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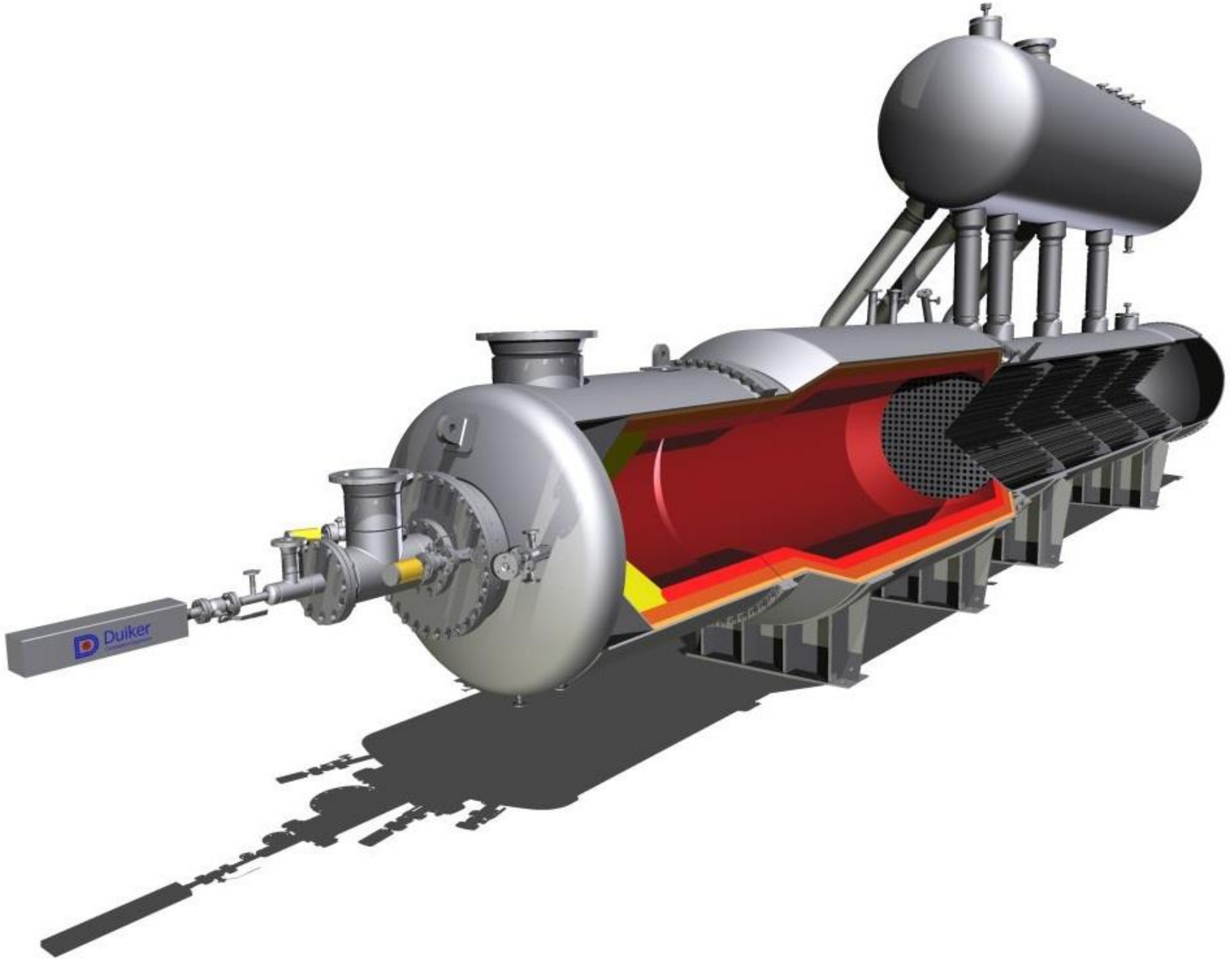
SRU Thermal Reactor Chemistry & Design

Roelof ten Hooven

Area Sales Manager



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Company Profile

- Engineering company specialized in process combustion equipment
- Founded in 1919
- ± 75 employees

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Goals of the SRU

- Recover elemental sulfur ($S_{2\text{-}8}$) from all sulfur species in the feed gases (AAG and/or SWSAG).
- Destruct other harmful components of the feed gases.
- Limit the formation of new harmful substances.

Basically, comply with emissions regulations!

