
**SMI Subsea R&D Workshop
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Subsea Production Water Management

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Subsea Challenges

SUBSEA TRANSPORTATION

- Flow Assurance
- Transportation of “Difficult fluids”
- Long distance transportation of gas/condensates
- Multiphase Flow

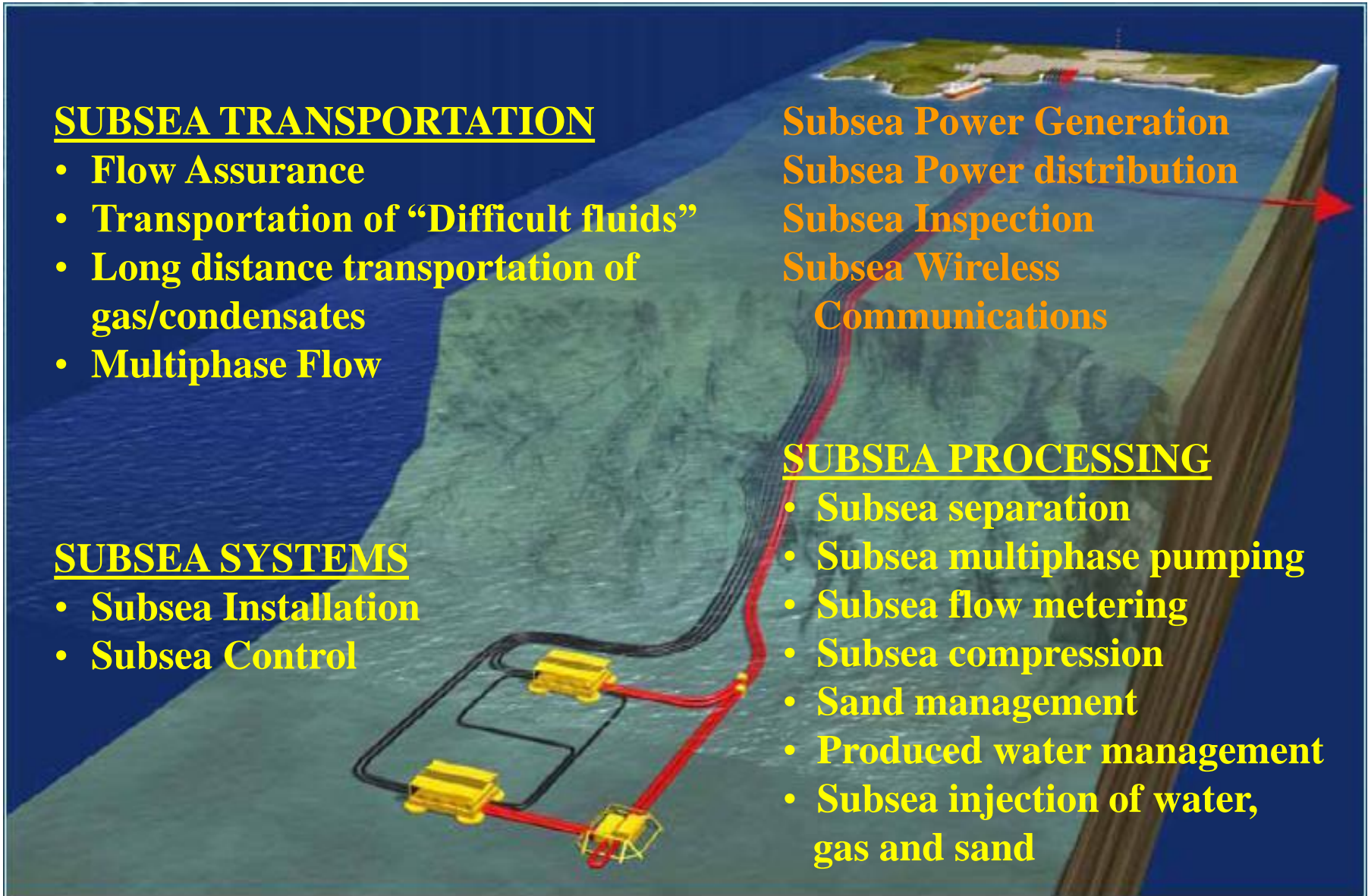
SUBSEA SYSTEMS

- Subsea Installation
- Subsea Control

Subsea Power Generation
Subsea Power distribution
Subsea Inspection
Subsea Wireless
Communications

