

SAFETY CHARACTERISTICS AT NON ATMOSPHERIC CONDITIONS



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PTB

Introduction 1 2

Determination 1

SC characterising
the mixtures
1 2 3 4 5 6 7 8

SC characterising
the ignition sources
1 2 3 4 5

SC describing the
explosion effects
1 2

Summary 1 2 3

Problem

- Atmospheric Conditions (D, EU)
 $-20^{\circ}\text{C} < T < 60^{\circ}\text{C}$
 $800 \text{ mbar} < p < 1100 \text{ mbar}$
- Listed SCD are mostly valid at atmospheric conditions
- Many industrial processes are run at non atmospheric conditions
- SCD at atmospheric conditions on the safe side?

Introduction 1 2

Determination 1

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Summary 1 2 3

- Safety characteristics describing the explosive mixtures
 - LEL, UEL, LOC, LEP, UEP, Flpkt -
- Safety characteristics describing the ignition sources
 - AIT, MESG, MIC, MIE -
- Safety characteristics describing the explosion effects
 - P_{max} , dp/dt_{max} , $V_{burning}$ -

Introduction 1 2

Determination 1

SC characterising
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1 2 3 4 5 6 7 8

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SC describing the
explosion effects
1 2

Summary 1 2 3

Determination

- Temperature \neq ambient temperature
same apparatus possible
identic criterion possible
- Pressure \neq ambient pressure
different apparatuses necessary
identic criterion not possible in every case

LEL, OEL, LOC Apparatuses

Ambient conditions
 $T \neq 20^\circ\text{C}$; $p < 1013 \text{ mbar}$

$p > \text{Ambient pressure}$

Introduction 1 2

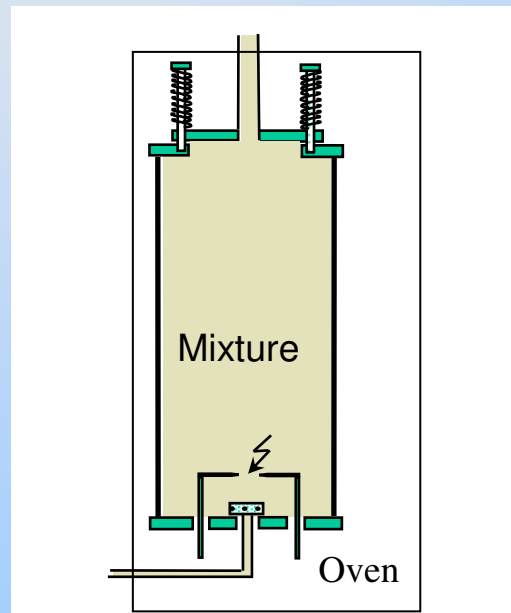
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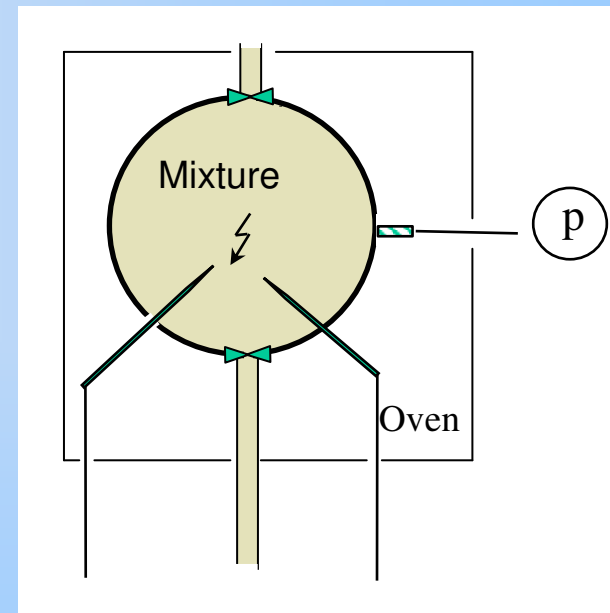
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SC describing the explosion effects 1 2