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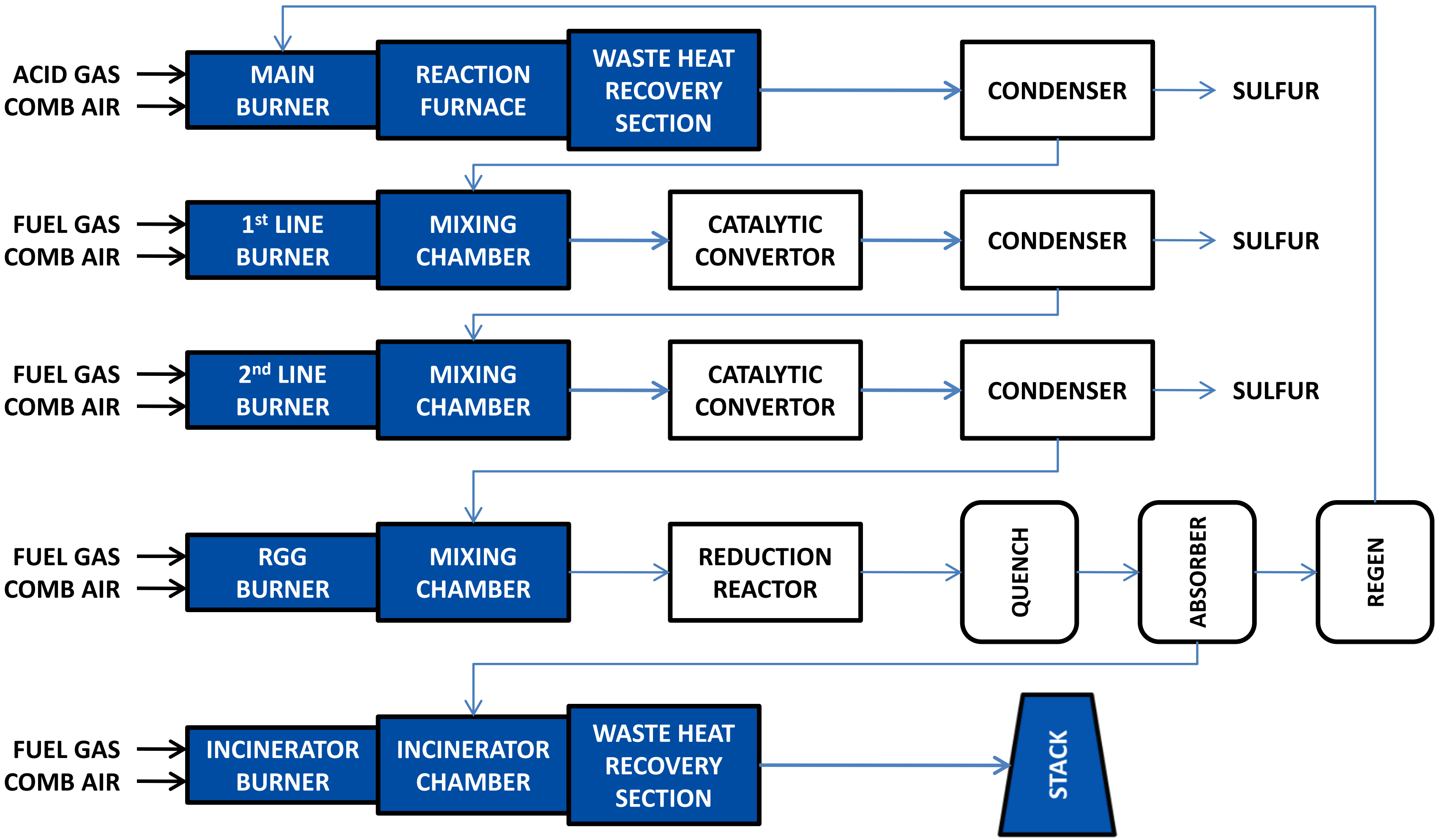
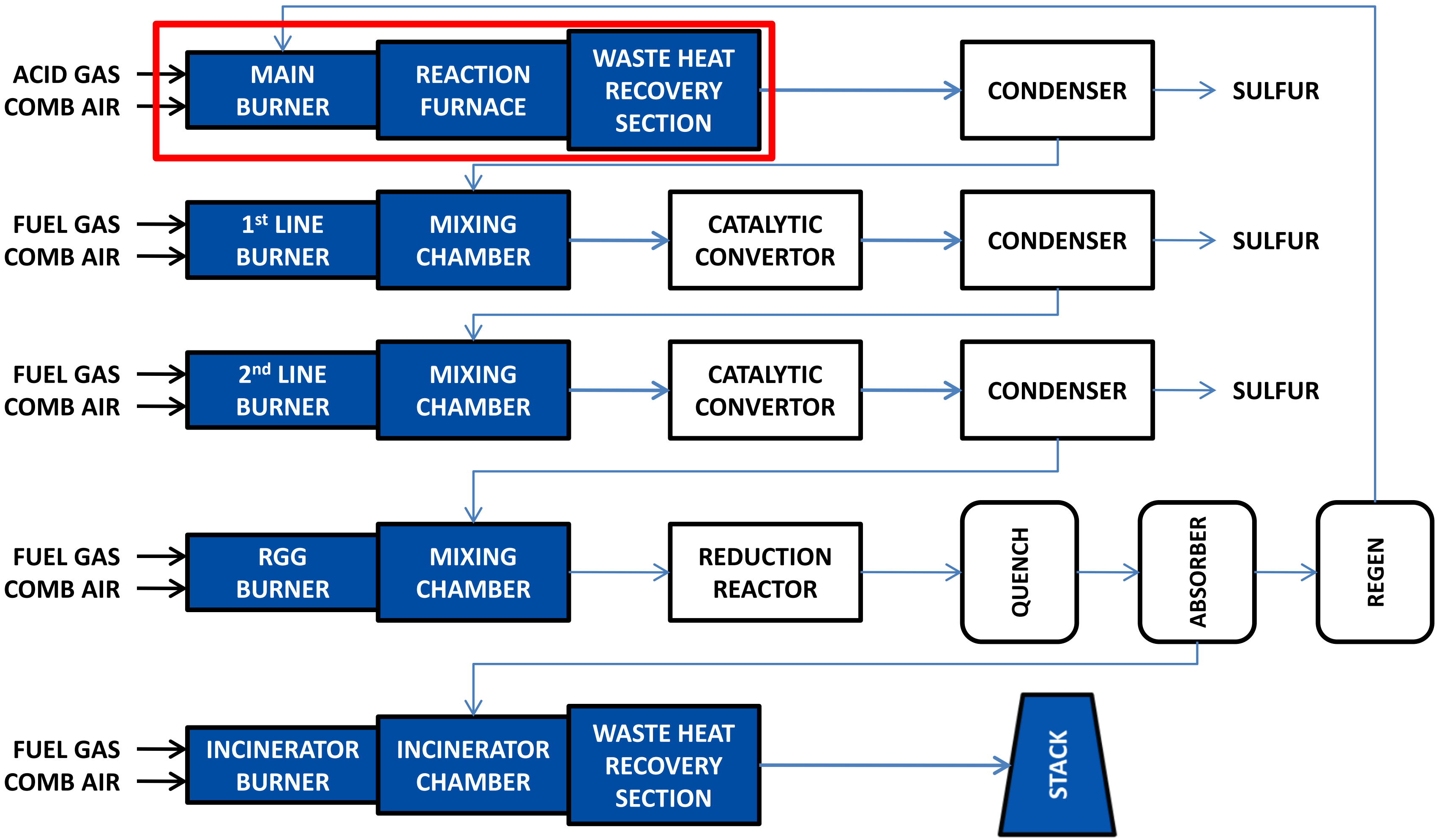
Typical Sulfur Recovery Unit



