- a. The safe auto /manual tripping of Gas Turbine /unit has been installed in the control system which will be triggered during emergencies. The same system got triggered automatically



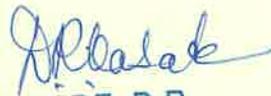

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during the fire incident and that prevented large scale damage to the Gas Turbine.

- b. Heat detectors have been mounted in all the compartments of the Gas turbine.
- c. The Gas Turbine Compartment has been provided with an Automatic Audio Visual Fire Alarm Notification System in the field as well as in the control room
- d. A Full-fledged Carbon dioxide flooding system has been provided in all the compartments of the Gas turbine for fire protection in the event of fire. This system has also acted automatically during the instant fire incident, but the commissioning team not adhering to the safety norms during the panic hour lead to fire accident and damage.
- e. The Gas Turbine compartment has been provided with Gas leakage detectors for immediate detection of any gas leakage within the Gas Turbine compartment.
- f. Fire hydrants system has been provided in the Plant Area.
- g. All Employees/workers at the Plant are provided with applicable Personnel protective Equipment (PPE).
- h. Additional CO₂, Dry Chemical Powder (DCP) and Foam Fire Extinguishers have been provided near the Gas Turbine area and areas around the plant.

11. It is submitted that the Fire Protection System presently installed at the Plant consists of hydrant system for different areas of the plant, high velocity water spray protection system for transformers and turbine lube oil tanks, medium velocity water sprays system for cable galleries, portable extinguishers and hand appliances for extinguishing small fires in different areas of the plant, carbon dioxide flooding system for GTG and the local electrical containers/ control cubicles

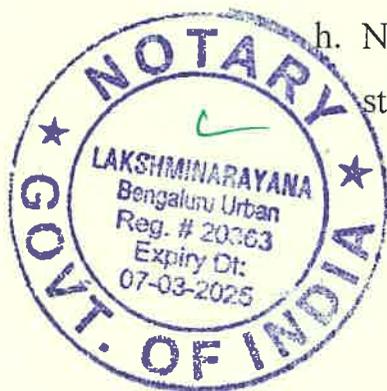


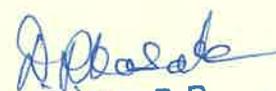

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room and mobile fire tender. Adequate number of Heat rise detectors and smoke detectors have been provided at strategic locations.

12. In addition to the above, after the instant fire accident, the Respondent No. 4th is taking further precautionary measures as indicated hereinbelow:

- a. The Standard Operation Procedure (SOP) for all types of operations pertaining to Gas Turbine will be prominently displayed.
- b. Safety Training for cases of emergency has been given to all employees by conducting onsite emergency mock drills.
- c. Standard Maintenance Procedure (SMP) for the Gas Turbine will be followed as per the recommendation of Original Equipment Manufacturer (OEM), M/s General Electric.
- d. Relevant safety precaution boards pertaining to procedure to be followed during an occurrence of fire inside the Gas Turbine enclosure will be displayed in addition to standard norms.
- e. The staff at the Plant will be trained in the safe operation and maintenance of the unit as well as in handling emergency situations. Only trained operating staff will be deployed for regular operation of the Plant.
- f. A pictorial view of the plant depicting the Safe Assembly Point and Emergency Exit Path has been displayed at conspicuous places at the plant to create awareness on safe evacuation routes in case of fire.
- g. M/s. GAIL India, the supplier of Natural gas to the Power Plant and M/s. GE, the original manufacturer of Gas Turbine, will conduct a seminar /class regarding the working of the Turbine and security protocols at the plant before its commissioning.
- h. No welding or cutting will be allowed near the furnace oil storage area.




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- i. Smoking will not be permitted within the Plant premises, "No smoking board" have been prominently displayed.

13. It is submitted that pursuant to the Root Cause Analysis into the fire mishap within its premises, the Respondent No. 4¹⁷ ensures that it has and will be further taking all measures required to ensure safety within its Plant including the above. No damage is caused due to the Fire in the areas surrounding the Plant. There has been no leakage of gas from the Power Plant and no explosion of the Gas Turbine and incident was only a fire mishap within the Gas Turbine Unit, and has caused no damage whatsoever to the surrounding environment or residences.

Wherefore, it is most humbly prayed that this Hon'ble Tribunal may be pleased to take on record the instant Affidavit, in the interests of justice and equity.

Place: Bangalore

Date: 9/3/2021

Identified by me

Advocate

No. of Corrections: Four



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S NO. 3302

ANNEXURE-R1



9F.05 Gas Turbine Fire Incident Root Cause Analysis

KPCL – Yelahanka, GT-1 (#GT247)

RCA committee approval vide PS:MSX:COMM:RCA:2020/01 Dtd 8th Oct 2020

Name (S/Shri)	Designation	Role	Signature
P D Siwal	Former Member (Thermal), CEA	Chairperson	
Surojit Mandal	GM/ Quality & HSE (BHEL, PSSR)	Convener	
Y M Babu	GM (BHEL, PSTS)	Member	
P Manojkumar	AGM (BHEL, CQ Hyderabad)	Member	
Madhusudan	Sr. DGM/ GT Engg (BHEL, HPEP)	Member	
Tapas Kumar Roy	Sr. DGM (BHEL, PSER)	Member	
Satyanarayana	TA to MD KPCL	Member	
Jagdish Rao	Senior Service Director, GE	Member	

Bharat Heavy Electricals Limited
India

28th December 2020



Executive Summary

BHEL has supplied and erected 1 x 9F.05 Gas Turbine based power plant at KPCL, Yelahanka, Bengaluru. The unit was under commissioning since the last week of September 2020. Various commissioning steps involving cranking, "false-fire", water wash and "first-fire" had been completed by 1st October 2020. The unit was being run to full speed no load (FSNL) in the intervening night of 1st & 2nd October 2020. At around 02:52 Hrs in the early hours of 2nd October 2020, fire incident occurred, resulting in damage to equipment and injuries to personnel. Subsequently three persons lost their lives during treatment for burn injuries at hospitals. RCA committee comprising of representatives from BHEL, KPCL & GE under the chairmanship of former Member (Thermal)), CEA was constituted on 8th October 2020 to analyse the root cause of the accident and suggest remedial actions to avoid repeat. This report summarizes the findings of the committee based on evidences collected.

The fire accident can be split into two distinct events:

- 1) Leakage of oil from bearing #2 of the Gas Turbine
- 2) Deflagration near the exhaust compartment doors causing injuries to personnel (1 BHEL person who was on duty to monitor the equipment in the vicinity of GT, 1 Contract supervisor engaged for safety supervision, 2 GE personnel & 11 KPCL personnel). Subsequently 1 GE and 2 KPCL personnel expired.

Based on available evidences the root cause of the oil leak from bearing #2 is non removal of mesh in the oil drain line which was temporarily used during oil flushing. The mesh choked and caused oil back-up into the bearing and overflow into the tunnel and subsequently to the compartments. Since this overflowing oil passed through the hot gas path, it had picked up enough heat to cause a fire within the compartment.

Based on eyewitness accounts the root cause of the deflagration near the south side of the exhaust compartment was due to accidental opening of the compartment doors while the automatic CO2 fire protection system was operational, thus interfering with its efficacy in limiting oxygen supply to the fire.

The actions of individuals who were injured from all three organizations indicate lack of adherence to safety procedures contributed to this incident.

Quality of supervision from GE under the TDI services also appeared inadequate. All activities and communications were not logged and escalated properly.

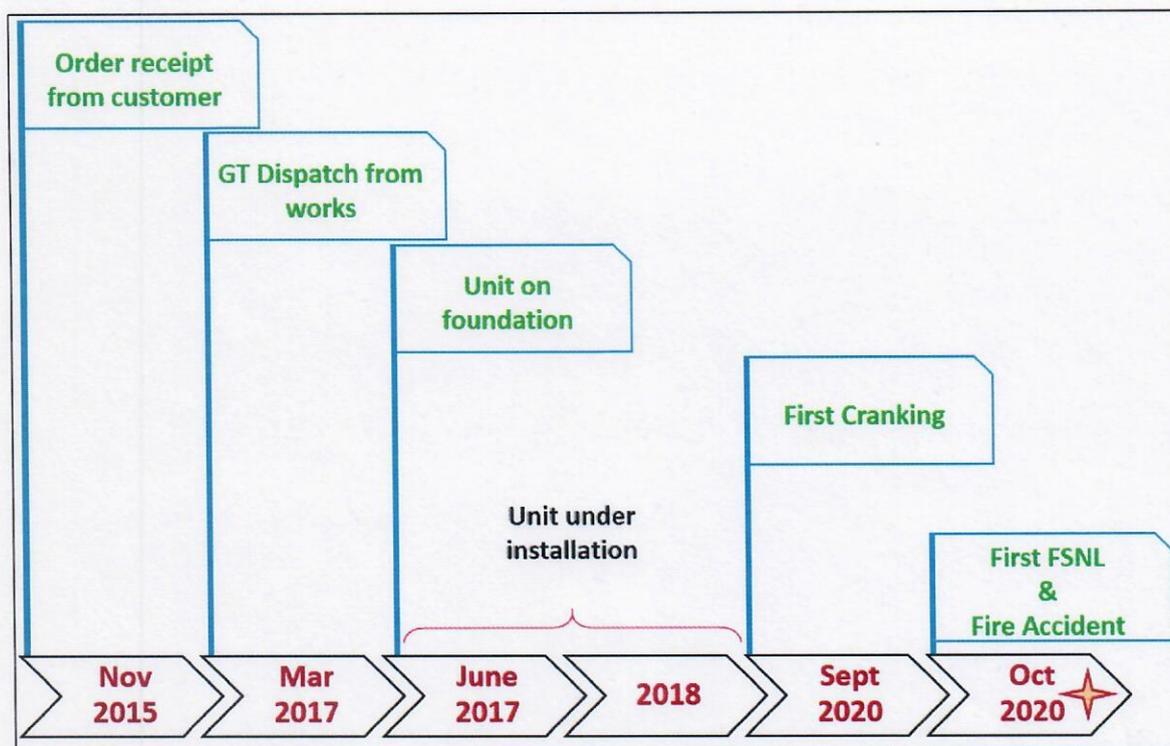
As part of corrective measures, M/s GE was consulted w.r.t design changes needed. They have reviewed with their design teams and confirmed that the design is adequate and no modifications are necessary.