Summary 1 2 3



Criterion: Flame



Criterion: Pressure Rise

Lower Explosion Limit

Temperature dependence

%/100K

Introduction 1 2

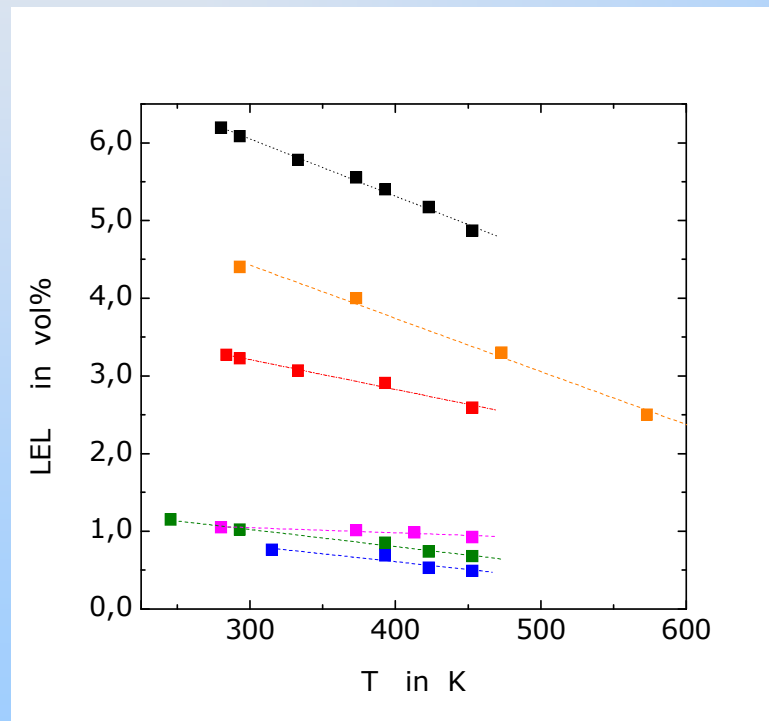
Determination 1

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SC describing the explosion effects 1 2

Summary 1 2 3



Cyclohexane - 9

Methanol - 11

Ethanol - 12

Methane - 15

Mesitylene - 18

Cyclohexanone - 21

Methanol + Mesitylene (3+7) - 25

Lower Explosion limit Upper Explosion limit

Temperature dependence

LEL UEL
%/100K

Introduction 1 2

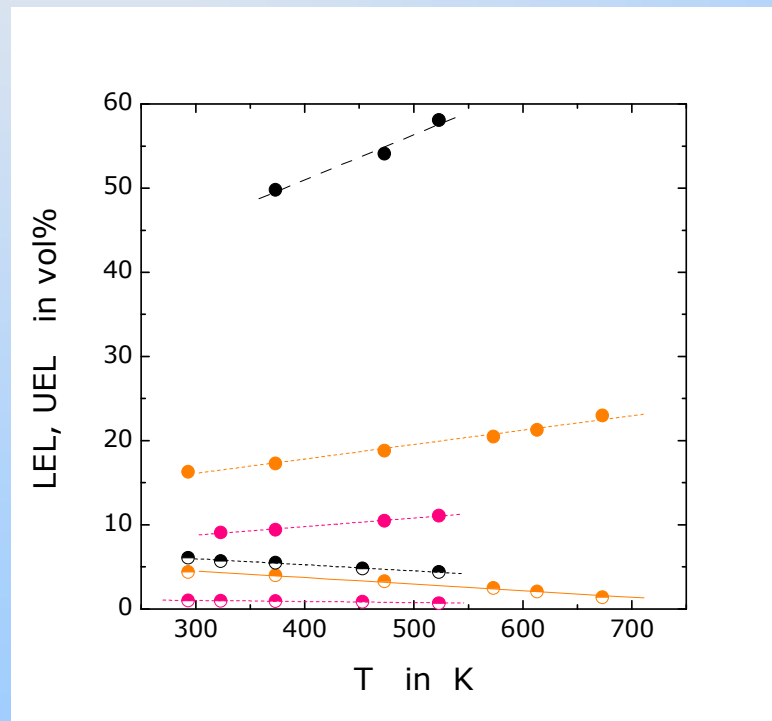
Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

