

SINOPEC STEAM CRACKING TECHNOLOGY OVERVIEW



中国石化
SINOPEC

SEI

2023-12-20



中国石化工程建设有限公司
SINOPEC ENGINEERING INCORPORATION

CONTENT

- Brief Introduction of SEI
- Technological Development History
- Highlights of Technology
- Typical Plants
- Summary

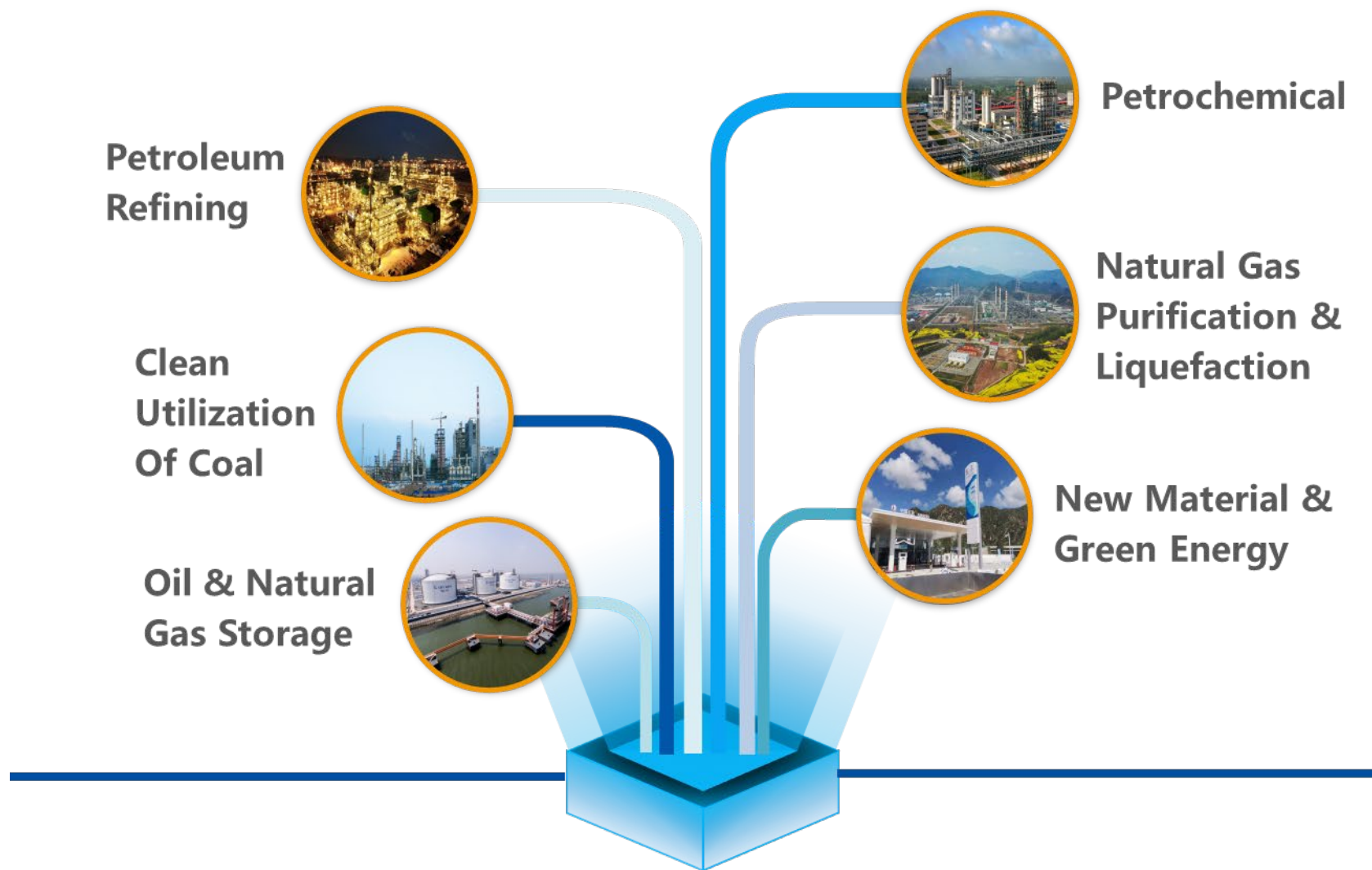
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中国石化工程建设有限公司 SINOPEC ENGINEERING INCORPORATION Ltd.

- ✓ **70 Years** experience in refinery and petrochemical engineering
- ✓ A **Reliable** engineering partner with **3,000+** successful projects reference
- ✓ A global **One-stop & Integrated** engineering solutions provider
- ✓ The **Leading & Flagship** company of China in refining and petrochemical engineering service

