

# Case study: Modification of Emergency Stop Valve following damage

## 1. Background

The 320 MW HTC unit was shut down for inspection of the HP Emergency Stop valve (ESV) and Governing valves (GV's) due to restricted valve movement experienced in operation. Upon opening the ESV it was found that the chest seat had come adrift and damaged the spindle seat as well as the steam chest location areas. The seat diffuser section had broken up and pieces went through into the GV's.

The ESV chest seat moved in the cavity between the valve spindle seat and chest body, severely damaging the location surfaces. Additionally, a crack was found at the rear of the original rear interference fit landing. See Figure 1 for the original design and Figures 2 and 3 for the damage.



Figure 1: Original design



Figure 2: Damage to ESV spindle head



Figure 3: Damaged ESV seat in position

Scanning of the actual components was done during the evaluation of the damage and repair options. The steam strainer was also damaged in the process and required replacement.

### 2. Original design

The OEM Design consisted of a sleeve shrunk fitted into the chest at two shrink fit landings. Landing 1 was on the inlet of the seat and landing 2 along the length of the sleeve after the axial landing that secured the seat in the axial position. The seat was seal/lock welded on the inlet outer diameter to secure it in position.

The design relied on the shrink fit and weld for axial restraint of the seat. The seat did not have a secondary restraint built into the design such that it would be restricted should it come loose. The seat has a relatively thin wall and is directly exposed to the steam. The chest in the area where the seat is located, has a much larger cross section and is also shielded from the steam by the seat.

This situation will cause thermal expansion differences between the chest and seat. Therefore, the radial shrink fit and axial location between the seat and chest will vary during thermal gradients. With steam temperature in an upward gradient the compressive strain in the seat and chest will increase and conversely, with lowering gradient, the compressive strain will decrease. With time and creep, the compression decreased, causing the seal weld cracking, resulting in the seat coming adrift.

The design with two radial interference fit landings and an axial landing in between, creates the risk of trapping moisture in between the radial landings. As the machine heats up the seat expands faster than the chest. The moisture trapped then builds pressure it reaches saturation temperature, the pressure then acts against the axial locating landing to assist in pushing the seat out of position toward the inlet of the valve.

The original design had a radial gap of more than 1mm between the seat at the outlet. This allowed movement and potential for vibration of the seat at the outlet. NDE of valve chest found a crack at the position of the original interference fit landing. The depth of the crack was found to be between 14 and 4 mm, see Figure 4.

The other ESV on the machine was also opened and the same failure mechanism in an earlier state was identified, see Figure 5.





Figure 4: Scanned damaged chest with the chest removed Figure 5: Crack in the weld of the LH ESV seat showing the position of the crack

### 3. Recovery

The valve seat design was customised to cater for the damaged chest as well as incorporating design improvements as per the following criteria:

- The valve function had to be restored to the original condition
- Avoid weld repair
- The repair time had to be kept to the minimum
- Uncontrollable variables had to be avoided
- Work had to be executing with activities in parallel as far as possible
- The weaknesses of the original design that lead to the failure must be addressed
- The solution had to conform to best practise engineering and design standards and had to be peer reviewed

The following actions were carried out in preparation:

- The damaged chest and components were 3D scanned to determine the exact geometry of the damaged components
- The geometry of the undamaged valve was scanned and used as reference geometry
- Critical required dimensions were measured and confirmed
- NDE (MPI) was done on all affected components and areas
- UT PAUT was done on the crack in the chest

- Weaknesses of the geometry was compared with best practice valve design to identify improvement options
- The new valve seat and machining contour was designed to incorporate the limitations of the geometry and design improvements

## 4. Proposed solution

- The new valve seat when fitted had exactly the same flow characteristics and geometry as the original design
- No weld repair of the chest will be required
- All damaged material including the crack was machined away for the new seat
- The stress characteristics of the seat is much better than the original due to the geometry of the interface and the fixation bolting
- Pressure relieve gaps will ensure the risk of trapped moisture was removed
- The new seat will have a backup restraint from the inlet steam strainer
- The seal/lock weld is was replaced with axial bolting
- The possibility of diffuser vibration was addressed by small clearance at the diffuser outlet
- Axial and radial interface landing geometry was designed to reduce thermal and mechanical stress
- The final design was subjected to peer review and approved without modification
- The seat material was changed for increased life expectancy
- The machining of the chest was done in situ while the new seat manufacturing took place
- Special tooling was designed and build for quick and accurate installation of the new seats
- Due to the improved design the decision was made to replace both ESV seats

## 5. Conclusion

The improved seats were installed in two units as planned and the valve is operating as required.

