Chemical Process Safety: Which parameters are important to perform a chemical reaction in a safe way?

(Presentation by Dr Stefan Gries, Boehringer Ingelheim Corporate Center)

Speaker : Liu Li (刘立)

EHS&S China, Boehringer Ingelheim

AGENDA 大纲

1. Session 1
- Process safety parameters
- Essential information to chemical processes
- Critical interactions of material
- Exothermic and run-away reaction
- Scale up

2. Session 2
- Runaway reaction
- PSCI Questionnaire & Typical Observations

3. Audience questions & discussions

SPEAKER BIO

Mr. Liu Li

- Chemist
- 13 years in Pharam Industry
- 8 years with Boehringer Ingelheim China
- Current position: EHS & S Manager

- Former positions in
  - Medicinal Chemsitry
  - Chemcial Process Research and Development
  - EHS&S

SPEAKER BIO

Dr. Stefan Gries

- Chemist
- More than 25 years with Boehringer Ingelheim
- Current position: Corp. EHS & S
  (occupational health, exposure control, soil and groundwater protection, EHS auditor)
- Former positions in
  - Local EHS (Safety Engineer)
  - Research & Development (Head of pilot plant)
  - Chemical Production (Head of production plant)

TRAINING STRUCTURE

1. Session 1

- Process safety parameters
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2. Session 2

- Runaway reaction
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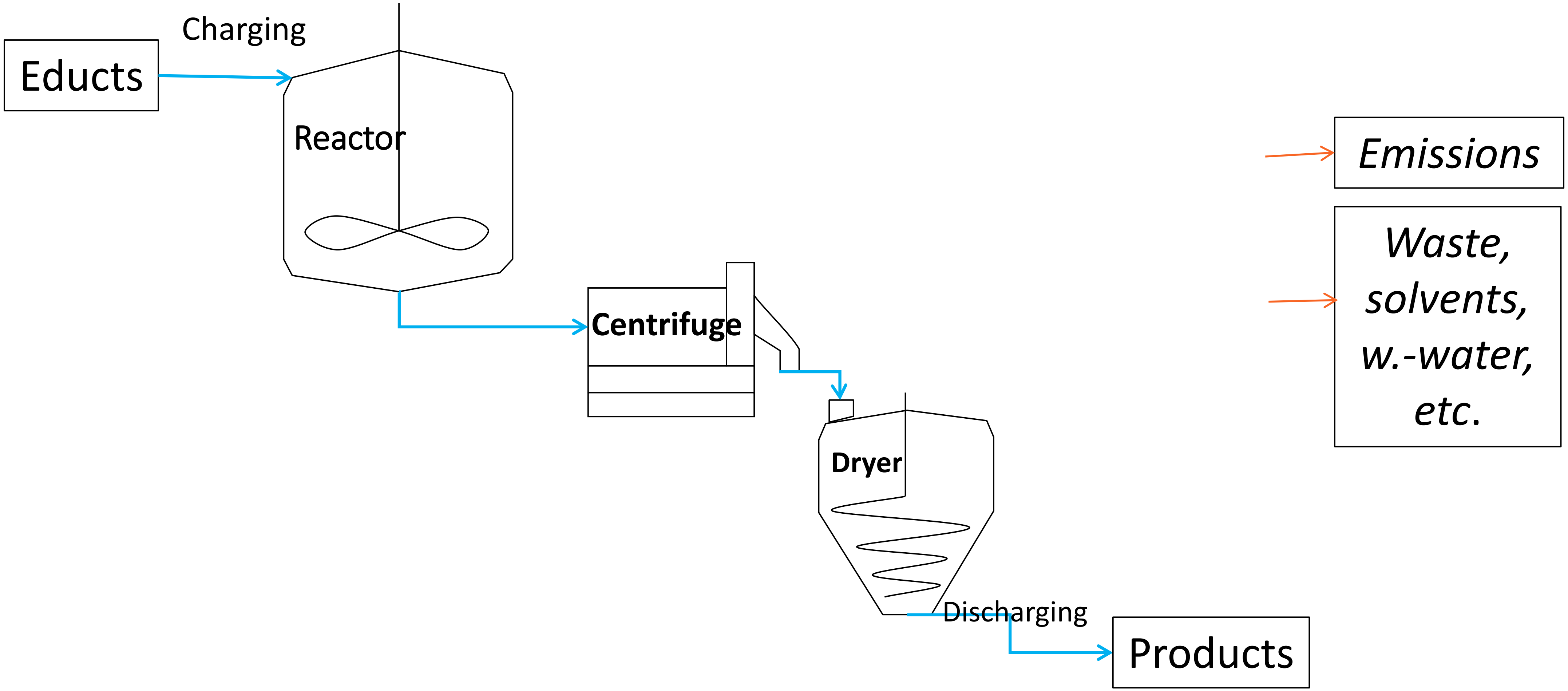
Chemical reaction in a production plant



Which information is necessary for a safe process?

- Knowledge about the used chemicals regarding thermal stability, physical safety parameters and toxicology
  - Educts
  - Products (incl. side products)
  - Reagents
  - Solvents & Auxiliaries

- Knowledge about the chemistry
  - Main reaction and side reactions
  - Waste streams (gas release, liquids and solids)
  - Consecutive reaction, decomposition?

- Reaction type
  - Batch reaction
  - Semi-batch reaction
  - Continuous flow reaction

What is necessary for a safe process?

- Calorimetric data of the chemical reaction
  - Adiabatic temperature rise
  - Gas evolution rate (→ reactor venting sufficiant?)
  - precipitation of solids (→ reduction of heat transfer, stirrer blocking?)
  - Accumulation of reactants, thermal output/time
  - Stability of reaction mixtures, distillation residues, etc.
  - Potential for runaway reaction, abnormal operating conditions
  - If necessary: investigation of the runaway reaction

- Knowledge about critical interaction between the used chemicals and other material
  - Material resistance of reactor & other equipment
  - Possible material contact (e.g. media supply)

What is necessary for a safe process?

- Plant equipment “state of the art”
  - Materials of the equipment = > material tests, corrosive data, etc.
  - Inertisation of equipment
  - Earthing of the equipment, explosion-proof equipment
  - Blow-down system, pressure relief valve, rupture disc,
  - Heating and cooling medium & capacity
  - Safety concept e. g. for electrical shut down

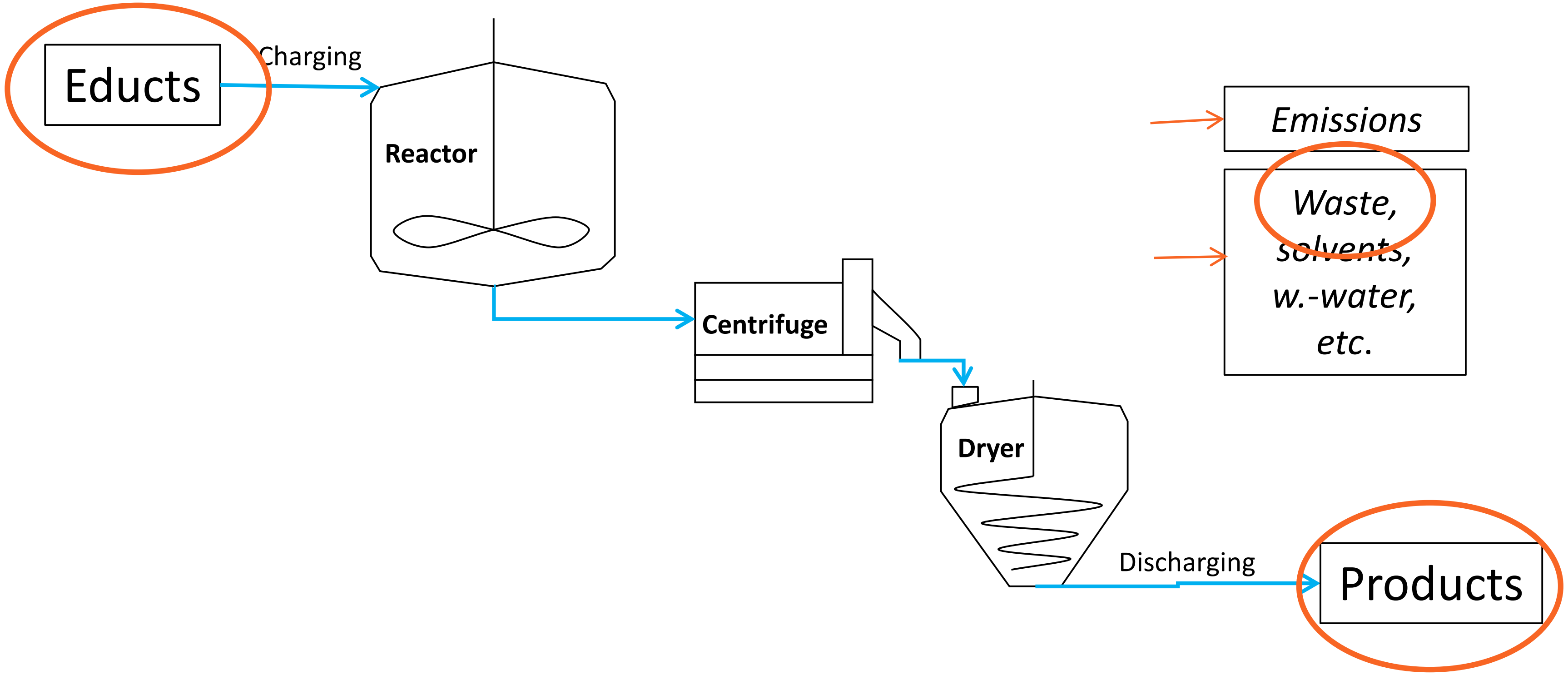
→ Process Hazard Analysis

Examination of the chemical properties and chemical process safety data together with the technical installation of the plant.

A safe chemical process is always an adequate combination of safe substance handling, known chemical process and adapted equipment.

