Criticality Classes for Physical Unit Operations

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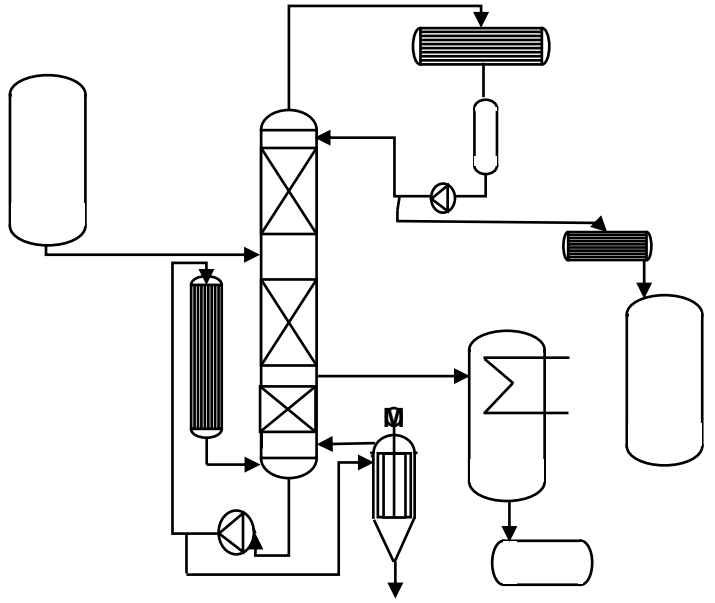
STK-Meeting Kempthal 23.-24.09.2025

Physical Unit Operations

- Drying
- Distillation, rectification
- Extraction
- Granulation, Coating
- Extrusion
- Filtration, centrifugation
- Melting in heat chambers
- Storage
- Transport

