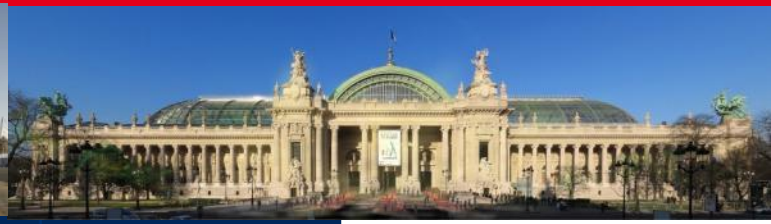
26th World Gas Conference

1 – 5 June 2015, Paris, France



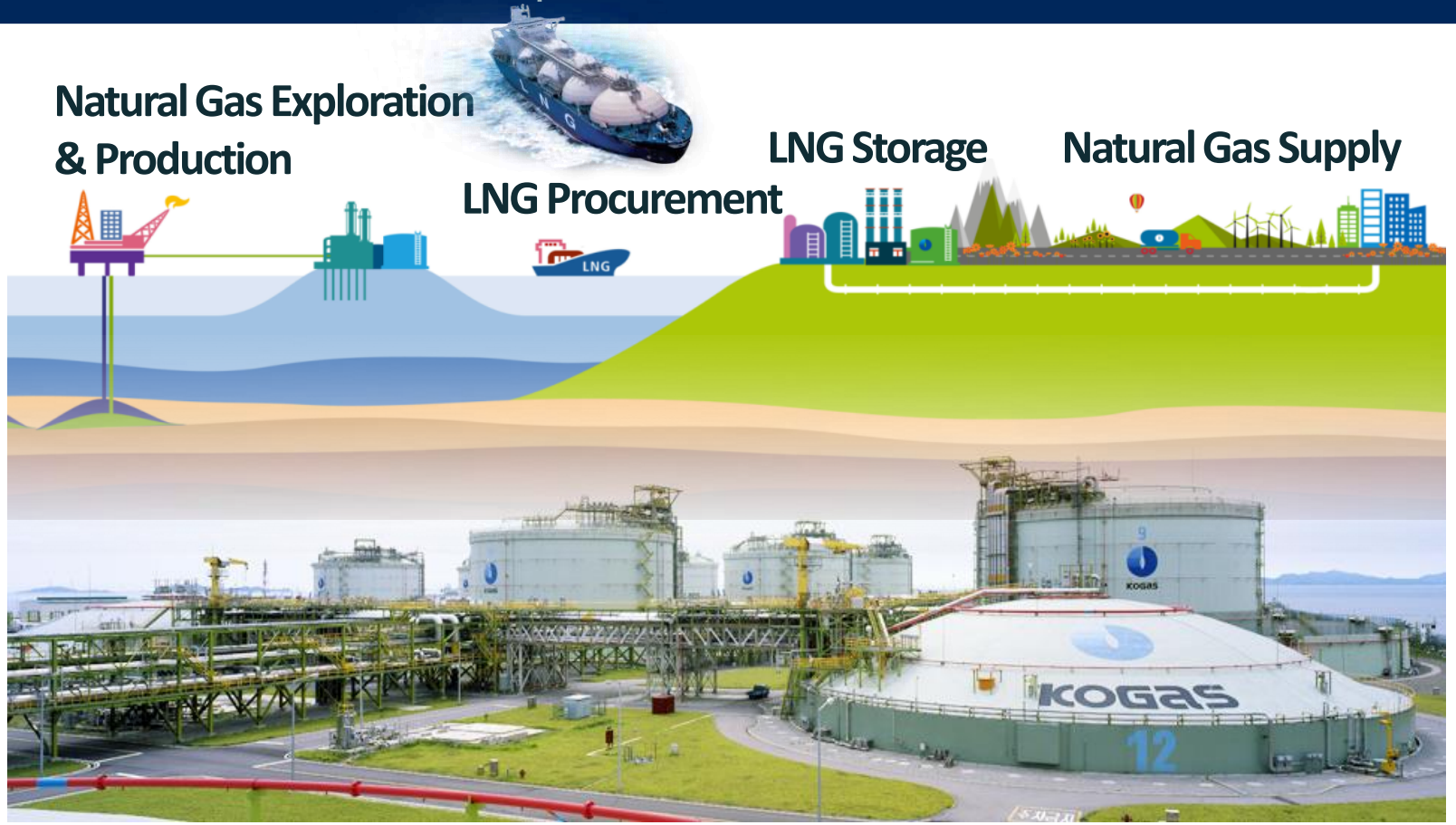



Studies on the FPSO Application of Natural Gas to Dimethyl Ether Process

Taekyong Song
KOGAS

WGCPARIS2015
WORLD GAS CONFERENCE

Contents


Natural Gas Exploration
& Production
LNG Procurement
LNG Storage
Natural Gas Supply
LNG
KOGAS
12

DME Dimethyl Ether

- organic compound with the formula CH_3OCH_3
- physically similar to LPG
- produced from natural gas, CBM, biomass, coal
- clean fuel, promising alternative automotive fuel

