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HAZARD ANALYSIS AND RISK ASSESSMENT IN THERMAL POWER PLANT

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ABSTRACT

This project deals with various types of hazard analysis and finding a risk assessment in thermal power plant. The safe working operation of a thermal plant needs to identify the hazards, assess the associated risks and bring the risks to tolerable level on a continuous basis. There are several unsafe conditions and practices in various process and equipments of the thermal power plant lead to a number of accidents and which can causes loss and injury to human lives, damages the property, interrupt production etc. A risk assessment is an important step in protecting the plant from such conditions. It helps us to focus on the risks that really have the potential to cause harm. The hazard resolution process is to assess the identified hazards in terms of the severity or consequence of the hazard and the probability of occurrence of each type of hazard. Risk classification by severity and probability can be performed by using a risk assessment matrix. This assessment allows one to assign a risk assessment value to a hazard based on its severity and its probability. This value is then often used to rank different hazards as to their associated risks. To determine what actions to take to eliminate or control identified hazards, a system of determining the level risk involved must be developed. A good mishap risk assessment tool will enable decision makers to properly understand the level of risk involved, relative to what it will cost in schedule and dollars to reduce that risk to an acceptable level. Risk determination is an essential and systematic process for assessing the impact, occurrence and the consequences of human activities on systems with hazardous characteristics.

KEYWORDS: Hazard Identification and Risk Analysis (HIRA), Frequency Rate, Severity Rate.

I. INTRODUCTION

Risk is always associated with the frequency of failure and consequence effect. Predicting such situations and evaluation of risk is essential to take appropriate preventive measures. The major concern of the assessment is to identify the activities falling in a matrix of high & low frequencies at which the failures occur and the degree of its impact. The high frequency, low impact activities can be managed by regular maintenance Whereas, the low frequency, high impact activities (accidents) are of major concern in terms of risk assessment. As the frequency is low, often the required precautions are not realized or maintained. However, the risk assessment identifies the areas of major concerns which require additional preventive measures.

The aim of hazard identification is to develop a comprehensive list of sources of risks and events that might have an impact on the achievement of each of the objectives (or key elements) identified in the context. This step in the risk assessment process involves the identification of hazards and the determination of their causes. Hazard identification is the process of defining and describing a hazard, including its Physical characteristics, magnitude and severity, probability and frequency, causative factors, and locations or areas affected. There are five basic methods of hazard identification that may be employed to identify hazards:

- Data from previous accidents (case studies) or operating experience
- Scenario development and judgment of knowledgeable individuals
- Generic hazard checklists
- Formal hazard analysis techniques
- Design data and drawings.

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When identifying the safety hazards present in a system, every effort should be made to identify and catalogue the whole universe of potential hazards.

II. SYSTEM DOMAIN

Thermal power plant is electricity generation plant which converts the fossil fuel stored energy to electrical energy by means of generating electricity. In other words, it is merely a chain of Energy conversion as follow:

- Chemical energy in the fuel is converted to Heat energy of steam.
- Heat energy of steam is converted to Mechanical or rotating energy of a rotating wheel called Turbine.
- The mechanical energy of Turbine is converted as Electrical Energy in a Generator.

