Development of 7% Nickel Quenched and Tempered Steel Plates for LNG Storage Tanks and Transportation Vessels

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ABSTRACT

Changes in energy situation around the worldwide oil crises have brought about an increase in demand for Liquefied Natural Gas (LNG) which is a promising alternative energy source, providing for lower CO₂ emissions than coal and petroleum with a huge geographical resource base. The onset of shale gas production, the consideration of LNG as a ship engine fuel and the expansion of the petrochemical industry are other drivers of demand for similar infrastructure.

The structural materials used for cryogenic tanks and vessels are tailored to combine high strength to minimize wall thickness, with good fracture toughness to prevent catastrophic failure at cryogenic temperatures. The cryogenic structural 9% nickel steel grade has been largely used as a main material of the inner walls of LNG tanks and LNG transportation vessels for more than 50 years thanks to its excellent properties at very low temperature. Indussteel has developed a premium experience in the metallurgy of this material to supply excellent as-delivered quenched and tempered steel specifically designed to be user-friendly in terms of forming and weldability, as well as to provide for the safest in-use properties.

With that extensive know-how, Indussteel has developed new alternative solutions to further cater for the evolving demand, aiming towards safe and economical construction materials.

This paper reports the research and development results on 7% nickel quenched and tempered steel, now introduced in ASTM Standard A553/A553M as Type III and adopted by ASME in Code Case N°2842 to provide for rules of construction. At the time of writing it is under ballot for incorporation into API 620 Appendix Q and will be considered for naval classes.

7% nickel steel plates provide an excellent level of strength, toughness properties and a very good ability to arrest brittle cracks at very low temperatures, equivalent to those of 9% nickel. The developed 7% nickel steel, branded CryElso™ 7 is more economical, and the reduction of nickel content also significantly contributes to save natural resources. 7% nickel steel is intended to be used for the construction of storage tanks for LNG, ethylene, ethane and other liquefied hydrocarbons, as well as for their transportation vessels and piping.

KEY WORDS: 7% nickel steel, cryogenic, LNG, storage tanks, strength, toughness, welding.

INTRODUCTION

Liquefied Natural Gas (LNG) is one of the cleanest, safest and most efficient energy sources available today. LNG boasts a number of advantages which are driving its growth:

- LNG takes up about 1/600th the volume of natural gas. This allows a greater volume to be stored and transported;
- LNG is colorless, odorless, non-corrosive and non-toxic;
- LNG releases far fewer greenhouse gases than other fossil fuels, making it an environmentally responsible choice, contributing to improved product quality and reduces maintenance costs. LNG produces 25% less CO₂ emissions than oil;
- LNG is safer than other fossil fuels: in the event of a leak, LNG will simply evaporate (in fact, there have been no major recorded incidents with LNG for the past century);
- On average, LNG costs about 30% less than oil or coal;
- LNG has vast and widely dispersed geographically resource base stably available for many years to come.

The global demand of LNG remains high years even in the face of changes in the energy situation since the oil crises and other worldwide events of the last decade and taking into account the importance of environmental issues. Because of this, the storage and transportation of LNG is increasingly important and the worldwide construction of LNG storage tanks (Fig. 1) and transportation vessels (Fig. 2) is expected to continue to get higher in the future. The onset of shale gas production, the consideration of LNG as a ship engine fuel (Fig. 3) and the