TECHNICAL SAFETY ASSESSMENT

FOR

SUSQUEHANNA STEAM ELECTRIC STATION

UNIT # 1

FEEDWATER PIPING EROSION
LINE NUMBER DLA-102-1
E/C POINT X-175

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1.0 Purpose: The purpose of this document is to provide a technical assessment of the pipe wall thinning in the feedwater system discovered during the erosion/corrosion inspections performed during the Unit # 1 - 6th Refueling and Inspection Outage (U1-6RIO). This Technical Safety Assessment (TSA) addresses:

- The condition discovered
- The method of discovery
- The safety significance of the condition based on the safety function of the component
- The predicted change in the condition over time
- The effect of the condition on the safety function of the component
- The recommendations necessary to ensure the safe operation of the plant

This TSA takes no credit for the weld build-up used to compensate for the lost base metal.

2.0 **BACKGROUND:**

2.1 **CONDITION DISCOVERED:** Localized erosion/corrosion, resulting in pipe wall thinning, was discovered on the feedwater line, DLA-102-1, inside primary containment on the 12" pipe immediately adjacent to the weld at the outlet of a 20" x 12" reducing tee. The erosion/corrosion inspection location is X-175 and the inspection zone is Zone 3B. The minimum wall thickness reading discovered was .482" with the mean reading in this zone, for the first row of measurements taken adjacent to the weld and circumferentially around the pipe, being .539". The design minimum wall for this piping is governed by hoop stress due to internal design pressures. Excluding corrosion allowance, the calculated design minimum wall for this piping is .438".

2.2 **METHOD OF DISCOVERY:** The predictive methods used in our Erosion/Corrosion Program identified a potential susceptibility to erosion for this primary system piping. For approximately 3 refueling and inspection outages erosion/corrosion inspections have been taking place on this system. Due to the magnitude of the measurements taken at this specific location during the U1-5RIO, the Erosion/Corrosion Program requirements dictated that continued monitoring of this location was required. Ultrasonic Test (UT) measurements taken during the U1-6RIO recorded measurements sufficiently close to the piping design minimum wall that an engineering evaluation of the condition was dictated by the Erosion/Corrosion Program requirements.

2.3 **ADDITIONAL INFORMATION:** This portion of the feedwater piping is part of the Reactor Coolant Pressure Boundary (RCPB). The other similar locations on the feedwater system inside containment were inspected and found to be acceptable. Therefore, this condition appears to be an isolated condition. The structural integrity of the RCPB is of paramount importance to Nuclear Safety. The following system design parameters apply to this piping:

- Piping Class - ASME Section III Sub-Section NB Nuclear Class 1 Piping
- Code of Record - ASME Section III, 1971 Edition with Addenda Through Winter 1972
- Material - Carbon Steel ASME SA-333 Grade 6 (Seamless Pipe)
- Pipe - O.D. = 12.75"; Sch. 80; $T_{nominal}$ = 0.688"
- Design Pressure = 1250 PSI
- Design Temperature = 575°F

3.0 **SAFETY FUNCTION:** The function of the feedwater system piping is to provide a path for feedwater to flow from the condenser, through the feedwater heaters to the Reactor Pressure Vessel (RPV). The safety function of the feedwater piping is to (1) maintain structural integrity as a part of the RCPB and (2) provide a path for the injection for flow from the High Pressure Coolant Injection (HPCI) system and the Reactor Core Isolation Cooling (RCIC) system to the (RPV). The feedwater piping is configured such that there are two separate main feedwater lines feeding the RPV and each line is divided into three smaller lines (12" nominal piping) which feeds the RPV. The HPCI system is connected to one of the main lines feeding the RPV and the RCIC system is connected to the other line.

The location of the area of pipe thinning is in the A feedwater loop, inside containment and downstream of the connection to the RCIC system. Therefore, a failure in the feedwater piping in this location would affect the RPV and consequently the core, and would also render the flow to the RPV from the RCIC system unavailable. The feedwater system piping provides other functions but none of these are classified as safety functions.