Sulfur Recovery Unit Thermal Stage



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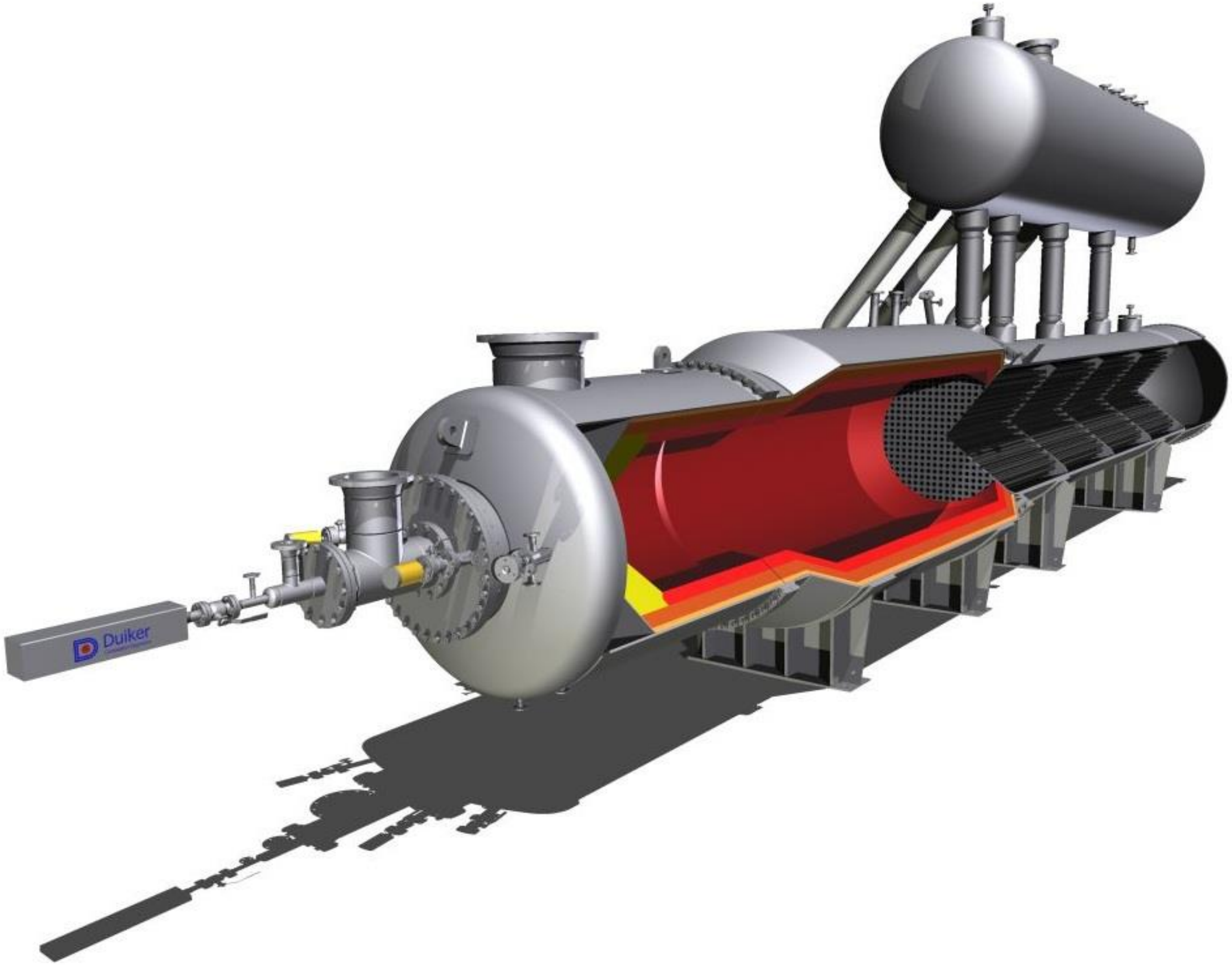

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Thermal Stage Objectives

- 65-70% Sulfur Recovery
- Ammonia Destruction
- Hydrocarbon Destruction
- By-product Conversion

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Sulfur formation in the Reaction Furnace

Claus reaction:

Acid gas

$$2H_2S + SO_2 \rightleftharpoons 1\tfrac{1}{2}S_2 + 2H_2O$$

Hydrogen sulfide | Sulfur dioxide | Sulfur | water

Sulfur formation in the Reaction Furnace

Acid gas

Combustion zone

$$H_2S + \boxed{1½O_2} \longrightarrow SO_2 + H_2O$$

Hydrogen sulfide + Oxygen (Air) → Sulfur dioxide + Water

Reaction zone

$$2H_2S + SO_2 \rightleftharpoons \boxed{1½S_2} + 2H_2O$$

Hydrogen sulfide + Sulfur dioxide ⇌ Sulfur + water

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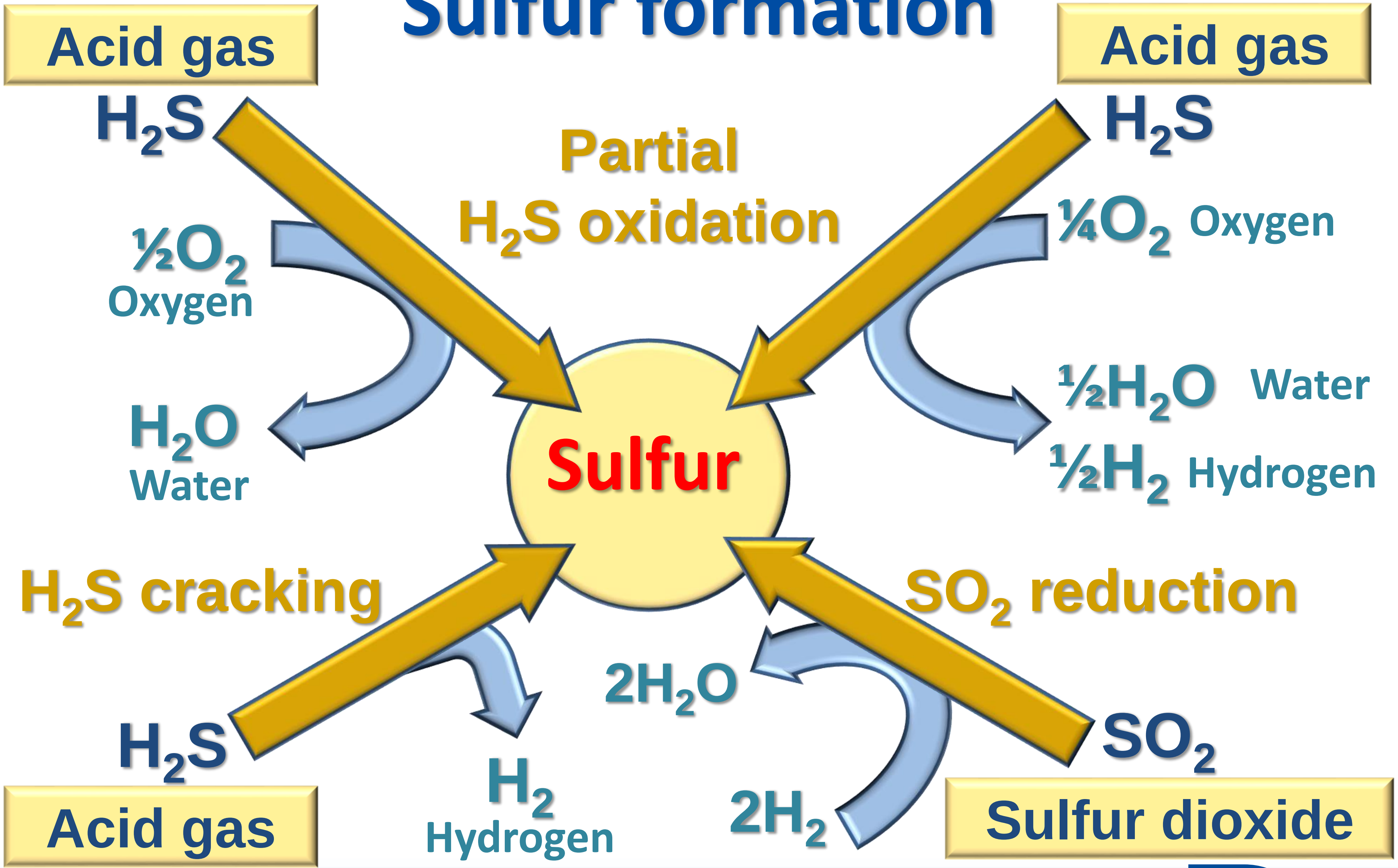
Sulfur formation