BUSINESS LINES



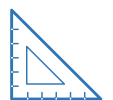
BUSINESS LINES



Technology Licensing



Engineering Consultancy



Engineering Design



Project Management Consultancy



Procurement Service



EPC Execution



Digitalized Factory

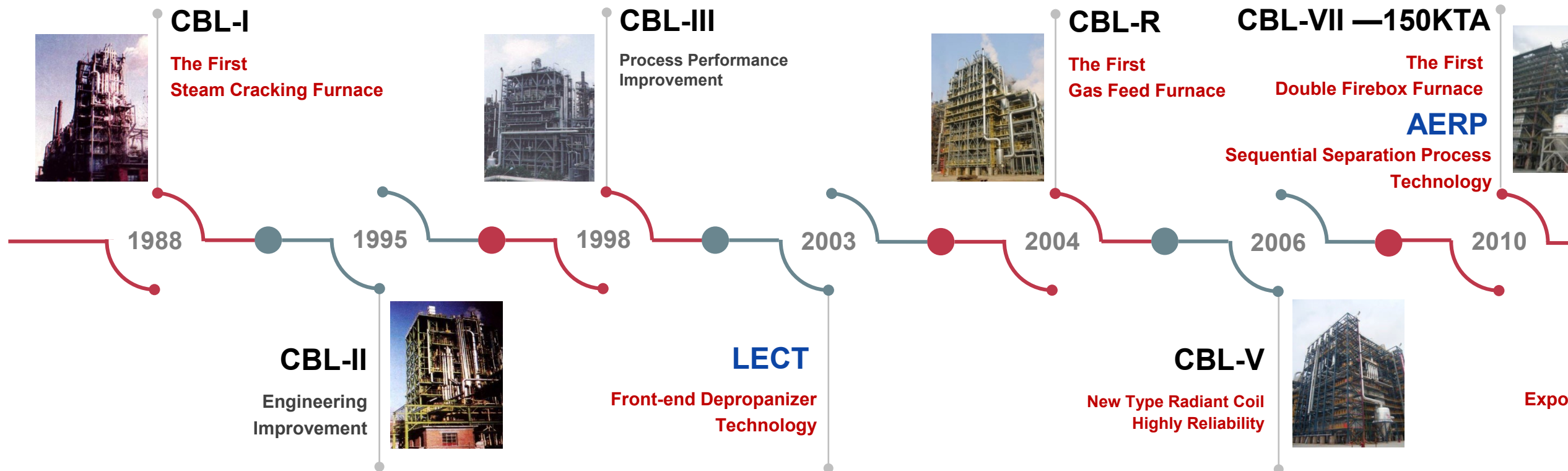


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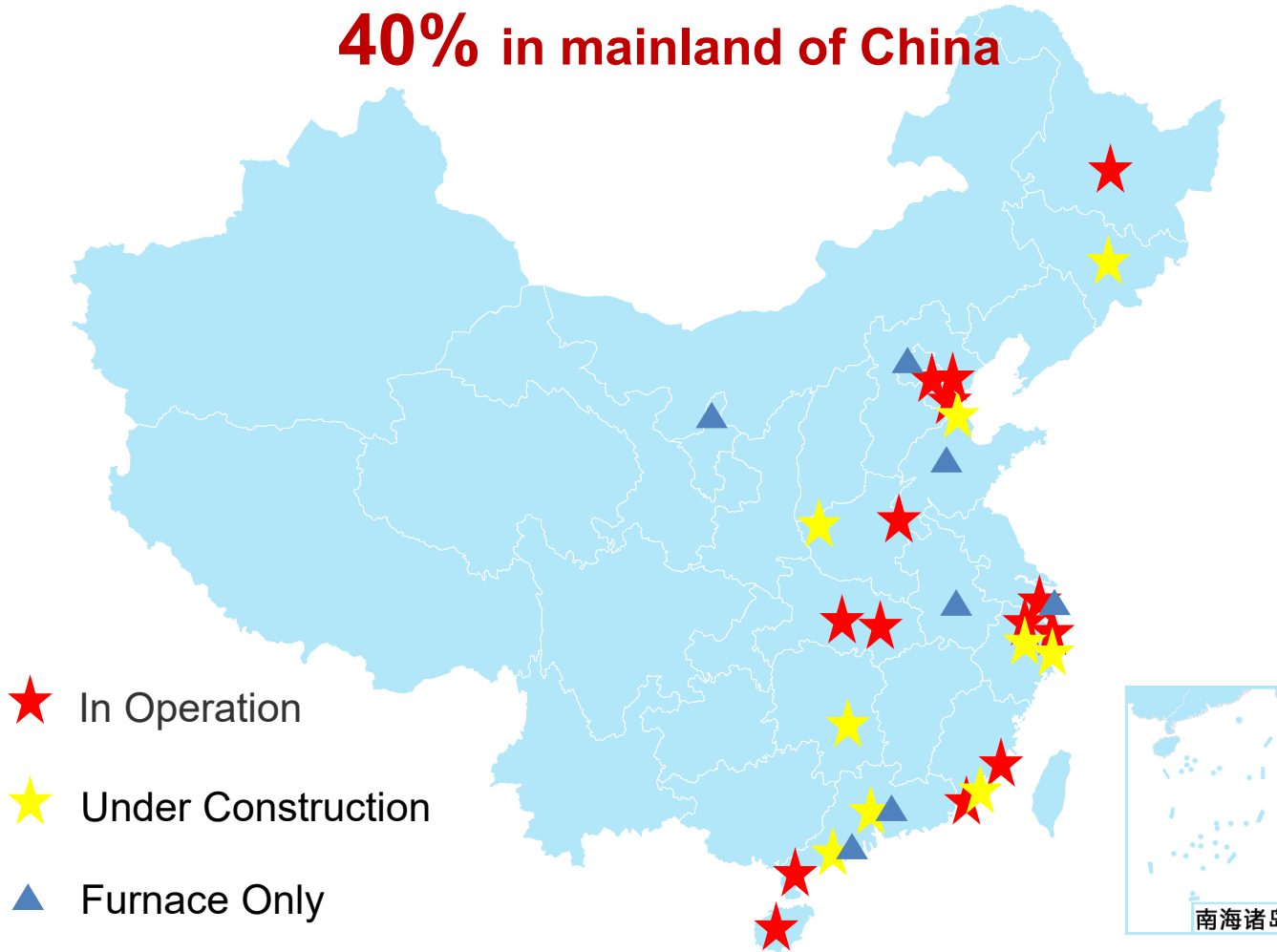
Technological Development History

Millstones of SINOPEC Steam Cracking Technology



Market Share

In recent 10 years
40% in mainland of China



Steam Cracker

- Total capacity: **19,720** KTA
- Max. capacity in service: **1,250** KTA
- Max. capacity under design: **1,500** KTA

Furnace

- Total number: **242**
- Total capacity: **28,995**KTA
- Max. gas furnace capacity :
300 KTA in operation
- Max. **single firebox** liquid furnace capacity :
200 KTA under construction
- Max. liquid furnace capacity :
300 KTA in design

Technological Development History

Sinopec Technology License list

No.	Client	Location	Scope	Capacity (KTA)	Feedstock	Startup	Remark
1	Sinopec Gulei Petrochemical Co. Ethylene Plant II Phase	Fujian, China	PDP	1,500	LPG, NAP	Expected 2027	Grassroots
2	Sinopec Yueyang Petrochemical Co.	Hunan, China	PDP	1,000	LPG, NAP, HVGO	Expected 2026	Grassroots
3	Sinopec Zhenhai Petrochemical Co.	Zhejiang, China	PDP, BED	1,500	LPG, NAP, HVGO	Expected 2026	Grassroots
4	Sinopec Luoyang Petrochemical Co.	Henan, China	PDP, BED	1,000	LPG, NAP, HVGO	Expected 2025	Grassroots
5	Sinopec Maoming Petrochemical Co.	Guangdong, China	PDP, BED	1,000	LPG, NAP, HVGO	Expected 2025	Grassroots
6	Sinopec Guangzhou Petrochemical Co.	Guangdong, China	PDP, BED	20 to 32	C2, LPG, NAP	Expected 2024	Expansion
7	Ningbo Huatai Petrochemical Co. Revamping and Expansion of Ethylene Plant	Zhejiang, China	PDP, BED, DED	600 to 850	C2, C3	Expected 2024	Expansion
8	CNPC Jilin Petrochemical Co.	Jilin, China	PDP, BED, EPC	1,200	LPG, NAP, HVGO	Expected 2024	Grassroots
9	Sinopec-Ineos Tianjin Nangang Petrochemical Co.	Tianjin, China	PDP, BED, EPC	1,250	C2, C3, LPG, NAP, AGO	Expected 2024	Grassroots
10	Sinopec Zhenhai Petrochemical Co. revamping and expansion of 1# ethylene plant	Zhejiang, China	PDP, BED, DED	1,000 to 1,300	LPG, NAP, HVGO	2023	Expansion
11	Sinopec Hainan Refining Co.	Hainan, China	PDP, BED, EPC	1,000	C2, LPG, NAP	2023	Grassroots
12	Sinopec Maoming Petrochemical Co. ethane to ethylbenzene plant	Guangdong, China	PDP, BED, DED	120	C2	2022	Grassroots

