# SELAS-LINDE GmbH Petrochemical Furnaces

Volkmar Lemme Munich, Sep 14, 2011



#### **TABLE OF CONTENT**



- 1. INTRODUCTION OVERVIEW
- 2. EDC FURNACES
- 3. KETENE FURNACES
- 4. CS2 FURNACES
- 5. ETHYLENE FURNACES

#### INTRODUCTION – OVERVIEW



SELAS has experience in designing and building diverse Specialty Furnaces which are not very common and require specific know how in design.

EDC Heater	Cracking Furnace	or production of VCM (	(Vinylchlormonomer)

as basis for PVC-production

KETEN Heater Cracking Furnace for production of Acetic Anhydride as basis

for cellulose acetate (synthetic fibre)

TiCl4 and O2 Gas heater for highly corrosive and reactive gases for

production of TiO2 (white pigment)

CS2 Production of CS2 from CH4 and Sulphur

MTP Gas heater for Coal to Gas, Coal to Liquid processes

(MTP = Methanol to Propylene)

Ethylene Cracking Furnace for production of Ethylene, Propylene and

Butadiene as basis for various plastics



#### **EDC FURNACES - EXPERIENCE**



SELAS has experience in designing and building EDC Cracking Furnaces since 1960

Built Crackers 132 altogether thereof 31 since 1987

SELAS has done EDC Furnace Design for all major Process Licensors:

• B.F. Goodrich >> GEON >> Oxy-Vinyls

Hoechst >> Vinnolit (Contractor: Uhde)

Solvay

Stauffer >> EVC

Monsanto

ICI

DOW

Mitsui Toatsu

PPG Industries



#### **EDC FURNACES – CRACKER FOR VESTOLIT, MARL**



EDC flow rate 64,6 t/h
Conversion ration EDC to VC 60,0 %
Product temperature 500 °C
Outlet pressure 12,5 bar, a
Absorbed heat 18,25 MW
Preheated liquid hot oil 220,8 t/h
Preheated liquid EDC 66,5 t/h
NOx - emission 100 mg/Nm³

Efficiency (LHV basis) 92,0 %



## EDC FURNACES – SELAS-LINDE PROPIETARY COMPUTER PROGRAMS



**VCM** Process Design EDC Cracking Furnaces

Step by step calculation of the reaction kinetics under consideration of process parameters

(like: pressure, temperature, residence time) across the radiant coil length.

Calculation of the main- and side reactions dependent from the process parameters, EDC

consistency and heat flux distribution

**CAPFA** Furnace heat balance

Fire box design

Combustion calculation

**CONVX** Design of convection section

EDC superheat

EDC preheat (if applicable)

Steam generation / -superheat

BFW preheat Air preheat

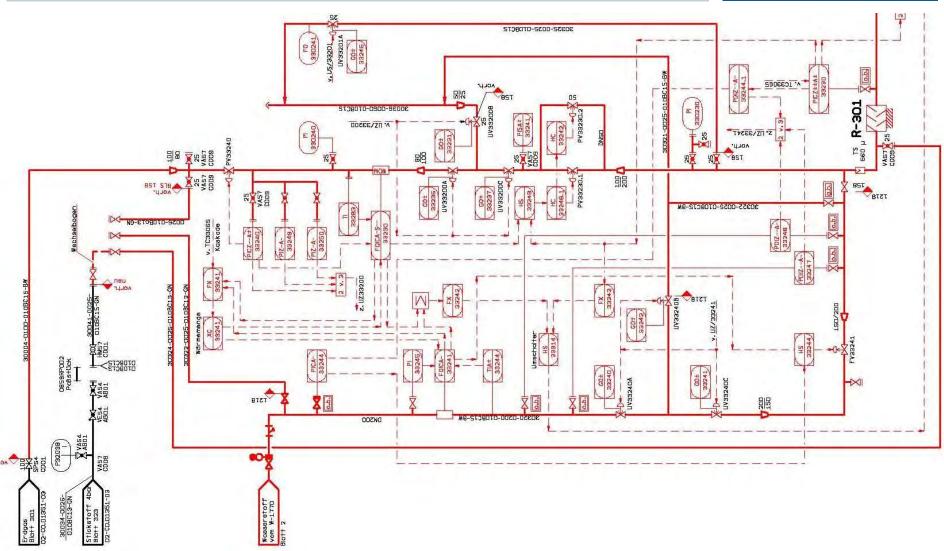
**WDURCH** Furnace lining calculation

**DRAFT** Stack design



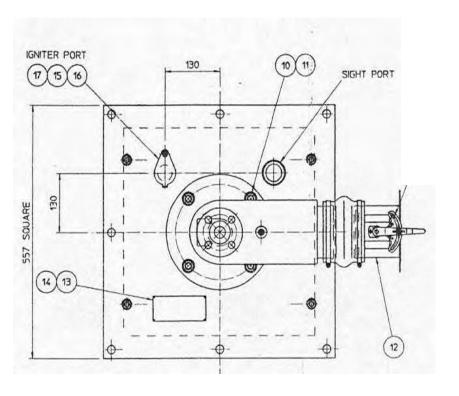
# EDC FURNACES – DUAL FUEL SUPPLY SYSTEM ( i.e. VESTOLIT / QVC )

