Colorado School of Mines

Center for Welding Research

Quarterly Report

January 8, 1984 - April 8, 1984

Use of Radioactive Tracers to Detect Cracking in Undersea Pipeline Welds

To date, the primary efforts on this project have been concerned with the selection of an appropriate tracer material, an evaluation of the current detection technology available through a literature search, and purchasing of welding consumables and other materials necessary for further progress in this research.

Selection of Tracer Material

The radioactive tracer selected for the final application of this research must be a beta-emitter with a half-life of the same order of magnitude as the lifetime of the pipeline or structure containing the weld. In addition, it must be an element that can be alloyed with the weld metal without significant deleterious effects on the weld's mechanical or corrosion properties and it must be soluble in a seawater solution at easily detectable concentrations. These criteria narrowed the list of potential isotopes to Ti-44, Co-60, and Ni-63. Ti-44 was eliminated as a potential candidate for this preliminary study using chemical detection methods when it was determined that atomic absorption methods are incapable of detecting titanium at the level of concentration expected for this study. (This should not be taken as a categorical elimination of Ti-44 as a potential isotope for the final application of this research as radioactive detection techniques will allow detection at much lower concentration levels and arc transferability problems associated with titanium can be avoided with specialized welding consumables and processes.) No such problems have been discovered with nickel or cobalt.

In order to evaluate the relative ease of detectability of cobalt and nickel, single pass bead-on-plate welds were made using a submerged arc welding process and a standard E70-S3 welding wire with powders of the two metals. From each weld, one gram of drill shavings was placed in 125ml of stirred artificial seawater (ASTM specification D-1141) and the concentration of the tracer element was monitored with time. The results of these tests are shown in the attached figures. The drop in nickel concentration between the 25 and 40 hour readings may be due to adsorption on the precipitated iron salts that first appeared during this period.

Radiation Detectability Limits

Scintillation detectors have been discussed in the literature that are capable of quickly and accurately measuring the beta emissions of krypton-85 in gas streams at concentrations as low as 0.001 ppb. (Krypton-85 has a half life comparable to those or the isotopes being considered and, thus, should release comparable levels or radiation.) A simple molar concentration calculation indicates that this is equivalent to a concentration in water ot about 0.0001 ppb. This should not be considered an accurate estimate of the detectability limit in aqueous solutions, however, because it does not take into account the increased absorption of beta-radiation in water, but should be accurate within one or two orders of magnitude and is very encouraging because it is three or four orders of magnitude better than what was first expected. Research and literature review is continuing in this area.

Stress-corrosion Testing Specimens

The final dimensions of the stress corrosion cracking specimens are dependent on the material properties of the chosen weld filler metal. The specific specimen geometry and dimensions chosen for this testing are shown in an attached figure and preparations for machining these specimens are in progress.