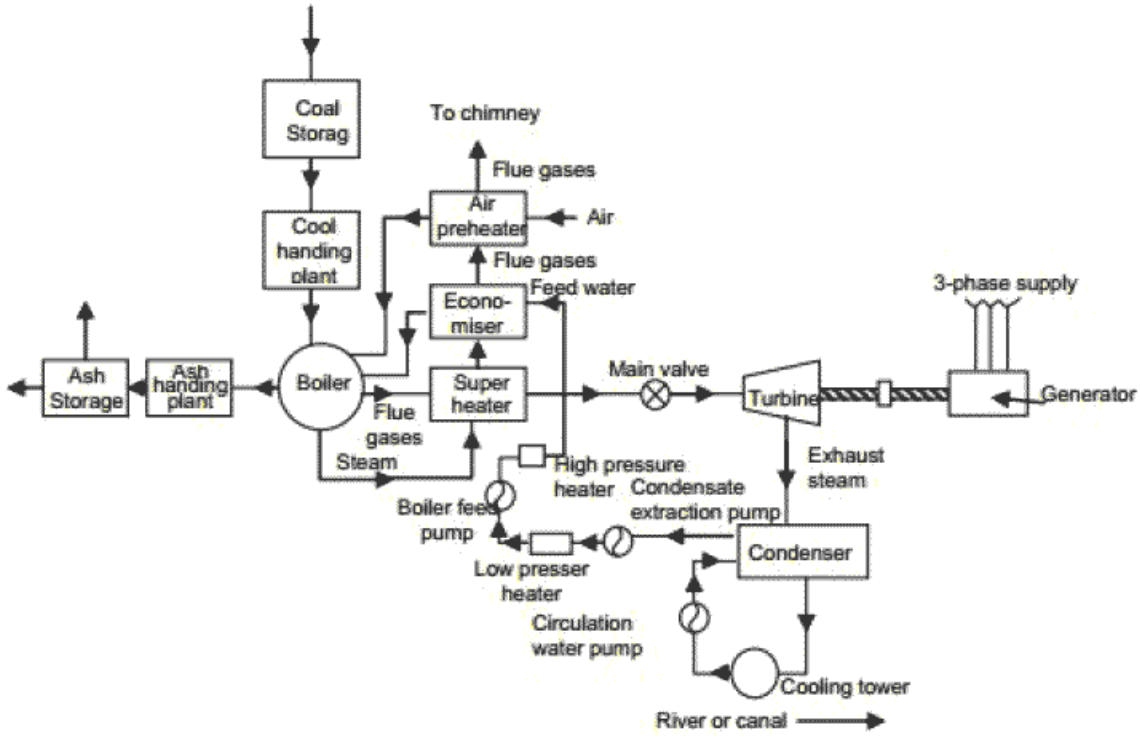

Fig. Block diagram of thermal power plant

The different types of systems and components used in steam power plant are as follows:

1. Coal handling plant
2. D.M. plant
3. Boiler and furnace
4. Turbine and Generator
5. Transformer and switch yard
6. Ash handling plant
7. Cable gallery
8. Fuel Storage Tank / Pump House/Batter

III. PROBLEM FORMULATION

The thermal power plant consist several risk and hazard in their various part of plant and its operational processes. This may cause harm to people, property and environment. Those hazards are for example "coal dust explosion" in the coal storage area and coal mill where fine particles of the coal present may occur when concentration of coal dust particles are within the explosive range. That can also occur in the plants where coal dust collectors are present due to the failure or low efficiency of the collector system.

Another most hazardous area of the thermal power plant is boiler room which includes furnace, boiler tank, water & steam tubes and exists for byproduct of coal combustion operation like fly ash, suspended ash and flue gases. The boiler room has risk of fire and explosion may caused Due to improper ignition of fuel, lack of air

supply in combustion chamber, improper pulverized coal lack of water, over pressure & over temperature ,cracks & metal fatigue in boiler body. The periodical inspection of the boiler is done as per "the Indian boiler act" but due to some sudden occurrence of hazardous event it may occur.

Flue gas the byproduct of combustion in furnace content high pollutant like SOx , NOx , CO2 and fumes of heavy metals like arsenic (Ar), Mercury (Hg), Boron (B). When they emits in excess amount from the permissible limit can cause hazard to flora and fauna.

There are several other hazards which can be listed to analyze for reduction are electrocution, Thermal Exposure, physical hazard, chemical exposure hazard, noise in turbine room, chronic and acute health hazard.

IV. METHODOLOGY

We use Hazard analysis and risk assessment method which include five steps-
1. System description
2. Hazard analysis
3. Risk assessment
4. Risk rating
5. Resolve the risk

Hazard in various operational area of the plant is as follows

Table .1 Hazards in Coal handling plant:

S. No.	Hazard	Description
1.	Fire in coal storage	Fire can occur in the coal storage due to excess environmental temperature in summer days. Or come in contact with external fire and explosion.
2.	Coal dust explosion in coal conveyer bunker	Confinement of coal bunker can have coal dust level up to lower explosive limit of coal dust, when got ignition can cause explosion
3.	Injury during coal handling like slip and trip	Various obstructs in the handling pathway of workers
4.	Respiratory problem due to coal dust	Very fine coal dust can cause respiratory problem
5.	Catches on conveyer belt	Loose clothing of worker can be catch by the moving parts
6.	Rail line and other transport line accidents	Carelessness of driver or personnel can cause accidents
7.	Injury during maintenance on ball mill	Heavy rollers have to be changed time to time during which physical injury can occure
8.	Fall from the height during work on conveyer belt, conveyer control room etc	Fallen structure, slippery surface, avoidance of PPE, imbalance of object or foot of worker
9.	Struck by falling object	Tools, coal pieces can fall from high operational area

