

# 17<sup>th</sup> INTERNATIONAL CONFERENCE & EXHIBITION ON LIQUEFIED NATURAL GAS (LNG 17)



## LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

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Host Association





# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

## Liquefaction units of most existing LNG base load plants:

- Complex
- Use industrial type gas turbines
- Require large plot space
- Limited turndown
- Not easily expandable
- Use large electric helper motors
- Release refrigerants to flare on start ups and shut downs



# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

**This paper describes a new LNG process design that:**

- Uses aeroderivative gas turbines
- Uses two closed refrigeration loops
- Uses a propane pre-cooling compressor and a mixed refrigerant compressor in a tandem configuration
- Uses PFHEs for pre-cooling and SWHEs for condensing and liquefaction
- Does not use large electric helper motors



# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

**This paper describes a new LNG plant design that:**

- Minimizes complexity and plot space
- Has high turndown
- Has low specific power consumption
- Eliminates flaring on start ups and shutdowns
- Has rapid start-up time
- Can use different aeroderivatives that have been used or proven by test to be acceptable for mechanical drive applications



# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

The liquefaction unit of this plant design uses three fundamental modules to produce LNG:

- Gas turbine / Compressor
- Pre-Cooling
- Liquefaction

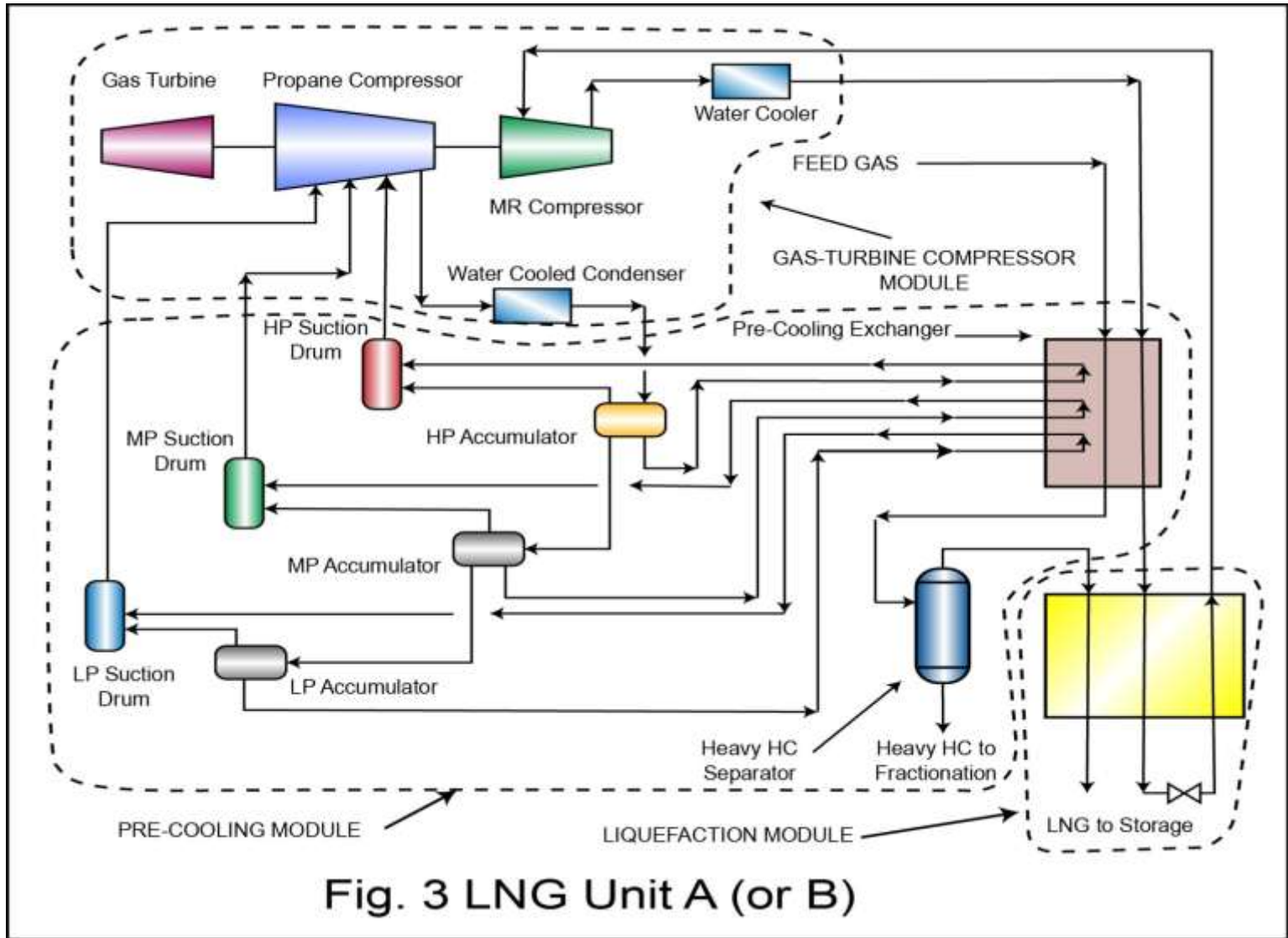
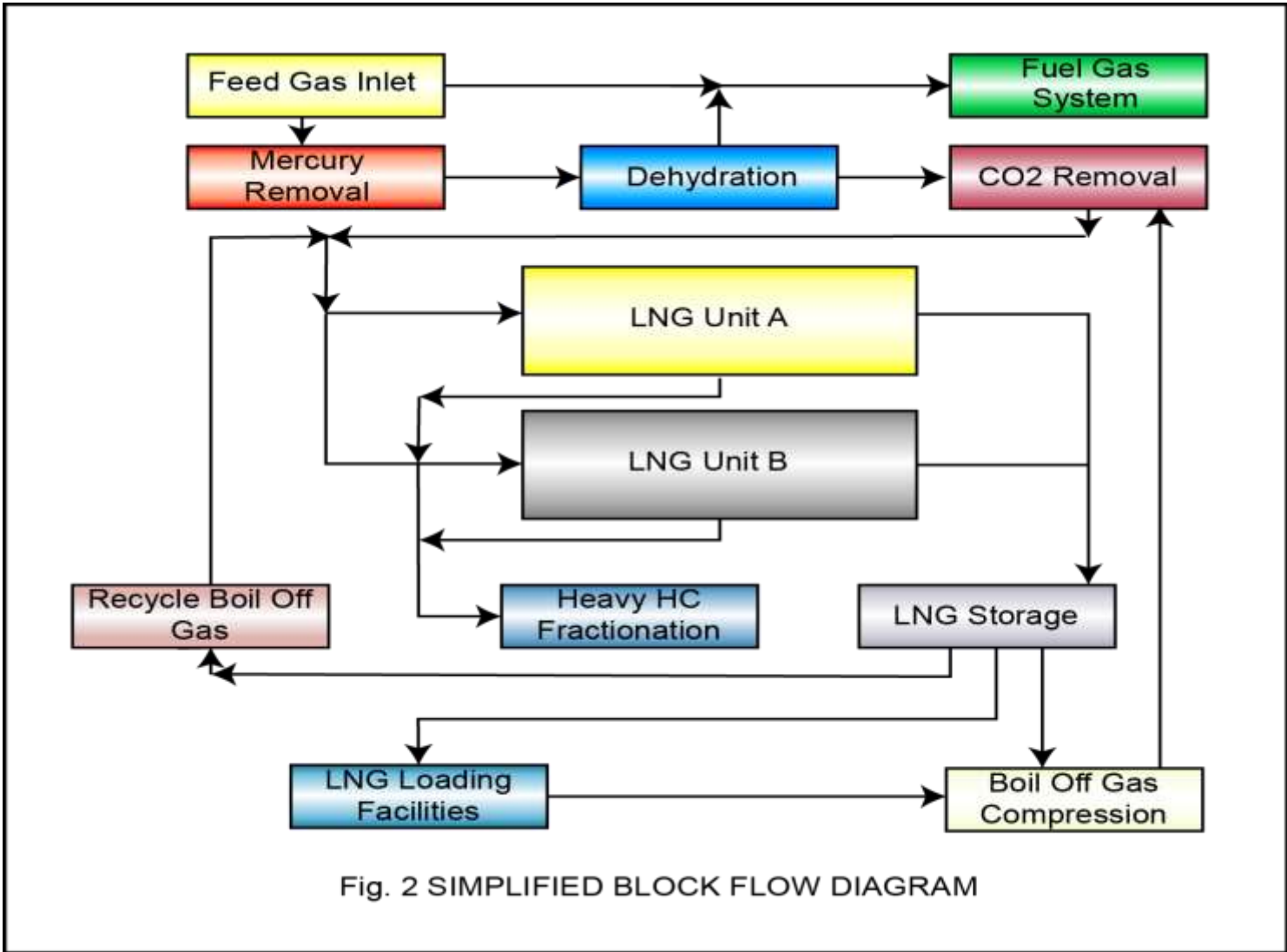