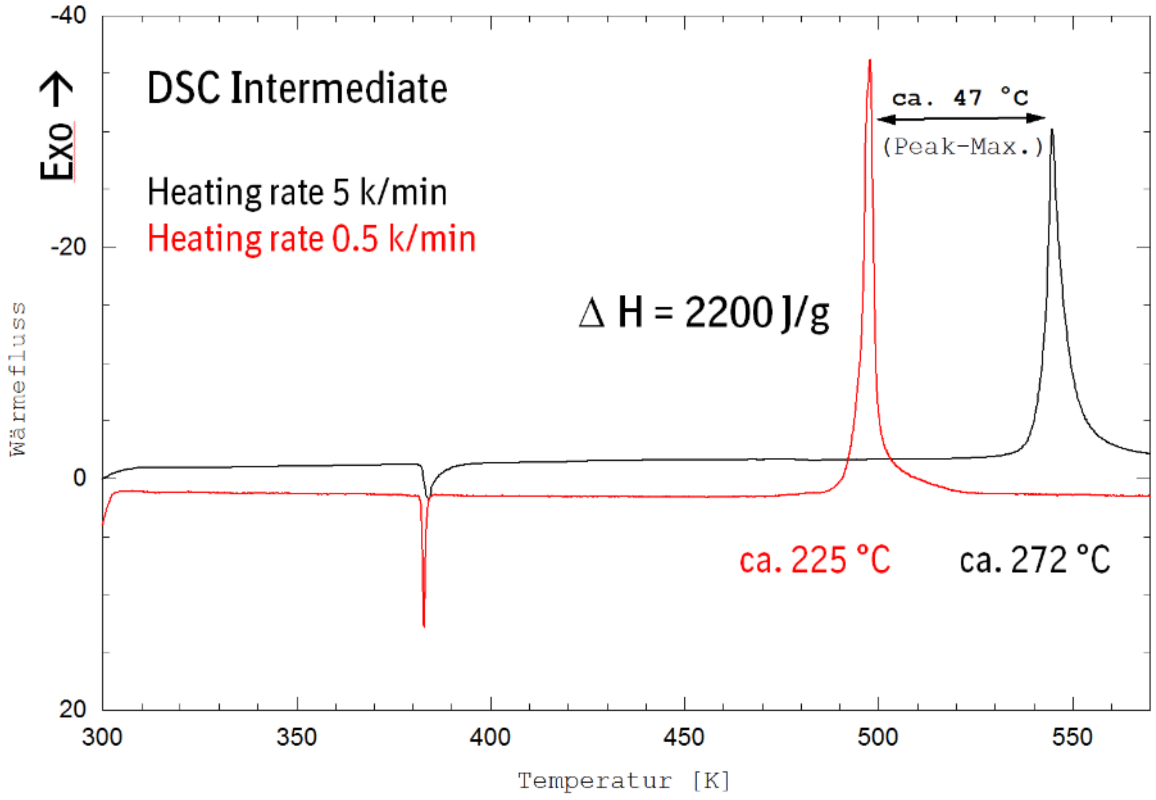
What is necessary for a safe process?

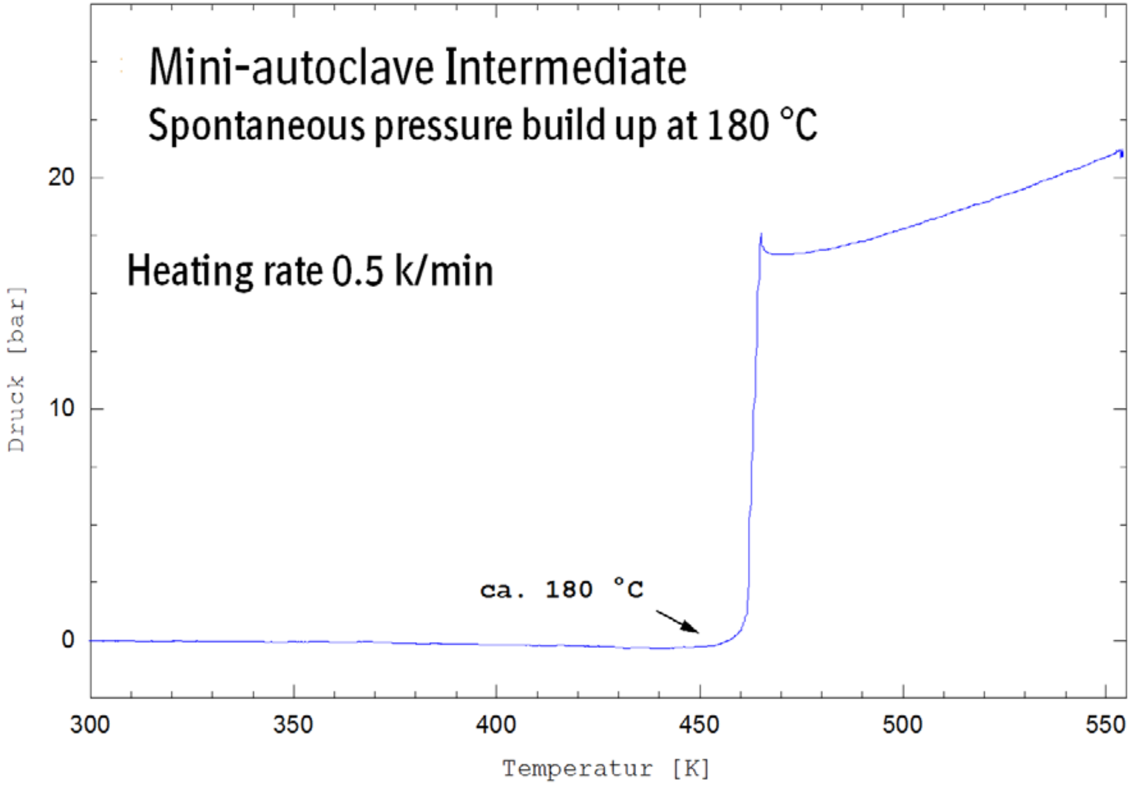
Thermal stability of chemical substances and reaction mixtures



Thermal stability of chemical substances and reaction mixtures

- Thermal stability:
  - Differential Scanning Calorimetry (DSC) or Differential Thermo Analyses (DTA)
- Decomposition test closed vessel (pressure build-up):
  - e.g. in a mini-autoclave





Known hazardous substances

- Typical chemical functions in thermodynamically unstable compounds:

-CΞC-	acetylene and acetylide
$-N_3$	azide and hydrogen azide
$-N \Xi N^+$	diazonium salts, triazene, tetrazene
-N=N-	azo compounds
-HN-NH-	hydrazide
>C=N=O	fulminates, oximates
>N-X	halogene nitrogene compounds
$-NO_x$	nitrites, nitrates, nitro- and nitroso compounds
-O-O-	peroxides, peroxy acids, ozonids
$-O-ClO_x$	(per-)chlorate, (hypo-)chlorite

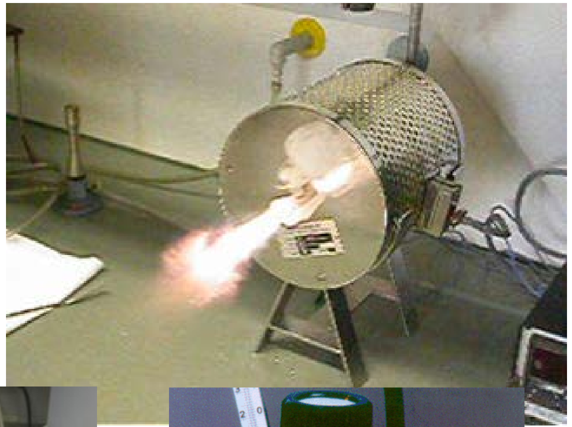
Known highly reactive substances

- Typical compounds or chemical functions:

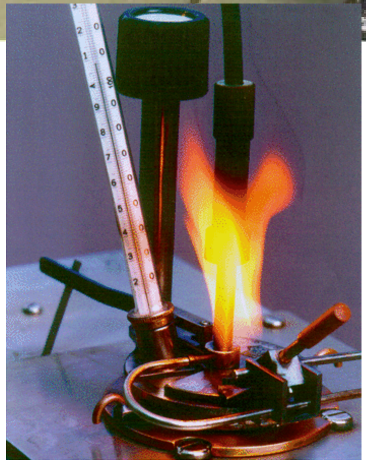
R-Mg-X	Grignard reagents
R-Li	organic lithium compounds
-COCl	acid cloride
-CO-O-OC-	acid anhydride
Na-, K-OR	Sodium-, Potassium alkoholate
$POCl_3$, $SOCL_2$	inorganic anhydride
„H_2SO_4“	conc. acids, lyes
NaH, $LiAlH_4$	hydride
Na, K, Mg, Li … metals	
O_2, H_2	gases
F_2, Cl_2, Br_2	halogen

General handling characteristic of substances

- Additional test for thermal stability
  - Thermogravimetry (TG) or combination TG/DSC; TG/DTA
  - Quasi-adiabatic heat aging in a Dewar flask (or an adiabatic calorimeter)
  - Time Pressure Test



- Flammability of solids or liquids
  - Combustion test
  - Flammability of solids
  - Smoldering temperature; minimum ignition temperature of a dust layer
  - (minimum) dust cloud ignition temperature
  - Ignition temperature of liquids
  - Flash point (of liquids)



General handling characteristic of substances

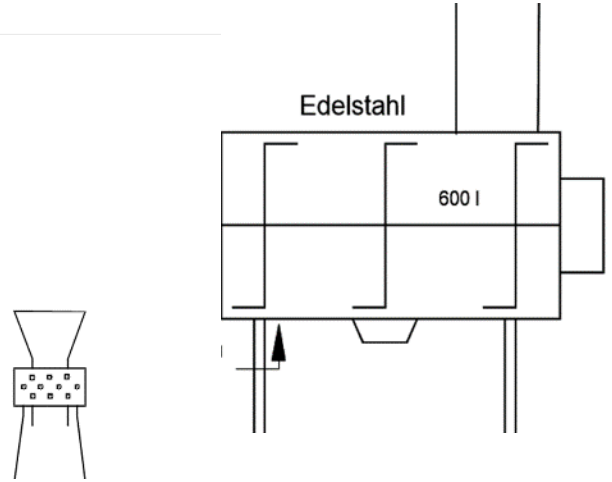
- Dust explosibility:
  - Dust explosion test
  - Dust explosion characteristics (p_{max}; $(dp/dt)_{max}$; K_{St}; explosion limits
  - Minimum ignition energy (MIE)

- Mechanical sensitivity, further safety characteristics
  - Sensitivity to impact
  - Sensitivity to friction
  - Self-ignition test
  - Conductivity

Details to: Dust stability/explosibility

- Mechanical sensitivity: Sensitivity to impact / friction

➢ Important for mechanical actions
(e.g. transport systems, in dryer with agitator, in a pin mill,)
→ maximum temperature & agitation time



- Maximum explosions pressure p_{max}

For most of the organic gases and vapors in mixture with air p_{max} is between 8 bar to 10 bar under initial atmospheric conditions.