The committee has opined that site installation checklists and safety protocols & procedures need revisiting and upgrading. It is also felt that all the three organisation should ensure that their employees adhere to safety requirements and instructions. Better coordination between them is essential to avoid such events in future.

Sumit M. V.



Project timelines



Event report

BHEL PSSR, YCCPP 1x370 MW. Event report from 25.09.2020 to 02.10.2020	
Date	Activity Carried out
25.09.2020	<ul style="list-style-type: none"> System mechanical walk down was carried out along with GE TFA. No non-conformities were found based on visual observations. Gas turbine (GT) was put on barring gear prior to Cranking activity. Barring gear speed is 6 RPM. No abnormality was found during the activity. H2 filling was done in generator & generator casing pressurized to 3.56 KSC.
26.09.2020	<ul style="list-style-type: none"> Cranking of gas turbine was done @19.20 hr for the first time under the advisory of M/s GE TFA. Higher officials of KPCL were present during cranking activity. The cranking speed reached to 704 RPM. No abnormality was observed. After Cranking, machine is kept on barring gear.
27.09.2020	<ul style="list-style-type: none"> GT compressor offline water wash activity preparation in progress. GT lube oil level in tank was normal.
28.09.2020	<ul style="list-style-type: none"> Red flag Review (RFR) meeting conducted with GE & BHEL HYD team for GT-FSNL & Synchronisation activity. Clearance given to site for Cranking and FSNL Gas booster compressor - A was run and fuel gas was charged up to Gas valve module with discharge pressure of 35 Kg. System was checked with soap solution & found no leakages. GT - Compressor Offline Water wash activity completed in presence of GE TFA.

Signature



Date	Activity Carried out
29.09.2020	<ul style="list-style-type: none"> • FSNL preparatory works in progress. GT was kept on turning gear. Final mechanical walk down with GE TFA carried out. No non-conformities were found based on visual observations. • Bus transfer system (BTS) checking completed. • Gas turbine start up checks completed.
30.09.2020	<ul style="list-style-type: none"> • GBC was put on service and Safety shut off valve (SSOV) leak test carried out. Verification of all gas control valves tests has been carried out by GE TFA. P2 Cavity test was again conducted before GT test fire. • GT – Generator Rotor & Stator 100 % earth fault protection checks completed. • GT false firing test conducted and after that GT test firing was done at 20:08 hr. No abnormalities were noticed.
01.10.2020	<ul style="list-style-type: none"> • GT was on barring gear. Lube oil level was checked along with GE TFA, found normal. Gas booster compressor A put on service. • GT- Generator Circuit breaker (GCB) remote operation checked with customer. • During FSNL attempt activity, turbine was tripped twice on CPD sensor fault in-between 14:08 to 15:30 Hrs. Again at 16:30 hrs, GT was tripped on Generator protection (dead machine trip). • Subsequently, GT was started at around 18:00. GT tripped at ~95% speed (2672 RPM) on HAZ gas detection in Gas valve module at 18:21 hrs. • After that GT was started again. It tripped on HAZ gas detection in Gas turbine compartment at 21:01 hrs, Speed 1061 RPM. Leaks were found in Gas turbine compartment. All leaks were attended and checked with soap solution.
02.10.2020	<ul style="list-style-type: none"> • At 00:24 hrs GT started again, GT trip at 1610 RPM on EGD protection at 02.00 hrs. • GT was started again at 02:12 hrs and achieved FSNL (3000 RPM) at 02:38 hrs. • GT was operating at FSNL. At 02:52 hrs, Bearing #2 load tunnel over heating detected and machine shut down initiated. Followed by that, fire is detected in bearing # 2 tunnel area. Immediately CO2 was released automatically in that zone. • After five minutes, fire broke out in GT exhaust compartment area. Some people who were near to the fire area, got injured and were immediately taken to hospital. • Other zone CO2 was released manually from Control room on fire panic and instruction from field. • At zero speed of turbine, GT Lube oil system switched off and H2 was released from Generator. MCC powered off. • Fire was extinguished by fire tenders in next one to one and half hrs.

Tanjit y mmm



Trip Log



Site Inspections

- The fire was localized only in exhaust and turbine compartments. No damages observed to components outside these two compartments.
- Deflagration occurred near the south side door and was visible from the north side of the exhaust compartment
- Personnel injuries occurred during the deflagration (1 BHEL, 1 Contract, 2 GE & 11 KPCL personnel). Subsequently 1 GE and 2 KPCL personnel expired.
- Significant amount of foam + water + oil was observed on the floor in the exhaust and turbine compartments. No oil seen outside the compartments.
- Components damaged due to fire exposure:
 - Instrumentation and cables inside the exhaust and turbine compartment
 - Insulations on compressor casing, exhaust frame & diffuser are partially damaged
 - Enclosure inner partition walls in intermediate compartment
 - Fire detectors & thermocouples in the bearing tunnel
 - Exhaust compartment vent fan (88BD) duct
- Components in the load compartment & accessory compartment are in good condition
- Components on the roof top of the enclosure are in good condition (except a ruptured bellow & soot affected filter in the 88BN fan)

Am, it my mind

South side turbine compartment door



Inside exhaust compartment



Transit my mind



Bearings



Bearing #1



Bearing #2

Turbine roof top



88TK&BN module



88BD discharge duct



Damaged bellow



88BD vent outlet

Inside turbine compartment



Buckled partition wall



Combustion chambers



Axial vent assembly

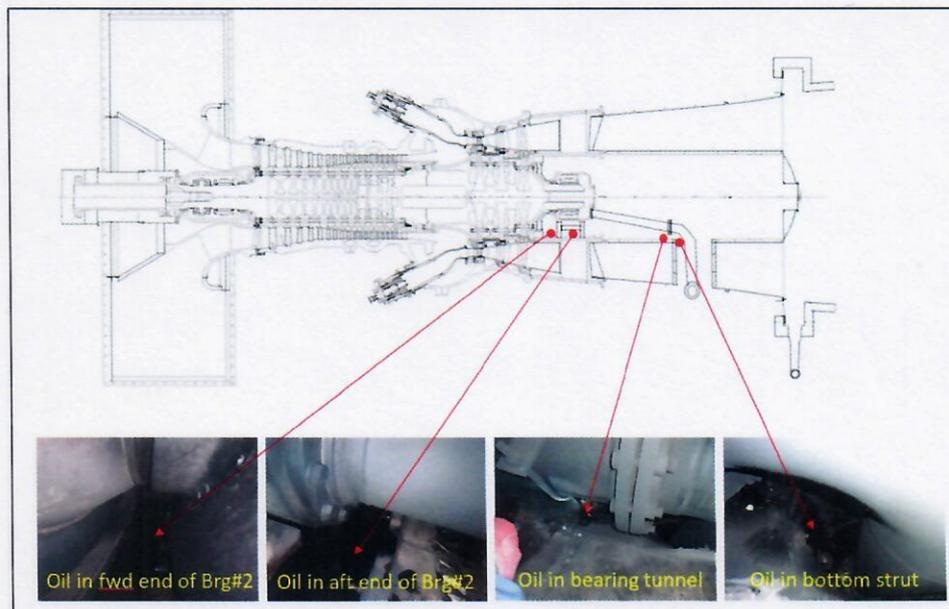
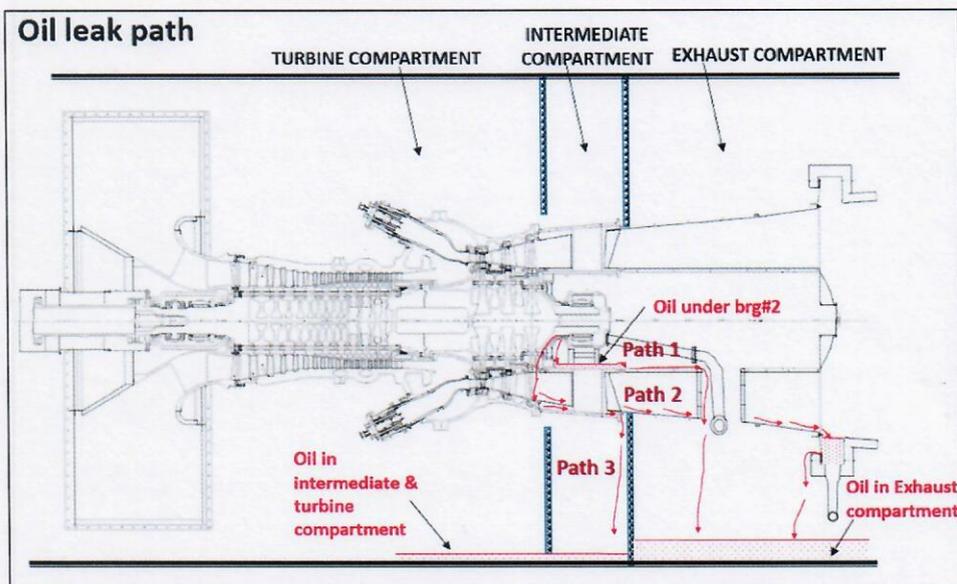
Final report

