Prevention and Control of Fire Hazards

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ISWA Study Tour
Waste to Energy 2013
Occurences of Fires 1999-2009 (Austria)

Lit.: Die österreichischen Brandverhütungsstellen
Loss by Fires 1999-2009 (Austria)

Lit.: Die österreichischen Brandverhütungsstellen
Fire Prevention Goals

• **Life Safety**
  – The primary goal of fire safety efforts is to protect occupants or workers from injury and to prevent the loss of life

• **Property protection**
  – The secondary goal of fire safety is to prevent property damage

• **Protection of operations**
  – By preventing fires and limiting damage the continuance of work operations is assured
Challenges in Industrial Fire Prevention

• Complex processes
• Presence of hazardous material
• High concentration of value
• High fire loads
• Rapid fire spread (also neighbouring plants)
• Significant hazardous potential outside the plant area too (toxic releases, smoke, fire fighting water, etc.)
For a fire to occur all factors have to be present at the same time!
Classification of Fires (EN 2:1992)

A. Fires of combustible solids (wood, textiles, etc.)

B. Fires of combustible liquids (petrol, oil, etc.)

C. Fires of combustible Gases (LPG, natural gas, etc.)

D. Metal fires

F. Fires of cooking oil or fat
Development of Fires

- **Initial Fire**: Extinguishment most likely
- **Fire Spread**: Extinguishment partly possible
- **Fully Developed Fire**: Only damage limitation possible
Smoke
Combustion Products

- Incomplete combustion leads to a high output of toxic combustion products

- Depending on the burning product, large amounts of persistent organic pollutants can occur
Smoke Volumes Produced of 10kg Material

- Expanded rubber: 25 000m³
- Cellulose/paper: 10 000m³
- Birch plywood: 8 000m³
- Polypropylene: 7 500m³
- Linoleum: 2 500m³
Fire Water
• Fighting bulk storage fires demands large amounts of water
• Foaming agents are often added for higher effectiveness of water as extinguishing agent
• Soluble storage material or combustion products can accumulate in the fire water
• Fire water may pollute groundwater
Fire Water
Ignition Sources (1)

- flames
- hot work
- hot surfaces
- hot particles
- friction and impact
- chemical energy
- hot materials and gases
- reactive, unstable and pyrophoric materials
Ignition Sources (2)

- engines, vehicles
- lightning
- radio frequency (RF) emissions
- smoking
- arson and sabotage
- self-heating
- static electricity
- electrical equipment
Causes of Fire in Industry

Causes of Fire [%]

- Open Fire
- Electricity
- Arson
- Lightning
- Hot Work
- Unknown
- Other

Lit.: Schneider D., Brandursachenermittlung
Self Heating of Bulk Material

During storage/disposal/handling of all combustible solids local temperature excursion may occur ("hot-spots")
What is the Problem?

Hot-spots may lead to glowing resp. smoldering
Heat generation $\Delta H$: heat of reaction etc.

Heat loss $Q_{ab}$: convection, conduction, (radiation)
Influencing Parameters - Summary

**Material specific parameters**
- composition
- chemical kinetics
- particle size distribution
- bed porosity
- heat conductivity

**Apparatus specific boundary conditions**
- geometry
- size
- surroundings

**Operating conditions**
- temperature
- gas velocity
Characterisation of Material via Datasheets

**Data sheet**
- density
- particle size
- heating value
- specific surface
- adsorption characteristics etc.

**Safety data sheet**
- ignition temperature
- self-ignition temperature etc.

safety-relevant substance data
Example: Activated carbon

- Ignition temperature: 500°C
- Self-ignition temperature: 280°C
Determination of Safety Relevant Parameters

Thermo-gravimetric Analysis

Differential-Thermo-Analysis

Storage experiment in a mesh basket

Packed-bed reactor

Dewar flask
The determined “material connected”, safety-related parameters are influenced by apparatus specific parameters of the experimental set-up.

The determined parameters do not consider the apparatus specific boundary conditions of the system to be investigated.
Mathematical Modeling

Physical model
- air inlet
- gas outlet
- stored material of any geometry
- bed porosity = f(location)
- chemical reactions
- effective heat transfer and heat loss
- buoyancy
- chemical reactions
- bed porosity = f(location)
- effective heat transfer and heat loss
- buoyancy

2d-Model
- conversation of mass, energy, momentum
- boundary conditions BC

Volume element
- gas
- solid

Physical model
- effective heat transfer and heat loss
- chemical reactions
- Bed porosity = f(location)

2d-Model
- conversation of mass, energy, momentum
- boundary conditions BC

Set of differential equations
- discretisation of space and time
- differential equations for each volume element

Set of algebraic equations
Storage Piles
Storage Piles

- without covering
- with covering
Storage Boxes
26.4.2009
RDF Facility
Fire at Waste Treatment Facility

• Auto ignition of refuse derived fuel (RDF) Material

• Poor alarm management

• Damage limitation through fire brigade
Fire at Waste Treatment Facility

Total loss:
2,4 Mio. €
Bunkers (waste incineration plant)
Rubber Waste Interim Storage
Rubber Waste Interim Storage - Geometry

Fires protection bank (Slope angle 45°)

Bank (Slope angle 70°)

max. 18m

65m

15m

58m

Flanks (Slope angle 45°)
Sealing of the site: Sept. 1999

Occurance of the fire: Feb. 8th 2000

- **Reason:**
  - Slipping of a flank after heavy rain
- **Extinguishment:**
  - Water was not successful
  - Brash, Sand
- **Type of fire:**
  - Gas fire
  - Source of fire in the middle of the bulk material
Rubber Waste Interim Storage - Chronology

During the day:
- 50°C
- 30°C

40°C/hour!!