➢ Important for e.g. venting pipes/filter units, for mills, dryers („dust containing air“)
→ explosion-resistant design

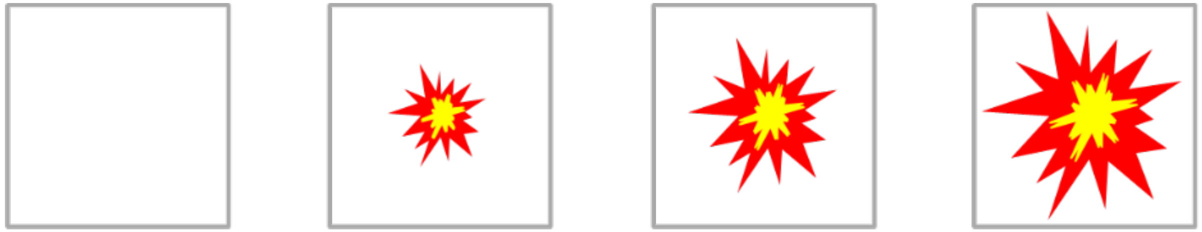
Details to: Flammability of solids or liquids

- Ignition temperature

Auto-ignition temperature (according to EN 14 522)	Temperature class	Maximum surface temperature
> 450 °C	T 1	450 °C
> 300 °C to 450 °C	T 2	300 °C
> 200 °C to 300 °C	T 3	200 °C
> 135 °C to 200 °C	T 4	135 °C
> 100 °C to 135 °C	T 5	100 °C
> 85 °C to 100 °C	T 6	85 °C

Details to: Dust explosibility

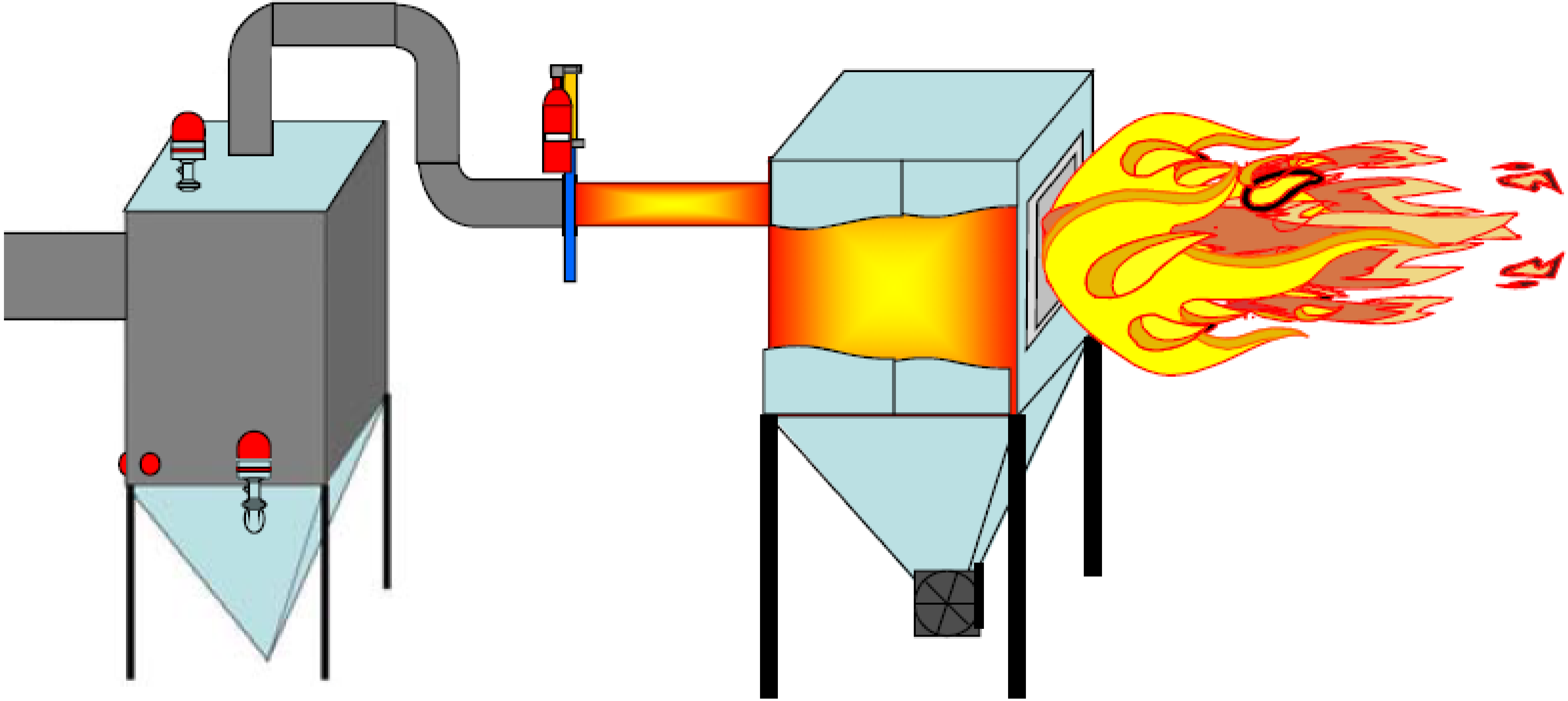
- Maximum explosion pressure rise $(dp/dt)_{max}$ and K_{St}



Dust explosion group	St 0	St 1	St 2	St 3
Kst $bar.m.s^{-1}$	0	$> 0 \leq 200$	$> 200 \leq 300$	> 300
Explosion characteristics	no explosion	weak/ moderate	strong	very strong

➢ Important for design of “explosion relief“, “explosion suppression” system

Examples of Process Equipment

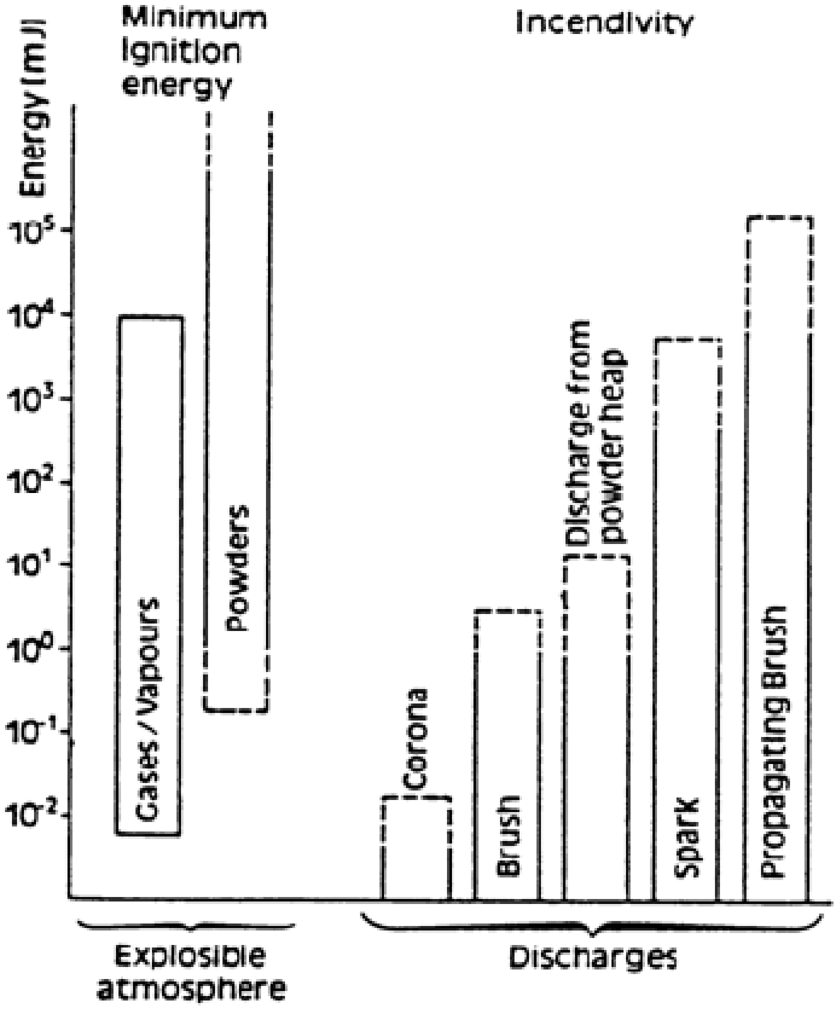


- If the K_{st} is above 300 bar m/s, the valve would not work

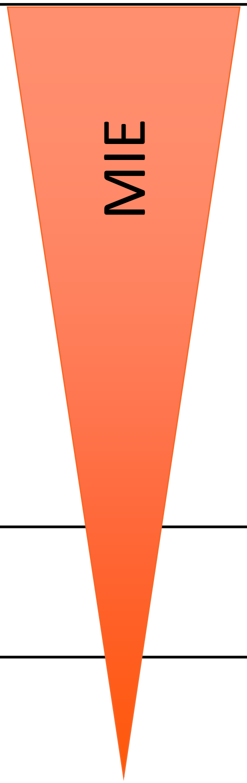
Details to: Dust explosibility

- Minimum ignition energy (MIE)