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Ammonia destruction

$$NH_3 + \tfrac{3}{4}O_2 \longrightarrow \tfrac{1}{2}N_2 + 1\tfrac{1}{2}H_2O$$

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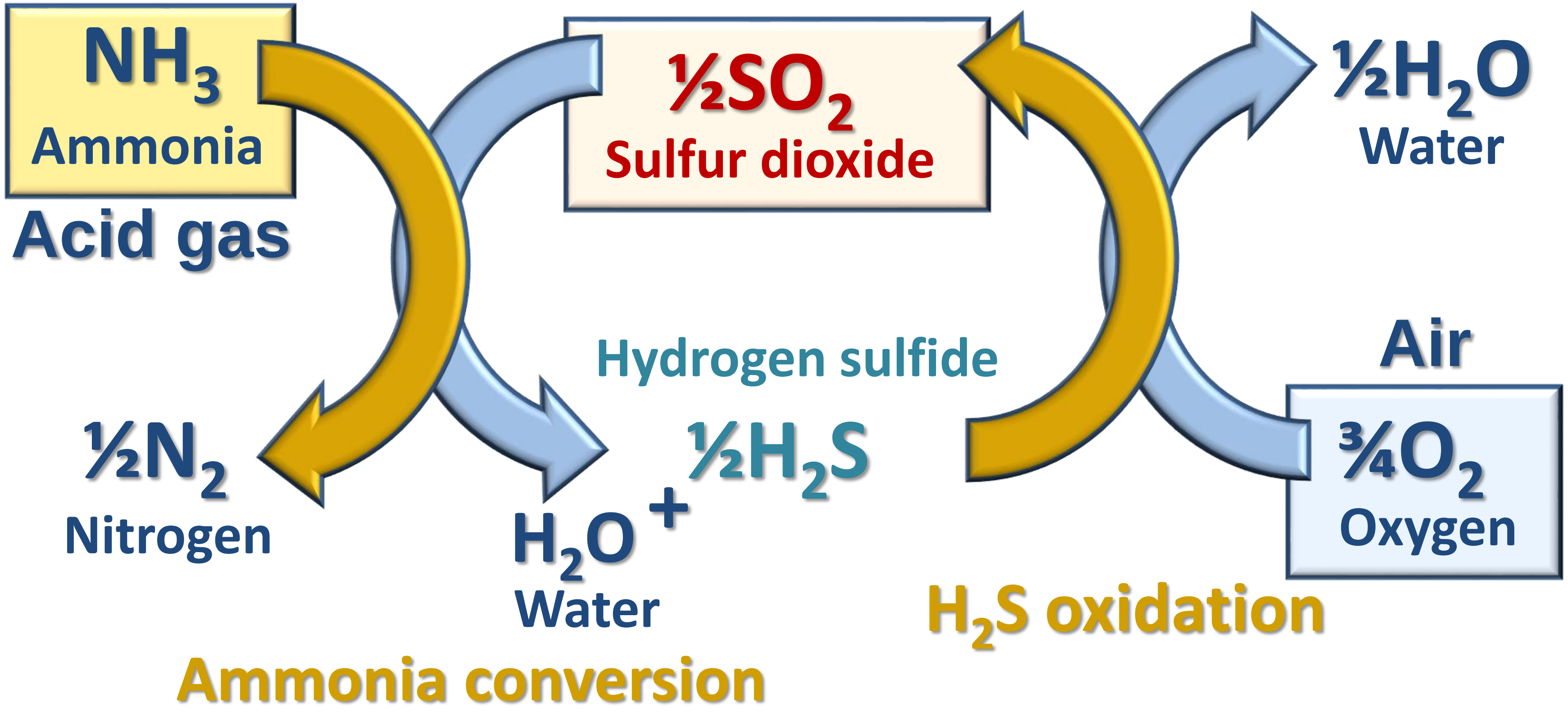

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Ammonia destruction

Remaining NH_3 at MRF outlet:

- Expected < 20 ppm
- Guaranteed < 100 ppm

Provided:

- MRF operating temperature > 1300°C (2372°F)
- Residence time > 1 sec

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Hydrocarbon destruction

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

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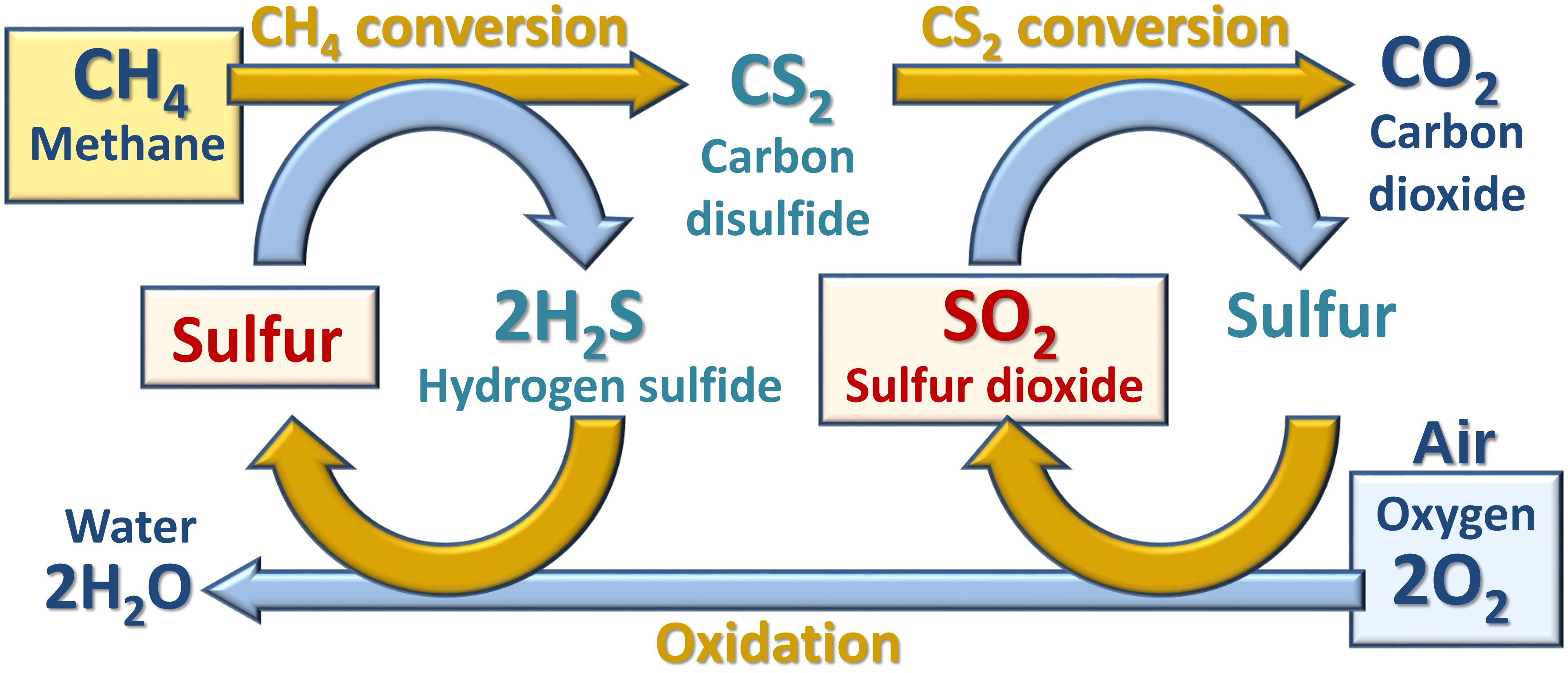
Hydrocarbon destruction

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$



SRU Combustion Basics

The degree of combustion depends on 3 factors, the three **T**’s of combustion:

- **T**emperature
- (Residence) **T**ime
- **T**urbulence

SRU Temperature

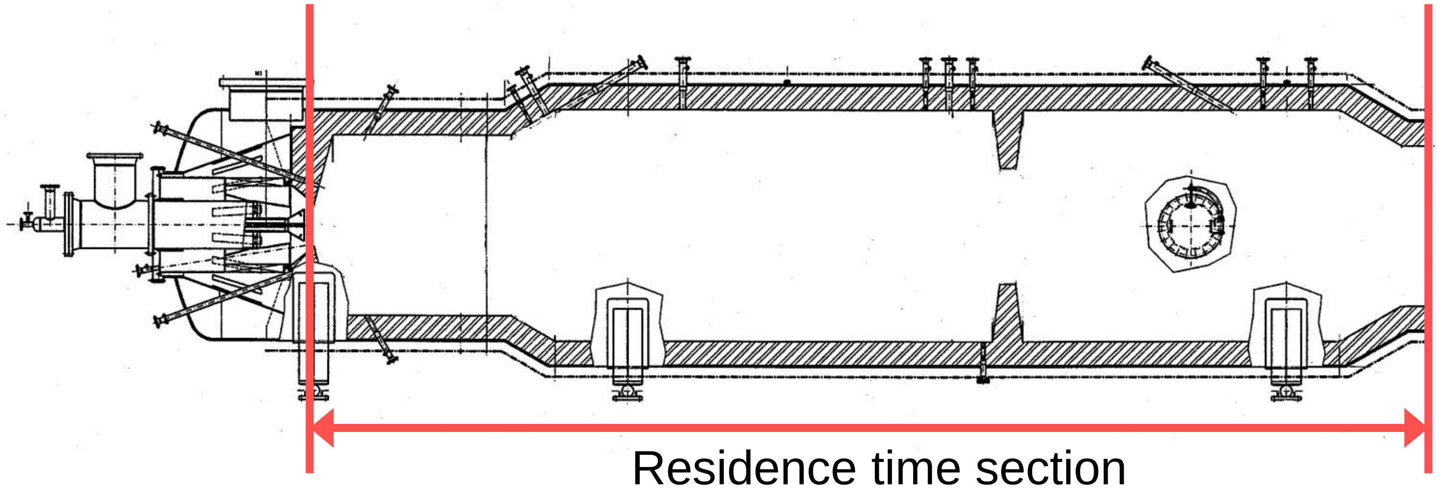
The overall temperature in the main reaction furnace depends on:

- Chemical reactions
  - Heat release and absorption
  - The stoichiometry
- Design conditions (set by process licensor)
  - Pre-heating of the combustion air / acid gas
  - Oxygen enrichment
  - Co-firing of fuel gas
  - Bypassing part of the amine acid gas

SRU Residence Time

Minimum: determined by reaction kinetics

Longer: better destruction of impurities.



