NEPRA Incident Alert # 2022-01/ Sep 15, 2022

Coal Dust Explosion

Summary

On March 2, 2022, at 16:47 hrs., a coal dust explosion caused a fire in the coal conveyor system of a coal-fired power plant while start-up activity was in progress after a scheduled outage. Prior to the explosion, one of the vibrating screen start attempts failed. Electricians checked the local panel under live electric work permit and found that the local panel breakers were in the "ON" position. Despite this, none of the vibration screen motors were running. Upon inspection, the electrician found no specific fault in the control panel and only re-set it to auto mode. The DCS operator initiated the auto start-up sequence for the vibration screen's motors. An explosion caused a fire just above the vibration screen box when the last motor was started. The most likely source of ignition was metal-to-metal mechanical friction between vibrating sieve with the body of vibrating screen at the time of motor start-up, which produced sufficient heat and sparks to ignite coal dust and caused an explosion.

Automatic sprinklers were activated in the area, conveyor belts were automatically shut off, and the DCS operator activated emergency shutdown of the entire coal handling system. As a result of the explosion and fire, the coal conveying system, electrical cabling as well as instrumentation accessories were damaged. Immediately, emergency services were dispatched to the scene to control the fire. Fire trucks and water bowsers arrived from nearby companies. As the smouldering coal became approachable and accessible, ERT team members entered the building and completely extinguished the smouldering coal with fire extinguishers.

Five (05) personnel sustained burn injuries. First aid treatment was provided at the plant clinic, then shifted to the hospital for further medical management. They were subsequently recovered in stable condition and resumed their normal duties.

Figure-1: Coal Handling Area after Explosion

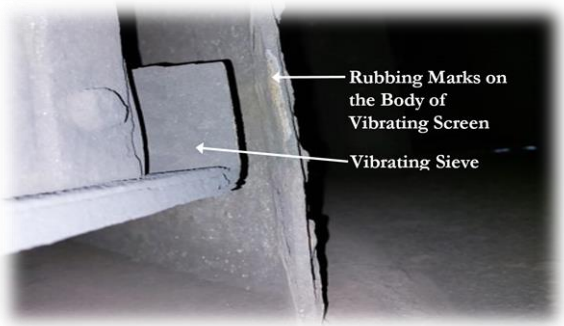

Figure-2: Vibrating Screen

Findings

1. Comprehensive design review process for all systems of the plant was conducted to confirm that no design input or output was missing. Original equipment manufacturer was consulted for design philosophy and any potential changes. No significant design modifications or process improvements suggested.
2. During the design phase, dust zones applications were covered and inherently safer design options were considered. The electrical equipment's, appliances, switches, connections, wiring, and fittings in the coal handling system were designed to be intrinsically safe.
3. An earthing and bonding inspection was performed and verified during pre-startup safety review process.
4. Coal dust layers were accumulating over a period of time in hidden spaces, on cable trays, side curbs, high elevated structures and beams.
5. Insufficient knowledge amongst staff about working in the potential coal dust confinement area. The staff did not predict the risk of coal dust accumulation.
6. Neither the risk assessment nor the pre-startup safety review program addressed the risk of coal dust layer accumulation and removal.
7. The vibration screens which are used for separating fines from lumps were inspected during scheduled outage, and all vibration rods and screens were found to be in good condition. After inspection, equipment was boxed-up with authorization via a formal box-up certificate.
8. At the time of motors start-up, the vibrating sieve stroked/rubbed against the vibrating screen body, produced sufficient heat and sparks to ignite accumulated coal dust and caused an explosion.
9. When the equipment was re-opened for inspection following the incident, rubbing marks were noticed, caused by mechanical movements between the mating parts.
10. Plant start-up after scheduled outage was not adequately supervised.
11. Maintenance staff didn't predict the level of coal dust risk and made improper decisions and actions without post-inspection of the system to identify faults and diagnose issues.
12. This specific activity/job was not evaluated by Job Safety Analysis (JSA) for its potential hazards. Only a Live Electrical Work Permit was issued in the coal dust zone.
13. In the initial detailed design stage of the project, HAZOP was conducted but detailed information on coal's behavior and characteristics relevant to self-combustion and its explosive nature were not ascertained since coal had not yet been mined.
14. In the Risk Register, critical equipment and processes in coal dust zones are covered however accumulation of coal dust outside primary equipment and its hazards are not adequately evaluated.

