Welding Saves Costly Pump Casings

Shock from rapid load changes in these 1600-psi boiler feed pumps called for inner casings made of chromium steel, an alloy difficult to cast without flaws. Carl Barlow tells how careful casting procedure and welding* licked the leak problem

CARL N BARLOW

Mechanical Engineering Inspector, Design & Construction Div, Power System of the City of Los Angeles

▶ THE HARBOR STEAM PLANT of the City of Los Angeles is built directly over the dome of a large oil field. Because this location makes it vulnerable to seismic shock, station design incorporates more safety factors than conventional plants of equal capacity. Original unit No. 1 and recently installed unit No. 2 are designed to pick up load quickly.

While this is one of the world's most modern steam-generating plants, five years' experience with unit No. 1 bears out the fact that improvements can be made in certain operating parts of the plant.

Designed as a hot standby for quick pickup if the other energy sources in the city fail, No. 2 unit operates as a spinning reserve generating 5000 kw when idling. Capable of withstanding extreme shock, it picks up to 75,000 kw in a few minutes, delivers it for two hours, and then returns to 65,000 kw, its rated output. All parts of this 900-psi 915-F unit are designed to withstand higher load shock than occurs in plants operating at lower pressures.

Feed Pumps. When "outage" occurs in one or more transmission lines and the quick pickup begins to function, one point of great load shock is in the boiler feed *pumps.* At 1600 psi they force feedwater through a closed heater and into the boiler drum, which operates at 1050 psi. When plant idles, one of two pumps carries the load. At maximum capacity, both pumps run in *parallel*, with their output varying from zero to normal full-load capacity against a variable discharge head, suction pressure and temperature. Under quick pickup they sometimes have to handle cold water.

On standby, the pumps normally take water at 12 psi and 245 F from a deaerating-heater storage tank. Upon an "outage," pressure increases to 140 psi and temperature to 360 F. As steam demand at the turbine throttle increases, subsequent flashing of water in the boiler drum surges the pumps from zero pressure to full-load conditions. This surging puts a terrific stress on the pumps because at this time they are each handling full *capacity*—375,000 lb an hr of water. Originally the pumps had inner-volute casings of carbon steel, Fig. 1, and handling such an enormous quantity of feedwater under these high-stress conditions proved more than the metal could long endure.

After 7000-hr service one casing gave way. It was repaired by fill-welding, remachining to oversize dimensions, and fitted with oversize wear rings. A spare casing and element were used while the manufacturer overhauled the carbon-steel casing—a costly process that might lead to the loss of a pump during "outage" when it is most needed. After 15,000 hr of service the casings were beyond repair, and it was evident they would have to be made of more enduring metal.

Chromium Alloy. The steam-design section of the Dept of Water and Power had conducted extensive research for *an alloy with higher wear-resisting* qualities, which would also resist oxidization and be suitable for high-temperature service. Many recent applications of chromium-steel alloy for other services indicated that it possessed all the desired *requirements.* Of those considered, 11½-13% chromium alloy (ASTM No. A221-39, Class A) has the most ductility at high temperatures with the least corresponding brittleness at room temperatures. It lasts about three to five times as long as carbon steel under extreme wear.

Peculiarities of this alloy make it difficult to cast. All parts of the mold where sections join must be gated and extra large risers used. The 11½-13% chromium alloy has amazing thermal sluggishness and does not readily flow into restricted areas. After pouring, when the metal is no longer plastic and is cooling between 700 to 400 F, it has a split and suppressed transformation. This creates internal stresses that result in cracking.

The alloy must cool completely in the mold as it will air-quench and set up added stresses at temperatures as low as 400 F. *Since this sluggishness* is an inherent quality of metals of this type, it is natural to suppose they would also show a tendency to crack from stresses caused by high heat during welding, or immediately thereafter. But when the proper procedures for preheating, welding and stress relieving are followed they can be welded without damage.

Casting the Alloy. The Byron Jackson Co, Vernon, Calif, had the original contract to supply the pumps for unit No. 1 with carbon-steel volute inner casings. The company was also given the job of replacing these casings, because it was the successful bidder on pumps *for unit No. 2. They ordered* castings for both contracts from the Utility Electric Steel Foundry of Vernon. The castings were poured during *a damp foggy night.* On arrival at the foundry next day it was learned the night crew, with heavy production and the need for molds and space, had removed the castings before they were completely cold.