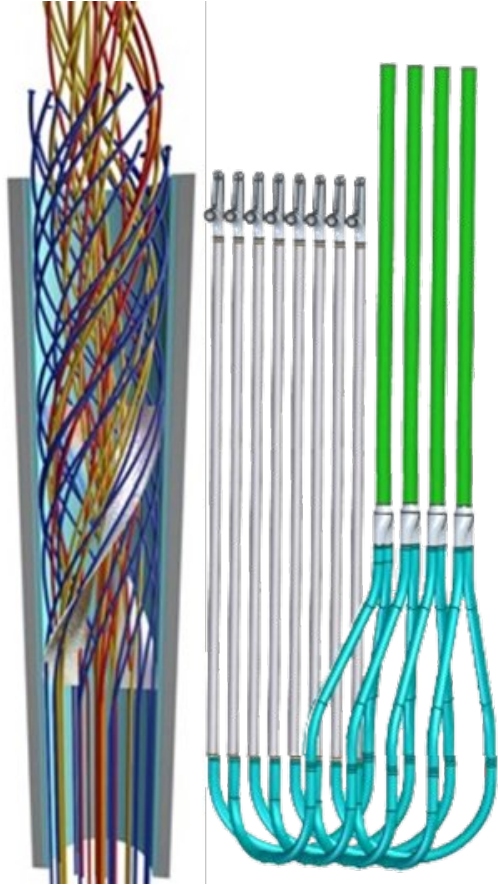
Technological Development History

No.	Client	Location	Scope	Capacity (KTA)	Feedstock	Startup	Remark
13	Sinopec Zhenhai Refining & Chemical Co.	Zhejiang, China	PDP, BED, EPC	1,250	LPG, NAP	2022	Grassroots
14	Gulei (Zhangzhou) Petrochemical Co.	Fujian, China	PDP, BED, EPC	1,000	LPG, NAP	2021	Grassroots
15	Heilongjiang Longyou Petrochemical Co. Ltd.	Heilongjiang, China	PDP, ED	450	C2, C3	2021	Grassroots
16	Ningbo Huatai Wealthy Polymer Material Ltd.	Zhejiang, China	PDP, ED	600	C2, C3	2021	Grassroots
17	Sinopec SK (Wuhan) Petrochemical Co.	Hubei, China	PDP, BED, DED	800 to 1,100	FCC dry gas, NAP, HVGO	2020	Expansion
18	Sino-Kuwait Zhanjiang Refinery & Chemical Co.	Guangdong, China	PDP, BED, EPC	800	C2, LPG, C5, NAP	2020	Grassroots
19	Sinopec Sabic Tianjin Petrochemical Co. LTD	Tianjin, China	PDP, BED, DED	1,000 to 1,300	C2, NAP, HVGO	2020	Expansion
20	Sinopec Shanghai Petrochemical Co.	Shanghai, China	PDP	790	C2, LPG, NAP, HVGO	PDP FINSH	-
21	Fujian Refining & Chemical Co. (Joint venture with Exxonmobil and Saudi Aramco)	Fujian, China	PDP, BED, DED	800 to 1,100	FCC dry gas, NAP, HVGO	2013	Expansion
22	Sinopec SK (Wuhan) Petrochemical Co.	Hubei, China	PDP, BED, EPC	800	FCC dry gas, NAP, VGO	2013	Grassroots
23	Tianjin Union Chemistry Co.	Tianjin, China	PDP, BED, DED	140 to 200	NAP, HVGO	2001	Expansion
24	Sinopec Zhongyuan Petrochemical Co.	Henan, China	PDP, BED, DED	140 to 180	C2, C3, NAP	2000	Grassroots

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Highlights of Technology——CBL Cracking Furnace



■ Proprietary radiant coil with long runlength and high selectivity

- Runlength increased by more than **50%**
- Solved the problem of short runlength when cracking at high selectivity

TECHNICAL ELEMENTS



*Split/Gradual changing
radiant coil*

Rapid heating and low
pressure drop



SERT located in section

Improve heat transfer coefficient
and slow down coking



*Bottom symmetrical large
bend tube structure*

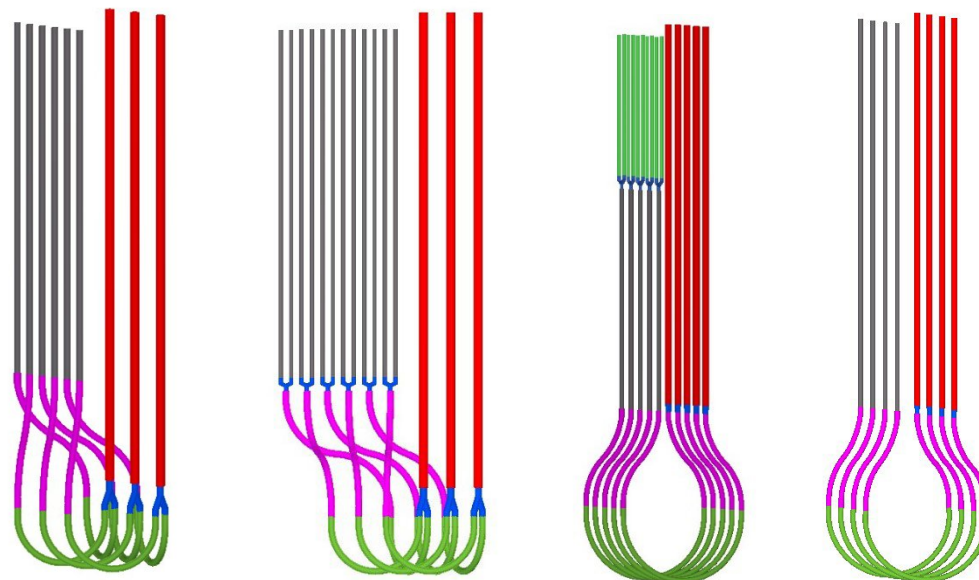
Excellent mechanical performance
in high-temperature environments

Highlights of Technology——CBL Cracking Furnace

Radiant Coil — Liquid Feed

■ TWO PASS COIL

- High selectivity
- Low residence time
- Low pressure drop
- Long runlength
- Patent in USA, Singapore, Russia, Kazakhstan, etc.



🎯 2-1

CBL-I, II, III, VII

2-1 coil first proposed in 1984.

🎯 4/2-1

CBL-IV

Started up in Liaoyang, China, in Apr., 1999.

🎯 2/1-1

CBL-V

Started up in Zhongyuan, China, in Nov., 2004.

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CBL-VI

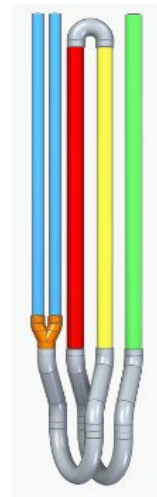
Started up in Guangzhou, China, in Feb., 2006.

Highlights of Technology——CBL Cracking Furnace

Radiant Coil — Gas Feed

■ FOUR PASS COIL

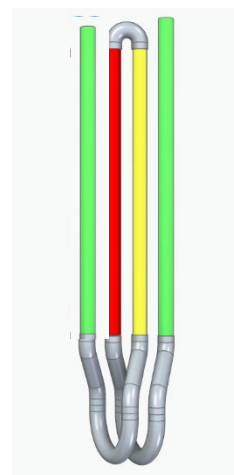
- Longer runlength
- Middle residence time
- Optimized in runlength, selectivity or conversion and cost
- Patent in USA, Russia, Singapore, Kazakhstan, etc.



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CBL-I, II, III, VII

First proposed in the early 1990s
and put into operation in 2004



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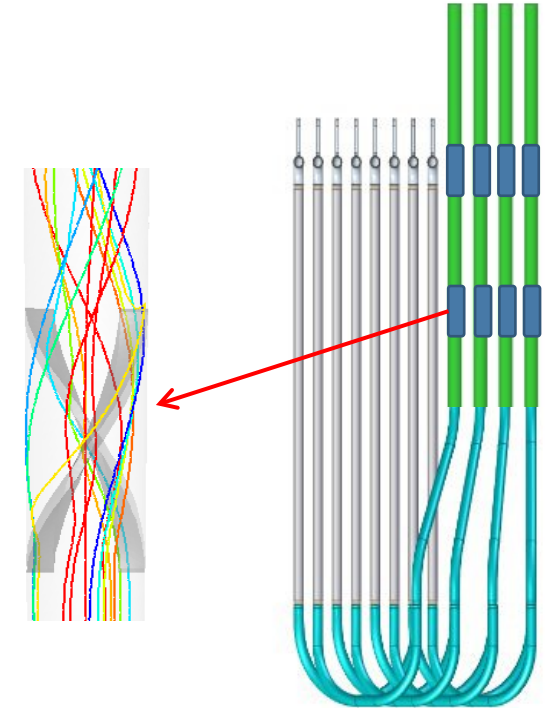
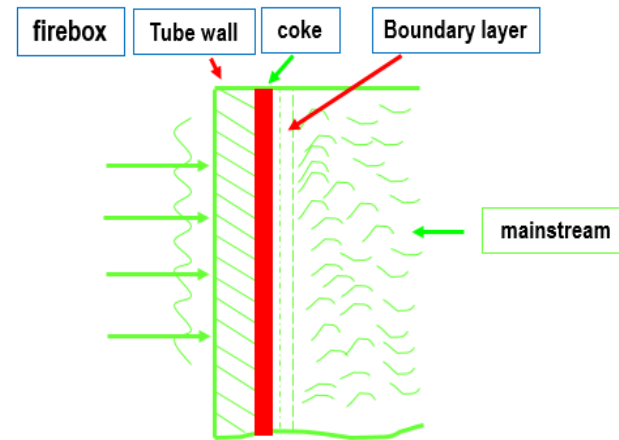
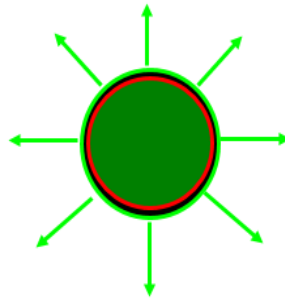
CBL-IV

Started up in Zhenhai,
China, in June., 2016.

