

AIR OVEN ACCIDENT INVOLVING PYROTECHNIC COMPOSITION

BY

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ABSTRACT

In December 2009; a fire occurred in an air oven while a pyrotechnic composition is getting dried. The major constituents of the composition are lead dinitrobenzoate and leadiodate which are co precipitated in the process. During the washing first washed with water and finally with denatured spirit. As the incident happened during non working hours no injuries to anybody. But significant fire / explosion damage was evident in the remnants of oven. The side by oven also fallen down from the table.

The incident was investigated by a team of organization officers. For analyzing the same, Fault Tree Analysis (FTA) technique is used. The entire lab Scientists, Engineers and other officers are involved in the investigation and brain storming session is conducted. The reasons evolved out of this investigation are human failure and equipment failure.

This paper summarizes the event, develops the various scenarios and arrives at a conclusion.

INTRODUCTION

Premier Explosives Ltd., is a well established organization; engaged in the manufacture of industrial explosives; explosive accessories; propellants and special devices for civil and defence use. Premier is a long time producer of pyrotechnics and rocket motors at their works located at Peddakandukur, Andhra Pradesh, India. One such item is delay composition.

Premier Explosives Ltd., in house R&D facility is recognized by Department of Scientific and Industrial Research (DSIR); India and University of Gulbarga; India.

This R&D is working on various high energy materials; pyrotechnic compositions; explosive devices and explosive accessories.

A development work on a new delay composition is in progress. The delay composition consists of leadiodate and leaddinitrobenzoate which are co precipitated from solution.

Incident

A project for development of delay composition is taken up. This composition is a mixture of lead dinitrobenzoate and lead iodate. Instead of mixing these two separately a method has been developed by co-precipitation where in both compounds will get precipitated.

One experiment has been carried out .The batch size is 150 grams. The precipitation process is completed. The material is filtered, washed thoroughly with water and final wash is given with denatured spirit. The denatured spirit is nothing but ethanol containing 1-2% undrinkable solvent. Ethanol is very volatile and will get evaporated very easily. The flash point is about 23°C and auto ignition temperature is about 363°C. The flammable limit is 6% minimum. It is a highly flammable material in presence of sparks and combustible material.

The so washed material is taken in a tray and kept for drying in an air oven. The oven is non flame proof type oven with coils directly heating the oven.

The material is taken in a tray and kept for drying in electrically heated hot air oven at about 5.00 pm and the lab is closed for the day at 5.30 pm.

The next day morning at 6.00 am when the lab and drying room are opened it is found that the oven containing the pyrotechnic composition got collapsed completely and another oven by the side on another table fell down.

The electrical oven used for drying is a non flame proof type with coils directly heating the air oven.

Inside the oven there are two partitions in the cabinet; dividing the cabinet into 3 parts.

The heating coils are placed at the bottom of the oven inside the cabinet and above the heaters, there is a perforated plate exposing the heaters to the open area. The Oven is provided with a covered vent. The cover can be opened or closed as per the requirement. The oven is for general use in the lab. The oven is being used for other materials drying also. Before keeping this material for drying; another explosive material is dried in the oven and removed.

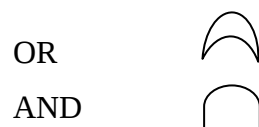
The oven is having one thermostat to control the temperature. The sensor is at a corner in the top compartment of the oven.

The remnants of the oven after the incident are thoroughly examined. The oven got completely collapsed and a clear bulge on all sides is observed indicating uniform damage on all the sides.

Incident investigation

For the investigation of this incident Fault Tree Analysis (FTA) method is used. Fault tree analysis was developed in 1962 for the U.S. Air force by Bell Telephone Laboratories. Later adopted and extensively applied by the Boeing Company.

In this methodology; to know the reasons for the unusual occurrence various causes for the event are identified by brain storming or open discussion with all connected with the event. The identified causes are laid out as a tree with the branches. They are connected by gates comprising either of the two following logical functions.



