13.6 SLUDGE LANCING EQUIPMENT (SLE)

Periodic sludge lancing enhances steam generator life by mitigating corrosion between its tubes and tube sheet. The present modular sludge lancing equipment has been designed to dislodge and remove sludge from secondary side of tube sheet of mushroom type steam generators of PHWRs. This equipment comprises of:

- Closed loop de-mineralised water circulation system
- High-pressure remote lancing Jet Manipulator Assembly (JMA)
- Remote Visual Inspection System (RVIS)
- Instrumentation & control system.

The equipment is basically divided into six process modules, specially designed JMA, control panels, electrical power supply panel and RVIS. All dimensions of modules are within 2.8 m. The modules are interconnected with suitable flexible hoses with cam type quick release couplings. This entire system including JMA & RVIS is monitored and manoeuvred by electronic instrumentation and PLC-based supervisory control units. Successful working of sludge lancing equipment is demonstrated on a steam generator mock up. The schematic flow diagram of the sludge lancing equipment is shown below.
The six process modules comprise:

- Air-operated double diaphragm pumps for removing the sludge water mixture,
- Sludge tank and Rotary Cleaner for removing sludge particles above 100 μ;
- 30 μ, 2 μ & 0.5 μ filter assemblies for removal of dislodged sludge,
- Storage tank with 4 cubic meter capacity and centrifugal pumps for circulation
- High pressure Triplex Plunger pump for generating high-pressure water at 250 bar at a flow of 250 lpm.

The high pressure lancing water in the nozzle head assembly generates multiple high velocity jets along the 3 mm wide inter tube lanes of the steam generator to clean the tube sheet. This high-pressure water jet dislodges the sludge from the secondary side of steam generator tubes (of limited heights ~ 150 mm) and tube sheet face, which gets collected on the bottom tube sheet. This is extracted to Sludge Tank (ST-1) by self-priming air operated double diaphragm pump (EP-1 or EP-2) capable of handling 0 to 18.0 m³/hour of sludge water. This sludge water is passed through the rotary cleaner and further filtered using basket and cartridge filter stages before being circulated to the high-pressure triplex pump. The discharge of the triplex pump is connected to the nozzle head of the jet manipulator assembly.

The specially designed compact pneumatically-operated manipulator carrying the nozzle head assembly (jet manipulator assembly) moves in forward and reverse directions, in the no tube lane by gripping to the steam generator tubes. The nozzle head is also moved vertically up/down for effective lancing. The camera positioning, control and lighting module of the Remote Visual Inspection System (RVIS) are connected to another pneumatically operated manipulator, for visual inspection of the tube sheet. The camera module of the RVIS houses four CCD cameras with 75, 50, 25 & 4 mm focal lengths and light source. The pan & tilt mechanism gives angular orientation to the camera module. The process modules are located in the ground floor and the manipulators & valve control stations are located close to the steam generator in the SG floor.

The equipment is maneuvered remotely from two control consoles. The interlocked equipment and manipulator controls are implemented using networked PLC-based control system.
Important equipment of the sludge lancing system

- Air operated diaphragm pumps (EP-1 and EP-2)
- Sludge tank (ST-1), Centrifugal Pump (BP-1), Rotary Cleaner (RC)
- Main storage tank (ST-2)
- High pressure Triplex plunger pump (TP)
- Main control panel
- Mock-up Assembly
- RVIS
- Cleaning operation
Performance evaluation of lancing nozzles

Snapshots of the ceremony of handing over of sludge lancing system to NPCIL, attended by Chairman, AEC, Director, BARC, CMD, NPCIL

Kundan Kumar, <kundan@barc.gov.in>