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TECHNICAL AUDIT FOR PROFIT AND PERFECTION
(A case study of Commissioning - Thermal Power Plant)

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ABSTRACT

Thermal power generation is the main source of electrical energy in our country. Fossil fuel, generally low grade, high ash content coal is the main fuel for our thermal power plant. Approximate 48 months are required to get power from Greenfield power plants. The plant is consists of various interconnected intricate systems, consisting multi-corers of rupees investment but when it comes to commissioning and operation stage, a lukewarm approach is adopted which creates in perennial maintenance problems. It also results loss of thousand man-hours along with huge generation loss and sleepless nights for maintenance personnel. This is further aggravated with coal/ash erosion problem of the boiler components. Many times due to urgency in commissioning of the unit, safety aspects are overlooked which may result very costly damage of the power plant. In thermal power plant boiler area is the major problem prone area which causes the low availability of the unit. Systematic commissioning of boiler and its auxiliaries with full involvement of the original equipment manufacturer (OEM) and the customer's trained staff with proper understanding the management hold the key for getting standard result. Hence an integrated approach needs to be followed to minimize un-scheduled costly outages and losses. A case study methodology has adopted here for profit and perfection using the technical audit. With the help of technical audit, the problem encountered during commissioning of power plant can be solved by keeping close watch and better maintainability of the plant can be insured which will bring remarkable profit and perfection.

KEY WORDS: C.F. Boiler (Coal Fired Boiler), HT Motors (High Tension Motor), I.D. Fan (Induced Draft Fan), OEM (original Equipment Manufacturer), MW (Mega Watt), S.H (Side Header), ESP (Electro static precipitator).

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INTRODUCTION

During the operation of 200 MW power plant or plants of larger size, it has been realized that many problems of operations are caused due to improper commissioning of the plant and equipments. To ensure plant testing and commissioning in orderly, logical and safe manner, developing of following commissioning documents should be insured carefully-

- Commissioning procedures.
- Checklists.
- Safety procedures.
- Records of initial operations.
- Records of station operations.
- Procedure for acceptance test.
- Follow up the procedures.

Unfortunately, during the commissioning times, trained manpower is not deputed by station authorities due to non availability skilled person. Most of the time during commissioning stage, adequate and trained human resource of engineering, supervisory, operation and maintenance are not available. Uncertain, ill trained human resource at the time of initial period of operation not only wrecks havoc on the equipments but also prevents in obtaining the fruitful utilization of the equipments and cost benefit on investment. It has been seen in some cases that even after synchronization of power plant, the clients construction staff are forced to deal with OEM who consider the operation and maintenance as a burden because they also do not have adequate resources of operation and maintenance.

LITERATURE SURVEY

Survey of the research literature indicates that either the research have been directed out on General Auditing Principles or Procedures and not on the Effectiveness of Quality Audit itself. This has also been confirmed by Rajendran and Devadasan (2005). The only exception is Health and Milne (2002) and Franka Piskar (2006) who have given some contribution to Value Added Audit but it is not the technical audit.

The contribution of Zutshi and Sohal, (2002) represent the practical experience of eight prominent auditors with respect to adoption of EMS/ISO 14001 (a quality system) by Australian

Organizations. The issues and benefits relating to the quality auditing processes are discussed. The aims of research by Terziovski et al (2002) were to examine the role of non financial auditors and the audit process with respect to the existing ISO 9000 Quality Standards. They concluded that conformance auditing has a role in the early stage of quality system implementation but it is not the technical audit.

However, the effectiveness diminishes as the quality system matures. It has been observed by research results that 89% of the organizations firmly follow implementation of audit recommendations. Audit results, showing thrust on quality audit is recognized of [Beecroft, (1996); Pivka and Ursi, (1999); Seddon, (2001); Heras et al., (2002); Magd and Curry, (2003); Fuentes et al., (2003); Pan, (2003); Piskar, (2003); Pivika, (2004);

Marki, (2005)]. They worked for their theoretical and empirical work. Bhatt et al. (2004) worked on quality and cost improvements in neonatal prescribing through clinical audit. By completing the audit cycle, improved therapeutic care has been achieved with more accurate drug monitoring

target and reduced the drug cost. Similar findings have also been reported by Wickramasinghe and Sharma (2005), Smith and Manna (2005), and Souillard et al. (2005). Oliverio Mary Ellen (2007) has given thrust to Audit Quality in U.K. Financial Report Counsel in Feb. 2007. S. Nagata et al, (2008), has given valuable information for improving Product Quality through Audit System in April 2008.