SUBSEA PROCESSING

- Subsea separation
- Subsea multiphase pumping
- Subsea flow metering
- Subsea compression
- Sand management
- Produced water management
- Subsea injection of water, gas and sand



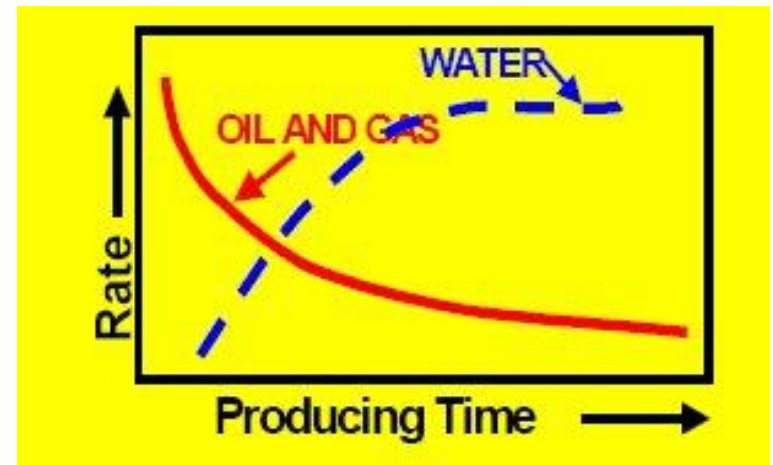
What is Produced Water?



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- Produced water are formation water that comes to the surface with the produced oil and gas.
- It is very saline, contains dissolved hydrocarbons and organic matters as well. It may include water injected into the formation, and any chemicals added during the production and treatment processes.
- Produced water is considered hazardous waste and requires special disposal and handling.
- Separation Technology need be deployed for treating the produced water to an appropriate quality for meeting the purpose of disposal and industrial use.

