LEARNINGS FROM WUERGENDORF ACCIDENTS IN 2002

Presented at
SAFEX May 2005

EXPLOSIONS AT WUERGENDORF IN 2002

- The operation
- Presentation of Events
- Contributory causes
- Investigation
- Lessons

INTRODUCTION

- 2 major accidents within 2 months
- Fatality in first accident
- Significant structural damage in both explosions

WUERGENDORF

Herstellung von Sprengöl
Manufacturing of Nitroglycol

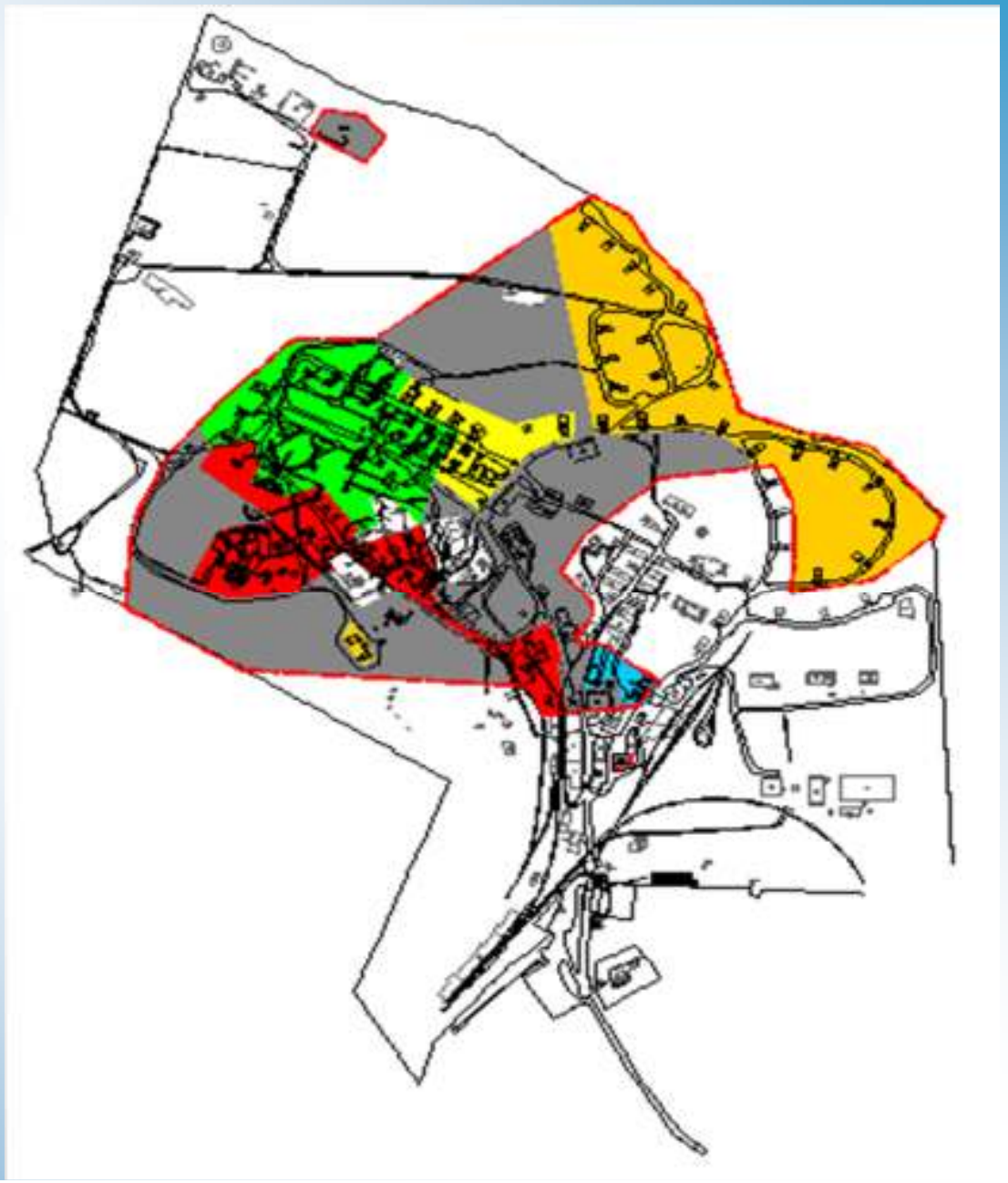
Herstellung von gel. Sprengstoffen
Manufacturing of Dynamites