SC characterising the ignition sources 1 2 3 4 5

SC describing the explosion effects 1 2

Summary 1 2 3



Methane	-11	+11
Cyclohexane	-9	+12
Methanol	-15	+12
Xylene	-20	+ 6

Limiting Oxygen Concentration

Temperature dependence

%/100K

Introduction 1 2

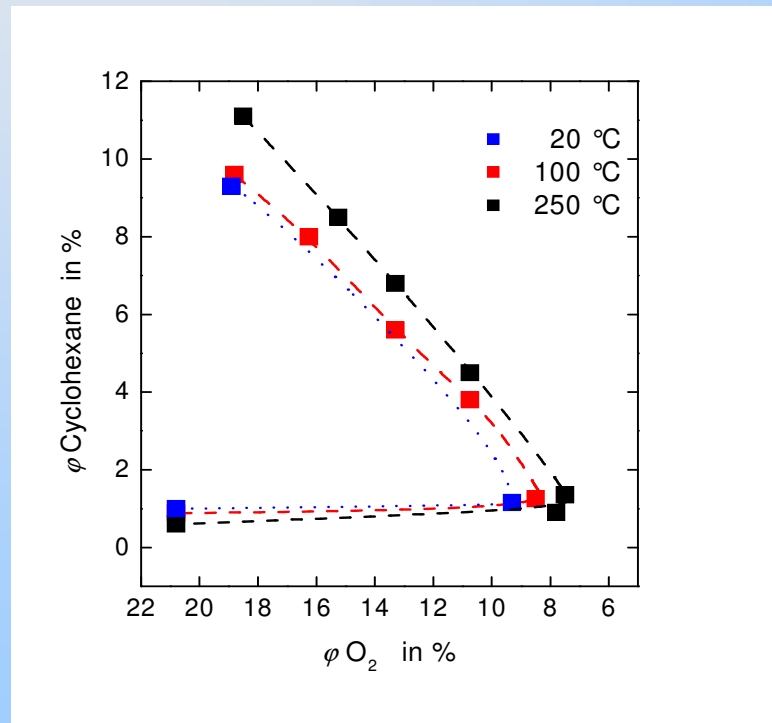
Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

SC characterising the ignition sources 1 2 3 4 5

SC describing the explosion effects 1 2

Summary 1 2 3



Cyclohexane -10

Propanol -12

Propylformiate -10

Dimethylether - 8

Hexane - 6

LEL UEL LOC

Pressure dependence at pressures < 1 bar

Introduction 1 2

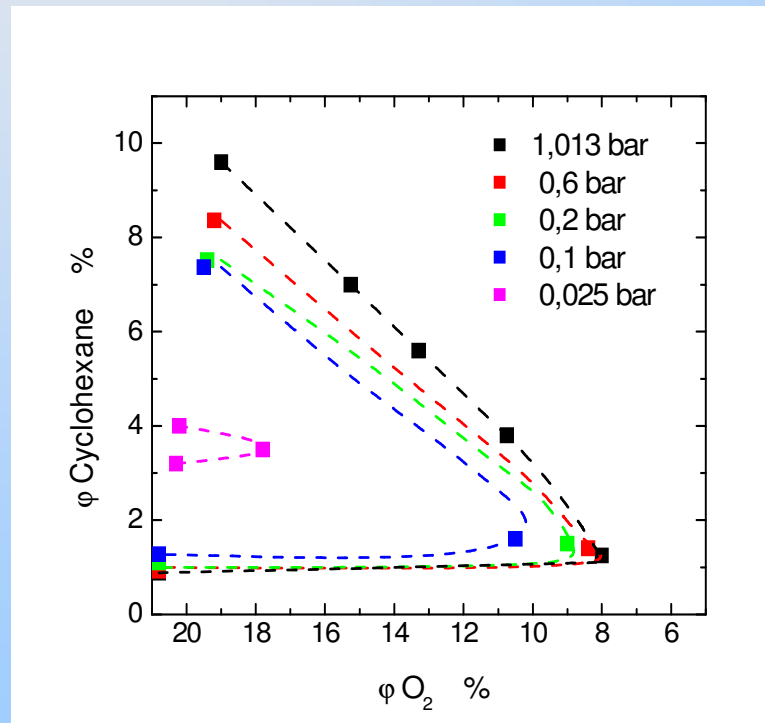
Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