Fig. 3 LNG Unit A (or B)



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CONFIGURATION	MTPA					
	PGT16	PGT25 +	RB211	PGT25+G4	LM 6000 PF	Trent 60
1GT-C/1 PC/1 LIQ	0,28	0,64	0,70	0,68	0,90	1,13
2GT-C/ 2 PC / 2 LIQ	0,56	1,28	1,39	1,35	1,80	2,26
3GT-C/ 3 PC /3 LIQ	0,85	1,93	2,09	2,03	2,70	3,39
4 GT-C / 1 PC / 1 LIQ	1,13	2,57	2,78	2,70	3,60	4,52
6 GT-C / 2 PC/ 2 LIQ	1,69	3,85	4,17	4,06	5,40	6,78

All GT-C modules are in the same service

Numbers are based on 20 ° C, de-rate factors and availability of 0.93





# SELECTION OF REFRIGERANT COMPRESSOR TRAINS

## Design Development – Driver Selection

- Gas turbine - compressor train selection was solicited from compressor vendors having experience in providing compressors for LNG plants of comparable size.



## SELECTION OF REFRIGERANT COMPRESSOR TRAINS

### **Main points from compressor vendor evaluations:**

- Both compressors can be driven at a common speed, but higher than the speed of the gas turbine. Therefore, a speed increasing gear will be necessary.
- A single barrel type casing for the MR compressor is feasible but has to be located on the outboard end of the train, for reasons of maintainability.
- Normal discharge temperatures of the MR compressor were found to be acceptable.
- In the event of a full recycle operation, the MR recycle gas would have to be chilled to an inlet temperature below ambient. This requirement can be accommodated within the process.



## SELECTION OF REFRIGERANT COMPRESSOR TRAINS

### **Additional points from compressor vendor evaluations:**

- The propane compressor with two side-streams requires a horizontally split casing. This compressor has to be located on the inboard side. Even though this compressor consumed less power, its shaft and bearings had to be sized to be suitable for the full power delivered by the gas turbine, and with appropriate margins.
- Efficiencies of the selected compressors were found acceptable and the required power margins were confirmed.



# REFRIGERATION COMPRESSOR APPLICATION IN PROCESS

## Compressor Train Controls:

- Propane and mixed refrigerant compressors will rotate at the same speed.
- Speed was optimized for the two services by use of a speed increasing gear box.
- Control of the propane compressor will be conceptually by speed variation.
- Control of the mixed refrigerant compressor will be either by inlet guide vanes or by suction throttling.
- Compensation for a higher discharge pressure of the propane compressor (and hence power requirement) as the cooling water temperature increases can be accomplished by increasing the speed of the turbine.



## MECHANICAL DESIGN FEATURES OF THE PROCESS

### Criteria for selection of Gas Turbine Drivers:

- Power output
- High efficiency
- Low weight to improve constructability and maintainability
- Suitability for mechanical drive, based on experience or validation tests
- High reliability and availability
- Turbine output speed to be preferably suitable for direct drive for refrigerant compressors.
- Multi-shaft design and ability to start without use of a large electric starting motor.



# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

## Candidates for gas turbine driver:

- GE LM6000 PF
- R-R Trent 60 DLE

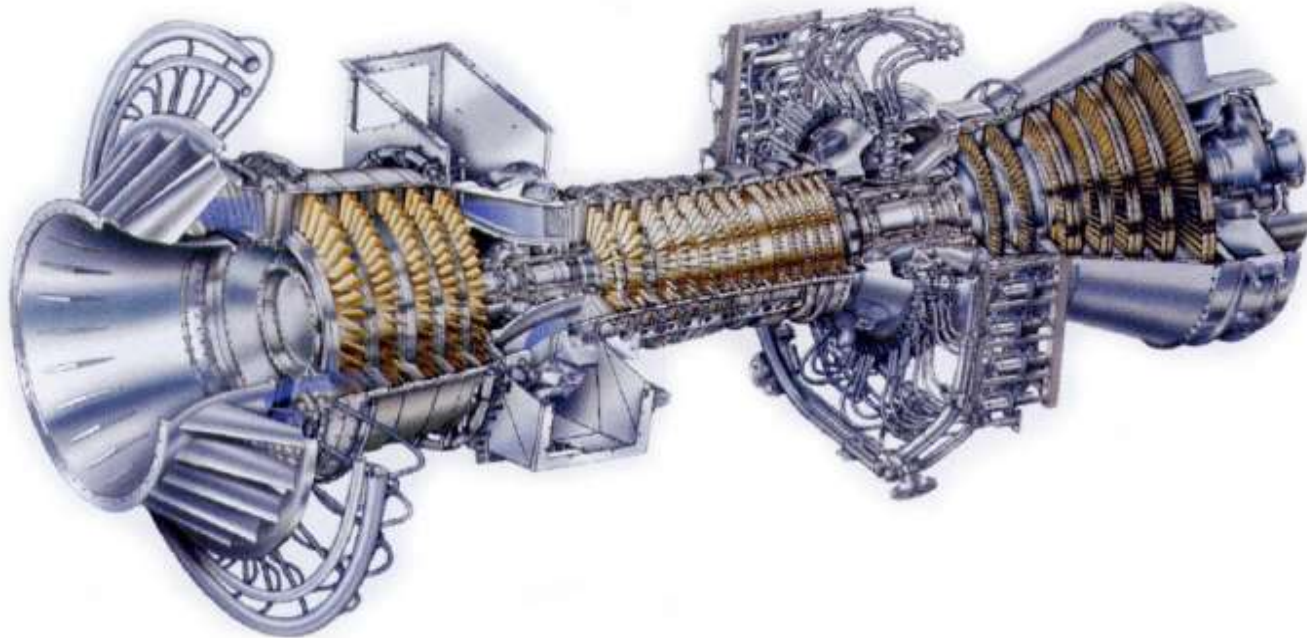


# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS

## LM 6000 PF Aeroderivative Gas Turbine

- No mechanical drive experience yet but recently selected for a new Australian LNG plant under construction
- Mechanical drive capability validated by extensive shop tests
- Power generation fleet has recorded 99.7% reliability.
- High start torque capability- no need for large helper motor
- Uses DLE technology
- Has high thermal efficiency of 43 %
- Two shaft spool configuration gas turbine engine
- ISO rating of 44 MW
- Starting torque capability and variable speed operation have been verified in shop tests

# LNG PROCESS USES AERODERIVATIVE GAS TURBINES AND TANDEM COMPRESSORS



**LM 6000 Gas Turbine**





## GAS TURBINE FEATURES – ROLLS-ROYCE TRENT 60 DLE

### Rolls-Royce Trent 60

- Three-rotor spool configuration
- Starting strategy similar to the LM6000
- Starter mechanism engages the intermediate pressure (IP) rotor
- Trent 60 power output is available only at the hot end
- Fleet includes both generator drive and mechanical drive applications.
- Combined fleet has recorded 99.31% reliability.
- Has high thermal efficiency of 43%
- ISO rating of 52 MW