Herstellung von Andex
Manufacturing of ANFO

Herstellung von Emulsions-Sprengstoffen
Manufacturing of Emulsion Explosives

Lagerung von Explosivstoffen
Storage of Explosives

Sonstige Gebäude
Other Buildings



STAFF WUERGENDORF SITE

EURODYN Sprengmittel GmbH	88
Orica Germany GmbH	20
DNES	116
DYNAenergetics	20
Total: March 2004	244

PRODUCTION CAPACITIES

Process	Operation Mode	Direct labor	Present output p.a.	Technical capacities p.a.	Utilization rate
Nitroglycol	2 shifts / 5 days	7	4.200 to	5.000 to	84
Dynamites	2 shifts / 5 days	35	12.000 to	15.000 to	80
Emulsions	1 shift / 5 days	2	5.000 to(bulk)	12.000 to	42
		3	320 to (pack)	460 to	70
Anfo Plant	1 shift / 5 days	1	3.400 to	4.100 to	83

Supply Chain:	15	
Lab:	7	
Workshop:	13	
Office:	5	
Total:	**88**	**July 2004: 85**

DYNAMITES

Paper wrapped:

diameter 22 - 40 mm

length 150 - 380 mm

weight 100 - 625 g

Extruded in PE:

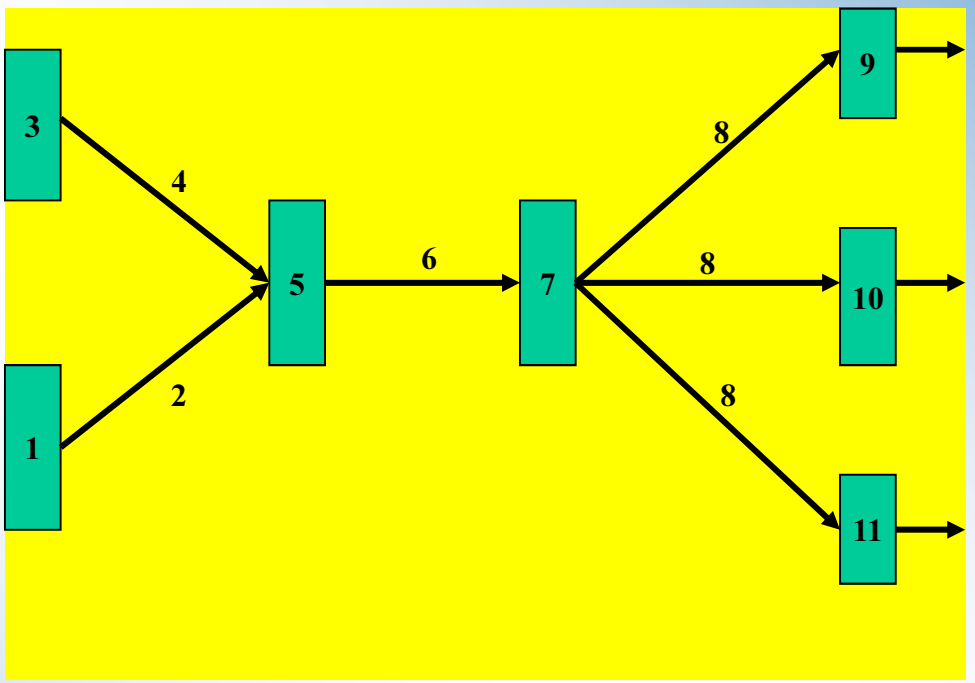
diameter 45 - 100 mm

length 380 - 730 mm

weight 1000 - 5000 g

PRODUCTION LINE FOR GELATINOUS EXPLOSIVES

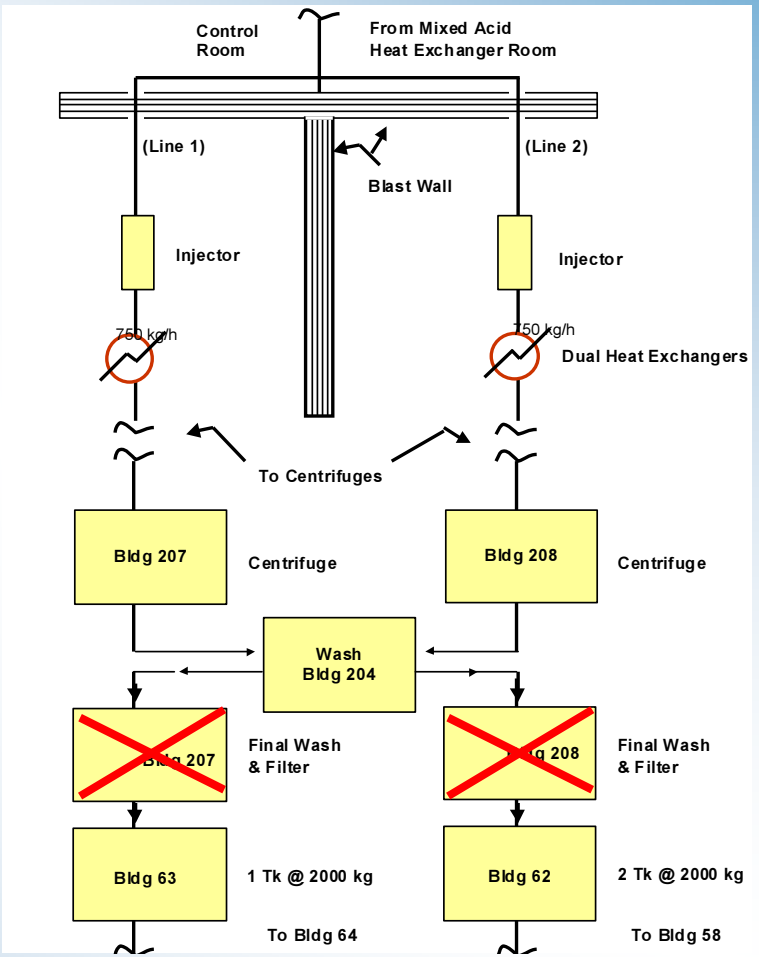
1 Plant for preparation of powder additives
2 Transport of powder additives
3 Production of nitroglycol
4 Transport of nitroglycol by emulsion
5 Mixing plant
6 Transport of explosive to the feeding station
7 Feeding station
8 Transport of explosive to the cartridge machine
9 Cartridge machine for small diameter
10 Cartridge machine for big diameter
11 Cartridge machine for rigid shells



NITRATION PROCESS

Continous- Injector- Process capacity 750 kg/h/line

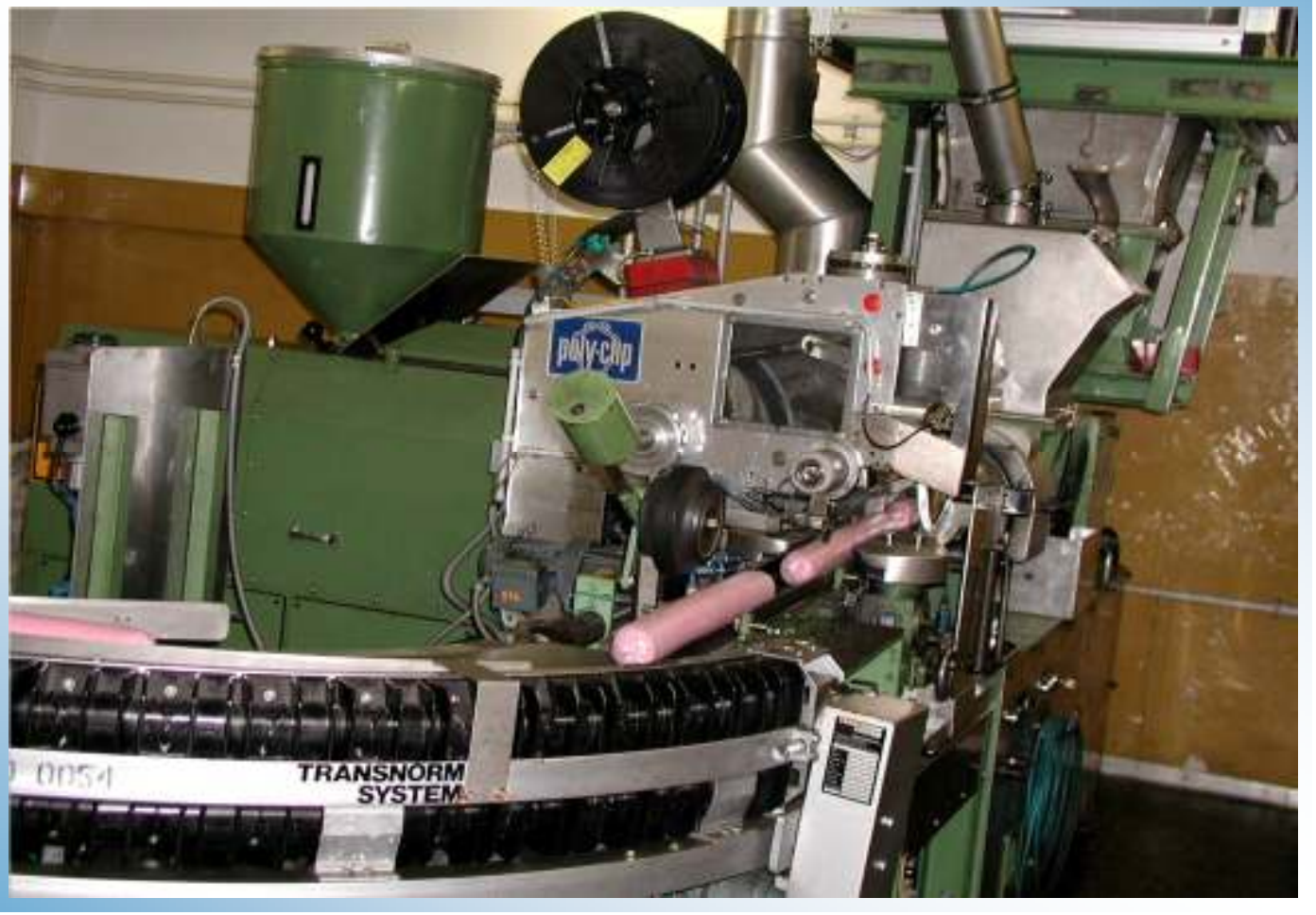
Advantages: two separate lines, remote control, small amounts of Nitroglycol