The air-quenched alloy at once began to show its peculiarities. Internal stresses were manifested by a myriad of tiny cracks on the surface and some deeper pits. The foundry elected to chip certain sections and fill with weld metal before sending to the contractor. After receiving the castings the contractor proceeded with the rough machining. As it progressed, small cracks localized into larger ones that extended through the castings.

After several machinings the castings were subjected to a hydrostatic test and many leaks found. An attempt to make repairs by fill-welding was not successful. The contractor now realized that *the procedure would have to be more* precise for alloy castings than for the carbon steel previously used.

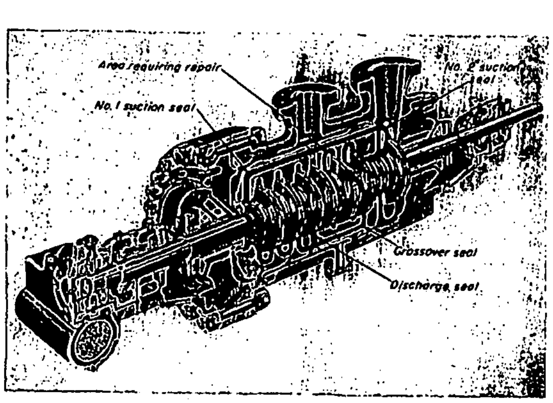
This costly experience showed the need of a different procedure. Time requirements of the original delivery date had expired and the production of now, completed casings would require 120 days. The Dept of Water and Power extended the delivery date, because of the serious problems involved in this new experimental type of casing. Obtaining finished inner-volute casings of this alloy was deemed extremely important because they would save many replacements in the Harbor Steam Plant. With one unit operating, a second scheduled for operation early in 1948 (now in operation) and three additional units under construction, the plant will have a total of 18 pumps.

A conference on the new casting procedure resulted in revising the foundry patterns to strengthen certain sections. Six replacement castings were poured on a bright, warm day and left in the mold till cold to prevent surface air-quenching. *No surface cracks or other* exterior defects were apparent upon removal from the molds.

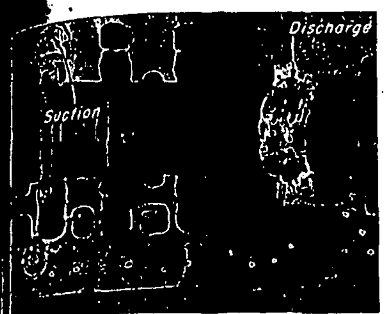
Hydrostatic Test. Because the contractor did not wish to chance a repetition of former trouble he gave the castings a hydrostatic test before machining them. Steel plates were fitted to the suction and discharge ports, welded in place, and drilled and tapped for pipe connections. Tests with cold water at 1500 psi were made. No exterior leaks were found, so the castings were delivered for machining. Fig. 2 and 3 show method of sealing ports.

Rough machining was completed after the exterior test. Next came part of the semifinished machining, only the mating faces and semifinish bore being done without removing the seals. The casing was then hydrostatically tested again. In the second test the inner casing was assembled in the outer barrel and tested with cold water at the discharge nozzle of the outer barrel, thus giving a crushing pressure similar to shutoff head in actual operation.

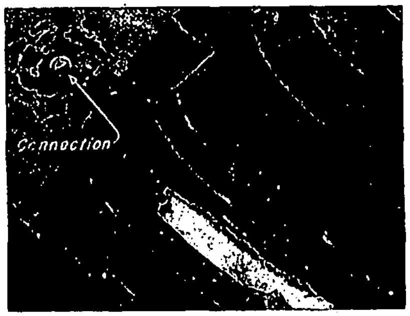
This test similates the action during "outage" when the pump works at maximum discharge pressure and the boiler drum reaches required liquid level. At that time the automatic valves close and the entire pressure is suddenly thrown into the area between inner casing and outer barrel, Fig. 1. Factory test is conducted at 3800 psi,



1 Inner casing slides into the outer barrel with close-fitting tolerances. Arrows indicate the closure points for testing. Suction passage is sealed at both ends



2 Closeup view of seals on No. 1 suction and discharge ports shown in Fig. 1 to make tests with cold water at 1200 psi



3 After the seal plates were welded to the suction and discharge ports they were drilled and tapped for test piping

* Data and illustrations from a study submitted to The James F. Lincoln Arc Welding Foundation in its recent $200,000 Design-for-Progress Award Program, for reports and advances and improvements made by the application of arc welding in design, fabrication, construction and maintenance.