SC characterising the ignition sources 1 2 3 4 5

SC describing the explosion effects 1 2

Summary 1 2 3



LEL: independent up to about 200 mbar, below increasing
 LOC: independent up to about 200 mbar, below increasing
 UEL: depending on the substance

Lower Explosion Limit Upper Explosion Limit

Pressure dependence at pressures < 1 bar

Introduction 1 2

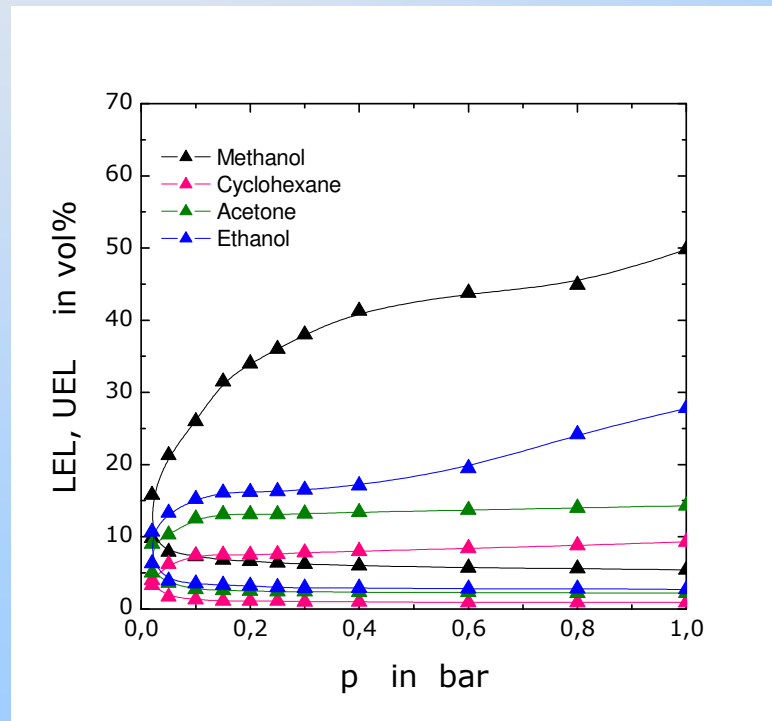
Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

SC characterising the ignition sources 1 2 3 4 5

SC describing the explosion effects 1 2

Summary 1 2 3



UEL: depends on the substance

LEL UEL LOC

Pressure dependence

Introduction 1 2

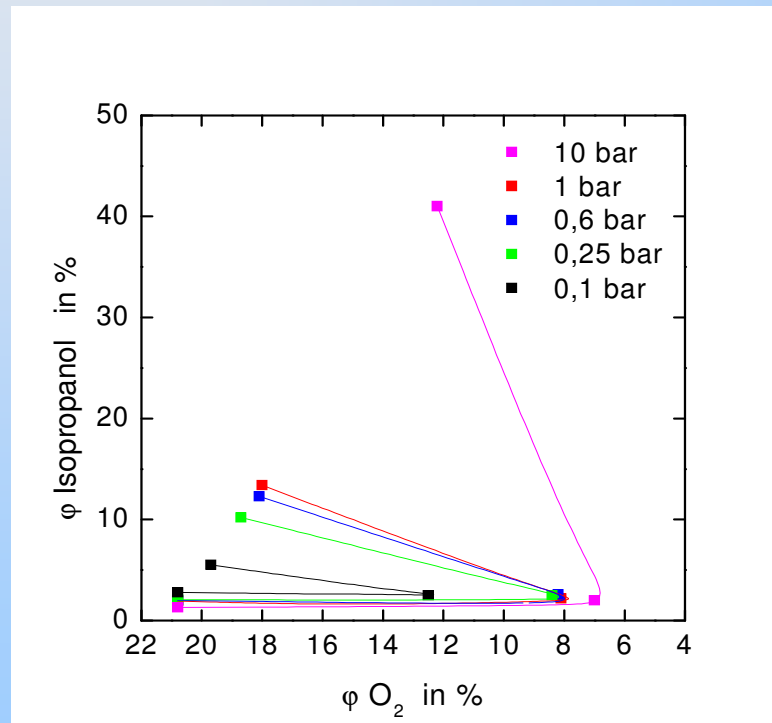
Determination 1

SC characterising the mixtures
1 2 3 4 5 6 7 8

SC characterising the ignition sources
1 2 3 4 5

SC describing the explosion effects
1 2

Summary 1 2 3



LEL: more or less independent
 SGK: depending on the substance
 UEL: depending on the substance;