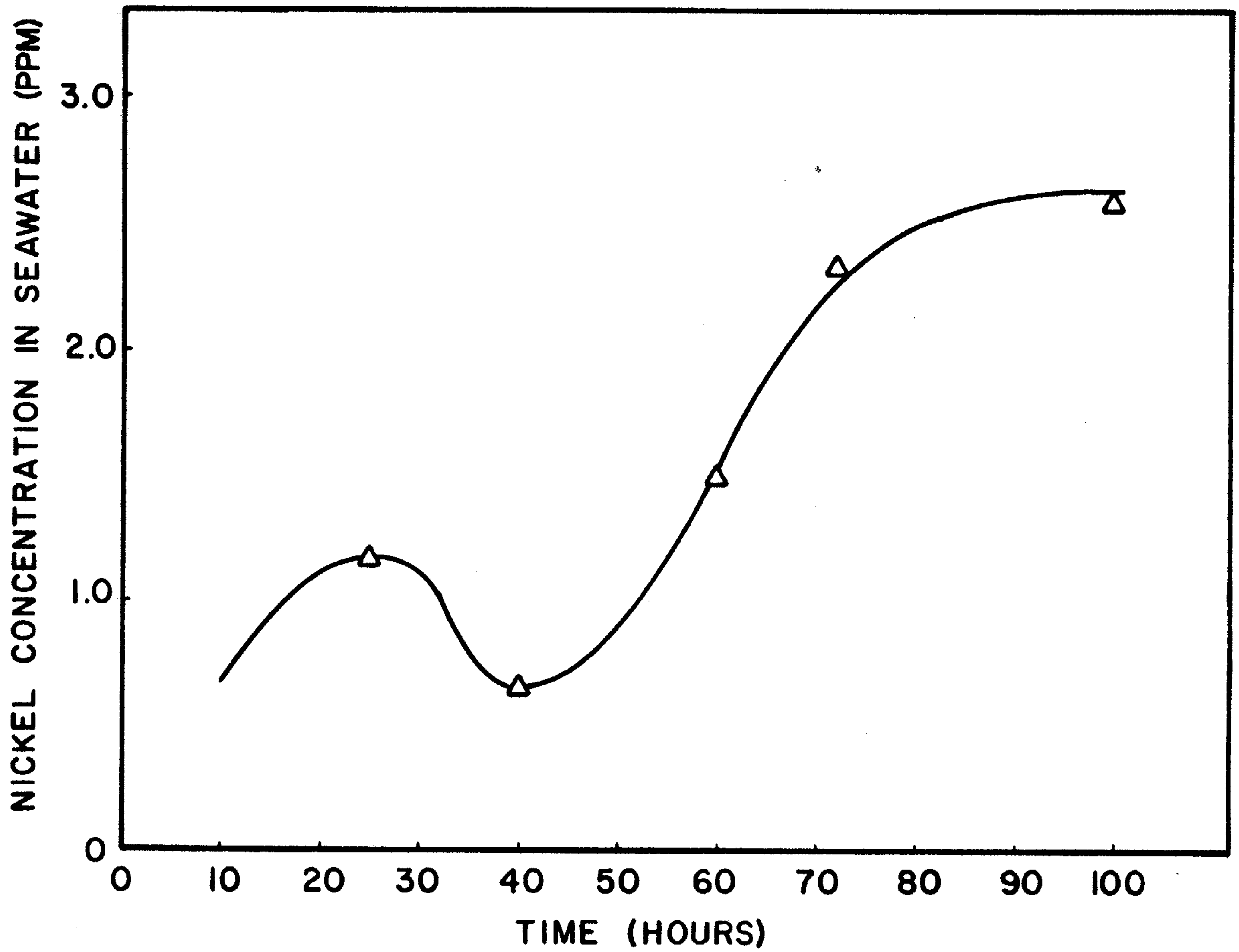
Purchase or Materials

The steel for this project has been selected and purchased and is currently being machined for welding. The welding consumable chosen is a maraging steel grade containing 18% Ni and 8% Co and having a yield strength of 300ksi. Both nickel and cobalt concentrations will be monitored in the solution. Experimental data available in the literature indicate that it will readily stress corrosion crack in an artificial seawater solution and this cracking may be greatly accelerated, if necessary, by the application of a slight anodic potential. (Since it is not the purpose of this research to accurately determine the stress-corrosion susceptibility of these steels, this is a viable method for increasing the speed with which experimental results can be obtained for this feasibility study.) This combination of properties makes this material ideal for the purposes ot this preliminary investigation.