Risk	Substance Name	MIE in air
High risk < 25 mJ	Hydrogen	0.01mJ
	Methanol	0.14 mJ
	n-HeptanE	0.24 mJ
	Acetone	1.15 mJ
	“Normal organic" dust	>10 mJ
	Paracetamol	<10 mJ
Medium risk 25 – 100 mJ	Wheat flour	~50 mJ
	Sugar powder	30-100 mJ
	Coal	30-100 mJ
Low risk >100 mJ	PVC	1500 mJ



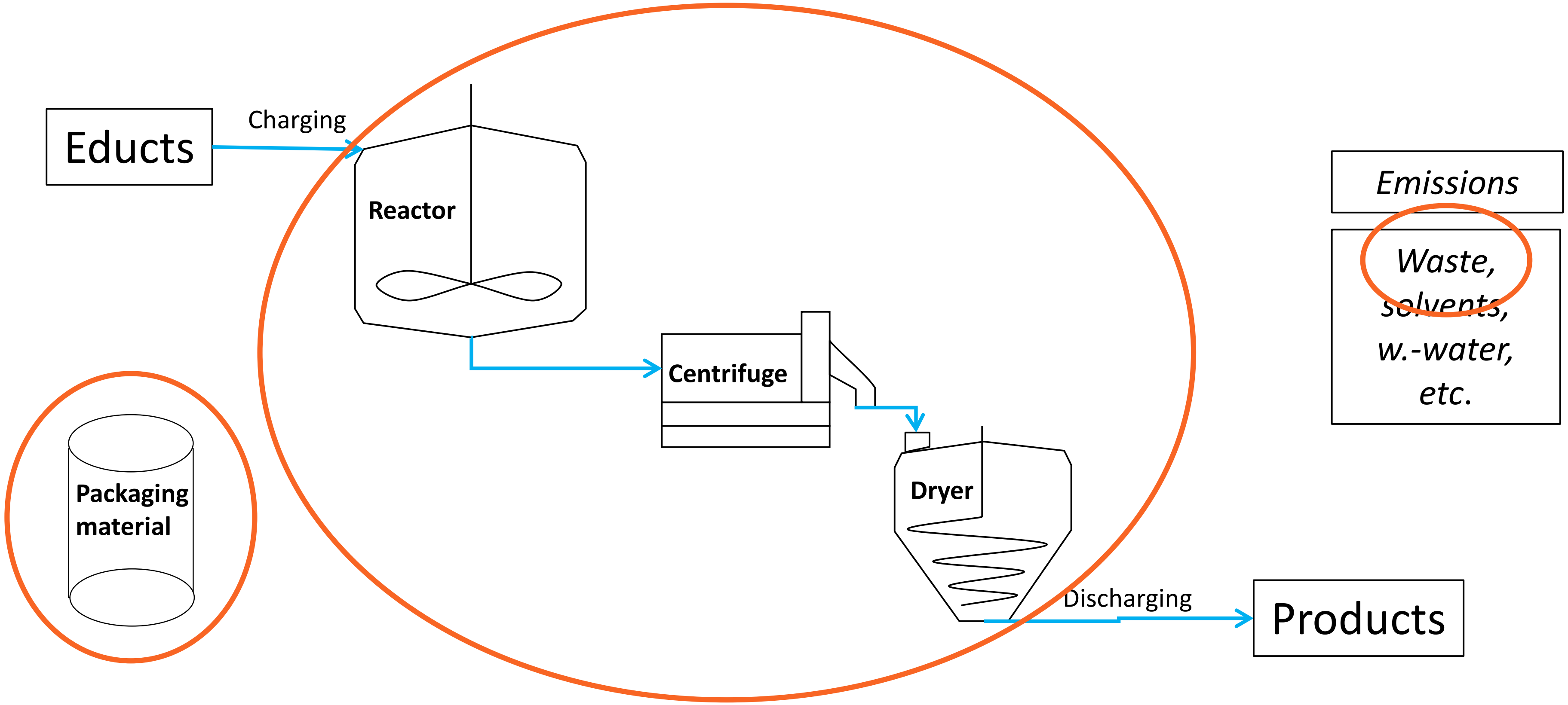
Resulting technical requirements of equipment



	Temperatur Class					
Explosion Group	T1 (> 450°C)	T2 (> 300°C)	T3 (> 200°C)	T4 (> 145°C)	T5 (> 100°C)	T6 (> 85°C)
IIA	Acetone Acetic acid Methane Propane Ammonia Benzene Toluene	Fuel Methanol Butan	Hexane Diesel Fuel oil	Acetal-dehyde		
IIB	Hydrogen cyanide	Ethanol Ethane	Hydrogen sulfide			
IIC	Hydrogen					Carbon disulfide

What is necessary for a safe process?

Critical interaction between the used chemicals and between chemicals and materials



Critical interaction between chemicals and materials

- Incident in a chemical production plant
  - Due to an operational error a mixture of thionyl chloride, ethyl acetate and acetyl chloride have to be disposed of. For disposal the worker used the empty thionyl chloride drum. Short time later the drum exploded.

- Result of safety examination in laboratory
  - No critical reaction between thionyl chloride, ethyl acetate and acetyl chloride.
  - But, the used drum was zinc-coated
    ➔ critical reaction under pressure build-up between ethyl acetate, thionyl chloride and zinc !

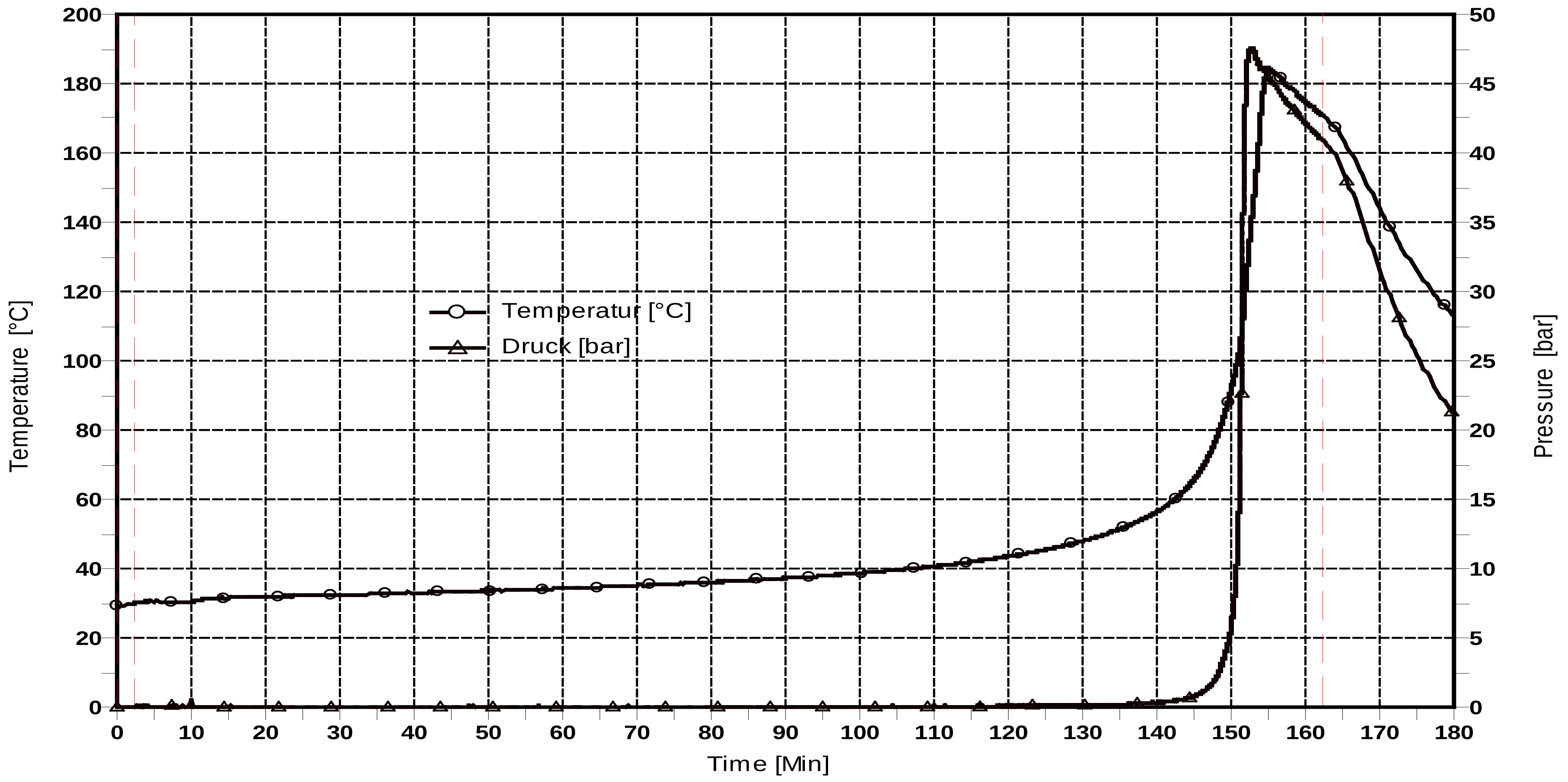
Critical interaction between chemicals and materials

- Incident in a chemical production plant B:
  - In a process the excess of $POCl_3$ is distilled off and purged into a 200 l steel drum with a PE-inliner. Approx. 10 h later the drum burst.
  - Between the batches the pipes were washed with acetone. Residual quantities of acetone remained in the pipes.

- Result of safety examination in laboratory:
  - Retarded critical reaction between acetone and $POCl_3$.