  etc

No reaction should take place in the process temperature range

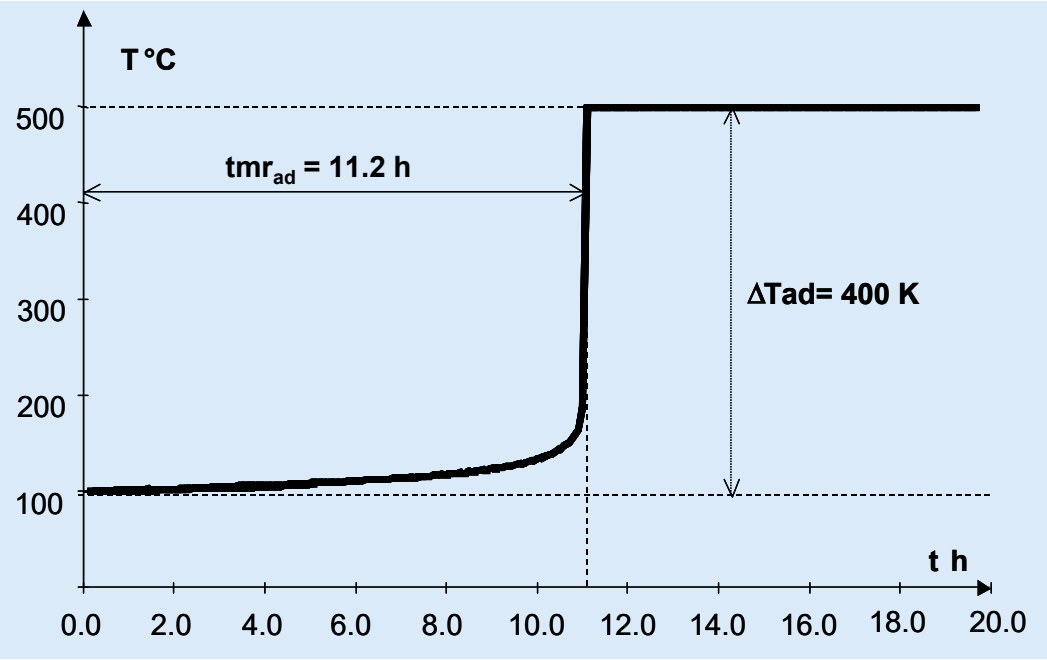


Thermal Stability
Characterisation of Secondary Reactions

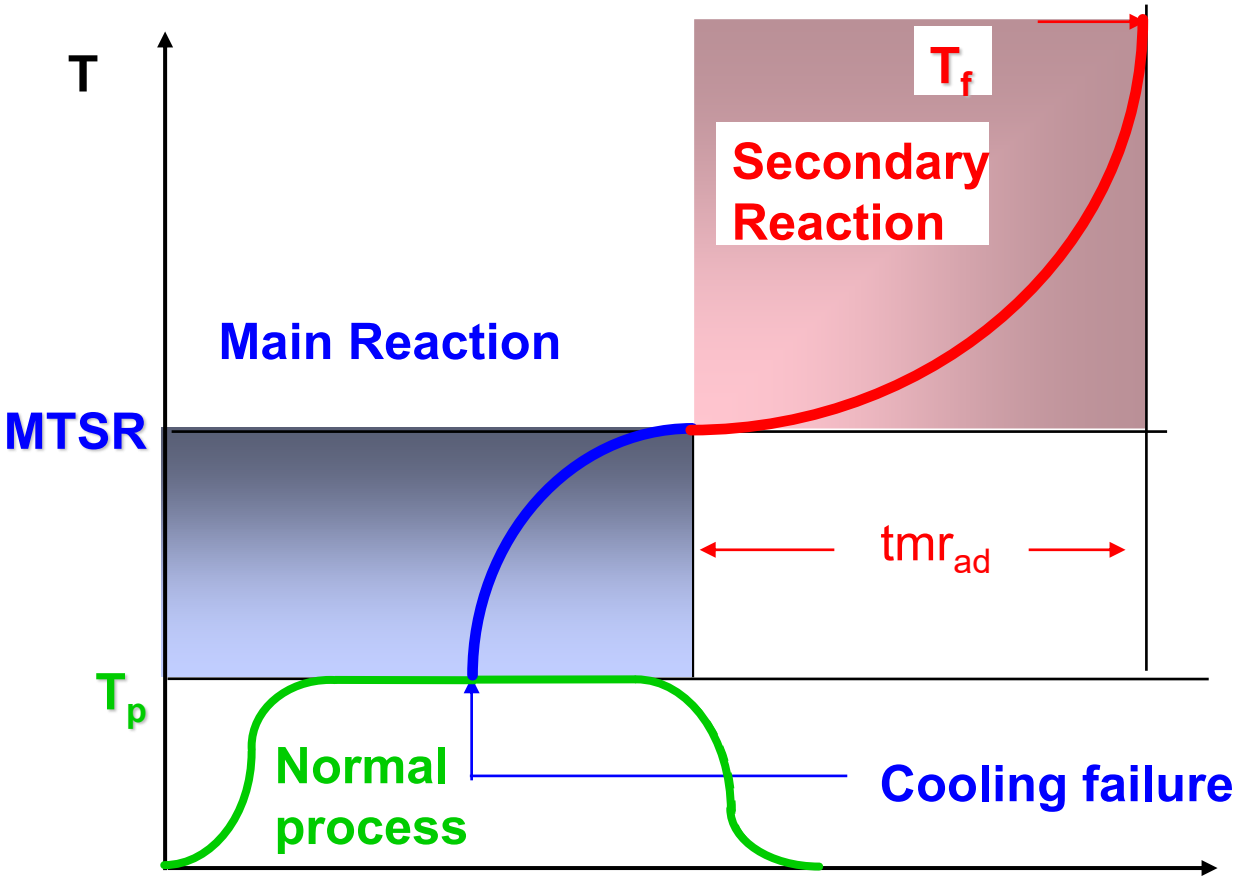
Information obtained in the laboratory about secondary reactions

- Energy linked to the consequences
- Time linked to the probability of triggering

➢ How may this information be used for the risk assessment at large scale?