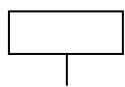
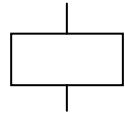
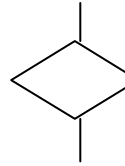
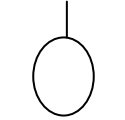
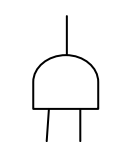
A fault tree is a graphical model of all parallel and sequential combinations of events that lead to the top event.

The 'OR' gate represents the union of events attached to the gate. An 'OR' gate can have any number of inputs (branches) running into it. The event above the gate is realized if any one or more in the inputs occur.

The 'AND' gate represents the intersection of events attached to the gate. An AND gate can also have any number of inputs running into it; but the event above the gate is only realized if all the inputs occur.

This method of analysis is versatile and systematic. This method forces the analyst to carefully examine the system, focus on the events that relate to the top event and describe the event sequences that lead to this event.

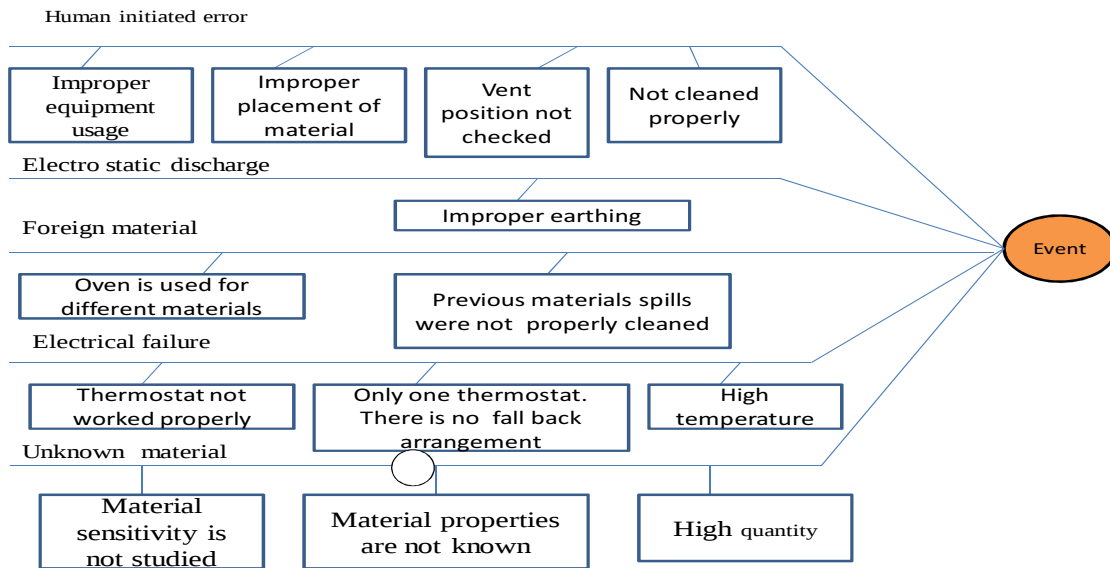
Description of Symbols used in fault tree

	Top event (The primary undesired event of interest)
	Intermediate event (Caused by more primary level events described below)
	Un developed event not developed any further because either it is not useful or data unavailable
	Basic initiating event does not need to be developed further
	AND Gate Logic gate where output occurs only if all inputs occur
	OR Gate logic gate where output occurs if any of the inputs occurs

As mentioned earlier the pyrotechnic composition is being developed in R&D. No previous experience in handling of the material. MSDS of leadiodate and leaddinitrobenzoate are available. But when these two are co precipitated the behavior of this compound is not known. No MSDS is available for this composition.

All the scientists; engineers and officers connected to development are made as a team. All the team members inspected the incident site and remnants are observed. A brainstorming for identifying all probable causes has been conducted.

The participants after visiting the remnants and discussing the incident identified various undesirable aspects and basing on those a model has been made as shown in figure. 1.



Discussion

1.0 Human initiated error:

The personnel working in the lab are qualified and having experience in manufacturing and handling of pyrotechnics and explosives. They are fully aware of the hazards involved in the operation.

