

Index

a

abrupt oxidation 52
absorbing oxygen 43
acrylic glass 83
activation energy 10, 42
aerodynamic heating 14
agricultural company 121
agricultural dusts 53
– chemical properties 53
– physical properties 53
agricultural products 24
agricultural substances 27
agricultural/granular materials 13
air striking 9
aircraft warning lights 102
alarm plan 131
ancillary services 108
– breakdown 108
animal food production plant 121
animal food silos 96
arc current 20
Arrhenius-type diagram 45
ash content 65, 67
ASTM 25
ATEX directives 33
audible pop 48
auto-ignition temperature (AIT) 15, 16, 18
– measurements 18
– testing 15
automated detection systems 129

b

BAM furnace 18
BAM oven 18, 34
Bench-scale testing procedures 25
BET method 6
biomass power station 91
Boudouard reaction 29
breathing apparatus 98

brush discharge 21, 22
bulk material 6
– accumulation 6
bulk cargo 96
bulk density 6
bulk goods 3, 6, 8, 9
– humidity 9
– ignition 8
– properties 9
– structure 9–10
bulk material 1, 3, 9, 11, 28, 29, 133
– storage 11
bulk porosity 6
burning components 53
– fat 53
– fibers 53
– proteins 53
– starch 53
bursting disks 132

c

CAD programs 136
calorific value 10, 54
carbon dioxide 9, 10, 112, 113, 120, 132
– storage 120
carbon monoxide 10, 28, 123, 130
chemical elements 10
chemical reaction, *see* fermentation
chemical species 10
Chinese black coals 4
chips 96
coal 9
– chemical structure 9
coal storage silos 81
combustible element 68, 73
– dust 68
combustible gas 51, 55
combustible materials 73
combustible products 73, 74

- combustible substances 67
 combustion gas 75
 combustion processe(s) 51, 59, 79
 combustion substances 79
 computer-aided design (CAD) 136
 corona discharge 21, 22
 cubic meters 1
- d**
- Danish Emergency Management Agency (DEMA) 100, 110
 Danish offshore industry 94
 darting flames 131
 daylight-insensitive spark detectors 85
 daylight-sensitive detectors 85, 88
 – application 88
 decomposition reaction 44, 52
 differential scanning calorimetry 25
 differential thermal analysis (DTA) 39
 DIFT 100, 101
 discharge funnel 128, 129
 disk separator 92
 distributing system 90
 DMT 124
 drencher systems 77
 dry maize dust 59
 dust-air mixtures 133
 – explosions 37
 dust cloud 13, 16, 19, 23, 55
 dust collection equipment 66
 dust deposit 48, 68
 dust dispersion 133
 dust explosion 51, 59, 67, 68, 70, 96, 97
 – events 117
 dust layers 66
 – self-heating 66
 – self-ignition 66
- e**
- electric arcs/sparks 20, 21
 electric current 14, 15, 19, 20
 electric/electrostatic spark ignition 66
 electric field 22
 electric hand lamp 21
 electric heaters 21
 electric lamps 21
 electric motors 69, 74
 electrical conductors 21
 electrical heating 14
 electricity system 106
 electromagnetic fields 20
 electromagnetic waves 14, 19
 electrostatic discharge 22, 23
 endothermic reaction 10
- energetic discharges 23
 Esbjerg Council Emergency Services 110
 excavation procedure 4
 exothermic chemical reactions 23
 exothermic decomposition reaction 40
 exothermic oxidation processes 38
 – characterization 38
 exothermic reaction 8, 10, 24, 33, 39, 40, 43, 47
 explosive gas 10
 explosion doors 71
 explosion hazard 1, 127
 explosion parameters 60
 – flame front position 60
 explosion pressure 70
 explosion severity 39
 – characteristic parameters 39
 explosive atmosphere 71
 explosive atmospheres 33
 external/self-heating dichotomy 13
 extinction system 84
 extinguishing equipment 76
- f**
- false alarms 91
 fast-acting extinguishers 72
 feeding system 90
 FEM codes 136
 fermentation 13
 fiber board factories 87
 fighting smoldering 114
 fine dust 4
 fire alarm systems 80
 fire brigade 109
 fire compartment 76
 fire compartmentalization 75
 – ceilings 75
 – fire walls 75
 – peripheral walls 75
 – screens 75
 fire compartments 75
 fire detectors 79, 129
 – system 130
 fire-explosion protection 65
 fire fighting 94, 119, 131, 122, 124
 – units 93
 fire gas detectors 81, 84
 fire-proofed steel 95
 fire propagation 132, 135, 136
 – components 136
 – scenarios 3
 fire protection silos 87
 fire research station 25
 fire risk assessment 33, 67