Failure Scenario:
Cooling Failure Scenario for Reactions



T_f: final temperature or end temperature T_{end}
(important for evaluation of the consequences)

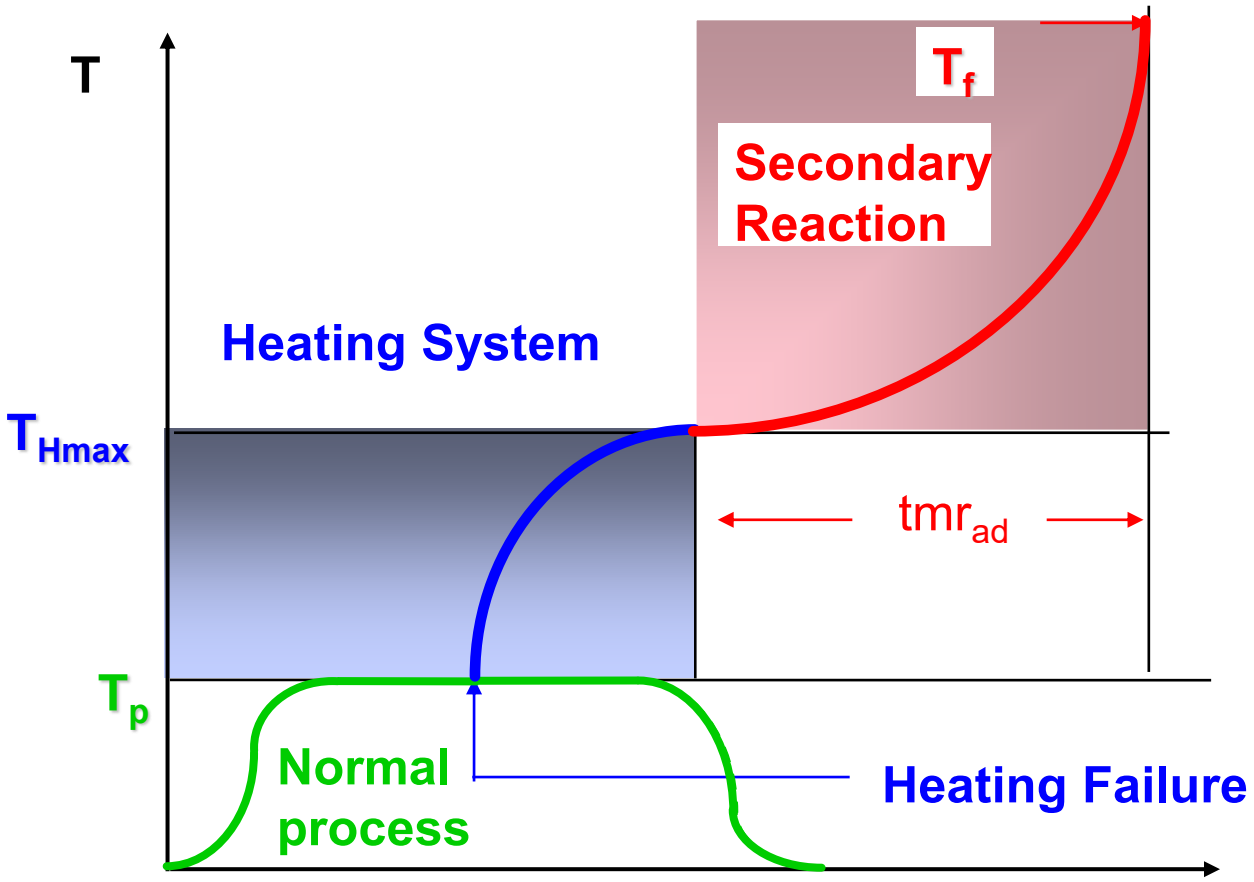
tmr_{ad} time to ‚maximum rate under adiabatic conditions

MTSR: **M**aximal **T**emperature of the **S**ynthesis **R**eaction

T_p: process temperature

Failure Scenario:

Heating Failure Scenario for Physical Unit Operations



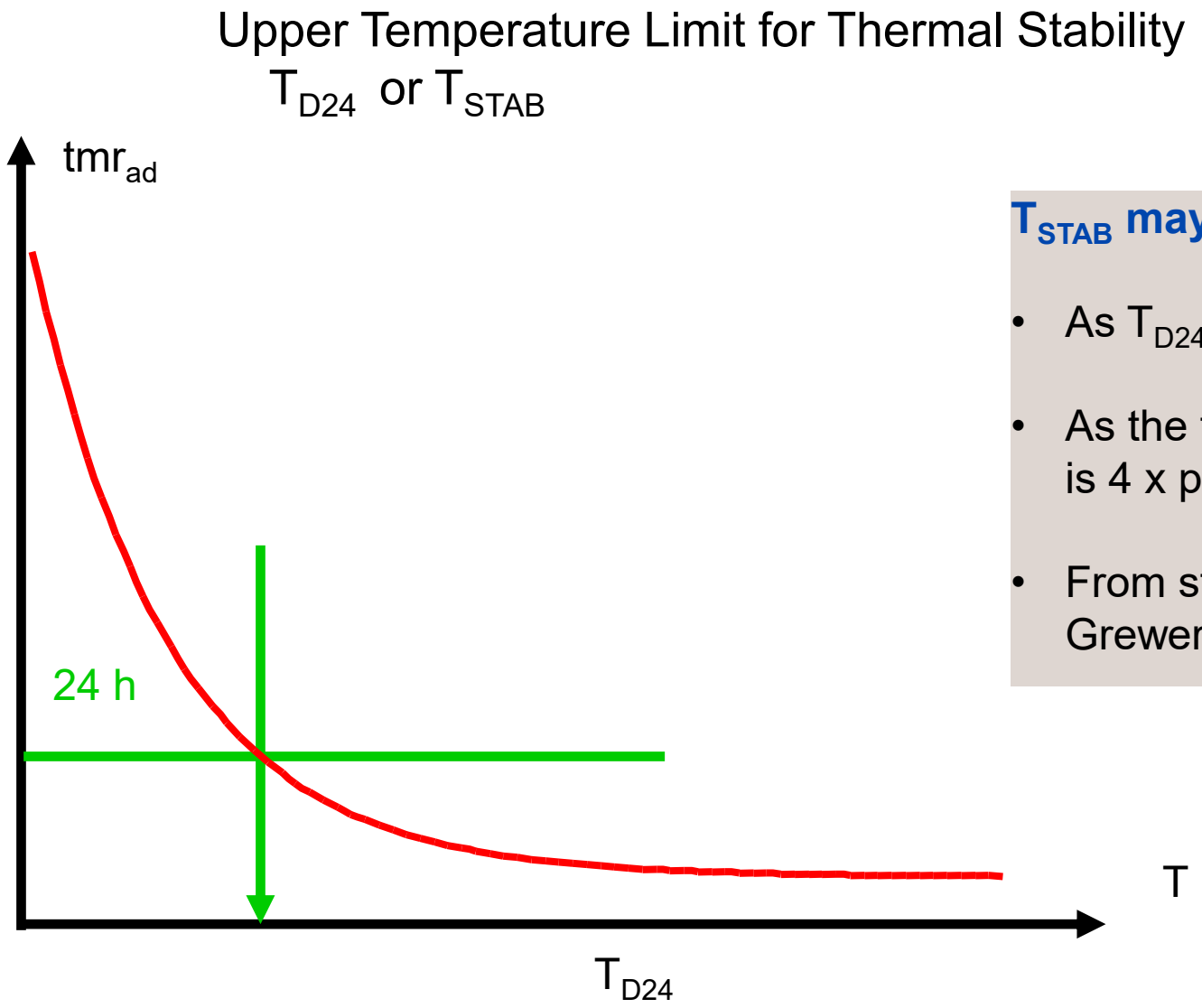
T_f: final temperature or end temperature T_{end} (important for evaluation of the consequences)

tmr_{ad} time to ,aximum rate under adiabatic conditions

T_{Hmax}: Maximum temperature of heating system

T_p: Process Temperature

From a time (tmr_{ad}) to a Temperature (T_{D24})



T_{STAB} may be determined:

- As T_{D24} for short time processes
- As the temperature at which the tmr_{ad} is 4 x process time
- From storage tests like Dewar tests, Basket tests, Grewer oven etc.