Critical interaction between chemicals and materials

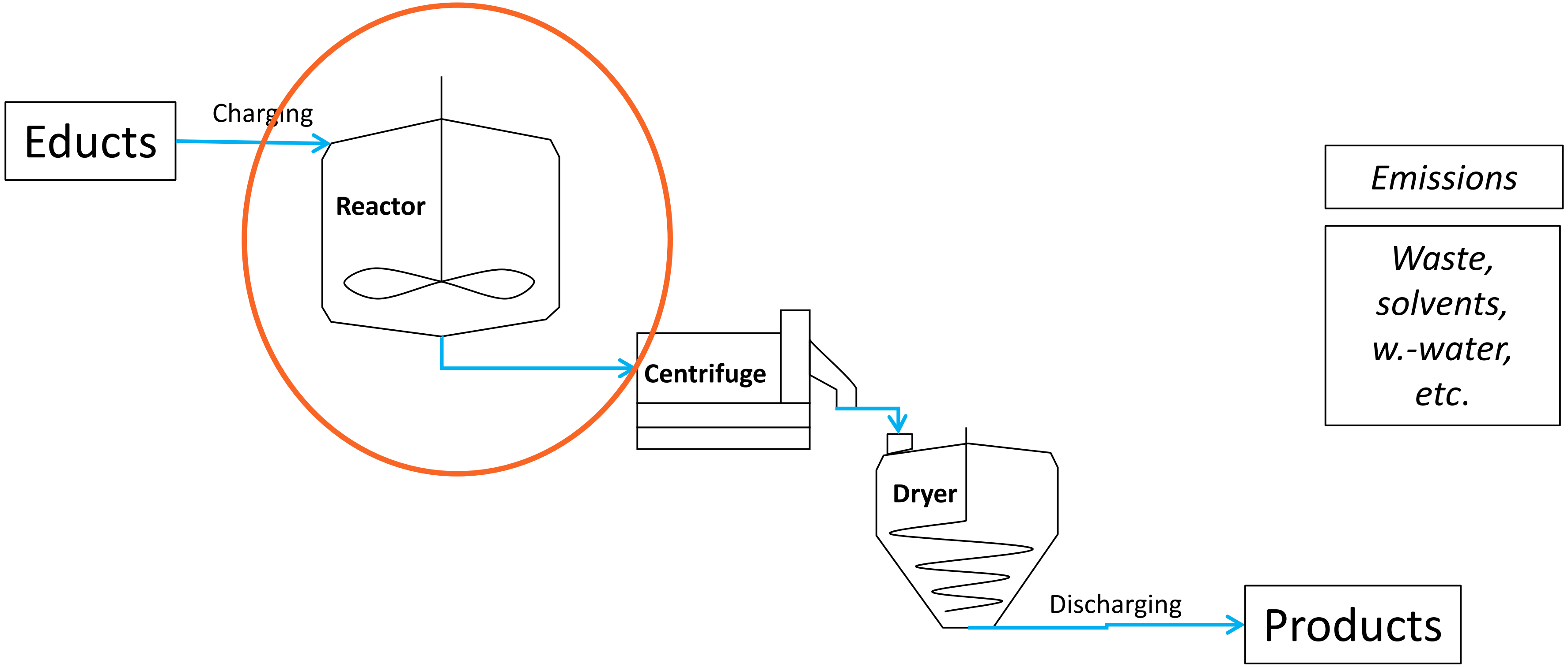
- Reaction experiment
  - closed cell test, $POCl_3$ overlay with ca. 5.8 weight-% acetone



What is necessary for a safe process?

Chemistry – chemical reaction

Calorimetric measurements for chemical reactions



Chemistry – chemical reaction

- The chemical reaction should be known, including side reactions and consecutive reaction. The chemical reaction can depend on the reaction temperature or the working procedure.
- Mass balance of the whole reaction is very useful
- Side products can have a big influence on process safety
- Are decomposition reactions known?
- Waste streams can contain highly reactive compounds or unstable substances (e. g. slow gas generation leading to a pressure build up in waste containers)

Working procedure for chemical reaction

- Batch reaction:

All reagents are charged to the reactor.
Then the content is heated to the reaction temperature.

- The accumulation of reaction partners is at the beginning 100 %.
- For an exothermic reaction, if the cooling capacity is not sufficient, an uncontrolled temperature rise occurs and a run away reaction is possible.
- Batch reactions should only be applied with endothermic or very slow reaction with smooth exothermic behavior.

What is in general the best temperature for running a exothermic batch reaction?

The lowest possible reaction temperature is in general the safest temperature!

Working procedure for chemical reaction

- Semi-batch reaction

One reaction compound (including solvent) is charged to the reactor.
The other compound is added over a defined time at the reaction temperature.

- The accumulation of reaction partners is at the beginning 0 %.
  Across the whole addition time the accumulation should be small.
- Always add the reactive compound.
  (Adding a catalyst or a compound in a huge excess is not a semi-batch process!)
- A stop of the addition stops further heat generation (if low accumulation).

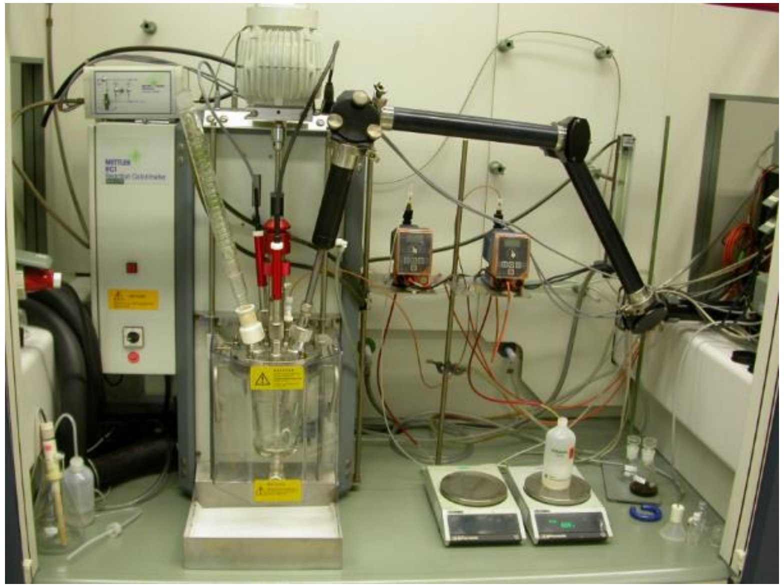
What is in general the best temperature for running a exothermic semi-batch reaction?

The highest possible temperature is the best! -> fast reaction -> less accumulation

Chemical reaction parameters, calorimetric measurements

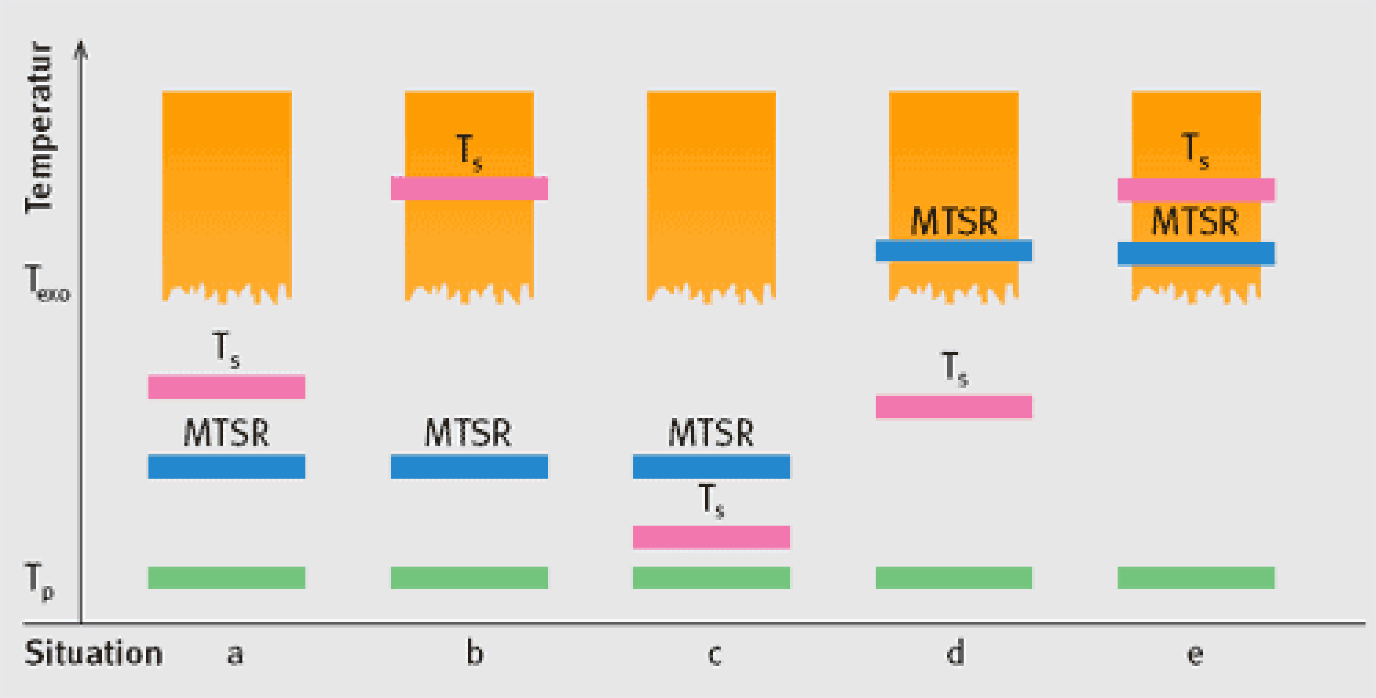
- Safety investigation of reaction under process like conditions:
  - Reaction calorimeter (e.g. Mettler RC1) with dosing, gas measurement etc.