4.0 **TECHNICAL DISCUSSION:**

4.1 **DESCRIPTION OF CONDITION:** Figure 1 attached to this TSA shows a super imposed view of the 5 sets of UT readings taken around the circumference of the pipe within a 2"-3" band centered axially on the eroded vicinity of interest on the pipe. Figures 2, 3 and 4 show Sections A-A, B-B and C-C from Figure 1 respectively. These sections show the current configuration of the three worst case eroded areas, as well as, three

levels of predicted wear for each area.

The levels of predicted wear for each area were developed for use in evaluating this condition in accordance with ASME Code Case N-480 and are intended to bound the postulated configurations which could exist at the end of the next cycle of operation.

An evaluation of the erosion/corrosion data available at this location yields the following range of wear rates:

- Average wear over 6 cycles considering the initial counterbore dimension - .029"/cycle
- Average wear over 6 cycles considering the pipe nominal wall - .034"/cycle
- Average wear over 6 cycles considering the pipe nominal wall and the manufacturer's tolerance - .048"/cycle
- The statistical mean of all measured points between the U1-5RIO and the U1-6RIO in the first row adjacent to the pipe to tee weld and measured circumferentially around the pipe - .088"/cycle
- The delta lowest grid readings between the U1-5RIO and the U1-6RIO - .137"/cycle

Based on this data, a bounding set of assumed wear rates of .050"/Cycle, .100"/Cycle and .150"/Cycle was selected for evaluating compliance with ASME Code Case N-480 and ASME Section III Sub-Section NB requirements. The .100"/Cycle wear rate is considered to be most representative of a conservative predicted wear rate. The rates on either side of this value are evaluated as representative bounds. The .050"/cycle wear rate is representative of normal system cycle wear. The .150"/cycle wear rate would account for unexpected amplified wear.

4.2 **EVALUATION PER ASME CODE CASE N-480:** The predicted conditions described in Figures 2, 3 and 4 were evaluated in accordance with the requirements of Code Case N-480. Paragraph -3420 specifies that the minimum predicted thickness be greater than or equal to .3 $T_{nominal}$ (.206") to permit further evaluation for continued service. In all cases this requirement is satisfied. Paragraph -3622 provides the evaluation procedure for evaluating local thinning. The local thinning criteria, Case 1, of Paragraph -3622.1 was used to evaluate the .050"/Cycle condition. The local thinning criteria, Case 3, of Paragraph -3622.3 was used to evaluate the .100"/Cycle and the .150"/Cycle conditions. These evaluation are documented in calculation PLS-9293 and the conclusion of this calculation is that the location of maximum erosion/corrosion on the feedwater piping (minimum T measured = 0.482") can be considered acceptable using the acceptance criteria of ASME Case Case N-480. No additional wall thickness due to the weld build-up is assumed and a wear rate as high as .150"/cycle is assumed.

4.3 **EVALUATION PER ASME SECTION III SUB-SECTION NB:** The predicted conditions described in Figures 2, 3 and 4 were also evaluated in accordance with the requirements of ASME Section III Sub-Section NB Section NB-3600. The evaluation assumed that the minimum predicted thickness existed 360° around the pipe circumference. For the properties derived from this condition the piping was evaluated for pressure and primary and secondary mechanical loads for all design basis loading conditions. The results of this evaluation were that:

- For the minimum predicted thickness which is shown as t_p = .332" in Figure 2 (worst case), all code allowables would be met for all primary and secondary mechanical loads for all design basis loading combinations. The calculated usage factor is 0.0557. The I.D. contour due to the eroded condition was evaluated in PLS-9293 using conservative stress indices and all code allowables were met.

- For the predicted thicknesses in Figure 2 (worst location), a code overstress condition will exist with respect to the hoop stress in the pipe. Although the code allowable will be exceeded, the piping will be capable of performing its intended safety function should it be called upon to do so for any and all design basis conditions since in no case does the overstress condition exceed the material yield strength at design temperature.