EGDN PLANT CONTROL ROOM

CARTRIDGING LARGE DIAMETER

3 cartridging lines
diameter 45 - 100 mm
capacity 4 - 16 to/shift/line



CARTIDGING SMALL DIAMETER

2 cartridging lines
diameter 22 - 40 mm
capacity 2 - 8 to/shift/line

EURODYN Sprengmittel GmbH

Fatal injury incident at Wuergendorf site

30.07.2002

1 operator killed

THE OPERATION

Manufacture and Packaging of Dynamite

Small Diameter
- wrapped in paper

Large Diameter
- wrapped in PE
- 2 shifts working 8 hrs each
- senior operation people on site on day of accident

1st INCIDENT

30 July 2002

- Building 49: Dynamite small diameter Packaging Machine: Rollex
- Machine exploded while employee was in room; around about 90 kg of Dynamite
- Possible causes: Foreign body introduced to either Auger or table
- Consequences: one fatality, Machine and Building destroyed

WHAT HAPPENED?

Above transfer tunnel

SEQUENCE OF EVENTS

Monday, 30 July 2002

4.08am	Operators start arriving for work
5.15am	Operators arrive at Processing Room, set up for production of Rollex (manning - 2 operators, one services machines, one packs product, in separate buildings)
5.30am	Rollex Machine starts up, operators rotate, go for breakfast during morning
11.00am	Fitter makes adjustment to machine, operators take turns for lunch break. Cleaning activity and poor quality cartridges returned.
12.35pm	One operator returns to Rollex Room
12.50pm	Explosion occurs

Problems on day

- Paper feed/adjustment, cartridge ejection, feed belt sticky, pusher, shear pin failure

EMERGENCY RESPONSE

Roadway

- Handled by Site Permit Holding Company
- Used existing procedures, full liaison with Police and Regulatory Authorities

EXPLOSION

Entrance to cartridging room

- Occurred in a dynamite cartriding room (Rollex Machine)
- Approx. 90 kg NG explodes
- One Fatality
  (Bruno Itschner,
  - 36 years - married, no children
  - 10 years' experience
  - 2 years in NG on Rollex Machine)
- No other casualties - fortunate as debris (broken concrete, steel, earth, etc.,) rained down over adjacent operating areas
- Extensive damage (projectile and overpressure) in immediate area to equipment, building and roadways, up to 120 metres from blast.
- Machine in 2000 pieces

WHY DID IT HAPPEN?

Feeding Station

Investigation

- **Local team set up to:**
  - manage clean up and recovery of equipment
  - gather background data
  - preliminary investigation

- **Company Team formed:**
  - formal remit,
  - external consultants involved,
  - followed 5-step process

- **Steps involved:**
  - interviewing employees
  - analysis of projectile path
  - re-construction of machine/forensic examination
  - examining system failures
  - preparing a root cause analysis (why diagram)

CONTRIBUTORY CAUSES ACCIDENT 1

- Operator in vicinity of Cartridging room when operating
- Work practises with no sound basis of safety
- Engineering changes with inadequate risk evaluation
- Management and employees lost basic understanding of design philosophies and operational intent of the processes
- A number of likely ignition sources were identified
- Foreign body in Stainless steel feed auger

CONTRIBUTORY CAUSES ACCIDENT 1 (Cont'd)

