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Vaporizing Burners-

Concepts for Premixed Combustion of Liquid Fuels

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Outline

- **Introduction**
- **partially premixed combustion**
  - flat-flame burner for liquid fuels
- **fully premixed combustion**
  - small scale radiant burner
  - small scale porous burner
- **Ongoing research projects**

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- **Premixed combustion has been identified as one of the key technologies in combustion engineering**
  - to reduce emission of pollutants.
  - to increase fuel flexibility
  - To make gaseous fuel technology accessible for liquid fuels
- Whereas premixed combustion for gaseous fuels is state of the art in many applications, **the implementation of premixing technology for liquid fuels reveals significant challenges**.
  - Suitable atomization/evaporation technology for various fuels (viscosity, boiling range)
  - Need for energy efficient and residue free evaporation
  - Preventing early ignition (during mixing, prior to combustion)

In premixing burners for liquid fuels (vaporizing burners), evaporation zone and combustion zone are fully separated

Two characteristic premixing types for liquid fuel combustion shall be defined:

- **Partially premixed Combustion:** The fuel is completely vaporized and partially mixed with air/off gas before it reaches the reaction zone.
- **Fully premixed Combustion:** The fuel needs to be completely evaporated and fully mixed with combustion air before it reaches the reaction zone.

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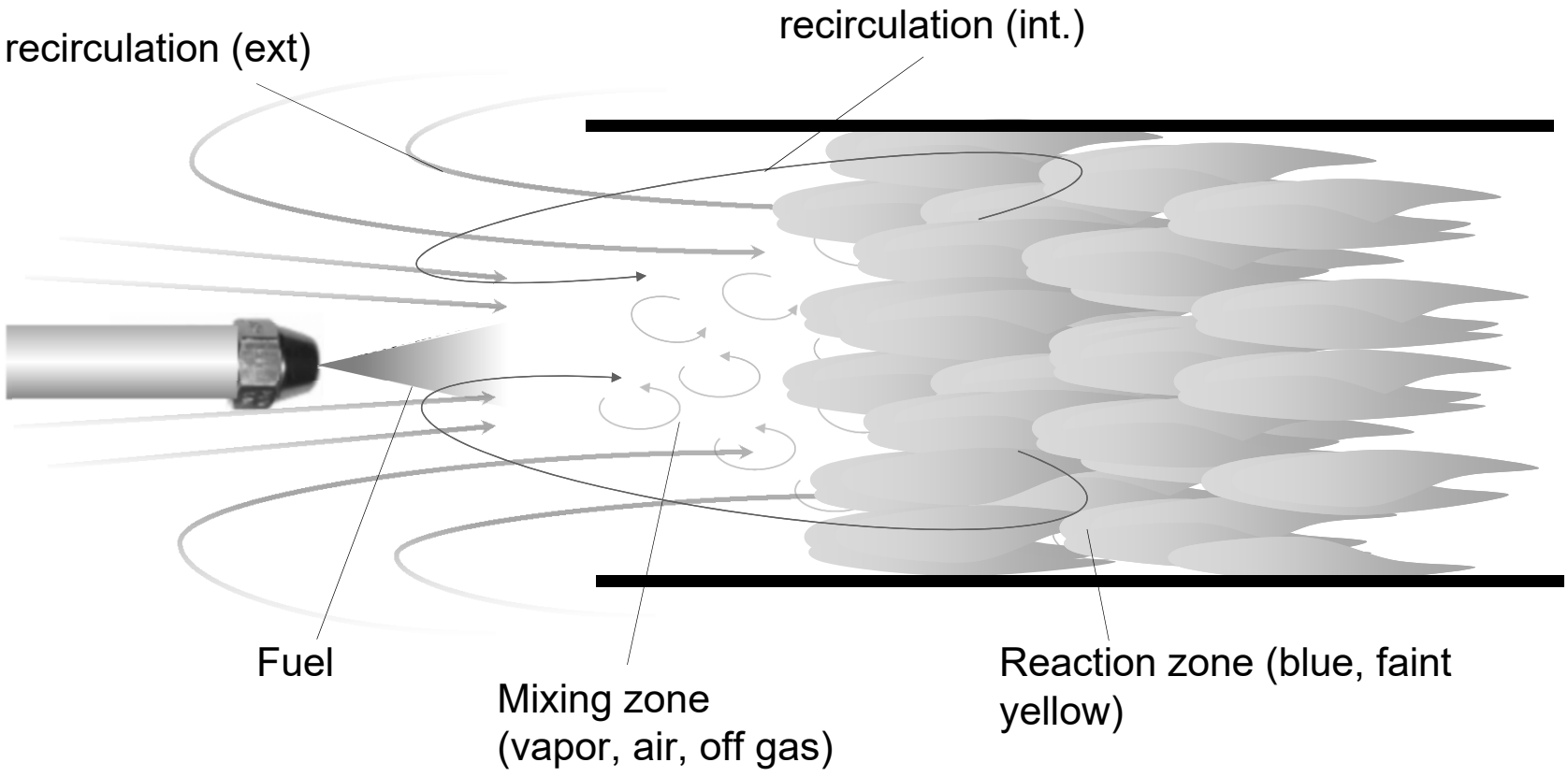
partially premixed combustion



characteristics of partially-premixed combustion:

