

# Automatic Fire Protection System for Hydraulic Excavator in Mining Industry

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**ABSTRACT:** Fire is a major concern who works in excavator machines operation at open cost mining areas. Fire can occur at any time against fires can be challenging. And most importantly, an unchecked and uncontrolled equipment fire can pose a serious threat of death or injury. Therefore, having a warning system that is capable of detecting fire and generating an alarm is important. And also provide the fire prevention system to stop the spread of fire to save the excavator machines Automatic fire sensing and suppression systems were built for use hydraulic Excavators. A line-type temperature sensor is mounted in the machine's engine and hydraulic pump areas to detect the heat from a fire while it is still small and easy to control. Two systems were tested. In one, the inside of the sensor consists of two conductors separated by a two polymer material whose electrical resistance with increases in temperature. When heated to a predetermined temperature, the control circuit response to the resistance drop. In the second system, the detection element of the sensor is comprised of thin metal tube containing Nitrogen charged metal hydride wire. The tube is sealed at one end and is connected to a sensitive solenoid valve at the other end. When exposed to the heat from a fire, nitrogen gas released from the metal hydride wire actuates the solenoid valve .in both the systems, the sensor signal compact cab mounted control panels to: initiate visual and audible operator's alarms, shutdown the diesel engine and release dry chemical extinguishing agent through a network of fixed hoses and nozzles onto the fire. In the test system the fire alarms used were a red light and a constant tone horn. The control panels are automatically monitored continually, to alert the operator to any malfunction in the control circuit. In The fire suppression systems can be manually activated from the cab or ground level. To measures the heavy duty mining equipment's like excavators machines to save Equipment, Operators and down time Cost.

**KEYWORDS:** Excavator, Fire Accidents, Automatic Fire Suppression System

## I. INTRODUCTION

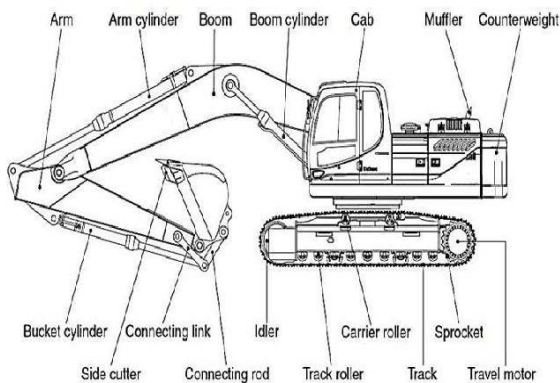
Heavy-duty mining Equipment require Automatic Fire Protection System to save Equipment, Operators and down time cost. The primary cause of "FIRE" on mining equipment is stated to be due to spillage/splash on hydraulic fluid or diesel on hot spots like exhaust manifold, turbo charger etc. Auto fire protection system is designed to take care of the above occurrences. The system is basically a temperature sensing system. The system operates by flooding the predefined fire prone areas with dry chemical powder from fixed nozzle locations. The activation is done either automatically by the sensing system or by manual operation □

## II. DESCRIPTION

My project is to execute an effective safety culture in the excavator machines and assess all possible potential or fire hazards in the job site. Management systems and their associated policies and procedures depend upon the actions of individuals and groups for their successful implementation. The successful execution of the procedure requires the actions of properly trained individuals who understand the importance of the under laying intent, who accept their responsibility for the task and this can be done by healthy safety culture. So, I am implementing which is the customized technique of automatic fire protection system (DCP-Dry Chemical Powder Type) to control the damaging effects and preventing fire hazards on the heavy duty mining equipments for EX-200/EX-210/EC-210/EX-600/ L&T 200/L&T PC 300 Excavators.

### EXCAVATOR:

**Excavators** (Hydraulic Excavators) are heavy construction equipment **consisting** of a boom, dipper (or stick), bucket and cab on a rotating platform known as the "house". The house sits atop an undercarriage with tracks or wheels. They are a natural progression from the steam shovels and often mistakenly called power shovels. All movement and functions of a hydraulic excavator are accomplished through the use of hydraulic fluid, with hydraulic cylinders and hydraulic motors. Due to the linear actuation of hydraulic cylinders, their mode of operation is fundamentally different from cable-operated excavators which use winches and steel ropes to accomplish the movements.