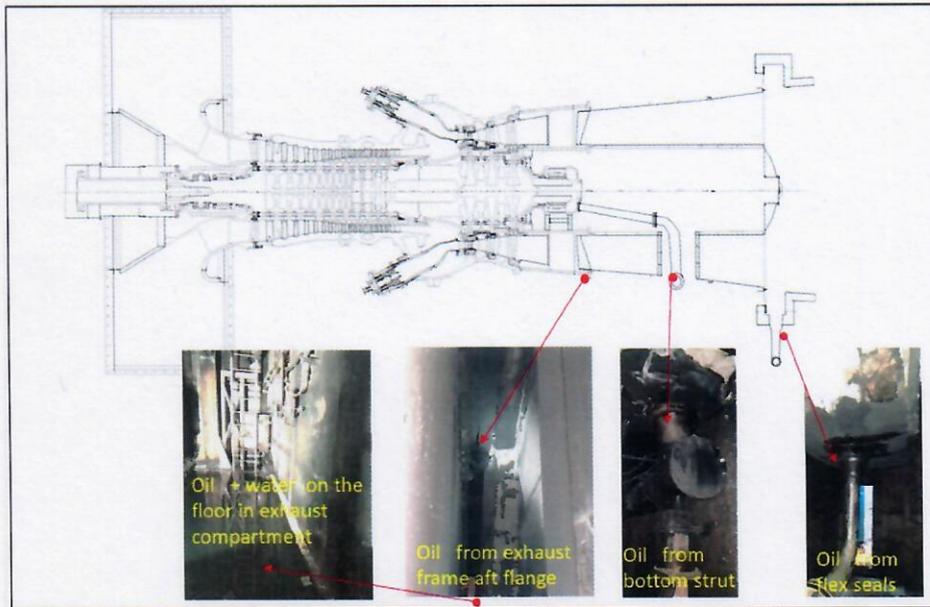
Observations

Oil leak path

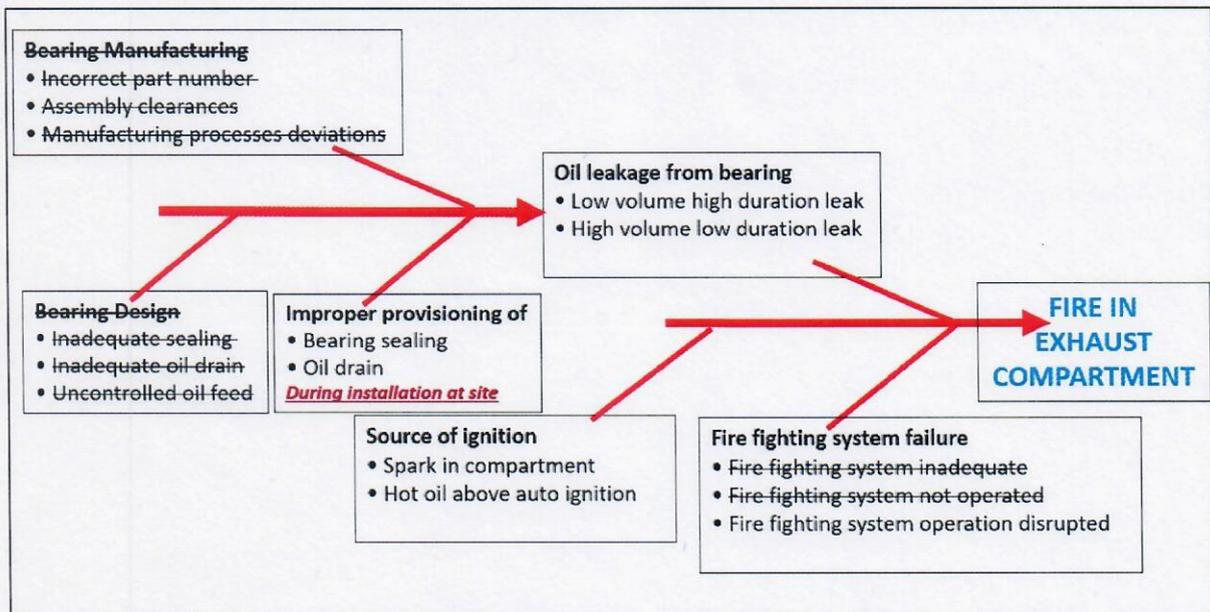
Oil has leaked from the forward seal of bearing #2. This oil has taken three paths to reach the compartment floors.

- Path 1: Oil accumulated under the bearing housing has flown aft in the bearing tunnel, wet the insulation and leaked from the bottom strut of bearing tunnel into the exhaust compartment
- Path 2: Oil has leaked over the stage-3 bucket into the exhaust flow path and flow aft into the flex seal cavity of the diffuser duct. Oil has then leaked across the flex seal into the exhaust compartment.
- Path 3: Oil has leaked over the stage-3 bucket into the exhaust frame cooling air annular space. This oil has leaked from the aft flange of the exhaust frame into the intermediate compartment. Subsequently this oil has found a path into the turbine compartment.





Analysis – Fish bone



Following causes from the Fish bone taken up for further evaluation

- Improper provisioning of Bearing sealing / Oil drain during installation at site
- Oil leakage from bearing : Low volume high duration leak / High volume low duration leak
- Source of ignition: Spark in compartment / Hot oil above auto ignition
- Firefighting system failure : Firefighting system operation disrupted

Prepared by [Signature]



Oil drain system stress test was carried out to try and recreate the conditions during the accident and identify malfunctions. Following were carried out:

- Piping system
 - Checked with boroscope & externally
 - Mist eliminator run to find large leaks
 - Windows and level indication installed at #2 bearing
- Methods
 - Run system as found
 - Run system at increased oil flow using
 - Lift oil system
 - Second AC oil pump (1.9 kg/cm² to 2.1 kg/cm²)
 - Increase regulator valve to limit (in stages to 2.68 kg/cm²)
 - Run fans (88TK and 88BN blowers)
 - Mist eliminator run up to 600 mm H₂O
 - Oil up to 175-180 F (180 F drain temp at trip)
 - Stop mist eliminator and drop vacuum to zero
- Results
 - **Leak could not be recreated**
 - Drain line does not reach 50% level (10-15 cm max, 30.5 cm ID)
 - Some drops at 3rd stage bucket seen only at the end of the test with increased oil temperature and pressure

Evaluation of possible causes

- Improper provisioning of Bearing sealing during commissioning at site
 - Mist eliminator vacuum from operational data is very low
 - However during lube oil system checks the mist eliminator performance found satisfactory
 - Bellow in bearing tunnel cooling fan is found damaged
 - Both the above can result in Low volume high duration leak
- Improper provisioning of Oil drain during installation at site
 - Detailed site simulation study undertaken by GE
 - Picture taken on 01.10.2020 10:45 AM by KPCL engineer indicate presence of strainer mesh in the drain line during operations on 1st & 2nd October 2020
 - Choking of this mesh during operation can lead to backing up of oil causing overflow from bearing seal. This will result in High volume low duration leak



Tanuja M. M.



- Low volume high duration leak
 - Damaged bellow and low mist eliminator vacuum can lead to Low volume high duration leak
- High volume low duration leak
 - Retaining a mesh used during lube oil flushing during operation resulting in restricted drain
 - Restricted drain can lead to backing up of lube oil level in the bearing housing and cause High volume low duration leak
- Spark in compartment
 - All instrumentation in the exhaust compartment are certified for EX-d
 - All junction boxes, conduit fittings and cables in this compartment are explosion proof
 - Possibility of sparking is very minimal
- Hot oil above auto ignition
 - Oil flow path to the exhaust compartment identified at site passes through the exhaust flow path
 - At FSNL, the exhaust flue gas temperature is 480 Deg C which is significantly above the auto ignition temperature of lube oil
 - The possibility of auto ignition of lube oil is very high
- Firefighting system operation disrupted
 - Statements given by GE & BHEL Engineers have confirmed opening of the enclosure door to inspect the oil leak.
 - Due to lack of CCTV footage, it not possible to ascertain the personnel who opened the door. The statements given to the committee are contradictory on this aspect. However opening of the doors is consistent in the statements given.
 - Opening the enclosure door when the CO2 firefighting system is limiting the oxygen availability by suppressant release and ventilation cut-off disrupts the functioning of the system
 - Supply of fresh oxygen can lead to a deflagration
 - From the available evidences, it is conclusive that the deflagration occurred due to opening of the door.
- Human factor and procedures followed at site
 - Elaborate quizzing of the engineers involved in commissioning from BHEL & GE has brought out the following:
 - Communications between GE TFA, BHEL & KPCL Engineers on “mesh in drain line” was not clear, predominantly verbal and contradictory statements were given. It appears to be one of the following is true (Committee is of the view first point is more likely)
 1. Concerned officials of all the three agencies have forgotten about the mesh in return line and did not remove it (Most Likely)
 2. All the three agencies agreed to keep the mesh in position for some time to avoid contamination of lube oil tank, without analyzing its consequences. (Less Likely)
 - This issue was either not communicated or not adequately communicated to site engineers by GE TFA. The issue was neither escalated by him to GE engineering team nor does it find a mention of it in RFR report and also not brought to the notice of senior



officers of BHEL site. It is said that the consequences of this mesh in the drain line was not understood by him.

- Safety signage were not in place on the enclosure.
- The personnel from all the three organization assembled near the GT, chose not to follow the emergency procedures which indicates the inadequacy in the safety training imparted to them.
- The doors were opened by someone out of inquisitiveness to investigate rather than allow the automatic firefighting systems to fight the fire.
- Some important parameters like lube oil level and lube oil level low alarm was not properly configured.
- No record of commissioning meetings were kept severely hampering the investigations.
- After the incident the mesh in oil drain lines were found removed.
- Adequate level of supervision from paid TDI services of GE, was not evidenced from the events discussed.