- separation of evaporating- and combustion zone, distinct premixing zone
- Separation achieved by high recirculation fluxes (inertisation and cooling of the reaction zone)
- large blueish flames, low energy density due to high recirculation rates
- moderate temperatures → reduced risk for high temperature NOx - formation
- Application: burners for tight emission regulations (domestic application in the EU)

main drawbacks

- increased noise emissions due to higher flow speeds and turbulent combustion
- additional parts for flame stabilisation might be necessary (flame tube, higher costs), as well increased blower powers to achieve higher impulses are t. b. prov.

partially premixed operation of a flat flame burner (power max. 180 kW)

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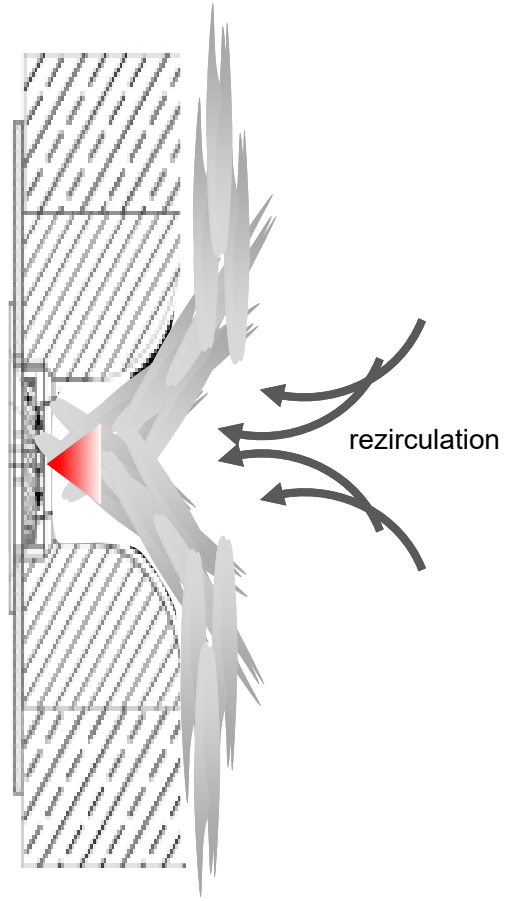
KÖRNER Feuerverzinkungsanlagen

flat flame burner for liquid fuels: concept



- flame orientation in radial direction
- flame mainly directed through shape of the burner-stone
- flame is heating the furnace wall, heat transfer to melter via radiation
- application: zinc-galvanizing plant

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Flat flame burner: start mode
Leistung 90 kW, non premixed operation

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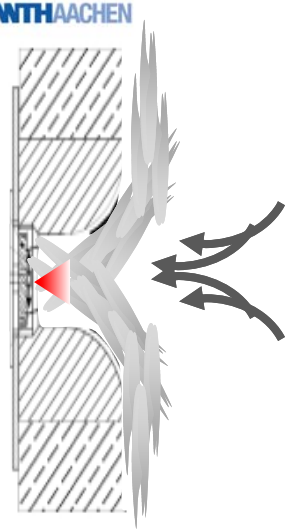
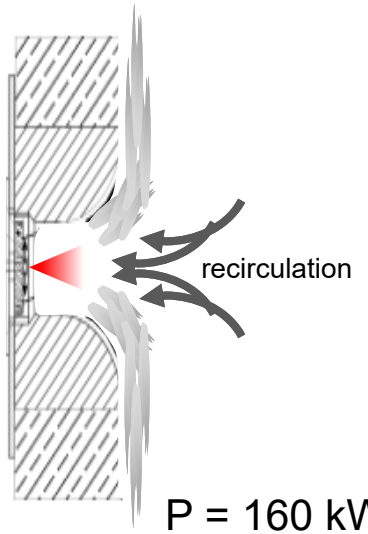
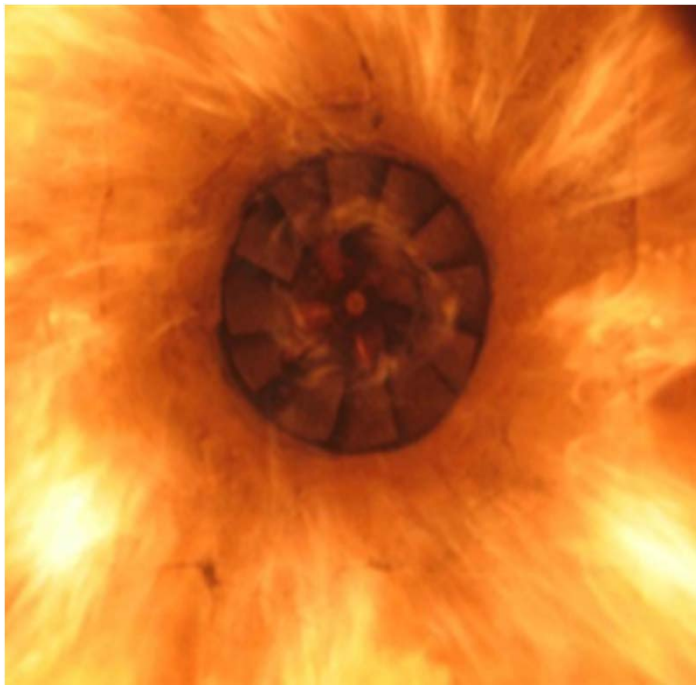