Table .2 Hazards in D.M. plant:

S.No.	Hazard	Description
1.	Fire hazard	Electric Motor Short Circuit / Fire in electrical panel
2.	Chemical burn	by Spillage of sulphuric acid and caustic soda lye during unloading, overflow, Damage on storage tank or pipe line
3.	High noise level	By various pump and equipments vibration

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Table 3: Hazards in Boiler and furnace:

S.No.	Hazard	Description
1.	Explosion in boiler	due to over pressure and temperature caused faulty gauge, inoperable trip system,due to improper combustion of fuel.
3.	Burn injury	due to hot water and hot steam pipeline leakage,Exposure to the hot surface of pipeline or machineries,by hot fly ash
4.	Water tube burst	due to Failure in boiler water level control
5.	Fire in diesel supply line	Due to leakage, overpressure rapture of pipe
6.	Physical injury	Catches on the moving part of the machinery like F.D. fans or motors
7.	Equipment damage	rupture of the equipment body due to over pressure and over temperature
8.	Sleep , trip and from the height	during routine work, maintenance or inspection,Fallen structure, slippery surface, avoidance of PPE, imbalance of object or foot of worker

Table 4: Hazards in Turbine and Generator:

S.No.	Hazard	Description
1.	Equipment damage	Damage on generator due to lack of lubrication in coupling shaft,Damage on generator due to lack of lubrication in coupling shaft
2.	Fire / explosion	on cooling oil,on hydrogen tank,Explosion in turbine due to cooling system failure,Explosion in turbine due to cooling system failure,Fire on cooling oil,Fire and explosion on hydrogen tank
3.	High noise level	Due to operation and vibration of equipment

Table 5: Hazards in Transformer and switch yard:

S.No.	Hazard	Description
1.	Fire on transformer	Explosion of transformer / Pneumatic actuator cylinders installed nearby,Transformer oil may splash up to long distance if transformer gets exploded due to fire.
2.	Electric shock and electric burn	routine work, maintenance or inspection of electrical panels in switch yard
3.	Slip , trip and from the height	during routine work, maintenance on switch yard

Table 6: Hazards in Ash handling plant:

S.No.	Hazard	Description
1.	Fire hazard	fire risk due to electrical short circuit or failure, overheating, ignition in accumulated coal dust

Table 7: Hazards in Cable gallery:

S.No.	Hazard	Description
1.	Cable room fire hazard	fire risk due to electrical short circuit or failure, over heating of cables,

Table 8: Hazards in Fuel Storage Tank / Pump House/Battery:

S.No.	Hazard	Description
1.	Fire hazard	Spillage or drain is risky because it may result in to back fire and consequent damage to plant.

Table 9: Hazards in Hydrogen plant:

S.No.	Hazard	Description
1.	Fire or explosion hazard	hydrogen is highly explosive any leakage of Hydrogen in turbo generator area or Hydrogen plant area may lead to explosion /Fire
2.	Electrocution	Electrodes used in generation panel can cause electric shock

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Establishing event Frequency and likelihood category Ranges

Frequency range of event can be established using a format that includes time between the occurrences, a qualitative description of these frequency range and categories or level of likelihood. A likelihood category chosen for the risk assessment to provide a frequency range to work when for example a likelihood category in table relates a frequency range and midpoint.

Table 10: Initiating event likelihood categories

Likelihood Category	General Definition
1- Very low	Very remote possibility of occurrence (0.000001>P)/ So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 10^{-6} in that life. Unlikely to occur, but possible
2-Low	Possible to occur once over 2-3 times the useful life of the process (0.0001>P>0.000001)/ Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-3}but greater than 10^{-6} in that life. Unlikely, but can reasonably be expected to occur.
3-Moderate	Possible to occur once over the lifetime of the process (0.001>P>0.0001)/ Likely to occur some time in the life of an item, with a probability of occurrence less than 10^{-2}but greater than 10^{-3}in that life. Will occur several times.
4-High	Possible to occur once per average process life cycle (0.01>P>0.001)/ Will occur several times in the life of an item, with a probability of occurrence less than 10^{-1} but greater than 10^{-2}in that life. Will occur frequently.
5- Very high	Possible to occur occasionally (P>0.1)/ Likely to occur often in the life of an item, with a probability of occurrence greater than 10^{-1}in that life.

