

# Work and Health Safety

## Fire safety in laboratories

Erstellt von der Stabsstelle Sicherheit 11/2010  
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"The fact that in many buildings decades may pass with no fires does not prove that there is no danger, but instead represents a stroke of luck for those concerned, the end of which must be expected at any time!"

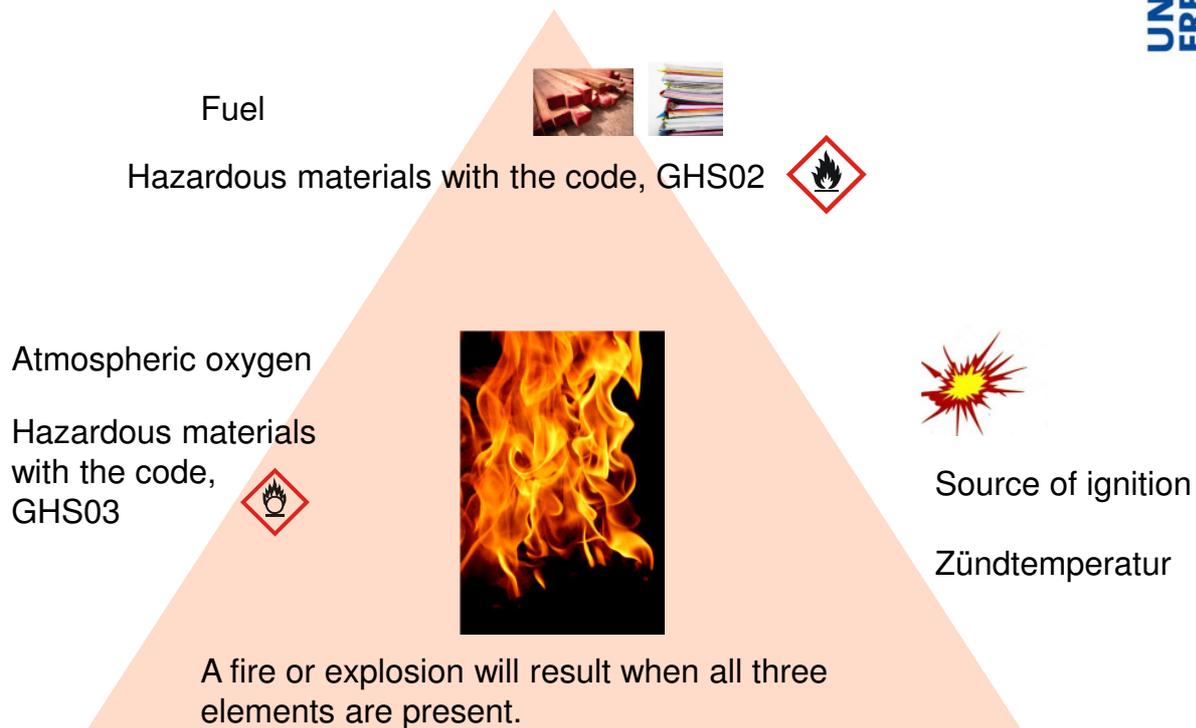
Oberverwaltungsgericht Münster, 10A 363/86 vom 11.12.1987

# Requirements for a fire

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# Combustible and Hazardous Materials

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Hazardous materials with the following GHS physical hazard classes (new):

- flammable gases
- flammable aerosols
- flammable liquids
- flammable solids
- materials and mixes that, when combined with water, form flammable gases
- pyrophoric liquids
- pyrophoric solids



Danger / Warning

Hazardous materials with the following hazard warnings (EU, old label)



Extremely flammable (F +), flash point  $< 0^{\circ}\text{C}$



Highly flammable (F), flash point  $0^{\circ}\text{C} \leq 21^{\circ}$

-

Flammable, flash point  $> 21^{\circ}\text{C}$

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# Oxygen, Hazardous

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Oxygen from air or as compressed gas in bottles



Hazardous materials with the following GHS physical hazard classes (new):

- oxidizing gases
- oxidizing liquids
- oxidizing solids
- organic peroxides



Hazardous materials with the following hazard warning (EU, old label)

- Oxidize (O)

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# Important Fire Potential Factors

