MT-SME-427(88)
Rev. 1

BYRON AND BRAIDWOOD UNITS 1 AND 2

(NRC BULLETIN 88-08 THERMAL STRESSES IN PIPING CONNECTED TO REACTOR COOLANT SYSTEM)

IDENTIFICATION OF UNISOLABLE PIPING AND DETERMINATION OF INSPECTION LOCATIONS

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NRC BULLETIN 88-08

1. PURPOSE

This report provides the basis and conclusions of the evaluation of the Byron and Braidwood Units 1 and 2 unisolable piping systems and components for potential thermal stress effects as described in NRC Bulletin 88-08 (June 22, 1988), Supplement 1 (June 24, 1988) and Supplement 2 (August 4, 1988).

2. SCOPE

This report addresses item 2 of Bulletin 88-08, "Actions Requested" for the Byron and Braidwood Plants, determination of locations for nondestructive examination to "provide assurance that there are no existing flaws". In addition, inspection guidelines are provided, to enhance the likelihood of detection of indications.

Determination of "unisolable sections of piping connected to the RCS which can be subjected to stresses from temperature stratification or temperature oscillations that could be induced by leaking valves and that were not evaluated in the design analysis of the piping" has been covered in an earlier transmittal [1]. The conclusions from this earlier work are summarized here in Section 4.

3. PROCEDURE

- o A plant specific systems review of piping attached to the reactor coolant system is performed to identify any unisolable piping which may be susceptible to the thermal phenomenon outlined in NRC Bulletin 88-08.

- o For any unisolable piping identified, piping isometric drawings are reviewed to determine critical locations where in-service inspection should be performed. Additionally, inspection guidelines to enhance detection of possible indications are provided.

4. CONCLUSIONS

The systems review to determine unisolable sections of piping has been completed, and is documented in reference 1. In this evaluation the unisolable piping has been defined as the piping from the reactor coolant system to the first check valve in the auxiliary piping under consideration.

It is concluded that portions of the following auxiliary lines in the Byron and Braidwood Units 1 and 2 plants must be considered under Bulletin 88-08:

- Normal and Alternate Charging (CVCS)
- Auxiliary Spray
- Safety Injection

The normal and alternate charging systems are connected to the reactor coolant loops (see page 4 and 5). When there is absence of leakage from the check valves, the elevation of the reactor coolant loops (heat source) creates a stable thermal gradient in the unisolable piping. Hence, the piping is not subjected to cycling thermal loadings under no leakage conditions.

When in-leakage is assumed, the relatively cold leakage has to flow up the 14 feet risers. This allows sufficient time for the leakage to heat up before reaching the hot section of the piping. Therefore, the thermal shock effect is minimized.