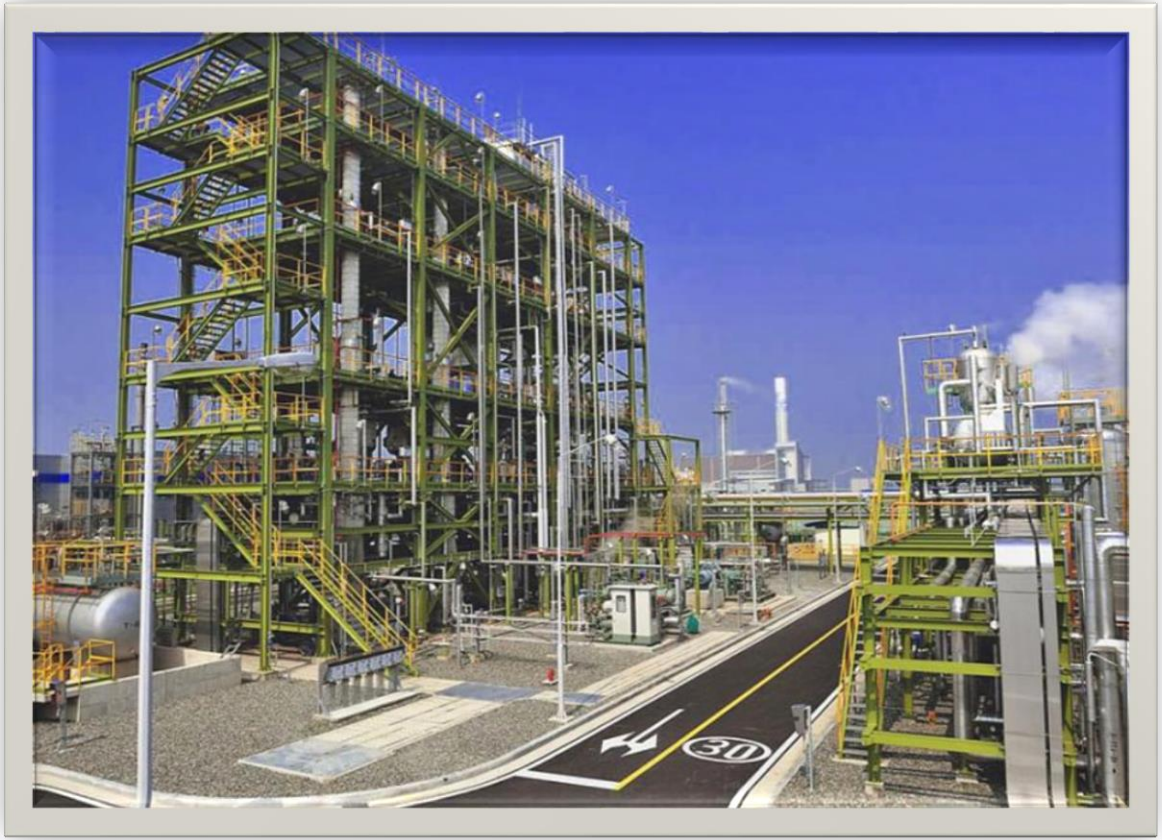
DME fuled BUS by KOGAS

KOGAS DME Technology

- **KOGAS DME Technology Development**
  - Catalyst and process development started in 2000
  - Tri-reformer and DME reactor design
  - 50 kg/day pilot plant
  - 10 metric ton/day demo plant in operation since 2008

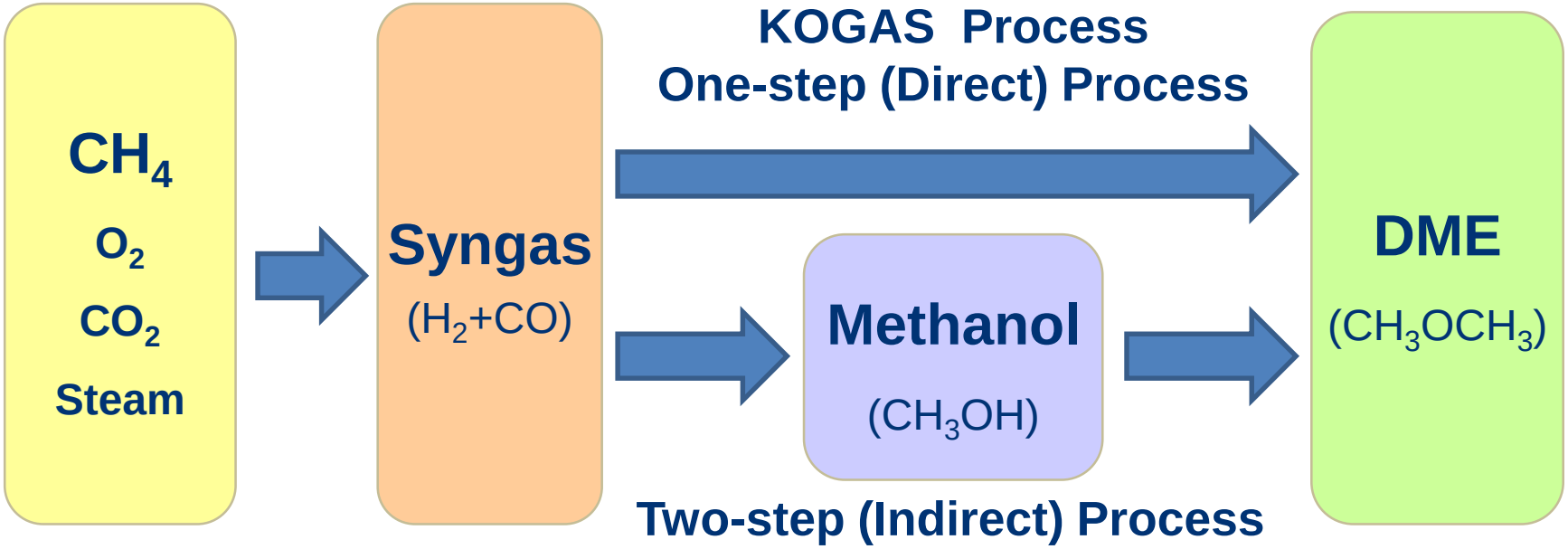
- **K-DME Engineering Designs**
  - Conceptual design : 1,000,000 metric ton/year
  - Basic engineering package : 300,000 metric ton/year

