PRODUCTION OF VEHICLES LNG AT AN LNG PLANT

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ABSTRACT
This paper presents an economic variant to produce vehicle quality LNG at an LNG plant. It is often mentioned in different media about the use of liquefied Natural Gas (LNG) as alternative fuel for vehicles. The reality is that LNG has been used as a clean burning alternative vehicle fuel in thousands of trucks, buses, waste collection trucks, and other vehicles in the United States for more than 15-years. LNG as fuel for vehicles is key to reduce emissions of nitrogen oxides (NOx), particulate matter (PM), sulfur oxides (SOx), and greenhouse gases (GHG). For the same power, an LNG truck will have 90% fewer NOx and PM emissions than a diesel truck, 100% fewer SOx emissions, and around 30% fewer GHG emissions. LNG powered heavy-duty vehicles can achieve low emission rates without excess control equipment as it is today required for diesel engines in most of developed countries. However, LNG composition is not usually suitable to that end. LNG needs to be treated to reduce the content of ethane, propane and other heavier components to obtain an LNG rich in methane that can be used as fuel in combustion engines. Thus, it is needed to comply with the Methane Number (MN) spec.

CONCEPT: Vehicle LNG Production Unit
Wood developed a study to adapt the LNG of a regasification terminal to meet the required specifications. Such development can be applied to any facility with LNG storage that considers producing vehicle LNG on spec. The proposed installation can be integrated into a continuously working LNG regasification terminal. The produced LNG for vehicles would be stored in a dedicated tank to be sent to the different service stations by trucks.

The target of this installation is to produce LNG rich in methane, to comply with the mentioned spec, and not the recovery of heavier hydrocarbons. Idea is that all product streams that don’t meet the mentioned spec for the LNG can be recovered within the LNG Terminal to use either as fuel gas or vaporized with the plant LNG. Foreseen capacity is a continuous production of vehicle LNG of 600 m3/d (which has been determined to fit 12 trucks of 56 m3 capacity (87% of truck tank usage)). One way to get the LNG in spec for vehicles would be to install a cryogenic column and feeding it with the LNG. The column would extract the heavier components (ethane/propene (C2/C3/H)) maximizing the methane recovery. However, when analyzing the methane and ethane boiling temperature it can be observed that the difference between them and the other is 83 C at 3 bar (g). Due to this difference these components can easily be separated, with a significant efficiency, by simply vaporizing part of the LNG that feeds the separation unit. Thus, a cryogenic column would not be needed.

The unit configuration to be installed in the facility would include namely the following sections:
- Pre-heater / Condenser
- Adjustment Heater
- Separation vessel
- Vehicle LNG storage tank

LNG feed is coming directly from the Low-pressure header of the LNG regas terminal at 6 bar (g) and 160 C. Thus LNG, flow controlled, feeds the pre-heater/condenser E-001 which main objective is to ensure the total condensation and subcooling of the overhead stream from the separation vessel D-001 whilst a mass vaporization of 80% is reached. The LNG partially vaporized will feed the adjustment heater E-002 where an outlet temperature of -117 C is specified.

As mentioned, the difference in the boiling points of methane and ethane will allow to achieve a sufficient separation just by adjusting the vaporization rate. This final adjustment would be done with E-002.

In order to meet a MN of 100 the power needed is 89 thermal kw.
That two-phase stream will flow down to a separator vessel, out of which there will be 2 streams:
- Vapor current form the overhead with a molar composition of 0.028 ethane
- Ethane rich liquid from the bottom (0.56 molar) and high methane content (0.25 molar)

The stream from the bottom will be sent to the battery limit of the unit. The destination point is the LNG Regas terminal reconcorder where it is mixed with the plant LNG, where it will be vaporized and injected in the natural gas network.

The stream coming out of the separator overhead will flow to the first exchanger where it will condense and subcool to -155 C using the LNG from the terminal as cooling media. This is the vehicle LNG stream.

Vehicle LNG is then stored in a dedicated tank at a -1.5 bar (g) to be pumped to the loading stations.

The loading stations are balanced with the existing BOG header in the LNG regas terminal (pressure of 0.18 bar (g) approx.) when loading the LNG into the trucks there will be a vaporization surge, such vapor will go to the BOG header, therefore it is very important to subcool the LNG at the first exchanger. This BOG is to be used in the LNG terminal as fuel gas for the SCVs, or recovered in the reconcorder.

CONCLUSIONS
The process is relatively flexible since the target, as said, is not to recover any of the components and therefore the yield of the adjustment heater can be varied by modifying the outlet temperature. The estimated cost of this installation is around USD 12,000,000 and its execution period is around 21 months until start-up.

DEFINITIONS and PFD
Methane Number: can be assimilated as the Octane Number used for gasoline. MN also indicates the fuel tendency to knock. There are not many regulations worldwide regarding MN calculation to this end. The California Air Resources Board (CARB) method is the most extended calculation. There is also another correlation developed by the Gas Research Institute (GRI) that is also based on the Octane number.

Other reference, or recommendation for the Mn calculation, is the E.ON calculation procedure that is based on experimental data. The European Association of Internal Combustion Engines Manufacturers (EUROMOT) recommends to use this method.

Targeting to validate the mentioned calculation methods Wood performed a study comparing the variation of the MN of the LNG with different LNG compositions using the 3 mentioned methods.

The following graph shows the variation of the MN vs the Wobbe Index (WI) for six different LNG compositions.

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