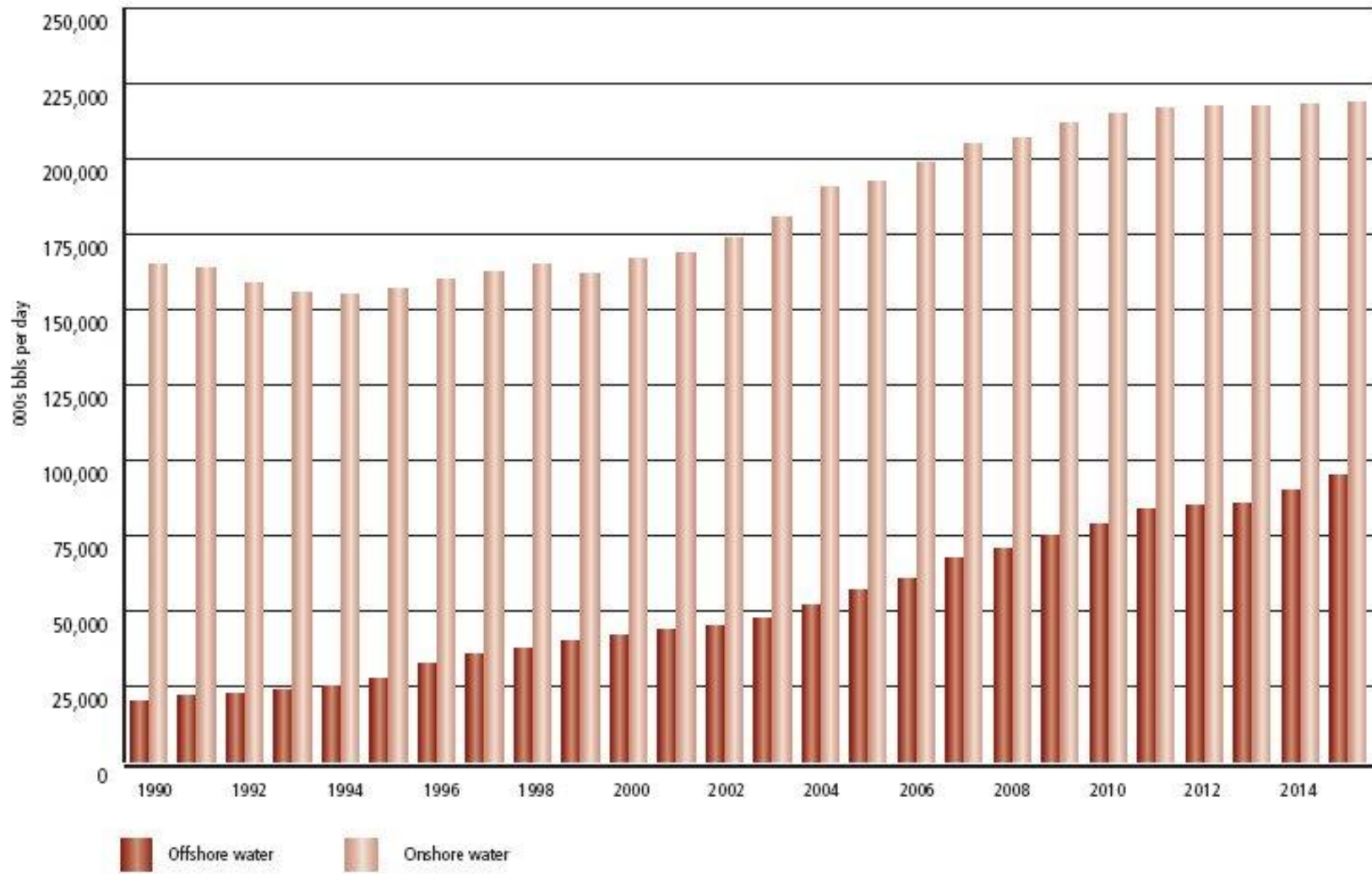


Produced water



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Source: EnergyFiles Ltd.

Current global water production associated with oil and gas fields is estimated at around 250 million bbl/day compared with around 80 million bbl/day of oil (**water-oil ratio ~ 3:1 or water cut of 75%**)

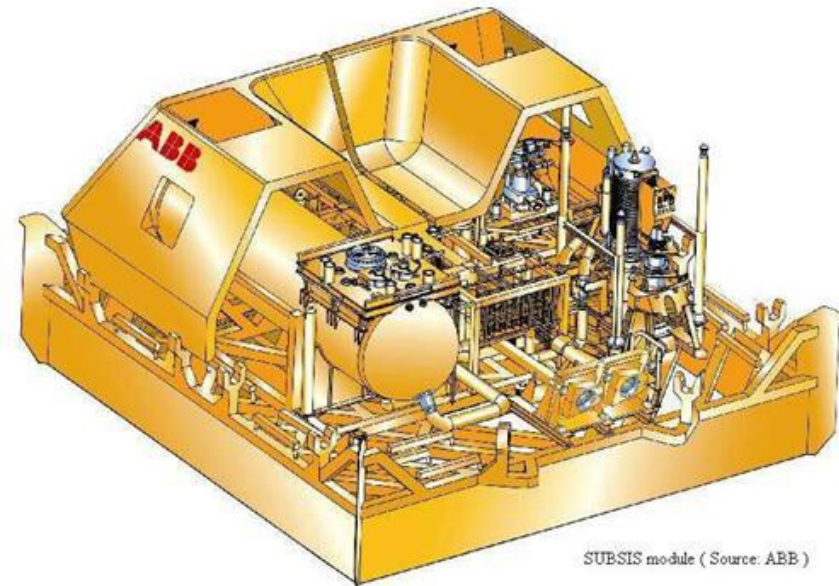
Offshore Disposal Limits

Offshore Disposal Standards for Several Oil Producing Countries.