KOGAS DME Demo Plant

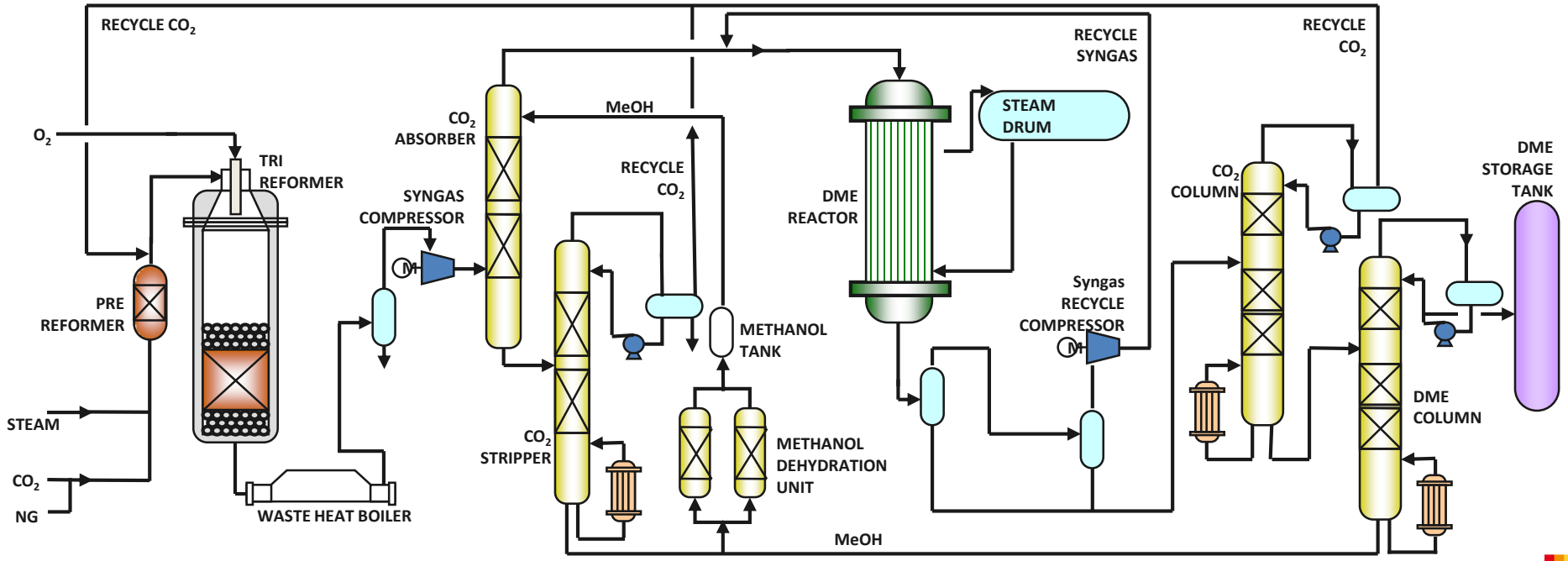


- Inchon, Korea
- 3,000 mt/year

One-Step DME Process

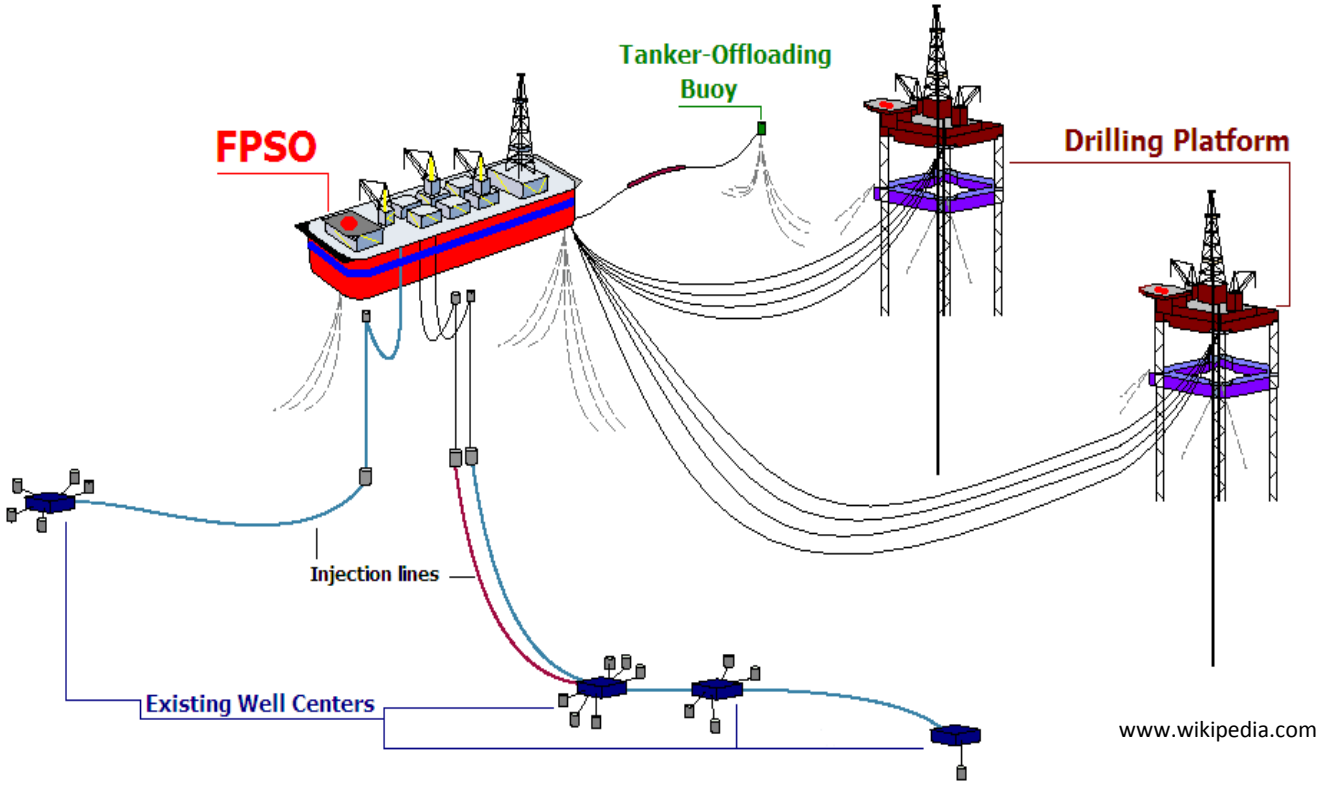


KOGAS DME Process



TRI-REFORMING | **CO_2 REMOVAL** | **DME REACTION** | **PURIFICATION**

FPSO Floating Production Storage & Offloading



www.wikipedia.com

Collaboration with DSME

Daewoo Shipbuilding & Marine Engineering

Topside ISBL (KOGAS)

Topside ISBL
- Tri-Reformer
- DME Reactor
- CO_2 Separation
- Purification

Topside OSBL
- Well fluid reception
- Inlet separation
- Power Generation
- ASU, Utility
- Flare Boom, etc.

