Health and Safety
Executive

HSE

Past Accident Review (PAR)

INTELLIGENCE FROM THE CHAOS

EVAN BALE
HEALTH AND SAFETY EXECUTIVE
UNITED KINGDOM

THE COST OF ACCIDENTS

Learning from past accidents

- Identifying immediate and root causes
- Preventing recurrences
- Formulating good explosives practice
- Targeting resources for:
  - Inspection (internal or regulatory)
  - Corrective action
- Training staff

Sources of Information for PAR

EIDAS Database

- HMIE Special Reports
- Company Reports
- SAFEX Reports
- US DoD

Database of Accidents

Report ID	Year	Location	Severity	Type of Explosives	Overview	Generic Cause	Immediate Cause
123	1924	Roslin UK	2 Fatalities 0 Injuries	Black powder	Explosion in press house of black powder mill shortly after press had been loaded.Press found almost intact while workmen thrown great distance and killed.Two seconds later the graphite mill exploded.Accident may have been caused by foreign body in powder	Fault with composition	Foreign body?
323	1974	Bofors Sweden	1 Fatalities 1 Injuries	Nitrocellulose	An explosion occurred in the final pressing stage where NC with a high nitrogen content and 30% water was being dehydrated with 96% ethanol. The cause was either adiabatic compression of the air/ethanol mixture or the presence of foreign bodies		Not Known
342	1972	Ardeer UK	2 Fatalities	Black powder	3000 lb of black powder blew up in a press house. Two workmen were killed. The cause of accident could not be found.	Not Known	Not Known
956	1907	Fontanet USA	2 Fatalities	Black powder	An explosion occurred in a press house of a black powder factory killing the two operators. The fire propagated to an edge runner in another building where 12 tons of powder exploded. The cause might have been operator error as the two men were new.	Human Error	Not Known
1022	1913	Hazardville USA	2 Fatalities 1 Injuries	Black powder	An explosion occurred in the press house of a black powder factory. The explosion propagated to the corning house which contained 1500lbs of powder. There was very little structural damage beyond a radius of 700 ft.		Not Known
1093	1925	Roslin UK	2 Fatalities 1 Injuries	Black powder	While pressing pellets in a cam press house, an explosion occurred, and resulted in the death of two workers and serious injury to a third girl. The building was destroyed without damaging the presses. There were 900 to 1,000 lb. of powder in the house		Faulty tool/machinery
1255	1881	Blackbeck UK	3 Fatalities 3 Injuries	Black powder	An explosion in the press house communicated to a cartload of powder near the door of the corning house, and to the corning house itself, distant 273 feet from the press house. It is believed the accident was caused by a blow from a wooden mallet.		Rough handling?

Activity	Definition
Assembling/disassembling	Denotes an operation in which the components of an explosives article are assembled or in which components are removed, e.g. insertion of fuzes into ammunition, insertion of wadding into shotgun cartridges, breaking down of ammunition.
Blending/Mixing	Denotes an operation in which explosives material is mixed or blended. This may involve the use of process equipment such as incorporators or simple manual operations performed with trays and rakes.
Centrifuging	Denotes an operation in which centrifugal force is applied to separate explosives material
Cleaning	Denotes an operation in which process equipment, work benches, etc., are cleaned of explosives. This may involve the use of decontamination reagents, solvents or simple scraping procedures
Coating	Denotes an operation in which explosives material is coated by a film of an inert substance or in which a film of explosives is coated onto some other material.
Crimping	Denotes an operation in which explosives material is sealed within a container by the process of crimping closed the opening.
Crystallising/Precipitating	Denotes an operation involving mixing of reagents to produce a precipitate of an explosives substance (e.g. mixing of sodium azide and lead acetate) or the cooling/evaporation of a liquid medium to produce crystals of an explosives material.

Risk ranking based on PAR

EIDAS data (1960-2012): UK, USA, Canada, Australia, S Africa

Process	No of incidents	No of fatal incidents	Fatality Rate (%)
Assembling & disassembling	255	13	5
Blending/Mixing	205	33	16
Centrifuging	4	0	0
Cleaning	53	8	15
Coating	6	0	0
Crimping	30	3	10
Crystallising & Precipitating	1	0	0
Cutting	70	3	4
Decommissioning	14	1	7
Disposal	156	9	6
Drilling	18	0	0
Drying	100	15	15
Extruding	73	2	3
Filling	210	15	7
Filtering	12	1	8
Handling	223	24	11
Inspection	8	1	13
Loading/Unloading	14	2	14