Highlights of Technology——CBL Cracking Furnace

Heat Transfer Enhancing —— SERT

- ✓ Change the fluid flow pattern
- ✓ Thinning the boundary layer
- ✓ Reduce the TMT
- ✓ Reduce the rate of coking
- ✓ Extend the runlength



Highlights of Technology——CBL Cracking Furnace

Heat Transfer Enhancing —— SERT

ADVANTAGE



TMT Temperature

The temperature of TMT **drop by at least 20°C** with SERT.



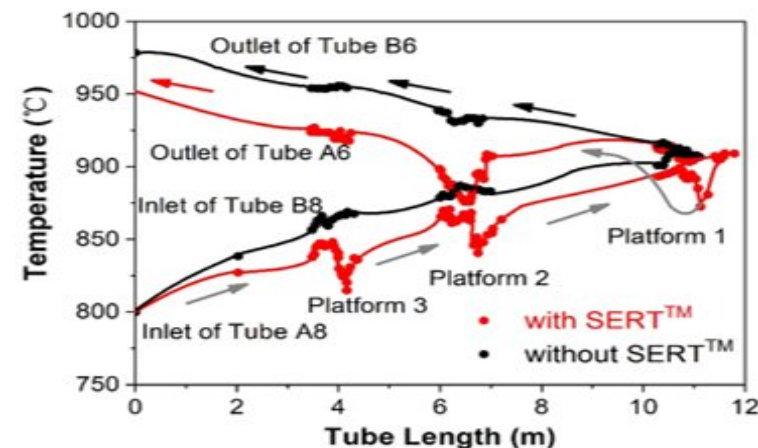
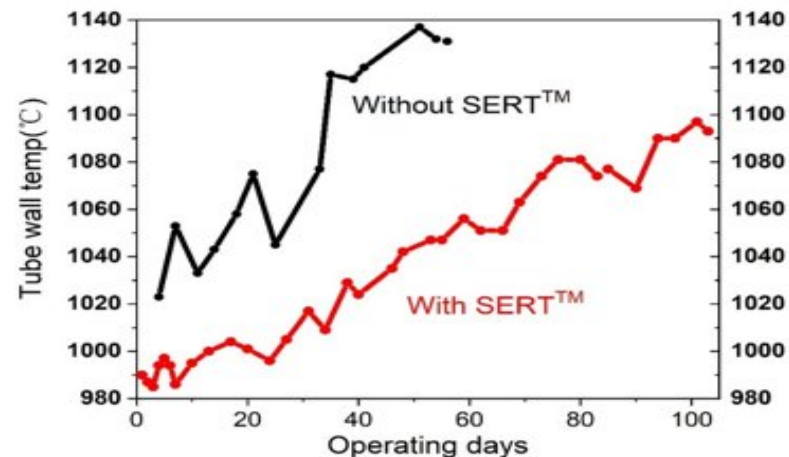
Runlength

The runlength of the cracking furnace **increased more than 50%** with SERT.



Capacity

The capacity **increased 5~7%**.



Applied to 244 furnaces, Up to a total of 20,975 KTA.

Highlights of Technology——CBL Cracking Furnace

High Energy Efficiency

■ Low Fuel Consumption

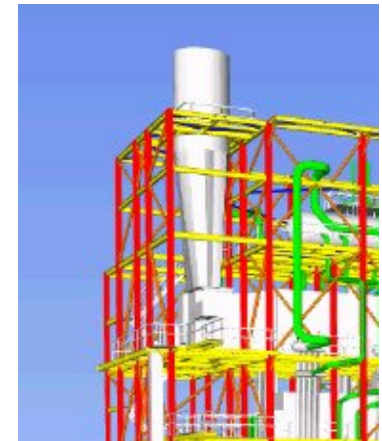
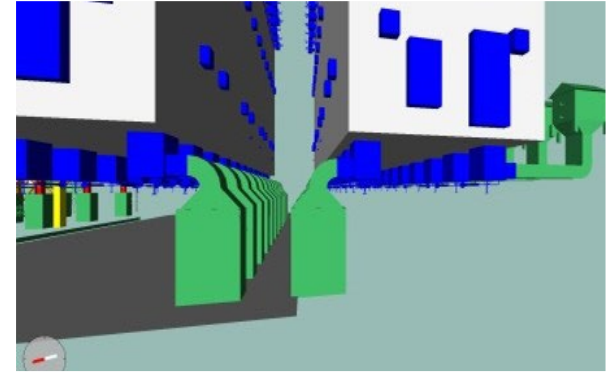
- Air preheat
- Optimized refractory design and new refractory material

■ High Thermal Efficiency

- >94% for gas feed
- >95% for liquid feed
- Low stack gas temperature

■ Low Power Consumption

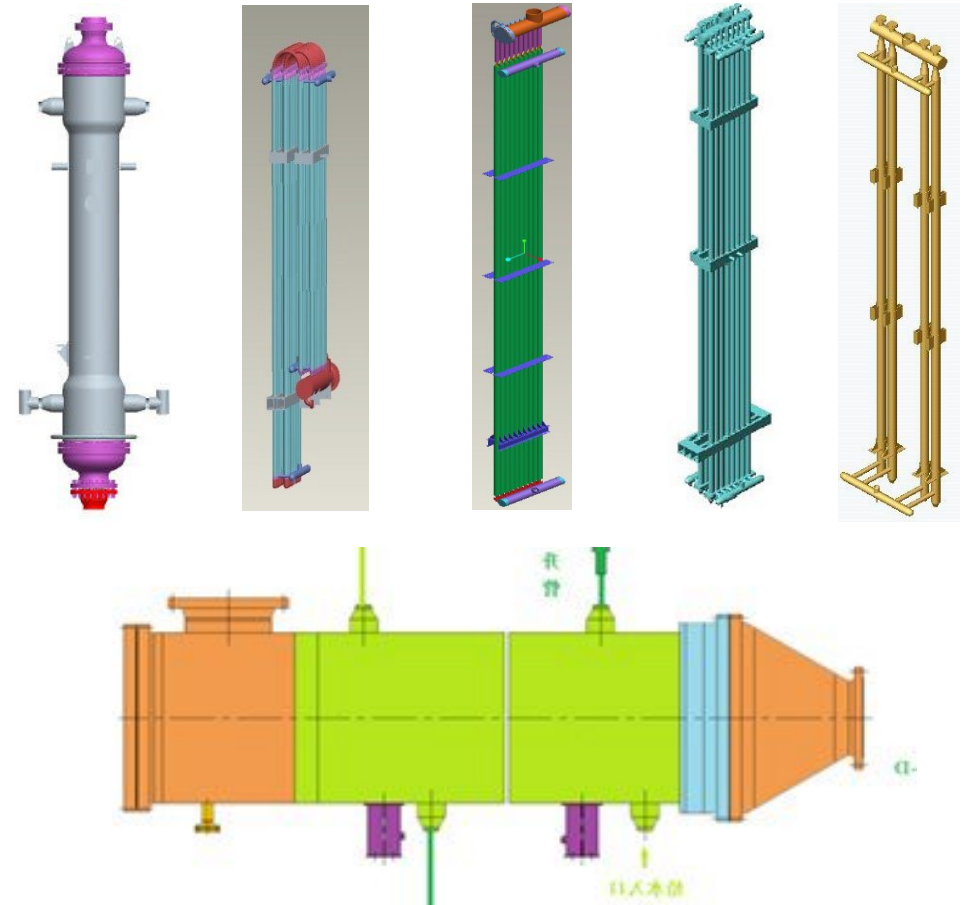
- Variable speed control



Highlights of Technology——CBL Cracking Furnace

High Steam Production

- Large Tube Diameter to Lower the Coking
- Lower Outlet Temperature:
 - One or two stages for NAP and gas feed
 - One , two or three stages for gas feed
- Different Type TLE can be Selected
 - LQC
 - U type LQC
 - Conventional TLE
 - Two or three stages TLE
- Less Mechanical Cleaning