- introduction 33
- fire shutters 76
- fire spread 75, 107
- fire triangle 2, 51, 73
- fire unit 76
- fish meal 114
- flame detector 81, 82, 83, 84, 89
- flame propagation 72
- flammability 48
 - explosion limits 129
 - parameters 55
- flammable atmosphere 22
- flammable bulk goods 8
 - materials 1, 128, 138
 - storage of 138
- flammable gas 1, 18, 47
 - gas mixture 20, 21, 22
- flammable gas/oxygen/inert gas mixture 119
- flammable material 2, 79
- flammable organic materials 93
 - animal feed 93
 - grain 93
 - sugar 93
 - wood pellets 93
- flammable solids 10
 - bulk materials 127
 - cellulose 10
 - coal 10
 - grain 10
 - wood 10
- flammable/combustible gases 13
- flammable volatile compounds 44
- foam-contaminated material 106
- foam layer 96
- foam system 77
- food dusts 51
 - chemical properties 51
 - physical properties 51
- food industry 117
 - flour 117
 - malt 117
 - milk powder 117
- food product 68
- plant 121
- free electrons 9
- fuel-oxidizer mixture 22
- fuller chronology 97

- g**
- gas adsorption techniques 7
- gas-air mixtures 15
- gas blows dust 59
- gas concentrations 108
 - carbon dioxide 108
- carbon monoxide 108
- flammable gases 108
- oxygen 108
- gas density 6
- gas discharge 22
- gas measurements 98
- gas-phase reaction 3
- gaseous reaction products 28, 74
 - carbon dioxide 28
 - carbon monoxide 28
 - smoldering fires 28
 - sulfur hydrogen 28
 - sulfur oxide 28
 - water vapor 28
- German Federal Immission Protection Act 119
- German Immission Prevention Rules 124
- German lignite coal 4
- Glor's test methodology 23
- Godbert-Greenwald furnace 18, 55
- grain dust 54, 56, 58, 63
 - explosibility 58
- grain industry plants 60
- granular material 13, 18
- granular solids 24
- granular substance 24
- grass pellets 101
- Grewer oven 48

- h**
- hand-operated fire detectors 86
- handling systems 106
- Hartmann tube 37
- hazard analysis factors 2
- hazardous conditions 62
- heat condensation 9
- heat detectors 85
- heat formation 10
- heat sensors 86
- heat transfer 111
- heating systems 96
- heavy smoke 103
- high-speed flames 72
- high temperature 15
- hot liquid 14
- hot plate test methods 26
 - ASTM E 2021 26
 - EN 50281-1-2 26
 - IEC 61241-2-1 26
- hot solids 14, 18
- hot spots 103
- hot surface area 16
 - effect of 16
- humidity 8
- hydraulic pressure 96

