FROM JACK-UP TO WTIV'S

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The first jack-up rig for oil and gas exploration was used over 65 years ago in the US Gulf of Mexico (GOM). These impressive structures are self-elevating out of the water enabling op-eration independent of wave height and have become the preferred rig type around the globe for shallow water. The construction of offshore wind farms has given rise to a new application of self-elevating structures in wind turbine installation vessels (WTIV). These WTIV's have a super large leg encircling crane (LEC) attachment for installation operations and propulsion system that allows to frequently change positions.

The legs of the WTIV consists of the foot (called spudcan) and the truss structure to which belong the vertical rack, chords and the bracings in between. Since 1970, Vallourec has been delivering seamless structural hollow sections of 690MPa (100ksi) yield strength for bracings to its customers for the largest self-elevating units like the CJ70 jack up rig or the NG20000 wind turbine installation vessel. In the last years Vallourec delivered for the largest LEC seamless hollow section up to 660 x 60 mm with yield strength of 690MPa/100ksi too.

Over a hundred new build WTIV's are expected to be built in the next 10 years to support the market development for offshore wind farm erections. Vessel commissioning and fabrication is accelerating with about 16 out of the 100 currently in construction or at the end of the design phase. In the US, Dominion Energy has started the construction of a new WTIV at Keppel AmFELS in Brownsville, Texas. This will be the first Jones Act compliant WTIV called the Charybdis named after a Greek mythological sea monster.

Figure 1 – Charybdis WTIV

To achieve Joe Biden´s plan of 30GW of offshore wind energy, the American Bureau of Ship-ping (ABS) indicates that an additional 5WTIV's will be needed to keep up with this ambition.

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Material and Alloy development

Superior quality, high strength steel is required for the construction of these new, cutting edge WTIV's. This will require manufacturers to have an intimate knowledge of steel chem-istry, manufacturing processes, and quality control. One concern in manufacturing this type of steelgrade for WTIV leg´s is cold cracking due to hydrogen introduction or high hardness that can impact material durability and toughness. Extensive and cumbersome precautions such as pre-heating, post weld heat treatment (PWHT) and extra low hydrogen content weld-ing consumables are taken to reduce the probability of cracking. Moreover, extensive non-destructive testing at the weld and adherent material needs to be performed with a waiting time up to 48 hours while further processing at the weld is interrupted. This is required due to the delayed cracking in case of the presence of high hydrogen concentrations in the heat affected zone of the weld.

In 2015 Vallourec started to design tubulars with low carbon content based on a well-balanced micro-alloying concept to ease fabrication, improve weldability and reduce the risk for cracking. Using purely martensitic alloys showed the above-described difficulties during fabrication at the shipyards leading to Vallourec developing a bainitic alloy which has by its nature a higher toughness compared to the martensitic ones. Vallourec went through an extensive approval program, for which the mill in Düsseldorf gained as first seamless pipe mill to be qualified according to ABS and DNV standards down to -60°Cfor steel with yield strength of 690MPa/100ksi.

Weldability

The bainitic alloy concept developed by Vallourec has a typical carbon equivalent (in accord-ance to IIW formula) of 0.55%, a critical metal parameter (Pcm) of 0.25% and a carbon equivalent in accordance to Thyssen formular (CET) of 0.33%.Whereas the common, pure martensitic alloys have typically slightly higher carbon equivalents and Pcm´s coming from the in general higher carbon content. This higher carbon content is the most important driv-er to differentiate between Zone III and Zone I of the Graville diagram [Graville] by evaluat-ing the preheating temperature of AWS D1.1 (ref).Vallourec's newly developed bainitic X100 (Vallourec´s proprietary grade Oceanfit® 100 WeldFIT) belongs to Zone I which states that cracking is unlikely and that the pure martensitic alloys are present in Zone III which is the worst Zone as it requires the previously described precautions.

Figure 2 – Graville Diagram [Graville]

Lab and in field trials with customers confirmed that the new Vallourec X100 is weldable without preheating and without PWHT, offers significant savings due to higher weld deposit rate, a wider range of fabrication as well as less rework of material related cracking. Find further details at Strötgen[et. al.].

Vallourec supports by its new developments the path to become a faster low carbon society and is able to contribute to lower the total cost of ownership and helps to reduce the lev-elized costs for offshore wind.

Graville, B. (1986) A survey review of weld metal hydrogen cracking.Weld World, 24 (9/10), 190–198.

Strötgen, D., Gourment, A., Hojda, R.(2021) "Welding performance of high strength X100Q / S690QLHHO seamless pipes without preheating for offshore structural applications" Pro-ceedings of The 31st International Ocean and Polar Engineering Conference, Rhodes, Greece, June 2021. ET