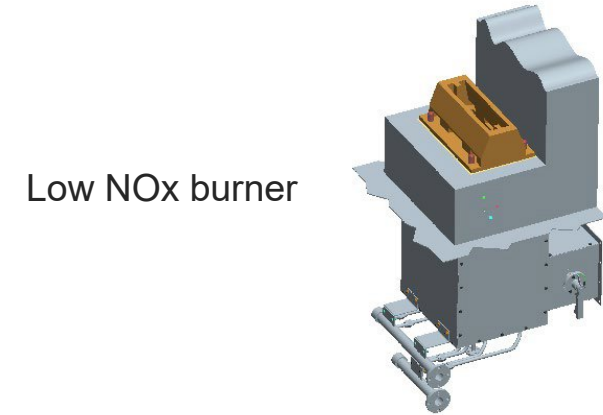


Highlights of Technology——CBL Cracking Furnace

Environmentally Friendly

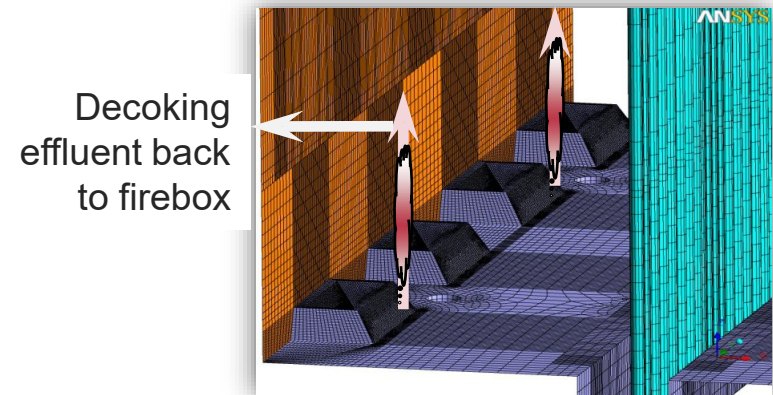
■ Low Emission

- Low NOx burner
 - ✓ NOx: $<60\text{mg}/\text{Nm}^3$
- SCR
 - ✓ Medium / Low / Ultra-low temperature
 - ✓ NOx $< 25\text{mg}/\text{Nm}^3$



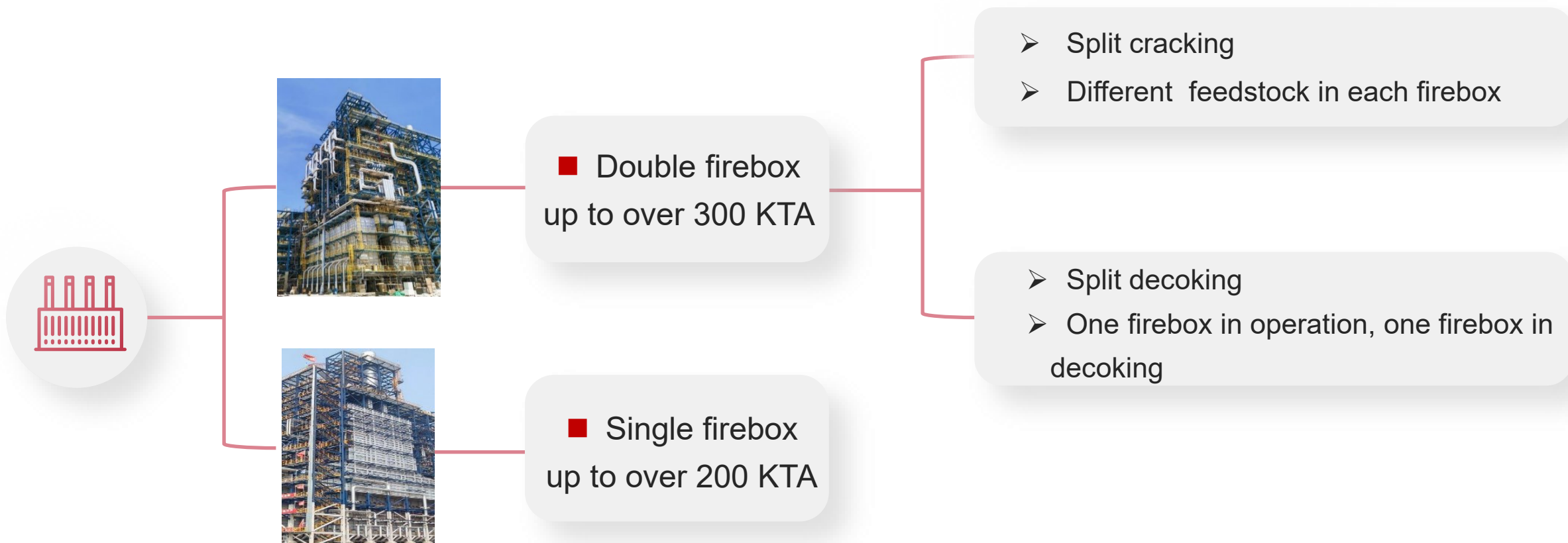
■ Decoking Effluent Back to Firebox

- Instead of decoking drum
- Coke burned in firebox to reduce waste solid



Highlights of Technology——CBL Cracking Furnace

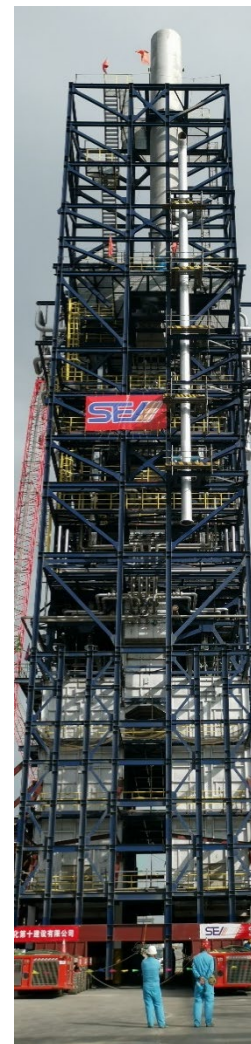
Ultra-Large Capacity Furnace



Highlights of Technology——CBL Cracking Furnace

Modular Design, Manufacture and Construction

- Radiant Section
- Convection Section
- Steel Structure
- Equipment



Highlights of Technology——CBL Cracking Furnace

Revamping furnaces using CBL tech.

■ Purpose

- Energy saving
- Feed flexibility
- Increasing capacity

■ Advantage

- Excellent performance with higher reliability
- Optimized casing study with Lower cost
- Limited construction duration



**Furnace revamped number
(CBL radiant coil) : 77**

**Furnace revamped number
(others) : > 40**

Highlights of Technology——CBL Cracking Furnace

Summary

■ Advanced Technology

- High olefin yields
- Leading position on runlength and heavy feed cracking
- High energy efficiency, low operating costs
 - ✓ Low fuel consumption
 - ✓ Low power consumption
 - ✓ High thermal efficiency : **94-96%**
 - ✓ Long runlength : **> 90 days**