Even then; some procedural mistakes were done in the case.

- i. The type of oven used for drying is not suitable for explosive or pyrotechnic composition drying. For drying explosives or pyrotechnic compositions; water jacketed ovens only to be used.
- ii. There is no standard operating procedure for the oven.
- iii. No pre operative check list for the oven
- iv. The material quantity is high compared to the quantity that is supposed to be dried in the oven.
- v. The tray containing the material is wrongly placed
- vi. There is no evidence of cleaning of the oven
- vii. The position of vent cover not known
- viii. No evidence of switching off oven while closing the lab

Operator unawareness or carelessness appears in all these instances. The senior research officials also not paid due attention towards systems.

Electro static discharge:

The oven is earthed at only one place using a crocodile clip. Condition of the clip is not known and no rigid earthing is provided. The safety plan of the Organisation is stating that all equipments should have two earthing connections. But in this particular case not providing a second earthing connection shows that the personnel are either innocent or careless.

Electrical Failure:

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It is also a rule that all the drying ovens should have two thermostats for redundancy. But the oven involved in the incident is having only one thermostat. There is no fall back arrangement. This is also a failure of implementation of systems.

Material characteristics:

The material is a new material. It is made in the lab for the first time and chemical properties are not known. No material safety data sheets are developed.

As a general rule of the company; all the properties of the materials should be known and MSDS should be available in the lab before they handle the chemical. It is also a failure of implementation of systems.

Foreign material:

The oven is being used for many materials. There is no evidence of cleaning the oven before introducing the chemical for drying.

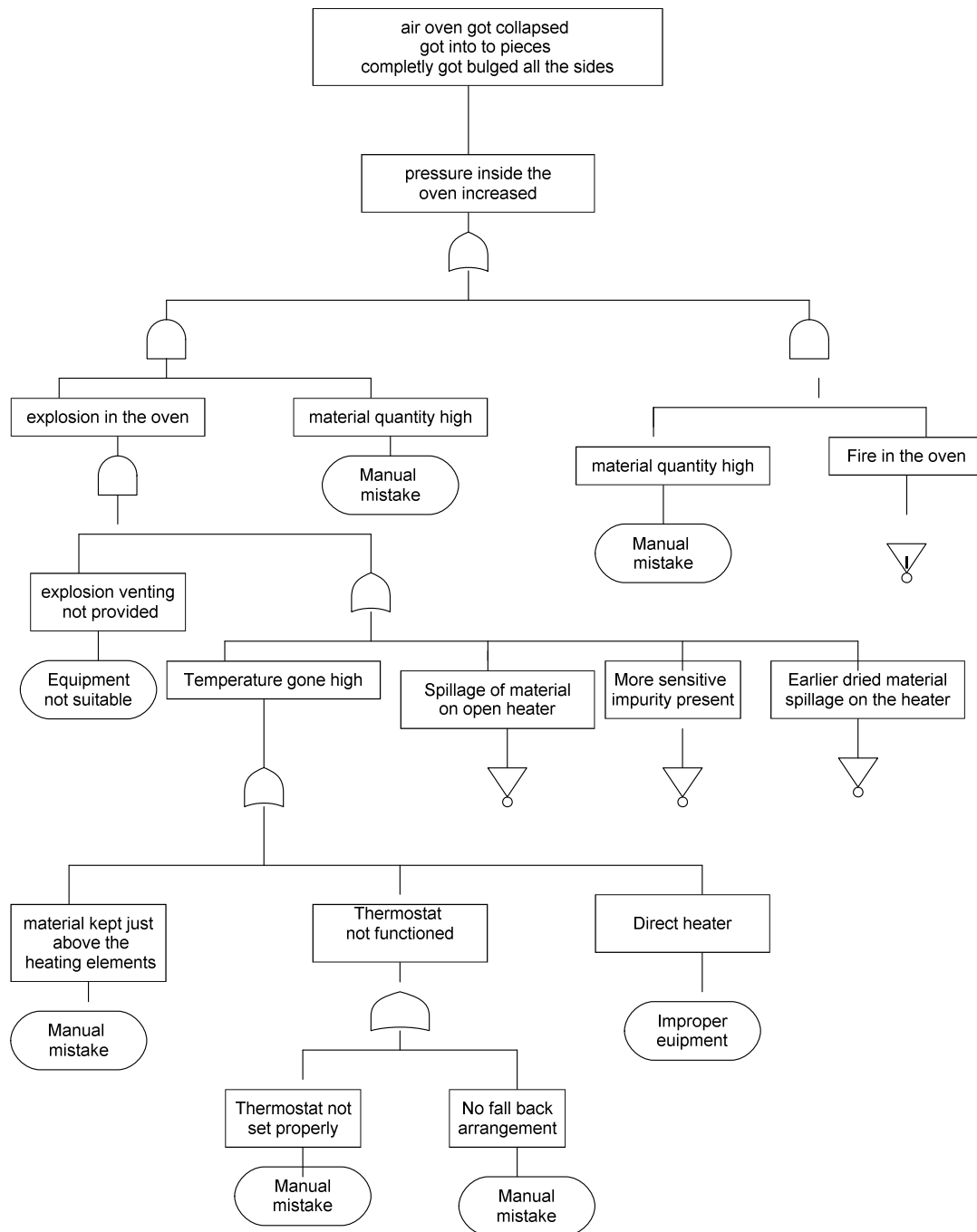
Generally material is kept in open trays for drying. There is every chance for spillage of material. The material may fall on the open heaters and may get heated up to high temperature and may create problem.