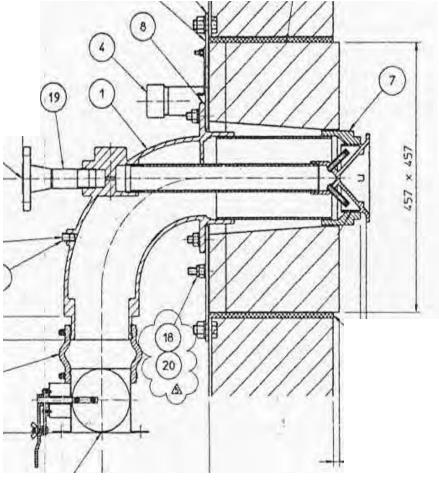




## EDC FURNACES – TYPICAL FORCED DRAFT NOZZLE MIX BURNER BY HCEL







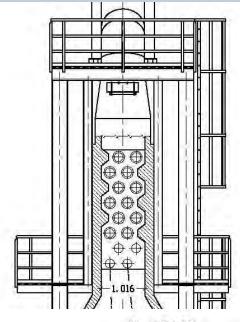
#### **EDC FURNACES - MECHANICAL SIDE - UPRIGHT**



THE LINDE GROUP

EL. +14. 900 PLATFORM

EL. +9. 900 PLATFORM



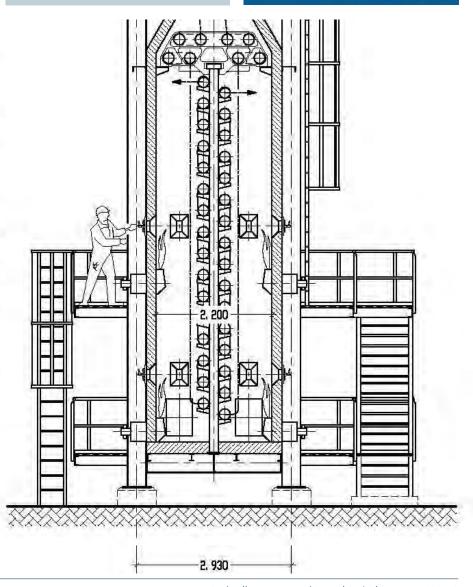
EL. +3, 800 PLATFORM

PEEPDOOR

ACCESSDOOR

EL. +1.000 PLATFORM

EL. +0.000

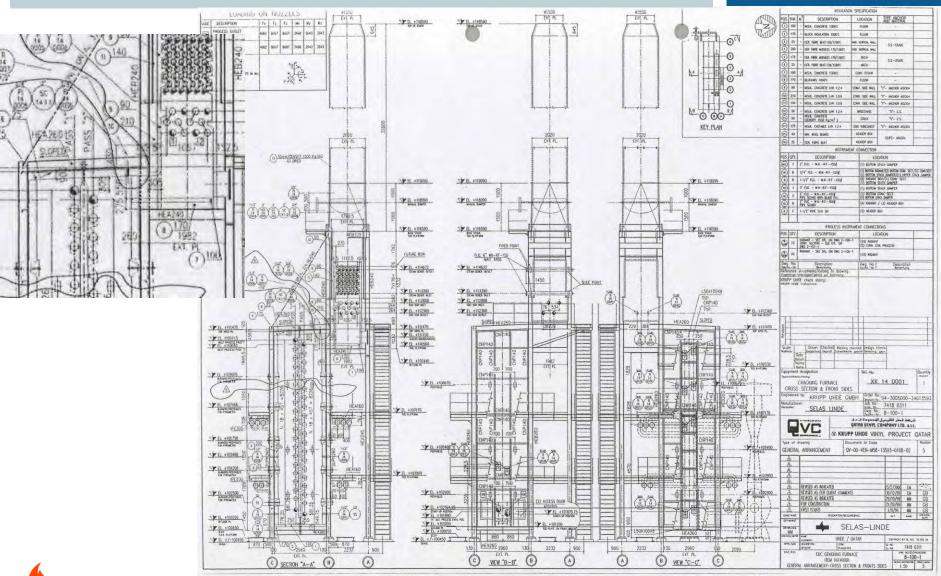




#### THE LINDE GROUP

#### EDC FURNACES - MECHANICAL SIDE - OFFSET (QVC)





#### **KETENE - WACKER**





# Highlights of Linde's Cracking Furnace Technology.



#### **Content – Overview**



Introduction