Topside

Hull

Hull
- Mooring system
- Offloading system
- Cargo system, etc

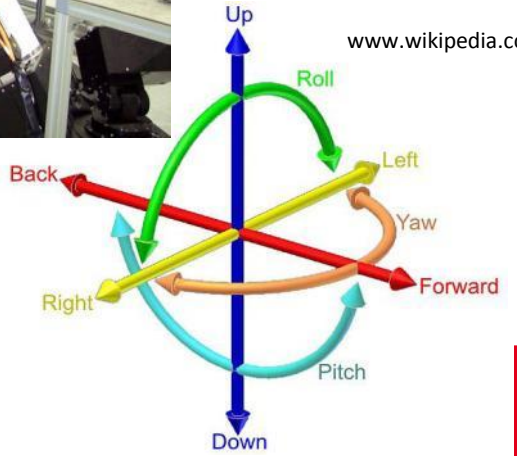
Topside OSBL & Hull (DSME)

Floating Platform

- Floating Platform
  - Ship Motion Impact on the Tri-reformer and DME reactor
  - Reactivity, Temperature Profile, etc.

- Specification
  - Max. Load : 3t
  - 6DoF (degrees of freedom)

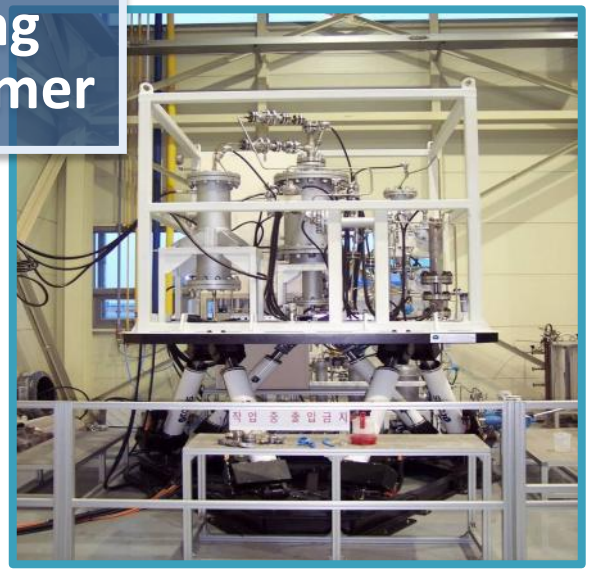
www.wikipedia.com



6 DoF motion

Floating Tri-reformer & DME Reactor

Floating Tri-reformer

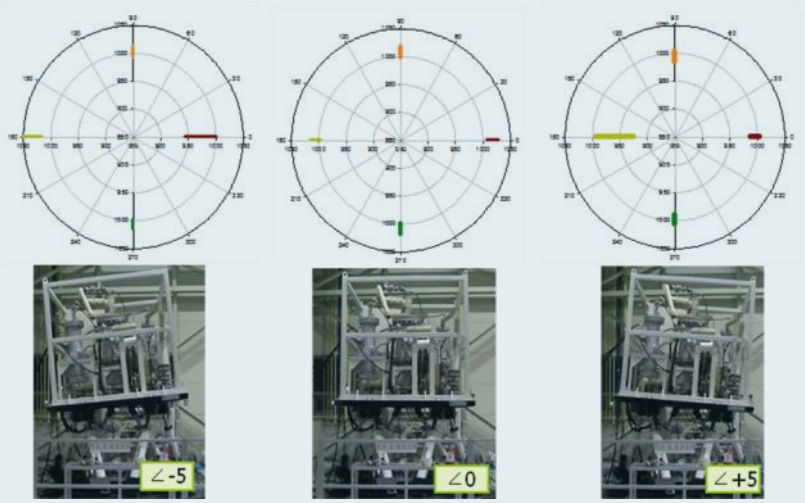


- Compare Floating Tri-reformer to Land-base Tri-reformer
- Check CH_4 Conversion, Syngas ratio, temperature profile, etc.

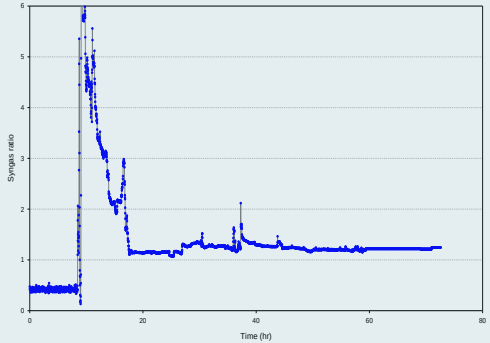
Floating DME Reactor

- Compare Floating DME reactor to Land-base DME reactor
- Check CO conversion, temperature and pressure profile, etc.

