CERAMIC INDUCTIVE CONDUCTIVITY SENSOR

PROXIMITY EFFECTS

Your FSI CTD has been provided with the latest sensor technologies available in high performance conductivity measurement. The CTD is equipped with a non-electrode ceramic inductive conductivity sensor. As a result of changes in the electrode geometry, this sensor is immune to calibration drift due to changes in the electric field. Several FSI users have asked us to put together a guide to the use of the FSI conductivity sensor in particular to the effects of changes in the external field of the sensor as a result of various mounting configurations. As it is impossible to imagine all of the various mountings that a CTD may be used in, FSI made a series laboratory measurements of the response effects that placement of the inductive sensor to both "large" insulated and conductive surfaces had. Note, "large" means that the structures were large when compared to the total external filed of the inductive sensor, and, therefore represent a "worse" case condition. The FSI inductive sensor is inherently an internal filed sensor with 90% of the sea water volume measured contained within the sensor center bore.

CERAMIC INDUCTIVE CONDUCTIVITY SENSOR CELL CONSTANT:

For the large ceramic sensor the cell constant is k = 1.4. For the small ceramic sensor the cell constant is k = 2.4. The cell constant is defined as the transfer constant from electrical resistance to conductance/volume ratio as measured by the sensor. This can be expressed in the formula:

$$C = k / R$$

Where:
C = Conductivity (mmho/cm)
R = Resistance (ohms)
k = Cell Factor

To determine the k factor for your conductivity sensor connect a 1000 ohm resistor in series with 7 turns of wire, k can be found from:

Re = R / n^2 = 1000/49 = 20.4
k = Cr * Re = Cr * 20.4

Where:
Cr = CTD Conductivity Reading
Re = Effective Resistance
R = Resistor Value
n = number of turns through the sensor

Note: the above determination of k is limited by the precision of the 1000 ohm resistor used. The ICTD measures 65 mmho/cm to a precision of .003 mmho/cm or .004% (40 ppm). To calibrate the inductive sensor it must be placed in a known conductivity bath, consult the manual calibration section for complete details.

Note: The inductive sensor cell constant can be modified by placement of a structure within the external field of the sensor. This modification will be stable if the effecting structure's position, relative to the inductive sensor, remains constant. In specific applications were the user is unable to keep structures outside a 15 cm radius sphere from the geometric center of the inductive cell, then the structures effect on the conductivity calibration can be determined through a single point calibration. The structure will only effect the slope of the sensor and not its offset.

FSI PROXIMITY TEST DATA:

FSI conducted two tests in a 30 cm diameter polyethylene tank. These tanks are used to calibrate all FSI sensors at the factory. A holding fixture was used to move an ICTD at fixed distances from the sidewall of the bath. A standard OCM manufactured by FSI was used to measure the conductivity of the bath. Differences from the OCM and ICTD were taken to determine the effect either structure presented. The bath had a nominal value of 50.0 mmho/cm and was allowed to drift as the tests were run. Two tests were conducted, one with the plastic sidewall of the bath, and a second with an 8" (20 cm) x 12" (30 cm) 316 flat stainless steel plate attached to the side wall of the bath. The instrument was initially placed were the value of the ICTD conductivity and OCM conductivity (both calibrated) agreed to within +/- .001 mmho/cm . The ICTD was moved through a series of distances down to 3.0 cm from the bath wall or bath wall with steel plate mounted, the instrument was then moved back through the same distances. To validate the experiment changes found at equal distances during movement toward and away the side were compared and found to validate the experiment. At each distance 6 data sets were collected. Each data set consisted of 10 each individual samples averaged together. In Figure 1 the raw data set is shown for both data sets. Note, the larger spread in the difference data as the ICTD approaches the obstruction, this is a direct result of small movements of the instrument due to the stirring currents in the bath. This is further illustrated in Figure 2, which shows the standard deviations as a function of distance from the bath wall.

In Figure 3 the data for each distance has been averaged into a single plot point. The insulated bath wall decreases the reading relative to the standard, and the stainless steel plate increases the reading; however, the combined effect of the decreased volume (the bath wall) and the increased conductivity of the plate tend to offset eachother, resulting in the slower growth of the error as a function of distance. In Figure 4 a theoretical line is plotted which has inverted and added the wall data to the S.S plate data. This line could illustrate the effect of a steel plate as it alone approaches the inductive sensor.