SRU Turbulence

The flow pattern determines the shape of the flame, the degree of mixing as well as the flame stability. Mixing is achieved through:

- Burner geometry
  - E.g. physical restrictions, swirlers, constrictions, etc.
- Pressure drop
  - Higher pressure drop = more energy!
- Design principle
  - Pre-mixing vs. diffusion flame principle

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Resulting Burner Requirements

- Intense mixing of acid gas and oxygen
- Recirculation of flue gas

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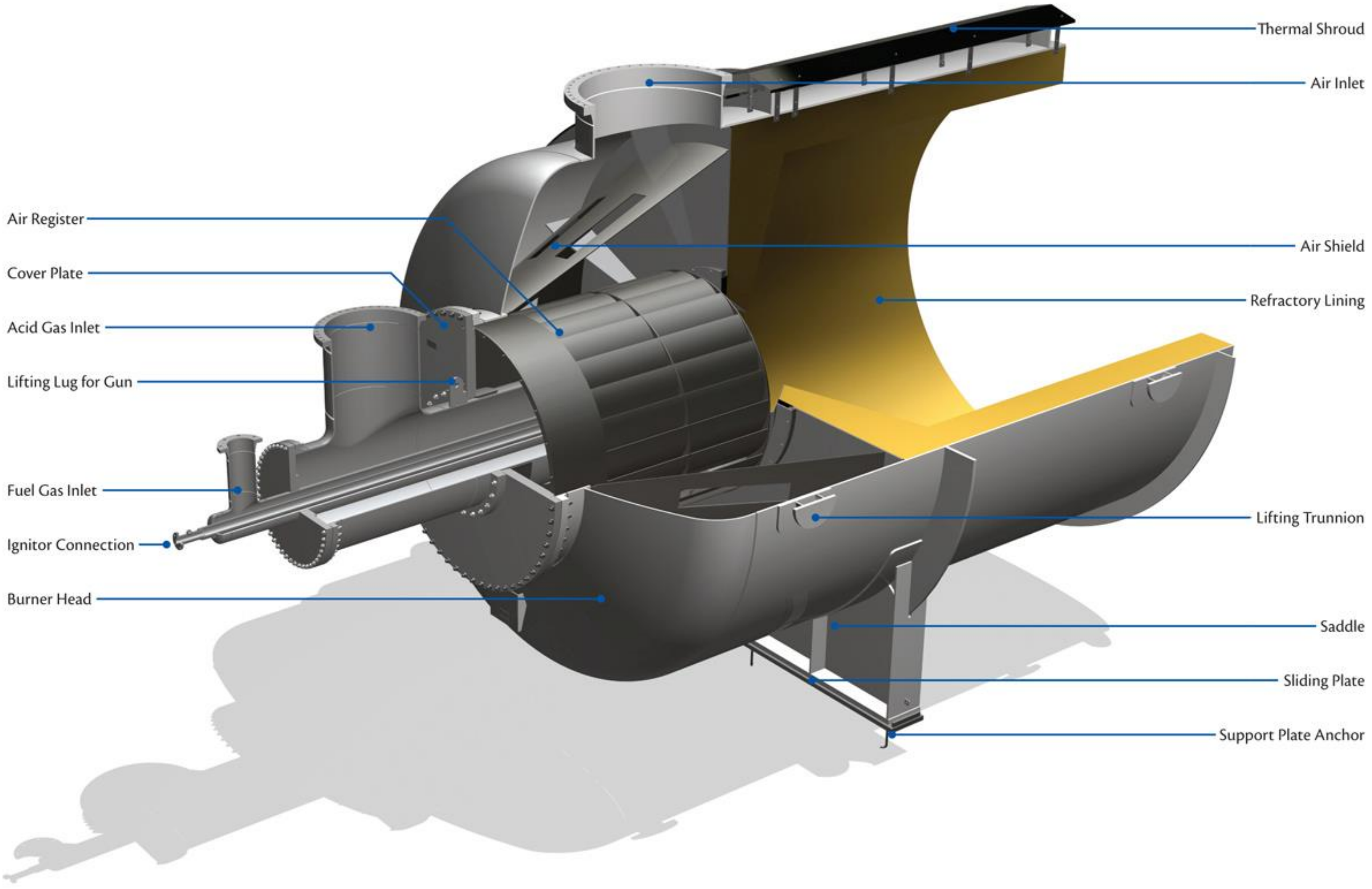
LMV Main Burner