Establishing event consequences category Ranges

The consequences relate the potential expected damage to property, people's life safety etc. The following table's gives the consequence rage related to the qualitative losses data first on the base of life safety consequences and other property damage consequences.

Table 11: Life Safety Consequences Categories

Consequences Level	General Description
1-Low	First aid
2-Moderate	Single person injury required hospital treatment
3-Heavy	Multiple person injury required hospital treatment
4-High	Life threatening injury or death On site
5-Very High	Life threatening injury or death Off site

The table give for selecting likelihood tolerance:

Table 12: Property damage categories

Consequence Level	Damage Factor Range (%)	General Definition
1-Slight	0-1	Limited localized minor damage not requiring repair
2-Light	1-10	Significant localized damage of some components Not requiring major repair
3-Moderate	1-25	Significant localized damage of some components Warranting repairs
4-Heavy	25-60	Extensive Process equipment damage requiring major repairs
5-Major	60-100	Major wide spread damage that may result in facility major structural damage and the release of contaminated combustion products OFF SITE

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Risk rating

Risk initiating event likelihood and consequences are assumed by taken reference of visited plant real activities. Risk Classification screening table is given below.

Table 14: Risk Classification Screening Table

S. N	Hazard Disciption	Initiating Event Likelihood	Unmitigated Consequences		Risk Class
			Life Safety	Property Damage	
1	**Coal Handling Plant Hazard**				
i	Fall from the height during work on conveyer belt, conveyer control room etc	3	4	-	C
ii	Fire in coal storage	2	1	2	B
iii	Coal dust explosion in coal conveyer bunker	1	3	4	B
iv	Respiratory problem due to coal dust	3	3	-	B
v	Catches on conveyer belt	2	2	2	B
vi	Injury during maintenance on ball mill	3	3	1	B
vii	Injury during coal handling like slip and trip	4	1	-	A
viii	Rail line and other transport line accidents	4	2	1	A
ix	Struck by falling object	4	2	1	A
2	**D.M. Plant Hazard**				
i	Fire hazard	2	3	3	B
ii	Chemical burn by Spillage of sulphuric acid and caustic soda lye during unloading, overflow, Damage on storage tank or pipe line	4	3	2	A
iii	High noise level	1	3	-	A
3.	**Boiler Hazard**				

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i	Explosion in boiler due to over pressure and temperature	1	4	4	C
ii	Explosion in boiler due to improper combustion of fuel.	1	4	4	C
iii	Water tube burst due to Failure in boiler water level control	2	-	4	C
iv	Burn injury due to hot water and hot steam pipeline leakage	3	3	3	B
v	Fire in diesel supply line	3	3	3	B
vi	Sleep , trip and from the height during routine work, maintenance or inspection	4	4	2	B
vii	Burn injury by hot fly ash	4	1	-	A
viii	Catches on the moving part of the machinery like F.D. fans or motors	3	2	1	A
ix	Burst of the equipment body due to over pressure and over temperature	3	1	4	A
X	Exposure to the hot surface of pipeline or machineries.	3	1	-	A
4.	**Turbine hazard**				
I	Fire and explosion on hydrogen tank	2	5	4	D
ii	Explosion in turbine due to cooling system failure	1	4	5	C
iii	Explosion in turbine due to cooling system failure	1	4	5	C
iv	Fire on cooling oil	3	3	3	B
V	High noise level	1	3	-	B
5.	**Switch Yard Hazard**				
i	Fire on transformer	3	-	4	C
ii	Electric shock and electric burn routine work, maintenance or inspection of electrical panels in switch yard	5	4	1	B
iii	Slip , trip and from the height during routine work, maintenance on switch yard	4	4	1	B
6.	**Other Hazard**				
I	Fire on ammonia storage tank	2	4	4	C
ii	Fire hazard on fuel storage tank	2	4	4	C
iii	Control room fire hazard	2	1	3	A
iv	Eye irritation and respiratory problem from the exposure of ammonia leakage from storage tank or pipeline	4	1	-	A

Hazard identification and risk analysis was carried out for a thermal power plant and the hazards were identified and risk analysis was carried out. The different activities were divided in to high, medium and low depending upon their consequences and likelihood. The high risks activities have been rated 'C' or 'D' are un-acceptance and must be reduced. The risks which are rated 'B' are tolerable but efforts must be made to reduce risk without expenditure that is grossly disproportionate to the benefit gained. The risks which are rated 'A' have the risk level so low that it is not required for taking actions to reduce its magnitude any further. The risk rating calculations were carried out by a qualitative method as mentioned in the table respectively.