Duraisamy, P., & James, Estelle & Lane and Julia & Jee-Peng Tan (1997), have written in their topic "Is there a quantity–quality tradeoff as enrollment increase, evidence from Tamil Nadu, India, have high lighted that increased enrollment of student requires increased resources and also it decreases the quality. Deolalikar, Anil & Hasan, Rana & Khan, Haider & Quibria, M.G., 1997, have pointed out in their research topic "Competiveness and human resource development" University Library of Munich, Germany, revised 1997, have the importance of human resource in quality education. David de la Croix & Matthias Doepke, 2007, in their topic "To segregate or to integrate- education, politics and democracy", said that it is the responsibility of Government to provide quality education to their citizen and resources for education should be managed by the Government. Alderman, suggested in their paper that the roll for private delivery of schooling services to poor households in developing countries is of importance if, college maintains good resource. Puja Vasudeva Dutta, 2006, suggests about the gap between the wages of teachers and its effect on quality education. Monazza Aslam, 2003, finds in their research the difference in government and private education in Pakistan and quality of education. Geeta Kingdon & Francis Teal, 2004, points out that the performance of students is related with the wage of the teachers. Geeta Gandhi Kingdon, 1997, describes the condition of female education in India.

Srivastava, S.B., March 2009, "Technical Audit for Improvement of Educational Quality" (A case study of Indian Engineering colleges where Customer itself is the Input and Final Product), has given good thrust on Technical Audit. Srivastava, S.B., October 2009, "Quality and Profitability Improvement by Technical Audit" a case study of process plant published in "International Journal of Computer Science and Engineering", indicates the importance of Technical Audit in process plant.

Srivastava, S.B., October 2009,"Technical Audit to Improve Maintenance Effectiveness" Published in proceedings of National Conference, "Engineering Trend in Mechanical Engineering, ETME 2009 at MMM Engineering. College Gorakhpur, .sponsored by "AICTE", is one of the important eye openers for industry owners. Again Srivastava, S. B., January 2010, "Manpower Assessment of a Chemical Plant" by Technical Audit – a case study, published in International Journal of "Engineering, Science and Technology" indicating the importance of technical Audit.

Srivastava, S, B., in January 2013, "Maintenance Effectiveness by Technical audit" published in "International Journal of Scientific and Engineering Research" has given good thoughts for maintenance engineers that the maintenance prevention can be achieved. The present work aims at giving more value to the Technical Audit which will result in the profit and perfection of the organizations e.g. audit of equipment effectiveness, system effectiveness, process effectiveness, method of audit etc. for reaching a step forward towards Zero defect in product. A case study of a C. F. Power Plant at commissioning stage is presented below for the same purpose.

DESCRIPTION

Detail description, technicality and correction during commissioning of thermal power plant is described as under -

TURBO-CHARGER

As far as concerned with turbo-generator set, the turbine and their auxiliaries are manufactured with utmost accuracy. There are many advanced test at shop floor level for turbine and generator manufacturing. Some of important tests are as under-

- Steam test.
- Full speed test.
- Over speed test.
- Dynamic balancing of generator rotor.
- Dynamic balancing of turbine rotor.
- Other electrical and mechanical test.

Turbo-generator sets are dispatched after taking the due care of site problems and also it is erected under strict supervision of specialists and millwright technicians. When commissioning activity starts based on the shop test records and measurements are taken during erection stage, the details are checked and the records are made as per check lists and procedures for smooth operation and for good maintenance practices. So, Turbo-generators and its auxiliaries pose lesser problems during post commissioning stages.

BOILER

Boiler and its auxiliaries are subjected to severe working condition because they handle abrasive materials like coal and ash. Sometimes ash contain in coal is even more than 45% which creates the dangerous problem in the components of boilers. Unscheduled pressure post outage, loss in coal mill system, problem on other major equipment like pre heater and ESP etc. are some of the problems related with the boiler system. So, the boiler maintenance crew is always on their toes to attend not only the planned maintenance work but most of the time, they are busy in attending crisis type maintenance job as such to keep the unit running.