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**Boiling Point**

**Temperature of Ignition**

**Flash Point**

**Explosive Limit**

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# Boiling Point

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The boiling point is the temperature at which a liquid passes into the gaseous state, i.e., the liquid and gas phases are balanced

## Examples:

|              |         |
|--------------|---------|
| Ethanol      | 78,3°C  |
| Diethylether | 34,5°C  |
| Aceton       | 56,2°C  |
| Toluene      | 110,6°C |

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# Temperature of Ignition

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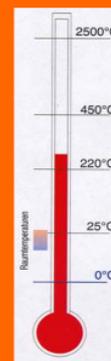


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= The ignition temperature is the temperature at which a substance in contact with air spontaneously catches fire by itself. No open flame or a spark is required when it reaches a certain temperature.

## Examples:

|                  |        |
|------------------|--------|
| Ethanol          | 425° C |
| Diethylether     | 170° C |
| Carbon disulfide | 102° C |



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# Ignition Hazard Due to Heated Air

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High danger of fire with use of hot air heat guns. These devices achieve up to 550 ° C, nearly the same temperature as a Bunsen burner. This applies not only to the heating wires in the interior of the equipment but also for the air jet.



Therefore:

- Do not operate near combustible objects, liquids or vapors
- Do not lay next to such substances
- basically, with precautions allowed for the exhaust tube, best used when firmly mounted in a bracket

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# Danger in heating and hot baths

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- To heat with a hot liquid bath, use only an electric heater
- Only use heat transfer media for which the maximum safe operating temperature is known.

e.g., PEG 1000 Polyethylene glycol  
max 230°C

e.g., Silicone oil  
max. 250°C

- = Laboratory equipment must always be fully removable from the heat source. Therefore, build experimental equipment so that the hot bath can be completely removed.

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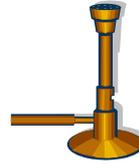
# Gas burners

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Bunsen burners must not have separate shut off valves because no pressurized gas should be allowed to remain in the gas line between the shut-off valve and burner after turning the burner off!  
Use only DVGW certified gas lines!



If a cartridge gas burner, the burner must be shut off completely. A burner with a sensor circuit should be protected against accidental activation. The storage cylinders must **not** be stored in safety cabinets with combustible liquids.



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# Flashpoint

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The flashpoint is defined as the lowest temperature at which a liquid will form an ignitable air-vapor mixture.

In contrast to ignition temperature, ignition does not spontaneously occur at the flashpoint; a source of ignition is still required.



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# Flashpoint

## Classification Criteria: EU (old) – GHS

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| Criteria                                                                    | Risk Statement        | Pictogram/Warning                                                                                    |
|-----------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------|
| Flashpoint $\geq 21^{\circ}\text{C}$ und $\leq 55^{\circ}\text{C}$          | 10 (Flammable)        | -/-                                                                                                  |
| Flashpoint $\geq 0^{\circ}\text{C}$ und $< 21^{\circ}\text{C}$              | 11 (Easily Flammable) | Easily flammable  |
| Flashpoint $< 0^{\circ}\text{C}$ u. Boiling Point max. $35^{\circ}\text{C}$ | 12 (Highly Flammable) | Highly flammable  |

| Criteria                                                                        | Kategorie, Hazard Statement                               | Symbol/Warnhinweis                                                                                      |
|---------------------------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Flashpoint $< 23^{\circ}\text{C}$<br>Boiling Point $\leq 35^{\circ}\text{C}$    | Kategorie 1, H224<br>Extremely flammable liquid and vapor | GH02<br><br>Danger   |
| Flashpoint $< 23^{\circ}\text{C}$<br>Boiling Point $> 35^{\circ}\text{C}$       | Kategorie 2, H225<br>Highly flammable liquid and vapor    |                                                                                                         |
| Flashpoint $\geq 23^{\circ}\text{C}$<br>Boiling Point $\leq 60^{\circ}\text{C}$ | Kategorie 3. Flammable liquid and vapor                   | GHS02<br><br>Warning |

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# Flashpoint – Examples

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**Acetone** Flammpunkt  $-20^{\circ}\text{C}$   
Siedepunkt  $+56^{\circ}\text{C}$