■ Low Maintenance

- Radiant coil life up to **10 years more**

■ Highly Reliability

■ Easy To Construct

■ Easy To Operate

■ Green Environment Protection



Highlights of Technology——Recovery

SINOPEC Ethylene Recovery Technologies

Liquid and Mixed Feedstock

LECT

Low Energy Consumption Technology

10 Applications

AERP

Advanced Ethylene Recovery Process

9 Applications

Ethane + Other Gas Feed

ART

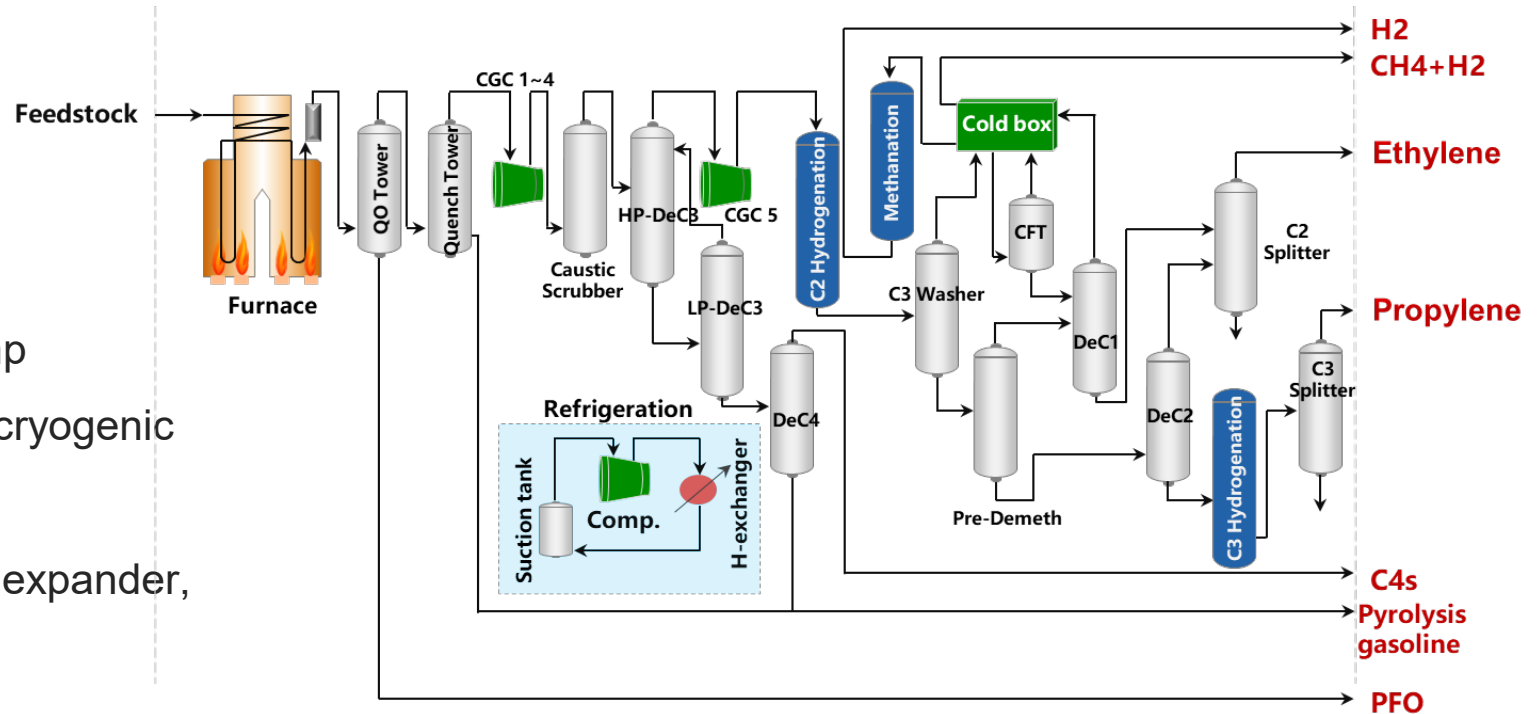
Advanced Recovery Technology

3 Applications

Highlights of Technology——Recovery

■ Features of LECT Technology

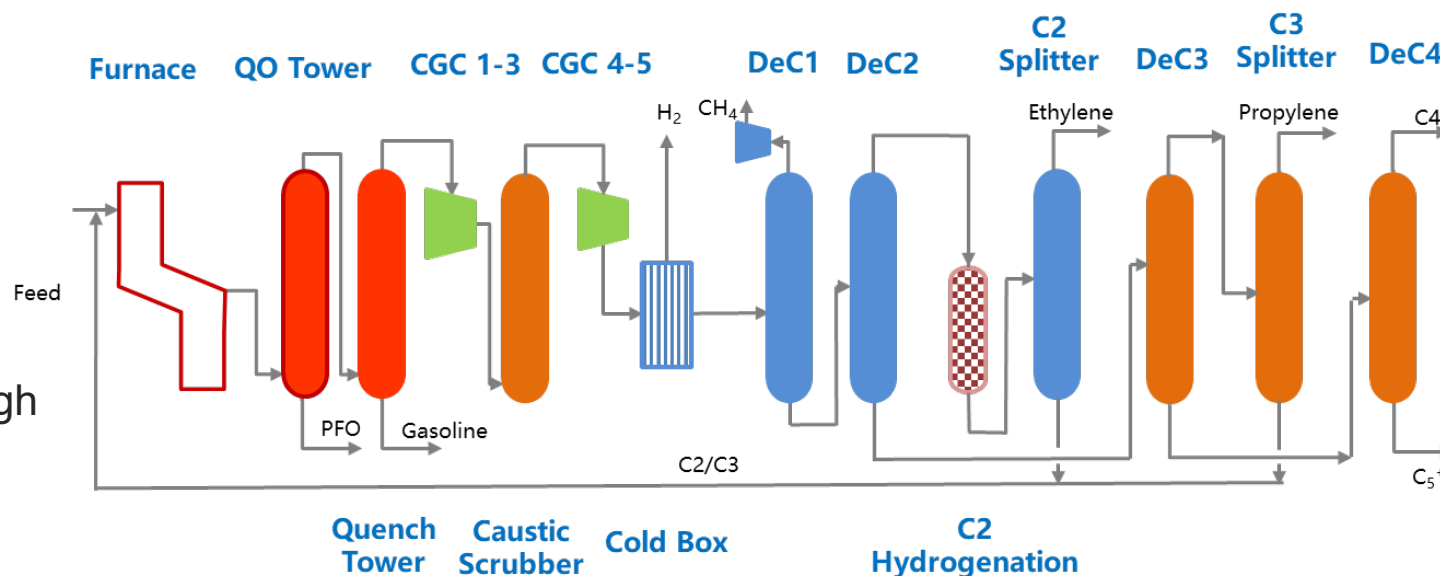
- Front-end depropanizer and front-end acetylene hydrogenation process
- Advanced QO viscosity control
- Charge gas five stage compression
- HP depropanizer and CGC 5th stage integrated into an open heat pump
- Distribution separation principle based cryogenic separation system
 - ✓ C3 Washer, C2 Washer, cold box, expander, high pressure dual-demethanizer
- Open heat pump system C2 splitter/ethylene refrigerant compressor
- Ethylene/Propylene cascade refrigeration



Highlights of Technology—Recovery

■ Features of AERP Technology

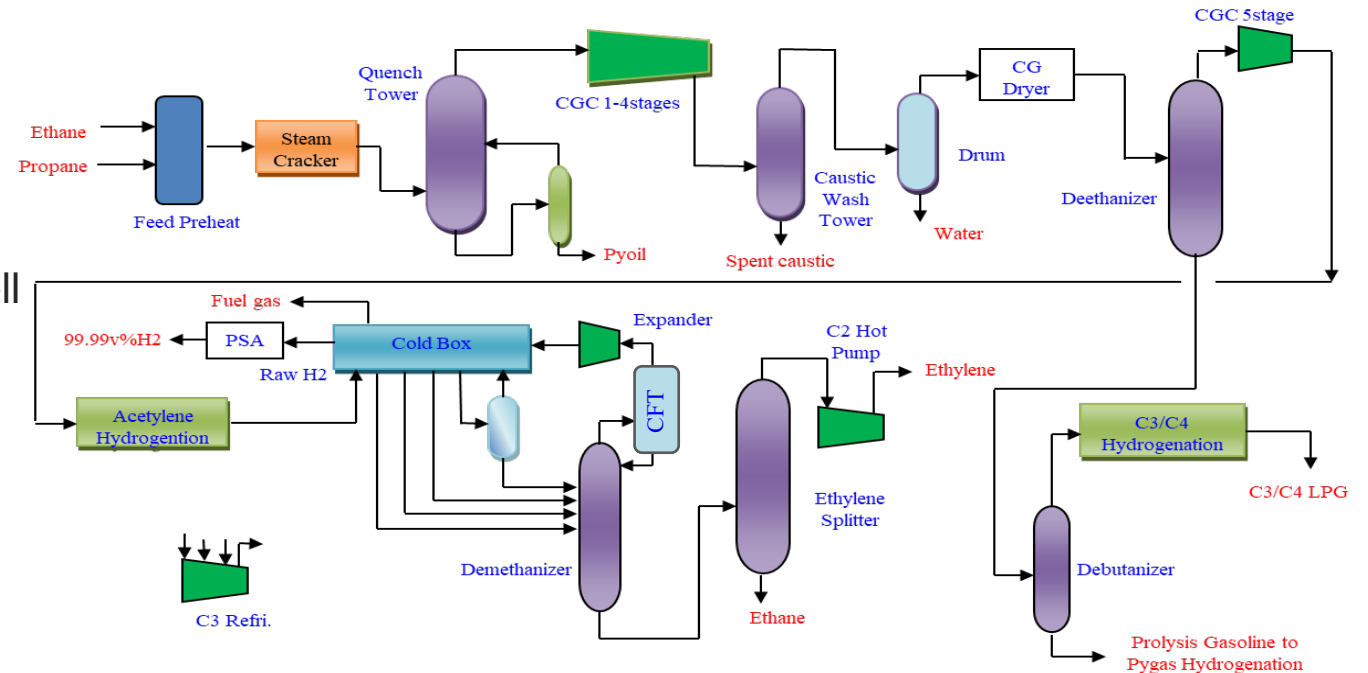
- Sequential separation process
- Advanced QO viscosity control
- Charge gas five stage compression
- Distribution separation principle based cryogenic separation system
 - ✓ C2 Washer, cold box, expander, high pressure dual-demethanizer
- High pressure C2 splitter
- Ethylene/Propylene cascade refrigeration