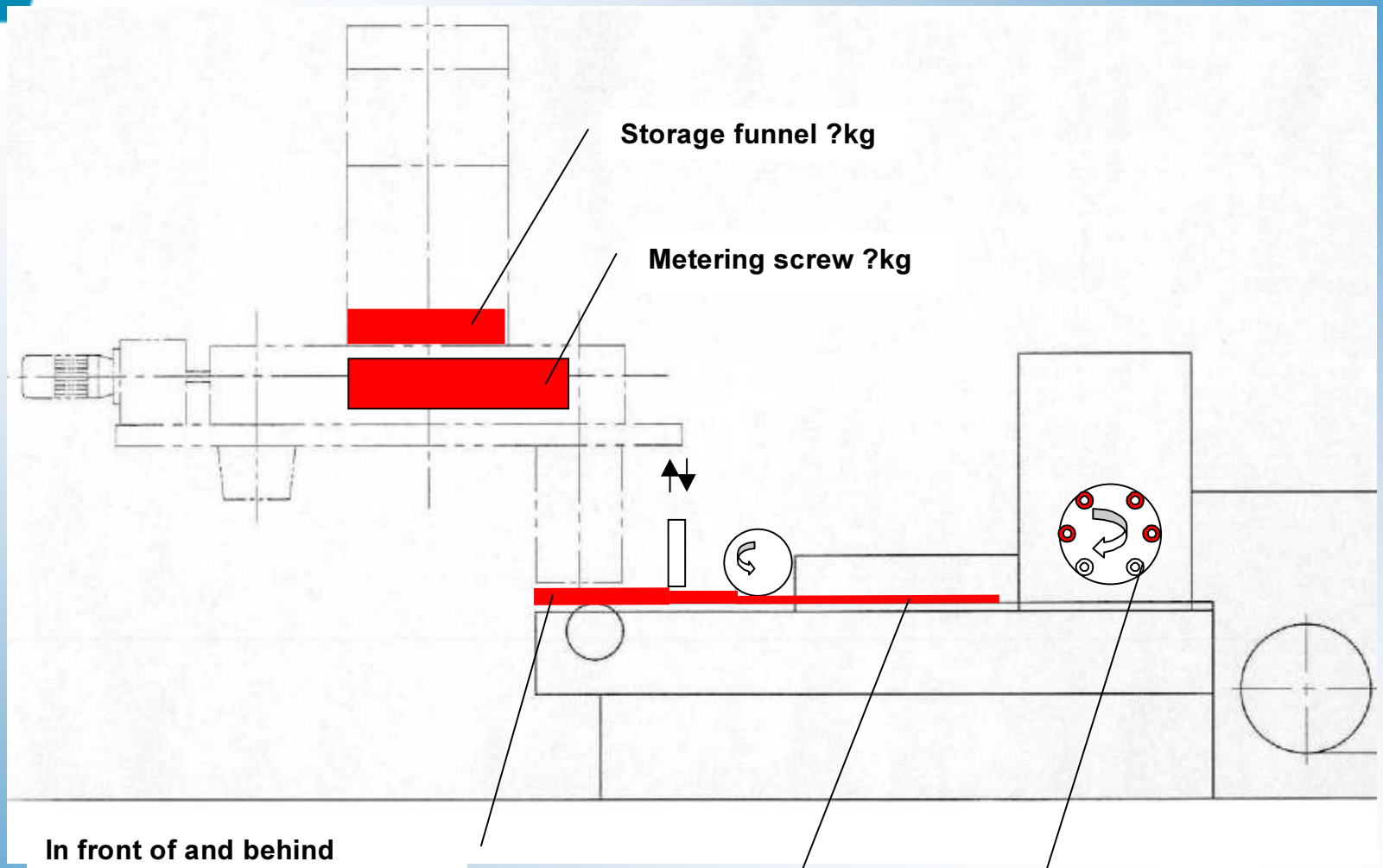
- Dropping of heavy waste tray
- Foreign body between steel knife and steel trough at end of packing table
- Waste process was changed just before explosion,smaller bins for waste explosive much more difficult to scrape trays into
- Trough of machine had been changed from plastic to steel

COURSE OF INVESTIGATION

- Looking for fragments of machine components and identification of this - documentation on maps
- Re-assembling of fragments if possible
- Trace analysis for possible cause at this fragments
- Check of used raw material and already produced cartridges
- Check of Quality Control documentation
- Looking for process cycle weaknesses
- Check of complete data's of production day (malfunctions of machine, time steps in production e.g.)
- Inspection of service and maintenance notes
- Interview of second operator

1st INCIDENT

EXPLOSIVES IN PROCESS



Amount of explosives from experience routine end of production 80-90 kg

COURSE OF INVESTIGATION

Looking for machine components

Revolver

2 cartridges insite

1st INCIDENT

SPECIFIC FINDINGS

- The victim was in the vicinity of the explosive cartridging room in breach of standard work practices. Whether he contributed in any way to the explosion could not be determined and because of the extent of damage caused by the explosion this may never be determined.

