KUALA LUMPUR 2012 WORLD GAS CONFERENCE

25th world gas conference

"Gas: Sustaining Future Global Growth"

TOTAL

An operator's approach to the floating LNG : process selection & risk management

D. Chrétien, LNG process development manager

E. Jeanneau, FLNG development manager

June 2012

Kuala Lumpur

Patron

IGU

INTERNATIONAL GAS UNION

UNION INTERNATIONALE DU GAZ

Host

MALAYSIAN Gas ASSOCIATION

Host Sponsor

PETRONAS

GENERAL

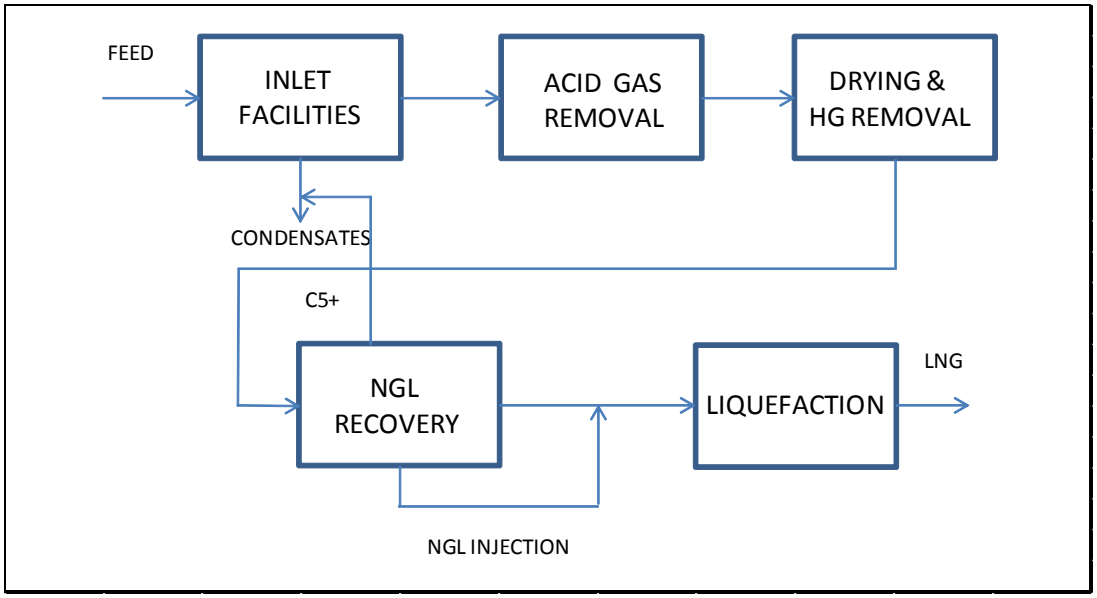
- F-LNG for offshore remote fields
- Main challenges
  - Process
  - Lay-out
  - Offloading
  - Rotating equipment

THIS PRESENTATION FOCUSES ON THE SAFETY IMPACT FOR EACH OF THE ABOVE FIELDS

CONTEXT

- Based on a generic case, not an actual field
- Capacity
  - 3.5 MMTPA of LNG
  - 20,000 bbl/day of condensat
- LPG's are extracted in the NGL extraction unit but re-injected in the gas.
- Liquefaction pressure = 80 bars
- LM6000 gas turbines
- Located in the Gulf of Guinea

PROCESS comparison



Two processes are compared:

- CO2 precooled nitrogen cycle
- Dual Mixed Refrigerant

PROCESS COMPARISON : PERFORMANCES

	N2 CYCLE	DMR
EFFICIENCY KWH/T	262	227
COMPRESSOR DRIVING	3 x LM 6000	3 x LM 6000
POWER PLANT	5 x LM 6000	4 x LM 6000
CRYO. HEAT EXCH.	PFHE REF. AT 80 BAR	SWHE NOT REF. AT 80 BAR
CRYO. EXCH. MECH. PROVEN AT SEA	YES	NO
SENSITIVITY OF CRYO. EXCH. TO OPERATION WITH MOTIONS	NO	YES
COMPETITION FOR CRYO EXCHANGER SUPPLY	YES	A LITTLE !
COOLING WATER	56 000 M^3/H	53 500 M^3/H