Improper equipment:

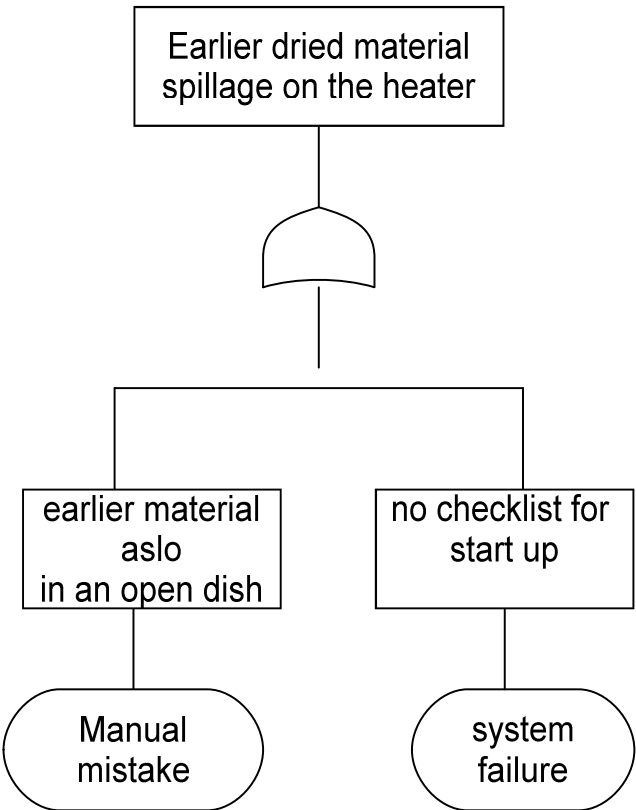
The oven used is an air oven and is directly heated by electrical heaters. This type of dryers can't be used for explosive and pyrotechnic material's drying as chances of temperature going high are more.

Basing on the above discussion a fault tree is developed as shown in tree 1 to tree 5