Due to limitation in transporting the equipments well assembled, the parts of boilers are dispatched in a sequence and their parts are assembled at the job site. Kilometers of pressure parts like tubes are welded at site and as per rough estimate about 25000 joints are made by welding at site. Due to complicate erection of boilers components and the shear nature of boiler because of handling the abrasive material as fuel, it is very important to plan and insure trouble free maintenance of unit from inception of the project. As commissioning date reaches close, management starts applying pressure for early commissioning of plant as such to meet the committed target date as such to avoid any other financial implications.

In such circumstances, shortcut methods are used by bypassing the interlocks and safety protection systems. Problems arrived due to shortcut method, mostly remain un-attended, un-solved and becomes as maintenance prone areas leading into un-scheduled outages, breakdowns, costly repair/replacement etc. apart from loss of efficiency of system. As the above back grounds and limitations are added with design, maintenance, erection etc. so, proper commissioning of boiler becomes more important. Following are the some of the problems faced during

commissioning of different type boiler plants of different capacities. Line diagram of thermal power plant is given in Fig. No.1., showing the different system of plant.

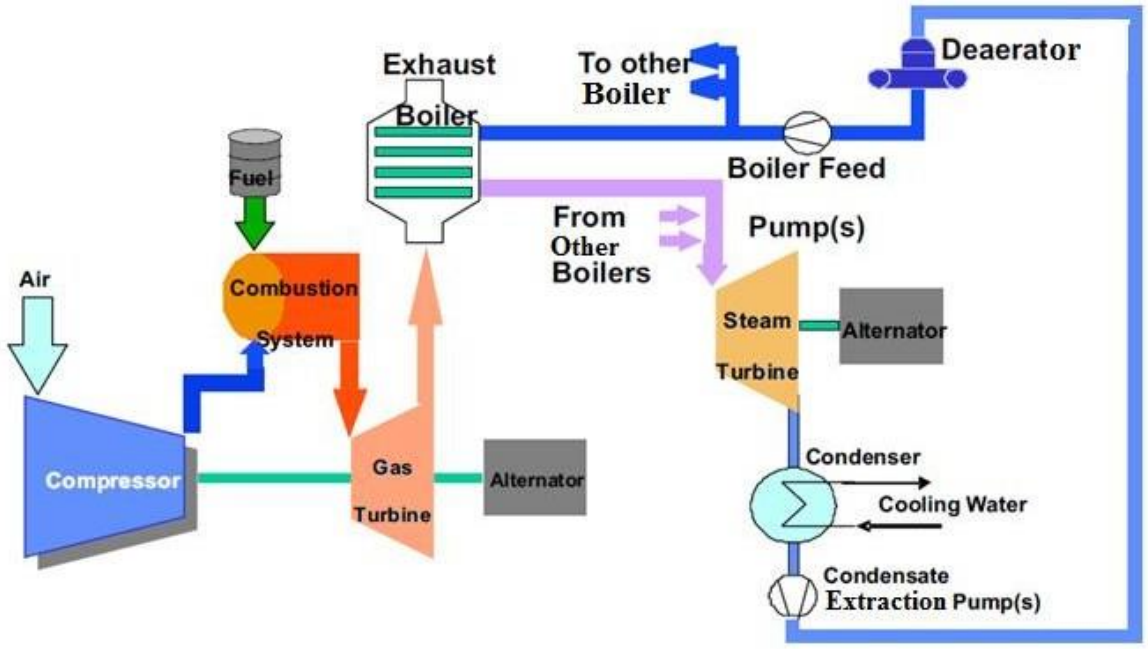

Fig.No. 1, Thermal Power Plant Concept (Line Diagram)

LONG STORAGE

Boiler erection materials are dispatched to work site in advance and stored at store yard for long time waiting for their turn of erection. Due to local environment and variation in climatic condition, material get affected even after taking due care in preservation. Foreign particles like sand, stone, dust, insects, rust grass etc. inter inside the tubes and get it choked. As inspection after erection is not possible, so, a choked tube starts failing during operation due to over heating. Line diagram of thermal power plant is given in Fig. No.1.

CLEANING METHOD DURING ERECTION STAGE

At the time of pre-assembly erection stage, tubes/coils are inspected for thoroughness by ball dropping test inside the tubes. In this test steel balls are passed through the tubes alongwith compressed air from one end and the same is collected at the other end. It was observed that in a 100MW, C.F. boiler that during the erection and after the test, the erectors have not checked the

test balls coming out at the other end. So, few balls stuck up inside the tube.