- Determination of:
  - Heat of reaction ΔH_R [J/g] or [J/mol]
  - Heat capacity c_p [J/g K]
  - Adiabatic temperature rise ΔT_{ad} [K] or [°C]
  - Degree of accumulation [%]
  - Gas release [l/min]



- Adiabatic investigation of abnormal operating conditions:
  - Determination of thermal stability under adiabatic conditions (no heat exchange, like DTA)

Thermal hazard potential of chemical reactions



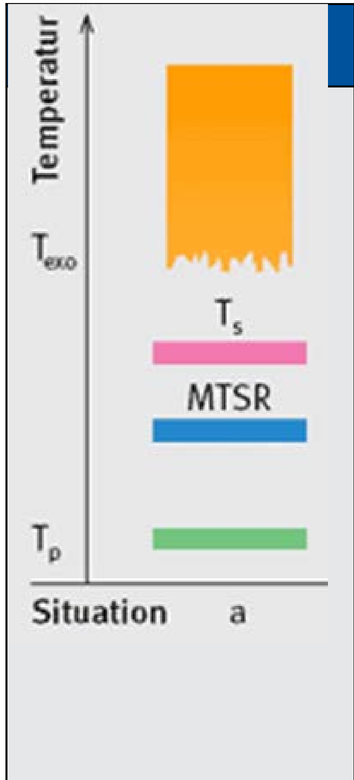
T_p : process temperature at the start of the deviation

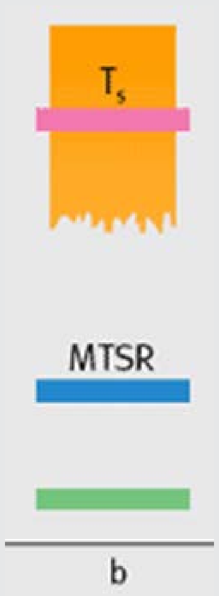
MTSR: maximum temperature of the synthesis reaction; MTSR = $T_p + \Delta T_{ad} \cdot \alpha_{accu}$

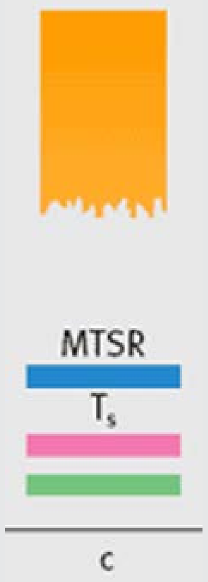
T_{exo}: the maximum temperature at which a substance or reaction mixture can just be handled safely

T_s: (=T_b) the boiling point in an open system

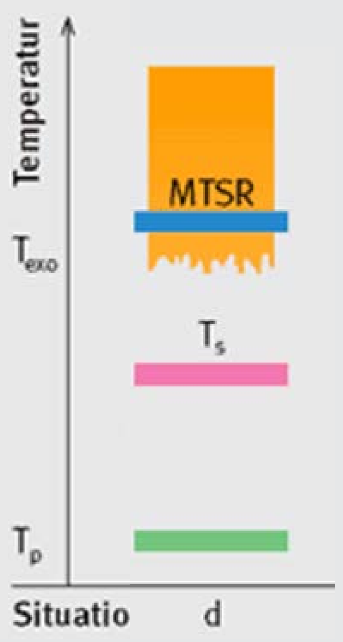
Thermal hazard potential of chemical reactions

	Description - criticality
	The boiling point of the mixture and the maximum reaction temperature stay below T_{exo}. Such processes may be regarded as inherently safe with respect to the process deviation evaluated.

Case	Description - criticality
	Absence of the boiling point barrier, but maximum reaction temperature below T_{exo}. The process may be regarded as safe.

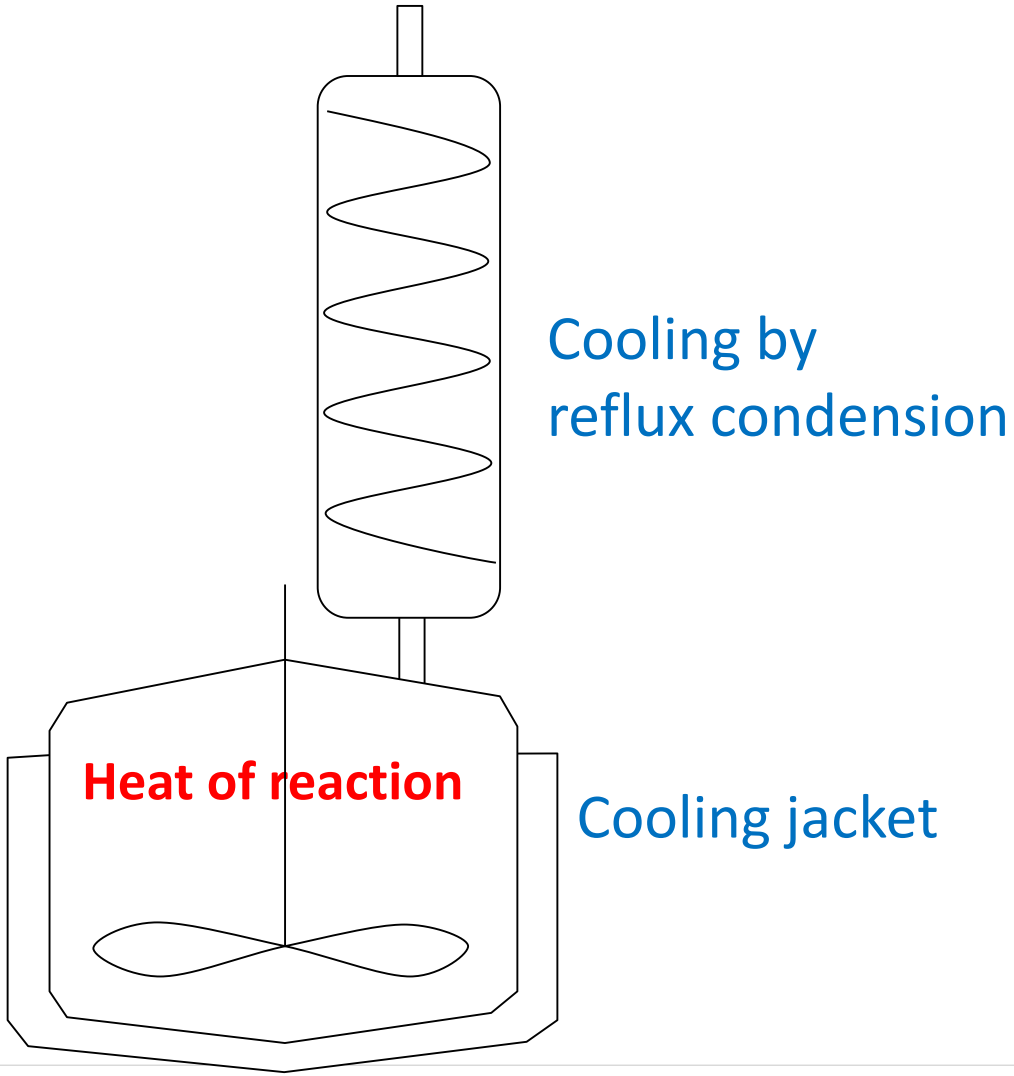
Case	Description - criticality
	The boiling point with its latent heat of evaporation may be considered as a safety barrier (adquate condenser!) In a closed system, the reactor must be designed for the maximum expected overpressure or be equipped with a pressure relief device. It would be better to reduce the accumulation so that the boiling point could not be reached.

Thermal hazard potential of chemical reactions

Case	Description - criticality
	It must be evaluated if the evaporation capacity provides sufficient safety. If not, additional organizational or technical measures have to be implemented. If the operation is performed in a closed system, the temperature corresponding to the relief valve's set pressure may not be too high.

Case	Description - criticality
	This case must be rated as problematic. In case of a (simple) cooling failure, the reaction can pass over the safe temperature range. Plant and/or process modifications should be evaluated in such situations.

Temperature control of chemical reaction



Heat balance of exothermic reactions

heat production

heat removal

Increased heat production

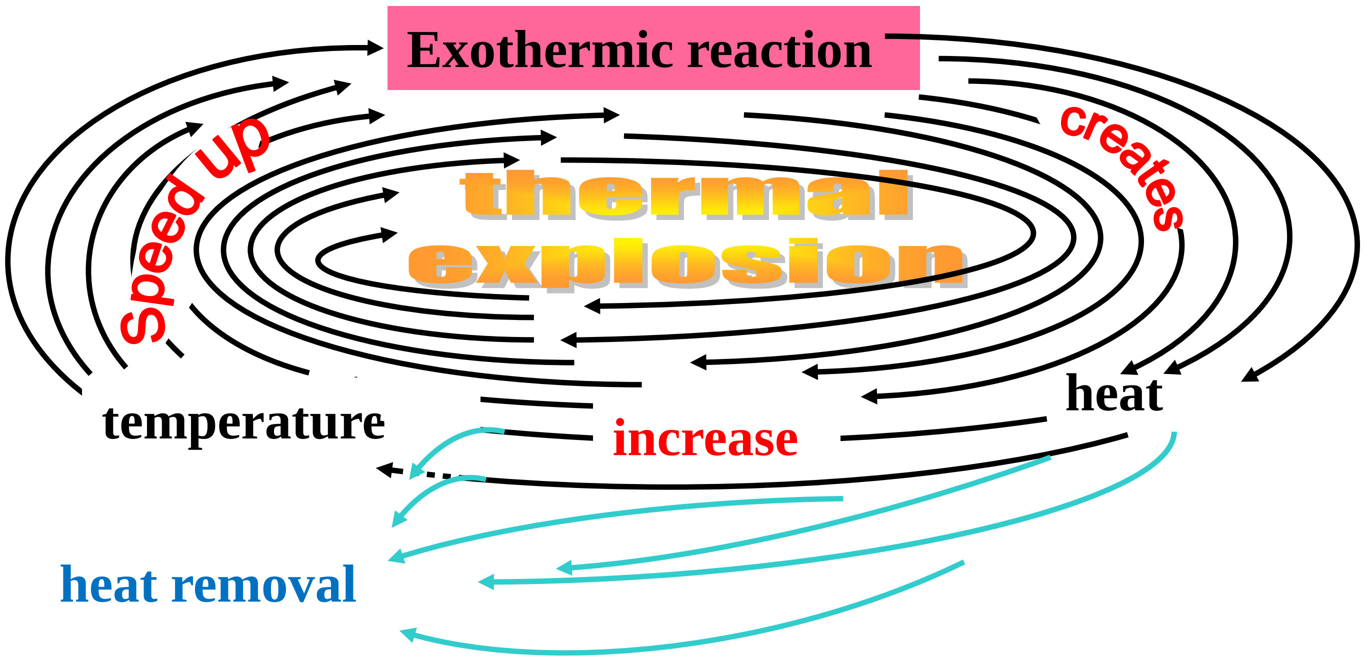
- Additional energy supply
  (e.g. heating, stirring, pumping)
- Higher concentration of reactants
  (e. g. missing solvent)
- Presence of a catalyst
  (e.g. rust, nonferrous metals)
- Initiation of other exothermic processes
  (e.g. side reaction, decomposition)