FINDINGS (2)

- Over the thirty years that this particular cartridging machine and associated facilities had been operated work practices have evolved which do not have a sound safety base taking into consideration that explosives were being handled. Complacency to the hazards and risks associated with NG based explosives has crept into the organisation at all levels on the site.

FINDINGS (3)

- Engineering changes had been made with little or no concern to the hazards and risks at hand. Many of these changes had been made some years ago and at the time may have been based on sound safe operational and engineering assessments. The reasons for such changes have been lost or forgotten in the current management structure.

FINDINGS (4)

- A number of likely ignition sources for the explosion were identified but none could be determined as the main source of ignition. A foreign body catching in the stainless steel feed auger or at the knife of the cartridging machine are regarded as highly probable ignition points but whether this foreign body was introduced further up-stream in the process or inadvertently by the operator could not be determined.

FINDINGS (5)

- Another possible ignition source could have been the accidental dropping of a heavy waste tray by the operator. This possibility is supported by sensitivity calculations and the fact that a change to explosive waste collection was made some weeks prior to the accident.

CONCLUSION

Searching for machine components

Management and employees at the factory not mindful of

- Design philosophies and operational intent of their operation
- Basic associated safe systems of work

What did we learn?

Feeding Station

WHAT DID WE LEARN ?

- Control of change, a vital safety element
- Importance of behavioural safety
- Importance of continuously reviewing plant and process
- Control of Foreign bodies, screws to personnel jewellery
- Visitors limited and controlled
- Production procedures and plant design need constant review
- Video control of process continuously
- Modification of work instructions (pictures vs. text)
- Other design of workwear, eliminate pockets
- Check of routines for shift change over

2nd INCIDENT

30 September 2002

- Building 207: Third wash process of EGDN.
- Explosion in building after production start over a weekend, around about 60 kg of EGDN.
- Possible causes: friction in ball valves of the EGDN transport; Vacuum forced EGDN to colapse.
- Consequences: Building and machinery destroyed.
- Last event prior to the explosion was the commencement of NG transport to the storage house which involved the remote opening of the valve.

BALL VALVES

2nd INCIDENT

NITRATION PROCESS

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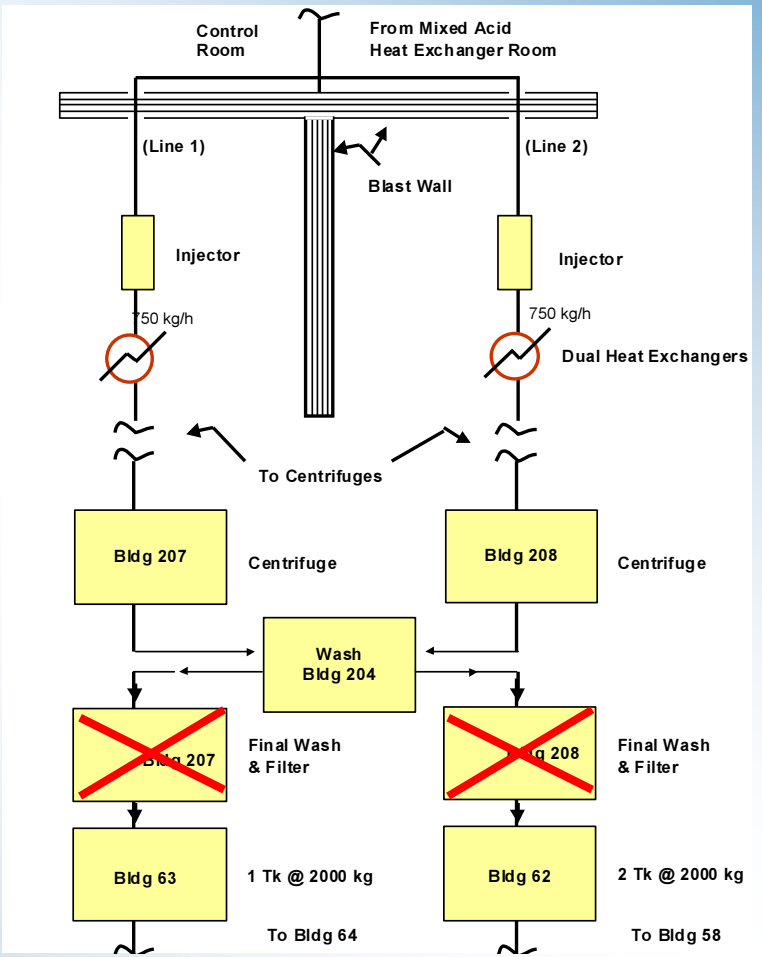