PROCESS COMPARISON : OPERABILITY

	N2 CYCLE	DMR
MAKE-UP	BY N2 UNIT OF THE PLANT	REQUIRES A FRACTIONNATION UNIT
	N2 STORAGE OF THE PLANT	ADDITIONNAL C2 & C3 STORAGES
	CO2 FROM AGR	N A
MAKE-UP MONITORING	NO	YES
START-UP FROM AMBIANT TEMPERATURE	ABOUT 6 HOURS	1 TO 1 ½ DAY
RAMP-UP 50 % TO 100 %	ABOUT 1 HOUR	2 TO 4 HOURS

THE N2 CYCLE IS EASIER TO OPERATE

PROCESS COMPARISON : AVAILABILITY

- DEFINITION OF AVAILABILITY :

$$\frac{\text{ACTUAL PRODUCTION PER YEAR}}{\text{PRODUCTION FOR 8760 H / YEAR}}$$

	N2 CYCLE	DMR
AVAILABILITY	96.1 %	95.4 %

Time production of nitrogen cycle is 0.7 % more than that of the DMR cycle.

PROCESS COMPARISON : SAFETY (1)

- HC INVENTORY

LIQUEFACTION MODULES	N2 CYCLE	DMR
HYDROCARBON INVENTORY	30 T	300 T
NATURE OF HYDROCARBON	METHANE	METHANE, ETHANE & PROPANE

- Need of costly mitigation measures for DMR
  - Safety gaps and / or fire walls : hull length
  - Module structure reinforcement because of higher over pressure with propane.

PROCESS COMPARISON : SAFETY (2)

- FLARE DESIGN

	N2 CYCLE	DMR
PEAK FLOWRATE (T/H)	1350	4000
NUMBER OF BLOWDOWN ZONES (FOR A 150 M LONG FLARE)	3	7

- Need of heat shielding and derogation to the Api recommended practices

PROCESS COMPARISON : SAFETY (3)

- 300 scenarios analysed for the overall plant
- Percentage of scenarios with risk of fatalities or to the asset

	N2 CYCLE	DMR	DIFFERENCE
RISK TO PERSONNEL	63 %	74 %	+ 11%
RISK TO ASSET	50 %	69 %	+ 19%

The difference comes from the liquefaction process only

HIGHER MAJOR RISK WITH THE DMR

PROCESS COMPARISON : CONCLUSION

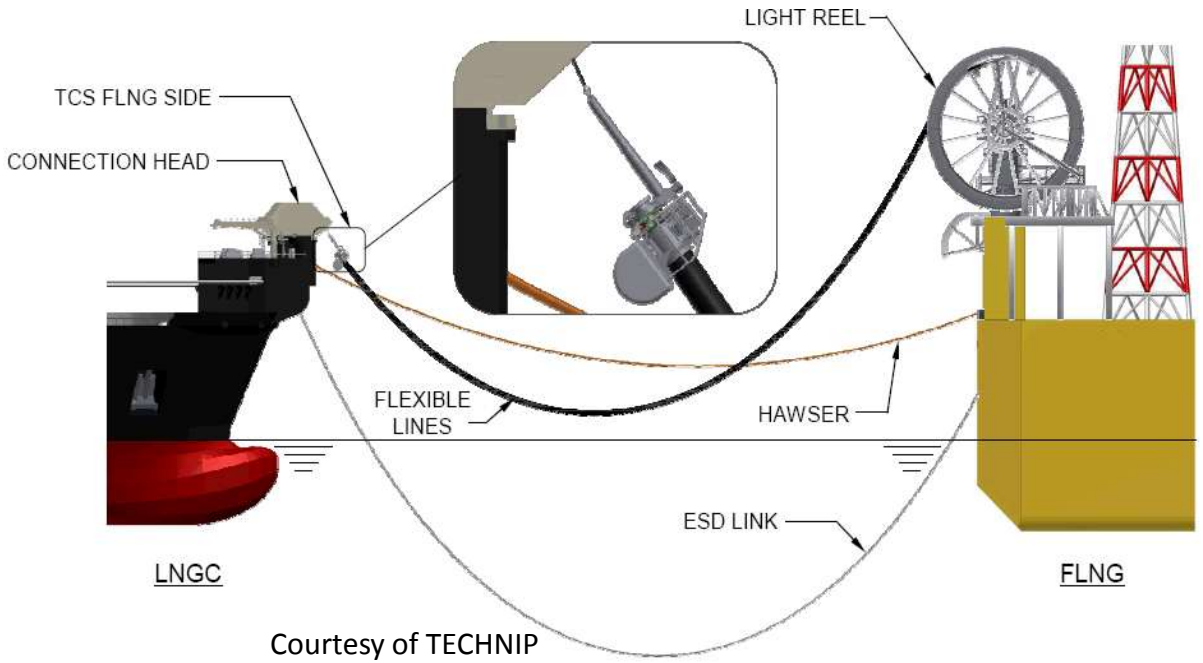
- No break through from one process to the other when considering the process, the operation, the availability
- The capital cost of the additionnal GTG for the N2 cycle is balanced by the safety mitigation measures for the DMR
- The DMR appears by far more risky