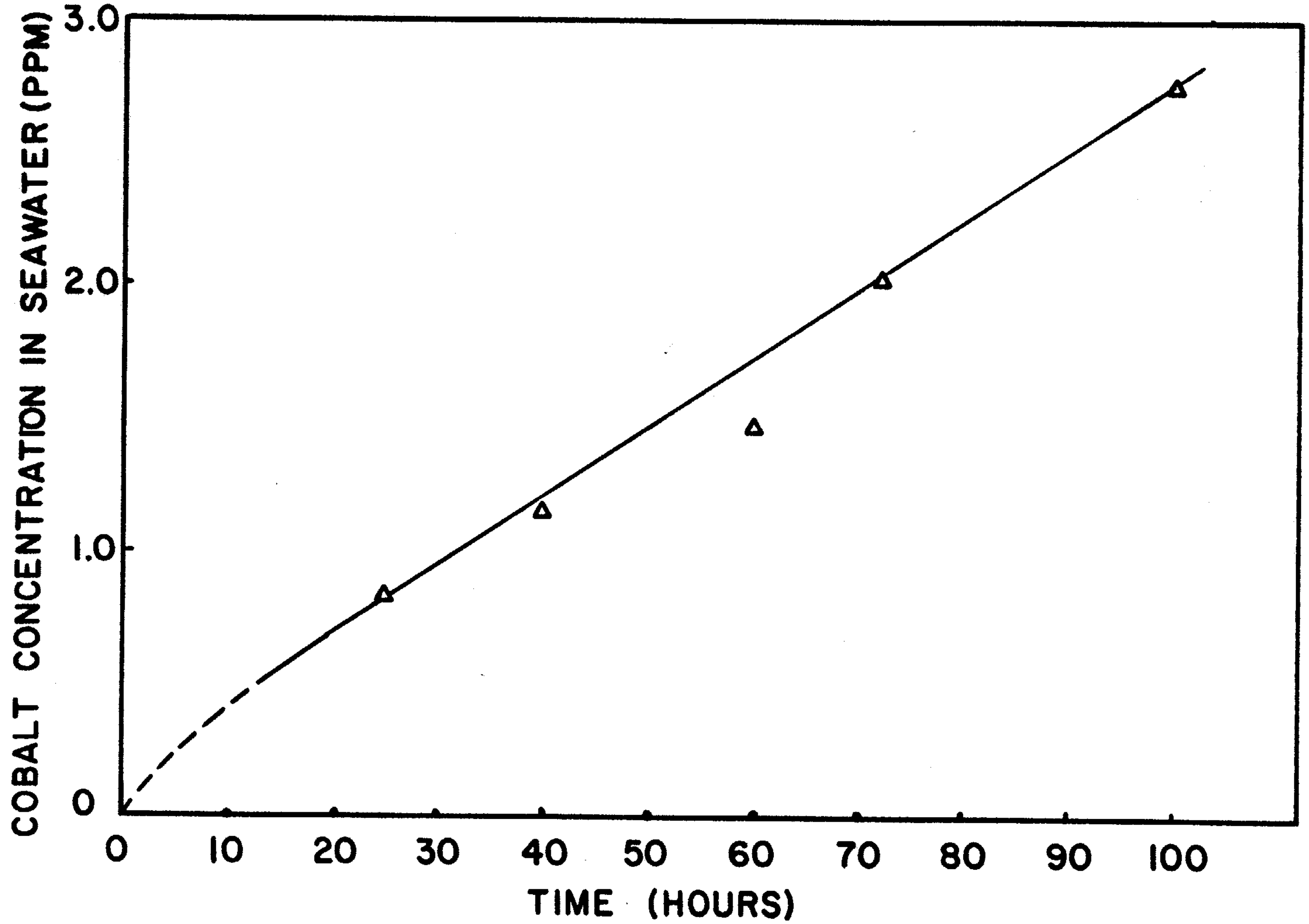
All supplementary chemical equipment necessary for the corrosion testing in this project that was not already available in the CSM Metallurgy Department has been acquired.