V. CONCLUSION

In this paper we observe that risk assessment is very helpful for finding hazards conditions in power plant. Hazard analysis and risk assessment can be used to establish priorities so that the most dangerous situations are addressed first and those least likely to occur and least likely to cause major problems can be considered later.

The first step for emergency preparedness and maintaining a safe workplace is defining and analyzing hazards. Although all hazards should be addressed, resource limitations usually do not allow this to happen at one time from the study carried out in the thermal power plant and the risk rating which were made and analyzed shows that various risks in the plant were more over certain distance. Improper use of personal protective equipment can be managed by appointing security specially to check if all are wearing personal protective equipment and if not the entry in the working are should be prohibited . In this project report we observe present scenario of existing safety measures and its efficiency. The risk rating of the present and possible hazard is evaluated which divide them into acceptable, tolerable and unacceptable risk level. Which risks are in unacceptable level there possible corrective action also recommended to improve safety measure and analysis. The results of this analysis will be of valuable to find out the consequence on emergency situation that may occur. With this knowledge, the level of preparedness can be assessed and measures taken to enhance capabilities through training and preparation of a more effective response to such occurrences.

VI. REFERENCES

[1] MIL-STD-882E 11 May 2012 Department Of Defense Standard Practicesystem Safety AMSC
[2] Sonja Vidojkovic a,Antonije Onjia b, Branko Matovic c, Nebojsa Grahovac c, Vesna Maksimovic c, Aleksandra Nastasovic a (2013) "Extensive feedwater quality control and monitoring concept for preventing chemistry-related failures of boiler tubes in a subcritical thermal power plant" Applied Thermal Engineering 59 683e694
[3] Sanjay Kumar& Dalgobind Mahto "Recent Trends In Industrial And Other Engineering Applications Of Non Destructive Testing" A Review International Journal of Scientific & Engineering Research, Volume 4, Issue 9, September-2013 183 ISSN 2229-5518
[4] T. Rajkumar*, Mrs.V.M.Ramaa Priyaa** "Boiler Drum Level Control by Using Wide Open Control with Three Element Control System" International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May-2013 204-210 ISSN 2229-5518
[5] Naresh Kumar1Umakant Yadav, 1Mukesh Kumar Rathi "To study the Erosion Behavior of H.V.O.F. Coating of 16Cr5Ni at the different velocity of slurry" International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013ISSN 2229-551 577-583
[6] V.G.Vijaya, A.Kumaraswamy "Design and Implementation of pH Control System for Boiler Feedwater using Industrial Automation Techniques" International Journal of Scientific & Engineering Research Volume 4, Issue 1, January-2013 1 ISSN 2229-5518
[7] Adel Alyan Fahmy and Loula A. Shouman "Deterministic Study on the optimum performance of counter flow Cooling Tower" International Journal of Scientific & Engineering Research Volume 3, Issue 6, June-2012 ISSN 2229-5518
[8] Md. A. A.Mamun, SubratoBiswas. "Waste Heat Recovery System by Using an Organic Rankine Cycle (ORC) , "International Journal of Scientific & Engineering Research, Volume 3, Issue 10, October-2012 ISSN 2229-5518 1
[9] Megha S.Kamdi1, Isha.P.Khedikar ², R.R.Shrivastava ³(2012) "Physical & Chemical Parameter of Effluent Treatment Plant for Thermal Power Plant" International Journal of Engineering Research & Technology (IJERT)Vol. 1 Issue 4, June – 2012 ISSN: 2278-0181
[10] Ali Musyafa1, Hardika Adiyagsa2 "Hazard and Operability study in Boiler System of The Steam Power Plant" IEESE International Journal of Science and Technology (IJSTE), Vol. 1 No. 3, September 2012,1-10