LEP UEP

Pressure dependence

Introduction 1 2

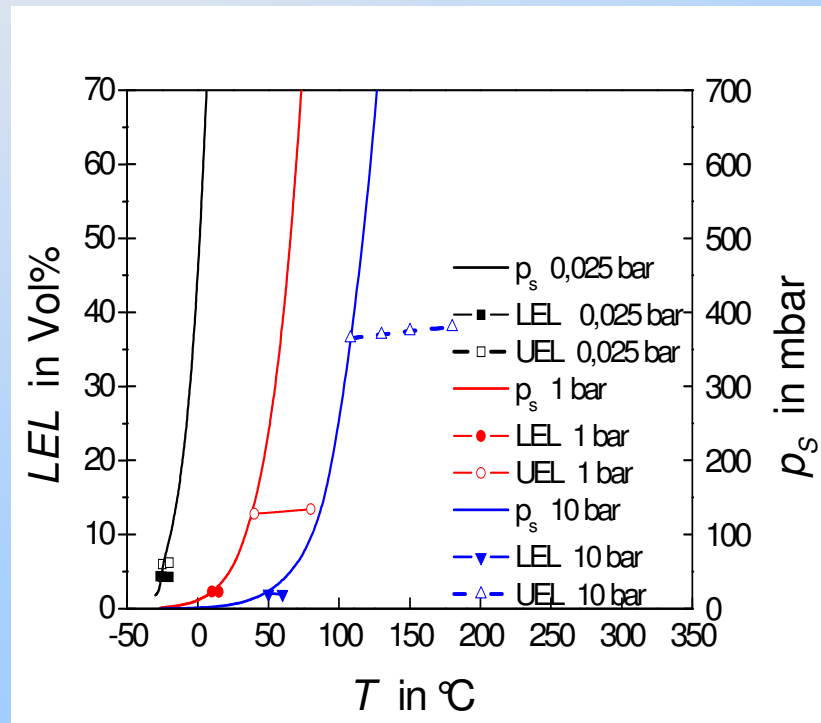
Determination 1

SC characterising the mixtures
1 2 3 4 5 6 7 8

SC characterising the ignition sources
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SC describing the explosion effects
1 2

Summary 1 2 3



LEP increases with increasing pressure

UEP increases with increasing pressure

Temperature range between LEP and UEP increases with increasing pressure

Auto Ignition Temperature Apparatuses

Introduction 1 2

Determination 1

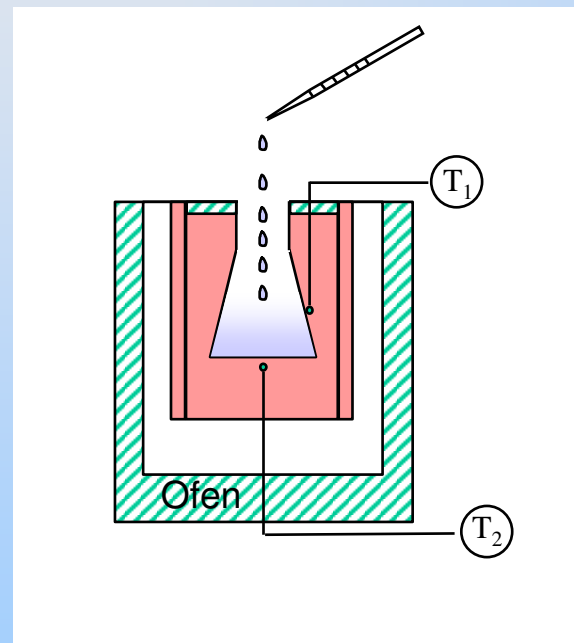
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SC describing the explosion effects 1 2