**Diethylether** Flammpunkt  $-45^{\circ}\text{C}$   
Siedepunkt  $+36^{\circ}\text{C}$

**Tetrahydrofuran** Flammpunkt  $-14,5^{\circ}\text{C}$   
Siedepunkt  $+66^{\circ}\text{C}$

**n-Hexane** Flammpunkt  $-22^{\circ}\text{C}$   
Siedepunkt  $+69^{\circ}\text{C}$



Highly Flammable



Danger

**Ethanol** Flammpunkt  $+12^{\circ}\text{C}$   
Siedepunkt  $+78^{\circ}\text{C}$

**Methanol** Flammpunkt  $+11^{\circ}\text{C}$   
Siedepunkt:  $+65^{\circ}\text{C}$

**Pyridine** Flammpunkt  $+17^{\circ}\text{C}$   
Siedepunkt:  $+115^{\circ}\text{C}$



Easily Flammable



Danger

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Examples of ignition sources:



- **Open flame**
- **Electrical apparatus**
- **Radiation**
- **Friction**
- **Chemical reactions**
- **Hot surfaces**
- **Static electricity**
- **Mechanically created sparks**

Ignition hazard due to static electricity can apply to:

- combustible liquids, e.g., during transfer; fast flow through tubes or spraying
- combustible dusts and granules, e.g., following turbulence; grinding; mixing; screening
- Suitable safety measures are, e.g.:
- Electrically ground conductive vessels and equipment

pour electrostatically non-conductive fluids slowly and not in free fall;  
keep the funnel's neck close to the bottom of the vessel.

# Explosive Atmospheres due to Flammable\* Liquids Stored in Refrigerators

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## Sources of ignition in refrigerators

- Thermostat
- Interior light
- Automatic defroster

15 ml methyl butane in a beaker stored overnight in a 4 ° C refrigerator created an explosive atmosphere. A spark from one of the sources of ignition in the refrigerator caused the explosion.

Small quantities of flammable liquids in a refrigerator (volume 100 liters) are sufficient to produce an explosive atmosphere:

|              |       |          |      |
|--------------|-------|----------|------|
| Diethylether | 10 ml | Ethanol  | 5 ml |
| Acetone      | 7 ml  | Methanol | 4 ml |

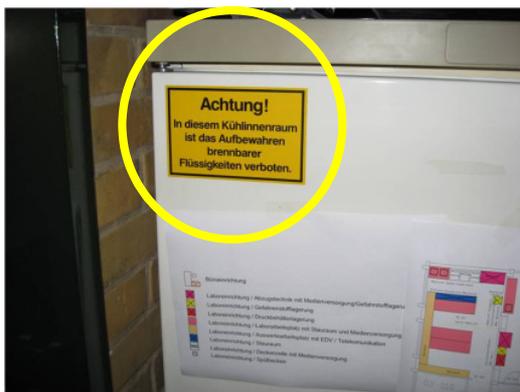
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# Flammable Liquids Must Not Be Stored in Standard Refrigerators

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Standard refrigerators shall be so marked:

Warning! Storage of flammable liquids in this refrigerator is prohibited.

No flammable liquids in standard refrigerators! Interiors are not explosion-proof! Even small containers, such as described, are sufficient to produce enough vapor to result in an explosive atmosphere within the refrigerator.



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# Explosion Protected Refrigerators

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An explosion-proof refrigerator is defined as a refrigerator without ignition sources in the interior, i.e., without interior lights, thermostats or automatic defrost. All electrical components are installed on the refrigerator's exterior.

Explosion-proof refrigerators shall be so marked:

„Nur Innenraum frei  
von Zündquellen“

ACHTUNG!  
Nur Innenraum frei von Zündquellen.  
Zur Aufbewahrung  
brennbarer Flüssigkeiten  
geeignet  
Kolben unbedingt beschriften und sichern (Stopfen, Klammer)!!