transition from non premixed to partially premixed operation mode

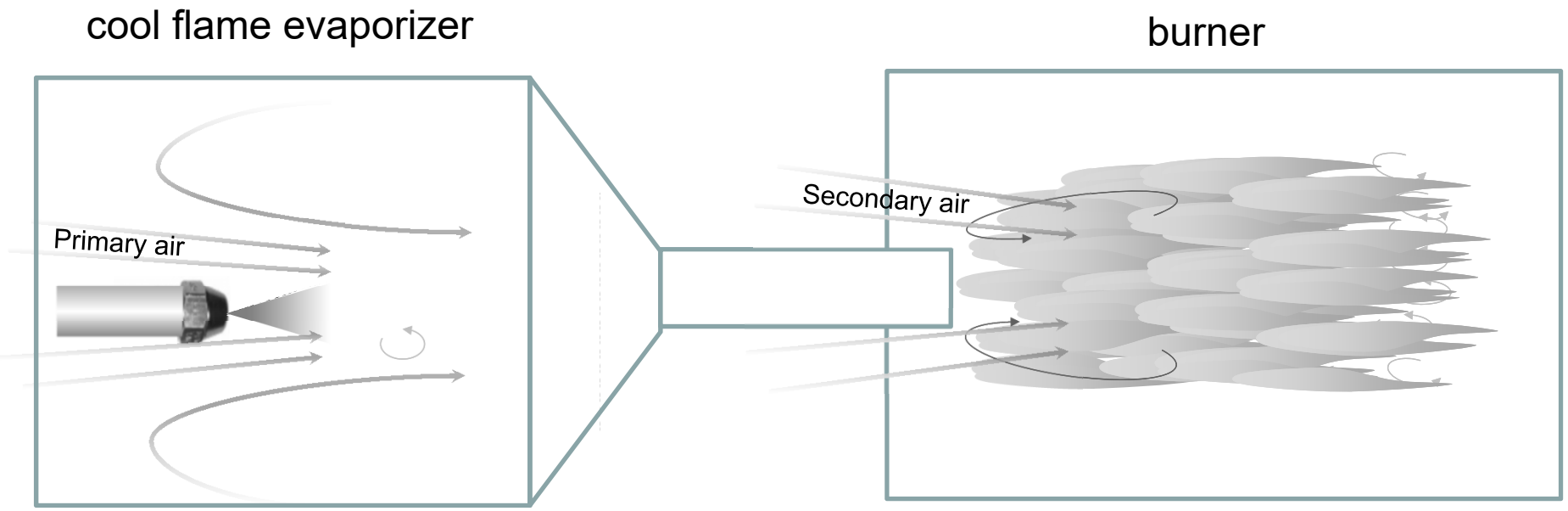


P = 90 kW

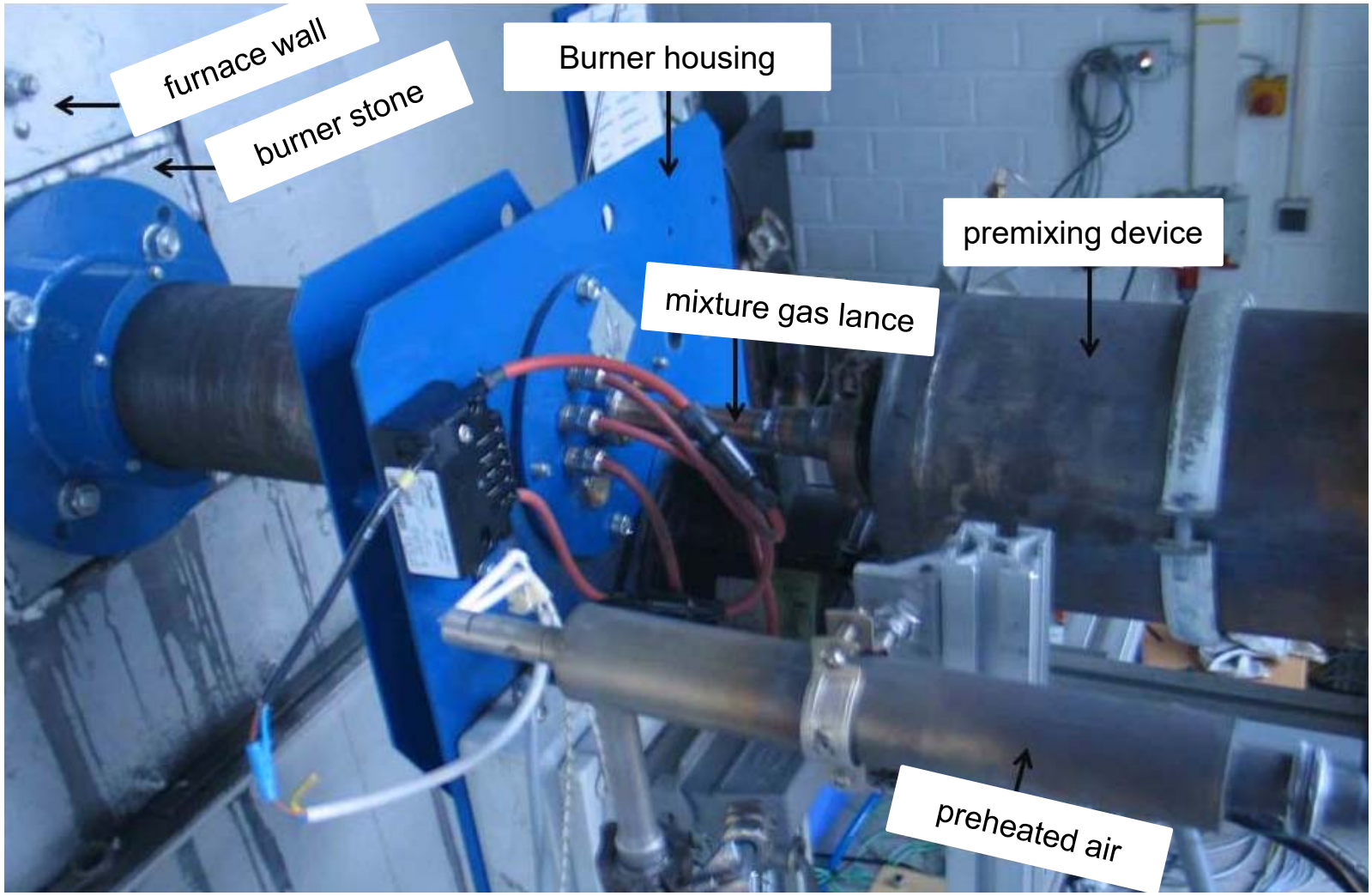
P = 160 kW



fully premixed operation for a flat flame burner (power max. 180 kW)