**Radiant Coil** 

Firing System

**Quench Exchanger** 

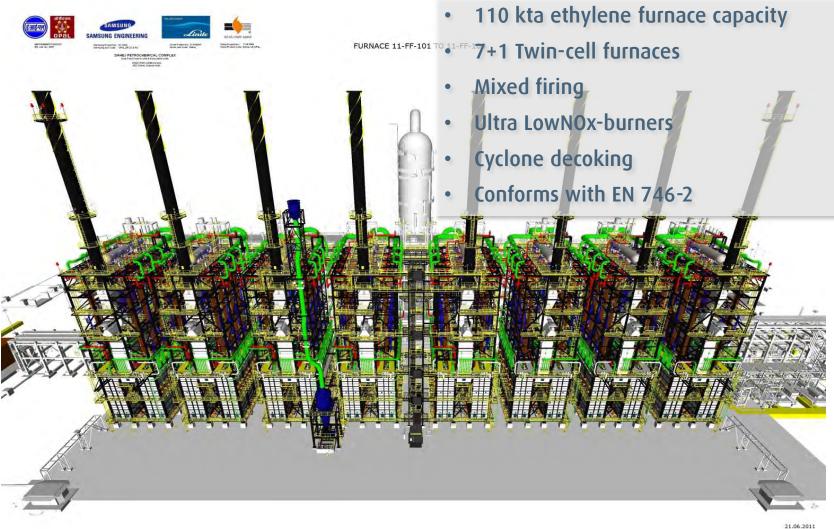
**Process Control** 

**Decoking** 

**Summary** 

### Selas Linde Plants in India: Opal Dahej







### Linde's recent cracking furnace reference

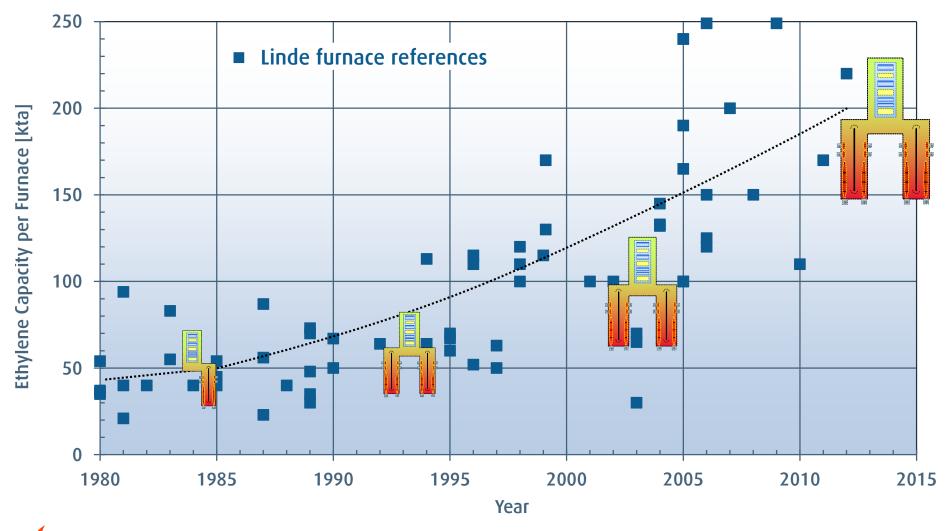


- 250 kta ethylene furnace capacity
- 6+1 Twin-cell furnaces
- 2 x 20 passes PyroCrack 2-2
- 62% conversion
- 45 days run length
- Three stage quench exchanger system (LQE as primary)
- 100% floor firing (2 x 30 burners)
- 162 MW fired duty
- Ultra LowNOx-burners with 100 mg/Nm³ NOx (rep. as NO2, dry)
- Firebox decoking
- Conforms with EN 746-2