Highlights of Technology——Recovery

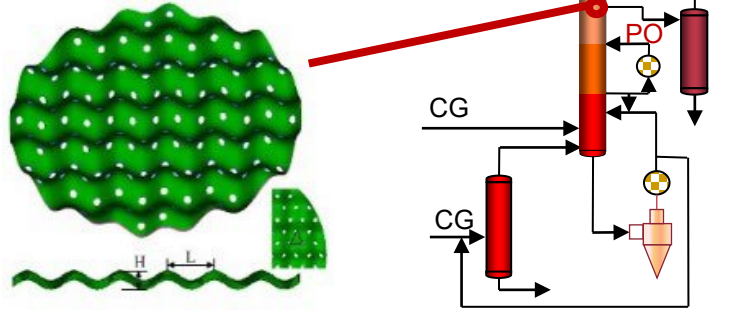
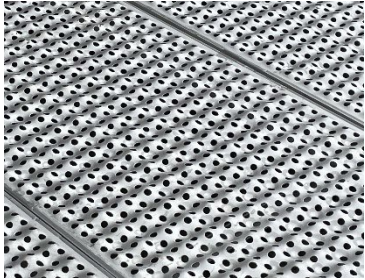
■ Features of ART Technology

- Front-end deethanizer and C2 hydrogenation process
- Single tower quench system
- Proprietary process water treating system
 - ✓ Coalescer, stripping-gas floating, nutshell filtration
- Cryogenic separation system
 - ✓ Cold box, expander, high pressure demethanizer, C2 recovery tower
- Open heat pump system C2 splitter/ethylene refrigerant compressor
- Ethylene/propylene cascade refrigeration



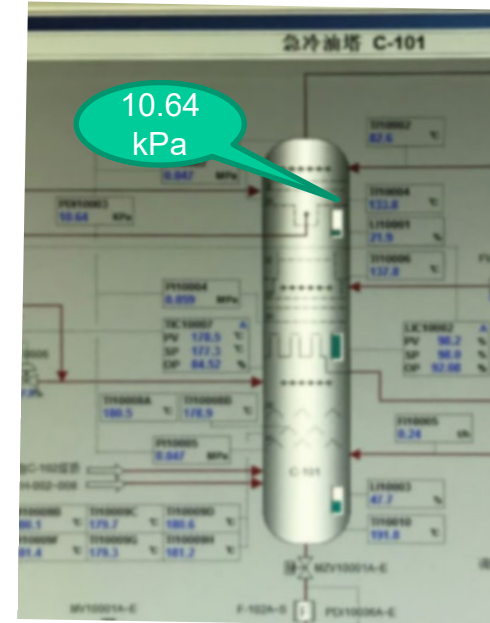
Highlights of Technology——Recovery

■ OWT: Orthogonal Wave Tray



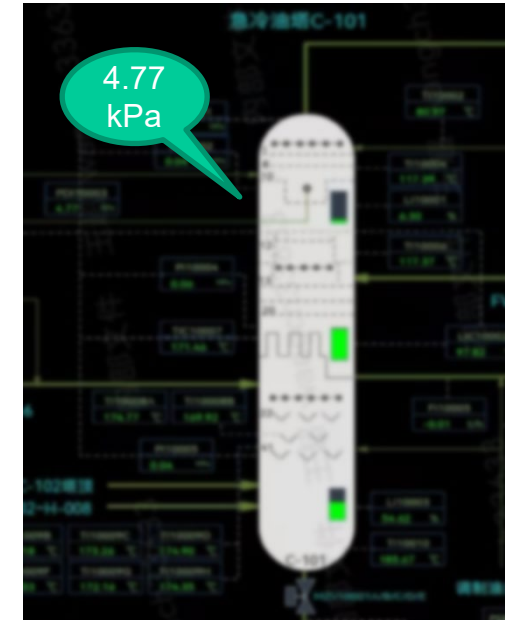
- No downcomer, high throughput and wide operating range
- Excellent self-cleaning ability, low possibility of clogging
- Uniform distribution of gas and liquid on the tray
- Low pressure-drop

- For revamp plant, column diameter can remain unchanged
- for new plant, column diameter can be reduced
- Ideal for large-scale installations



Before Expansion

800KTA QO tower PDI
(Fixed valve)



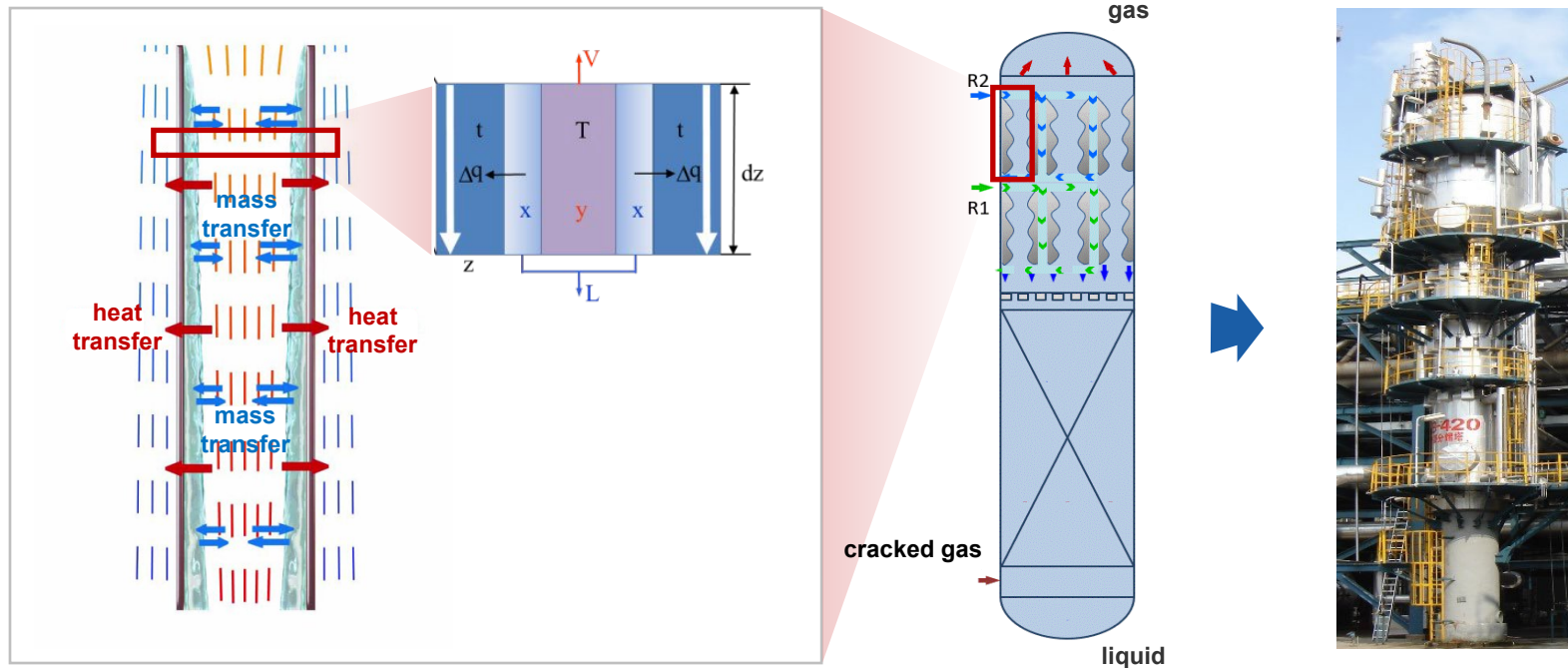
After 38% Expansion

After Expansion to 1.10MTA
(OWT with same shell)