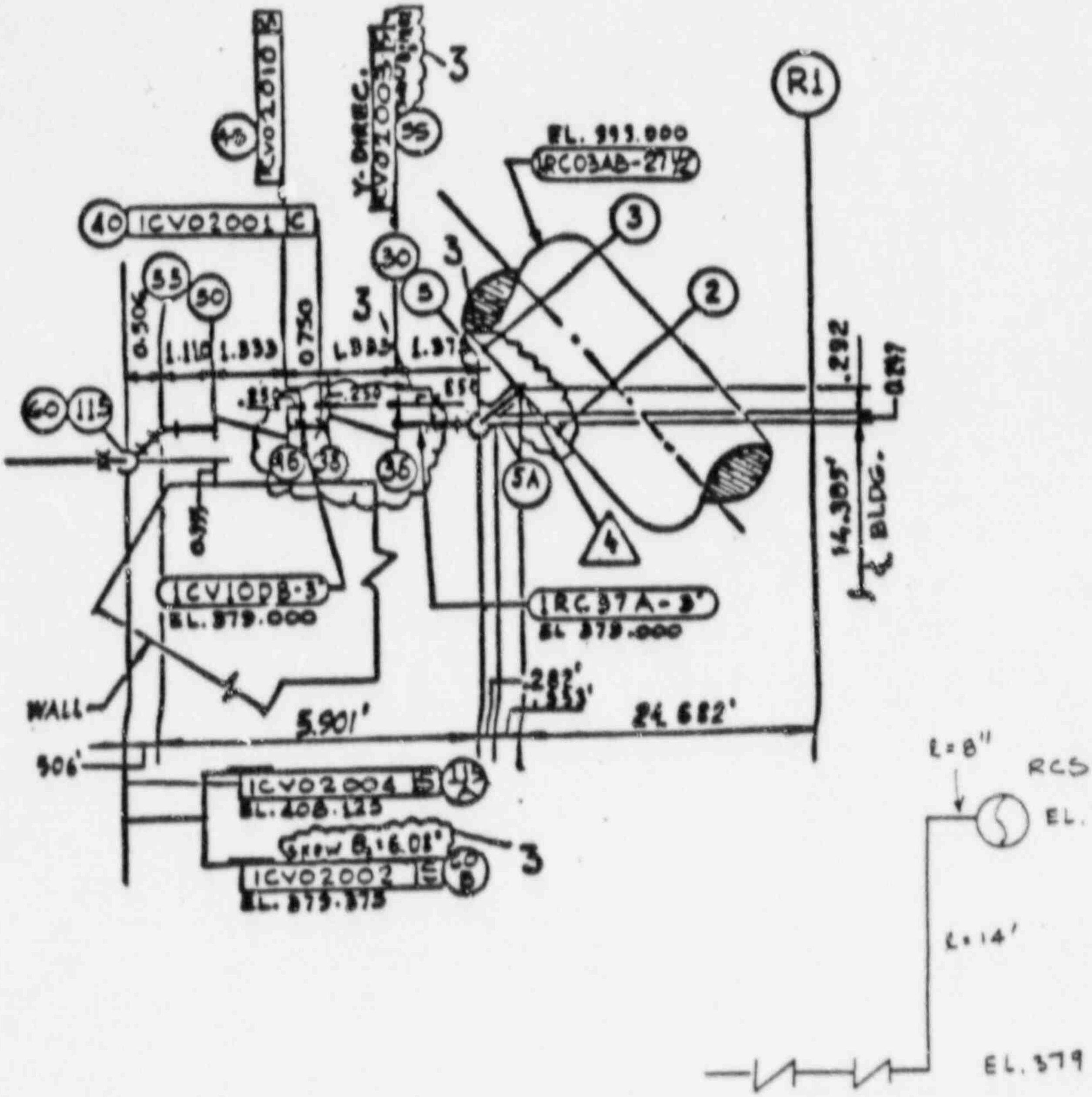
The auxiliary spray lines are potentially subject to temperature-induced cyclic fatigue due to the piping layouts that have cold traps (cold trap refers to the cooler water at the bottom of a vertical riser). Warm water (470°F) from the regenerative heat exchanger can propagate to the cold trapped piping and cause hot-to-cold temperature cycles. Further propagations of the now-cooled leakage to the pressurizer spray or cold leg(s) can cause cold-to-hot temperature cycles.

The charging/SI branch line potential leakage will be at the temperature of the charging pump discharge. Leakage could cause cold-to-hot temperature cycles to occur most likely at the high points of the branch line piping adjacent to the reactor coolant cold legs.

The technical basis for determination of the specific locations for nondestructive examination is documented in Attachment 1. It is concluded that the locations identified in figures C to G need to be nondestructively examined under Bulletin 88-08. If any pipe welds exist between the welds identified, they should also be included in the inspection. Guidelines to enhance detection of possible indications are provided in attachment 2.