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# Explosion Limits

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Lower Explosion Limit – UEG/LEL

Upper Explosion Limit – OEG/UEL



“lean mixture”

Explosive Range

“rich mixture”

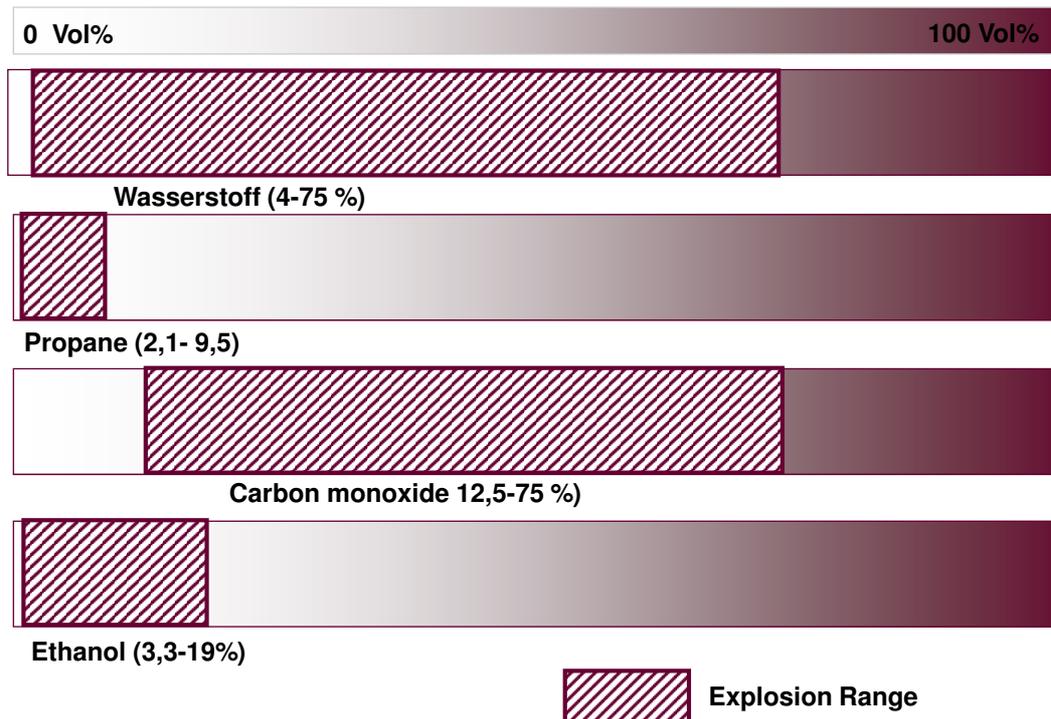
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# Explosion Limits

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# Fire and Explosion Caused by Organic Peroxides

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Many organic compounds can combine with atmospheric oxygen to form peroxides. These are of low volatility, but, particularly during distillation, can produce enriched gas mixtures that could decompose **explosively**.

Liquids that tend to form organic peroxides must therefore:

- Be tested for the presence of peroxide and the peroxides removed before distillation or evaporation is begun.
- Be protected from light



Examples

Diisopropylether  
Diethylether  
Tetrahydrofuran  
Dioxane

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# Storage of Flammable\* Liquids in Safety Cabinets

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Safety Poppet Valve



Temperature Sensor



Gasket

Safety Cabinets have three safety mechanisms:

- Safety Poppet Valve
- Temperature Sensor on the door
- Gasket around the door opening

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# Storage of Flammable Liquids in Safety Cabinets

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These flammable liquid safety cabinets fulfilled their function and protected the containers inside them during a major fire at the University of Ulm in 1999.



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# Storage of gas cylinders in gas cabinets

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During the fire at the University of Freiburg chemistry laboratory in 2006, a safety cabinet protected this compressed gas cylinder.



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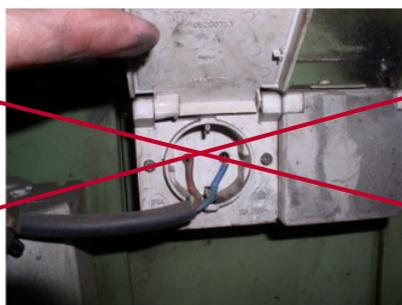
# Electrical Equipment Can Cause Fires

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- ▶ Visually inspect before every use!
- ▶ Use no defective electrical appliance, extension cord, power strip, etc.
- ▶ Immediately mark any defective electrical appliance, cable, etc., then repair, or discard and replace.
- ▶ Regularly test portable electrical equipment