Highlights of Technology——Recovery

■ CFT: Condensating Fractionating Tower

- Conception of “heat and mass transfer coupling tiny fractionation unit”
- Falling film continuous mass transfer and heat transfer through inter-wall coupling technology



Used as C2 recovery tower
70% reduction in ethylene loss in tail gas

Highlights of Technology——Recovery

■ High Ethylene and Hydrogen Recovery

- Ethylene: $\geq 99.7\%$ for mixed feed; $\geq 99.5\%$ for ethane feed
- Hydrogen: $\geq 88\%$ for mixed feed

■ Low Energy Consumption

■ Better Performance Of Quench System

- High gasoline fractionator bottom temperature
- Low oil content in treated process water

■ Long Turn Around



Highlights of Technology——WAO

Wet Air Oxidation (WAO):

■ Processing Object & Purpose

- Spent caustic from steam cracker, refinery and propane dehydrogenation.
- Remove sodium sulfide and improve the biodegradability.

■ Technical Characteristics

- Reaction conditions : 190°C、3.0MPa
- The S²⁻ in treated spent caustic is less than 1.0mg/L.
- Internal circulation oxidation reactor (Well adapted to water quality and quantity shocks)
- Integrated heat exchange system (Lower operating energy consumption)



SINOPEC technology wet air oxidation unit



Comparison of water inlet and outlet of the unit

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Typical Plants——Grassroots

Gulei Ethylene Plant

- Feedstock
 - Naphtha
 - Butane
 - Propane
- CBL-R: 2 furnaces, 200 KTA per furnace
CBL-VI: 6 furnaces, 150 KTA per furnace
- Modular construction of furnaces
- LECT ethylene recover technology

Ethylene: 125t/h, start up in 2021



Typical Plants——Grassroots

Zhenhai 2# Ethylene Plant

- Complicated Feedstock
 - Propane, straight-run naphtha, coking tail oil, cracking tail oil, hydrocracking light naphtha, liquefied gas, reforming C5 and C6, raffinate.
- Heavy oil account for over 30%
- CBL-R : 2 furnaces, 200 KTA per furnace
CBL-VII: 6 furnaces, 150 KTA per furnace
CBL-III: 1 furnaces, 150 KTA per furnace
- AERP ethylene recovery technology
- Oil-in to on-spec ethylene within 6 hours

Ethylene: 156t/h, start up in 2022



Typical Plants——Grassroots

Ningbo Huatai Ethylene Plant

- Feedstock
 - Light hydrocarbon, propane, ethane
- CBL-R : 5 furnaces, 150KTA per furnace
- ART ethylene recovery technology
- High efficiency process water treatment technology



- Oil: 71-174ppmw
- Turbidity: 10-126ppmw

Comparison of inlet and outlet water quality of the device

Ethylene: 75t/h, start up in 2021



Typical Plants——Furnace

- Feed: HVGO, AGO, NAP, C2/C3, LPG, C5
- Liquid Furnace: CBL-V / IX;
- Gas Furnace: CBL-R
- Total 10 Furnaces
- Capacity: 120 / 200 KTA each
- Feed in on Aug.12th, 2013/ in Jan. 2021



Wuhan 800/1,100 KTA Ethylene Complex

- Feed: AGO, NAP, C2/C3, LPG
- Liquid Furnace: CBL-III, VII;
- Gas Furnace: CBL-R
- Total 9 Furnaces
- Capacity: 150 / 200 KTA each
- Planned start-up in May of 2024



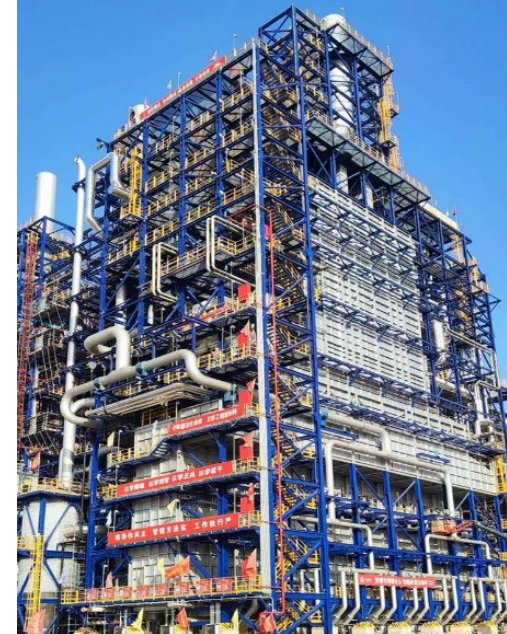
Ineos Sinopec Tianjin Petrochemicals Limited
1,250 KTA Ethylene Complex

Typical Plants——Furnace



- Feed: Naphtha
- Liquid Furnace: CBL-III
- Capacity: 150 KTA
- Started-up in Feb. of 2022

Zhenhai 150 KTA Single Firebox
Liquid Feed Furnace



- Feed: Naphtha
- Liquid Furnace: CBL-III
- Capacity: 200 KTA
- Planned start-up in May of 2024

Ineos Sinopec Tianjin Petrochemicals Limited
200 KTA Single Firebox Liquid Feed Furnace
(World's Largest Single Firebox Furnace)

Typical Plants——Furnace

- Feed: HVGO、NAP, C2/C3, LPG,
- Liquid Furnace: CBL-VI;
- Gas Furnace: CBL-R
- Capacity:
 - ✓ 200/300 KTA Gas Feed
 - ✓ 140 KTA Liquid Feed
- Feed in on Sep. 28th, 2020



Zhongke 800 KTA Ethylene Complex
(World's Largest Gas Furnace)

- Feed: C2, LPG, NAP
- Gas Furnace: CBL-R
- Double firebox
- Split Firebox Decoking
- Feed in on Nov. 9th, 2012



Malaysia 90 KTA

- Feed: HVGO、NAP
- Liquid Furnace: CBL-VII;
- Double Firebox
- Split Firebox Decoking
- Feed in on Mar. and Apr., 2014



Fujian 150 KTA /Exxon Mobile/
Saudi Aramco Ethylene
Complex

Typical Plants——Expansion

Considerations:

Existing plant process

Client specific requirement: new or replace, operation...

Site condition: area, space, underground

Regulation, codes & standards, specifications update

Construction time



Fujian Project

Typical Plants——Expansion

Expansion/revamp: Fujian refining & petrochemical company

■ **PLANT : 800KTA→1100KTA 37.5%↑**

- Add two new 150KTA CBL-VII furnaces
- Recycle furnace revamp from 120 to 150KTA
- Reuse tower shell, compressor foundation & casing
- Lower investment
- Shorter construction period: 70 days

OWNER:



ExxonMobil



	Before Expansion	After Expansion
Capacity	800KTA	1100KTA
Ethylene Recovery	99.73	99.85
Propylene Recovery	99.77	99.87
Specific Energy	Base	-2.3%

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SUMMARY

- Advanced & complete technology of steam cracking
- Best solution for complex feedstock
- Rich experience of both technology licensing and engineering
- Full life cycle service

Contributing to society

乐业奉献

Devotion

竞争创新

Innovation

诚信为本

Harmony

宽松融洽

Lifelong responsible for engineering product

Sincerity

永久对工程负责

Win-Win cooperation

合作共赢

Together, let's do better !

SINOPEC

团结和谐，务实稳健

Contributing to society and relief

Compliance

SEI

严格规范

A Provider of Quality Project

石化精品工程的创造者

THANK YOU



中国石化
SINOPEC