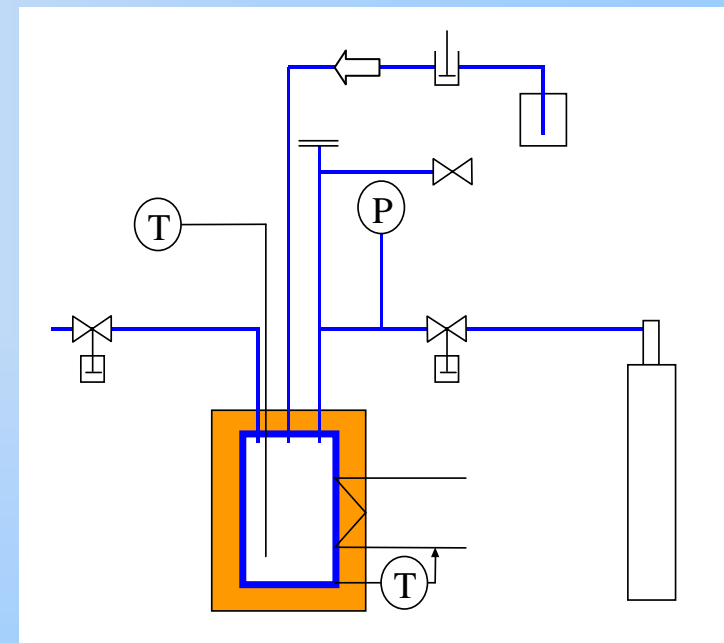
Summary 1 2 3

Ambient Conditions



Criterion: Flame

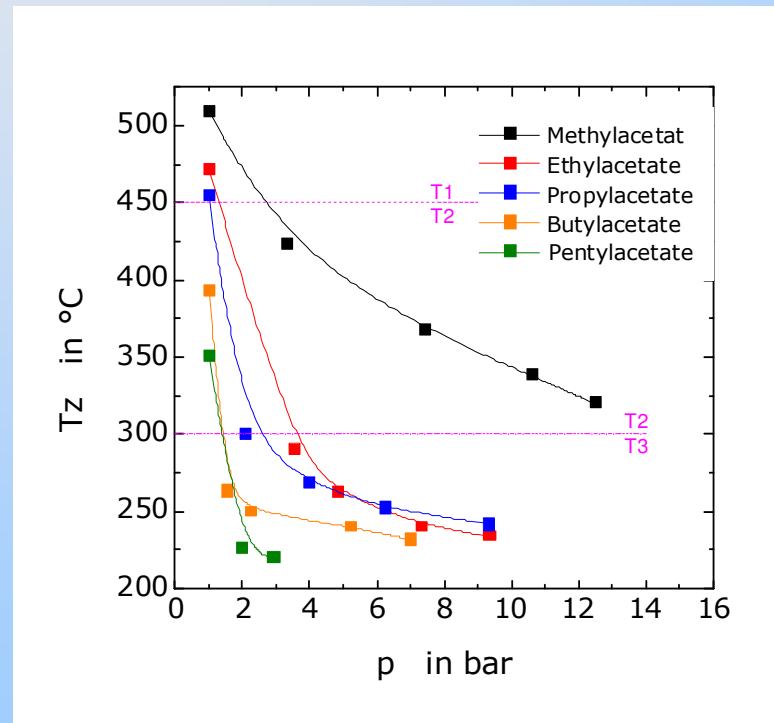
$p \neq$ Ambient Pressure



Criterion: Temperature rise

Auto Ignition Temperature

Pressure dependence



Degree depends on the substance



„ranking of dangerousness“
(temperature classes)
can not be transferred

Introduction 1 2

Determination 1

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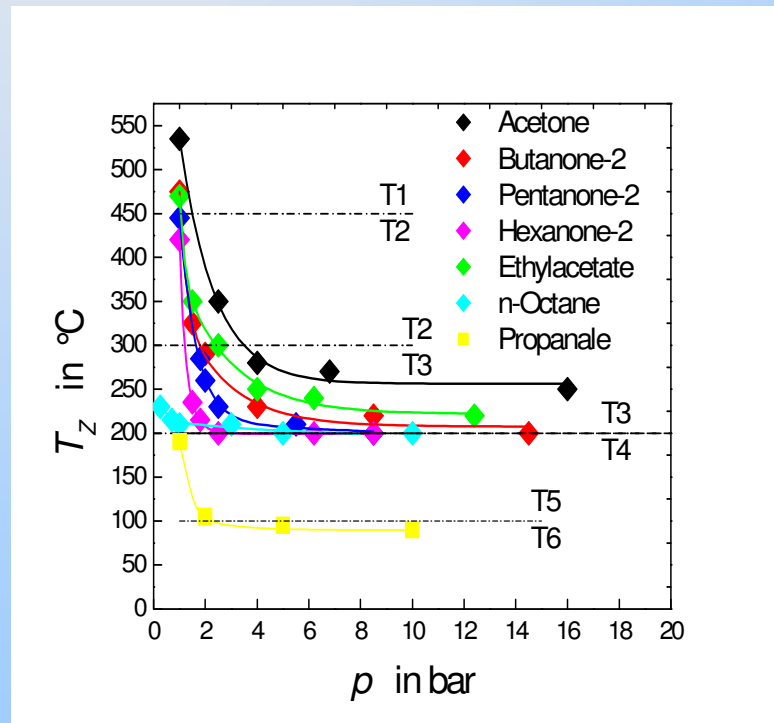
SC characterising the ignition sources 1 2 3 4 5

SC describing the explosion effects 1 2

Summary 1 2 3

Auto Ignition Temperature

Pressure dependence



Degree depends on the substance



„ranking of dangerousness“