### **Furnace Capacity and Layout**



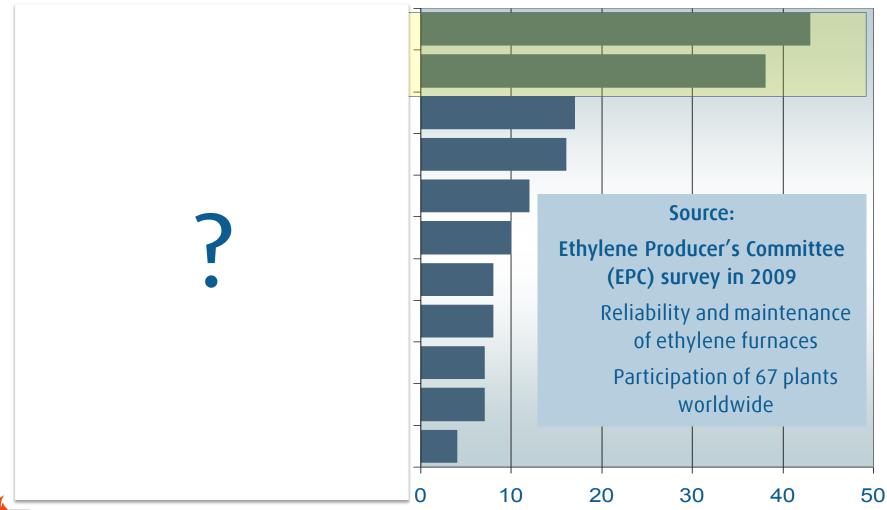




### Reliability of Furnaces



#### Most important causes for furnace outage:



#### **Content - Overview**



Introduction

**Radiant Coil** 

Firing System

**Quench Exchanger** 

**Process Control** 

Decoking

Summary

### **PYROCRACK Coil Design - Increase of Selectivity**



Small diameters at inlet

Rapid temperature rise

Large diameters at outlet

Small pressure drop

Short coil length

Short residence time

**PYROCRACK - Coil** 



### PyroCrack™ Radiant Coils for Gas Cracking



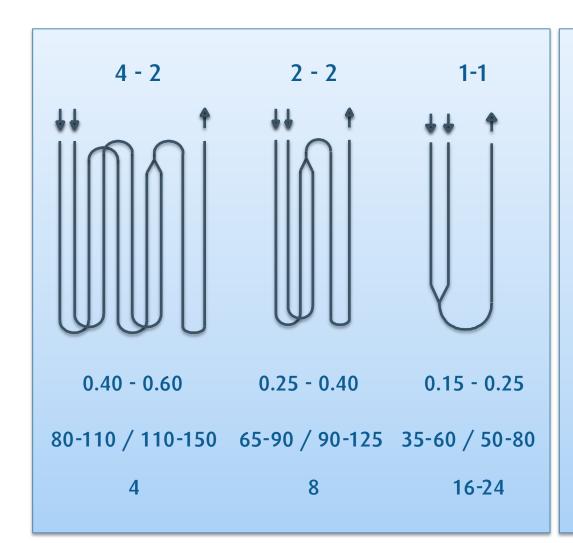
PyroCrack Coil Type

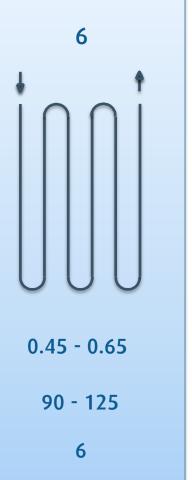
Schematic arrangement

Residence Time [sec]

Tube I.D [mm]

Equivalent number of coils

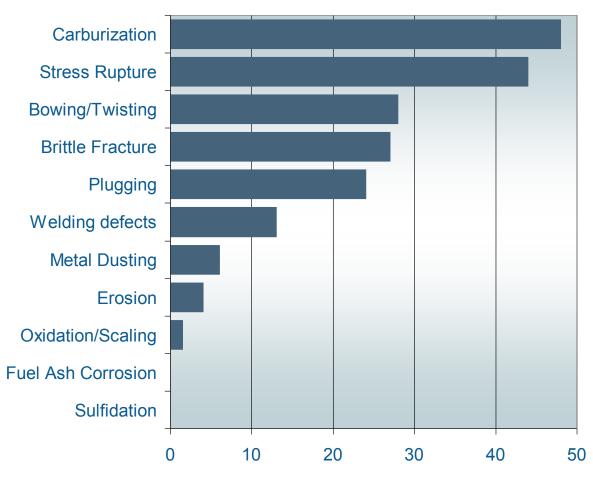




#### **Radiant Coil Failures**



#### Mechanisms of radiant coil failure:



Linde furnace design has focus on preventing tube failures



### Return Bend Design - PyroCrack Coils

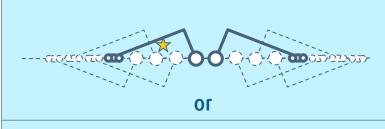


#### **PREVIOUS SOLUTION**

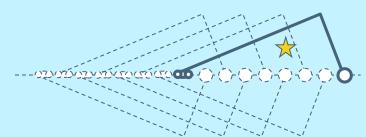
(Top View)