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

[11] Mahamudul Hashan, M. Farhad Howladar, Labiba Nusrat Jahan and Pulok Kanti Deb, (2012) "Ash Content and Its Relevance with the Coal Grade and Environment in Bangladesh" International Journal of Scientific & Engineering Research, Volume 4, Issue 4, April-2013 675 ISSN 2229-5518
[12] Dr.JAGDISH C. HUNDEKARI, "Prolonged Occupational Exposure to Stressful Stimuli(Heat) as a Cause of raised Atherogenic Index in Thermal Power Station Workers International Journal of Scientific & Engineering Research" Volume 3, Issue 9, September-2012 1 ISSN 2229-5518 IJSER © 2012 http://www .ijser.org
[13] Ismail, O. S and Adewole, "Performance Evaluation and Environmental Impact Assessment of Systems with Waste Exergy Emissions, O. S." International Journal of Scientific & Engineering Research Volume 3, Issue 7, July-2012 1 ISSN 2229-5518 IJSER © 2012 http://www .ijser.org
[14] Ankit Tiwari, "Risk Management in Energy Industries of India" International Journal of Scientific & Engineering Research, Volume 3, Issue 10, October-2012 ISSN 2229-5518
[15] G.G. Pandit, S.K. Sahu and V.D. Puranik, Natural radionuclides from coal fired thermal power plants – estimation of atmospheric release and inhalation risk, Radioprotection, vol. 46, n◦ 6 (2011) S173–S179C _EDP Sciences, 2011DOI: 10.1051/radiopro/20116982s
[16] Raviprakash kurkiya, Sharad chaudhary ,"Energy Analysis of Thermal Power Plant" , International Journal of Scientific & Engineering Research Volume 3, Issue 7, July-2012 1 ISSN 2229-5518 IJSER © 2012 http://www .ijser.org
[17] Pronobis Marek , Wojnar Wacław "The rate of corrosive wear in superheaters of boilers for supercritical parameters of steam Engineering Failure Analysis 19 (2012) 1–12"
[18] Manas Ranjan Senapati , "Fly ash from thermal power plants – waste management and overview" Current Science, VOL. 100, NO. 12, 25 JUNE 2011
[19] G.G. Pandit, S.K. Sahu and V.D. Puranik "Natural radionuclides from coal fired thermal power plants –estimation of atmospheric release and inhalation risk Radioprotection", vol. 46, n◦ 6 (2011) S173–S179C _EDP Sciences, 2011 DOI: 10.1051/radiopro/20116982s
[20] Bettina Susanne Hoffmann , Alexandre Szklo (2011), "Integrated gasification combined cycle and carbon capture: A risky option to mitigate CO2 emissions of coal-fired power plants", Applied Energy vol. 88 (2011) 3917–3929
[21] A. Rahmani a, T. Bouchami b, S. Bélaïd c, A. Bousbia-Salah d, M.H. Boulheouchat c , (2009) Assessment of boiler tubes overheating mechanisms during a postulated loss of feedwater accident , Applied Thermal Engineering 29 (2009) 501–508
[22] Otakar jonas and lee machemer, a tutorial paper on steam turbine corrosion deposits problem and solution ,proceeding of the therty seventh turbomachinary symposium (2008)
[23] Prashant Agrawal, Anugya Mittal, Manoj Kumar, S K Tripathi, "Mercury Exposure in Indian Environment due to Coal Fired Thermal Power Plants and Existing Legislations- A Review Indian Journal of Forensic Medicine and Pathology." April -June, 2008, Vol.1, No.2
[24] G.C. kisku and S.k. bhargava, assessment of noise in middium level thermal power plant, indian journal of occupational and environmental medicine dec 2010 vol.10, issue3, 132-139
[25] Alameddin, A. N. and Luzik, S. J., "Coal Dust Explosions in the Cement Industry",. Industrial Dust Explosions, ASTM STP 958,
[26] Research paper "Control of Respirable Dust" by Schowengerdt, F.D. & Brown, J.T. in the April 1976 issue of "Coal Age Magazine".
[27] Kenneth L. Cashdollar and Martin Hertzberg, Eds., American Society for Testing and Materials, Philadelphia, 1987, pp. 217-233.
[28] Steam Plant Operation 8th Ed. - Everett B. Woodruff ISO/IEC Guide 51 Safety aspects—Guidelines for their inclusionin standardsISO/IEC Guide 73 Risk management—Vocabulary—Guidelinesvfor use in standards
[29] Risk Management Guidelines, Companion to AS/NZS 4360:2004.

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