- Cooling down to 25°C
- Sealing of the area
- Renovation of the flank
Rubber Waste Interim Storage - Chronology

- Installation of measuring heads (Temperature, gas composition)
- Inerting/cooling with CO2 (g) and N2 (l)
- Search for the source of fire (July 2000)
Rubber Waste Interim Storage - Chronology

2nd Fire: Jul. 22nd 2000
2nd Fire: Jul. 22nd 2000

- **Reason:**
  - Stack effect because of the opening of the area
- **Extinguishment:**
  - Water, foam
  - Sealing with soil material
- **Type of fire:**
  - Gas fire
  - Source of fire in the middle of the bulk material
Rubber Waste Interim Storage - Chronology

- Inerting/cooling with CO₂ (g) and N₂ (l)

- Clearance of the area
Rubber Waste Interim Storage - Clearance
Rubber Waste Interim Storage – Fire Source

Fire source (ca. 300m³)

Small fire source

max. 18m
65m
15m
58m
Extinguishment - Options

• **Burning Out:**
  – USA, void areas
  – 1 Mill. Tyres -> 200,000 l Pyrolysis oil + Gases

• **Sealing of the site (no other measures):**
  – 1 kg Rubber -> ca. 0.76 l Pyrolysis oil but less Gases
Extinguishment - Options

• Clearance of the area and Ext. with water
  – intensification of the combustion in the beginning
  – localisation of the source of fire may be difficult

• Application of water with lances:
  – Only makes sense when water is applied on the source of fire
  – Disadvantage may be the pollution of the groundwater
Chain of Action

- Prevent
- Detect
- Learn
- Fight

Prevention and Control of Fire Hazards
Integral Fire Safety

Fire Safety

Preventive Fire Protection
- Structural
  - e.g.
  - Fire Areas
  - Fire Barriers
  - Escape Routes
  - Building Materials
- Technical
  - e.g.
  - Alarm Systems
  - Exting. Systems
  - Vent. Systems
  - Fire Seals
  - Evacuation

Fire Defence
- Organisational
  - e.g.
  - Prevention
  - Organisation
  - Supervision
  - Extinguishment
  - Evacuation
- Fire Service
  - e.g.
  - Rescue
  - Salvage
  - Extinguishment
  - Security
Fire Legislation in Austria

- Federal laws
  - ArbeitnehmerInnen-schutzgesetz
  - Gewerbeordnung
  - Elektrotechnikgesetz
  - VbF, VEXAT, etc.

- Regulations/Standards
  - ÖNORM
  - OIB Regulatives

- State laws
  - Baugesetzung
  - Feuerpolizeigesetz

- TRVB
  - Technische Richtlinien Vorbeugender BS

- ÖBFV-RL
  - Richtlinien des österr. Bundesfeuerwehr-Verbandes
Housekeeping

• Mechanical treatment produces large amounts of dust

• Occurrence of dust is a latent fire and explosion risk

• Good housekeeping is a basic measure of fire prevention
Fire Brigade

- Keep in touch with your local fire brigade
- Set up and exercise emergency plans with the fire service
- Establish plant fire brigades for high risk facilities
Prevention of Spontaneous Ignition

- Closed system – self-inerting due to gas production
- Mixing vs. not mixing
- Height of bed
- Angle of slope
- Mixtures of various materials problematic
- Particle size distribution / distribution of bed porosity
- Critical gas velocities
- Complex geometries, obstacles
- Operating temperatures
- Time
High Risk Storage Facilities

- Storage of non-compacted waste with organic and high calorific content in uncovered heaps
- Storage of waste with organic and high calorific content in unwrapped bales.
Low Risk Storage Facilities

- Storage of waste in wrapped bales which provide altogether for bad conditions for self ignition

- Storage of waste in thin-layers with a high built-in density and covering causing a lack of oxygen

- Storage of stabilized waste from MBT (Mechanical or Biological Treatment) whose organic matter and high calorific material has already degraded.
Covering of Flankes
Wrapping of Bales
Zoning of Storage Areas
Fire Detection

Accumulated amount of loss

2/3 of all fires

1/3 of all fires

6 am 6 pm 6 am

Time

Lit.: Richter B., Anlagensicherheit

Prevention and Control of Fire Hazards
Crushing Units

• IR Detection

• Spray nozzels or inerting
Infrared Detection
Measuring Lances

• Temperature monitoring

• Monitoring of combustion products like CO or CO₂
Automatic Extinguishment Systems
Fire Water Retention
Covering Fire Risk

- Plant fire brigade
- Automatic extinguishment system (e.g. Sprinklers)
- Combined detection and Extinguishment system
- Fire areas, Venting systems, Operational fire protection
- No measures necessary
- Automatic fire detection system

Building fire risk

Content fire risk
Literature

(1) Die österreichischen Brandverhütungsstellen (2009) Brandschadenstatistik der österreichischen Brandverhütungsstellen