**Center of Gravity** 

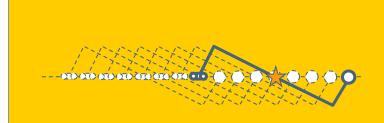


A) Short return bends stiff system low stresses



B) Long return bends flexible system high stresses

#### **IMPROVED SOLUTION**



C) S-shaped return bends flexible system low stresses no guide-pins required extended coil life



#### **Radiant Coil Failure Prevention**



S-Bends

No guide pins and bumpers

Inline coil arrangement

- no coil bending
- no hot spots
- reduced stress
- increased coil life and run length





#### **Radiant Coil Installation**



- special device for easy exchange (patented by SL)
- allows maximum degree of prefabrication also for replacement coils
- reduces downtime during major overhaul period



#### **Content – Overview**



Introduction

**Radiant Coil** 

Firing System

**Quench Exchanger** 

**Process Control** 

Decoking

Summary



#### Firing and Burners & Burner Types



#### **Sidewall Burner**

- Typical Firing Capacity0.3 0.45 MW per Burner
- Typical design: partial premix (but also nozzle mix)
- Typical: staged fuel for NOx reduction



#### Floor Burner

- Typical Firing Capacity1.0 - 3.3 MW per Burner
- Typical design: nozzle mix
- NOx reduction by staged fuel or staged air and flue gas recirculation



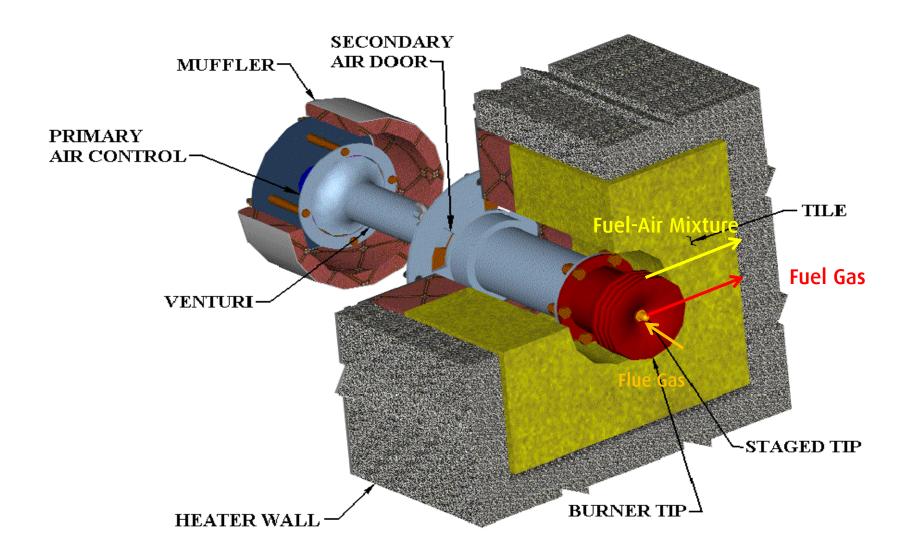
Increasing requirements over last years

Emission (NOx)
Fuel Flexibility
Operation / Safety



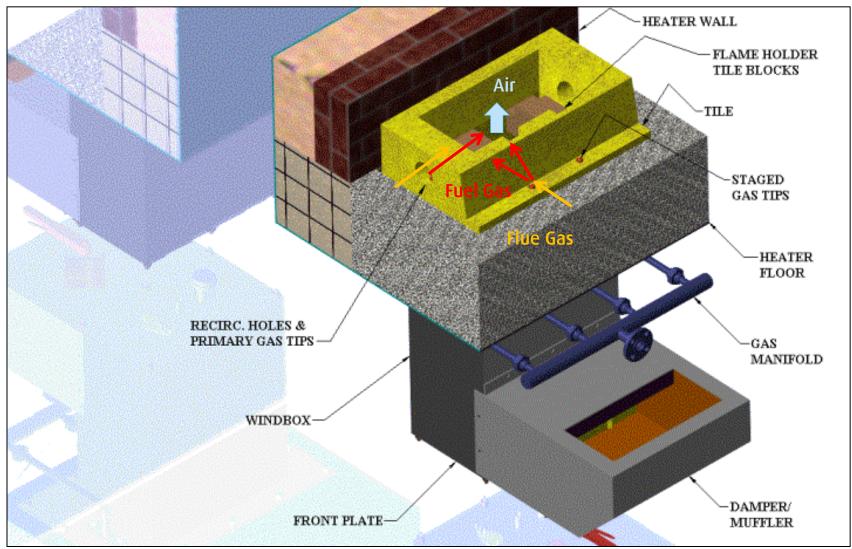
# Typical modern Radiant Wall Burner – Example Callidus LE-CARW Burner (Staged Fuel)