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Introduction 1 2

Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

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SC describing the explosion effects 1 2

Summary 1 2 3

Maximum Experimental Safe Gap Apparatus

T up to 250°C 300 mbar < p < 3 bar

Introduction 1 2

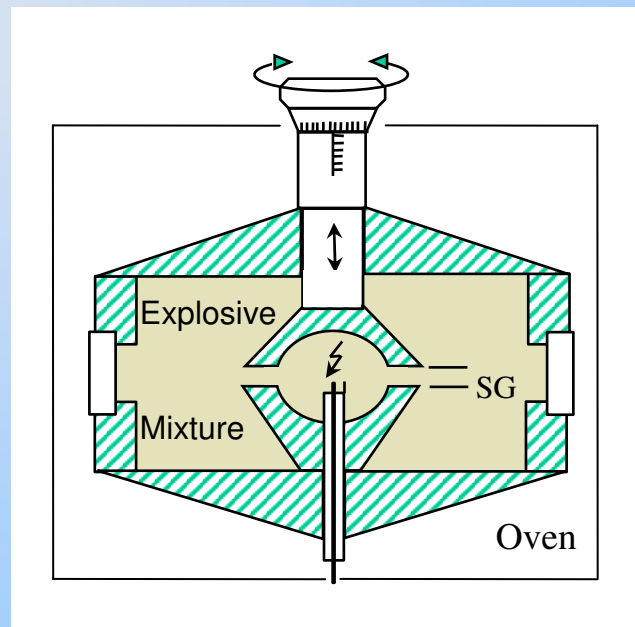
Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

SC characterising the ignition sources 1 2 3 4 5

SC describing the explosion effects 1 2

Summary 1 2 3



Criterion: Flame

Maximum Experimental Safe Gap

Pressure dependence
 $300\text{mbar} < p < 3 \text{ bar}$

Introduction 1 2

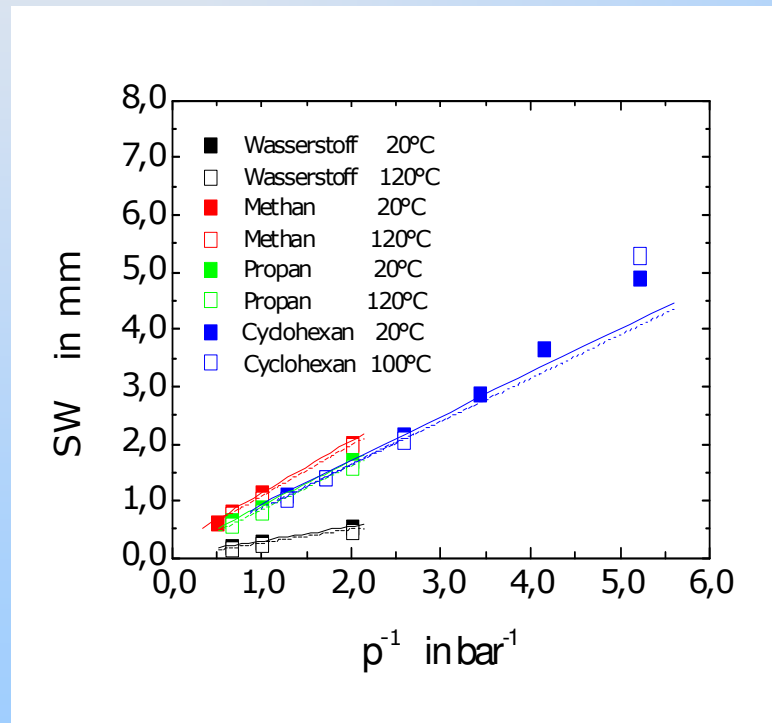
Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