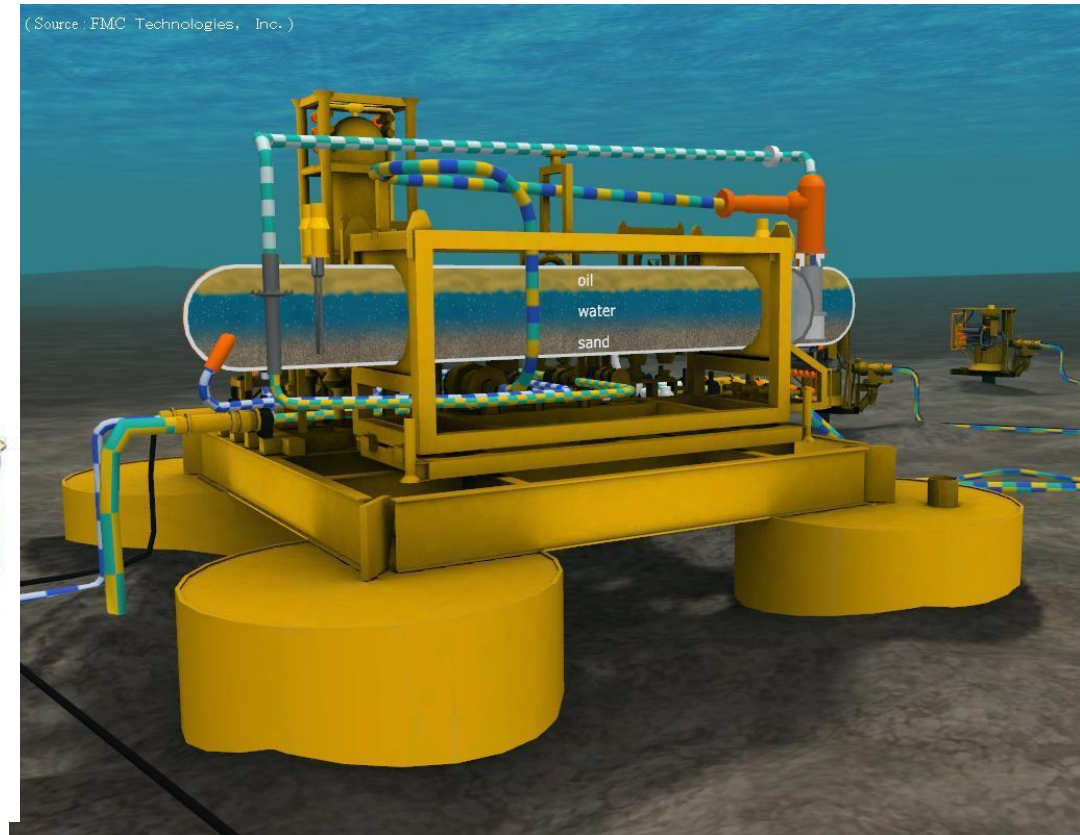
Ecuador, Colombia, Brazil	30 mg/l All facilities
Argentina and Venezuela	15 mg/l New facilities
Indonesia	25 mg/l Grandfathered facilities
Malaysia, Middle East	30 mg/l All facilities
Nigeria, Angola, Cameroon, Ivory Coast	50 mg/l All facilities
North Sea, Australia	30 mg/l All facilities
Thailand	50 mg/l All facilities
USA	29 mg/l OCS water
	Zero discharge inland water

- Physical Separation
 - gravity separation/hydrocyclone
- Flotation
- Coalescence
- Membrane Processes
 - microfiltration, ultrafiltration, etc
- Solvent Extraction
- Adsorption
 - Organo clay, activated carbon, kapok fibres, etc
- Hybrid Methods

Subsea Water Separation



(Source: FMC Technologies, Inc.)



Sea floor (also called subsea) separation involves a large module that sits on the sea floor. Fluids from one or more wells are sent there for separation. The oil is lifted to a platform or to a floating production and storage and offloading (FPSO) vessel, while the water is typically pumped directly to an injection well.

Research Challenges

Unit Processes and Their Application to Produced Water Treatment.

Treatment Method	De-Oiling	Suspended Solids Removal	Iron Removal	Ca & Mg Removal Softening	Soluble Organic Removal	Trace Organics Removal	Desalination & Brine Volume Red	Adjustment of SAR	Silicate & Boron Removal
API Separator	✓	✓							
Deep Bed Filter	✓	✓							
Hydroclone	✓	✓							
Induced Gas Flotation	✓	✓							
Ultra-filtration	✓	✓							
Sand Filtration		✓							
Aeration & Sedimentation		✓	✓						
Precipitation Softening				✓					✓
Ion Exchange			✓	✓					✓
Biological Treatment					✓				
Activated Carbon						✓			
Reverse Osmosis							✓		
Distillation							✓		
Freeze Thaw Evaporation					✓		✓		
Electrodialysis					✓		✓		
Chemical Addition								✓	

✓ = Indicates that the technology is applicable as a potential remedy as indicated by data collected from pilot or commercial scale units.