### SPECIFICATION OF EXCAVATOR-L&T PC 300

1. Model -Komatsu SAA6D114E
2. Type-Water-cooled, 4-cycle, direct injection
3. Aspiration-Turbocharged, after cooled
4. Number of cylinders- 6
5. Type. . Hydra Mind (Hydraulic Mechanical Intelligence New Design) system, closed-center system with load sensing valves and pressure compensated valves

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6. Fuel tank -605 to 160 ltr
7. Coolant-32.0 to 8.5 ltr
8. Engine - 35.0 to 9.2 ltr
9. Flywheel Horse Power-180kw,242 HP, 1990 rpm
10. Operating Weight:- 30800-31510 kg
11. Bucket Capacity:- 0.52-1.80m<sup>3</sup>
12. Arm Crowd Force: 171 kN 17400 kgf 38,360 lb.
13. Travel Speed 5.5 km/h, 4.5 km/h, 3.2 km/h

**HAZARD IDENTIFICATION: FIRE ACCIDENT**



**III. PROCESS METHODOLOGY**

**FIRE**

A process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke; combustion or burning.

**COMMON FIRE HAZARDS**

- Not exceeding the maximum occupancy within any part of the building.
- Maintaining proper fire exits and proper exit signage (e.g., exit signs pointing to them that can function in a power failure)
- Compliance with electrical codes to prevent overheating and ignition from electrical faults or problems such as poor wire insulation or overloading wiring, conductors, or other fixtures with more electric current than they are rated for.

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- Placing and maintaining the correct type of fire extinguishers in easily accessible places.
- Properly storing and using, hazardous materials that may be needed inside the building for storage or operational requirements (such as solvents in spray booths).
- Prohibiting flammable materials in certain areas of the facility.
- Periodically inspecting buildings for violations, issuing Orders To Comply and, potentially, prosecuting or closing buildings that are not in compliance, until the deficiencies are corrected or condemning it in extreme cases.
- Maintaining fire alarm systems for detection and warning of fire.
- Obtaining and maintaining a complete inventory of fire stops
- Ensuring that spray fireproofing remains undamaged.
- Maintaining a high level of training and awareness of occupants and users of the building to avoid obvious mistakes, such as the propping open of fire doors.
- Conducting fire drills at regular intervals throughout the year.

## **FIRE SAFETY**

**Fire safety** is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building.

## **FIRE SAFETY SYSTEM CONFIGURATION**

- Automatic Detection of Fire
- Automatic flooding of extinguishing agent
- Activation of Audio Alarm
- Shut off Equipment(Optional)

The detection of fire is primarily made by a sensor cable, which can detect fire anywhere along its length. The sensor cable which is highly flexible is routed throughout the equipment so as to cover areas prone to fire due to spillage like turbo-Charger exhaust manifold transmission, parking brake etc., In the event of fire/overheat condition, the sensor cable gets shorted and the solenoid valve on the nitrogen cylinders gets activated (energized).initiating the extinguishing process. The pressurized gas from nitrogen cylinders enters into the DCP cylinder assembly. There by rupturing the CO2 cartridge housed inside the Dry Chemical Powder Cylinder. The CO2 will propel the Dry Chemical Powder through hose to the predefined nozzle points. The engine shut off relay (optional) is also thereby shutting off the engine to prevent further spread of fire. The built in buzzer and external horn unit starts sounding continuously and stops only after the system is reset. The system can also reset itself automatically after two minutes.



## AUTO FIRE PROTECTION PARTS

S.no	Parts	Qty
1	Dust Cap for Nozzles	24
2	Rupture Disk ( DCP Cylinder )	4
3	Fuse 3 Amps	5
4	Dry Chemical Powder ( ABC class with 90% mono Ammonium Phosphate)	40kgs
5	Rupture Disk (Nitrogen Cylinder)	2
6	Knob (Nitrogen Cylinder)	2
7	Pressure Gauge	2
8	High Pressure Valve	2
9	' O' Ring Kit for Dcp Cylinder Assy	2
10	CO2 Cartridge-300 gms	4
11	Splicing Connector	5
12	Locking Pin-Nitrogen Cylinder	2
13	Non Return Valve	1

### 1. Sensor Cable

The sensor cable is a fixed temperature digital sensor and capable of initiating an alarm once its rated temperature (180 dec C) is reached. at this temperature the heat sensitive polymer insulation melts and yields the inner conductors to move into contact with each other and initiating the signal to the control unit and the extinguisher circuit.

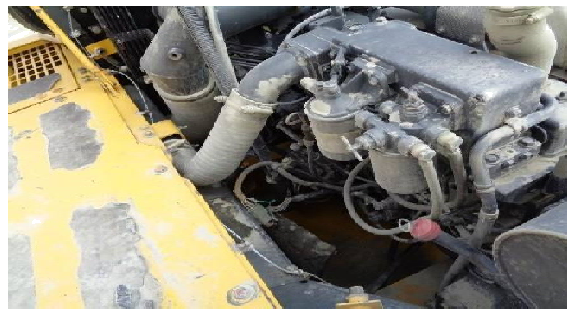


### 2. Control Unit

The control unit is located inside the cabin and controls the operation of the system. it is connected to the battery of the equipment and contains inbuilt power conditioning circuits to enable isolation and operation of the system at an input volt 18V TO 30V DC.