Health and Safety Issue

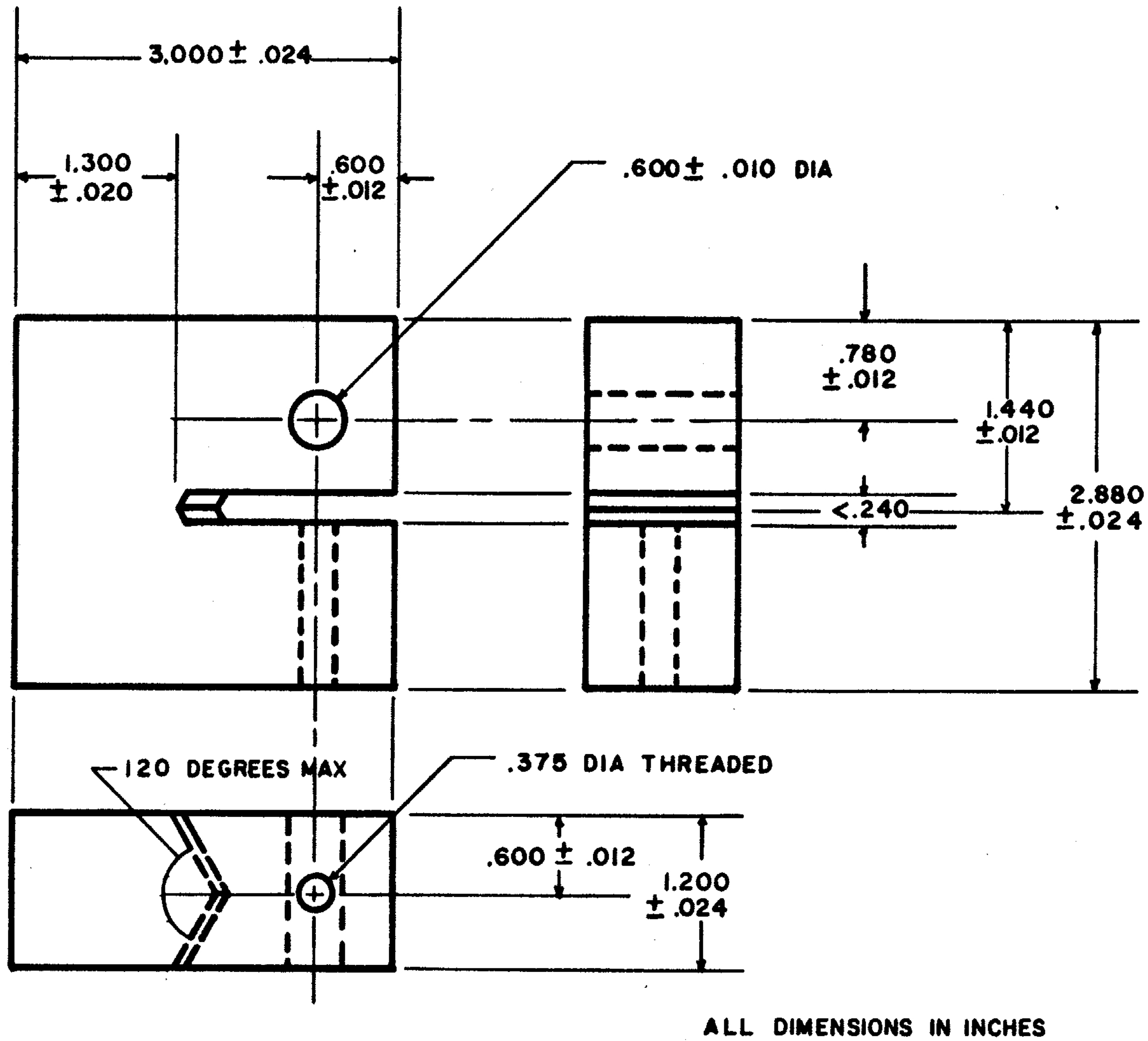
In the original proposal, it was suggested that the radioactive tracer element be included in the welding consumable prior to welding. This has disadvantages associated with the need to limit the exposure of the welder to radioactive fumes and storage of the radioactive consumables prior to welding. If, however, a material like (non-radioactive) cobalt is included exclusively in the middle passes of the weld, it may be possible to accomplish the same effect by irradiating the weld AFTER welding, causing the cobalt to transform into cobalt-60 and producing the desired distribution of radioactive tracer without any of the environmental or industrial health and safety problems originally forseen. This possibility will need to be more thoroughly investigated in future work.