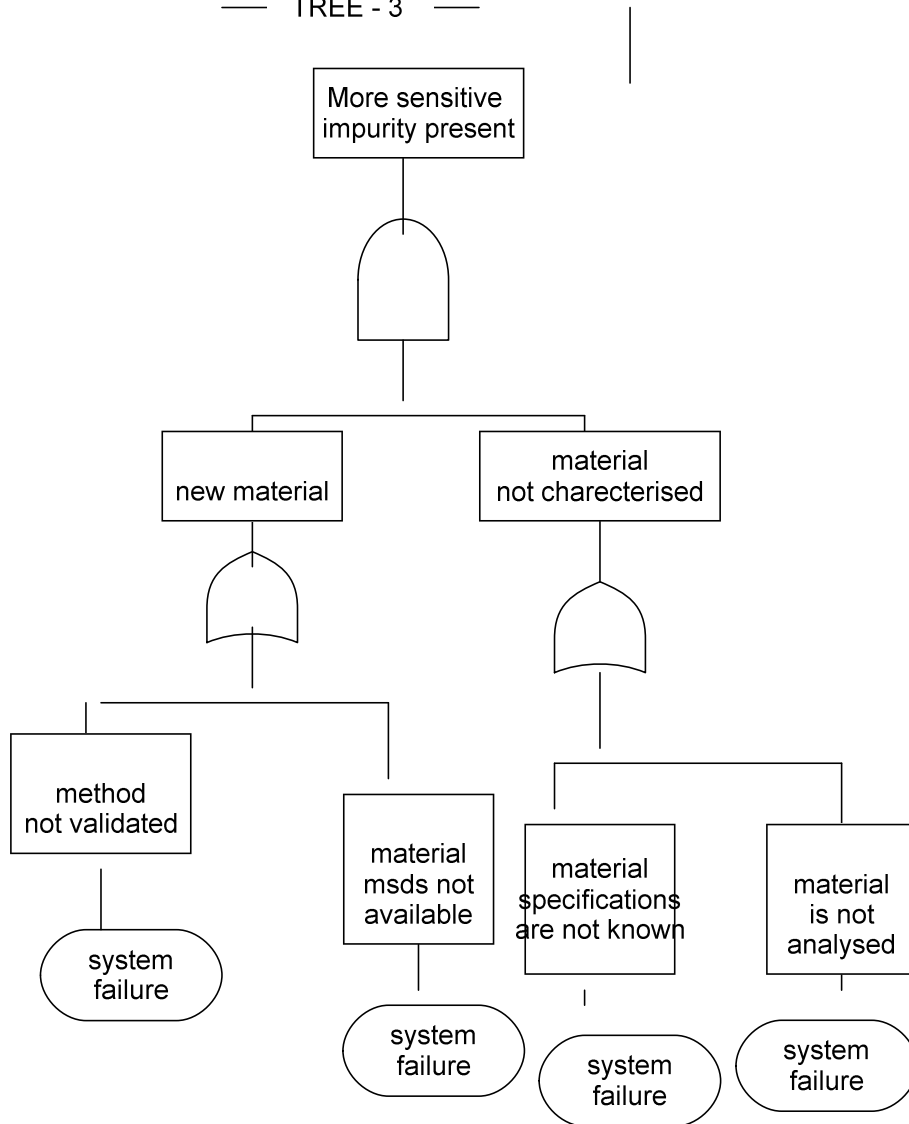
_____ TREE-1 _____



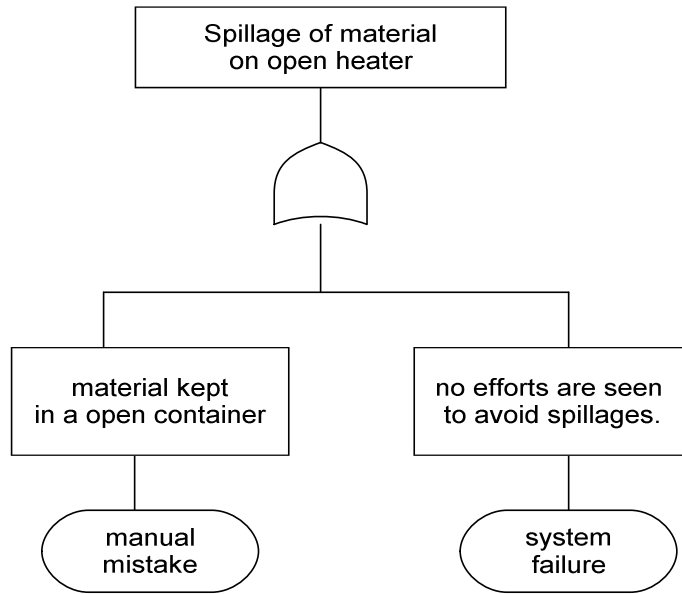
Tree-2



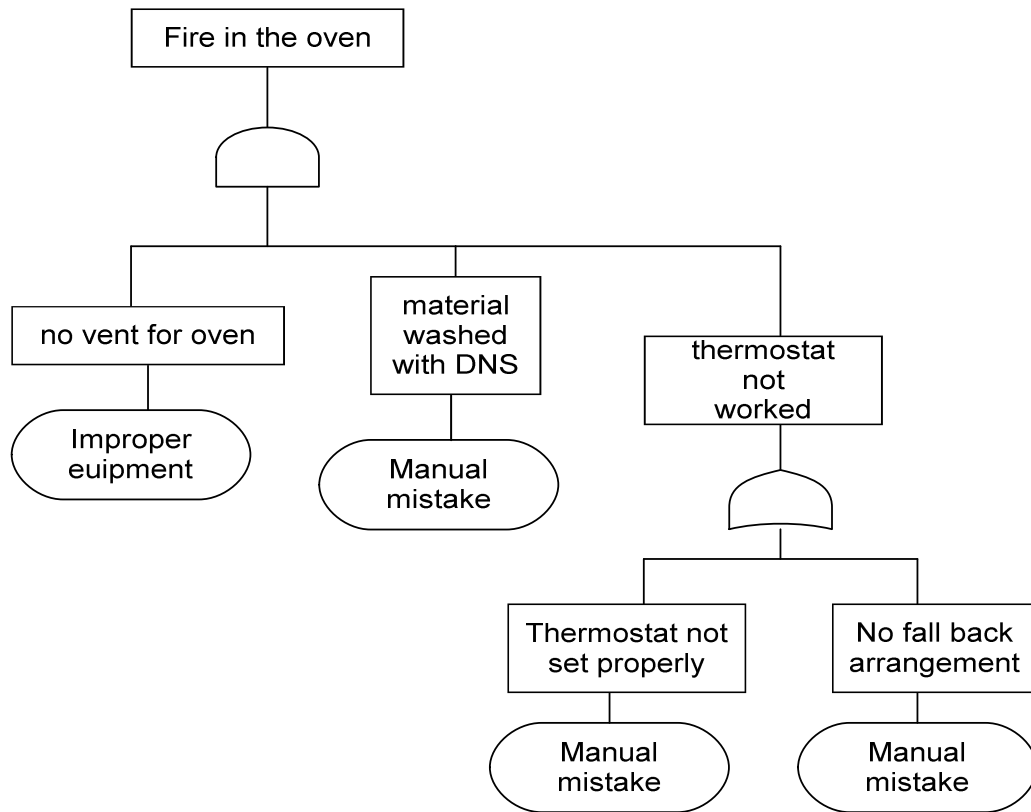
— TREE - 3 —



Tree - 4



Tree – 5



The above fault tree shows various reasons that might have caused the incident

With the available data and the analysis the most probable reasons appear to be manual mistake, faulty equipment or/and systems failure.

The mistakes committed by the persons can be listed as

- i. Non implementation of systems,
- ii. Not following the check list and operating instructions.
- iii. Unmanned operation
- iv. Material characteristics and safety hazards involved are not established
- v. Suitability of the equipment is not taken into consideration.

The problems associated with the equipment can be listed as

- i. It is a air oven using open heaters for drying.
- ii. It is fitted with only one thermostat.
- iii. It is not provided with explosion venting.

Conclusion

From the above case study it can be established that FTA is a very handy tool for unusual occurrence investigation. It will lead the investigation to root cause and give a concrete reason for the occurrence,

It will also drive the analyst to find out the remedial methods to avoid reoccurrence of the faults.

The incident taken for case study clearly spells out the reasons for the happening and suggests that training for the people concerned, systems and procedures for all operations and HAZOP studies for all the operations either in production or in research and development is very essential for a safe working and good manufacturing practices.

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