Conclusion

- Inadequacy of evidence (lack of CCTV footage, incorrect operating data due to uncalibrated / unconnected instruments, inconclusive and inconsistent dispositions by eye witnesses, Incomplete RFR report made available by GE (only the summary of RFR was given), etc.) from the day of event severely constrains the RCA evaluations. The committee is forced to rely on circumstantial evidence.
- From the quantum of oil leak (close to 10,000 lit) only during the last run (disposition by site engineers confirming that no leaks were seen in the prior runs is considered) indicates that it was a High volume low duration leak. This is possible only by a restriction in the drain line. Photographic evidence found, points to this as the prime reason for the oil leak.
- Site management to investigate about the removal of mesh in oil drain line after the incident.
- Since the unit was run at FSNL for 20 min prior to fire detection, adequate temperatures were available in the exhaust flue gas flow path to cause auto ignition of the lube oil and resultant fire in the bearing tunnel and exhaust compartment.
- Disruption to the operation of the fire suppression system by opening of doors led to a deflagration.
- Quality of supervision from GE under the TDI services appeared inadequate. All activities and communications were not logged and escalated properly.
- BHEL site engineers should ensure systematic commissioning of the unit with proper documentation and protocols.
- Inability to grasp the consequences of leaving the mesh in the drain line by the GE TFA and BHEL engineers mistake of not removing the mesh after oil flushing appears to be the main reason for this incident.
- Inadequate EHS standard followed at site and the inadequate safety training to personnel involved at site (including Customer personnel).
- GE to again relook at the adequacy of the system philosophy to address the high oil leakage in a very short span of time leading to such incidents. BHEL to incorporate any changes / improvement, if suggested by GE

Sumit M. V.

ANNEXURES

1.	Annexure - 1	Statements made to the committee
2.	Annexure - 2	GE Mech TFA final checklist 26 th Sept 2020
3.	Annexure - 3	Details of RFR call – 28 th Sept 2020
4.	Annexure - 4	KPCL Yelahanka 9FB_RFR_Summary_18Nov'20 by GE
5.	Annexure - 5	Borescope inspection comments by M/s GE
6.	Annexure - 6	List of CFT meetings

Amojit Kumar

ANNEXURE-1Statements made to the committeeBHEL Personnel

1. Mr. E R Harikrishnan, GM KPCL projects, BHEL provided the background on the methodology being followed for installation and commissioning of the plant at Yelahanka.

Following is the brief:

- a. Gas Turbine was being installed and commissioned by M/S BHEL with intermittent technical assistance by M/s General Electric Field Engineers.
- b. GE Field Engineers were either witnessing the various installation activities at site or reviewing the BHEL protocols for works done in their absence at site, as requested
- c. A Red Flag Review (RFR) was done as per GE new unit start-up protocol relying on inputs from BHEL site team and reviewed by GE Field Engineers and Engineering team to ascertain the completeness of systems necessary for commissioning of the unit. Inputs for non-GE supply scope were provided by BHEL. GE's Field Engineers carried out checks and obtained inputs from BHEL site for checks done by BHEL & KPCL and uploaded these into GE's portals. Mr. Ashwin from GE, JFTC, Bangalore was coordinating the RFR calls.
- d. Clearance for "first-fire" (i.e. starting the unit with fuel injection and ignition) was accorded in the RFR after ascertaining that all necessary pre-requisites are met as per the received information from BHEL.
- e. As part of unit commissioning to FSNL, the unit experienced multiple starts due to various events and could achieve FSNL on the seventh attempt. A detail of the chronology is placed in ANNEXURE-1
- f. Only a handful of BHEL, GE and KPCL engineers (about six) were in the field when unit reached FSNL and were monitoring the unit from safe distance. Rest of the persons were in the control room.
- g. At field, it came to the notice of persons that Unit tripped and CO2 fire suppression system had activated from the noise made by venting of fuel gas and the blaring of CO2 system hooters.
- h. Mr. Harikishnan was on the north side of the unit and was at a safe distance due to CO2 release happening into the compartments. Suddenly a bright light was noticed which made the personnel on the north side to jump the window and move out of the GT hall. Visible Fire had then broken out in the exhaust and turbine compartments.
- i. It appears that it was during this time between the unit trip and the appearance of the bright light on the north side that a group of personnel had come from control room and gathered on the south side of the enclosure. These personnel had then experience burn injuries. Mr. Harikrishnan didn't witness the events on the south side as he was on the north side and there is no clear view between the two sides.
- j. Immediately on realizing the tragedy that had taken place on the south side, actions were taken to shift the injured personnel to hospitals. Fire tenders were called for fighting the fire inside the GT compartments. It took about 2 hrs. to douse the fire.

Handwritten signature in blue ink.

2. Name: Aman Saini (Dy. Manager /6138098)
Department: Mechanical Commissioning (BHEL)
I was there to take care of Generator and seal oil system. GT tripped and CO2 was released. I was near to H2 dryer system. Suddenly I heard a sound of blast and I ran toward the main road. I went back to Gas room to vent out the H2 for safety.
3. Name: Kasaiah (Dy. Manager/6101488)
Department: Electrical (BHEL)
Location: Static Excitation room.
I was at static excitation room during FSNL, I heard venting sound and came out of the excitation room and moved towards the GT North side and was standing. In few minutes' time I heard sound with fire from GT and immediately jumped along the end wall
4. Name: Binu Krishnan PK (Dy.Engineer/2768356)
Department: Mechanical Commissioning (BHEL)
During GT FSNL, I was assigned to monitor HRSG. I was on top of HRSG, steam was coming out of HP drum vent & HP MS vent & that time pressure was 5 Kg/cm2. Informed control room to close HP drum vents & MS vents. After closing heavy sound came, understood from control room that GT tripped on fire protection. I came down to HRSG North, after few minutes' heavy sound came with lot of smoke.
5. Name: Nipul Das (Sr. Manager / 2208954)
Department: Mechanical Commissioning (BHEL)
After the final walk down there was no communication from GE about removal of the mesh. The mesh was removed in September 2020.
6. Name: Nitish Kumar Behera (Junior Executive / 6210643)
Department: Mechanical Erection (BHEL)
During GT FSNL, I was assigned to monitor GT field. I was on the north side of the GT when the unit tripped on fire protection. We saw CO2 being released. I prevented personnel on the north side from going near the enclosure as CO2 release was happening. I moved to the south side of the GT to check and prevent personnel from coming near the enclosure. On reaching the south side, I saw that the GE mechanical TFA had opened the door of the exhaust compartment and was viewing inside. He then left towards the turbine compartment leaving the door open. I closed the compartment door. The entire compartment was filled with white smoke because of which it could not be seen if oil was leaking on the floor. I stood slightly away from this door to prevent others from opening / entering. At this time, a group of personnel came down the stairs from the control room. These personnel reached near the door and opened it in spite of my repeated requests not to open the door. When the door opened, there was a deflagration and I was thrown aside by 3-4 meters. I have suffered 40% burns and an injury to my fingers. Was in hospital for more than a month and am recovering at home now. Physiotherapy is being done to regain movement to the fingers damaged during the accident.

Tanjay mmm

KPCL Personnel

7. Name: B Srinivas (SE - Acting CE)

Department: Electrical (KPCL)

During GT FSNL I was in the control room. After the unit tripped we as a group went down near the GT enclosure. Normally when such events occur a gathering of people happens and things get discussed. We were also doing the same. My back was to the enclosure. Suddenly I felt searing heat at my back. Instinctively I put my hands behind my head to protect it. I was then thrown away. I don't remember events after that. I have burn injuries to my hand and back of head. I am recovering.

8. Name: Mahadeva Prasad (EE)

Department: Turbine & HRSG (KPCL)

During GT FSNL I was on the upper floors of the HRSG concentrating on the steam generation and the lineup of vents. Suddenly we heard the sound made by venting of Gas and understood that the GT had tripped. I climbed down the stairs. I saw lot of smoke coming out from the vent duct outlet for the exhaust compartment ventilation fans. On reaching the ground floor, I walked from the north side towards the generator with an intention of reaching the south side. As soon as turned around the generator and reached near the LCI compartment, I saw a ball of flame shoot out for an instant from near the compartment door. Fearing for further such events, I jumped out of the building and ran away. After some time I returned and picked the injured personnel including GE Mechanical TFA and took them to hospital in my personal car. We had to move around three to four hospitals before all personnel in my car could be admitted. It was a scary experience.

9. Name: Shekhar Rao (AEE)

[The person who provided the images of gas turbine lube oil drain pipeline of Bearings No.1 & 2 as existing on 01.10.2020]

Department: Turbine (KPCL)

The photograph provided by me is taken by me on my mobile phone. It was taken on 1st October 2020 at around 10:45 hrs. I have a habit of taking pictures whenever I visit site. This picture was also taken as part of this habit. I am a novice in Gas Turbines and did not realize the significance of this picture. Later when on site during the lube oil tests being conducted, I showed these pictures to the GE engineers on site. Now my management has directed me to share the actual picture to GE and I have complied.

Shekhar Rao

GE Personnel

10. Name: P Ashok Kumar (TFA)

Department: Mechanical (GE)

At the time of the GT trip, I was in field. The fire alarm sounded in the field. I looked into the exhaust compartment through the window and saw CO2 smoke coming into the compartment. Since CO2 release would take at least 30 min, I called the controls TFA Mr. Venkatesh Pala on phone to find what happened. He told that the tunnel temperature was high and CO2 had released. He enquired if the unit could be put on turning gear for which I replied in the affirmative. All this time I was facing the generator. When I turned towards the GT compartment saw two persons (one from BHEL and one from KPCL) had opened the turbine compartment door. They dipped their hand into the leaked substance on the floor and said "This is oil not water". I then turned my face towards the exhaust compartment, at this instant the fire ball hit me with searing heat. I then turned around and started running. A KPCL engineer who was also injured in the fire ball was also running. I just followed him. He jumped into a civil water tank, I too jumped into a tank just besides that. I dipped myself two to three times completely in the water to douse my burning face and hair. After some time BHEL commissioning engineer came and called me out for taking to hospital. I was taken to hospital in KPCL engineers personal vehicle. There were no beds in the first two hospitals we went. Was admitted into the third hospital and treatment was started. It took more than one hour to reach emergency in hospital. Initially because of dousing in water my skin looked OK. However, in this one hour blistering and burn indications started surfacing. Have been treated and am continuing treatment at home. GE doctors are regularly in touch. Am recuperating, but keep getting back pain from time to time.