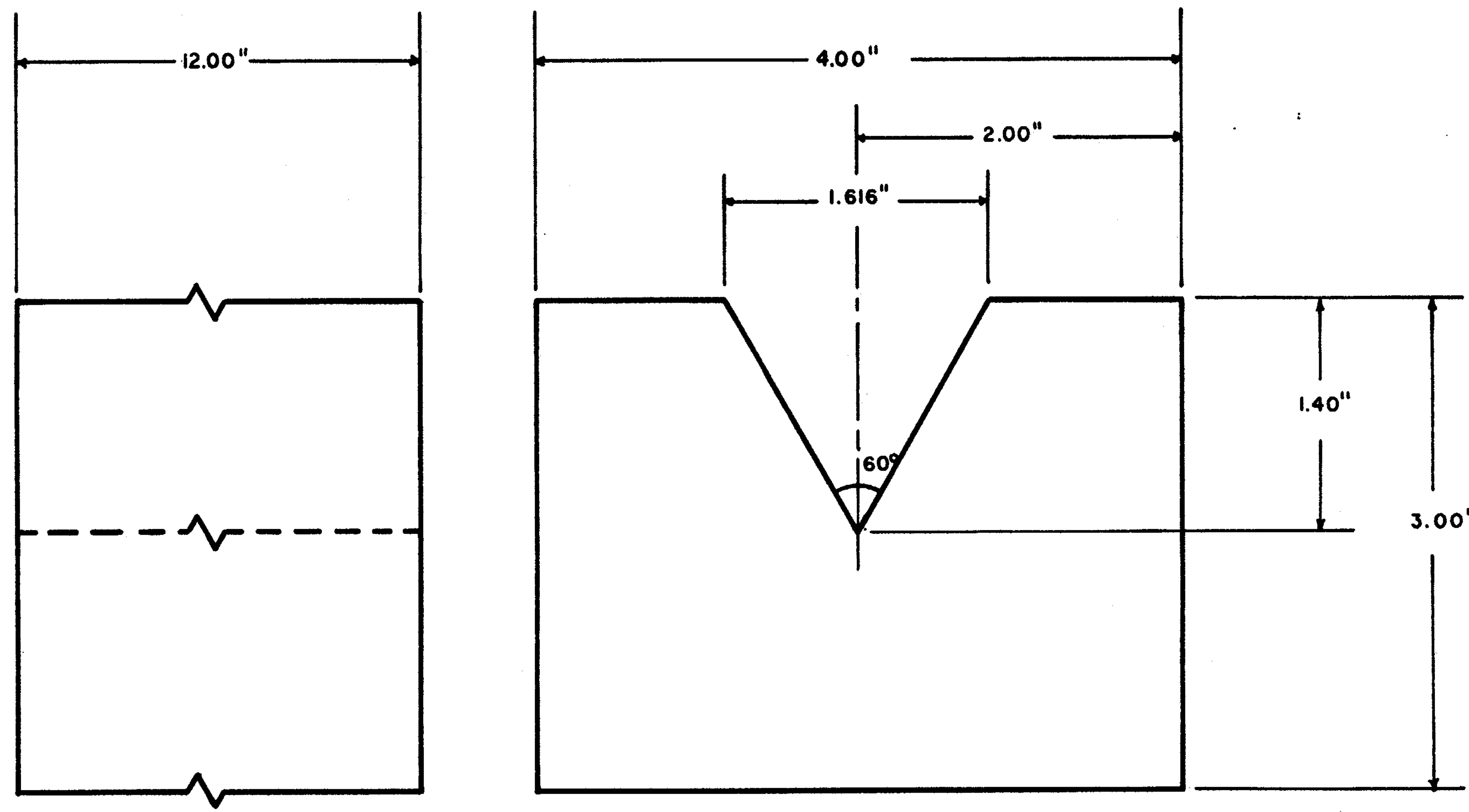
CORROSION OF 48% NICKEL SHAVINGS IN ARTIFICIAL SEAWATER



CORROSION OF 8% COBALT SHAVINGS IN
ARTIFICIAL SEAWATER



MODIFIED ASTM E399 FRACTURE SPECIMEN



WELDING V-NOTCH