Initiating Systems Automated Plant Pyrotechnic Fire

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A plant operator was burnt in a pyrotechnic fire in the auto sieving compartment S4-1 at 23h48 on the 6th December 2011. He sustained burns to his left ear, top of his head and both knees.

Picture – Cordoned off Area where the Incident Occurred

Background

Employee was burnt in a pyrotechnic fire which occurred in the auto sieving compartment S4-, ISAP. The fire occurred whilst the operator was manually loading a tray of G -

Composition pyrotechnic powder into the auto tipping machine above the auto sieving machine.

Picture of the damage and equipment.

Process Description

1) The auto loader, drying ovens, stationary loader, auto tipper and auto sieving machines work in unison to allow for the automated handling of pyrotechnic powder in building S4.
2) Most of the tasks required to move and handle pyrotechnic powders through this sequence of operations were considered to be **high risk tasks** at the time the plant was built, and hence it was decided that the whole sequence should be automated.
3) Entry to the back end of the drying ovens and into the sieving compartment is allowed via interlocked doors. These interlocks prevent entry to the compartments while equipment is in operation. The interlocks also prevent equipment from being started when the

compartment doors are open. The Operating Instructions are clear in that:

- The loading of wet pyrotechnic trays onto racks in the Loading Compartment S4-2. There are 3.33kg of pyrotechnic powder per tray handled one at a time to a maximum of 6 trays.
- The preparation of the auto sieving machine including the placement of two empty buckets under cloth funnels under the auto –sieving machine. No powder is present in the compartment when this task is performed.
- The removal of a 75% full bucket of sieved powder from under the sieving machine. Up to 8kg of powder is handled at a time.
- The removal of a 25% full bucket of powder fines from under the sieving machine. Up to 3kg of powder is handled at a time.
- The removal of empty trays from the compartment. Traces of powder can be present stuck to the trays (dirty trays).
- The procedure is to spray the trays with a lissapol water solution.
- The spraying down and cleaning of the auto tipper and sieve with lissapol water and then dismantling the sieve for removal to the wash bay.

For the rest of the operations these machines are operated remotely by the Pyrotechnic Loading and Sieving Operator via a SCADA control panel.

This equipment was originally operated by Technician Operators who also had the duties to repair and maintain the equipment. In the beginning of 2011 it was decided that the **"Operator Maintainer"** concept was not appropriate for the S4 Pyrotechnic Drying and Sieving plant and plans were made to move the Technician Operators to other part of the ISAP Plant and to train Plant Operators who's duties

would be to operate the equipment only and not to repair and maintain the equipment.
These Plant operators were trained in the first quarter of 2011.This full process is automatic, however the operator was operating the process manually and was loading a tray of G - Composition pyrotechnic powder into the auto tipping machine by hand.

Video Footage (Importance)

The video footage captured immediately before the incident was downloaded and examined. It was evident from the footage that the Stationary Loader was parked in its home position. When the stationary loader is in the home position the operator can open the interlocked door to the compartment and enter the compartment at will.

Twenty four hours of history was downloaded from the video surveillance camera in the compartment. A full account of the contents of this footage was made and it conclusively shows that both the injured operator, the previous afternoon shift operator and the morning shift operator, were all carrying out and were probably accustomed to operating in a non-permissible, hazardous and abnormal way and not wearing the prescribed PPE, contrary to what they had said in the interviews.

What Transpired?

- The stationary loader was in the home position.
- When the stationary loader is in the home position the operator can open the interlocked door to the compartment and enter the compartment at will.
- The employee was operating the process manually and was loading a tray of G pyrotechnic powder into the auto tipping machine by hand.
- He was holding the lid to the auto tipping machine open with his left hand and attempting to load a tray of

pyrotechnic powder into the auto tipper with his right hand.