experimental setup, premixing device



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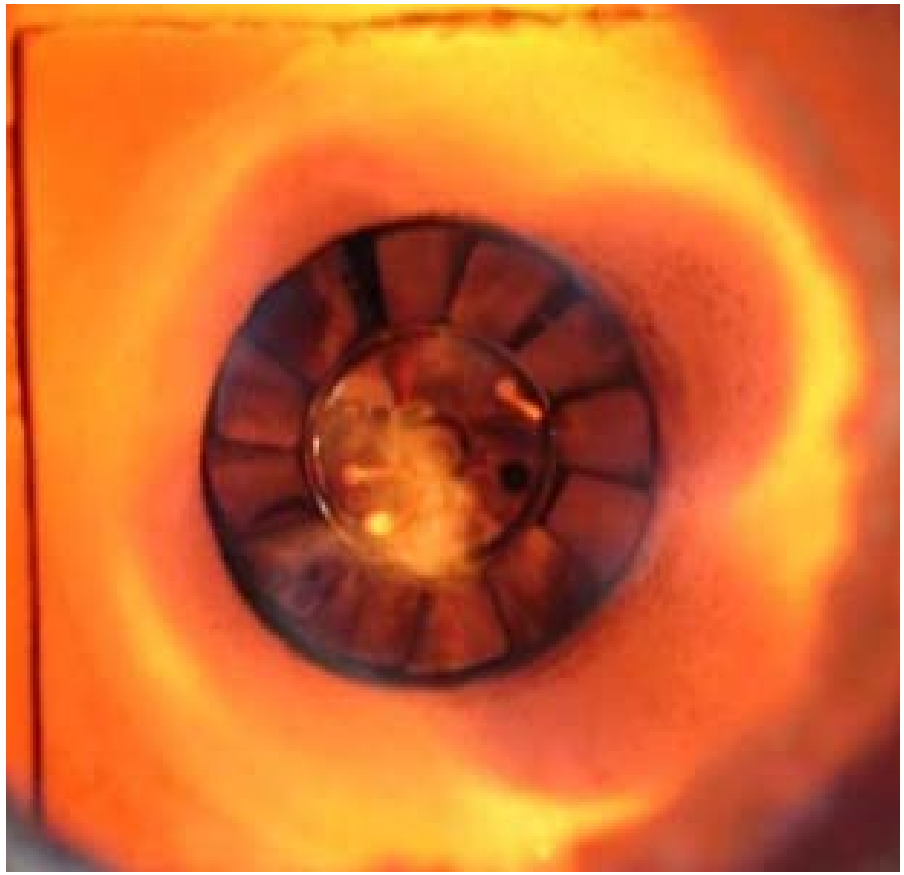
Premixed operation with external premixing device (cool flame reactor)