I had observed the mesh in the drain line on the final walk down. I had intimated to the BHEL team participating in the walk down (Mr. Shankar Narayana, Mr. Nipul Das , Mr. Binu, Mr. Uma Maheshwar Rao, Mr. Ajit KK). They said they want to retain the mesh in place. While making e-mail listing the pending list after the walk down I have missed mentioning this point as there were lot of activities going on at site. I have also not escalated this our engineering. When quizzed by the committee on why this issue was not escalated adequately, Mr. Jagdish Rao Sr. Service Director of GE answered on behalf of Mr. Ashok and mentioned that the consequences of this mesh in the drain line was not understood by him.

P Ashok Kumar

From: Periathambi, Ashok Kumar (FieldCore) <AshokKumar.Periathambi@ge.com>
To: Shankar Narayan (sn@bhel.in) <sn@bhel.in>, 'NIPUL DAS-PSSR' <nipul@bhel.in>
Cc: J Umamaheswar Rao <jumrao@bhel.in>, ajitkk@bhel.in, Alaawar, Samer (GE Gas Power) <samer.alaawar@ge.com>, Pala, Venkatesh (FieldCore) <Venkatesh.Pala1@ge.com>, Bawra, Balraj (FieldCore) <Balraj.Bawra1@ge.com>
Sent: Sat, 26 Sep 2020 12:43:13 +0530 (IST)
Subject: Remainder: Balance activity before GT first fire.

Dear Sir,

As discussed earlier, before GT first fire the following activity completion required.

1. Gas valve module final strainer box up with original gasket.
2. GT compartment inside IGV accumulator charging completion.
3. Fuel gas header pipe line flexible hose coupling lock wash locking and tightening.
4. GT compartment door locking.
5. GT compartment inside cleaning.
6. RFR completion.
7. GT Co2 system inline.

Regards,
P. Ashokkumar
+91 7708361769

Periathambi

From: Wilson, Ashwin (GE Gas Power) <Ashwin.Wilson@ge.com>
 To: Periathambi, Ashok Kumar (FieldCore) <AshokKumar.Periathambi@ge.com>, Pala, Venkatesh (FieldCore) <Venkatesh.Pala1@ge.com>, Dhayalan, Balaji (FieldCore) <Balaji.Dhayalan@ge.com>, Rao, Jagdish (GE Gas Power) <Jagdish.Rao@ge.com>, Rayaprolu, Srinivas (GE Gas Power) <Srinivas.Rayaprolu@ge.com>, Pothula, Suresh Babu (GE Gas Power) <suresh.babu.pothula@ge.com>, Rout, Susanta Kumar (GE Gas Power) <susantakumar.rout@ge.com>, Krovvidi, S r kali prasad (GE Gas Power) <Srkaliprasad.Krovvidi@ge.com>, Chandrashekar, R (GE Gas Power) <rchandrashekar@ge.com>, Amanaganti, Sandeep (GE Gas Power) <sandeep.amanaganti@ge.com>, Desu, Swathi (GE Gas Power) <Swathi.Desu@ge.com>, Das, Jaydeep (GE Gas Power) <jaydeep.das@ge.com>, Mathan, Radhakrishnan (GE Gas Power) <Mathan.R@ge.com>, Kulkarni, Rahul (GE Gas Power) <Rahul.Kulkarni@ge.com>, Alaawar, Samer (GE Gas Power) <samer.alaawar@ge.com>, Ghizzawi, Farouk (GE Gas Power) <Farouk.Ghizzawi@ge.com>, bhisatya@bhel.in, madhusudan@bhel.in, Raman Anoop Kumar <anoop.kumar@bhel.in>, 'SUSHILA XESS-EDN' <sushila@bhel.in>, 'ajitkk@bhel.in', 'sn@bhel.in', 'jumrao@bhel.in', nipul@bhel.in, 'CHANDRASEKHAR E' <shekharec@bhel.in>, Bawra, Balraj (FieldCore) <Balraj.Bawra1@ge.com>, Shetty, Shanath (GE Gas Power) <Shanath.Shetty@ge.com>
 Cc: Gupta, Nitinkumar (GE Gas Power) <Nitinkumar.Gupta@ge.com>, Thangaraj, S (GE Gas Power) <S.Thangaraj@ge.com>
 Sent: Mon, 28 Sep 2020 16:26:07 +0530 (IST)
 Subject: RE: KPCL SN 900107 - RFR Call

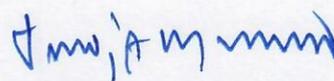
Participants:

BHEL: J Umamaheshwar Rao, Shankar Narayan, Ajith K K, Anoop Kumar, Madhusudan.
 GE: Ashok Kumar, Balraj Bawra, Venkatesh Pala, Srinivas Rayaprolu, Shanath Shetty, Swathi Desu, Susanta Rout, Jaydeep Das, Samer Alaawar, Ashwin Wilson, Jagdish Rao, Kali Prasad.

Notes:

- Unit cranking performed on 26 September.
- Offline water-wash planned for 28 September.
- Unit first fire planned for 29 September.
- GT synchronisation planned for 30 September.
- Unit borescope inspection completed.
- OSM configuration completed.
- Fuel gas chromatography submitted; parameters are within specifications.
- 9x FGPA cards require replacement.
 - Site plans to proceed with existing cards.
 - Risk of alarms, or unit trip, or unit not being able to ramp-up with these cards.
 - Replacement cards are expected to be at site next week.
- Additional TILs (post February 2019) review completed; GE to share TIL list to BHEL.
- BHEL to provide excitation SAC list to GE TA.
 - Completed; SAC uploaded to RFR portal.
- Unit overspeed test planned after GT synchronisation.
 - Green rotor run in and overspeed test completed in BHEL factory.
 - Site team to ensure the control system functionality by means of overspeed simulation.
 - Refer guidelines in TIL 1345-R4 for overspeed test.
- GT will be operated in part load until HRSG and steam turbine commissioning.
- DLN tuning request submitted.
- BHEL to submit schedule for HRSG and ST commissioning to allow planning for TA availability and DLN tuning during GT full load.
- All SACs in portal are complete; to update RFR and release unit for first fire.

Regards,
 Ashwin



-----Original Appointment-----

From: Wilson, Ashwin (GE Gas Power)

Sent: 28 September 2020 09:26

To: Periathambi, Ashok Kumar (FieldCore); Pala, Venkatesh (FieldCore); Dhayalan, Balaji (FieldCore); Rao, Jagdish (GE Gas Power); Rayaprolu, Srinivas (GE Gas Power); Pothula, Suresh Babu (GE Gas Power); Rout, Susanta Kumar (GE Gas Power); Krovvidi, Sriraj (GE Gas Power); Chandrashekar, R (GE Gas Power); Amanaganti, Sandeep (GE Gas Power); Desu, Swathi (GE Gas Power); Das, Jaydeep (GE Gas Power); Mathan, Radhakrishnan (GE Gas Power); Kulkarni, Rahul (GE Gas Power); Alaawar, Samer (GE Gas Power); Ghizzawi, Farouk (GE Gas Power); bhisatya@bhel.in; madhusudan@bhel.in; Raman Anoop Kumar; 'SUSHILA XESS-EDN'; 'ajitkk@bhel.in'; 'sn@bhel.in'; 'jumrao@bhel.in'; nipul@bhel.in; 'CHANDRASEKHAR E'; Bawra, Balraj (FieldCore); Shetty, Shanath (GE Gas Power)

Cc: Gupta, Nitinkumar (GE Gas Power); Thangaraj, S (GE Gas Power)

Subject: KPCL SN 900107 - RFR Call

When: 28 September 2020 11:00-12:00 (UTC+05:30) Chennai, Kolkata, Mumbai, New Delhi.

Where: Microsoft Teams Meeting

Team – requesting you time for the subject prior to the unit first fire and FSNL.

- Site status:
 - GT cranking on 26 September.
- Activities for 28 September:
 - GT false fire test.
 - GT offline water-wash.
 - GT first fire.
- FSNL on 29 September, GT synchronisation on 30 September.
- Fuel sample analysis complete and in specification.
- Unit borescope inspection completed.
- Open ER case review.
- OSM configuration completed.
- Final review of system audits checklists.
- Record any incomplete audits for follow-up after FF.
- Updated TIL list.
- If all necessary steps are completed, release the unit to FF.

Thanks,
Ashwin

Join

Microsoft Teams Meeting

+91 22 6219 2546 India, Mumbai (Toll)

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284 007 960#

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teams@myvideo.ge.com

VTC Conference ID: 1188407291

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Tanjit my name

1. This summary report has been provided on specific request of BHEL and nothing in this summary shall vary any contractual relationship in existing contracts between GE and BHEL.

2. Please note that this summary report is subject to confidentiality terms between GE and BHEL and is being issued for limited purposes of providing information of the overall RFR checks and does not amount to any opinion or views on the ongoing Root Cause Analysis being conducted in relation to the fire incident at KPCL site, Bengaluru.

Trupti M. M.