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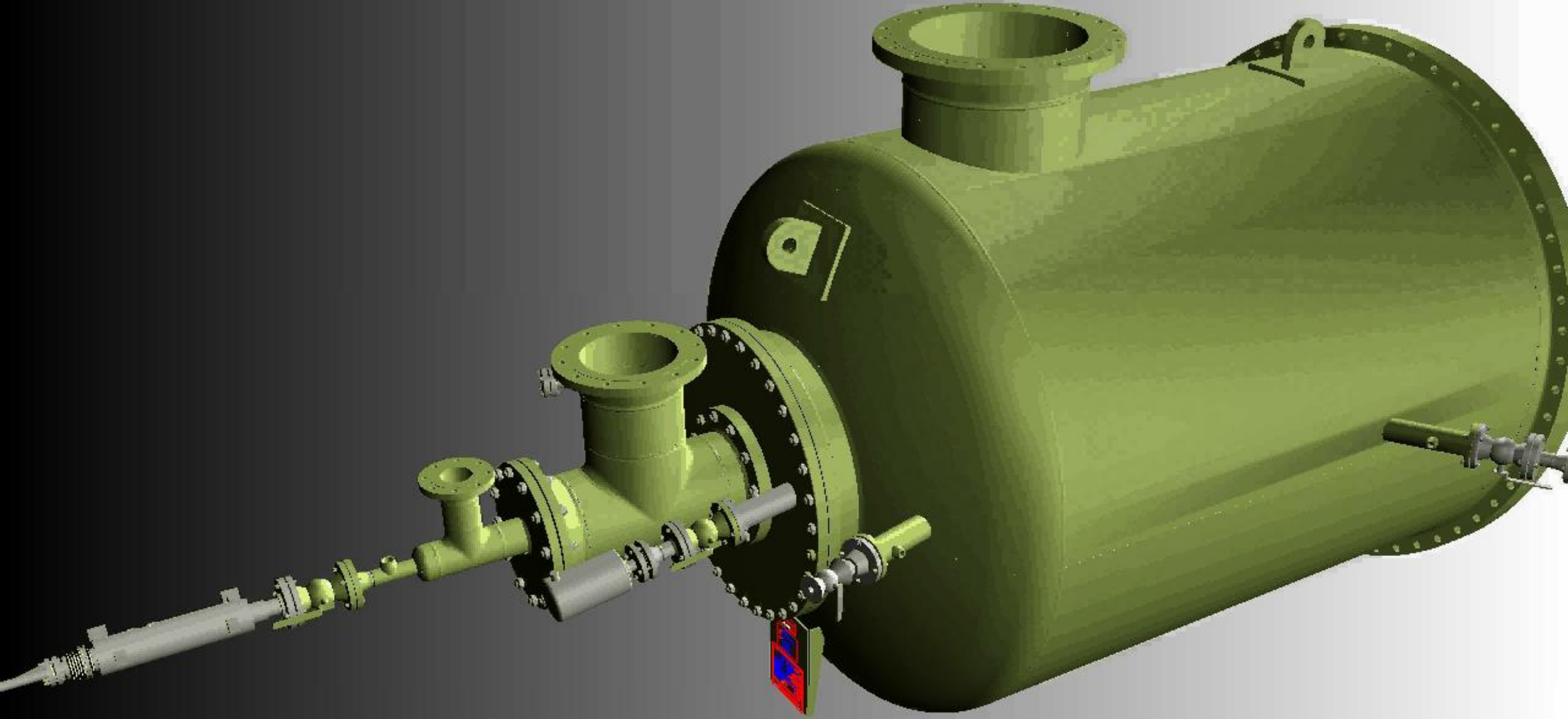
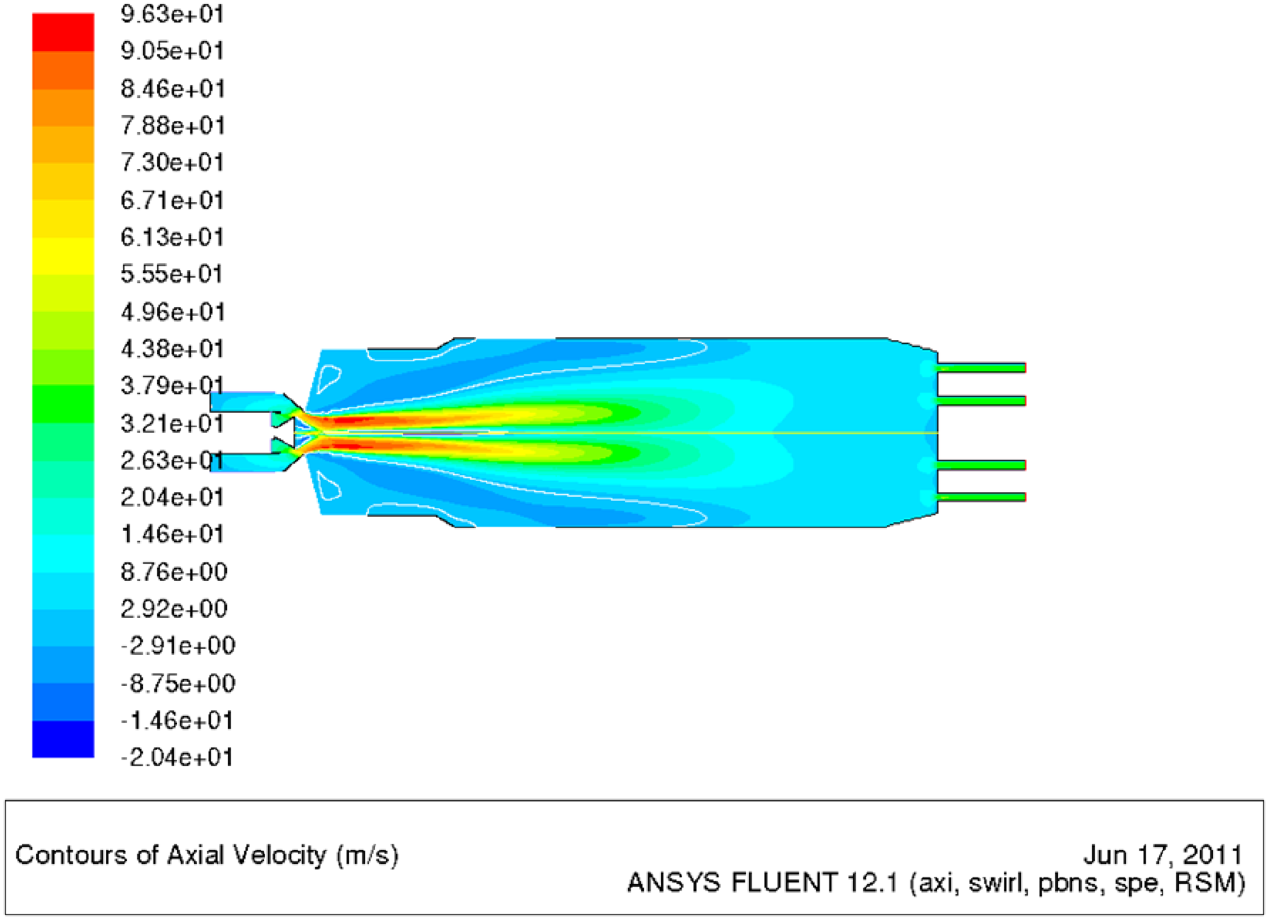
LMV Main Burner



