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TO: J. S. Parker

FROM: J. M. Frame - J. M. Fox *J.M. Frame* *J.M. Fox, Jr.*

SUBJECT: PROJECT C-362 - CORROSION OF STAINLESS STEEL IN CONCENTRATED UNH SOLUTIONS - TRIP REPORT

REFERENCE: Memo to File, April 30, 1951 - Corrosion of Stainless Materials by Concentrated UNH Solutions - J. M. Fox

Introduction

In accordance with recommendation number two of the reference document, J. M. Fox and J. M. Frame visited the Mallinckrodt Chemical Works and the Vulcan Copper Company during the period May 1-4. The purpose of this trip was to gather first hand information on Mallinckrodt's experience with stainless steels in service with concentrated UNH solutions and to discuss with Vulcan the possibilities of welding the tubes to the tube sheets and of solution heat treating the UNH evaporators being furnished for Project C-362.

Conclusions:

In general it can be said that austenitic stainless steels in the fully solution heat treated state will give satisfactory service in concentrated UNH solutions. Where heat treatment is impractical or impossible, the higher grade stabilized materials (309 SCb as against 347) are to be preferred. Molybdenum containing stainless steels are to be avoided.

Specifically it is concluded that the order for the UNH concentrators being furnished by Vulcan for Project C-362 should be altered to include welding of the tubes to the tube sheets, in addition to rolling as presently specified, and to completely solution heat treat all parts of the unit in contact with process solutions, with the exception of the tube bundle. This exception is made because the tube bundle and shell are inseparable in the present design, which makes heat treating impractical. Specific recommendations and marked up prints are being transmitted to P. M. Murphy by letter.

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At least one spare evaporator unit should be procured. This should be designed for complete heat treatment of all parts.

Discussion:

The Mallinckrodt Chemical Company has a step in their ore refining process in which a uranyl nitrate solution is concentrated to a boiling point of between 270° to 300° F. This corresponds to a composition somewhat more concentrated than the normal hexahydrate salt. This concentration is carried out in a triple effect evaporator the final effect of which normally runs at a temperature of 250° to 270° F under approximately 9 lbs. per sq. in. gage pressure. The composition of the effluent is approximately 100% hexahydrate which corresponds to the expected concentration from the product evaporators in the waste metal recovery process. Excessive maintenance has been experienced with the tube bundle in the third effect of the continuous evaporator and with the coils in the final boil-down tanks. No maintenance has been required on the boil-down tanks themselves which are of 304 stainless, solution heat treated after fabrication. Recent very careful determinations have indicated no measureable reduction in plate thickness on these tanks during almost five years of service. The heating coils for the final boil-down step have been fabricated of 1" sch. 40 butt welded stainless pipe. Types 347 and 309 have both been used, with the latter slightly the superior. The average life of these coils has been about two years, with frequent repairs required at the welds joining 20 foot sections to form the finished coil. No heat treatment has been specified to date. However, coils now on order of 304 ELC material will be heat treated after fabrication. Weld failures appeared to be due to under-cutting of the weld metal through chemical attack on the parent metal.

The difficulty with the third effect tube bundle has primarily been with steam leaks and subsequent wire drawing between the tubes and the tube sheets. Initiation of these leaks is felt to be due to chemical corrosion. The first unit installed in June of 1946 contained type 347 tubes rolled into 347 tube sheets. Repairs were required every two to three months and the unit was replaced after a total of 23 months operation. The second tube bundle was fabricated of 304 seamless tubes rolled into 304 tube sheets and lasted fourteen and one-half months. Frequent repairs were required. A third unit of 347 tubes rolled into 347 tube sheets was installed in August of 1949. This unit was removed after seven months operation and all tubes re-rolled and seal welded at both ends. The unit was set then set aside as a spare.

As a check on the theory that rolling of the tube ends might be causing a stress corrosion the fourth tube bundle was fabricated with five tubes rolled and welded, the others were welded only. This unit was installed on April 1, 1950 and removed on August 27, 1950 after five months of operation. A total of seven leaks were found, none at tubes which were both rolled and welded. All leaks appeared to be in the weld metal and were repaired by grinding down and rewelding. The third unit, which had been repaired and set aside as a spare, was re-installed on August 27, 1950. During a plant shut down in November, this unit was removed and tested for leaks. Four leaks were found and repaired. The unit was returned to service on November 15, 1950 and has been in operation to the time of this writing.

As an explanation of the comparatively long life of the first tube bundle it should be noted that the process conditions during its service period were not as extreme as those imposed on later units. —

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A centrifugal type entrainment separator in the evaporator line from the final effect of the continuous evaporator has shown excessive attack at points where erosion from liquid spray might be expected in addition to chemical attack. No particular problem has been encountered at other points in the vapor lines or condenser.

Numerous corrosion test coupons of both welded and as received metal have been exposed in the final boil-down tanks. These were examined and definitely support the general conclusions as previously stated.

Mr. Keller repeated his observation that Cb and Mo containing types were inferior to the same materials not containing Cb and Mo in this service. If field repairs are expected it then becomes necessary to specify Cb stabilized stainless. In replaceable units this would not be necessary.

The talks at the Vulcan Copper Company centered around the possibility of welding the tubes to the tube sheet, in addition to rolling, and the general problem of heat treating tubular exchangers. The Vulcan engineers agreed that with the present design for our uranium evaporators it would be perfectly feasible to weld the tube ends and that under the circumstances and conditions described to them it would probably be desirable to do so. A suggestion was made that the combination of corrosion and subsequent wire drawing because of steam leaks might be avoided by use of double tube sheets. This suggestion has some merit, but also has the one obvious disadvantage that should a steam leak develop between a tube and one of the inner tube sheets there would be no chance of repair by welding. Rerolling might or might not alleviate such a condition depending upon the degree of wire drawing having taken place before repairs were instigated.

Mr. Rommel stated that to his knowledge the Vulcan Company has had no experience with the heat treatment of tubular exchangers, particularly in the size range of our UNH concentrators, and that consequently they would hesitate to accept any responsibility on a job calling for heat treatment of such a unit. None of the Vulcan engineers would state that it could not be done, but were of the opinion that some development work might be required on ways and means of supporting the bundle while in the furnace and during the quenching operation. In agreement with Hanford personnel, all were of the opinion that it would be unwise to attempt heat treatment of an exchanger with the tubes assembled in the shell. Our unit would have to be re-designed with a separable tube bundle if heat treatment were to be attempted.

Mr. Linton, one of the Vulcan engineers, expects to be visiting the Combustion Engineering Company soon and will consult with them on the problem of heat treating large tube bundles. He has promised to communicate the results of his conversation with them on this matter to us.

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