High Focus Areas & Lessons Learned

1. When people exposed to blast waves in the explosion zone may suffer inner ear damage. The explosion pressure is typically 35 to 100 mbarg. Thus, an appropriate treatment and audiometric testing should be considered immediately after an explosion incident.
2. Conduct an extensive awareness program to educate all employees while working in hazardous dust zones having potential explosive environments.
3. In case of failure or encountering unusual findings during normal start-up, it is more prudent to perform an in-depth investigation to find the underlying causes through appropriate fault diagnosis and troubleshooting rather than rushing towards an immediate start-up.
4. Revise the inspection program for the equipment's to address abnormal vibrations, misalignments, loose objects, potential rubbing parts, and normal wear & tear in order to prevent mechanical friction, overheating, and mechanical sparks that may cause fire.
5. The box-up certificate should include inspection pictures of the equipment before boxing up for record and history purposes.
6. Maintain the integrity and reliability of overload protection devices on drive motors in the PM program, as overloading will raise the operating temperature above “normal”.
7. Identify and fix deteriorated grounding and bonding points including alligator clamps, to dissipate electrostatic charges and prevent electric sparks, by conducting regular inspections and resistance tests.
8. Keep a history of preventive and corrective maintenance complete details for each piece of equipment throughout its lifecycle.
9. Conduct HAZOP revalidation study/update risk register to cover all equipment’s and processes in the coal crusher house to anticipate and address all unforeseen or unusual explosive scenarios to identify the inherent risk associated with the different activities, spreading of the coal dust, classification of dust zones, potential ignition sources (such as personal smoking materials, hot work in the area, open flames, electric sparks, impact sparks, mechanical friction and sparks, hot surfaces at/above 65 deg. C, thermal decomposition, and electrostatic discharge), and consider additional specific control measures/precautions of suitable dust control, dust extraction, dust suppression, collection and filters systems to reduce the risk to “As Low as Reasonably Practicable” (ALARP). Communicate the results to all interested parties involved in critical and hazardous activities.

10. Standard Operating Procedure shall include all activities and its specific control measures/precautions that will mitigate potential hazards as identified in the HAZOP study or risk register.
11. The JSA procedure should be revised to include all critical activities in the Coal Dust Zone, including live electrical work.
12. Establish procedure for enforcing adequate site supervision for startup, shutdown, and critical activities/tasks.
13. The inherent controls, process equipment, and ventilation system should be maintained and functional in the dust zone (Class II, Division 2 locations) according to IEC 60079-10-2, NFPA 499, and NFPA 654.
14. Consider the non-sparking tools in the dust zone area. Avoid dropping tools by using wrist straps. Sparks can be generated when normal tools are used, drop, or otherwise strike metal equipment with metal tools or objects.
15. Consider static dissipative footwear in PPE assessment for potential dust zones.
16. SOP should be modified to include regular inspections to find out source of dust release and to avoid accumulation of dust layers at elevated structures, beams, cable trays, side curbs, crevices, and fissures, as well as open and hidden areas, in order to remove trapped/deposited coal dust residues with a mechanized cleaning system.
17. Surfaces should be cleaned in a way that minimizes the generation of dust clouds. Sweeping with compressed air causes dust clouds and should not be allowed unless the area is vacuumed before blow-down by air, electrical power and other sources of ignition should be turned off or removed from the area, and no hot surfaces present that can ignite dust clouds or layers, then use only low gauge pressure 15psi (103kPa) compressed air.
18. Use a vacuum cleaner approved for dust collection in Class-II hazardous locations or use a fixed pipe suction system with a remote dust collector.
19. Display danger signs on both sides of the entrance doors for the explosion hazard. Danger sign shall be in Urdu, English and/or in a language understood by workers. The signs shall be readable at a minimum distance of 5 feet.