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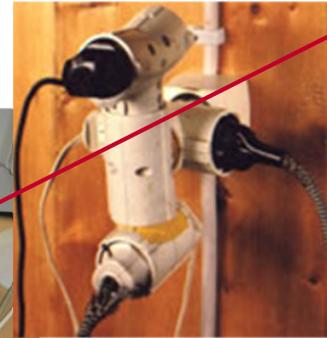
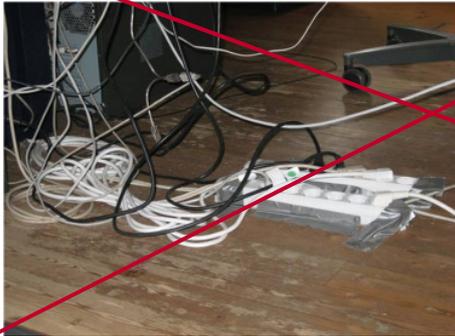
# Electrical Equipment Can Cause Fires

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- No overloads on power supply
- No stand-by mode
- No cable spaghetti



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# Fire in the kitchenette of the Mathematics Institute of Freiburg University in 2005

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# Fire in the kitchenette of the Physics Institute at Freiburg University in 2008

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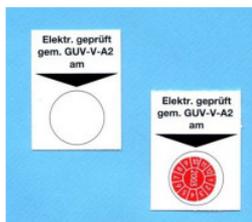
## Increased attention is needed regarding coffee machines, electric kettles, etc.

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- ▶ Regular testing of portable electrical appliances such as coffee machines, kettles, microwaves, etc., is a must - even privately owned devices must be tested!



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# A Fire Is Always Accompanied by Smoke

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Smoke from a fire is often underestimated. A building can be completely filled within 2-3 minutes.

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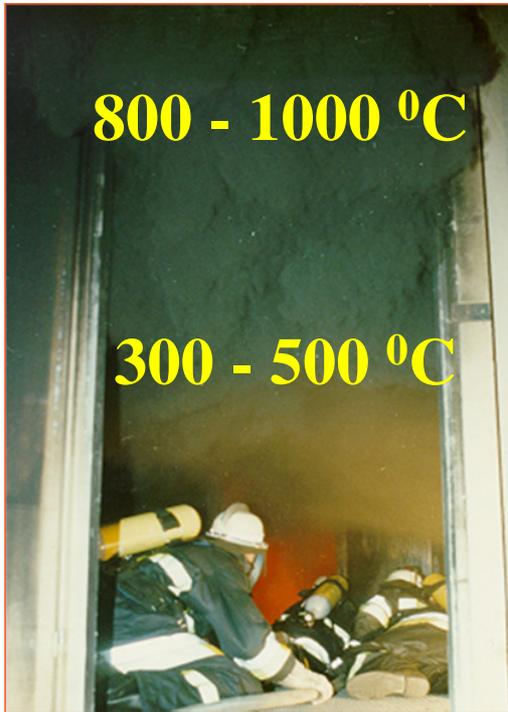
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## Measures for fire prevention / fire precautions

### Structural fire protection:

- Fire zones
- Escape and rescue routes
- Emergency exits



### Operational / Organizational fire protection:

- Reduction of fire loads
- Training of employees regarding:



Notausgänge = Emergency exits  
 Available fire-fighting equipment (Fire extinguishers, fire blankets, safety showers, etc.)  
 Conduct in case of fire