Reference	Title	Item	Section	Checks Completed	Inputs provided by BHEL	Date Completed	GE TA Present Onsite
SAC-GT-001	Gas Turbine Foundations	1	Walk-down Pre-work Foundations	Y	Y	9/17/2020	Y
		2	Anchor Bolts, Nuts, and Washers	Y	Y	9/17/2020	Y
		3	Foundation Base Plates and Horizontal Restraints and Fixators	Y	Y	9/17/2020	Y
		4	Fixators and Baseplates	Y	Y	9/17/2020	Y
		5	Comments	Y	Y	9/17/2020	Y
SAC-GT-002	Gas Turbine	1	Alignment	Y	Y	9/17/2020	Y
		2	Coupling installation	Y	Y	9/17/2020	Y
		3	Enclosure	Y	Y	9/17/2020	Y
		4	Instrumentation	Y	Y	9/17/2020	Y
		5	Inlet Guide Vanes	Y	Y	9/17/2020	Y
		6	Variable Stator Vanes	N/A	-		
SAC-GT-0701	System Audit Checklist - Combustion Arrangement	7	Comments	Y	Y	9/17/2020	Y
		1	First stage Wheelspace Thermocouples	Y	Y	9/17/2020	Y
		2	DLN2+ PM1 & PM4 Orifice Plates	N/A	-		
SAC-GTACC-0416	System Audit Checklist - Oil Systems	3	Hardware Installation Checks	Y	Y	9/24/2020	Y
		1	Walk-down Pre-work	Y	Y	9/20/2020	Y
		2	Pre-flush Walk-down - MLI 0416 Lube Oil system	Y	Y	9/20/2020	Y
		3	Pre-flush Walk-down - MLI 0418 Trip Oil system	Y	Y	9/20/2020	Y
		4	Pre-flush Walk-down - MLI 0434 Hydraulic Oil system	Y	Y	9/20/2020	Y
		5	System Walk-down post flushing	Y	Y	7/30/2018	Y
		6	Functional testing	Y	Y	9/20/2020	Y
SAC-GTACC-0417	System Audit Checklist - Cooling and Sealing Air Systems	7	Comments	N/A	-		
		1	Walk-down Pre-work	Y	Y	9/20/2020	Y
		2	System Walk-down: Air Extraction	Y	Y	9/20/2020	Y
		3	System Walk-down: Cooling Fan Module	Y	Y	9/20/2020	Y
		4	Functional testing	Y	Y	9/20/2020	Y
SAC-GTACC-0420	System Audit Checklist - Cooling Water Systems	5	Comments	-	-		
		1	Walk-down Pre-work	Y	Y	9/25/2020	Y
		2	System Walk-down	Y	Y	9/25/2020	Y
		3	Cooling water to Generator Final Assembly	Y	Y	9/25/2020	Y
		4	Cooling water to Gas Turbine Flame and lube oil coolers	Y	Y	9/25/2020	Y
		5	Cooling water to Atomizing Air system [Dual Fuel units only]	N/A	-		
		6	Cooling Water to Fuel Gas Purge Air Cooler (9FB.01)	Y	Y	9/25/2020	Y
		7	Cooling Water Module (A076)	Y	Y	9/25/2020	Y
		8	Functional testing	Y	Y	9/25/2020	Y
SAC-GTACC-0422	System Audit Checklist - Fuel Gas Systems	9	Comments	-	-		
		1	Walk-down Pre-work	Y	Y	9/25/2020	Y
		2	Fuel Gas System Walk-down	Y	Y	9/25/2020	Y
		3	Gas Supply	Y	Y	9/25/2020	Y
		4	Gas Conditioning	Y	Y	9/25/2020	Y
		5	Fuel Gas Heating	Y	Y	9/25/2020	Y
		6	Fuel Gas Filtration	Y	Y	9/25/2020	Y
		7	Fuel Gas Metering	Y	Y	9/25/2020	Y
8	Fuel Gas Module	Y	Y	9/25/2020	Y		

Amir M...

Reference	Title	Item	Section	Checks Completed	Inputs provided by BHEL	Date Completed	GE TA Present Onsite
SAC-GTACC-0426	System Audit Checklist - Fire Protection Systems	9	Fuel Gas Piping	Y	Y	9/25/2020	Y
		10	Fuel Gas Purge System Walk down	Y	Y	9/25/2020	Y
		11	Functional testing	Y	Y	9/25/2020	Y
		12	Strainer runs	N	-		
		13	Comments	-			
		1	Walk-down Pre-work	Y	Y	9/25/2020	Y
		2	System Walk-down prior to Pressure Testing	Y	Y	9/25/2020	Y
		3	Tank Filling	N/A			
		4	Tank & Cylinders	Y	Y	9/25/2020	Y
		5	System Walk-down post Pressure test	Y	Y	9/25/2020	Y
		6	System Walk-down post Pressure test	Y	Y	9/25/2020	Y
		7	Functional testing	Y	Y	9/25/2020	Y
		8	Comments	-			
SAC-GTACC-0432	System Audit Checklist - Inlet Air Heating Systems	1	Walk-down Pre-work	Y	Y	9/25/2020	Y
		2	System Walk-down	Y	Y	9/25/2020	Y
		3	Interconnecting Piping	Y	Y	9/25/2020	Y
		4	Inlet Heating Control Valve(s) (MLI A037)	Y	Y	9/25/2020	Y
		5	Functional testing	Y	Y	9/25/2020	Y
		6	Comments	-			
SAC-GTACC-0436	System Audit Checklist - Heating and Ventilation Systems	1	Walk-down Pre-work	Y	Y	9/25/2020	Y
		2	System Walk-down MLI 0436	Y	Y	9/25/2020	Y
		3	Functional testing	Y	Y	9/25/2020	Y
		4	Comments	-			
SAC-GTACC-0471	System Audit Checklist - Inlet and Exhaust Systems, Performance Monitor	1	Inlet Plenum	Y	Y	9/25/2020	Y
		2	Exhaust System	Y	Y	9/25/2020	Y
		3	Inlet System	Y	Y	9/25/2020	Y
		4	Walk-Down Pre-work	Y	Y	9/25/2020	Y
		5	System Walk-Down - 0471	Y	Y	9/25/2020	Y
		6	System Walk-down - 0492	Y	Y	9/25/2020	Y
		7	Anti-Icing / Heating or Chilling Heat Exchanger / Coil	N/A			
		8	Functional testing	Y	Y	9/25/2020	Y
		9	Comments	-			
SAC-GTACC-0461	System Audit Checklist - Waterwash	1	Walk-down Pre-work	Y	Y	9/25/2020	Y
		2	Water Wash Piping system walk-down	Y	Y	9/25/2020	Y
		3	False Start Drain Lines walk-down	Y	Y	9/25/2020	Y
		4	Water wash Skid walk-down	Y	Y	9/25/2020	Y
		5	Functional testing	Y	Y	9/25/2020	Y
SAC-CTRL-HAZG	System Audit Checklist - Hazardous Gas Detection	1	Walk-down Pre-work	Y	Y	9/9/2020	Y
		2	Hazard Gas Detection	Y	Y	9/9/2020	Y
		3	Functional testing	Y	Y	9/9/2020	Y
		4	Comments	Y	Y	9/9/2020	Y
		1	Control Panel / Field Devices	Y	Y	9/25/2020	Y
		2	Controller Software	Y	Y	9/24/2020	Y
		3	Human Machine Interface	Y	Y	9/23/2020	Y

Tanjit Manna

Reference	Title	Item	Section	Checks Completed	Inputs provided by BHEL	Date Completed	GE TA Present Onsite	
SAC-CTRL-TCP	System Audit Checklist - Turbine Controller	4	Combustion Dynamic Monitoring (CDM)	Y	Y	9/23/2020	Y	
		5	Blade Health Monitor (BHM)	N/A				
		6	Network	Y	Y	9/23/2020	Y	
		7	Housekeeping	Y		9/9/2020	Y	
		8	Commissioning - MBC	Y		9/23/2020	Y	
		9	Commissioning	Y		9/23/2020	Y	
		10	Comments	-				
		1	Initial Software Checks	Y		9/19/2020	Y	
		2	Applicability of PSB, TIL & ETC	Y		9/19/2020	Y	
		3	Pre-power Checks	Y		9/21/2020	Y	
SAC-CTRL-LCI	System Audit Checklist - Load Commutated Inverter Controller	4	Power-On Checks	Y	Y	9/23/2020	Y	
		5	Running Checks	Y		9/23/2020	Y	
		6	Housekeeping	Y	Y	9/19/2020	Y	
		7	Comments	-				

Final

#	TA	Skill	Mobilization Date	Demobilization Date	# of Days
1	Sinoj Nair	GT Mechanical TA	13-Mar-17	17-Mar-17	4
2	Jafar Ali	GT Mechanical TA	28-Mar-17	2-Apr-17	5
3	Ashokkumar Periaithambi	GT Mechanical TA	19-Jun-17	30-Jun-17	11
4	Ashokkumar Periaithambi	GT Mechanical TA	11-Jul-17	22-Jul-17	11
5	Ashokkumar Periaithambi	GT Mechanical TA	9-Oct-17	18-Oct-17	9
6	Ashokkumar Periaithambi	GT Mechanical TA	17-Jan-18	2-Sep-18	228
7	Ashokkumar Periaithambi	GT Mechanical TA	30-Oct-18	23-Nov-18	24
8	Ashokkumar Periaithambi	GT Mechanical TA	10-Jan-19	22-Jan-19	12
9	Ashokkumar Periaithambi	GT Mechanical TA	15-Oct-19	25-Oct-19	10
10	Syed Akhiluddin	Borescope TA	18-Oct-19	19-Oct-19	1
11	Avinash Gajjar	GT Controls TA	20-Oct-19	25-Oct-19	5
12	Venkatesh Pala	GT Controls TA	7-Sep-20	2-Oct-20	25
13	Ashokkumar Periaithambi	GT Mechanical TA	16-Sep-20	2-Oct-20	16
14	Balraj Bawra	LCI/Electrical TA	18-Sep-20	2-Oct-20	14
15	Syed Akhiluddin	Borescope TA	21-Sep-20	22-Sep-20	1

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General Electric International Inc.