- The lid slipped out of his left fingers and dropped towards its closed position.
- This knocked the tray out of his right hand and it tumbled and fell striking the cover on the left side of the auto sieving machine. The impact set off the pyrotechnic composition that was falling from the tray. This caused a flash fire of approximately 250ms duration. This fire in turn set off five trays that were waiting in the racks behind the auto sieving machine. This caused a second but overlapping fire of similar duration which could have attained an instantaneous temperature of 1400 ^{o}C. In a total of 20 kg of powder ignited in the fire.
- The following images downloaded from the Video monitoring cameras show the sequence of events which took place in the Sieving Compartment S4-1 in which the employee was burnt.

Employee entered compartment at 23:47:43 and removed the top tray from the loading rack.

As can be seen, Employee gave the tray a sniff presumably to detect amyl acetate fumes. Subsequently he must have decided that the tray was wet as he left the compartment and only returned at 23:47:57, a full 15 seconds later with what we believe was a tray presumably drier pyrotechnic powder which he has exchanged from the trolley parked outside the cubicle door.

The next sequence starts at 23:47:57 and finishes at 23:47:59. This gives an idea of the extreme pace at which the employee was operating: the entire set of actions from the employee approaching the auto tipper with a tray to him dropping the tray with it falling to strike the side of the auto sieve and initiating the flash took less than 2 seconds. The actual flash was over in less than 250 milliseconds.

Employee approached the auto tipper at 23:47:57 with tray of dry G composition.

Employee grabbed auto tipper hatch to open it. Tray was held precariously in right hand only.

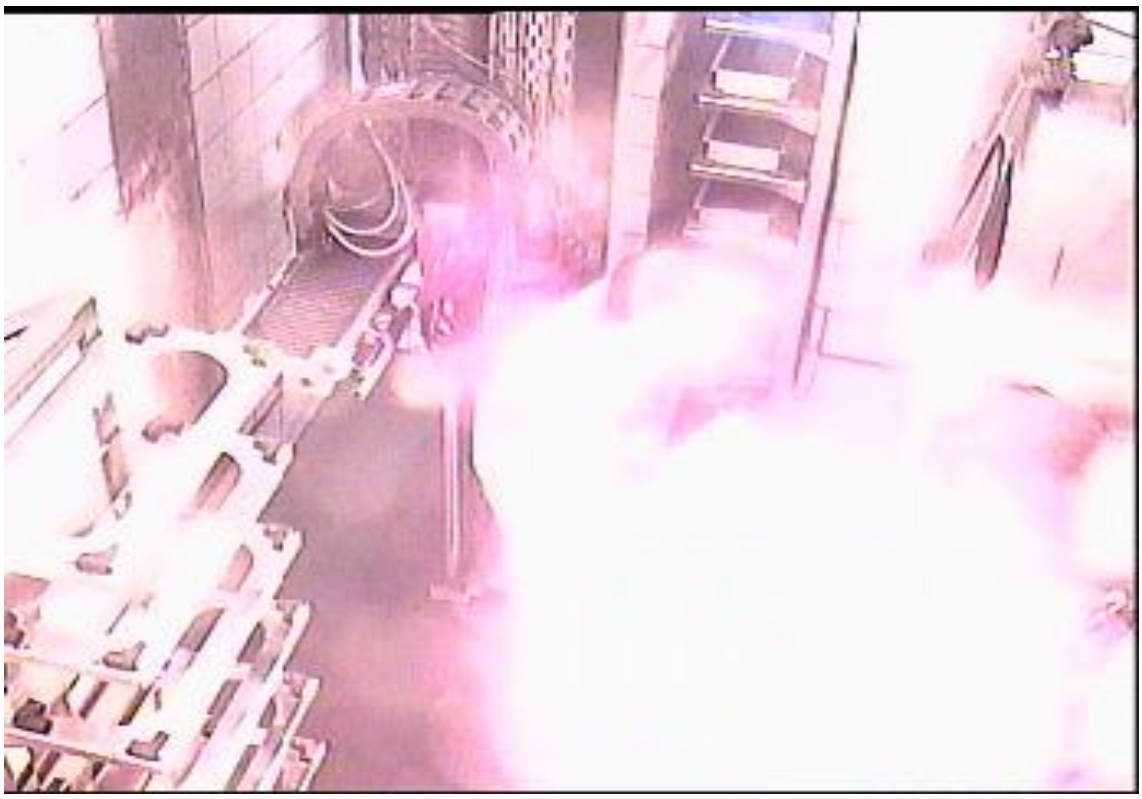
Employee tried to insert tray of G composition into auto tipper but lost his grip on the tipper hatch which began to fall under gravity.