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- Introduction
- non premixed combustion
  - Industrial scale burner with air staging
- partially premixed combustion
  - flat-flame burner for liquid fuels
  - premixed oil burner for radiant tubes
- **fully premixed combustion**
  - small scale radiant burner
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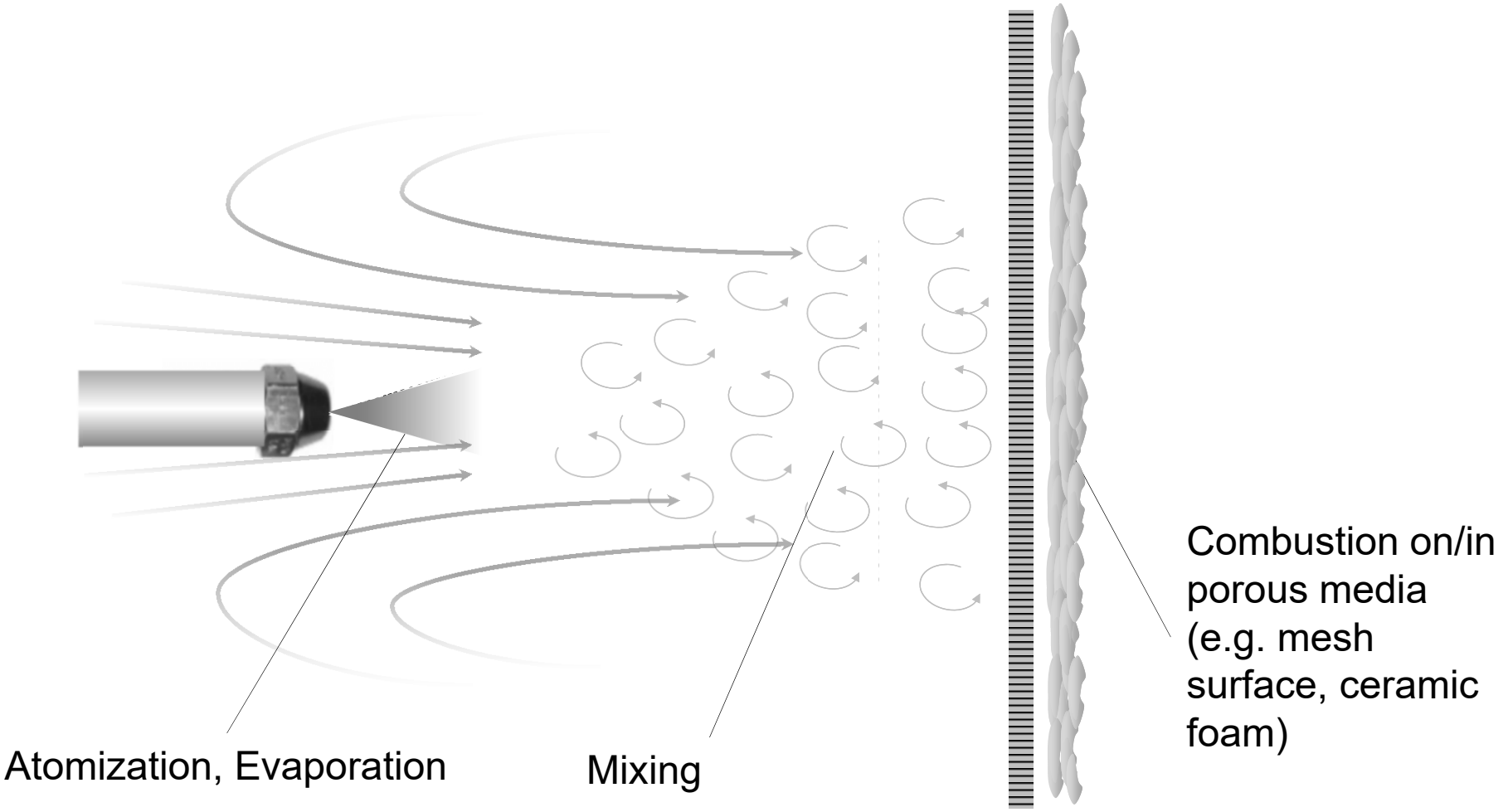
fully premixed combustion



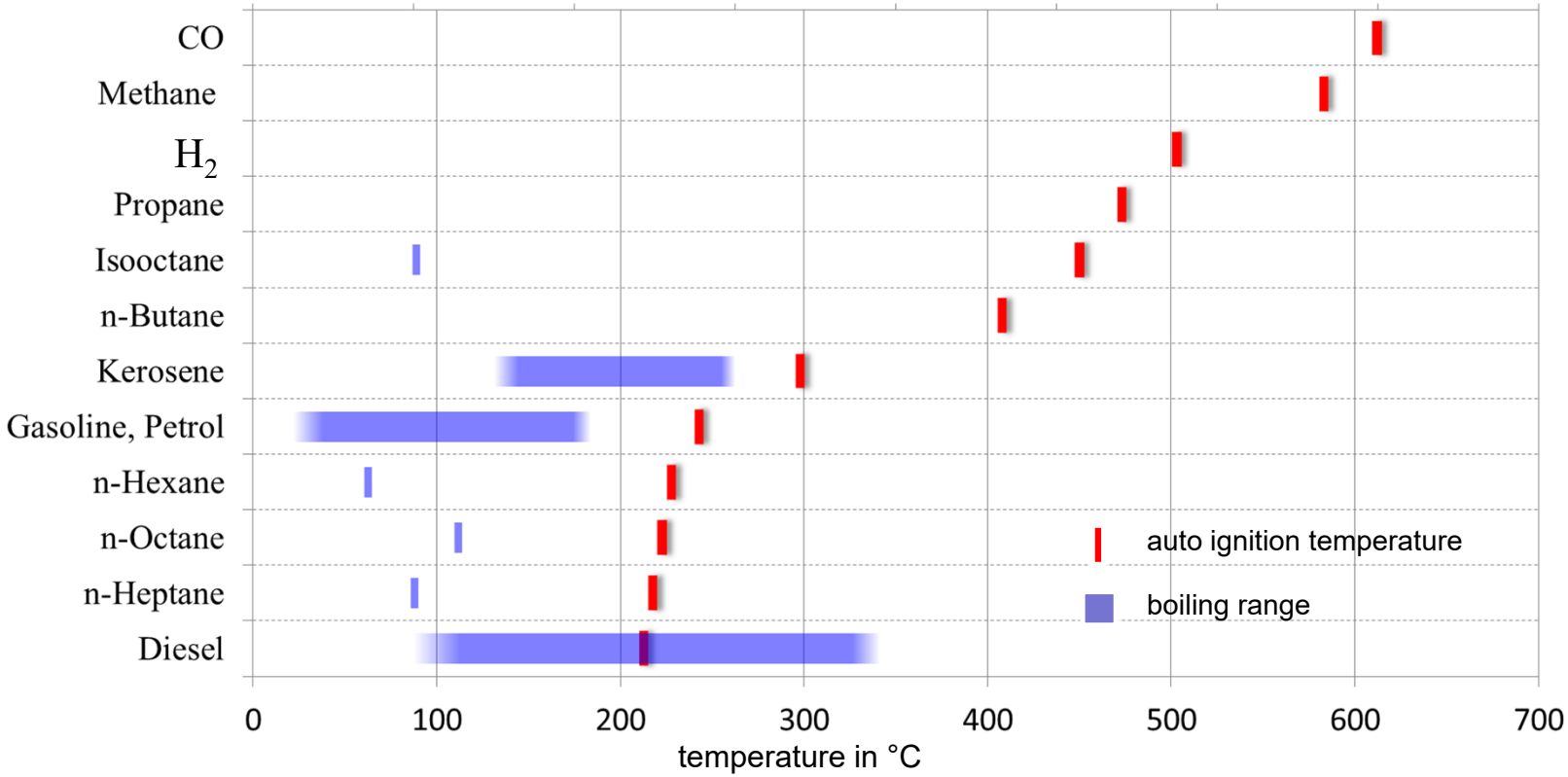
characteristics of fully-premixed combustion:

- Complete separation of evaporating/mixing- and combustion zone
- fully homogenious mixture allows for extensive control of the combustion process
- Laminar combustion, flame stabilization on/in porous media → very silent flames
- Generally low NOx - emissions
- Application: burners for tight emission regulations (domestic application in the EU), fuel processor for fuel cell systems, catalytic burners

main drawbacks

- Very complex thermal management in the premixing zone, strongly depending on the operational area
- Risk of unintended ignition of the fuel air mixture in the mixing area due to flash back or insufficient thermal management (self ignition)
- Porous media may show limited lifetime when exposed to high temperatures

Auto ignition temperatures and boiling ranges in °C

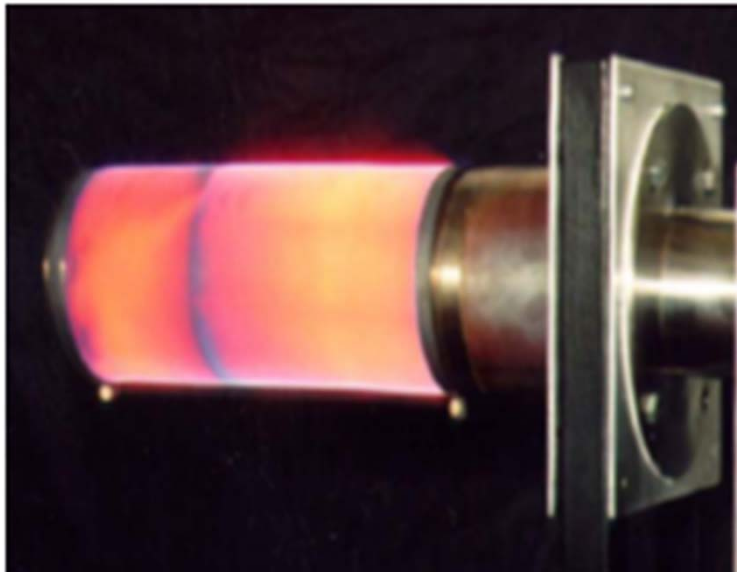


- The temperatures needed for complete evaporation of technical fuels like diesel and IGO are associated with the boiling range which lies between 100 °C and 350 °C.
- However, the auto ignition temperature for Diesel fuel lies far below the upper limit of the boiling range.
- Hence **premixing of diesel/igo and air is a critical process as temperatures beyond auto ignition temperature are needed** and the risk of ignition is given.