# Typical modern Floor Burner – Example Callidus Flat Flame LE-CFSG





### Linde has decent insight into the design of firing system



Floor Firing

Few burners / less maintenance

High automation (duty & comb. air)

Avoids back-firing

Flexible for fuel gas quality

High turn-down ratio

Mix Firing

Combines advantages

Sidewall Firing

Optimal heat flux

Longer run length

longer coil life

allows high fireboxes and compact furnace design

Firing concept selected on a case by case decision



### **Safety and Automation**



Depending on customer requirements we can provide highly automated systems also allowing remote ignition using retractable HV Igniter lances

For compliance with requirements along EN746-2 we provide flame scanners for every second burner for surveillance at firebox temperatures below 760 °C



#### **Content – Overview**



Introduction

**Radiant Coil** 

Firing System

**Quench Exchanger** 

**Process Control** 

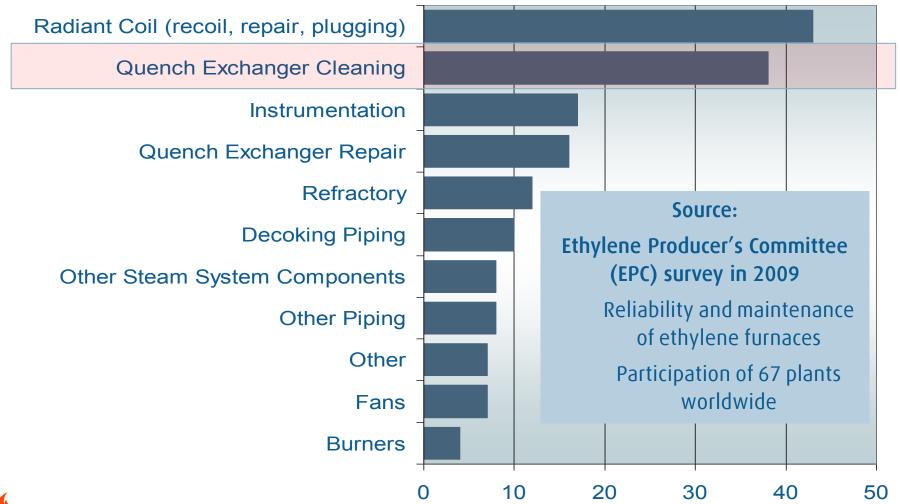
Decoking

Summary

#### Reliability of Furnaces



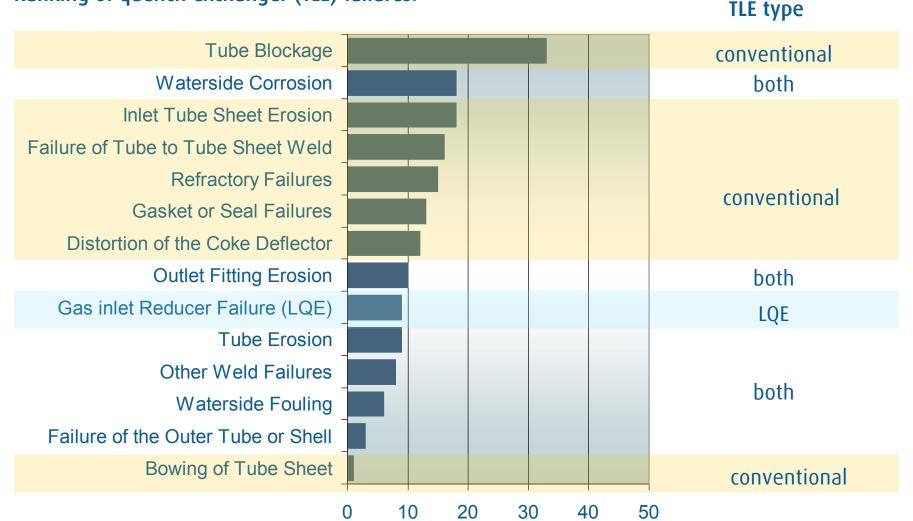
Most important causes for furnace outage:



#### **Quench Exchanger Failures**



Ranking of quench exchanger (TLE) failures:



### **Erosion and Tube Blockage**



Example: Ethane cracking high severity



### **Quench Concepts**



stages

TLE type

application

single

conventional

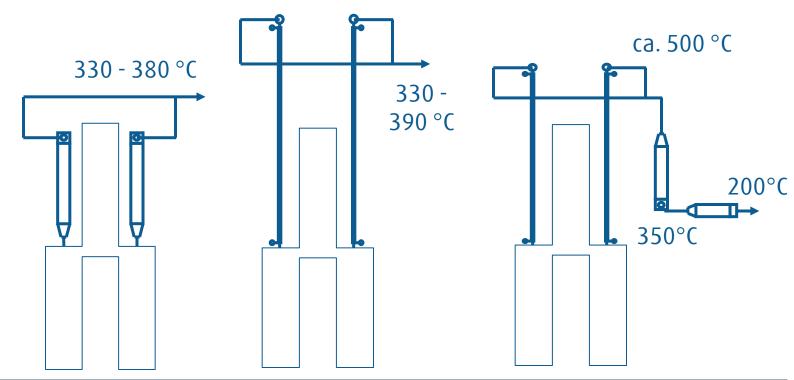
linear (LQE)

liquid cracking

two/three

both

gas cracking





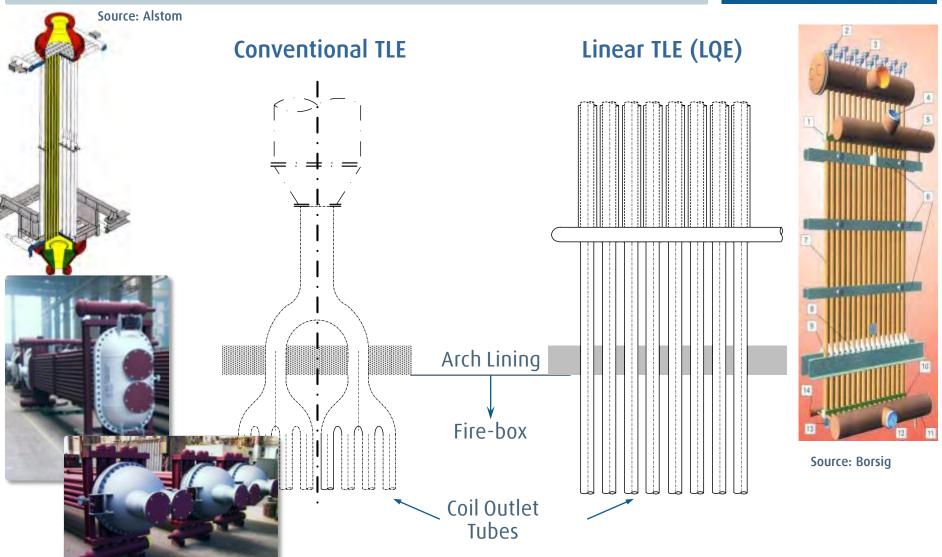
SELAS-LINDE

35

### Coil / TLE Connection

**SELAS-LINDE** 





# Linear quench exchangers (LQE) are providing reduced maintenance and maximum availability



#### LQE arrangement

 One exchanger tube per each coil outlet tube

#### Mechanical

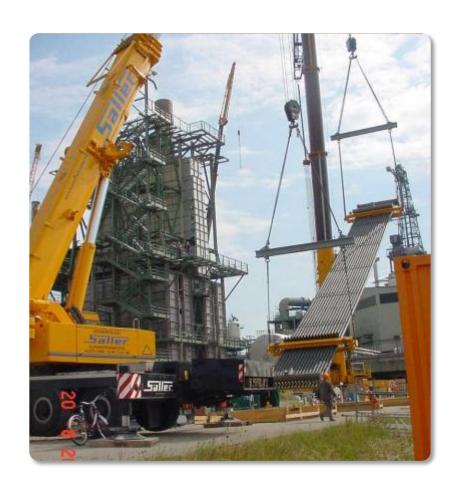
- No cast collector fittings
- No refractory lined inlet cone
- No tube sheets, no erosion