Date: 4 November 2020

Mr. ER Harikrishnan
 General Manager - Karnataka Projects
 BHEL PSSR
 KPCL Yelahanka Site

Dear Sir,

Please find below the comments on the Borescope inspection report of 9F.05 KPCL Yelahanka Unit (SN# 900107) for the Compressor section, Combustion & Turbine sections conducted during 21st to 23rd October 2020

Compressor section:

1. Inlet Guide Vanes appear to be in good condition.
2. One rotating blade, stage-0 (R0) is seen with a minor edge damage. The damage looks smooth. Site is advised to perform a red dye inspection to ensure there is no indication at the damage before startup.
3. Compressor blades and vanes from stage-1 thru stage-14 appear to be in good condition.
4. Two rotating blades of stage-15 (R15) are seen with impact damage on edge. Minor impact damages are also seen on one rotating blade of stage-16 (R16) and three rotating blades of stage-17(R17). These appears to be minor damage and can be addressed in next opportunity when component is exposed. Site is advised to inspect inlet per PSIB 20130813 A for any breach or leaks to avoid such impact damage.
5. Minor Surface oxidation is seen on the rotor surface and on casings. Adhere to GEK 28156 for preservation if unit is not being operated for long durations.

Combustion section:

Overall combustion section appears to be in good condition.

Turbine section:

1. Stage-1 Nozzles /stage-1 Shrouds /stage-1 buckets appear to be in good condition
2. Stage-2 Nozzles /stage-2 Shrouds /stage-2 Buckets appear to be in good condition. Soot like deposit observed on stage-2 nozzles and buckets.
3. Oil/deposits observed on Stage-3 Nozzles /stage-3 Shrouds and stage-3 buckets. Black soot like deposits are also seen on stage-3 nozzles and stage-3 buckets

Please note that this report is subject to confidentiality terms between GE and BHEL and is being issued for limited purposes of sharing the BI observations and does not amount to any opinion, findings or views on the ongoing Root Cause Analysis being conducted in relation to the fire incident at KPCL site, Bengaluru.

Issued by: GE Gas Power Inspection & Life Extension Services Team

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**1st RCA committee meeting on Fire accident on 9F.05 Gas Turbine at KPCL Yelahanka site on
12.10.2020 & 13.10.2020**

Members Present

Chairman RCA Committee Mr. P D Siwal, Former Member (Thermal), CEA	pdsiwal@yahoo.com
BHEL Mr. Surojit Mandal, BHEL PSSR Mr. Y M Babu, BHEL PSTS Mr. E R Harikrishnan, BHEL KPCL Site (Coopted to the committee) Mr. J U M Rao, BHEL KPCL Site (Coopted to the committee) Mr. P Manoj Kumar, BHEL Corp Quality (Couldn't attend due to health reasons) Mr. Madhusudan, BHEL HPEP Mr. Tapas Kumar Ray, BHEL PSER Mr. Kamaldeep Gupta, BHEL HPEP (Coopted to the committee) Mr. Abhiram Thatavarthy, BHEL HPEP (Coopted to the committee) Mr. Anoop Kumar R, BHEL EDN (Coopted to the committee)	surojit@bhel.in ymbabu@bhel.in erh@bhel.in jumrao@bhel.in pmanoj@bhel.in madhusudan@bhel.in tkray@bhel.in kamaldeep@bhel.in abhiram@bhel.in anoop.kumar@bhel.in
KPCL Mr. Satyanarayana, TA to MD KPCL	pctpkpcl@gmail.com
GE Gas Power Mr. Jagdish Rao, Senior Service Director, Mr. Mathan Radhakrishnan, Engineering Manager, Fleet management Mr. Sudhakar Todeti, Principle Engineer, Systems Engineering	jagdish.rao@ge.com mathan.r@ge.com sudhakar.todeti@ge.com

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2nd RCA committee meeting on Fire accident on 9F.05 Gas Turbine through VC on 20.10.2020

Members Present

Chairman RCA Committee Mr. P D Siwal, Former Member (Thermal), CEA	pdsiwal@yahoo.com
BHEL Mr. Surojit Mandal, BHEL PSSR Mr. Y M Babu, BHEL PSTS Mr. P Manoj Kumar, BHEL Corp Quality Mr. Madhusudan, BHEL HPEP Mr. Tapas Kumar Ray, BHEL PSER Mr. Kamaldeep Gupta, BHEL HPEP (Coopted to the committee) Mr. Abhiram Thatavarthy, BHEL HPEP (Coopted to the committee)	surojit@bhel.in ymbabu@bhel.in pmanoj@bhel.in madhusudan@bhel.in tkray@bhel.in kamaldeep@bhel.in abhiram@bhel.in
KPCL Mr. Satyanarayana, TA to MD KPCL	pctpkpcl@gmail.com
GE Gas Power Mr. Jagdish Rao, Senior Service Director, Mr. Mathan Radhakrishnan, Engineering Manager, Fleet management Mr. Sudhakar Todeti, Principle Engineer, Systems Engineering	jagdish.rao@ge.com mathan.r@ge.com sudhakar.todeti@ge.com

T. Manoj Kumar

**3rd RCA committee meeting on Fire accident on 9F.05 Gas Turbine at KPCL Yelahanka site on
06.11.2020**

Members Present

Chairman RCA Committee Mr. P D Siwal, Former Member (Thermal), CEA	pdsiwal@yahoo.com
BHEL Mr. Surojit Mandal, BHEL PSSR Mr. Y M Babu, BHEL PSTS Mr. P Manoj Kumar, BHEL Corp Quality Mr. Madhusudan, BHEL HPEP Mr. Tapas Kumar Ray, BHEL PSER (Could not attend due to engagement at Namrup) Mr. Kamaldeep Gupta, BHEL HPEP (Coopted to the committee)	surojit@bhel.in yimbabu@bhel.in pmanoj@bhel.in madhusudan@bhel.in tkray@bhel.in kamaldeep@bhel.in
KPCL Mr. Satyanarayana, TA to MD KPCL Mr. Narendra Prasad, ED BTPS, KPCL	pctpkpcl@gmail.com
GE Gas Power Mr. Jagdish Rao, Senior Service Director, Mr. Mathan Radhakrishnan, Engineering Manager, Fleet management Mr. Sudhakar Todeti, Principle Engineer, Systems Engineering	jagdish.rao@ge.com mathan.r@ge.com sudhakar.todeti@ge.com

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4th RCA committee meeting on Fire accident on 9F.05 Gas Turbine through VC on 24.11.2020

Members Present

Chairman RCA Committee Mr. P D Siwal, Former Member (Thermal), CEA	pdsiwal@yahoo.com
BHEL Mr. Surojit Mandal, BHEL PSSR Mr. Y M Babu, BHEL PSTS Mr. P Manoj Kumar, BHEL Corp Quality Mr. Madhusudan, BHEL HPEP Mr. Tapas Kumar Ray, BHEL PSER Mr. Kamaldeep Gupta, BHEL HPEP (Coopted to the committee) Mr. Abhiram Thatavarthy, BHEL HPEP (Coopted to the committee)	surojit@bhel.in yimbabu@bhel.in pmanoj@bhel.in madhusudan@bhel.in tkray@bhel.in kamaldeep@bhel.in abhiram@bhel.in
KPCL Mr. Shekhar Rao, KPCL	
GE Gas Power Mr. Jagdish Rao, Senior Service Director, Mr. Mathan Radhakrishnan, Engineering Manager, Fleet management Mr. Sudhakar Todeti, Principle Engineer, Systems Engineering	jagdish.rao@ge.com mathan.r@ge.com sudhakar.todeti@ge.com

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5th RCA committee meeting on Fire accident on 9F.05 Gas Turbine through VC on 26.11.2020**Members Present**

Chairman RCA Committee Mr. P D Siwal, Former Member (Thermal), CEA	pdsiwal@yahoo.com
BHEL Mr. Surojit Mandal, BHEL PSSR Mr. Y M Babu, BHEL PSTS Mr. P Manoj Kumar, BHEL Corp Quality Mr. Madhusudan, BHEL HPEP Mr. Tapas Kumar Ray, BHEL PSER Mr. Kamaldeep Gupta, BHEL HPEP (Coopted to the committee) Mr. Abhiram Thatavarthy, BHEL HPEP (Coopted to the committee)	surojit@bhel.in yimbabu@bhel.in pmanoj@bhel.in madhusudan@bhel.in tkray@bhel.in kamaldeep@bhel.in abhiram@bhel.in
KPCL Mr. Satyanarayana, TA to MD KPCL	pctpkpcl@gmail.com
GE Gas Power Mr. Jagdish Rao, Senior Service Director, Mr. Mathan Radhakrishnan, Engineering Manager, Fleet management Mr. Sudhakar Todeti, Principle Engineer, Systems Engineering Mr. P Ashok Kumar, GE Mech TFA	jagdish.rao@ge.com mathan.r@ge.com sudhakar.todeti@ge.com

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6th RCA committee meeting on Fire accident on 9F.05 Gas Turbine at BHEL PSTS Noida on 28.12.2020**Members Present**

Chairman RCA Committee Mr. P D Siwal, Former Member (Thermal), CEA	pdsiwal@yahoo.com
BHEL Mr. Surojit Mandal, BHEL PSSR Mr. Y M Babu, BHEL PSTS Mr. P Manoj Kumar, BHEL Corp Quality Mr. Madhusudan, BHEL HPEP Mr. Tapas Kumar Ray, BHEL PSER	surojit@bhel.in yimbabu@bhel.in pmanoj@bhel.in madhusudan@bhel.in tkray@bhel.in
KPCL Mr. Satyanarayana, TA to MD KPCL (Joined through VC)	pctpkpcl@gmail.com
GE Gas Power Mr. Jagdish Rao, Senior Service Director (Joined for 1 hr, registered that GE will provide comments by 4 th Jan 2021, which can be added as addendum)	jagdish.rao@ge.com

Handwritten signature: Surojit Mandal

ANNEXURE-R2

**REPORT OF PRELIMINARY ENQUIRY REGARDING THE ACCIDENT IN GAS TURBINE AREA AT M/s
KPCL- 1X370 MW COMBINED CYCLE POWER PLANT, YELAHANKA, BANGALORE ON 13-10-2020.**

A. PREAMBLE:-

An incident of fire accident was reported near the Gas Turbine area at M/s KPCL- 1 x 370 MW- Combined Cycle Power Plant, Yelahanka, Bangalore on 02-10-2020. In this backdrop, the Director, Department of Factories, Boilers, Industrial Safety and Health, Karnataka has included the Joint Director of Boilers, Bangalore also in the team formed for investigation into the accident along with other officials of the Department through an un-official note dated 05-10-2020. Hence the Joint Director of Boilers, Bangalore has visited the accident site on 13-10-2020 and conducted preliminary enquiry regarding the accident.