examples for premixing technology for liquid fuel combustion

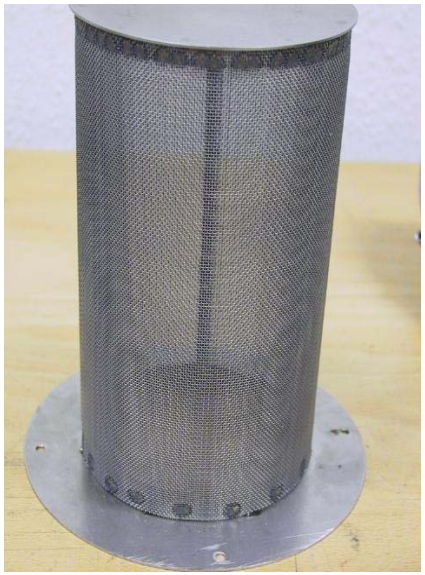
- Combustion in porous media

- Reforming, catalytic combustion

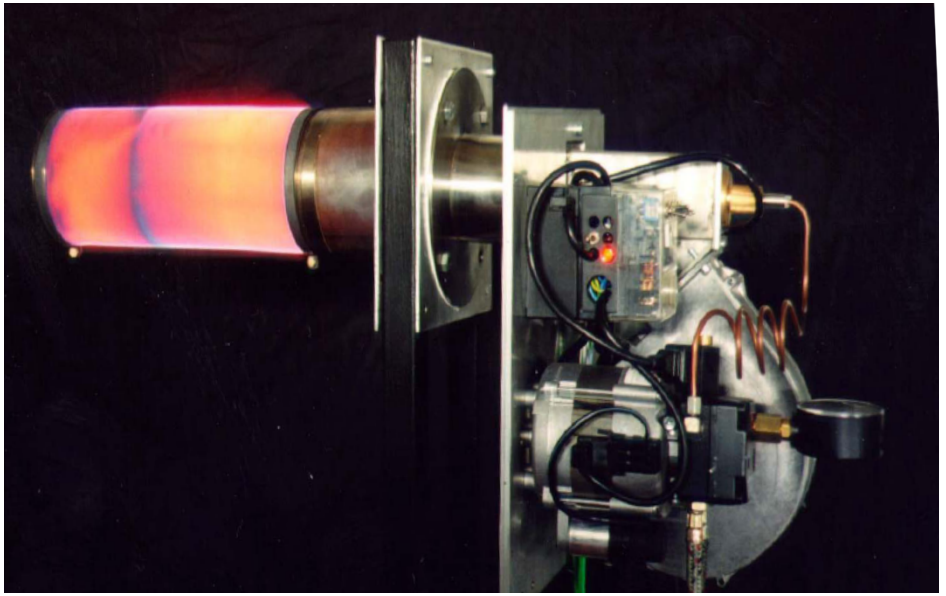


The radiant burner- a concept for surface small scale combustion of liquid fuels

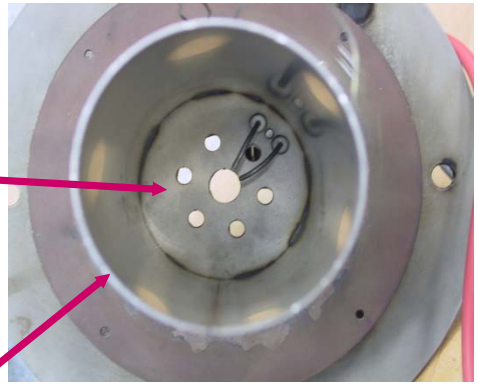
fully premixed combustion



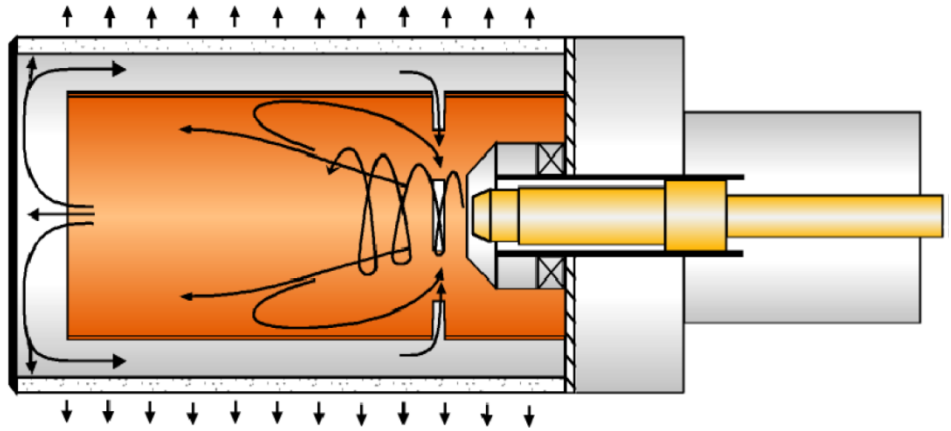
burner surface mesh



burner in operation



view on a typical air inlet plate (through the flame tube)