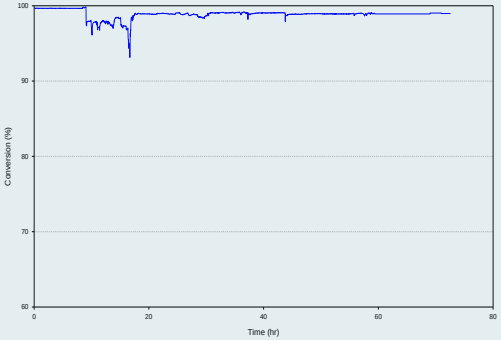
Ship Motion Effect Test Result



Wall Temperature Profile of Tri-reformer



Syngas Ratio



Methane Conversion

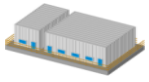
Modified Reactor Design for FPSO Application

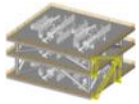
DME FPSO Pre-FEED

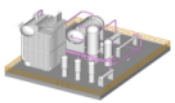

ASU


ASU

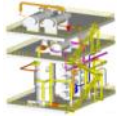

Storage & Utility


Offloadig


Refrigeration & Chilled Glycol

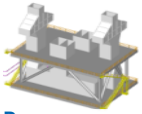

Steam Generation

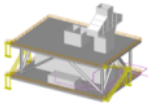

DME Purification

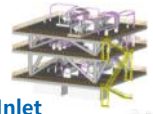

DME Synthesis 1


DME Synthesis 2


DME Synthesis 3


Power Generation 1


Power Generation 2


Inlet Separation & Stabilization


Desulfurization


Reforming 1

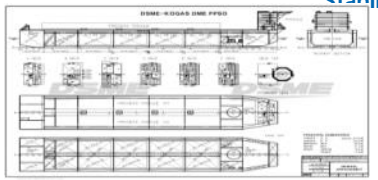

Reforming 2

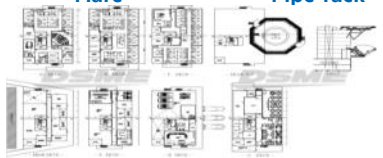

CO2 Removal 1

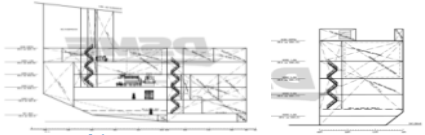

CO2 Removal 2

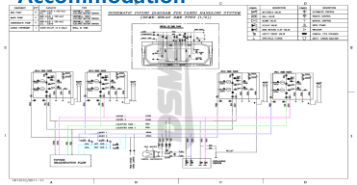

Flare

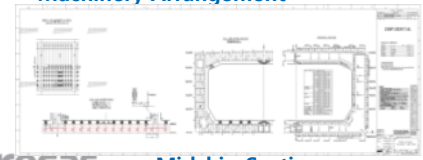

Pipe rack

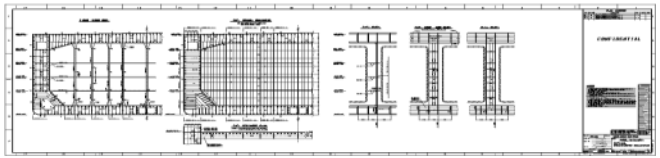

General Arrangement

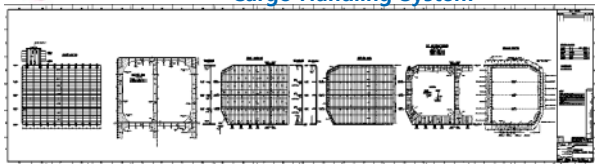

Accommodation


Machinery Arrangement


Cargo Handling System


Midship Section


Typical Trans. Bulkhead


Typical Cargo Tank

DME FPSO Pre-FEED : Design Basis

Wind Conditions

Return Period	1 hour mean [m/s]	1 minute mean [m/s]	3 second gust [m/s]
1 yr	14.0	16.2	18.0
10 yr	17.8	21.5	23.0
100 years	25.0	30.1	34.1

Products Specifications

DME
- H2S: ≤ 3mg/kg
- Purity: 99.6 wt% pure

Methanol
- H2S: ≤ 3mg/kg
- Purity: 98.0 wt%

Production Rate
- DME: 3000 TPD (4976 m^3/d)
- Methanol: 725 TPD (949 m^3/d)
- Condensate: - Max. 230.4 TPD @ Rich case

Feed gas composition

	Base Case	CO_2 Low Case	CO_2 High Case	Rich Case
Component	Mole Fraction	Mole Fraction	Mole Fraction	Mole Fraction
CO_2	0.10010	0.05001	0.25000	0.10020
N_2	0.00300	0.00300	0.00300	0.00300
CH_4	0.84635	0.89364	0.66045	0.75355
C_2H_6	0.02640	0.02790	0.03820	0.05600
C_3H_8	0.01140	0.01200	0.02660	0.04540
n-C4	0.00260	0.00280	0.00640	0.01110
i-C4	0.00440	0.00460	0.00720	0.01200
n-C5	0.00090	0.00100	0.00180	0.00300
i-C5	0.00160	0.00160	0.00270	0.00450
C6	0.00110	0.00120	0.00170	0.00310
C7	0.00130	0.00140	0.00120	0.00290
C8	0.00040	0.00040	0.00030	0.00180
C9	0.00040	0.00040	0.00040	0.00340
H_2S	0.00005	0.00005	0.00005	0.00005
TOTAL	**1.00000**	**1.00000**	**1.00000**	**1.00000**

Wave Characteristics

Criteria/ Return Period	Hs [m]	Tp [sec]
1 yr	3.0	7.6
10 yr	4.4	8.9
100 years	6.2	9.5
Towing	11.10	12≤15.1≤18.2

Hull dimensions

- Length Overall, LOA: 319 m
- Length between PP, Lpp: 319 m
- Breadth Molded: 60 m
- Depth Molded: 31.5 m
- Draught, Design: 16 m
- Draught, Scantling: 17 m

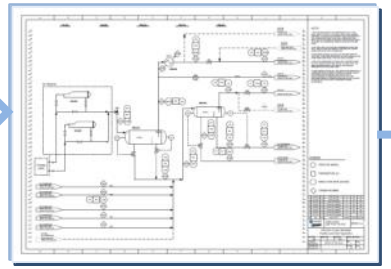
Cargo Storage Capacity

	Gross Volumes	Estimated Offloading Volumes
DME Storage Tanks (m^3):	178,000	40,000
Methanol Storage Tanks (m^3):	41,000	20,000
Condensate Storage Tanks:	TBA	TBA
DME Production:	3,000 TPD	
Production Storage Capacity:	35.7 day	