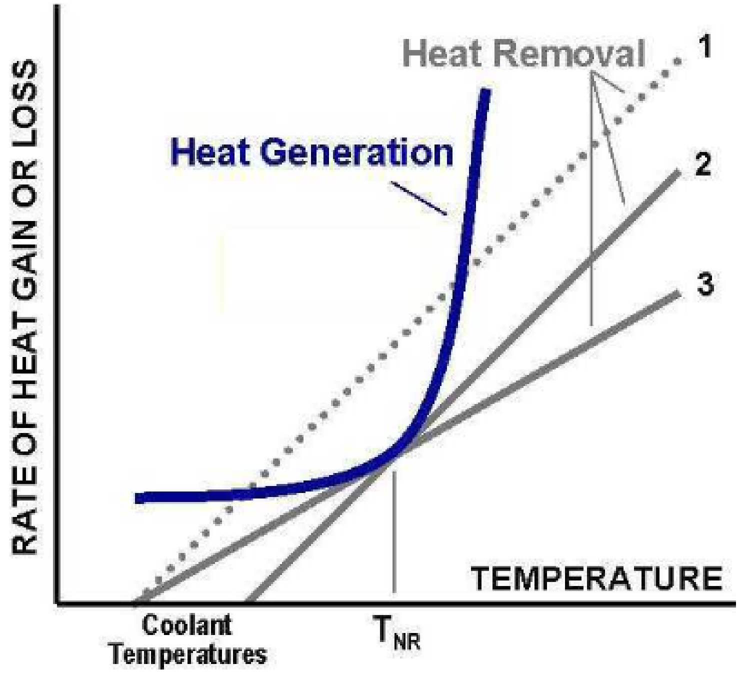
Decreased heat removal

- Loss of cooling
  (e.g. pump failure, solvent evaporated)
- Degrade heat transfer
  (e.g. fouling, adhesion)
- Increase of viscosity
  (e.g. higher degree of polymerization)
- Inadequate mixing
  (e.g. pump failure, solvent evaporated, stirrer failure)

Exothermic and run-away reaction

- An exothermic reaction produces heat which leads to an increase of the reaction temperature if the cooling capacity is not sufficient.
- A runaway reaction is an exothermic chemical process, which leads to uncontrollable reaction conditions due to an uncontrolled rise of the reaction speed.

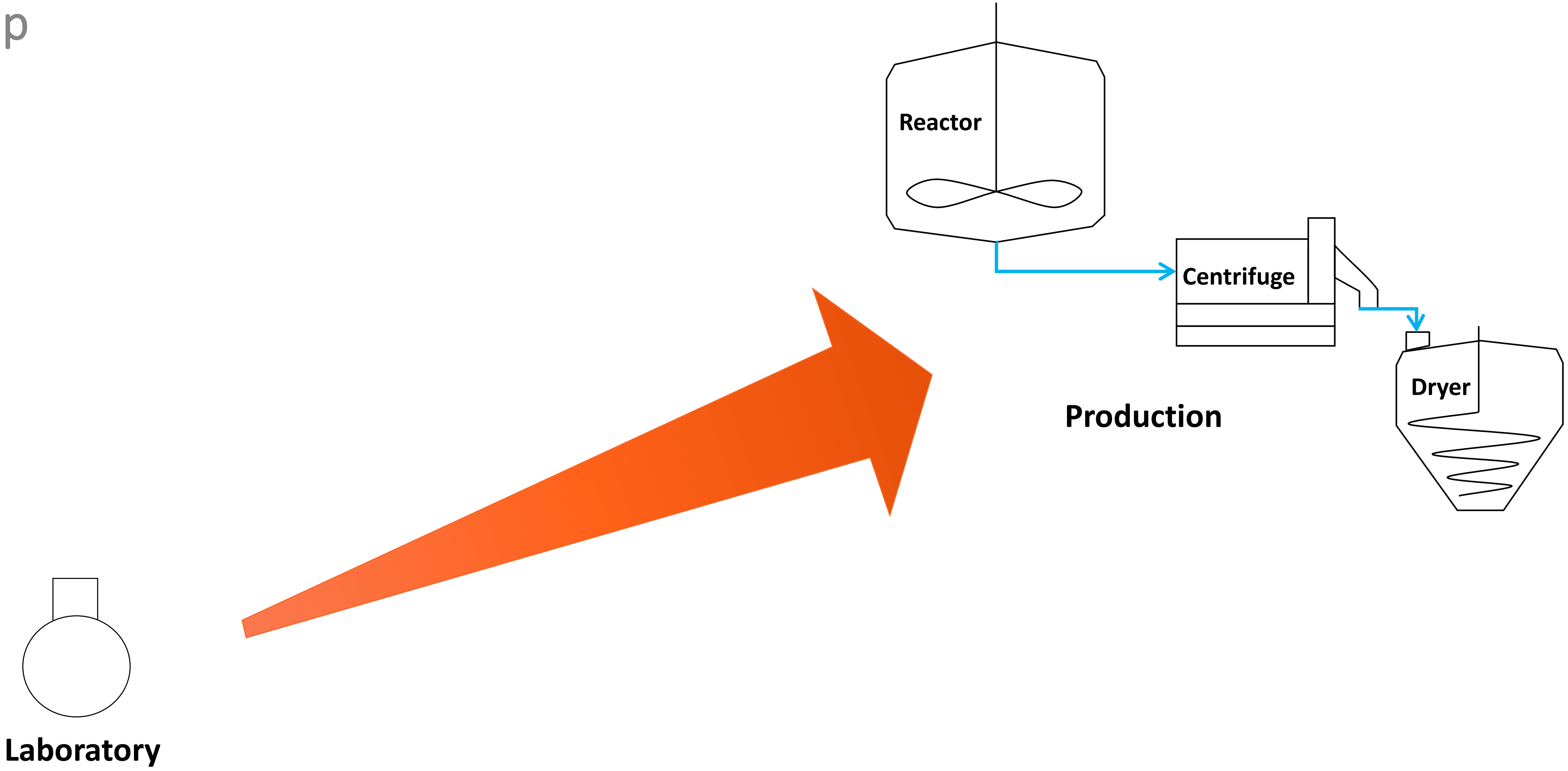




Exothermic reaction and run-away reaction

What is necessary for a safe process?

Scale up



Scale up laboratory → (pilot) plant

- Example of a heat balance change during the scale up
  - From laboratory (1 l) to pilot plant (1 m^3).
  - Dosing controlled reaction
  - Exothermic reaction
  - Reaction heat of 360 kJ kg^{-1} (= 0,1 kWh kg^{-1})
  - Density of reaction mass is 1 g cm^{-3}
  - Reaction temperature 80 °C
  - Filling degree is 100 %
  - Heat transmission of both apparatus are 500 W m^{-2} K^{-1}
  - Effective temperature difference for cooling is 30 K

Scale up – laboratory – (pilot) plant

	Laboratory	Pilot or production plant	
Reactor size	1 l	1 m^3	Factor 1000
Cooling surface	0,046 m^2	4,4 m^2	Factor ~100
Specific cooling power	15 kW m^{-2} (= 500 W m^{-2} K^{-1} * 30 K)		
Cooling power	**0,69 kW** (= 15 kW m^{-2} * 0,046 m^2)	**66 kW** (= 15 kW m^{-2} * 4,4 m^2)	Factor ~100
Reaction power with 3 h dosing time	0,03 kW (= 0,1 kWh kg^{-1} * 1 kg /3h) *heating required*	33 kW (= 0,1 kWh kg^{-1} * 1000 kg /3h) cooling sufficient	
Reaction power with 2 h dosing time	0,05 kW (= 0,1 kWh kg^{-1} * 1 kg /2h) *no cooling required*	50 kW (= 0,1 kWh kg^{-1} * 1000 kg /2h) cooling sufficient	
Reaction power with 1 h dosing time	0,1 kW (= 0,1 kWh kg^{-1} * 1 kg /2h) cooling sufficient	**100 kW** (= 0,1 kWh kg^{-1} * 1000 kg /1h) **cooling insufficient**	

Expectation of an EHS auditor

R&D → scale up → production

Amounts of substances	Location	Working documents	Guidance documents
miligrams to grams	Research & Development Laboratory	- Lab documentation - First observations to process safety	- Policy „Safe Research & Development“ - Lab safety SOPs
grams to kilograms	Transfer from tab to kilolab / pilot plant	- Basic safety report - Transfer report	- Regulation to „Basic safety examinations“ - Transfer protokoll
kilograms	kilolab / pilot plant	- Batch records - Safety assessments - Process safety examinations	- Guidelines for safety examinations - SOPs to substance handling etc.