### 3. Horn Unit

The horn unit is provided to alert the operators and other people around. On activation the horn unit provides an intermittent sound at a level of 100db.



## IV. MANUAL OPERATION

### a) Nitrogen Cylinder Assembly

Nitrogen Cylinder Assembly containing Nitrogen gas pressurized up to 600 PSI. It contains a plunger mechanism housed in a stainless steel head on which a solenoid valve is fitted to contain the nitrogen inside (for automatic activation). A rupture disk is provided to contain the pressure in the cylinder. A high pressure valve for charging the nitrogen gas and a pressure gauge to indicate the pressure of nitrogen in the cylinder is also provided. A Knob is provided to operate the system manually. The main advantage of this Nitrogen Cylinder is to enable operation of the fire system even in the **absence of the power to the system.**





## V. ELECTRICAL CABLE

Wire is a single electrical conductor, whereas a cable is a group of wires swathed in sheathing. The term cable originally referred to a nautical line of multiple ropes used to anchor ships, and in an electrical context, cables (like wires) are used to carry electrical currents.

All interconnection between Control Unit and subassemblies are made with cable harnesses and terminated with reliable military type connectors with rubber boots for easy installation. Appropriate joints have been provided to ensure separation of cabin from the equipment at the time of transshipment.

## IV. EXTINGUISHER SYSTEM

### a) DCP Cylinder Assembly

DCP Cylinder has Dry Chemical Powder in unpressurised condition. It contains an inlet port of the Nitrogen/ CO<sub>2</sub> to enter in and an outlet port of the extinguisher powder to be propelled out. The outlet port also contains a housing in which a rupture disk is located to prevent the ingress of moisture into the DCP Cylinder and also prevent the extinguisher powder from flowing out of the cylinder under normal condition.

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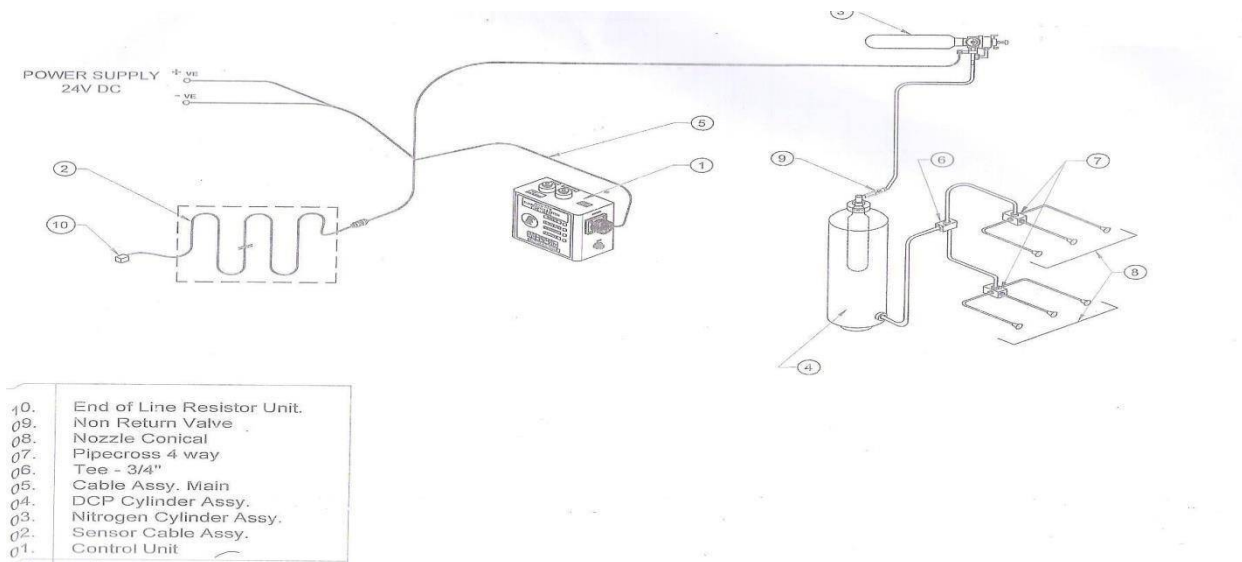
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### b) Distribution System

The distribution system is meant for carrying the extinguisher powder from the outlet of the DCP cylinder to the end of nozzles. This done by network of high pressure hoses, pipe cross distributors and nozzles. Other hardware items like elbows, couplers etc. are used wherever required.