In both cases it can be seen that "large" structures such as the bath wall or large conductive structures should be maintained outside a 15 cm radius sphere about the inductive conductivity sensor. If the specific application requires that they be mounted closer to the sensor then they must be rigidly mounted and the slope of the conductivity sensor corrected for their proximity effect.

The user must remember that the structures used in this experiment are "large" and are not typical of standard instrument mountings on water samplers or other lowering devices. A good rule of thumb is to keep sensors outside of the 10 cm radius circle and large structures outside a 15 cm diameter, then you will not effect the factory calibration.

In summary, the inductive conductivity sensor affords the user the highest level of measurement accuracy and stability. The sensor does have a small external field, however, is principally and internal volume sensor. If the user is careful in the placement of the CTD and associated equipment the factory calibration will be maintained. This document is supplied as a guide to sensor placement, if you have specific questions or requirements consult the factory.

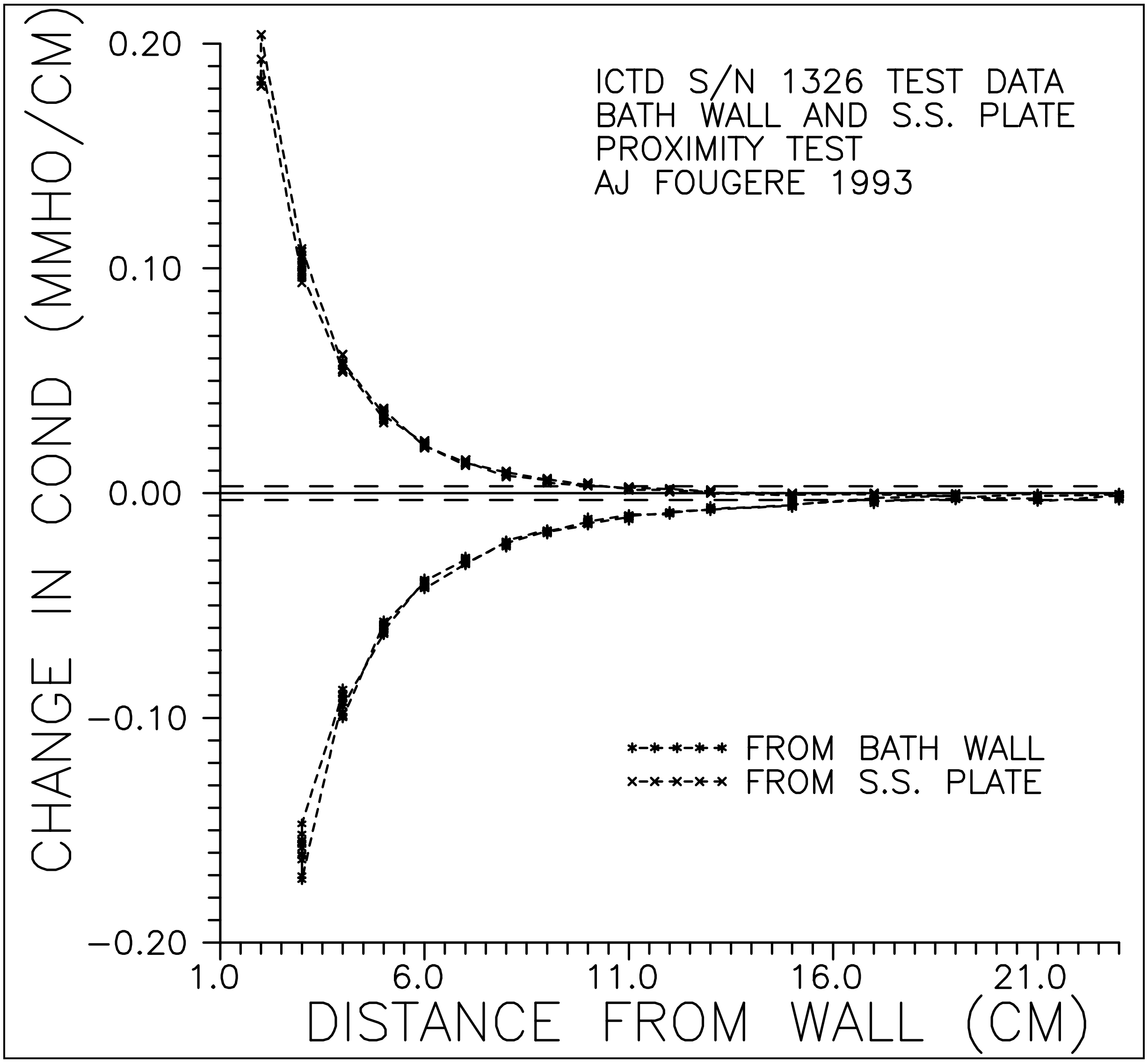

Figure 1

RAW DATA WALL EFFECT ON INDUCTIVE SENSOR