At the time of commissioning when the boiler was put into the operation, repeated tube rapture started in the flatten S.H. and final S.H. zone. OEM group was puzzled because of rupturing the tubes could not be pin pointed. After repeated failure and repair, one steel ball was found at the welding joint of platen S.H. binding coil. Another test ball was found stuck up with header to tube nipple joint in final super-heater area. To avoid such type of human errors, testing with steel balls should be discontinued and a soft sponge balls should be used for this test.

ACID CLEANING

Acid cleaning of pressure parts, during boiler commissioning is an important milestone activity and it is carried out under strict supervision of specialists. Any deviation of specifications in acid cleaning operation will result in tube failure and there may be other related problems during operation of the unit. Two serious problems faced due to negligence in acid cleaning are narrated as below-

- In first time acid cleaning process, super heaters and water wall tubes are considered. In one unit of 100 KW, it was observed that after taking due a precaution of emergency and safety aspects, the acid cleaning process was started. Big size acid circulation pumps, two numbers (one running and one standby) were operated for acid circulation and when the acid reaches in the pressure parts i.e. inside contours of boiler tubes, one by one both pumps failed due to gland leakages resulting the acid spilled on the HT Motors. Now, there was no any other means to arrange the mass transfer of acid into the acid solution to drain ponds with clear water. Now, the acid solution was pushed out with filling lines and drains for days. With traces of lean acid mixture inside the tube, particularly in the super heater tubes (non drainable portions), the repeated super heater tubes failure started during operation causing unscheduled stoppages.
- Here is another very bad example which occurred in 200MW boiler. As a standard practice, the down comer pipes are covered with orifice plates inside the drum to streamline the acid circulation. Platen water wall down comers are smaller in diameter than the water wall down comers. While covering the down comers with small diameter, the orifice plate of platen water wall was inadvertently fixed on the main down comer which got slipped and went straight inside the pipe. The group responsible the job did not report to the concerned about this grave mistake and acid cleaning operation was completed. Now, when the boiler was put into the regular operation, repeated water wall tube rapture started at higher loads. Though the water circulation system and other critical design parameters were studied thoroughly but the reason of repeated rapture could not be discovered. Now the management has decided to cut the ring header holes and to clean it again. During inspection of ring header pipe with site make periscope, the orifice plate was located inside the ring header obstructing the passage near the T-joint.

Now, the header was cut at T-joint again and orifice plate was removed along with other foreign objects. There after the system was normalized.

Here it is said that a full-proof system should be adopted for acid cleaning. Pumps handling the water are not suitable for acid cleaning. Design of pumps varies for handling different chemicals and their conditions. Similarly, piping materials are also different for different fluids.

SAFETY VALVES

Safety Valves are the critical areas where slippages occur. Before safety valve floating operation, valves have to be checked properly for its seat and disc. The hydrostatic plug fitted inside the safety valve should be removed before light up the boiler. There was an instance where hydrostatic test was conducted by applying the safety gags on top of the safety valves. After hydrostatic test, boiler light up instruction was given. Though confirmation was given that the gags on safety valves have been removed but actually it was not removed.

