Technical article 1

Assessment of Code Compliance of Proximity Welds and Weld on Weld Practice in Offshore Steel Structures

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Welding is an important fabrication technique for joining of steel members in an offshore installation. Fundamentally it is a multidisciplinary subject that requires knowledge of physics, chemistry, metallurgy, electrical and mechanical engineering for a sound outcome. With the advance of the technology the welding equipment are becoming more efficient producing desirable outcome if practiced within set of specified parameters defined by welding specification procedure (WPS). WPS is prepared from international standards, technical specifications and recommended practices to meet the technical criteria set by engineering projects as well as companies and local authority requirements. Each code contains a set of specific practices providing directions for fabrication of the welds, which is required to be followed to achieve the production of an engineering sound weld. Sometime in the fabrication stage however, due to the fabrication misconducts or space limitation some of these requirements are not fully adhered to. Example of this is the required minimum distance between two adjacent welds. Most international standards and specifications require a minimum distance between two adjacent welds during fabrication of offshore structures. If the minimum distance is not practiced the new weld is placed in the vicinity of or on the existing weld joint, it results in Locally Intensified Welded Joint and the phenomenon is termed as proximity welds or weld on weld. This results in a noncompliance joint as per design code.

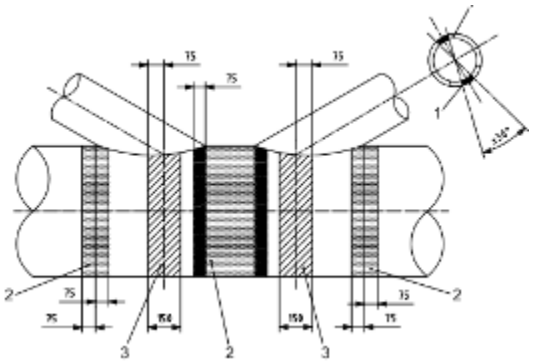

Figure 1: Prohibited Location (1, 2 and 3) for Circumferential Welds on Cord and Longitudinal Seams on Stubs, After ISO 19902

Most international codes and specifications require a minimum distance between two adjacent welds. That is, welding of two adjacent joints are required to be carried out with a specified distance from each other. Most of these codes however, have not provided a technical justification and explanation of the requirement for the minimum distance between the welds. It is stipulated that if the weld on weld practice is not envisaged in the WSP at the design or fabrication stages it may adversely affect the in-service performance of the joint. It is envisaged that the minimum distance is recommended in order to avoid any possible adverse effect on mechanical performance of the welded joint. Amongst these mechanical properties, fatigue and ultimate strength to a larger extent and fracture and cracking performance (especially in the zone where it is protected by CP (Cathodic Protection)) to some extent are affected.

Fatigue properties and performance of the joint is an important parameter in engineering design. The importance of minimum required distance for fatigue is threefold; effect of stress concentration from each weld proximity, effect of residual stress, and imbedded defect generated during welding. Concern over ultimate strength seems to be more of change in the microstructure of HAZ (Heat Affected Zone) to a hardened microstructure with reduced toughness. The change in the microstructure of the HAZ also has a profound effect on the environmentally assisted cracking performance of the joint in the submerged section, where hydrogen generation from CP application may potentially affect the joint performance. Drawing from above, weld on weld and proximity welds joints has implications both on the integrity of in-service structures as well as the new tubular structure in the fabrication stage.

As such, the ability to make an informed decision on the integrity of the noncompliance joint and the possible course of action upon the identification of the joint during the inspection both at the fabrication stage and in the service is of most importance.

Review on a number of offshore structure cases revealed that weld on weld and proximity welds though are a noncompliance with some design codes however it might not be an integrity threat and requires systematic assessment. In the several offshore case studies, where the fatigue performance of a weld on weld joint was subjected to engineering analysis, the result has indicated the performance of some of critical joints are acceptable with reference to the design life.
With focus on fatigue performance of joints containing weld on weld and weld proximity as a part of ongoing investigation in

Figure 2: Weld on W and Weld Proximity Identified During Inspection

PETRONAS it has been possible to propose a three level assessment methodology to assess the code compliance of the offshore structure joints containing weld on weld and weld proximity. These methodologies are in three levels, where the assessment starts from high level global analysis in level 1 and progresses to local modeling using Finite Element Analysis (FEA) and mechanical testing in Level 2. Level 3 is an assessment methodology for a scenario when weld on weld or proximity weld joint contains a sizable flaw.