DATA FROM INSULATED BATH WALL &

INSULATED BATH WITH MOUNTED STAINLESS STEEL PLATE

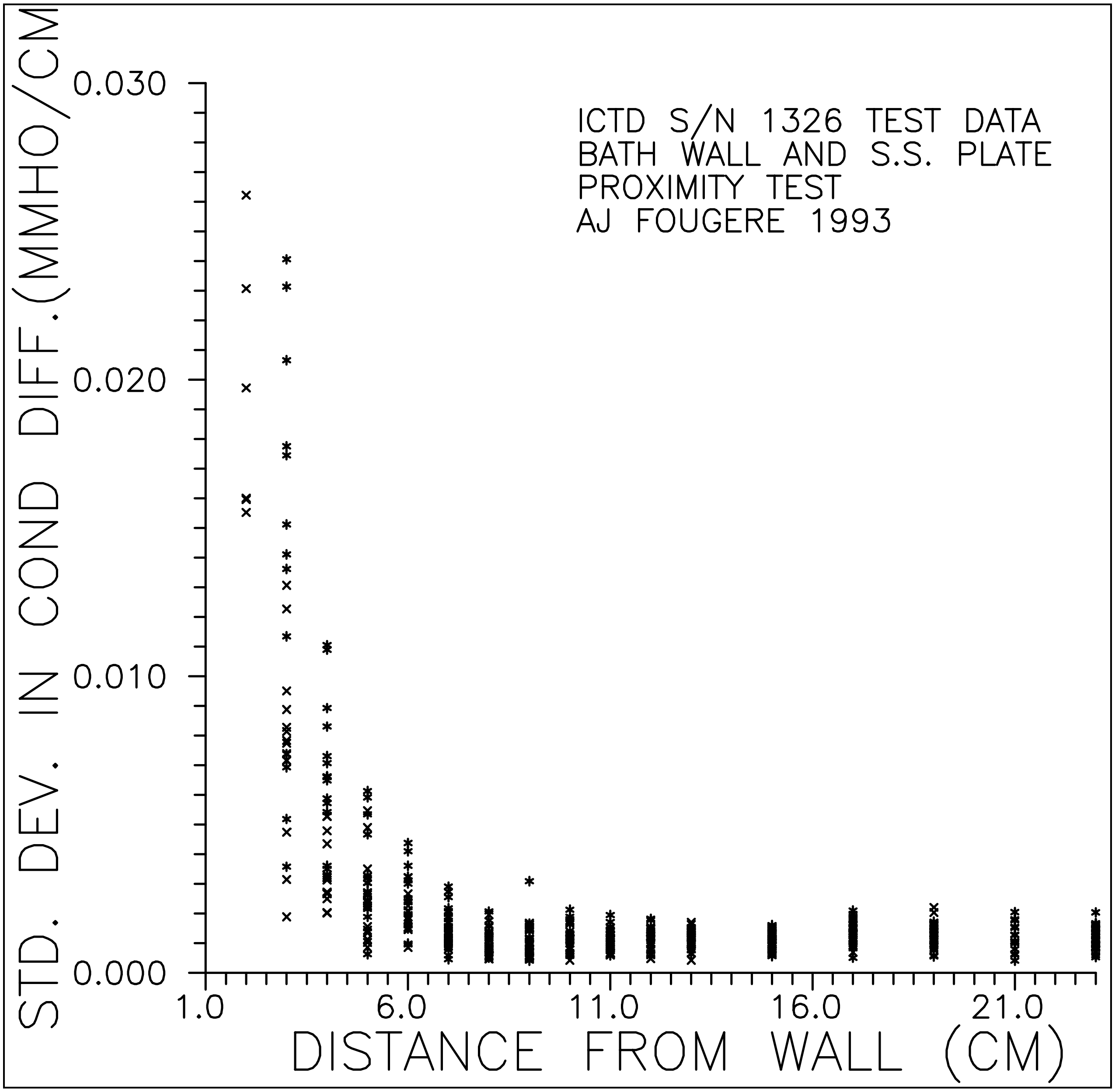

Figure 2

STANDARD DEVIATION OF MEASUREMENTS

BOTH DIRECTION MOVEMENT DATA

BOTH TYPES OF WALL

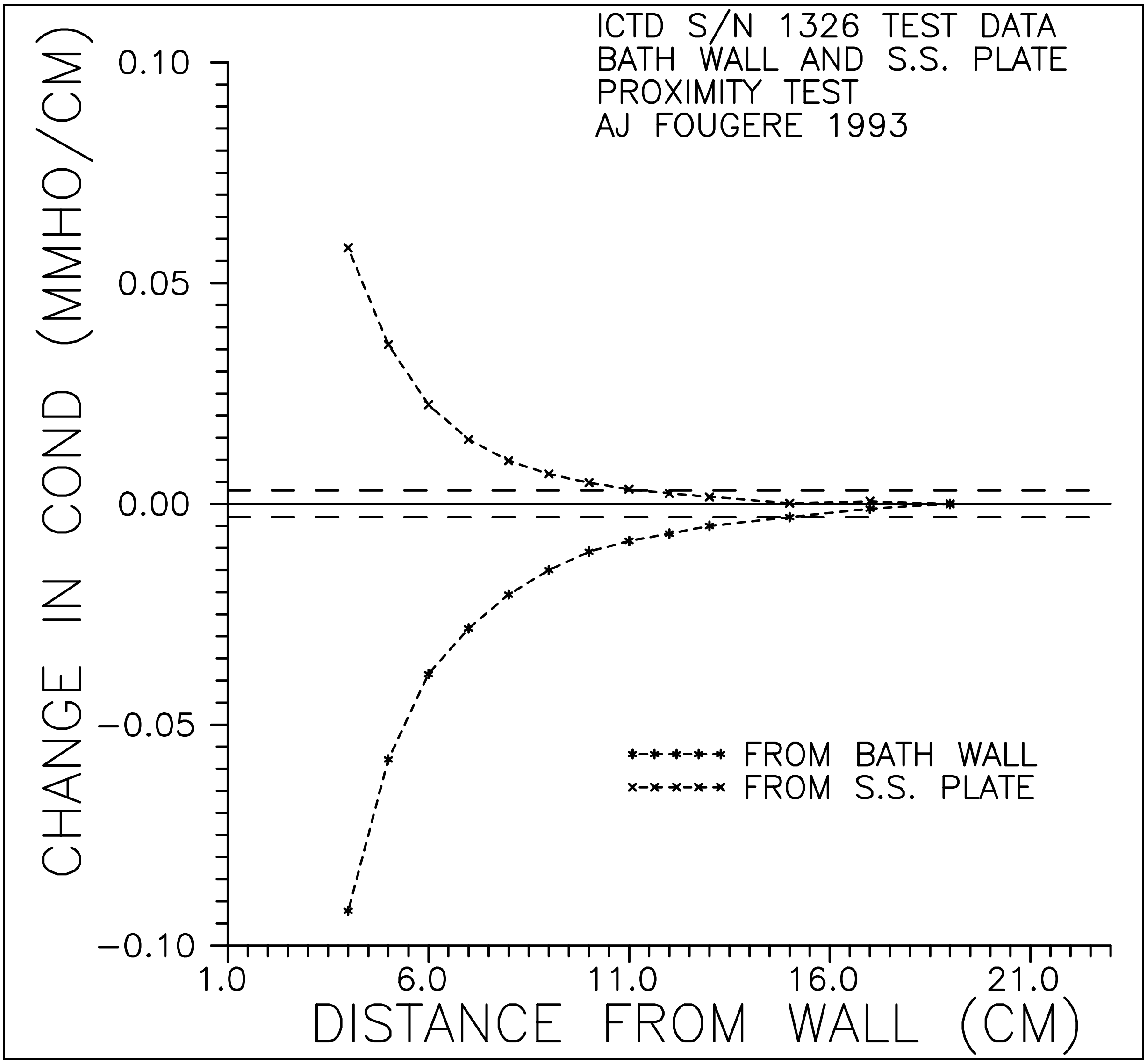

Figure 3

DATA AVERAGED FOR EACH DISTANCE

INITIAL OFFSET CORRECTED

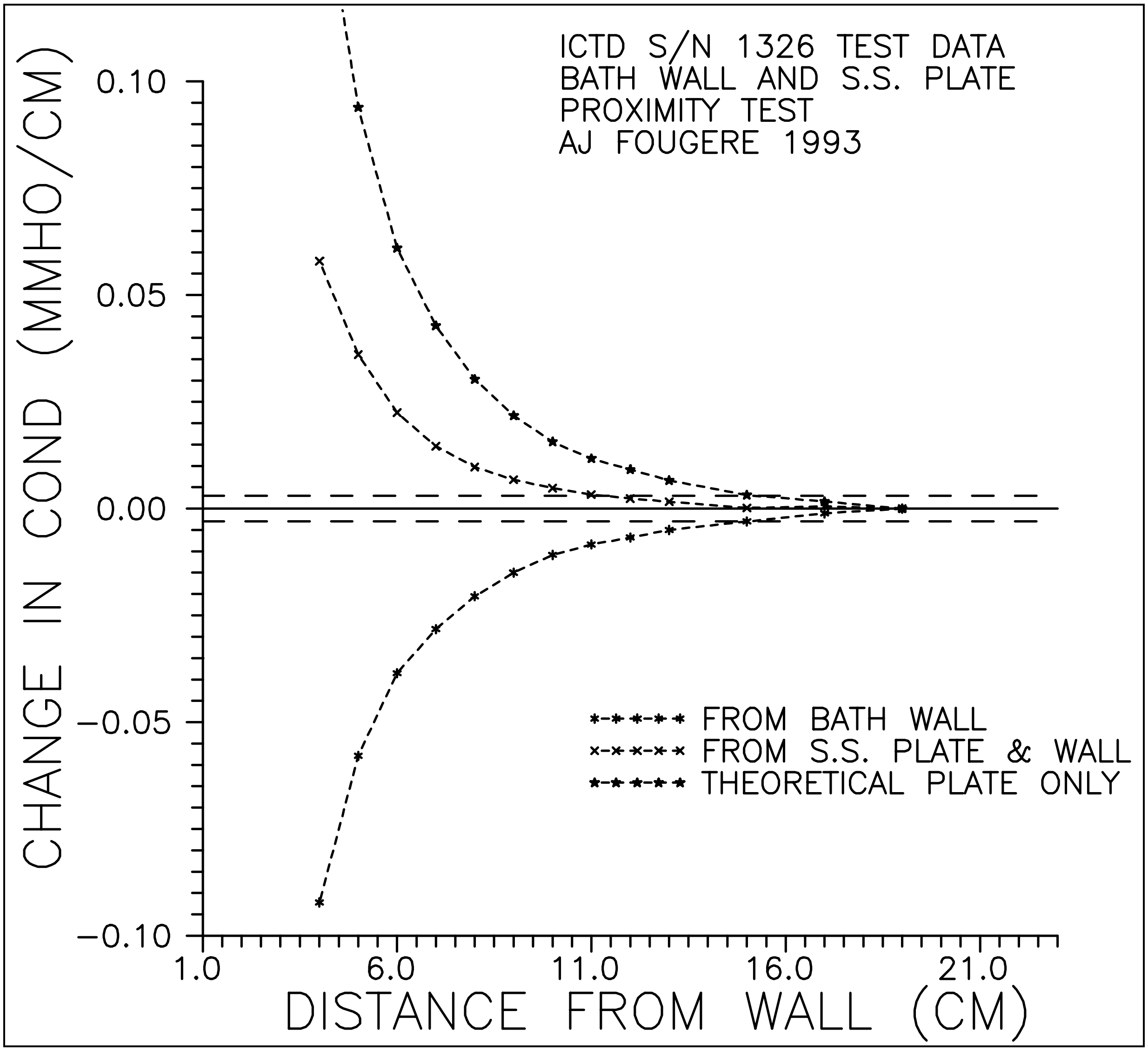

Figure 4

AVERAGED DATA WITH

THEORETICAL FREE SPACE S.S. PLATE EFFECT SHOWN