5. REFERENCES

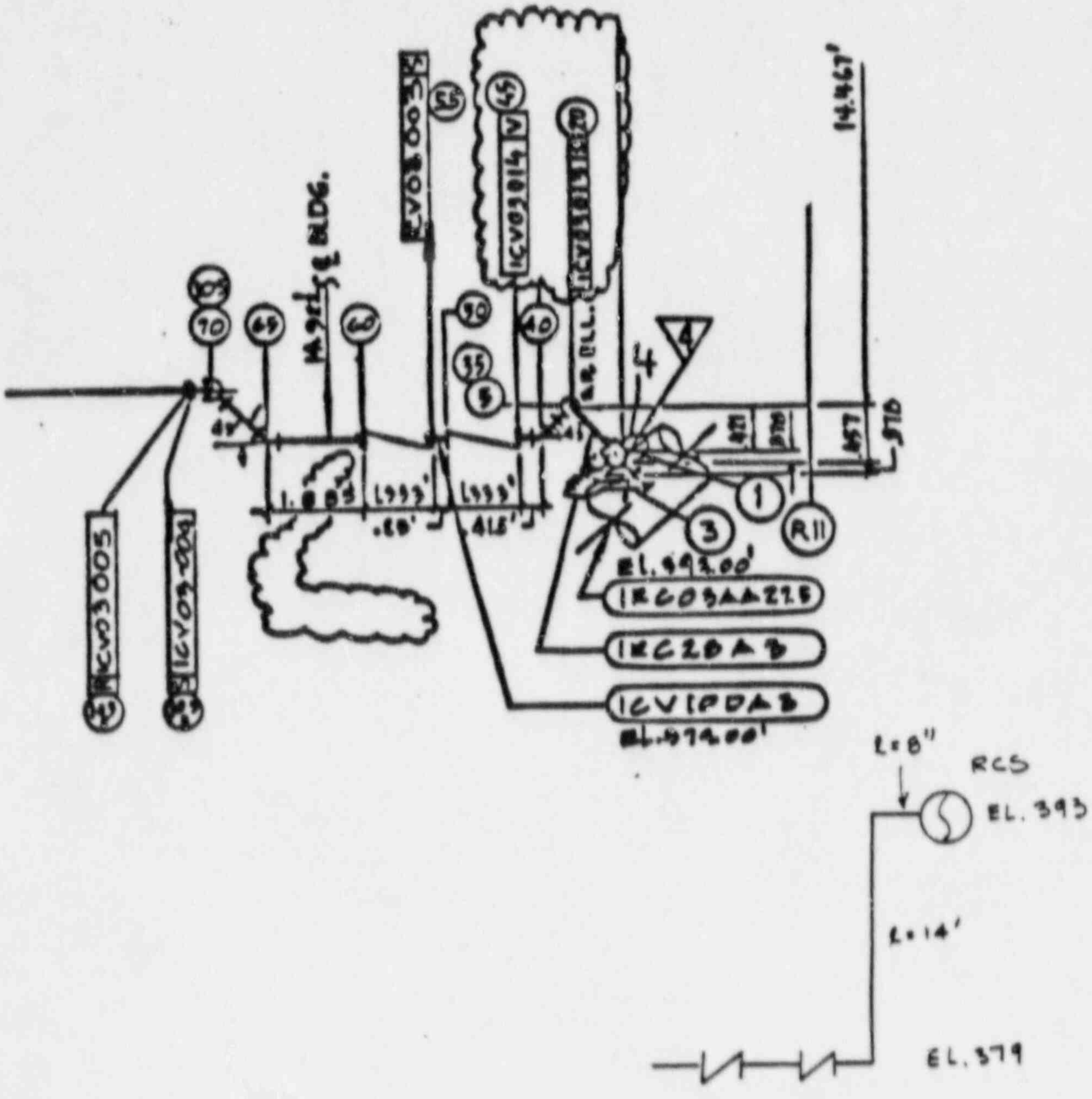
1. Letter, H. Walls to D. Elias, "Potential for Temperature Stratification in the Reactor Coolant Piping," number CAE 88-301, CCE-88-412, August 8, 1988.