4.4 **CONSEQUENCE OF PIPING FAILURE:** The location of interest on the feedwater piping is on a 12" section of piping inside containment. This portion of the feedwater piping is classified as high energy fluid system piping. FSAR Figure 3.6-2 shows that the location of interest is an evaluated break location. The piping could be postulated to fail in one of two general ways (1) the piping could thin rapidly and overstress, thus forming a double ended guillotine type break or (2) the pipe may thin slowly, thus leading to a leak before break scenario. The effects of each scenario is described below:

<u>Double Ended Guillotine Break</u>

According to the Bechtel M-199 Piping Specification, pipe DLA-102 is a 12" Schedule 80 pipe. A 12" Schedule 80 pipe has a flow area of 0.7058 ft^2. Therefore, a double ended guillotine break would have a flow area of 1.4116 ft^2. The SSES FSAR, Chapter 6.3.3 considers a spectrum of pipe breaks as part of the licensing basis of the plant. Two methods of analysis depending on break size were used, one for small breaks and one for large breaks. The transition from small break methodology to large break methodology occurs at a break area of 1.0 ft^2. Therefore, a double ended guillotine break at this location and area would be considered a large break.

Pipe breaks of the size of this potential break have been analyzed for SSES and found to be acceptable from a design standpoint (FSAR 6.3.-10). The peak cladding temperature for a break of this size is bounded by breaks of other sizes. The worst case transient on the containment is governed by a larger break in terms of peak containment pressure and a much smaller break in terms of peak containment temperature. The worst case radioactivity release has been determined to be a steam line break outside containment (FSAR CH 15.6).

In addition, a pipe break was originally postulated very near to this location. Therefore, appropriate pipe rupture restraints are currently in place to accomodate the effects of a pipe break.

Therefore, a double ended guillotine type line break at the location of interest is within the design basis of the SSES plant. The consequences of such a failure, however, would lead one to classify this condition as having high safety significance.

<u>Leak Before Break Scenario</u>

If the piping were to continue wall thinning and begin to slowly leak through the wall, the guidance of Technical Specification 3/4.4.3 would be consulted. This Technical Specification states, among other things, that unidentified Primary System leakage rates of greater than 5 GPM or a total leak rate (identified or unidentified) of greater than 25 GPM over any 24 hour period places the plant in a Limited Condition for Operation (LCO). This LCO requires the leakage to be reduced to an appropriate leakage rate within 4 hours or the plant to be placed in hot shutdown within the next 12 hours and cold shutdown within the next 24 hours. The leakage rate of 5 GPM is much less than the critical leak rate for 12" piping calculated from fracture mechanics considerations. Therefore, if reasonable assumptions are made concerning the behavior of the piping, it is expected that the Technical Specification leakage limits would lead to a plant shutdown and piping repair prior to catastrophic piping failure.

5.0 **CONCLUSIONS AND RECOMMENDATIONS:** The overall conclusion of this TSA is that the feedwater piping in its as found and worst case predicted configurations will be capable of performing its intended safety function should it be called upon to do so for all design basis events for the operating cycle between the U1-6RIO and the U1-7RIO. For the as found configuration and the worst case predicted configuration in this interval, the acceptance criteria of ASME Code Case N-480 have been satisfied.

For the event of a feedwater line piping failure in the location where pipe wall thinning was observed during the U1-6RIO, it is concluded that the plant is designed to handle a catastrophic failure of this pipe with no adverse consequences to the health and safety of the general population. Therefore, it is concluded that continued operation of the plant with this condition through the current operating cycle poses no undue risk to the health and safety of the general population.