i

- ignite materials 74
- ignition energy 2
- ignition sensitivity 3, 34
 - characteristic parameters 34
- ignition sources 2, 13, 14, 51, 68, 74
 - characteristics 14
 - external 13
 - introduction 13
 - limitation 68
 - self-heating 13
- ignition temperatures 55
- impact energy 48
- incombustible matter 54
- inductive circuit 18
- industrial installation processing combustible solids 33
- industrial plants 55, 67
- industrial powders 13
- inert gas 69, 119, 125, 128
 - injection 128
 - system 77
- inerting system 127
- infrared spectra 82
- injection nozzles 84
- injection sockets gas pipes 128
- inorganic residue 54
- insulating powder 23
- intermediate reactions 10
- IR flame detectors 83
- IR signal channels 89
- isolating devices 72
- isothermal hot storage experiments 44

k

- kinetic model 41, 42
- K_{\max} value 38
- Knudsen diffusion 3

l

- ladder truck 100
- laser beam 4
 - interaction 4
- layer ignition temperature 34, 36
- Lichtenberg discharge 22, 23
- light-density solids 20
- light energy 14
- light-transmission cables 85
- limiting oxygen concentration (LOL) 119
- linear burning rate 75
- long ducts 62
- low-energy discharge 22
 - brush discharge 22
- low ignition energies 66

– sugar 66

- lower explosion limit (LEL)*** 37, 52
- LPG tank ships*** 100

m

- machine rooms*** 75
- Maciejasz index (MI)*** 39
- malt silo*** 124
- test inertization*** 124
- mathematical model*** 59, 136
- self-ignition*** 136
- maximum allowable concentration (MAC)*** 131
- maximum explosion pressure*** 71
 - reduction of*** 71
- maximum rate of explosion pressure rise*** $(dp/dt)_{\max}$ 52
- mechanical equipment*** 65
 - bucket elevators*** 65
 - conveyors*** 65
 - grinders*** 65
 - mixers*** 65
- metal powders*** 9, 120
 - aluminum*** 9
 - brass*** 9
 - carbon black*** 9
 - metallic electrode*** 22
 - metallic plate*** 34
 - methane*** 15
 - air*** 15
 - dust ignition*** 19, 62

- minimum explosive concentration (MEC)*** 37

- minimum ignition energy (MIE)*** 14, 37

- values*** 21

- minimum ignition temperature (MIT)*** 34

- MIT cloud test*** 35

- MIT layer test*** 35

- mobile crane*** 103, 104

- model fire scenarios*** 136

- moisture*** 29, 57, 65

- moisture contents*** 111

- monatomic gases*** 10

- Moroccan esparto grass*** 27

- multistorey grain*** 117

n

- neighboring cells*** 111

- Newtonian cooling*** 135

- nichrome wire*** 15

- nitrogen atmosphere*** 115

- nitrogen storage tank*** 119

- non-automated fire detectors*** 86

- non-burnt gases*** 107

non-flammable gas 14, 120
non-homogeneous dust 62

o

on-site fuel 97
optical sensors 82, 85
organic bulk materials 1
organic dusts 54
organic materials 120
– smoldering fires 120
organic substances 39, 54
output signals 81
oven-basket test method 25
oven tests 25
oxidation reaction 114
oxidizing model 54
oxidizing substances 47
oxygen atoms 9
oxygen content 69
– reduction of 69
oxygen molecules 3

p

particle density 8
particle porosity 7
particulate radiation 19
pentagon explosion condition 67
peripheral installations 33
– bucket elevators 33
– conveyors 33
– sieving machines 33
petrochemical processing 19
physisorbed water, *see* moisture
plant automation 66
plastics industry 19
platinum wire 48
pneumatic delivery systems 96
pneumatic extraction systems 96
poisonous gases 109
polymeric resin particles 23
polypropylene powder 117
powder bed surface 110
powder heap discharge 22
powder technology 6
pre-fabricated construction elements 111
pressure-resistant buildings 70
pressure-resistant equipment 70
primary explosion 53
primary ignition scenarios 19
project-specific spark 84
– extinction system 84
propagating brush discharge 22, 23
protected escape routes 77
protective equipment 73