Process	No of incidents	No of fatal incidents	Fatality Rate (%)
Machining	44	2	5
Maintenance	76	12	16
Melting	11	3	27
Milling	65	6	9
Nitrating	57	4	7
Packing	23	2	9
Pressing	447	5	1
Pumping	18	0	0
Rolling	74	1	1
Sieving	35	2	6
Soldering	24	0	0
Spinning	6	2	33
Storage	87	10	11
Testing	138	4	3
Transfer	4	3	75
Transport	23	5	22
Washing	5	2	40

Risk ranking based on PAR

EIDAS data (1987-2012): UK, USA, Canada, Australia, S Africa

Process	No of incidents	No of fatal incidents	Fatality Rate (%)
Assembling & disassembling	147	4	3
Blending/Mixing	85	7	8
Centrifuging	4	0	0
Cleaning	23	1	4
Coating	2	0	0
Crimping	8	0	0
Crystallising & Precipitating	1	0	0
Cutting	29	1	3
Decommissioning	8	0	0
Disposal	80	3	4
Drilling	9	0	0
Drying	31	3	10
Extruding	20	1	5
Filling	72	5	7
Filtering	8	1	13
Handling	74	1	1
Inspection	5	1	20
Loading/Unloading	3	0	0

Process	No of incidents	No of fatal incidents	Fatality Rate (%)
Machining	32	1	3
Maintenance	36	3	8
Melting	3	0	0
Milling	32	3	9
Nitrating	18	0	0
Packing	9	2	22
Pressing	212	1	0
Pumping	13	0	0
Rolling	60	0	0
Sieving	16	1	6
Soldering	19	0	0
Spinning	6	2	33
Storage	38	3	8
Testing	71	1	1
Transfer	5	0	0
Transport	12	1	8
Washing	2	0	0

LESSON LEARNT?

FREQUENCY		
	1960 TO 1987	1987 TO 2012
1	PRESSING	PRESSING
2	HANDLING	ASSEMBLY
3	FILLING	BLENDING/MIXING
4	BLENDING/MIXING	DISPOSAL
5	ASSEMBLY	HANDLING
FATALITY RATE		
	1960 TO 1987	1987 TO 2012
1	TRANSFER	SPINNING
2	WASHING	PACKING
3	MELTING	INSPECTION
4	LOADING	FILTERING
5	TRANSPORT	DRYING

Site-specific factors to consider

- Sensitiveness of explosives handled
  - foreseeable stimuli
- Quantities of explosives handled
- Potential effects
  - hazard type 1, 2, 3 or 4
- Energy available
  - especially in fault conditions
- People at risk
  - manual or remote operations

2. Capturing good explosives practice

- For each accident type
  - Retrieve info from EIDAS
    - description, analysis, recommendations
  - Identify incident causation
    - immediate & root causes
  - Identify appropriate control measures
    - recommendations, published guidance, experience
  - Formulate good explosives practice
    - disseminate

Example

"2te of PETN detonated during a drying operation. The immediate cause was uncontrolled temperature increase in a drier due to malfunction of a thermostat controlling the steam valve"

Initiating stimulus:	Heat
Generic fault condition:	Auto decomposition in oven
Specific fault condition:	Temperature excursion beyond operating limit
Underlying cause:	Thermostat failure, possibly due to: poor maintenance; or lack of redundancy in control system (poor design)

- Recommendations
  - from accident investigation report
  - from published good practice
  - generated by working group

Use of PAR to generate question sets

Initiating Stimulus	Fault condition	Questions to ask
Fire/heat	Heating for longer than specified time	How are heating times/cycles controlled? Manually or automatically Are compositions sensitive to prolonged heating? Are there controls against prolonged heating for automatic operations? Are there controls against prolonged heating for manual operations?
Fire/heat	Temperature excursion	What is the ignition temperature of the composition? What is the max temperature the oven could reach? How is temperature controlled? Are there redundant thermocouples? Are there independent safety systems? Is there potential for common mode failure? Are high temperature alarms installed? Are drenchers installed? How activated? Redundancy? Are there safeguards against human error for manual systems?