- Practical fire-fighting exercise

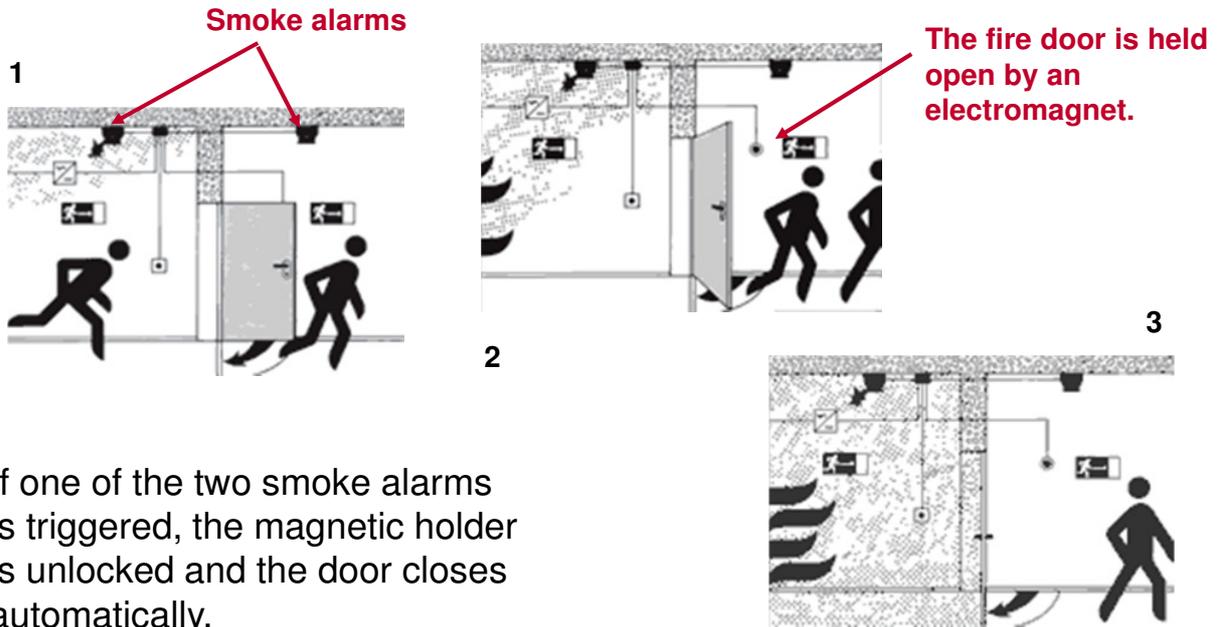
# Structural fire protection: fire zones and self-closing fire doors

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## Self-closing fire doors



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## Self-closing fire doors

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Self-closing fire doors equipped with smoke detectors may remain open during the day - in case of fire, due to smoke, the doors close **automatically**.



Smoke alarms

... but only if the door is not blocked or wedged open!

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# Structural fire protection: Escape and rescue routes

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Follow the escape and rescue signs!



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# Structural Fire Safety: Emergency Exits

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Emergency exits  
must be accessible  
and openable  
from the inside at all times!

Emergency exits are equipped with panic locks, i.e., they can be opened from the inside at any time without a key!



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# Organizational Fire Safety: Conduct in Case of Fire

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Leave the building immediately at the sound of an alarm and/or as soon as possible.

Warn your colleagues; take people needing assistance with you.

Do not use any elevators when leaving the building!



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# Organizational Fire Safety: Conduct in Case of Fire

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**For buildings with a fire alarm system, electronic public address system and/or audible warning signal:**

**Never ignore an  
alarm signal!**

**This time, it could be the real thing!**

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# Organizational Fire Safety: Conduct in Case of Fire

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Never try to escape down a smoke-filled staircase – it could be fatal!

Use the alternative escape route. If this is not possible, stay in your rooms. Seal the space under the door. Make yourself known to fire and rescue personnel from a window.



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# Organizational Fire Safety: Conduct in Case of Fire

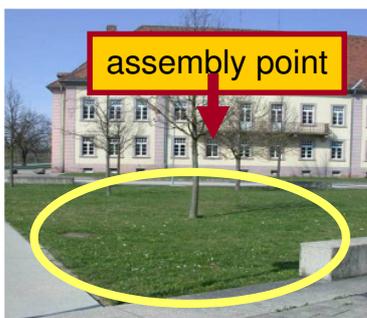
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Go to the assembly point immediately

Collect as a work group or department and determine if all members are safe. Stay there until the fire department gives further instructions or reopens the building!



Examples

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# Organizational Fire Safety: Fire Regulations

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The fire safety regulations of the University of Freiburg contain much information on the behavior of fires.

Inform yourself promptly!