protective system 72
– operation 72
pycnometer 8
pyrolysis gases 103

r

radio masts 102
raw components 121
reactive system 10
regression curves 45
remote burning objects 18
residual dust 68
risk analysis 33
risk assessment 2, 65
risk identification 33
roof clearance 105

s

sawdust 96
screw connections 21
screw conveyor 88
secondary explosion 53
self-combustion process 33
self-heating ignition 23
self-heating process 13, 112, 114
self-heating substances 18
self-heating theories 24
self-ignition 96, 135
– process 27
– symptoms 74
– temperatures 44
semiconductor sensors 81
sensing systems 83
SFPE handbook 24
silicon atom 9
silicon dioxide molecule 9
silo batteries 1
silo cells 106, 108, 111, 112, 121, 123
– carbon monoxide 112
silo complex 111
silo contents 107
– compacting of 107
silo discharge unit 87
silo fire 118, 119, 121, 124
silo fire fighting 119
– inert gases 119
silo installation 37
silo plant 103, 124
silo roof 109
silo side wall 99
silo surfaces 108
– temperature measurements 108
small-flame ignition 19
small-flame tests 19

- smoke alarm 91
 smoke detectors 80, 81, 84, 90, 91
 – ionization 80, 81
 – optical 80
 smoldering combustion 112, 114
 smoldering fire 28, 114, 117, 137
 smoldering fire propagation 27
 – physical characteristics 27
 smoldering gas explosion 110, 112
 solid dangerous goods 45
 – classification 45
 solid materials 2, 9
 – humidity of 9
 solid particles 7
 – coal 7
 – cotton 7
 – grain 7
 – wood 7
 solid residues 3
 spark detector 84, 85, 88, 89, 90
 – application 90
 spark extinction systems 84
 spatial distribution 75
 – fire load 75
 – fire resistance 75
 spontaneous combustion 24
 spontaneous reactions 10
 spray nozzles 96
 static electricity 19, 21
 steel reinforcing bars 99, 107
 storage equipment 69
 – conveyors 69
 – dust control unit 69
 storage installations 74
 sulfur hydrogen 28
 sulfur oxide 28
 sunflower extraction groats 121
 sunflower seed 111
 suppression systems 72
- t**
- telephone masts 102
 temperature of emission of flammable volatiles (TEV) 39
 temperature plot 42
 temperature sensors 84, 88
 test inertization 118
 TG test 39
 thermal analysis 39
 – differential scanning calorimetry 39
 – thermogravimetry 39
 – data 25
 – DSC 25
 thermal decomposition 1
- thermal engines 74
 thermal stability 44
 – parameter 44
 thermogravimetric analysis 39, 43
 thermogravimetry 41
 three-dimensional geometries 135
 timber frame 95
 toxic atmosphere 131
 tramp metal 14
 transition stage 29
 transport-controlled reaction 135
 transport system 94, 107
 triggering element 86
 – buzzer 86
 turbulence 53
- u**
- UV flame detectors 83
 UV/IR detectors 83
 UV/IR flame detector 89
 UV radiation 83
 UV signal channels 89
- v**
- vacuum dryer 9
 vapor atmospheres 55
 vegetable pellets 105
 ventilation hatches 95
 vibratory sieve 4, 5
 VIS flame detectors 83
- w**
- water extinction system 84
 – closing blades 84
 – dirt collectors 84
 – injection nozzles 84
 – magnetic valve 84
 – pressure controller 84
 water jets 107
 water smoldering fires 8
 water vapor 10, 29, 120, 129
 wheat dust 56
 wheat grain 111
 white-hot temperatures 21
 wire-basket cubes 25
 wood-containing silos 96
 wood chips 87, 96, 117
 wood pellets 93, 98, 99, 100, 101, 105, 107
 wood waste 96
 wood working industry 117
 – chips 117
 – wood dust 117
 wood working machinery 97