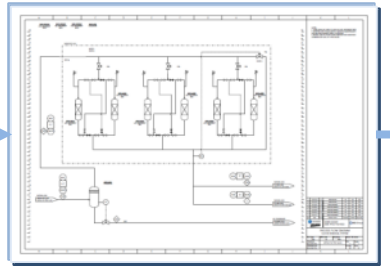
Process Flow Diagram

Natural Gas

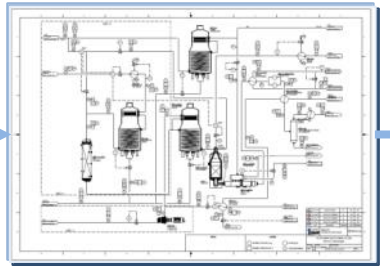
Inlet Separation & Stabilization



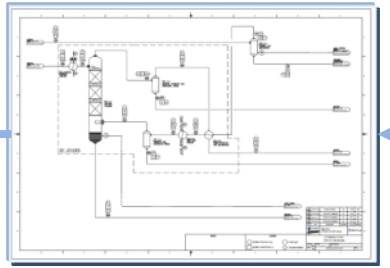
Sulfur Removal



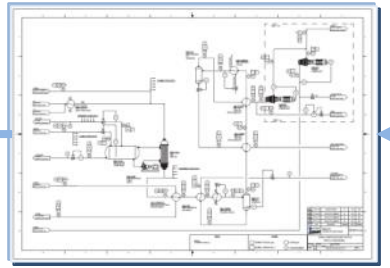
Pre-Reforming & Reforming



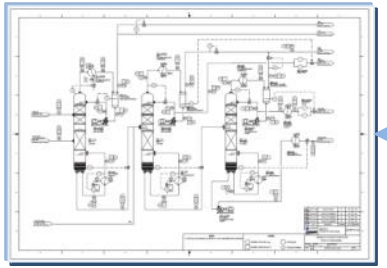
CO_2 Removal



Syngas Compression & DME Synthesis



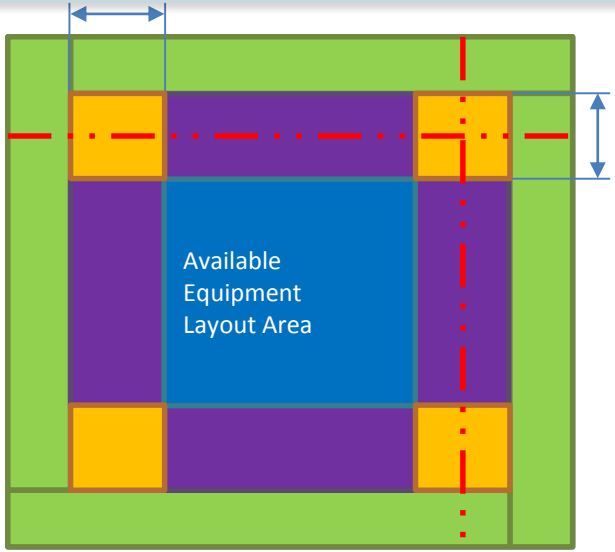
DME/MeOH Recovery & Purification



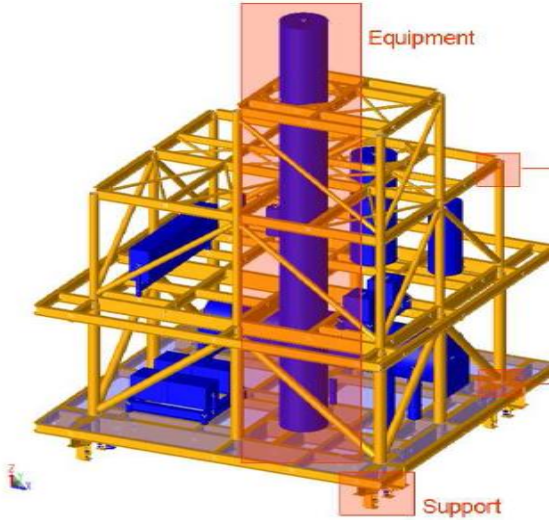
DME

Module Design

Topside equipment should be located inside vertical column & diagonal brace area.



Equipment Layout Area in Module

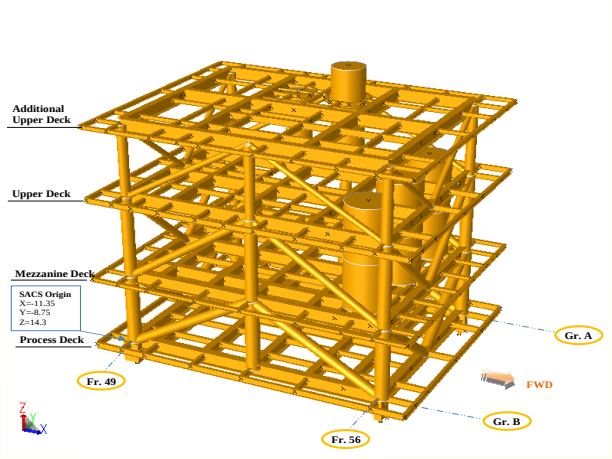


Typical Module Structure Example

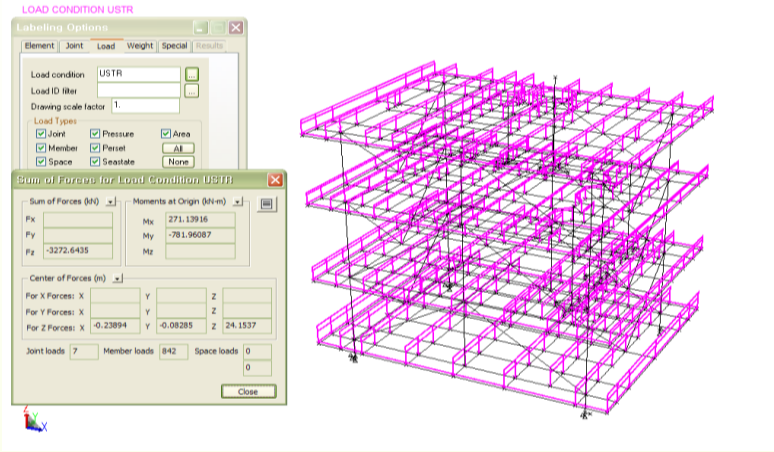
Structural Analysis

Structural Analysis :
Analyze module structure considering topside weight, ship motion

