

# Key Innovations

- First LNG plant designed with electric motors as process drivers
- First large scale gas turbine plant
- First totally air-cooled facility
- First gas turbine driven / air cooled plant
- First Frame 6 single shaft, fixed speed gas turbine drivers for C3 service
- First Frame 7 single shaft, fixed speed gas turbine drivers for MR service
- Use of steam turbine as starter/helper
- First hydraulic expander in liquefaction plant
- Use of a hybrid fresh water/seawater system
- First dual Frame 7 gas turbines as mechanical drivers (both services)
- Development of 5 x Frame 5 driver configuration
- Pre-assembly of air fin coolers prior to erection
- Optimization of air cooler temperature approaches
- First use of printed circuit heat exchangers
- Dual Frame 7 GT's (did not use helper motors continuously)
- Split-MR process design for power balance
- Concept of combining Split-MR APCI design with dual Frame 7's and continuous running helpers to increase capacity upwards to 4.7 Mtpa
- First to use starter motor as a generator to balance power
- Shortest FEED schedule of 5.5 months
- First LNG train of 5 MTPA
- Concept of recovering waste heat from Frame 7's for combined power cycle and heat duties

## KBR LNG Firsts



*"We have been at the forefront of the LNG industry for 30 years and continue to find innovative solutions for tomorrow's challenges."*

## KBR Have Pioneered:



- The design of the three bundle main cryogenic exchanger to improve LPG recovery, eliminate the need for C4 recycle, provide faster start-up and increase reliability with feed composition changes.
- The design of the main cryogenic exchanger to withstand the MR compressor shutdown pressure equalization, in order to minimize refrigerant losses and provide faster start-up
- The concept of allowing feed gas to flow through the main exchanger for a short time after refrigerant compressor trip to vaporize the liquid MR inventory and prevent thermal shock in the warm end of the main exchanger.
- Pumping forward liquid from the scrub tower reflux drum into the feed to the middle bundle of the main exchanger to stabilize the feed to the fractionation unit and enhance condensing in the middle and cold bundles.
- The design and installation of a two stage end flash system to save power and produce fuel at required pressure as well as to permit efficient extraction of helium if it is present in the feed.
- The design and installation of nitrogen strippers for efficient removal of nitrogen from LNG.
- The use of a four stage propane refrigerant system in LNG plants.

- The application of variable suction pressure (using guide vanes) on the propane refrigeration compressor to optimize LNG production by balancing the power consumption of the propane and MR compressors.
- The design and use of butted tubesheet shell and tube exchangers for the prechilling exchangers to avoid maldistribution and thus increase efficiency.
- The use of the three bed molecular sieve system and its isobar reactivation to reduce cost, simplify operations, extend life of the desiccant and minimize impact on fuel gas system.
- The use of CFD in studying air recirculation in air coolers and gas turbine exhausts in LNG plants.
- The design and installation of fuel gas mixing drums to dampen the rate of change of the fuel heating value to avoid shutdowns of gas turbines/boilers.
- The use of fractionation feed holding drum to decouple the fractionation from the liquefaction unit thus improving operation flexibility and expediting fractionation start-up.
- The design and installation of a depropanizer that allows simultaneous production of refrigerant-grade and commercial-grade propane.
- The design and installation of the top flash/bottom fill mixing system and top/flash/fill plate mixing system for LNG tanks, to protect against stratification and rollover.

## KBR LNG Firsts

- Replacement of propane cycle with more efficient scheme
- Large Rotoflow compressors
- High frequency pipe bending machine at construction site
- Pre-cast concrete pipe racks

- Design based on steam and cooling water
- First LNG plant designed with electric motors

- Concept of freezing and filtering the mercury in the scrub column bottom (KBR patent)

- 1st Frame 6 (C3) single shaft, fixed speed gas turbine drivers
- Frame 7 (MR) single shaft, fixed speed gas turbine drivers
- Use of steam turbine starter/helper
- 1st hydraulic expander in LNG plant
- Preassembly of 100m flare structure into 5 section
- 1st to integrate large commercial scale GTL plant with LNG plant

- Development of 5 x Frame 5 driver configuration
- Optimization of air cooler temperature approaches
- 1st printed circuit heat exchangers
- Dual Frame 7 GT's
- 1st to go with top nozzle configuration on main refrigerant compressors

- Shortest FEED schedule of 5.5 months
- Award of first single train of 5 MTPA
- Concept of recovering waste heat from Frame 7's for combined power cycle and heat duties

- RFSU for fastest developed project from FEED award – 48 months