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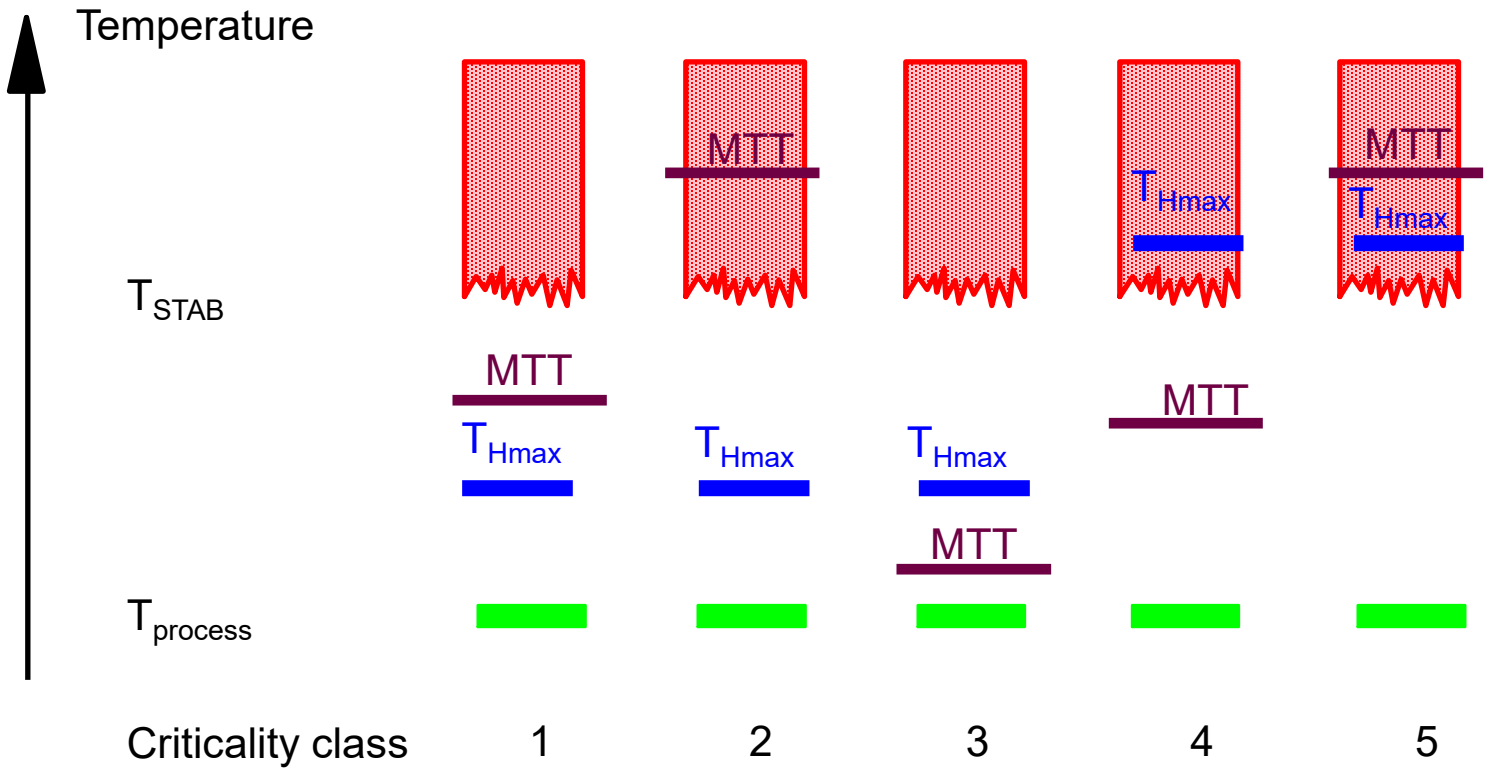


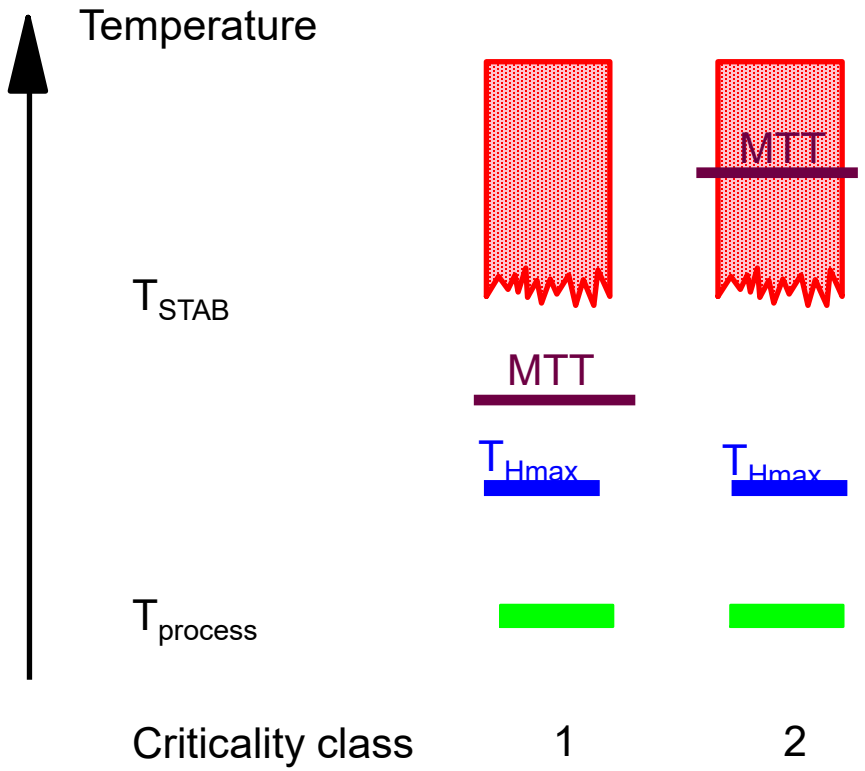
T_p Process temperature
Defined by operating mode