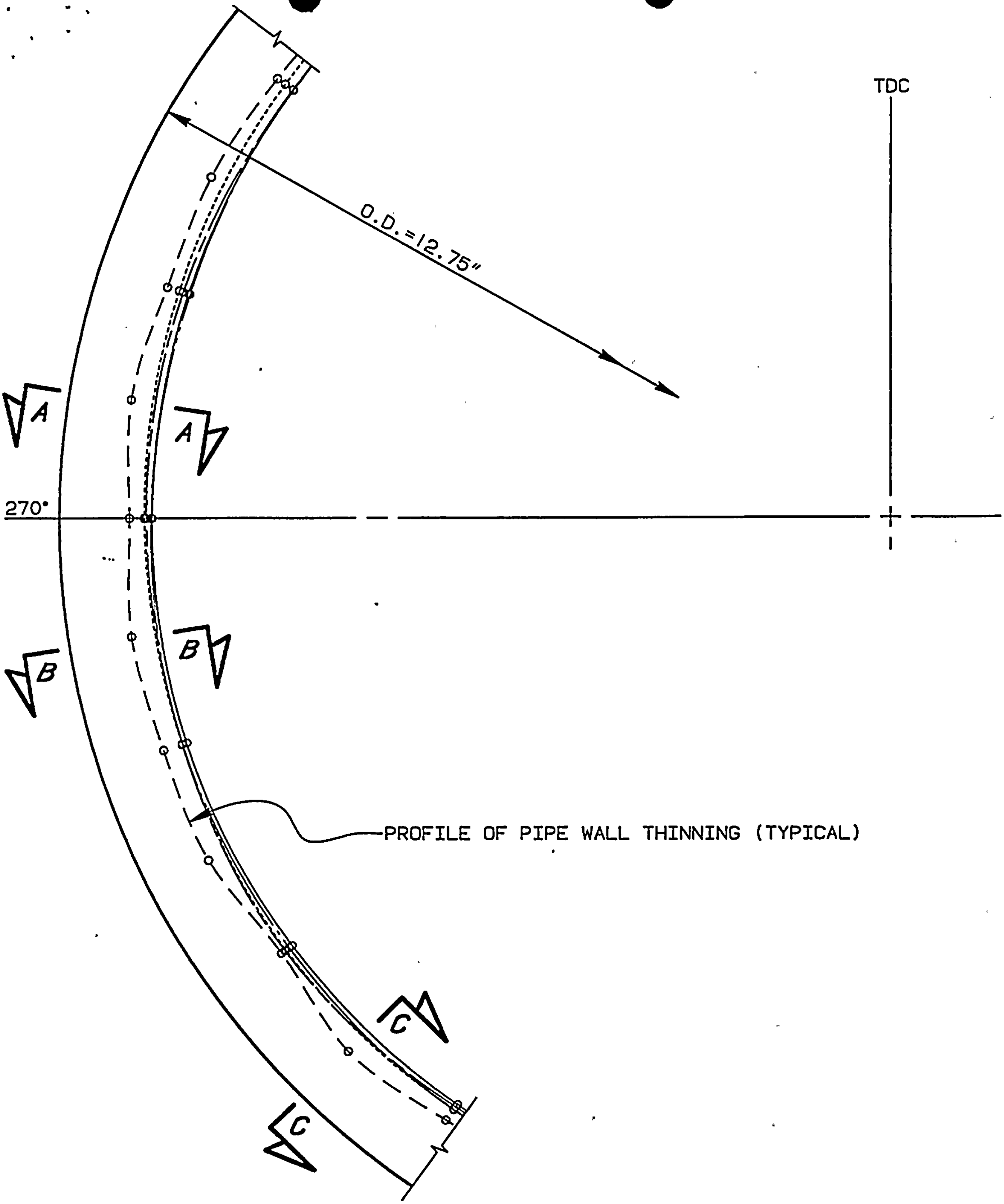
TDC
O.D.=12.75"
270°
A
A
B
B
C
C
PROFILE OF PIPE WALL THINNING (TYPICAL)