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Summary 1 2 3



$$MESG_T(p) = \frac{p_0}{p} \cdot MESG_T(p_0)$$

p_0 : pressure to relate on
 p : pressure
 T : temperature



„ranking of dangerousness“ remains

Maximum Explosion Pressure Apparatus

Ambient conditions $T \neq 20^{\circ}\text{C}$ $p \neq 1013 \text{ mbar}$

Introduction 1 2

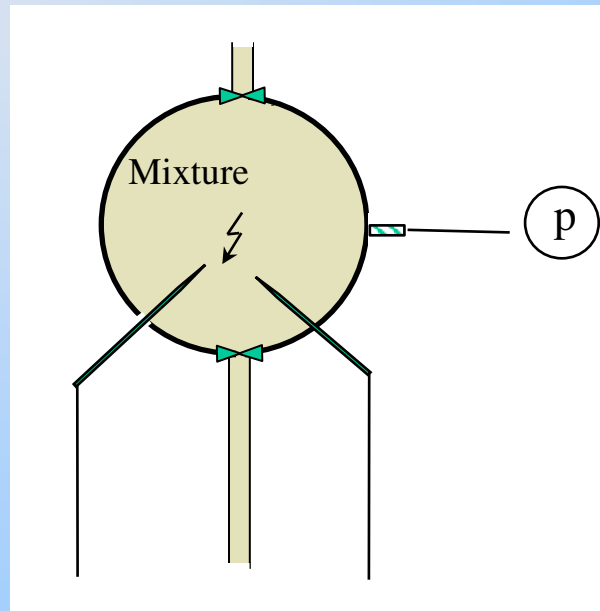
Determination 1

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Summary 1 2 3



Criterion: Pressure Rise

Maximum Explosion Pressure

Pressure and temperature dependence
 Pressures up to 10 bar; Temperatures up to 250 °C

Introduction 1 2

Determination 1

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Summary 1 2 3

$$P_{\max}(T,p) = \frac{P_{\max}(T_0,p_0) \cdot p \cdot T_0}{T \cdot p_0}$$

p_0 : pressure to relate on

p : pressure

T_0 : temperature to relate on in K

T : temperature in K

Introduction 1 2

Determination 1

SC characterising the mixtures 1 2 3 4 5 6 7 8

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SC describing the explosion effects 1 2

Summary 1 2 3

Temperature dependence

- Explosive mixture
explosion range is enlarged with increasing temperature \Rightarrow
SCD at ambient conditions **not on the safe side**
- Ignition sources
energy necessary for ignition decreases with increasing temperature \Rightarrow
SCD at ambient conditions **not on the safe side**
- Effects of an explosion
Degree is reduced with increasing temperature \Rightarrow
SCD at ambient conditions **on the safe side**

Pressure dependence

Introduction 1 2

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Summary 1 2 3

- Explosive mixture
explosion range (LOC, UEL) is enlarged with
increasing pressure ⇒
SCD at ambient conditions **not on the safe side**
Exception LEL
Temperature range between which explosive
mixtures can exist (LEP, OEP) is shifted to higher
temperatures and is enlarged with increasing
pressure ⇒
LEP at ambient conditions **on the safe side**
UEP at ambient conditions **not on the safe side**

Pressure dependence

Introduction 1 2

Determination 1

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Summary 1 2 3

- Ignition sources
energy necessary for ignition decreases with increasing pressure \Rightarrow
SCD at ambient conditions **not on the safe side**
- Effects of an explosion
Degree is enlarged with increasing pressure \Rightarrow
SCD at ambient conditions **not on the safe side**