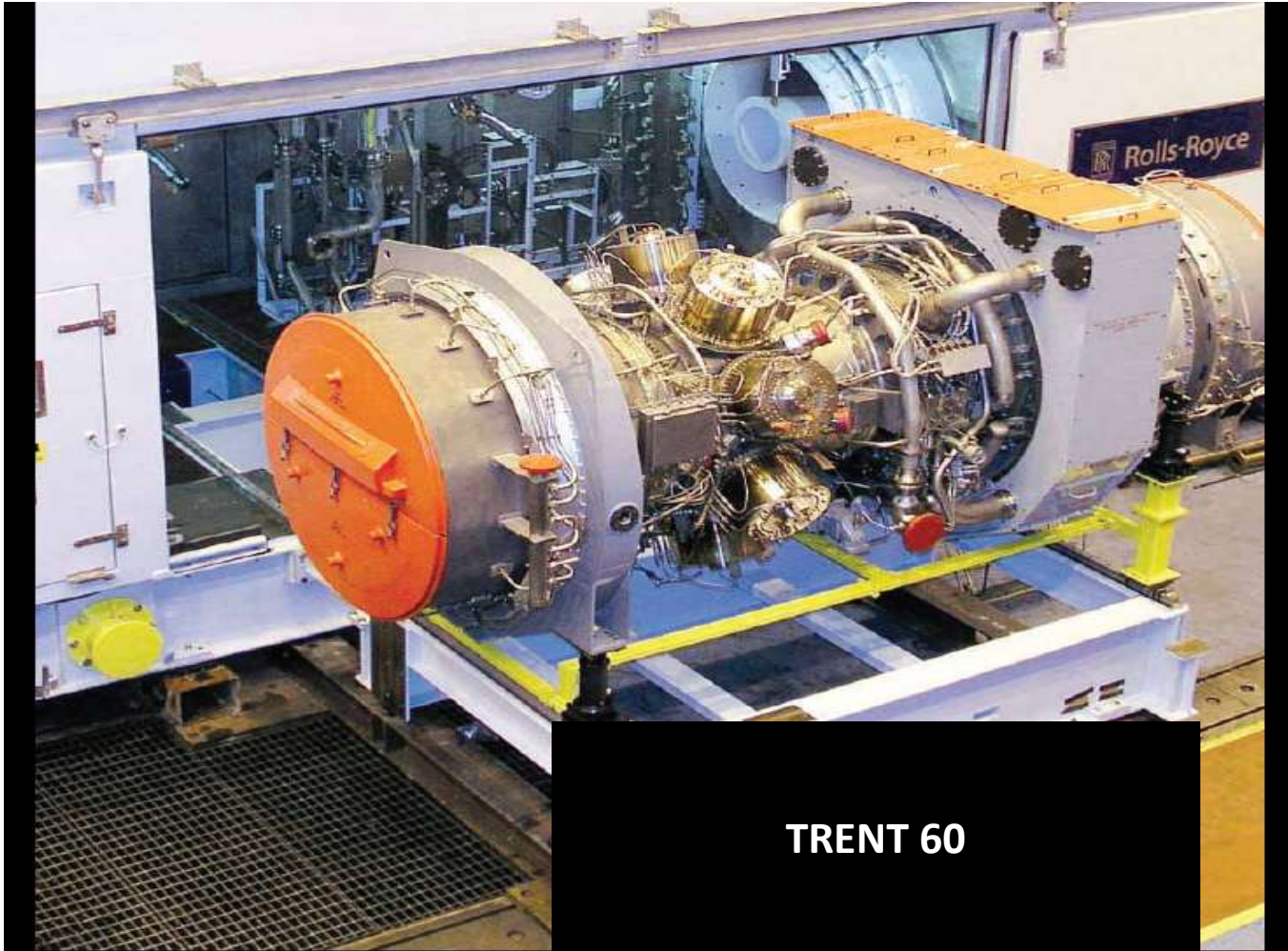


## **GAS TURBINE FEATURES – PROVEN EXPERIENCE VS. VALIDATION THROUGH TESTING**

### **Rolls-Royce Trent 60**

- Trent 60 has also undergone similar tests to those performed on the LM6000.
- Six machines have been in mechanical drive operation since 2007 in pipeline compressor applications in the Middle East.
- Another six have joined the mechanical drive fleet for pipeline operations in Russia.
- Three more have been ordered by the original customer.

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