The falling hatch struck the side of the tray of G composition and the employee lost his grip on the tray

The Tray of G composition began to fall whilst the employee tried to move his left hand down to catch it.

The employee was unable to catch the tray which struck the side of the Auto sieving machine and initiated the G Composition at the point of impact.

The G Composition initiation spread.



Even further spread and employee engulfed in flame

<u>After the Fire</u>

After the fire, the injured employee rushed out of the compartment and ran to the safety shower at the south side of building S4. He stood under the shower for some time and removed his full length rubber gloves and dropped them on the floor. He later moved to the safety shower at building S3 as it is closer to other plant personnel who could assist him. This is when he reported the incident to his Shift Manager.

The fire drenching system activated within 12ms after detecting the flash of the fire. This system sprayed water across the inside of the doorway and on either side of the outside of the doorway in the corridor outside the compartment. It also flooded the compartment with water which drained off in the effluent channel provided. The

drenching system effectively prevented the fire from spreading to an open trolley containing 6 trays of dry powder parked in the corridor almost directly opposite the door to the compartment.

Damage was caused to equipment where air lines, sensors, cables, buckets, socks and protective bellows were burnt. The compartment was blackened from the fire. The repairs to equipment and re-painting of the compartment eventually took four days. The incident had no effect on any adjacent equipment or operations, other than to stop their operation during the repair period.

Overall plant production was not affected since there were sufficient stocks of G Composition powder.

Employee informed his Shift Manager when he was at the safety shower at S3. The Plant Manager attended to him and alerted the Duty Security Officer, who arrived within 5 minutes. The Duty Security Officer dressed the burns on the employee’s ear, head and knees.

At the same time the Plant Manager was informed. He arrived at the plant within 12minutes. The Plant Manager removed the employee’s fire retardant jacket and trousers and collected his rubber gloves, dust mask and safety glasses and placed them at the entrance to the sieving compartment of future examination by the investigating team. The employee was also wearing Company issued cotton long john underwear and it is assumed that this may well have prevented worse burns to his legs.

Pictures – safety glasses, gloves and dust mask.

About half an hour later an ambulance arrived and the injured employee was taken to the local Hospital.

Importance of PPE

Definitions:	Nature of Task	PPE Required
	Normal	2 Piece flame retardant overall, safety glasses long rubber gloves, dust mask & conductive shoes
	Hazardous tasks - Abnormal	Two piece Kevlar Suit- with long john trousers, Face Shield, long rubber gloves, dust mask & conductive shoes
	Supervision	Navy blue dust coat, safety glasses, dust mask & conductive shoes

- Required and per Operating Instruction

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Piet Morune - Plant Operator Loading and Sieving Shift C

Take Home Messages

- Good explosives practices remain applicable, manual processes or automated processes.
- On-going Basis of Safety Training is critical.
- Camera monitoring proved to be integral in establishing root causes as well as the identification of non-conformances – off line planned job observations can also be conducted.
- Continue with actual planned job observations to test the conformance levels and understanding.
- Assess PPE requirements and conformance. Applicability of PPE.
- Zero tolerance rules remains applicable – ensure that these rules are adhered to – example when working with pyrotechnic powders.
- Emergency equipment and proper emergency plans are critical – saved this employee's life.
- Sharing the learning is critical – group wide and industry wide.

More will be added in terms of the presentation, including but not limited to:

Possible Video Footage
And other evidence.

Kind Regards
Henry Merrick
Group Safety and Health Manager