FIGURE 1

SECTION A-A

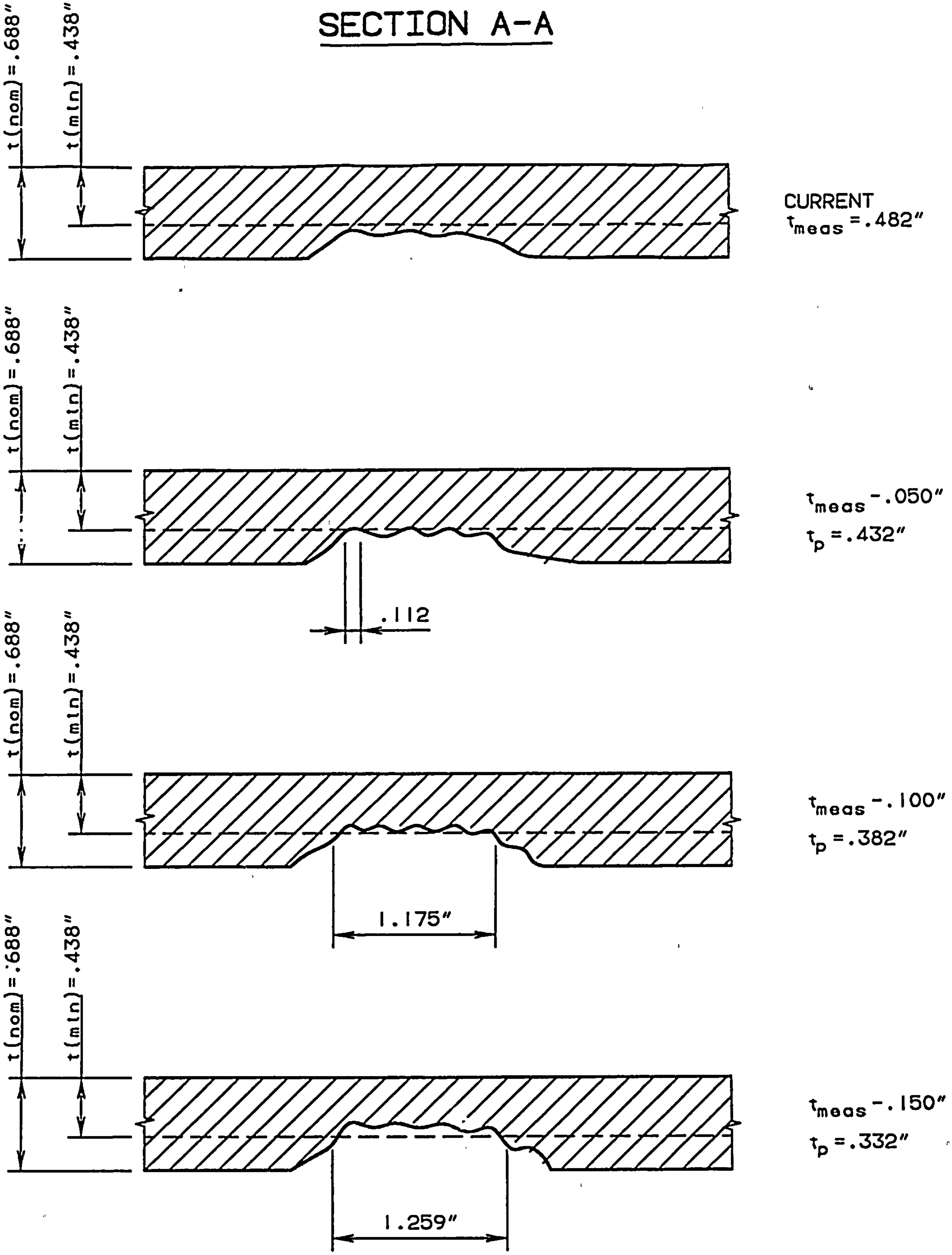