Risk management

- FLNG Layout based on SAFETY criteria
  - The living quarter are located up-wind of the process
  - Turret mooring with thruster capability to increase ventilation and enhance the safety of offloading operations
  - Tandem LNG offloading at the FLNG stern
  - The flare and the vents are located at the stern, down-wind of all process facilities

Risk management

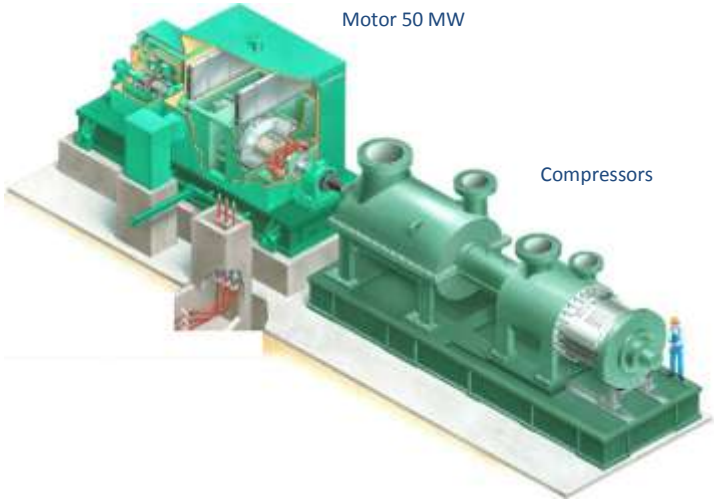
- LNG Tandem offloading selected on SAFETY criteria
  - 100m distance between FLNG and LNGC
  - Collision risk highly reduced
  - Naval operation simplified in approach, berthing & residence



Courtesy of TECHNIP

Risk management

- Electric-only drive selected on SAFETY & Operation criteria
  - Gas turbine located up-wind of the process
  - No hot point nor flames in the process area
  - Operating flexibility with N+1 turbines
  - High availability and quick restart after a shut-down



Conclusions

- As the results of the risk management studies, Total made safety its utmost priority – the imperative around which the entire FLNG design process has revolved.
  - Reduced inventories of flammable substances
  - Enhanced operational safety during LNG offloading
  - Secured and isolated living quarter

