

1.12.17. NON-DESTRUCTIVE EXAMINATION TECHNIQUES FOR QUALITY ASSURANCE AND RELIABILITY OF TUBE TO TUBE SHEET WELD JOINT OF STEAM GENERATOR FOR PROTOTYPE FAST BREEDER REACTOR (PFBR)

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Prototype Fast Breeder Reactor (PFBR) is a pool type Sodium cooled fast breeder Nuclear Reactor being constructed by India. Steam Generators of PFBR project are very critical equipments as they remove heat from secondary sodium circuit and generate steam for producing power. These steam generators are having single boundary for Liquid Sodium and water/steam. Sodium flows in shell side and water/steam in tubes in these steam generators. Tube to tube sheet weld joint in steam generators is the only weld joint in this sodium water/steam boundary. Water and Sodium react violently and large scale wastages are generated which results in long period shut down of reactor in case of any leak through sodium water boundary. Therefore reliability of tubes and tube to tube sheet weld joints is very critical in Steam Generator for economical operation of PFBR. Reliability of tubes is achieved by adopting highest standards of tube manufacturing and quality control tools during manufacturing. Reliability of Tube to Tube Sheet weld joints is achieved by adopting many essential steps starting from design of the joints and including manufacturing process and quality control methods. In general, Steam Generator tubes are inserted through tube sheet holes and fillet type weld joint is made between tube and tube sheet. A crevice is formed in this type of weld joint between tube sheet hole inside diameter and tube outside diameter which is a probable source of many issues during operation of steam generators. This type of joint is also not amenable to volumetric NDE examinations and therefore 100% efficiency cannot be guaranteed. In PFBR steam generator design, tube to tube sheet weld joint is a full penetration type butt weld joint. This butt joint is made between tubes and spigots (Nipples) of tube sheet which are prepared by machining and welded by automatic Internal Bore Welding (IBW) process. The joint so prepared is away from high stress locations and is also amenable to volumetric NDE examination.

Various Quality Assurance techniques are employed to get the required quality and reliability of tube to tube sheet weld joint of PFBR Steam Generator. Pre-fitup actions for this weld such as fine surface finish of weld edge preparation (WEP) and ultra fine cleaning in and around WEP area are implemented for avoiding any contamination in the welds. Tight fitup dimensional requirements are set and achieved during fitup for this weld joint to achieve the final dimensional profile and defect free weld joint. Tungsten electrode set up requirements, Pre Heat temperatures and flow of purging gas at outside and inside surface of weld joint are strictly followed to get the required quality and profile of weld joints. Each tube to tube sheet weld joint is individually heat treated locally by special method for relieving the residual stress immediately after welding. NDE examinations such as Visual, Dye Penetrant, Profile Measurement, Rod Anode X-ray Radiography and Helium Leak are carried out for every single joint to monitor and control the quality of each weld joint during fabrication. Each of these joints is also Hydro Tested at a specified test pressure for final acceptance of joint.

The details of various NDE techniques and processes developed and used for quality control purposes for tube to tube sheet weld joint of PFBR Steam Generator are described in this paper.