Expectation of an EHS auditor

R&D → scale up → production

Amounts of substances	Location	Working documents	Guidance documents
kilograms to tons	Transfer from pilot plant to production	- Transfer report - Risk assessment - Technical measures	- Transfer protokoll - SOP „Risk assessement/ HAZOP“
kilograms to tons	Production plant	- Batch records - Change Control documents - Maintenance of technical installation	- SOP „ CC“ - SOPs „Maintanance“
kilograms to tons	Transfer to other plants	- Transfer report - Risk assessment - Technical measures	- Transfer protokoll

Usefull Links/ Infos

- https://www.bgrci.de/fachwissen-portal/topic-list/hazardous-substances/
- https://downloadcenter.bgrci.de/resource/downloadcenter/downloads/R003e_Gesamtdokument.pdf

Accident Prevention & Insurance Association - data sheets
[BG-Merkblätter R 001-007]

PSCI Auditor Training 2019

Runaway Reaction Explosion

(taken from a presentation by Lamy Bao)

PSCI Questionnaire & observations

(Presentation from Dr. Stefan Gries Boehringer Ingelheim Corporate Center, Corp. EHS&S)

Speaker: Mr. Li Liu Boehringer Ingelheim Corporate China. EHS&S

TRAINING STRUCTURE

1. Session 1
   - Process safety parameters
   - Essential information to chemical processes
   - Critical interactions of material
   - Exothermic and run-away reaction
   - Scale up

2. Session 2
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   - PSCI Questionnaire & Typical Observations

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Investigation Report - Explosion in T-2 Labs

- **Location: Jacksonville, Florida (USA)**
- **Incident: Explosion in Reactor due to runaway reaction**
- **4 employees killed, 32 injured (including 28 from surrounding community**
- **Explosion force: Equivalent to 1,400 lbs of TNT (≈ 635 kg TNT)**

- **Causes:**
  - **Company did not recognize the worst credible scenario**
  - **No redundancy in cooling system**
  - **Inadequate pressure relief device**

Reaction Hazards - Historical Data of Incidents

(Ref. Book: Chemical Reaction hazards by John Barton)

Following data was collected for 189 industrial incidents in UK involving thermal runaway reactions:

- **134 incidents were classified by processes, key ones are:**
  - **Polymerization (condensation): 64 (48%)**
  - **Nitration: 15 (11 %)**
  - **Sulphonation: 13 (10%)**
  - **Hydrolysis: 10 (7%)**
  - **Raw Materials Quality: 15 (11%)**
  - **Others: 13%**
- **34 incidents were caused because there was no study done for reaction hazards**

Reaction Hazards – Incidents by Causes

(Ref: Book: Chemical Reaction hazards by John Barton)

- **35 incidents were caused by mischarging of reactants or catalysts (29%)**
- **32 incidents were caused by temperature control (27%)**
- **25 incidents were caused by maintenance (21%)**
- **17 incidents were caused by agitation (14%)**
- **11 incidents were caused by human error (9%)**

PSCI Questionnaire and Typical observations

Audit Questions Summary – Process Safety

Topic	Question summary
Process Safety	76: Top 3 most hazardous process activities conducted at this facility 77: Process hazard assessment 78: Evaluated the impact of its operation on the community Evaluated the impact from the activities of neighboring businesses 79: Risk assessment for explosion of flammable liquids, vapors, powders, and gases 80: Preventive maintenance of safety relevant equipment. 81: Handling compressed gases safely 82: Bulk chemical handling procedures 83: Safety measures around direct fire equipment (e.g. boiler, incinerators, ovens etc.)

Process Safety - Typical Observations

77	Does the facility perform Process Hazard Assessment (PHA)? *Aim is to identify processes or operations that could present significant risks in case of deviation (exothermic reactions, use of flammable, combustible or toxic materials, processes involving extreme temperatures or pressures).*	… • Collection of process information (process safety data, design information, operating parameters, and equipment specifications) • Hazard evaluations capturing significant risks during process development, preliminary engineering, and upon completion of process design? • Sizing of pressure vessels and relief devices according to appropriate codes and standards? • Flammable storage areas separate from production and well managed?

No safety data for any chemical reaction are available (example: heat of reaction, adiabatic temperature rise, decomposition temperature,…)
The auditee has made some improvement to collect process safety data and to conduct PHA for high sophisticated chemical reaction (nitration, oxidization, hydrogenation etc.) running at site. Nevertheless the interpretation of this data and the transfer into safety measures for the production is not always reliable.
Basic safety data for chemical processes are available from the Development report. However data are archived and in case of changes these data are not any more reconsidered, since there is no systematic approach in place to cover chemical safety data in a change control system.

Process Safety - Typical Observations

Most of the vent pipes coming from safety valves or rupture disks have at least 3 ninety degree angles. Therefore there is no evidence about the pressure profile inside the venting pipe. This leads to back pressure build up in case of activation with a certain risk for pipe bursting.
The reactor where the bromination takes place misses a safety valve or rupture disc respectively. Furthermore the adiabatic reaction heat is not known.
The explosion vent of the fluid bed dryer in the Bromhexine clean rooms is venting into the cleanroom.
In the chemical production building, the venting pipes of the safety valves end close to the floor in the production room. Taking into consideration the highly hazardous nature of the ingredients (e.g. Oleum, CO, SO_3) this may lead to fatal accidents in case of a pressure relief.

Process Safety - Typical Observations

79	Does the facility perform risk assessment related to the explosion of <u>flammable liquids, vapors, powders, and gases</u> in processing operations (including storage, transfer and charging)? Does it include the following steps?	• Assessment of the hazards (Minimum Ignition Energy, Kst classification rating, Impact sensitivity etc.) of the handled combustible dusts and powders • Hazardous area classification (zones according EU-ATEX and Classes according to US-NFPA) … • Installation of special electrical equipment for flammable vapors, gases, combustible dusts, … • Periodic testing of grounding and bonding circuits, lightning arresters, and electrical distribution equipment? • Maintenance/calibration done for critical safety equipment (e.g. sensors, instruments, valves, interlocks, reactors, condenser etc.) at suitable intervals. • Assessment of the hazards due to mechanical ignition sources? • Installation of special electrical equipment for flammable vapors, gases, combustible dusts, and wet areas? • Periodic testing of grounding and bonding circuits, lightning arresters, and electrical distribution equipment? • Maintenance/calibration done for critical safety equipment (e.g. sensors, instruments, valves, interlocks, reactors, condenser etc.) at suitable intervals. • Assessment of the hazards due to mechanical ignition sources?

Process Safety - Typical Observations

Safety data like MIE, St Class etc. are available for most of the finished products (API). No data is available for isolated intermediates. Hence it could not be proven if the Fluid Bed Drying of intermediates can be done safely.
The company has not assessed the hazards (Minimum Ignition Energy, K_{st} classification rating, Impact sensitivity etc.) associated with combustible dusts and powders being handled in various operations at site.
At the installations in the production area stainless steel clamps were installed instead of using copper wires for grounding and bounding. No evidence was provided showing that this type of bounding grounding is as safe and effective as copper wires.

Process Safety - Typical Observations

The Customer product is received in packaging, treated in anti-static agents and the specifications for the finished product require it to be packaged in liners that are treated with anti-static agents. However, the material handled in the intermediate steps is not treated with anti-static agents. Site personnel assume that the minimum ignition energy is low enough to warrant this type of packaging if the incoming and finished product are packaged in anti-static treated liners.
There is no gas detector near the ethanol recovery device at VB1 workshop, no O2 detector at centrifuges which used N2.
In the production plant, grounding points and grounded piping are installed. A detailed SOP for working in Ex-zones is available and trained. But an instruction, how to ground mobile equipment (e.g. solvent drums) is not included in this SOP.
An Ex light in the hydrogenation room was labeled as “Ex ed IIB T4”, which was not the proper type for hydrogen environment.

Process Safety - Typical Observations

80	Describe how the facility ensures preventive maintenance of safety relevant equipment.	• Pressure safety relief valves/rupture disks • Bonding/earthing systems • Mass transfer systems (e.g. piping systems) • Pressurized vessels • Explosion prevention system (e.g., prevention of static electrical discharge) • Is there emergency power supply for relevant equipment?

Anti-static bridge connection of pipes for transporting flammable chemicals is very rusty in Building A-6.
Most of the P+IDs presented during the audit where not up to date. Furthermore the guidelines of ISO14617 regarding the symbols are not followed. P+IDs should always be up to date, showing the "as build" situation to avoid any risk due to mistaken identity of any component of an equipment.

Process Safety - Typical Observations

81	Does the facility provide a means for handling compressed gases safely that includes:	Inspection and approval before acceptance of delivery? Storage in a segregated area designed for compressed gases? Separation or barriers to manage compatibility issues? Gas classification labeling? Regulator, hose and flexible connection inspections?

PSCI Questionnaire

82	Has the facility developed and implemented bulk chemical handling procedures that include:	Not applicable Specific unloading and loading procedures? Identification sampling before unloading? Hose inspection? Fire protection? Spill control measures (dike or bund area)?

Storage of Oxalyl Chloride is done under “normal” conditions (Hyderabad room temperature in the warehouse).
As of the “Tech Pack” information, the storage temperature should not exceed -10°C.
Even if there are some newer SDS available that storage at middle European room temperature range (max. 25°C) might be sufficient, the company could not show evidence that the change of storage conditions was assessed.

The bulk unloading process needs improvement. The unloading area is asphalt but no defined retaining volume in case of any spillage is provided.

Process Safety - Typical Observations

83	What are the safety measures around direct fire equipment (e. g. boiler, incinerators, ovens etc.)? *Consider gas accumulation, steam overpressure...*	

In the Building B, Water For Injection (WFI) system, the clean steam generator operates at 65 psig with a safety relief valve venting directly to the room. In the case of activation, 155°C steam would be released and fill the room.

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About the Secretariat
Carnstone Partners Ltd is an independent management consultancy, specialising in corporate responsibility and sustainability, with a long track record in running industry groups.

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