**Verhalten im Brandfall**  
Ruhe bewahren!

**Brand melden**  
Notruf 2000  
von jedem Telefon an der Universität zu jeder Zeit  
vom Mobiltelefon 112

**Notfallmeldung**

WO ist der Notfallort?  
WAS ist geschahen?  
WIEVIEL? Verletzten?  
WER auf an?  
WARTEN auf Rückfragen!  
Alarm auslösen, wenn notwendig

**Feuer löschen**

- Feuerlöscher nutzen
- mehrere Feuerlöscher gleichzeitig einsetzen
- brennbare und explosive Materialien - sofern gefährlos möglich - aus Brandfläche entfernen
- kein Risiko eingehen

**In Sicherheit bringen**

- gefährdete Personen warnen
- hilfsbedürftige Personen mitnehmen
- Fenster und Türen schließen
- Fluchtwegsklempfzeichen folgen
- keine Aufzüge benutzen
- Stammplatz aufsuchen, Vollständigkeit kontrollieren

**Feuerwehr einweisen**

- Zufahrtsweg für die Feuerwehr freibehalten
- Ortskundige Personen zur Einweisung der Feuerwehr aufstellen
- Hinweise auf besondere Gefahrensituationen

**In case of fire**  
Keep calm!

**Report the fire**  
Emergency number 2000  
from any phone at the university at any time  
from cell phone 112

**Report**

WHERE is the fire?  
WHAT happened?  
HOW MANY injured?  
WHO is phoning?  
WAIT for further questions  
Activate the fire alarm, if necessary.

**Extinguish fire**

- Use portable fire extinguishers.
- Use several fire extinguishers simultaneously
- Remove flammable and explosive materials from danger zone, avoid any risk.
- Do not endanger yourself.

**Go to safety**

- Warn endangered persons.
- Take along helpless people.
- Close windows and doors.
- Follow green signs to escape.
- Do not use elevator.
- Go to the assembly point, assess completeness.

**Assembly point:**

**Instruct the fire brigade**

- Keep the access for the fire brigade free.
- The fire brigade has to be guided by persons with knowledge of location and incident!
- Give instructions about special dangers.



Report the fire

Get to safety

Report details at the building's assembly point

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# Organizational Fire Safety Emergency Number

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The fire department can be called from any university telephone using the phone number:

**2000**

This number may also be used to call an ambulance.

Otherwise, use the following emergency numbers:

**0-112 Fire Department Control Center**  
**0-19222 EMS Control Center**

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# Organizational Fire Safety: Fire Extinguishers

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## Learn!

- Where are the fire extinguishers?
- What kind of fire extinguishers are there?
- Which fire extinguisher should you use first in case of fire?



Dry Powder Extinguisher CO2 Extinguisher



Combustible Metal Extinguisher

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# Requirements to extinguish a fire

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Fuel



Hazardous material coded GHS02



~~Atmospheric Oxygen~~

~~Hazardous material coded GHS03~~



Source of ignition

Ignition Point

**A fire cannot continue to burn in the absence of oxygen.**

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# The Types of Fire

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## Combustible solids (flames and embers), e.g., wood, paper, textiles



**Combustible solids (flames and embers), e.g., wood, paper, textiles**



**Combustible metals, e.g., Al, Mg, Li, Na, K**



**Combustible fluids (flame forming), e.g., petrol/gasoline, Fat, Oil, Alcohol**



**Grease fires (vegetable & animal oils and fats) in deep-fat fryers, baking equipment and other kitchen facilities**



**Combustible gases (flame forming), e.g., Methane gas, Propane gas**

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# Fire Extinguishers

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- Carbon Dioxide CO<sub>2</sub>

CO<sub>2</sub> extinguishers are stored pressure extinguishers, i.e., they maintain the extinguishing agent under a constant high pressure within the whole container. They are easy to use. The CO<sub>2</sub> evaporates completely.



- Dry Powder

Dry powder extinguishers are “loaded”. The extinguishing agent is contained in the extinguisher under no pressure. A compressed gas is stored separately in a steel cylinder or cartridge within the extinguisher. The whole extinguisher is placed under pressure only when put into use.