FIGURE 2

SECTION B-B

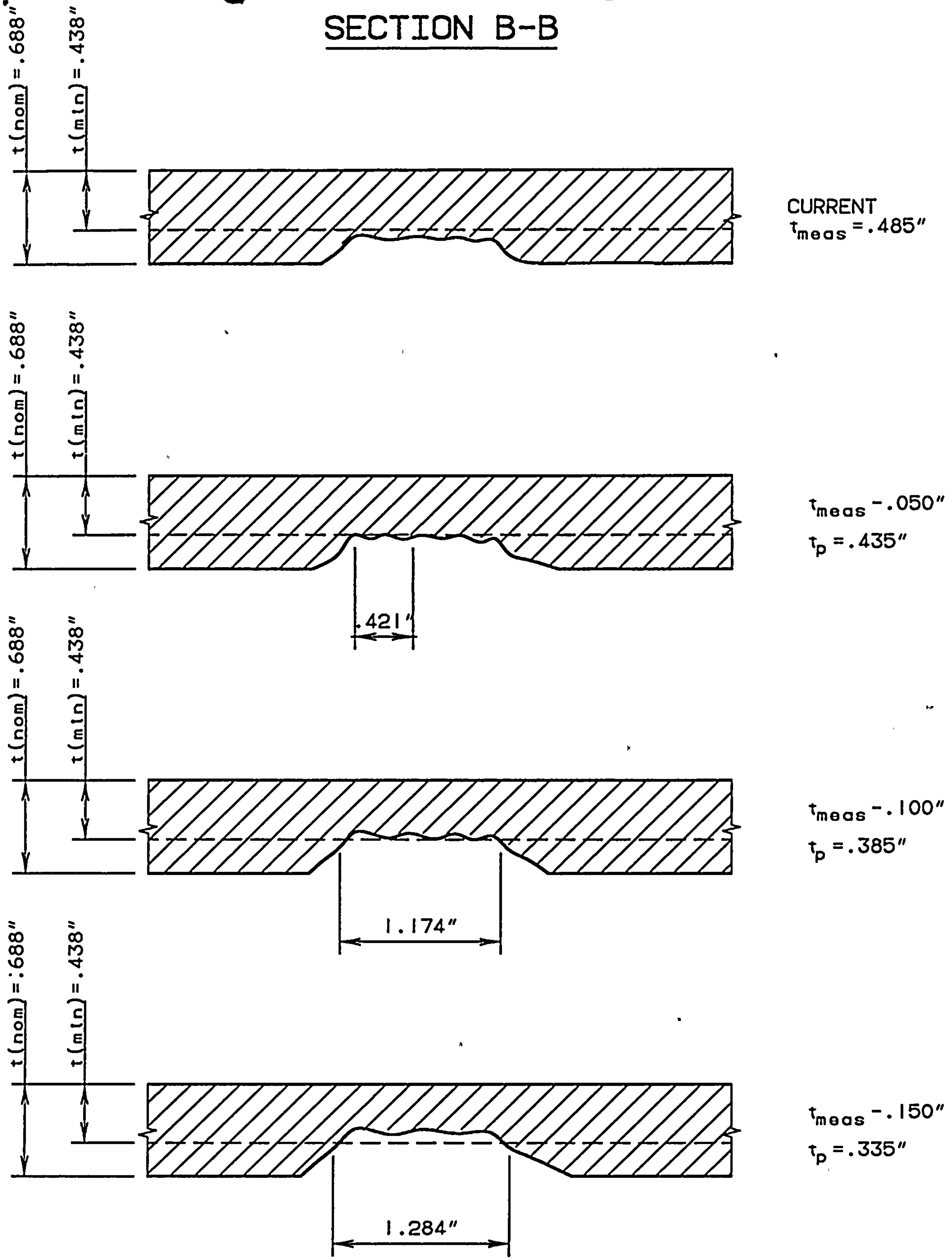

FIGURE 3