Remote control of NG plant by computer

NITRATION PROCESS

Capacity: 2x 750 kg/h

= 1500 kg/h

No damages

Only minor flying bricks

Building 200 (one of two Nitrators & Related Equipment)

Centrifuge

n = ca. 3500 min^{-1}

Safety issue:
Acidic nitroglycol in centrifuges (appr. 1 - 2 kg)

Wash Building 204 after explosion

Safety issue: Disposal of nitroglycol contaminated material (liquid/ solid) in a bund

2nd INCIDENT

ORICA

Testing Vessel

Building 208

Safety issue: approx. 400 kg nitroglycol in vessel

Pump Building 207.1

Partly damaged

SAFETY ISSUES IMMEDIATELY AFTER INCIDENT

Priority	Location	Situation
1	Wash house 204 Wash & filter house 208	appr. 200 - 400 kg nitroglycol contaminated material (liquid/solid) in each bund
2	Centrifuge houses 201 and 202	appr. 1- 2 acidic nitroglycol in each centrifuge
3	Final wash & filter house 208	appr. 400 kg pure nitroglycol in vessel/separator
4	Storage houses 062 and 063	appr. 40 - 100 kg pure nitroglycol in building 062, appr. 1000 - 1200 kg pure nitroglycol in building 063
5	Destroyed final wash & filter house 207	nitroglycol contaminated ground and soil