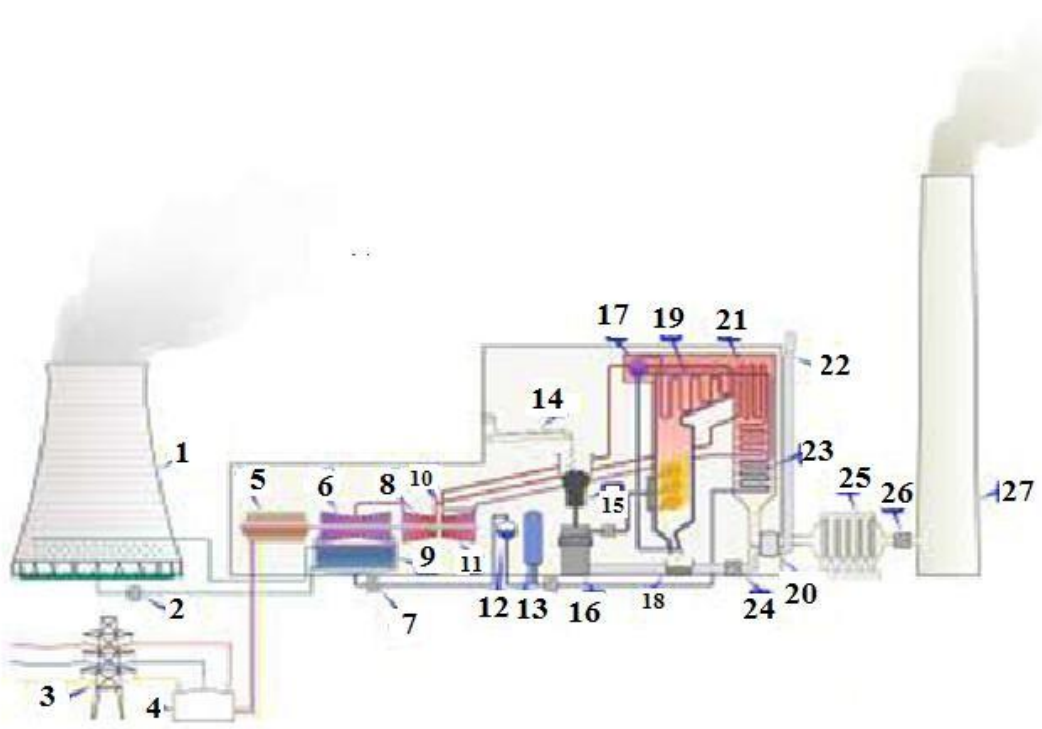

Fig. No. 2, Units of thermal power plant

1. Cooling tower
2. Cooling water pump
3. Transmission line (3-phase)
4. Step-up transformer (3-phase)
5. Electrical generator (3-phase)
6. Low pressure steam turbine
7. Condensate pumps
8. Surface condenser
9. Intermediate pressure steam turbine
10. Steam Control valve
11. High pressure steam turbine
12. De-aerator
13. Feed Water heater
14. Coal conveyor
15. Coal hopper
16. Coal Pulverizer
17. Boiler steam drums
18. Bottom ash hopper
19. Super-heater
20. Forced draught (draft) fan
21. Re-heater
22. Combustion air intake

23. Economizer
24. Air pre-heater
25. Precipitator
26. Induced draught (draft) fan
27 Flue gas stack

Now, after increasing the boiler pressure 80%, the blunder was noticed and by that time, due to thermal expansion, enough damage has been done to the safety valves. Safety valve spindle of two valves out oF five safety valves got bend beyond repair. Now the valve were kept isolated (gagged) till imported new spindles of valves were air lifted from OEM and then fitted.

As a word of caution, these serious laps can be happening even after capital maintenance of the boilers. Similarly while adjusting the blow downs and get pressure, if, due care is not taken, safety valves start malfunctioning creating the nuisance to maintenance personnel.

In another case, it was observed that the designer has give two 90° bends for drum safety valve inlet pipes. When the floating operation started, valve flanges started to fail due to heavy abnormal vibrations, shaking the whole drum level floor with flange bolt coming out of the joint. More than 30 times the floating operation was carried out before rectifying the design deficiency. The condition was so that the staff denied to go near the safety valves even for normal inspection.

MILL PLANT

In Fig. No. 2, coal mill is shown at 16. Commissioning of the milling plant is itself a major activity. Any deviation in Mill System commissioning will affect the boiler operation and efficiency loss of the boilers. Mill system mainly consists of –

- Centrifugal fans.
- Mill coal feeding arrangement.
- Coal transport through pipelines.
- Coal Mills.
- Conveyors.

Coal Mill plant handles the raw coal, so, most of the part are prone to erosion. A number of commissioning checks and procedures are to be adopted for mill system, like following-

- If, clean air test is not conducted properly it will result un-equal coal flow through mill discharge pipe to the furnace.
- Combustion will be affected which will have cascade effect on flue gasses and steam temperature if, problem in clean air test.

Coal Mill plant requires a continuous monitoring and setting with critical clearness for obtaining smooth operation and timely maintenance. A simple duct mounted seal air fan created havoc and repeated shut downs in 300 MW unit.

Commissioning Engineers come across the following problems during commissioning and post commissioning stage of the mill system –

- Failure of Mill duct guard seal.
- Excess vibration in primary air fan.
- Failure of bearing housing of primary air fan.
- Excess wear on Mill Rollers.
- Mill Vertical shaft failure.
- Failure of control system.