Institute of Explosives Engineers
VOICE OF THE EXPLOSIVES INDUSTRIES

TAKING IT FORWARD

HSE

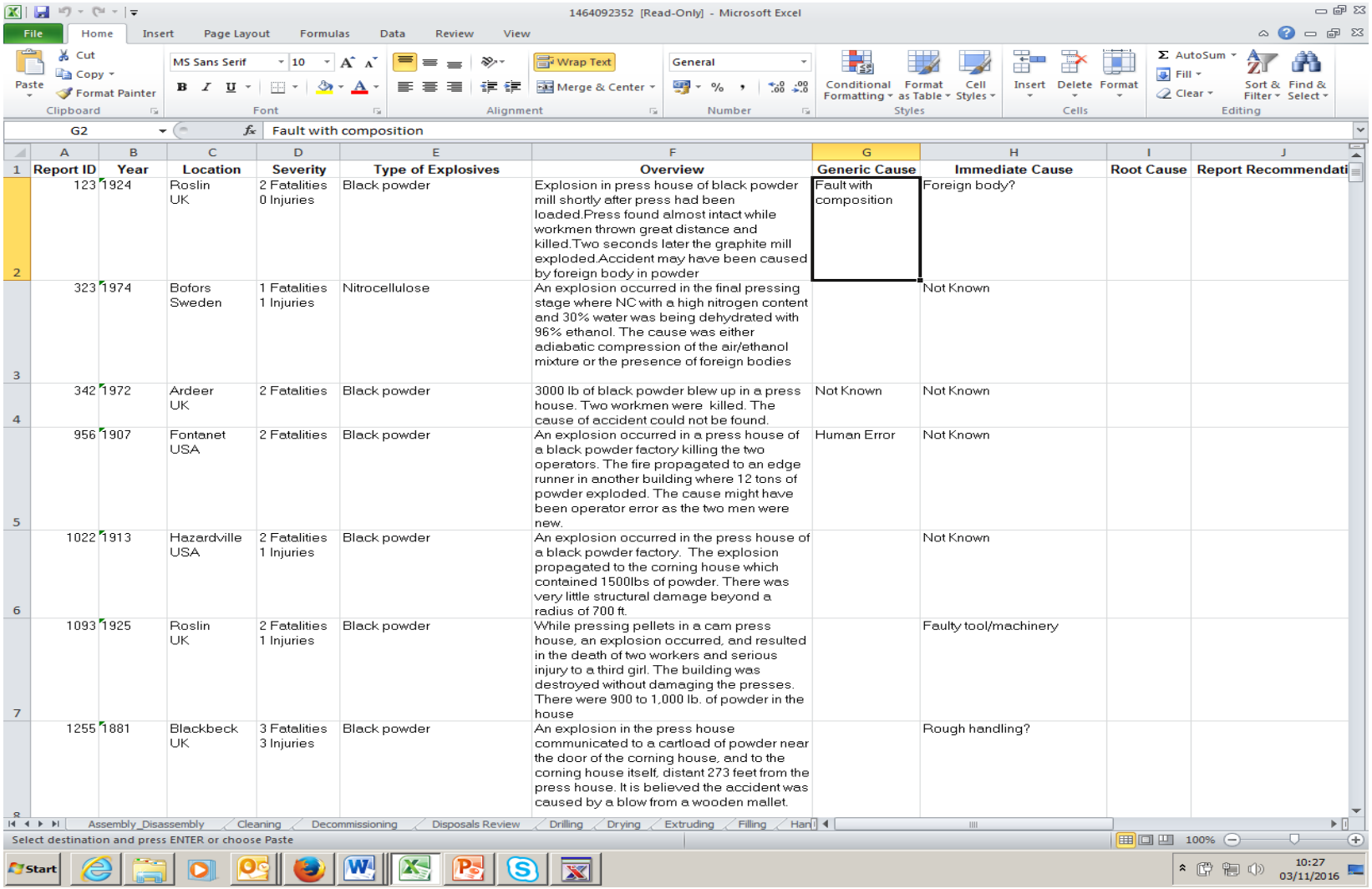
Industry and HSE Working Groups

Developed further by industry

Results and findings published by IExpE on behalf of industry.

iexpe.org/Past-Accident-Review-Information

secretariat@iexpe.org



1464092352 [Read-Only] - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View