T_{Hmax} Maximum temperature of equipment heating system
Defined by equipment

T_{STAB} Temperature limit for thermal stability may be T_{D24} or limits taken from tests like basket or Grewer etc
Defined by thermal stability of contents

MTT Maximum temperature for technical reasons (often related to pressure)
Defined by equipment

Criticality Classes for Physical Unit Operations Classes 1 and 2



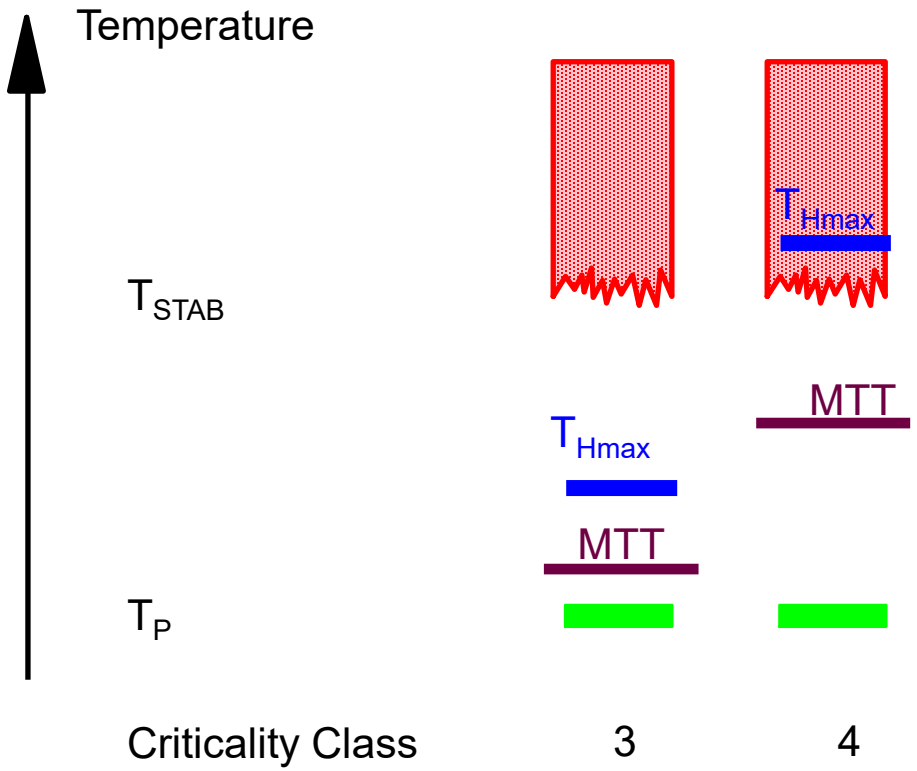
Secondary Reaction is not triggered

Technical limit is not reached

Scenarios are uncritical

No special measure required
Except avoiding heat accumulation (confinement) conditions

Criticality Classes for Physical Unit Operations Classes 3 and 4



Class 3:

Secondary reaction is not triggered

Class 4

Secondary reaction may be triggered

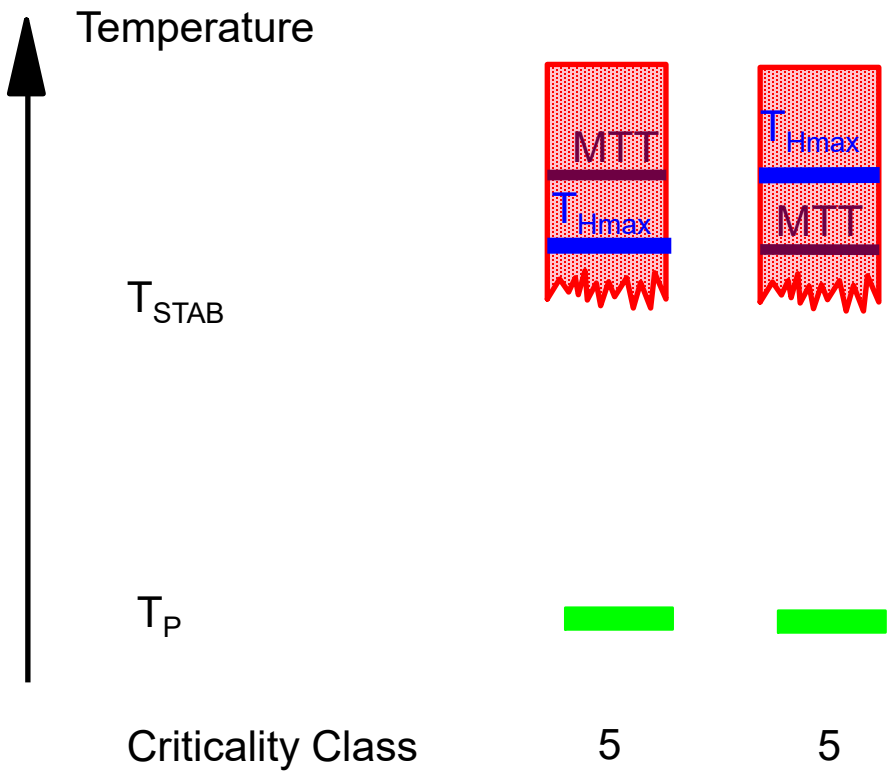
Classes 3 and 4

Scenarios are critical

Technical limit may serve as a barrier

It must be sized using the behavior at MTT.

Criticality Classes for Physical Operations
Class 5



Secondary reaction is triggered

Scenario is critical

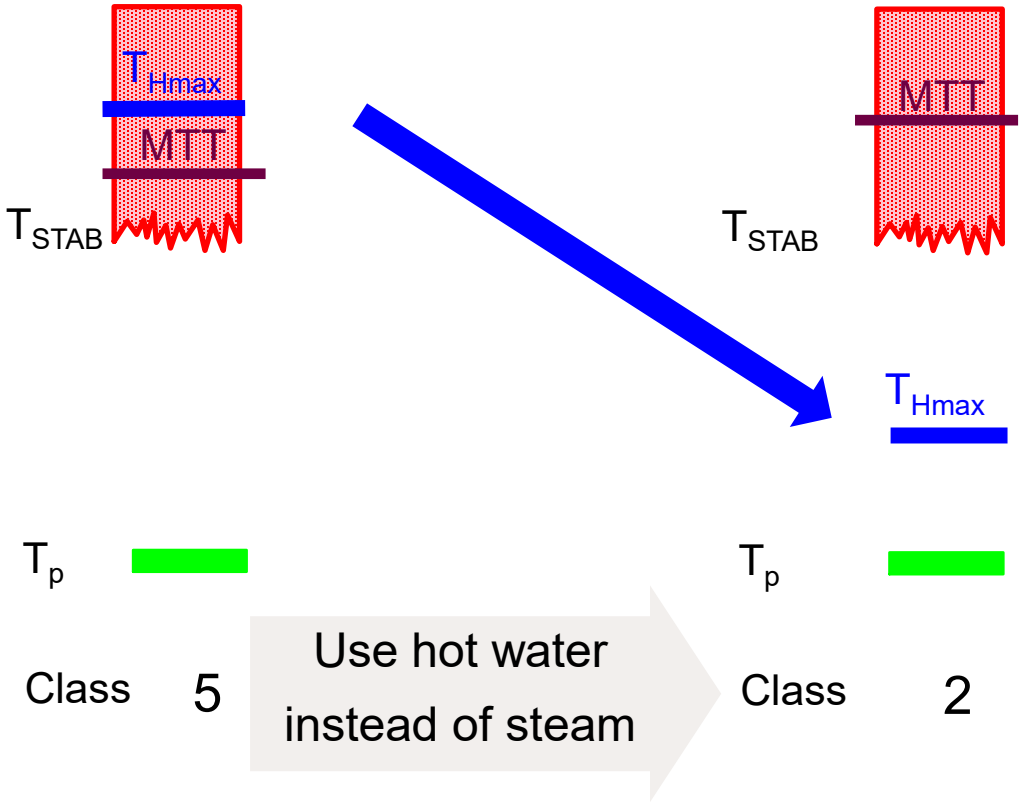
Due to high power at MTT or T_{Hmax},
the technical limit may NOT serve as a barrier