SAFETY, SIMPLICITY and OPERABILITY

Animation

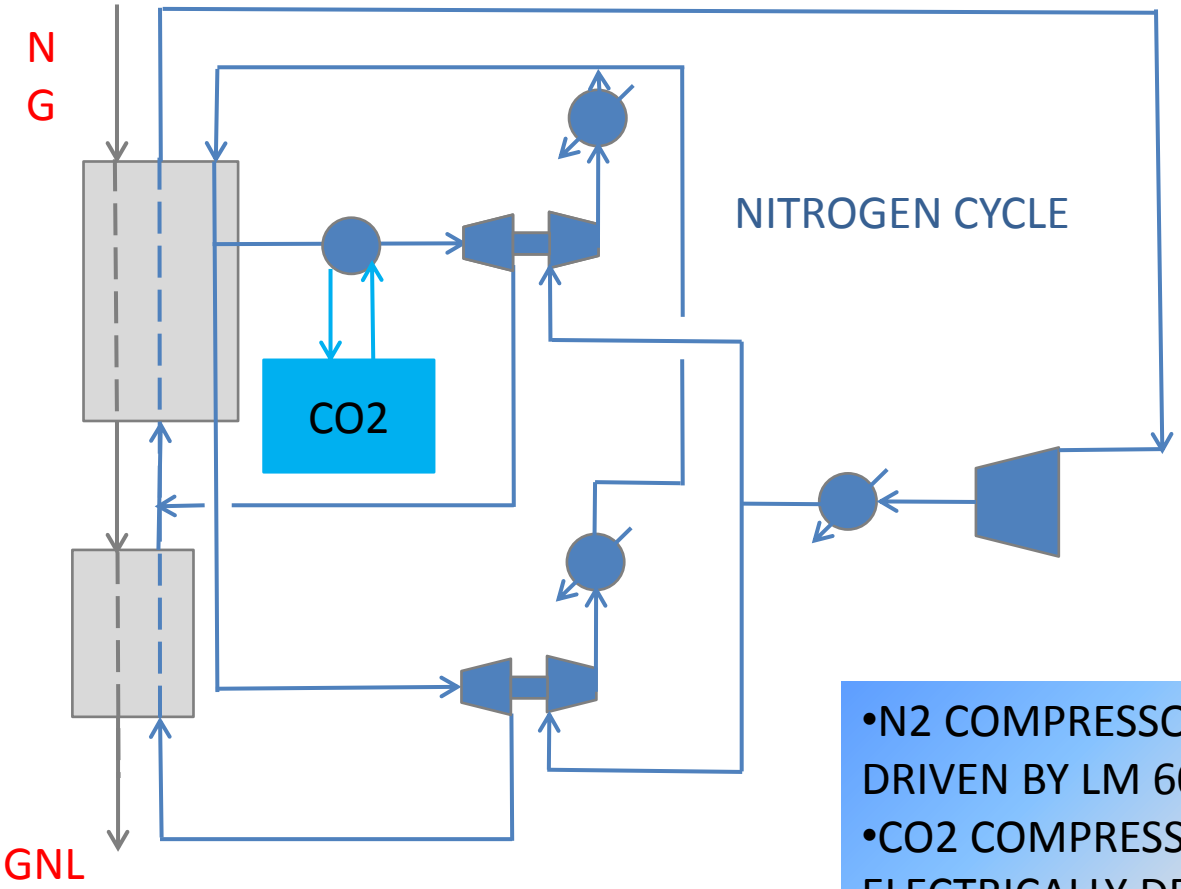
Animation (2 min),

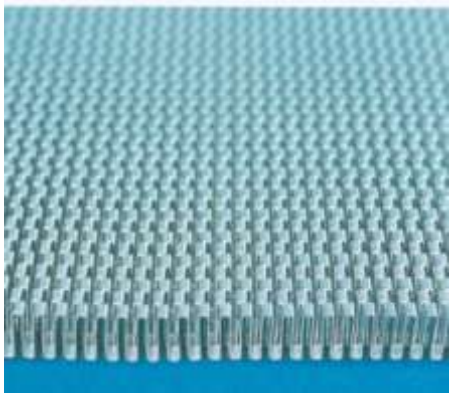
Animation

Animation

Animation (2 min),

PROCESS DESCRIPTION : NITROGEN CYCLE