LMV Burner Axial Velocity



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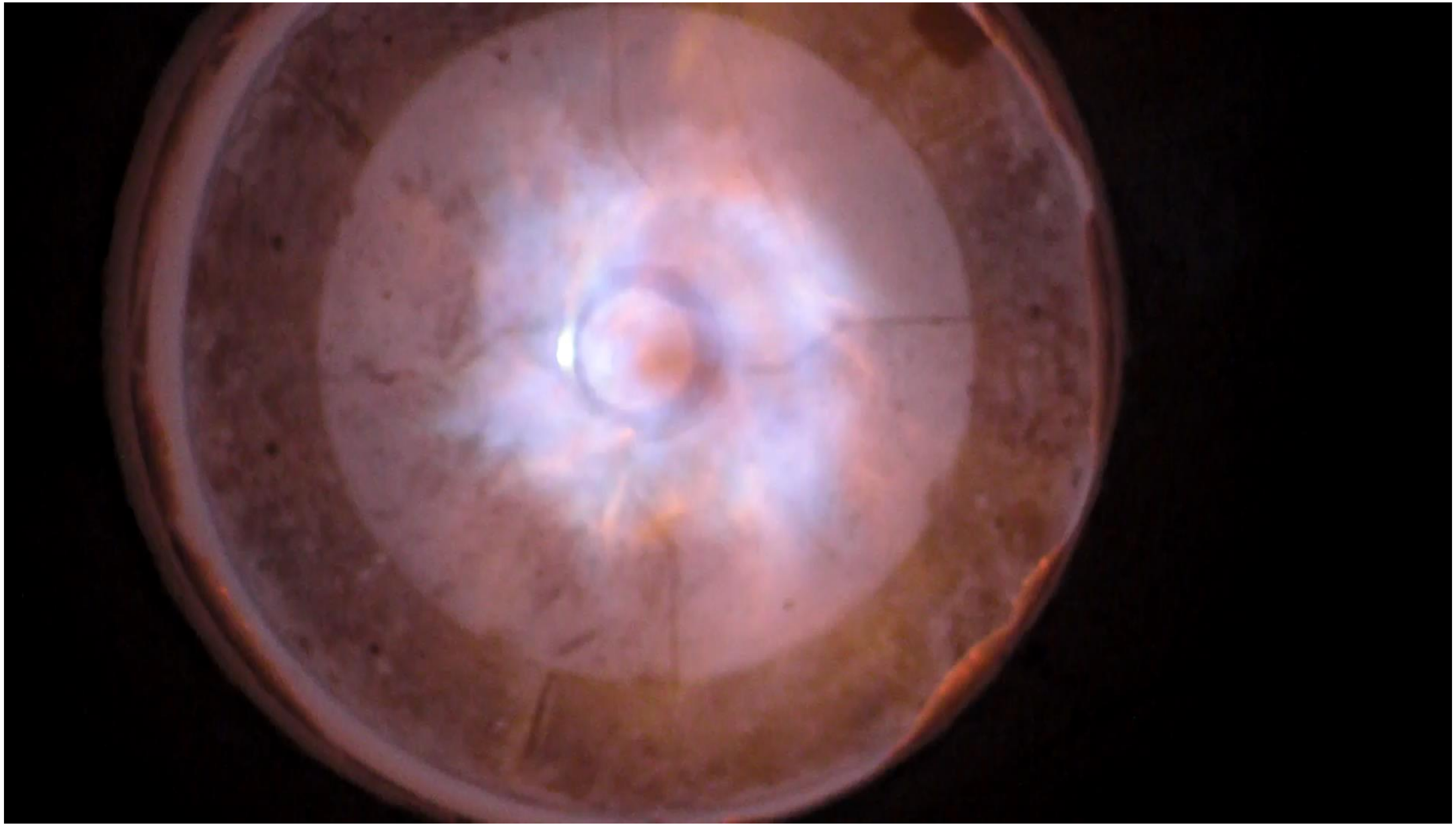
Turbulent combustion



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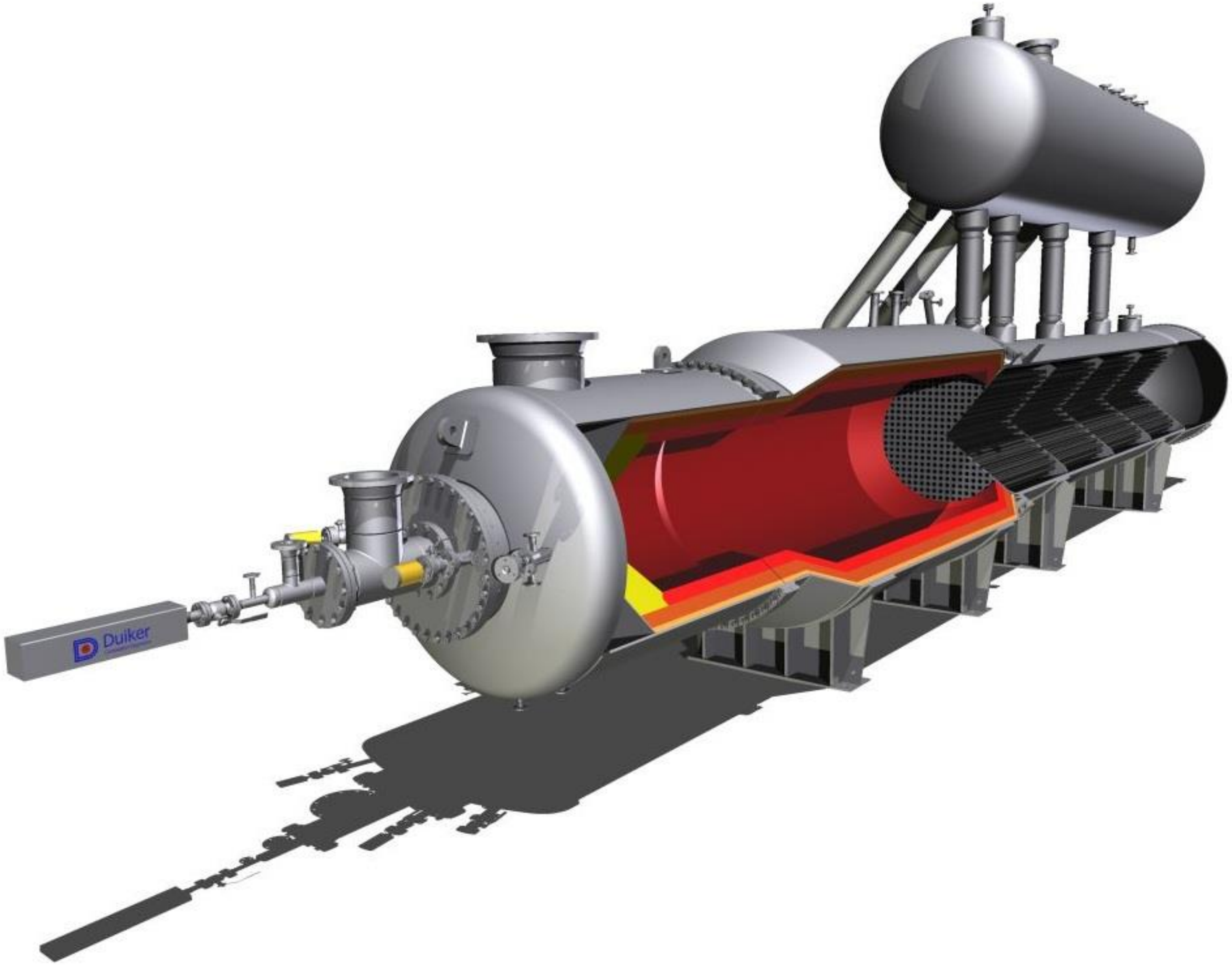

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