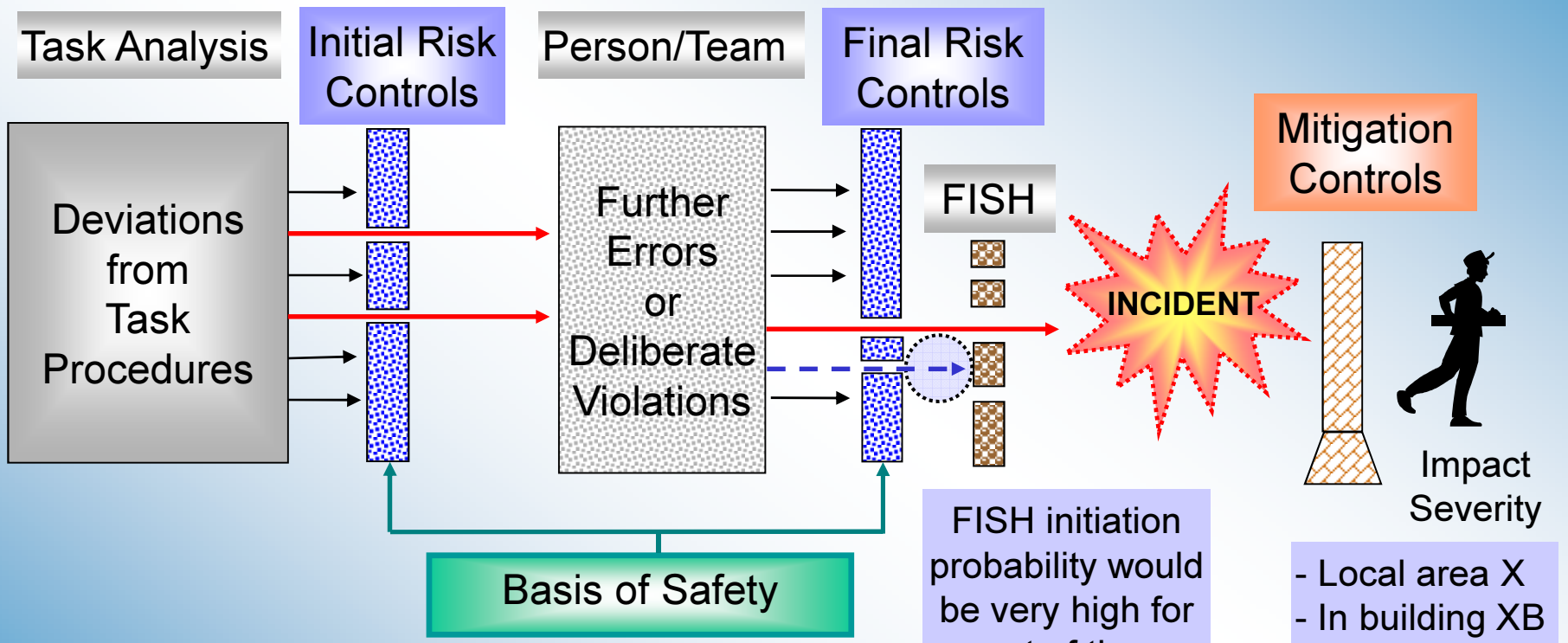
RECOMMENDATIONS FOR WUERGENDORF FACTORY

Turrent and frame of Rollex cartridging machine

Extensive action list (36 items) from investigation covering:

- previous audit action close-out
- site procedures
- safe operating procedures
- process safety (BOS)
- hazard studies
- protection systems
- remoting high risk operations
- re-training
- reinforce adherence to standards
- formal review of completion prior to re-start

“Task Deviations” Accident Model



LESSONS

Frame of Rollex machine was covered with 2 metres of debris

FOR ACQUISITIONS

- Due diligence to include process safety as well as SH&E Leadership/Management
- Understand the process and critical controls
- Identify gaps and action accordingly

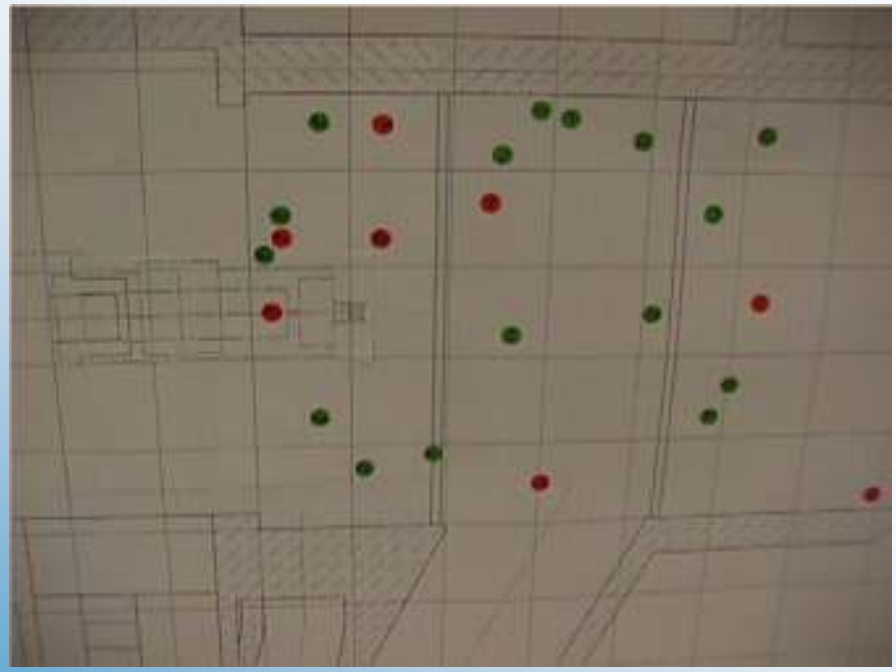
LESSONS (cont'd)

Individual items numbered and photographed

FOR ALL ORICA OPERATIONS

- Reinforcement by management of adherence to safe systems of work (need to be fully implemented to be effective)
- Awareness of dependence on core systems
  - procedures (safety operations, maintenance, etc.) in place and followed
  - training is adequate
  - timely close out of audit and incident actions
- All employees to be vigilant and mindful of potential hazards in processes and materials
- Inherent process safety (Basis of Safety) understood, standards maintained and non-conformances are detected and investigated.

LESSONS (cont'd)



Projectile Analysis on a plot diagram

FOR ALL ORICA OPERATIONS

- Critical processes identified using Periodic Hazard Study procedure
  - identify hazards
  - assess risks
  - controlled risks through design, procedures and training
  - audit
- Internal audit programs effective
- External audit programs target more closely operational level.

DO WHAT WE SAY!

OTHER OUTCOMES

- Strengthened hazard studies and training in the German organization
- Management changes at Wuergendorf
- A review of acceptable FAR criteria, which has led to a focus on truly remoting this dangerous process
- Strengthening of audit action close-out process
- Scheduled BOS audit of Troisdorf processes

OTHER OUTCOMES (cont'd)

- An operational review of procedures and safe work instructions across Orica globally
- Acceleration of the Basis of Safety renewal process within the Explosives Group, which will be directed by a Review Board and which will include a mandatory audit program once the new documents are available.