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REMOTELY MAINTAINED WASTE TRANSFER PUMP (U)

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REMOTELY MAINTAINED WASTE TRANSFER PUMP

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ABSTRACT:

Westinghouse Savannah River Company (WSRC) operates the Savannah River Site (SRS) for the Department of Energy (DOE). Waste from the processing of irradiated material is stored in large shielded tanks. Treated liquid wastes are to be transferred from these tanks to the Defense Waste Processing Facility (DWPF) for incorporation in glass suitable for storage in a federal repository. Characteristics of the wastes range from water-like liquid to highly viscous wastes containing suspended solids. Pumping head requirements for various conditions ranged from 10 meters (35 feet) to 168 meters (550 feet). A specially designed, cantilever type, remotely operated and maintained pump was designed and built to transfer the wastes. To demonstrate the design, a prototype pump was built and tested thoroughly with simulated waste. Severe vibration problems were overcome by proper drive shaft selection and careful control of the space between the pump shaft and fixed running clearances (sometimes called seals). Eleven pumps are now installed and six pumps have been successfully run in water service.

BACKGROUND

The Savannah River Site has operated since 1953 producing defense materials by the irradiation and separation of various radioactive materials. This activity has resulted in the production and accumulation of large volumes of highly radioactive wastes which are presently stored in large storage tanks. Construction of the DWPF was begun in 1983 to incorporate the radioactive waste in glass suitable for permanent storage in a federal repository.

Three different waste streams will be transferred between the waste storage tanks and the DWPF. Wastes vary in consistency from that of water to liquid containing 10% or more suspended undissolved solids with high viscosity resembling latex paint. Pumping facilities are located up to 600 meters (2000 feet) apart with vertical lifts up to 20 meters (65 feet).

Processing facilities for radioactive materials at the SRS are located in heavily shielded buildings and operated and maintained using remote handling equipment. Traditionally, single piece, cantilever pumps, which can be serviced by large overhead cranes, have been used to transfer liquid materials in these facilities.

DESIGN CRITERIA

Basically, the cantilever pump is a vertical motor-driven pump with the motor and two sets of shaft bearings located above the tank top. The pump itself is located at the lower end of a 1.7-meter (5-1/2 foot) shaft and has no bearing support. This design avoids the use of bearings in a highly radioactive, corrosive and erosive medium. Although shaft bearings are kept free of pumped liquids, bearing failure ultimately occurs and has been the predominant cause of mechanical failure.

Preparing a failed unit for repair or disposal requires rigorous and expensive decontamination of the pump portion exposed to radioactive liquid. Therefore, the new pump unit consists of two separate assemblies which can be serviced remotely. An upper assembly incorporates the motor and bearings and upper shaft, and a lower assembly contains the pump and lower shaft. Shafts of the two assemblies are designed to be coupled and uncoupled remotely from an overhead crane with lifting hooks and an electric wrench. A long draw bolt through the hollow motor shaft is connected to the top of the lower pump shaft to engage and disengage the coupling connecting the two shafts. The lower end of the draw bolt is threaded and the bolt is inserted into the lower pump shaft with an electric wrench. Before the draw bolt is tightened, the coupling ends of the two shafts are oriented by bumping the motor and engaging a spring-loaded pin into a hole in the shaft coupling.

To meet process requirements for transferring batches of waste of about 23,000 liters (6000 gallons) each, a nominal pumping rate of 380 liters per minute (100 gpm) was selected. The broad range of fluid characteristics (fluid viscosities range from 0.6 to 30 centipoise) require pumping heads ranging from 10 to 168 meters (35 to 550 feet) of water. A 3600 rpm electric motor with variable frequency speed control serves as the pump driver. With the impeller design selected, speeds between 900 and 2800 rpm deliver the required flow.

PROTOTYPE PUMP TEST

To ensure integrity of the design, a prototype pump was built and tested before finalizing and releasing the design for production model pumps. In early tests using water as the pumped medium, vibration caused by shaft whip at motor speeds above 2000 rpm was excessive and caused metal contact between the shaft and fixed running clearances. Initially, a 7.6-cm (3-inch) solid drive shaft was used, but experimentation with different size solid shafts, impeller redesign, and both fixed and floating running clearances did not resolve the vibration problem.

The Du Pont Engineering Department then engaged Vibco, a consultant company of mechanical engineers at the University of Virginia, for advice on running clearances and rotor dynamics. Examination of a rotor dynamics mathematical model developed from the design did not identify the source of the problem. Further investigation by Vibco led to a two-part solution. Replacement of the solid drive shaft with a stiff 10-centimeter (4-inch) diameter hollow shaft raised the shaft natural frequency above the maximum operating speed, a critical factor. Second, calculations showed that the shaft could be stiffened further by reducing the clearance between the shaft and running clearance at the pump housing. The diametral running clearance was reduced successively from 20 millimeters (80 mils) to 5 millimeters (20 mils). Subsequent tests with the prototype pump verified that vibration was low and acceptable.

The prototype pump passed a 100-hour endurance test with simulated sludge waste containing 20% suspended solids. However, subsequent testing with simulated precipitate material containing abrasive, suspended solid particles created severe erosion of the metal surface of the shaft running clearances. Replacement of the type 304L stainless steel with Stellite 6® partially alleviated the problem, although it was necessary to use Stellite 12® to achieve acceptable wear.

PRODUCTION MODEL PUMPS

A total of twelve production model pumps were built in addition to the prototype pump. The twelve production pumps were thoroughly tested for performance at the vendor's shop before shipment to SRS. Each pump was operated over a wide range of flows at 1000, 2000, and 3000 rpm, and easily met the vibration specification of 3 mils measured at the motor housing. Remote capability was demonstrated with two of the completed pump assemblies by interchanging the motor and pump units and repeating the performance tests.

Unique design and precision machining by the pump vendor, Barrett Haentjens Pump Company, produced a shaft coupling design which provides motor and pump assemblies which are well balanced and interchangeable, providing flexibility and requiring a minimum of spare parts. Failed motor units can be replaced rapidly. In addition to the original applications identified, subsequent projects at the SRS have specified additional pumps of the same design.

Presently, eleven pumps are installed in several different facilities and six of the installed pumps have been run satisfactorily in water service.

[NOTE: At the time of this design and development work, E. I. du Pont de Nemours and Company, Inc., was the operating contractor at the Savannah River Site.]

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