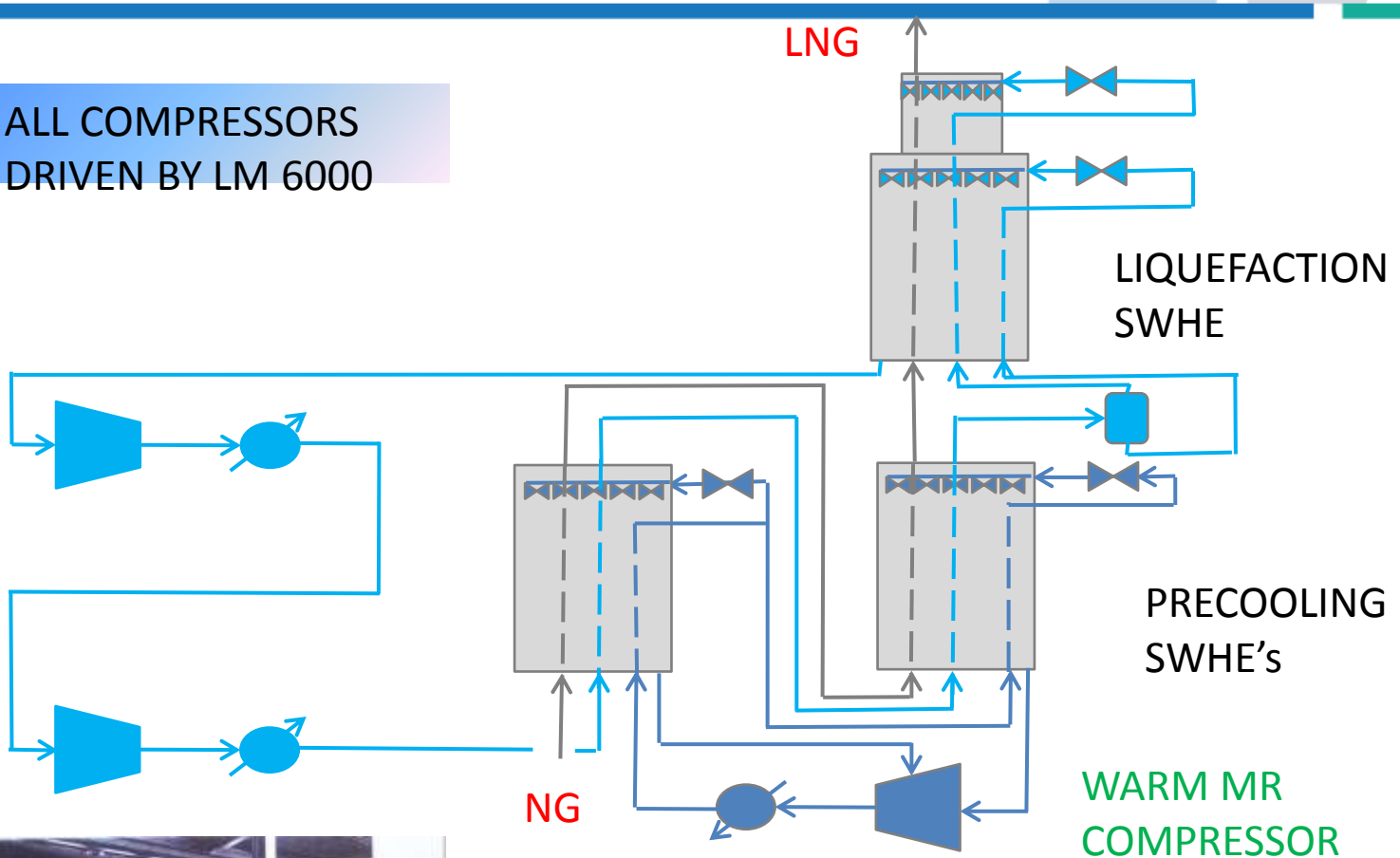


PFHE fins

- N2 COMPRESSORS DRIVEN BY LM 6000
- CO2 COMPRESSOR ELECTRICALLY DRIVEN

PROCESS DESCRIPTION : DMR CYCLE

ALL COMPRESSORS DRIVEN BY LM 6000



SWHE