Schematic sketch of a combustion process

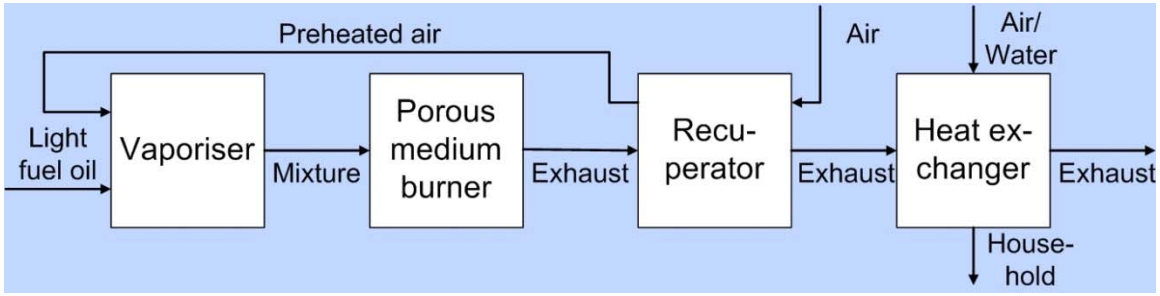
small scale burner

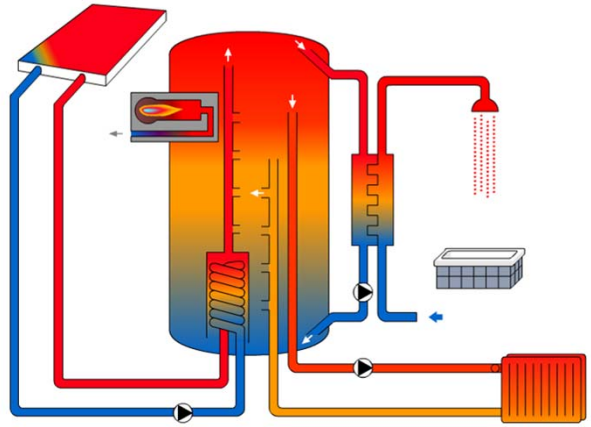
for light fuel oil in the power range

1 kW to 8 kW

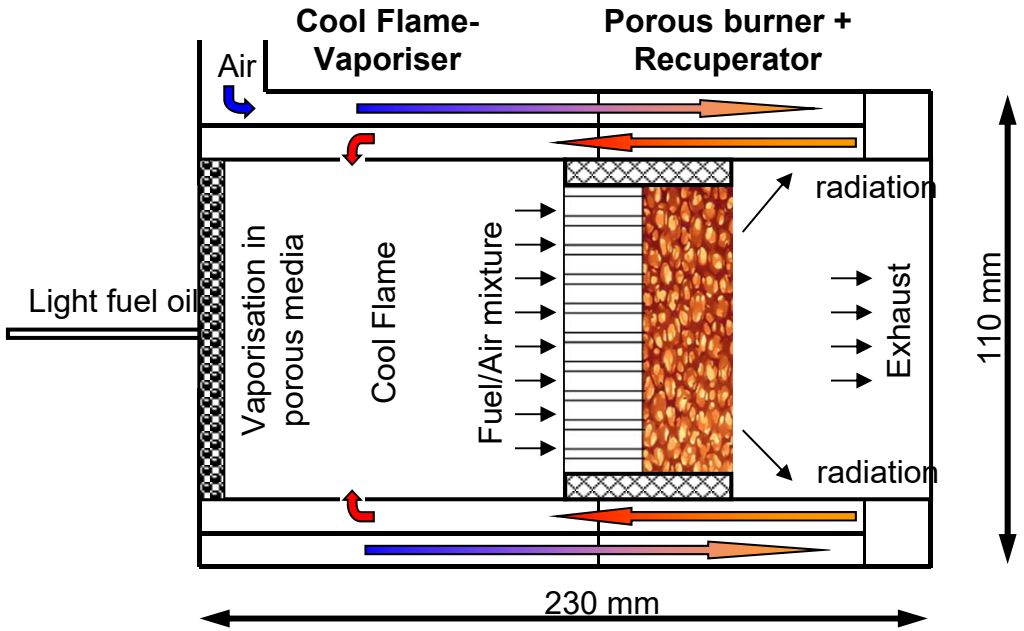
for a solar heating storage

Vaporizing burner module 1 kW – 8 kW

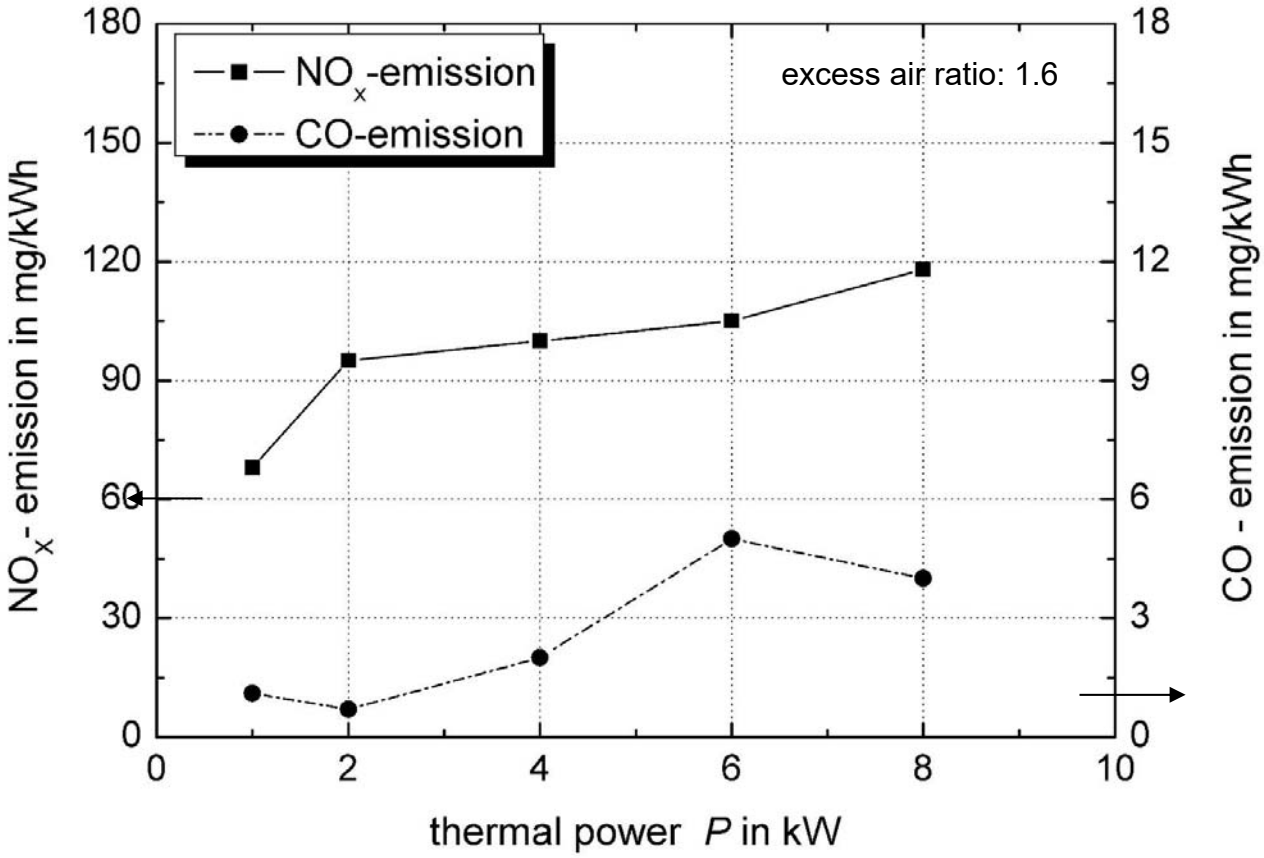




solar heating storage



Concept



Values corrected to a N-Content of 140 mg/kg (DIN EN 267)

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Thank you for your attention!

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