### SCHEMATIC DIAGRAM OF AUTO FIRE SUPPRESSION SYSTEM



### AUTOMATIC OPERATION

In the event of fire, on detection of a short condition in the sensor cable, the Control unit energises the solenoid valve fitted on the Nitrogen Cylinder Assembly (Top) there by releasing the pressurized Nitrogen into the DCP cylinder. This will rupture the CO2 cartridge and propel the dry chemical powder and discharge through predefined Nozzles Points.



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In case of Overheat/ Fire

- The two conductors of the sensor cable shorts at the spot of fire/ overheat.
- The built in Audio alarm gets activated.
- The external Horn starts sounding.
- The solenoid valve located on the Nitrogen Cylinder Assembly gets energized.
- The Pressure in Nitrogen Cylinder Assembly gets released and flows into the DCP Cylinder.
- The rupture Disc of Nitrogen/CO2 Cartridge gets rupture and the gas propels the Dry Chemical Powder.
- The rupture disc located at the outlet port breaks and propels the DCP out.
- The Dry Chemical Powder gets propelled out and flows into the distribution network consisting of pipe cross, hoses etc.
- The Nozzle Cap opens out and Dry Chemical Powder gets released through the nozzles.

## V. CONCLUSION

Fire is a major concern who works in excavator machines operation at open cost mining areas. Fire can occur at any time against fires can be challenging. And most importantly, an unchecked and uncontrolled equipment fire can pose a serious threat of death or injury. So we have using automatic fire suppression system to avoid fire accidents on open cost mining areas. To measures the heavy duty mining equipment's like excavators machines to save Equipment, Operators and down time Cost. Hence, by implementing this system large amount of Human Life can be saved.

## REFERENCES

1. Design of Wireless Automatic Fire Alarm System Wen-hui Donga, Li Wanga, Guang-zhiYua, Zhi-bin Meia Procedia Engineering, volume 135, pages 413 – 417, (2016)
2. Automatic Fire Classification and Extinguish System Using Embedded Based Neural Network S. Kumaravel,R. RavishankarS. SriramInternational Journal of Emerging Research in Management &Technology (Volume-4, Issue-9) September (2015)
3. Whole-body Vibration Exposure of Drill Operators in Iron Ore Mines and Role of Machine-Related, Individual, and Rock-Related Factors Dhanjee Kumar Chaudhary ,Ashis Bhattacharjee , Aditya Kumar Patra , Nearkasen Chau Safety and Health at Work 6 (2015) 268-278
4. Challenges in integrating halon-alternate agents into automatic fire extinguishing systems (afes) Steven E. Hodges, 163 Aero Camino, Goleta, CA 93117 Cost-Effective Design of Self Activating Fire Extinguisher (S.A.F.E) Deep Shrivastava, RainaShrivastava Volume 4, Issue 11, November (2014 )
5. Fire accident prevention system in heavy vehicles K.Somasundaram, S.Gopal International Journal of Engineering and Technology, Volume: 03,(2014)
6. Work Health & Safety legislation; the fire engineer's neglected Duty? P.A. (Tony) Enright Case Studies in Fire Safety 2 (2014) 1–8
7. A Study into the Standardization of Using Fire Detectors in Rail Vehicles for ChinaLIU Xiao-lu\*, WANG Wen-qingProcedia Engineering 52 ( 2013 ) 240 – 244
8. Automatic Fire Detection: A Survey form of Wireless Sensor Network PerspectiveMajidBahrepour, Nirvana Meratnia, Paul Havinga (2008)
9. Processing the lifetime of bucket wheel Excavator parts in strip mine technologies Zoran Marinkoviæ, Goran Petroviæ Mechanical Engineering Vol. 2, No 1, (2004), pp. 109 – 124
10. Aspects to improve cabin comfort of wheel loaders and excavator according to operators L.F.M. Kuijt-Eversa, F. Krausea, P.Vink Applied Ergonomics 34 (2003) 265–271
11. Wireless Sensor Network based Fire Monitoring and Extinguishing System in Real Time.Environment P. N. Narendra Reddy, P. I. Basarkod, S. S. ManviVolume: 03, Issue: 02, Pages:1070-1075 (2011)
12. Safety analysis of autonomous excavator functionality D. Sewardu C Paceu,R . Morreyb,I . Sommerville Reliability Engineering and System Safety volume 70 15 March (2000) pages 29-39
13. Safety algorithms for excavator engine control RafalKlaus , Andrzej Urbaniak , Automation in Construction 7 \_(1998). 391–40