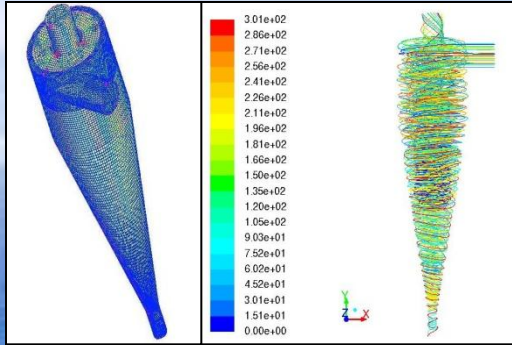
(Source : Cecilia, 2011)

On-going Subsea Research in CORE



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Compact Separators

Subsea Processing

**Membrane
Separation for
Produced Water**

**Multiphase
FlowMeters**

Multiphase Pumping



Subsea Compression

CORE compliments and add value to the leading equipment manufacturers in terms of system design and integration. CORE will focus on the following:

- Provide generic research and development to enhance and optimize the performance of current equipment and/or processes
- Carry out research and development in novel methods and/or processes to supplement or improve the current technologies
- Look at technology transfer from other industries – applying mature technology used in other industries into subsea

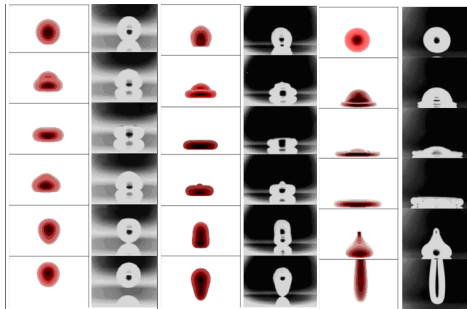
- Compact separation –compact separators for subsea gas-liquid and liquid-liquid separation
- Multiphase pumping – develop simpler, smaller and more reliable methods
- Multiphase flow metering – develop novel flow metering methods
- Subsea produced water separation and management
- Online measurement of quality of produced water – develop novel measurement methods
- Flow Assurance
- Heavy Oil

Flow Assurance Research



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Homogenous Multiphase Flow

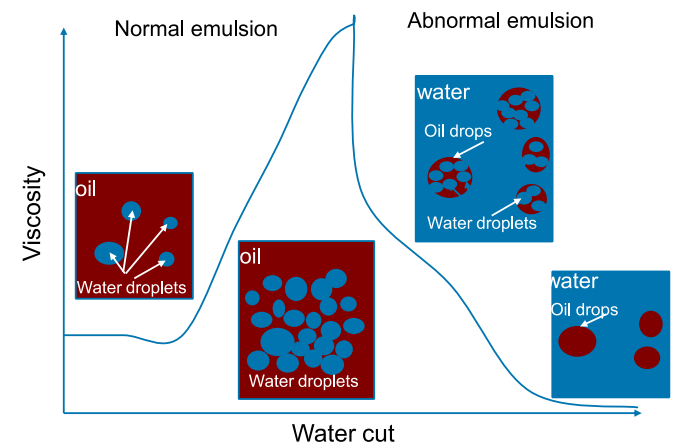
A/Prof Loh Wai Lam
Dr Cheng Ming (IHPC)

Particle Erosion in Downhole Equipment

Dr Tomas Karasek (IHPC)
A/Prof Christina Lim

Down-Hole Multiphase Equipment Design & Analysis

Dr Arther Lim (IHPC)
A/Prof Loh Wai Lam



Heavy Oil Multiphase Flow Study

Dr Cary Tarangan (IHPC)
A/Prof Loh Wai Lam

Three-Phase Oil-Water-Air Flow Loop

Flow Loop Length	- 40m
Flow Loop diameters	- 2", 4", 6"
Max Water flowrate	- 72m ³ /hr
Max Oil flowrate	- 72m ³ /hr
Max Air flowrate	- 1020m ³ /hr
Design pressure	- 18 bar
Max Operating pressure	- 13 bar