B. OFFICIALS PRESENT DURING ENQUIRY ON 13-10-2020:-

1. Sri. K.M.Pratham, Joint Director of Boilers , Bangalore
2. Sri. K.Shankarappa, SE(M), KPCL
3. Sri. G. Narayanappa EE(Commissioning), KPCL
4. Sri. Pulikeshi.C, EE(E,P) & Safety, KPCL
5. Sri R.M.Mahadevaprasad, EE(M1), KPCL
6. Sri. E.R.Hari Krishnan, GM, BHEL
7. Sri. K.K.Ajithkumar, Sr.DGM, BHEL

C. NATURE OF ACCIDENT:-

It is learnt that the commissioning activities were going on in 1 x 370 MW Yelahanka Combined cycle power plant. On 01-10-2020, the commissioning activities have commenced at around 14-30 hrs.

At around 02-52 hrs of 02-10-2020, it is learnt that Gas Turbine tripped on Fire protection in bearing 2 tunnel area and CO2 system has operated automatically to quench the fire. The engineers and other personnel overseeing the commissioning activities have come from the control room near the exhaust compartment at zero meter level which is below the bearing 2 tunnel area and a sudden rush of flame has occurred which came out of the exhaust compartment and a total of 15 persons were injured due to fire burns at that point of time. Further it is learnt that a total of three injured people have later succumbed to the injuries and died, one injured person is said to be critical in hospital and other eleven people are said to be out of danger.

D. TECHNICAL DETAILS OF THE WORKING AND NATURE OF THE POWER PLANT:-

The said power plant is combined cycle power plant with an installed capacity of 370 MW. The construction of the plant was started in the year 2015 and completed in the year 2020. The complete Engineering, procurement, construction (EPC) contract was awarded to M/s BHEL.

The said plant was to be commissioned by M/s BHEL and after the trial operation, reliability operation and performance guarantee test of the plant, it was supposed to be handed over to M/s KPCL for regular operations and maintenance.



Accident file
28/11



The main equipment manufacturer / suppliers are;

1. Regasified liquefied Natural Gas (RLNG) supply – M/s GAIL
2. Gas Turbine and Accessories – M/s BHEL in collaboration with M/s General Electric, USA (236.825 MW)
3. Heat Recovery Units (Steam Boilers) – M/s BHEL, Trichy
4. Steam Turbine / Generator – M/s BHEL (133.225 MW)

The General working principle of the CCPP is as under;

The RLNG is supplied from M/s GAIL terminal inside the plant premises is fed to the Gas Turbine combustion chamber through gas piping (Max pressure-34 KSC, Maximum Flow Rate- 12.81 Kg/Sec).

The gas entering the combustion chamber of the Gas turbine gets ignited and due to the flow of combustion exhaust gases, the Gas turbine rotates (rated speed of 3000 rpm) which in turn is connected to the Generator generating a maximum power of 236.825 MW at base load.

The exhaust gas coming out of the Gas turbine exhaust duct enters the HRSG zone at 657 Deg C (Heat Recovery Steam Boilers) wherein a total of 294 TPH, 23TPH & 30TPH of steam is generated at a maximum pressure of 134 KSC(G), 35.5 KSC(G) & 4.8 KSC (G) from HP, IP & LP circuits respectively.

This steam is fed in stages into the steam turbine connected to a Generator generating a maximum of 133.225 MW power.

The final exhaust gas at 100 Deg C is let out to atmosphere through the stack.

The HRSG's (Steam Boilers- 03 no's) are all inspected, tested and certified for use up to 22-03-2021 by the Boiler Directorate, Karnataka.

Safety systems , Interlocks and Control Systems;

The RLNG line has a vent at the GAIL metering station for immediate venting of unused gas in case of emergency. The gas line has vents near Gas conditioning skid and accessory module to let out the unused/entrapped gas out to atmosphere in case of emergency.

The entire operational system of the power plant is controlled by Max DNA and Mark VI e systems. There is a provision of auto operation and manual operation of important functions and emergency safety systems.

The exhaust compartment of the gas turbine is a closed structural chamber and a continuous negative pressure is maintained inside the chamber during operations as per the design.

The exhaust compartment has two door openings on either side at the ground level for entry and inspection during stoppages. The doors are locked through latches and dual layered glass windows are provided for viewing through the chamber.

All necessary trip instruments including the fire detection and trip mechanism are available for safeguarding the gas turbine and also a Carbon-di-oxide fire protection system to quench any fire inside the gas turbine compartment.

The entire exhaust compartment is fitted with gravity dampers with vent ducts on top to allow any gas or air which may develop positive pressure to escape out to the atmosphere.

The HRSG's (Steam Boilers) are mounted with all the required safety systems as required under the Indian Boiler Regulations, 1950.

The steam turbine is also controlled through DCS systems and has all the required safety systems required for safe operation of the turbine and accessories.




E. BRIEF NOTE ON THE INCIDENT:-

The commissioning activities of the power plant were going on and several dry run tests were also carried out by the commissioning team of BHEL in coordination with KPCL, M/s General Electric and several other equipment suppliers. All the commissioning activities were being carried out as per available written protocols of the equipment designer and supplier.

The BHEL commissioning team had planned to achieve the rated maximum speed (Full Speed No Load) of 3000 rpm on the Gas Turbine and later to synchronise the Power Output to the grid which would have happened at least 6 hours after achieving the rated maximum speed (FSNL) of Gas turbine for conducting electrical tests.

The activities were started at 14-30 hrs of 01-10-2020 and the maximum rated speed of 3000 rpm (FSNL) of Gas turbine was achieved at around 02-38 hrs on 02-10-2020. Later, at around 02-52 hrs on 02-10-2020, the Gas turbine got tripped on Fire protection in one of the bearing house (bearing no-2 tunnel) through automated safety instrumentation systems.

The Fire alarm notification as indicating "Fire at bearing 2 tunnel of GT " was appeared in the control room. The CO2 fire protection activated on auto due to sensing of fire. The inlet RLNG gas feed to the turbine has stopped and was let out through the provided vents to atmosphere activated through automated instrumentation systems.

Some of the commissioning personnel have gone near the exhaust compartment at around 03-00 hrs of 02-10-2020 to find out the ground reality of the fire. During this process, it is learnt that a flame jet has gushed out of the bottom ground level doors and the flame has hit several personnel who were standing in and around the GT south side area resulting in burn injuries to 15 people at that point of time. Personnel in the control room have further activated all the zone wise CO2 Fire Protection System as well as switched off the bearing lubrication oil systems as a precautionary measure.

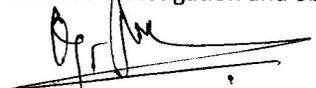
Later the plant personnel have observed lot of fire in the exhaust compartment due to burning of lube oil which had accumulated on the floor due to leakage from turbine oil system. It is estimated that around 10,000 litres of lube oil would have spilled on the floor due to this failure / leakage from bearing. The lube oil servo prime 32 has a flash point of around 200 deg C and there is every chance and possibility of this lube oil to ignite when it comes into contact with the exhaust gas from the Gas turbine, which is around 657 Deg C during normal operation. It is learnt that there was only one flash of flame outside the exhaust compartment.

The KPCL /BHEL staff observed that there was fire inside the compartment due to burning of spilled lube oil at ground level and flames found spreading up to roof of the GT compartment. Later, the fire fighting personnel from the factory as well those from GAIL and Karnataka Fire Services pressed into operation to put off the fire. In all, seven fire tenders were pressed into operation. The Fire was eventually doused off after fighting for 75 minutes by around 4.30 AM and cooling was continued till around 5.15 AM. It is also learnt that the fire alarm and hooter was on during the said incident.



A high level committee has been formed headed by Sri. P.D. Siwal, Former CEA member Thermal and including experts from M/s BHEL, M/s GE and M/s KPCL to ascertain the root cause for the incident and suggest the remedial measures to prevent recurrence in the future.

This preliminary report is based on the inputs given by the personnel present during the enquiry and also investigation and observations at the site of incident.


K. Shankarappa, SE(M), KPCL


E R Hari Krishnan, GM, BHEL


G. Narayanappa, EE (Commissioning), KPCL


K.K.Ajithkumar. Sr.DGM BHEL


Pulikeshi, C EE (E,P) & Safety, KPCL


R.M.Mahadevaprasad, EE(M1), KPCL


(K.M.Pratham)
Joint Director of Boilers, Bangalore

Bangalore, Dated 23-10-2020

Report submitted to the Director, Department of Factories, Boilers, Industrial Safety and Health, Bangalore for kind perusal.

ANNEXURE-R3









▲ DANGER
Watch for falling material
Safety signs and labels are provided for your information. For more information, visit us at www.safety.com

SERVO
SERVO