- Foam
- Water
- Combustible Metal

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# Fighting a fire using a dry powder fire extinguisher

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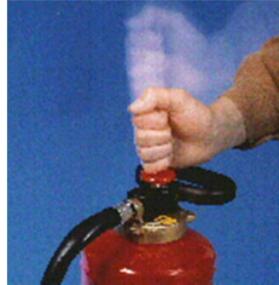
Dry powder extinguishers are A B C fire extinguishers



They are suitable for extinguishing fires involving combustible solids, liquids and gases.



Pull safety pin



Charge the extinguisher



Aim nozzle

Look at the fire extinguishers in your work area. There are various models of powder extinguishers. The activation method is described on each extinguisher.

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# Fighting a fire with a CO2 fire extinguisher

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CO2 extinguishers are for type B – combustible liquid – fires and for electrical fires



Pull safety pin



Use fire extinguisher

Never return a used fire extinguisher to its original location!

Immediately inform Stabstelle Sicherheit (Tel. 203-9031). It will arrange to have the used fire extinguisher refilled.

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# Combustible Metal Extinguishers

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Extinguishers for combustible metal fires are used specifically for that purpose, particularly for fires involving the alkali and alkaline earth metals.

Combustible metal fire extinguishers use finely milled alkali chlorides (often sodium chloride) as the extinguishing agent. These agents have high reaction and temperature stability. They are sprayed from the extinguisher under an especially low pressure to gently cover any burning metal with an air-tight layer.

Combustible metal fire extinguishers should always be at hand during experiments using alkali or alkaline earth metals.



Combustible Metal Extinguishers

# Action When a Person Is On Fire

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Extinguish fire on persons

- With an emergency shower
- Or with a fire extinguisher



At one time, there were concerns about using carbon dioxide extinguishers for fires on persons - that is no longer the case!

# An important fire safety measure

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## Wear a lab coat!



Standard equipment: long lab coat with long, close-fitting sleeves and a cotton content of at least 35%

**Remove your lab coat quickly in case of fire – by doing so, the fire can be prevented from crossing over to your underlying clothing!**

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# Fire Extinguishers must be instantly accessible at all times!

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# Organizational Fire Safety: Reduction of Fire Load

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# Grease Explosion

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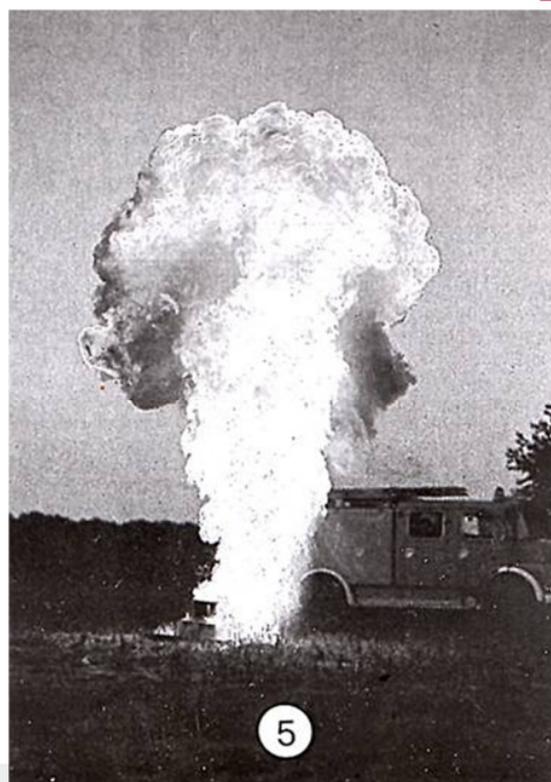
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**20 ml Wasser in 1L brennendem Öl**

The following photos were taken within  
**3 seconds**



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## Practical fire fighting instruction is offered by Stabstelle Sicherheit / Office of Health and Safety.

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Office of Health and Safety provides a fire safety seminar and subsequent fire-fighting exercises for employees of the university on the last Thursday of every month.

More information and registration is available online at:

<http://www.sicherheit.uni-freiburg.de/termine/loschuebung2010>

# The Stabstelle Sicherheit / Office of Health and Safety Team – central telephone number 203-9031

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Stefan-Meier-Straße 8, 2.OG  
(On the corner of  
Stefan-Meier-Str. / Albertstr.)

More info at our homepage: [...] or under  
“Wie geht das?”

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