Process or process conditions must be revised

Example Paddle Dryer

- Process
  - Temperature (product) Tp = 50°C
  - Duration 12 h Vacuum 300 mbar
- Thermal stability:
  - Dewar test gives DLT 120°C T_{STAB} = 110 °C
  - Equivalent to T_{D24} – 10 °C
- Maximum temperature
  - T_{Hmax} = 160 °C (Steam 5 bar-g)
  - Continuous monitoring of T_P and P
- Maximum temperature for technical reasons
  - Defined by pressure (MAWP = 1 bar-g)
  - MTT = 122 °C

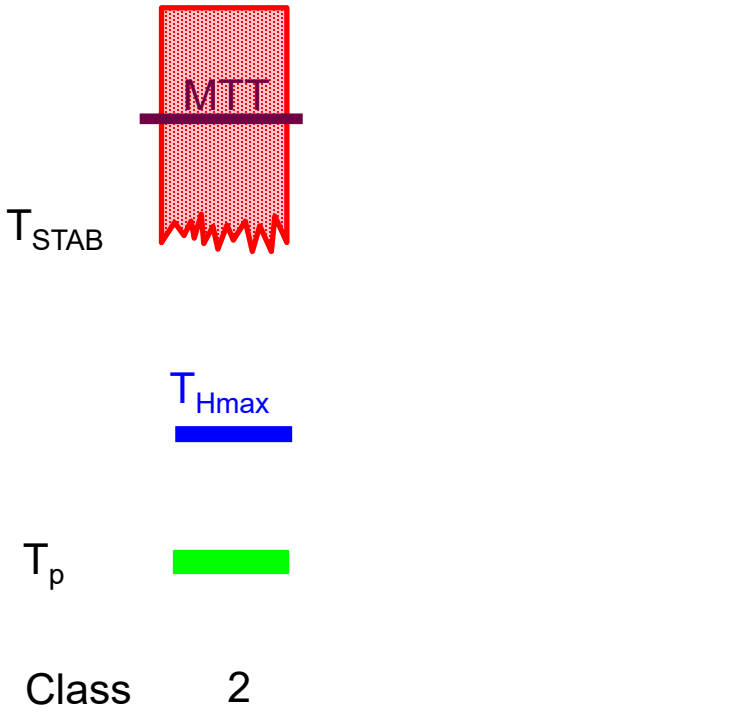
Source Cosmodry



Example Storage

- Storage in 200 litre drums diameter 60 cm
  - At room temperature. Tp = 25°C solution in toluene
  - Duration 2 months
- Thermal stability
  - High energy potential no gas release
  - tmr_{ad} < 4 x 60 d = 240 days
  - T_{stab} = 60 °C
- MTT
  - Governed by pressure 0.5 bar-g
  - MTT = 88°C
- T_{Hmax} = 50 °C High temperature during summer

- Criticality class 2:
  - No special measure required
  - Avoid heat accumulation conditions at temperatures above 25 °C



Conclusions

- Energy input due to reaction replaced by equipment heating system
- Cooling failure replaced by heating failure
- Reaction data replaced by technical data of heating system
- T_{D24} may be replaced by a temperature limit for the thermal stability.
  - T_{D24} may be defined by different tests (DSC, Dewar, Basket, Grewer, etc.)
- Criticality classes serve as a guide for defining a protection strategy
- In Classes 3, 4, 5, the behaviour at MTT must be determined quantitatively.

Thank you

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