FURNACE PROBLEMS

In most of the power plant bypassing the furnace safety system is very common features for reducing the commissioning time. Instead of making the safety system more reliable and full safe, the following short cut system is adopted to cut commissioning time in most of the plant by–

- Bypassing the important interlocks.
- Bypassing the protection system.
- Bypassing the safety logics

These short cut methods are approved without considering its impact of damage because of pressure of management for meeting the target dates. Instead of identifying and rectifying the defects, short cut procedures are continuing even after commissioning. Due to adoption of short cut methods, following problems may arise-

- Furnace puffs.
- Minor explosion.
- Damage to buck stays.
- Ash leakage in pent house due to improper sealing of roof tubes.
- High excess air and high gas temperature.
- High specific energy consumption.
- Excess Mill part wear.
- Low Mill output.
- Boiler efficiency loss.
- Pollution and dust nuisance.

Once the damage occurs, rectifying the problem prone area and bringing it near to original shape is difficult even after the arrangement of good finance and very skilled manpower. It was observed in a 200 MW unit, a serious expansion took place due to bypassing of some furnace safety precautions.

In a C.F. Boiler, if, burner and burner wind box are not set properly, the whole concept of fire ball gets deviated leading the un-equal firing condition. Buck stay bends; buck stay pin shearing and furnace puffs are some of the common problems experienced in most of the power plant furnaces.

PROBLEMS RELATED WITH OTHER AUXILLARIES

In general, during boiler commissioning, every equipment and system related with boiler

operation is equally important. Suppose if, the dampers of a fan are not being set properly, it will give the following problem during the operation –

- Air leakage will be excess.
- There will be control deviations.
- There may be the speed fluctuations.
- There may be combustion problems.

Similarly, there are other problems like –

- If, electric motors are not checked and commissioned properly, total system will be affected.
- If, controls are not tuned, and regimes are not set properly, it can cause spurious and hide out tripping.
- If, calibration of instruments is not done properly, it will give spurious measurement.
- If, timely warning system is not commissioned, big disasters may come.

- If, accurate measurement of parameters is not there, the boiler safety will be questionable.

Once a problem was faced in commissioning of a 200MW boiler, there were five drum level indicators in control room and all the five were giving the different readings with a wide range of variation and also not matching with the direct level gauge glass readings. Also surprising that control engineers did not believe on level gauge glass reading which indicate the serious problem with calibration of instruments.

CONCLUSION

It has been discussed in details regarding the problems pertinent to commissioning of power plant. Now the question is how to minimize / eliminate the problems or human error or equipment defects during commissioning. From above discussions, it is clear that problems can be minimized only by adopting the rigid controls by practicing engineers. The directives from management should also be there mentioning to avoid the shortcut methods. Conclusions are as under to achieve trouble free commissioning of the unit.

Identify customer commissioning group well in advance. Customer commissioning team and OEM commissioning team should start checking the equipments when erection process is nearing to completion stage. All the activities should be divided into small segments and detailed check lists and as well as commissioning protocols should be prepared.

Each activity should be checked in detail with erection measurement readings, deviations etc. and signed by concerned parties. Any defects arising should be rectified and noted down. In equipment protocol, important reading like alignment, blue matching details, vibration readings, loading conditions, abnormalities etc. if any, should be recorded.

Before starting any main equipment, say I. D. Fan, all other connected protocols like lube oil system, dampers, fan impeller clearance, motor test certificate with no load readings, connected control and instrument should be checked and clearance from concerned agency should be obtained. It is good practice to involve the erection agency so that team sprit and better working

environment can be achieved. It is preferable to write the short comings as and when noticed so that rectification at early stage can be arranged.

Encourage free discussion and suggestion for improvements. This will reduce human errors and fear complex as well as improve operator's confidence level. Avoid victimization and fault finding in individuals. Keep management informed about all the activities as well as about the shortcomings so that management can break upon the scheduled targets and assist by way of rushing spares, additional manpower, specialists, financial approval etc. as per requirement.

Before starting any important mile stone commissioning activity like acid cleaning, boiler light up, steam blowing, safety valve floating, coal firing etc. check all the safety aspects in detail preferably twice times, train OEM group, inform all concerned about the detail of operation, expected duration, requirement of inputs, procedures, details of subsequent operations, anticipated troubles etc. so that team sprit and involvement on the job are created. It is important

to collect maximum details and information during such activity which will helps in overcoming the problems arising during regular operation of plant and equipments.

Keep close watch on developments and incorporate the improvements for better maintainability of plant and equipment after commissioning.

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