#### **Availability**

- No plugging
- No mechanical cleaning



- Reduced maintenance
- Maximum availability







#### **Content – Overview**



Introduction

**Radiant Coil** 

Firing System

**Quench Exchanger** 

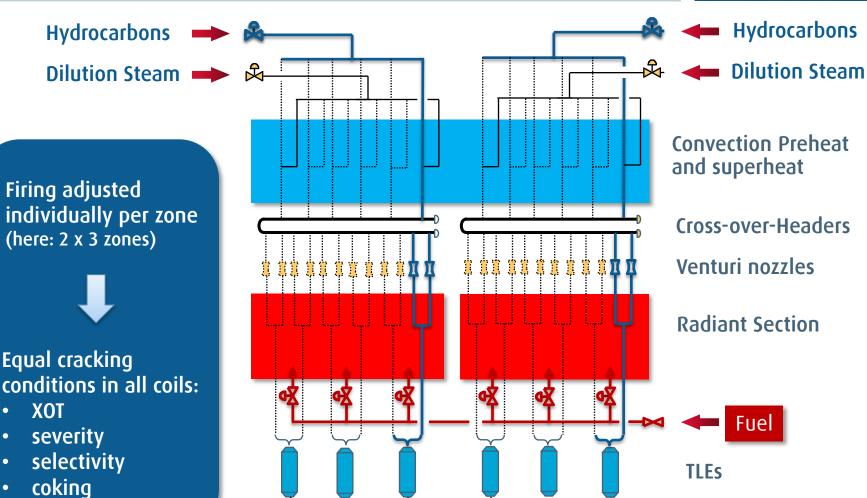
**Process Control** 

Decoking

Summary

#### Linde Fuel Balancing – Focus on process optimization



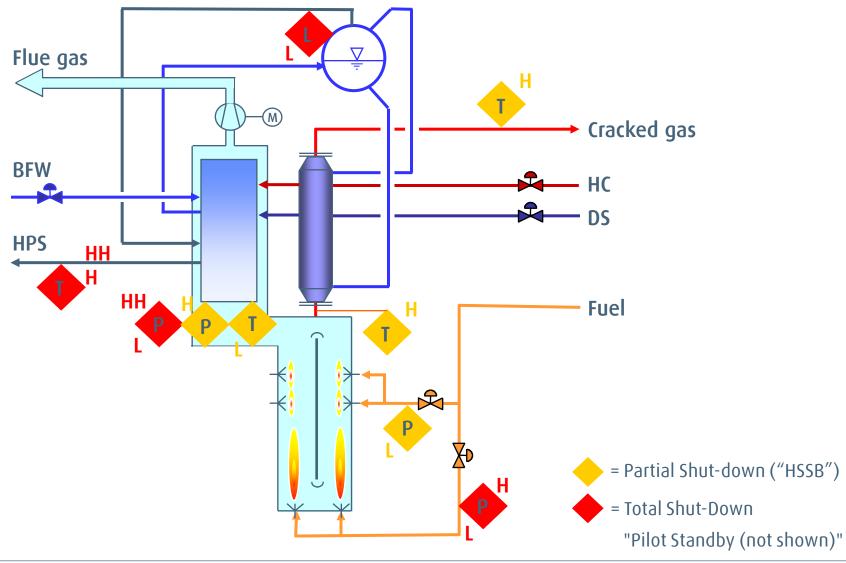




**Cracked Gas** 

### Staged shut-down concept leads to improved availability







#### **Content – Overview**



Introduction

**Radiant Coil** 

Firing System

**Quench Exchanger** 

**Process Control** 

**Decoking** 

Summary

#### Design aspects for efficient decoking



- Identical conditions for all coils
  - Equal coil inlet conditions (XOT) due to collecting header at convection outlet
  - Venturi nozzles at coil inlet ensure same throughput of steam and air for each coil
  - Individual control of coil outlet temperature for each radiant coil group
- No undefined distribution
  - Each radiant coil outlet tube is directly linked with one individual quench exchanger tube
  - All quench exchanger tubes have the same throughput of steam and air too
- ID of quench exchanger higher than ID of radiant coil outlet tubes
  - No erosion at the inlet of the quench exchangers
  - No blockage of exchanger tubes



All radiant coils and quench exchanger tubes are evenly and reliably decoked



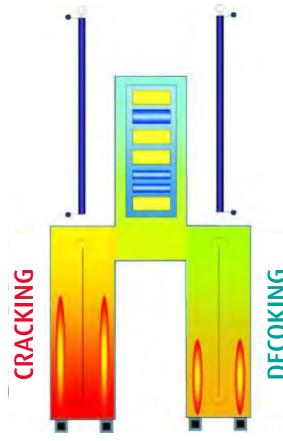
# Cell decoking enhances flexibility for high capacity furnaces





One furnace cell in decoking mode
One furnace cell in normal operation

- Double set of cracked gas/decoking gas valves
- Flue gas monitoring in the individual fireboxes (02, C0)
- Material upgrades in convection section/crossover
- Production remains at 50 % during decoking
- Increased operational flexibility
- > Long-term experience available



# Recent furnace section reference with cell decoking feature





- BP "GOFER" Project
- Cologne, Germany, 2008
- 5 new furnaces replace18 (!) old ones
- 100 kta EthyleneCapacity per furnace
- Naphtha, LPG, UCO
- Cell Decoking Feature (4.5 + 0.5 concept)

# Thank you for your attention.

