



Upgrading Pumps for Nuclear Applications

ART WASHBURN
SULZER PUMPS

The Oconee Nuclear Station (USA), operated by Duke Power, commenced operation in 1973. To date, it has produced more electricity than any other nuclear power plant in the United States. In 1995, the owner reclassified the pressure boundary portions of its commercial circulating water pumps for safety-related service and recently awarded Sulzer a contract to upgrade twelve large cooling water pumps to nuclear-safety standards.

▶ Located in north-west South Carolina (USA), Oconee Nuclear Station (Fig.1) includes twelve circulating water pumps for its three 870-MW generating units to transfer water from Lake Keowee through the condensers.

The pumps are Sulzer – formerly Baldwin-Lima-Hamilton – single-stage semi-axial flow vertical (SAFV) pumps. Originally manufactured as a commercial component for circulating water pump application, the



1 Duke Power has awarded Sulzer Pumps a contract to repair and upgrade to nuclear-safety standards twelve cooling water pumps for the Oconee Nuclear Station in the USA.

pumps perform a safety-related service to function as a conduit to channel fluid from the lake to the discharge flumes and provide suction head to safety-related cooling water pumps. They are affected by a recent reclassification of the pressure boundary. While existing pressure-retaining pump components do not require back-fit by replacement or design justification, all repairs and replacement of

2 When upgrading a cooling water pump to nuclear-safety standards, much attention was paid to the identification of weld defects, using non-destructive examination techniques.



pressure-retaining pumps obligate safety-related design, procurement and traceability of materials, as well as standardized fabrication and inspections.

Duke Power commissioned Sulzer Pumps to repair, dedicate and seismically qualify for nuclear safety-related service the twelve pumps after more than 25 years of service.

Rules for Safety-related Work

The work on the Oconee pumps is carried out in the Sulzer Shreveport service center located in north-western Louisiana (USA), which has performed nuclear repair activities over the past three years as well as non-nuclear repairs for over 25 years. The service center was recently selected as the Sulzer primary nuclear repair center.

A customer-approved nuclear quality assurance program has been established at the Shreveport service center to support nuclear repair activities. The program's scope includes sensitive process steps like document control, equipment calibration, procurement, design control, inspections, certification of co-workers, material handling and storage, as well as work operations. Project work on the Duke Power pumps was performed according to instructions reviewed and accepted by the customer and an authorized nuclear in-service inspector.

No construction code or standards applied to the original design of the pump other than design drawings and bills of material. This resulted in significant challenges during the implementation of the project with regards to design – which included modifications and seismic qualification – as well as

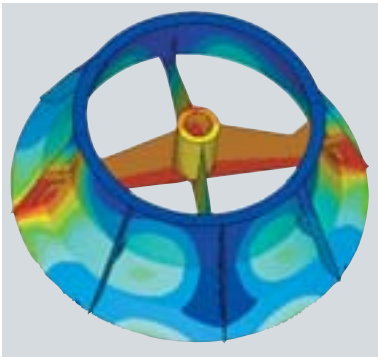
procurement and traceability of material. Much time and effort were involved between the utility and Sulzer in reviewing historical documentation to understand the original design of the pumps.

Precision Work on Large Components

The inspection of the units resulted in identification of numerous deviations from original design drawings. For example, certified weld inspectors at the Shreveport service center discovered numerous issues with weld conditions and weld configurations (Fig. 2). Extensive weld repairs were required for the rebuild effort. Size and weight of the pump parts made the repair activities a challenging task for the machinists and mechanics at Shreveport. Weld repairs alone required in excess of 320 kg (700 lbs) of weld wire. The pump assembly weighed more than 28,000 kg (62,000 lbs) while some parts and 2.5-m diameter bores required machining to tolerances as low as 0.076 mm (0.003"). The majority of carbon steel components exhibited corrosion damage after 25 to 30 years of operation requiring extensive repairs. A new coating system was necessary since the original coatings included hazardous materials (lead and asbestos).

Seismically Safe Design

To ensure the safety of the pumps in the case of an earthquake, a seismic finite-element stress analysis was carried out (Fig. 3). The analysis verified pump design integrity with respect to seismic loading in combination with operating loads. Stresses were calculated for pressure-retaining components, an-



3 A finite-element stress analysis was generated to seismically qualify the pumps in the case of an earthquake and operational loads (suction bell figure shown).

chor bolts and welds for pressure-retaining components, as well as significant components which provide overall support of structural integrity. As the documentation of the original pump was not reliable enough to substantiate materials of construction to support assumptions made in the seismic analysis, positive material identification via optical-emission spectrometer and hardness testing were performed on pressure-retaining components to validate material specifications. Thus the allowable stress data used in the fi-

nite-element analysis could be based on equivalent ASME code material as documented by these measurements.

Risk of Cracking Eliminated

During periodic inspections on the accessible portions of the installed cooling water pumps, Duke Power had detected cracking of the pump suction bell inner ribs, which connect the suction bell to its bearing. A finite-element model of the entire SAFV pump was used to identify the root cause for the suction bell cracking. Vortex shedding of fluid flow around solid objects like the suction bell support struts excites these objects, and the vibration leads to fatigue cracking of the affected parts. With a modified design, the peak stress was reduced by the factor of 13, thus eliminating the risk of cracking in the refurbished pumps.

The first pump repair was completed in 2000, with one pump being repaired and upgraded each year since (Fig. 4 and 5). The fourth pump is scheduled to be upgraded and shipped back to the customer by April 2003. Both careful coordination between Duke Pow-



4 A semi-axial flow vertical impeller assembled on shaft is ready for pump assembly.

er and Sulzer as well as a focus on the many project activities has led to zero impact to generating capacity for the Duke Power Oconee Nuclear Station. ◀

CONTACT

Sulzer Pumps (US) Inc.
 Art Washburn
 7401 Atkinson Drive
 Shreveport, LA 71129
 USA
 Phone +1 (1)318-682 30 45
 Fax +1 (1)318-686 05 62
 art.washburn@sulzerpumps.com



5 After extensive repair and upgrading, one of twelve cooling water pumps is transported back to the customer.