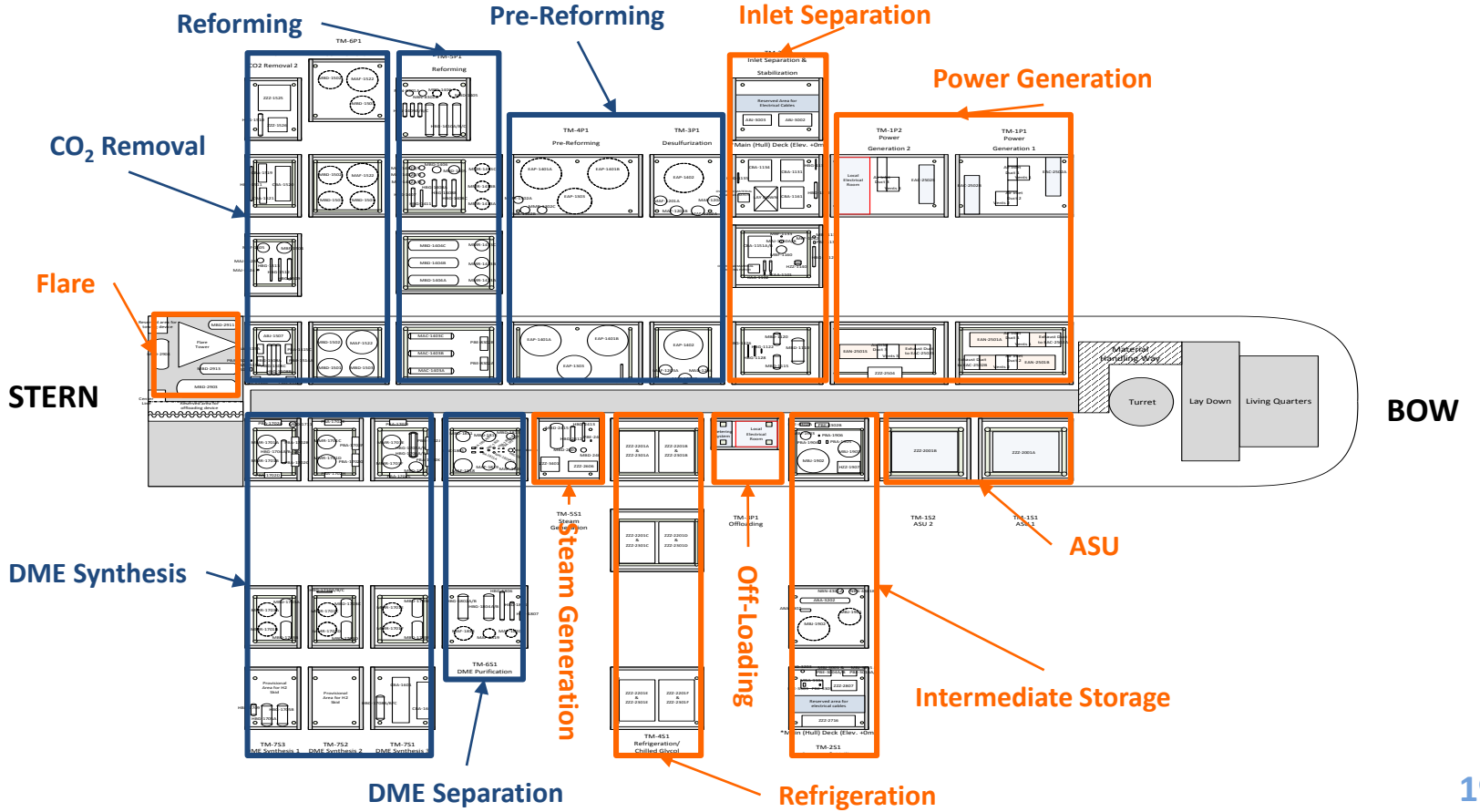
Reforming Module Structure



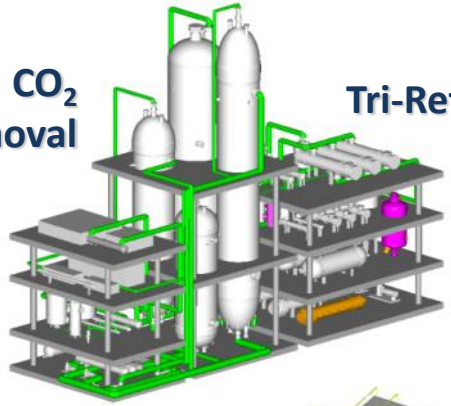
Reforming Module Load Calculation



Topside Layout Overview



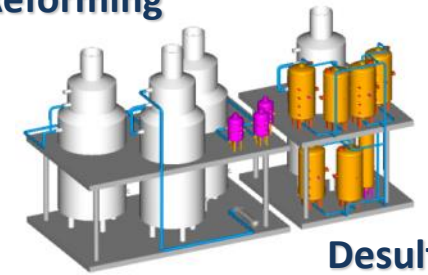
3D Modeling



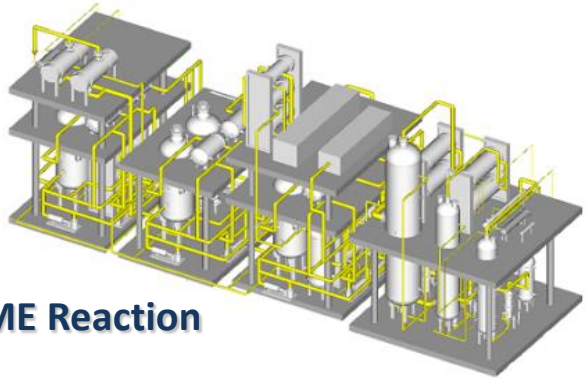
CO_2 Removal

Tri-Reforming

Pre-Reforming

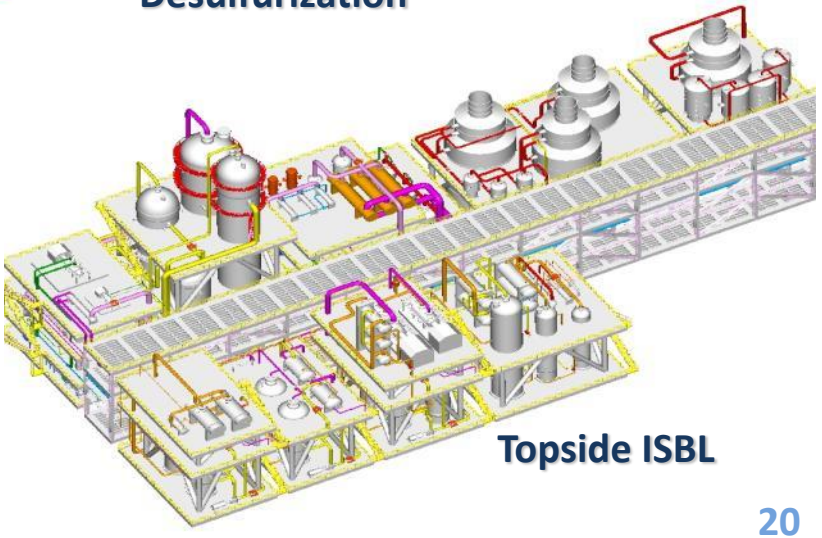


Desulfurization



DME Reaction

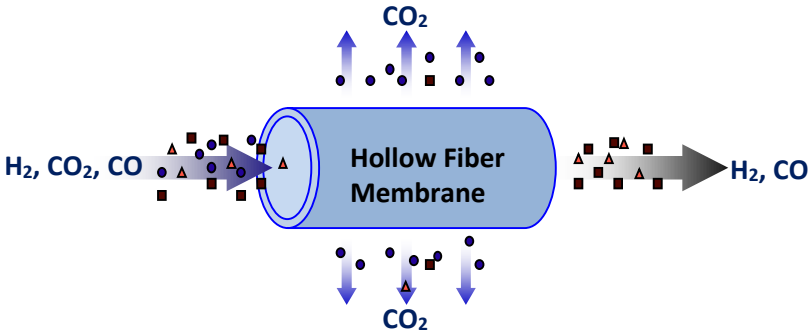
Purification

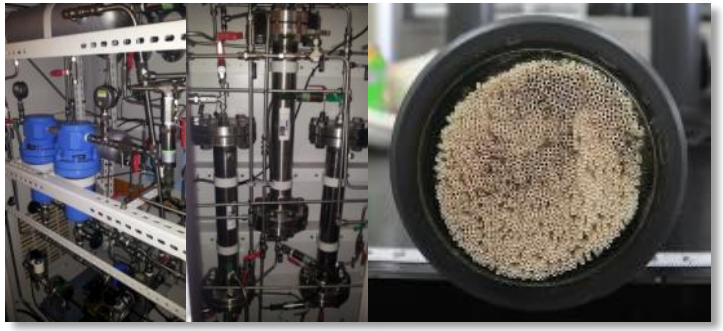


Topside ISBL

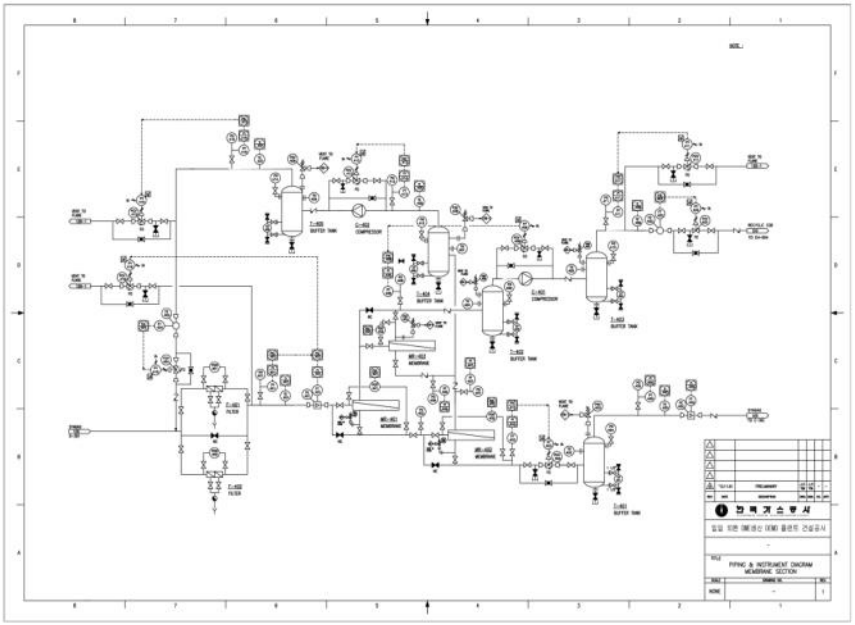
3D Modeling

Current Work : CO_2 Separation by Membrane





Bench Scale Membrane System



P&ID of Membrane Separation System for 10tpd DME Demo Plant

Current Work : Stackable Structural Reactor

Catacel SSR®
(Stackable Structural Reactor)
by Johnson Matthey

KOGAS Catalyst

Bench Scale SSR System

Conclusions

- KOGAS carried out Pre-FEED study for DME FPSO based on KOGAS' DME process.
- KOGAS tested ship motion effect on the main reactors for the optimized process design of DME FPSO.
- KOGAS is developing new reformer and CO_2 separation system for the FPSO application.

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