SECTION C-C

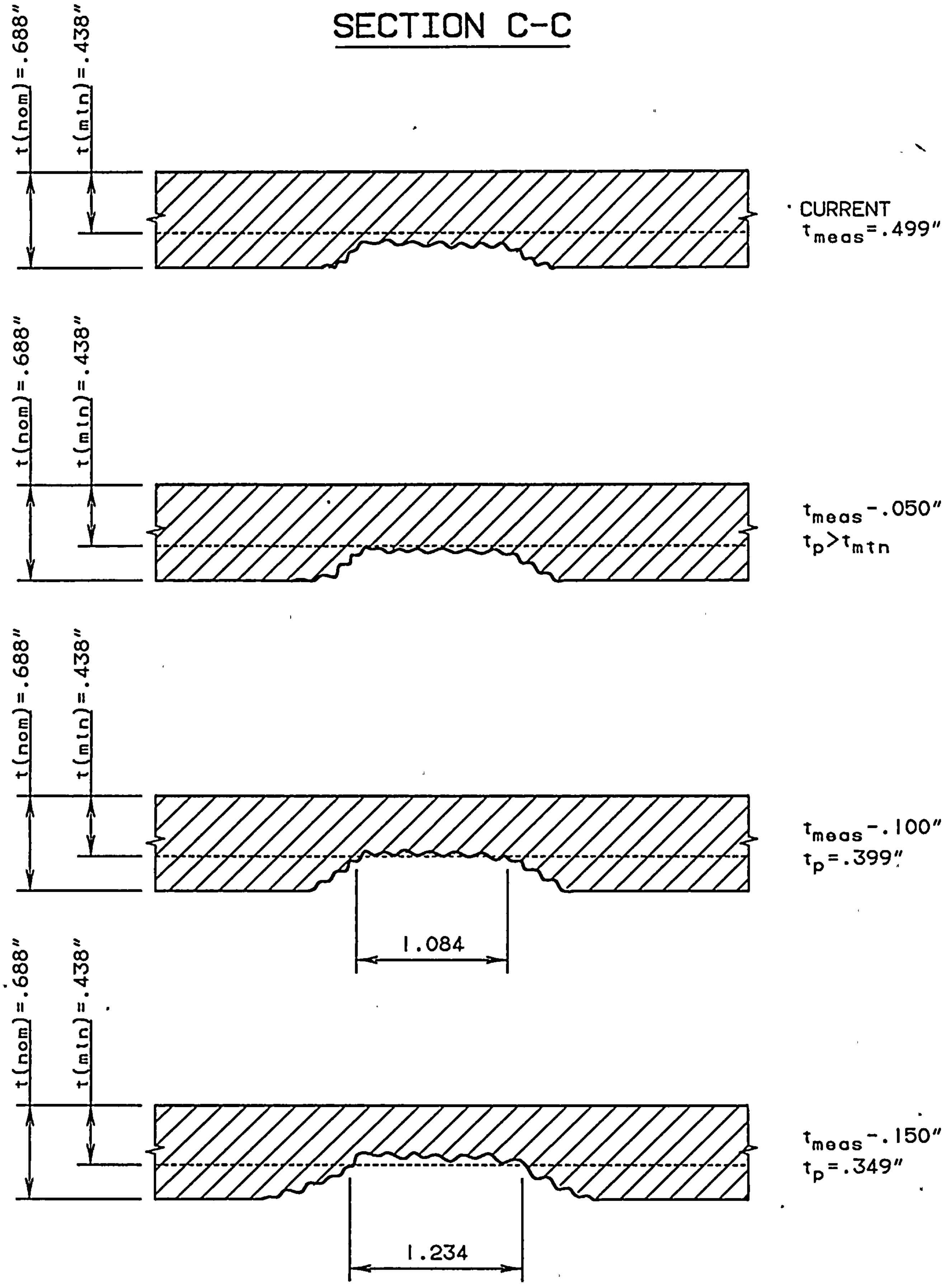

FIGURE 4