Cut Copy Format Painter Paste — Clipboard

MS Sans Serif 10 — Font

Wrap Text Merge & Center — Alignment

General — Number

Conditional Formatting Format as Table Cell Styles — Styles

Insert Delete Format — Cells

AutoSum Fill Clear Sort & Filter Find & Select — Editing

G2 fx Fault with composition

	A	B	C	D	E	F	G	H	I	J
1	Report ID	Year	Location	Severity	Type of Explosives	Overview	Generic Cause	Immediate Cause	Root Cause	Report Recommendati
2	123	1924	Roslin UK	2 Fatalities 0 Injuries	Black powder	Explosion in press house of black powder mill shortly after press had been loaded.Press found almost intact while workmen thrown great distance and killed.Two seconds later the graphite mill exploded.Accident may have been caused by foreign body in powder	Fault with composition	Foreign body?		
3	323	1974	Bofors Sweden	1 Fatalities 1 Injuries	Nitrocellulose	An explosion occurred in the final pressing stage where NC with a high nitrogen content and 30% water was being dehydrated with 96% ethanol. The cause was either adiabatic compression of the air/ethanol mixture or the presence of foreign bodies		Not Known		
4	342	1972	Ardeer UK	2 Fatalities	Black powder	3000 lb of black powder blew up in a press house. Two workmen were killed. The cause of accident could not be found.	Not Known	Not Known		
5	956	1907	Fontanet USA	2 Fatalities	Black powder	An explosion occurred in a press house of a black powder factory killing the two operators. The fire propagated to an edge runner in another building where 12 tons of powder exploded. The cause might have been operator error as the two men were new.	Human Error	Not Known		
6	1022	1913	Hazardville USA	2 Fatalities 1 Injuries	Black powder	An explosion occurred in the press house of a black powder factory. The explosion propagated to the corning house which contained 1500lbs of powder. There was very little structural damage beyond a radius of 700 ft.		Not Known		
7	1093	1925	Roslin UK	2 Fatalities 1 Injuries	Black powder	While pressing pellets in a cam press house, an explosion occurred, and resulted in the death of two workers and serious injury to a third girl. The building was destroyed without damaging the presses. There were 900 to 1,000 lb. of powder in the house		Faulty tool/machinery		
8	1255	1881	Blackbeck UK	3 Fatalities 3 Injuries	Black powder	An explosion in the press house communicated to a cartload of powder near the door of the corning house, and to the corning house itself, distant 273 feet from the press house. It is believed the accident was caused by a blow from a wooden mallet.		Rough handling?		

Assembly_Disassembly Cleaning Decommissioning Disposals Review Drilling Drying Extruding Filling Han

Select destination and press ENTER or choose Paste

100%

Start

10:27 03/11/2016

Findings from Reviews

Generic Heading	Overview	Severity	Immediate Causes/unsafe acts or conditions	Root Cause	Report Recommendations	Measures for preventing ignition	Measures for ameliorating effects	Key Lessons Identified
Faulty Munition/Handling Error	Premature ignition of a damaged munition	~126 deaths	accidental rupture of the pyrotechnic membrane	Disabled Safety Systems		Check Safety Systems on before further work, permitting procedures, LOTO, interlocks, training, procedural controls		
Faulty equipment	Dentonation of explosive trapped in threaded portion of warhead casing	2 injuried	Misalignment during assembly allowed explosive into screwholes. Screw insertion detontated explosive	Misalignment of component during assembly resulting in seal failure	Modify process to prevent contamination of screw holes with explosive, updated design	Re-design of compents & assembly process, communication processes improved		Design Failure, Poor communication
Operator error	Death during EOD sweep of munitions range	1 Dead	EOD team member picked up a suspected M42 grenade	Violation of SOPs		Training, observe SOPs		Operator error, observance of SOPs
Fault with Rrange	Five soldiers investigating burning time fuze on demo range, all injured by explosion of unmarked charge	5 injuried	Detonation of unmarked charge	Inadequate briefings/warning, inadequate maps and boundry markings, lack of safety officers	Review and revise SOPs		Safe seperation distances, improved briefings, safety supervision	Training, SOPs, Supervision
Violation of procedure	Boresight left in barrel created barrel explosion	Equipment damage, no injury	Boresight left in gun barrel due to failure to follow procedures	Failure to follow procedures, lack of clarity on roles/responsibilites, rushed to undertake task, lack of experience/training	Familiarity of safety regulations, Clear roles & responsibilities	Assure correct use of procedures, additional checks prior to firing, clear lead/responsibilities	Should have used practice for warhead rounds	Competent/trained staff, defined responsibilities, follow procedures, better scheduling

Lessons forgotten/ignored?

1964	Violation of procedure	Boresight left in barrel created barrel explosion	Equipment damage, no injury
2006	Violation of procedure	Boresight left in barrel created barrel explosion	Equipment damage, no injury
2008	Improvements partially implemented	Boresight left in barrelpressurised weapon	Life chaging injuries to firer