Note: No inspections required for this line

Reference: Isometric Drawing ICVC2 Rev 3. (Sargent and Lundy)

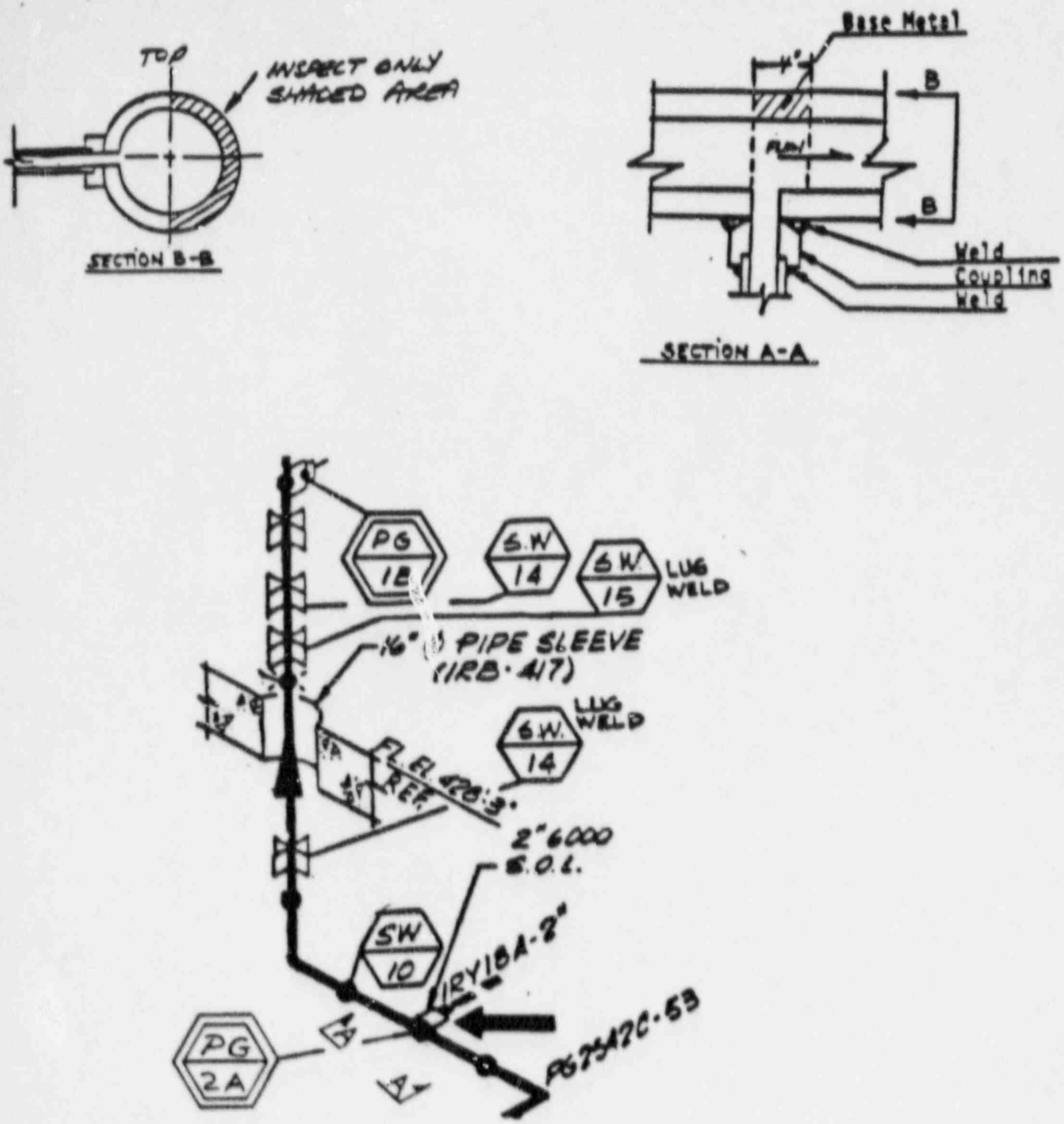
Figure A. Normal Charging Line (CVCS), Byron/Braidwood



Note: No inspections required for this line

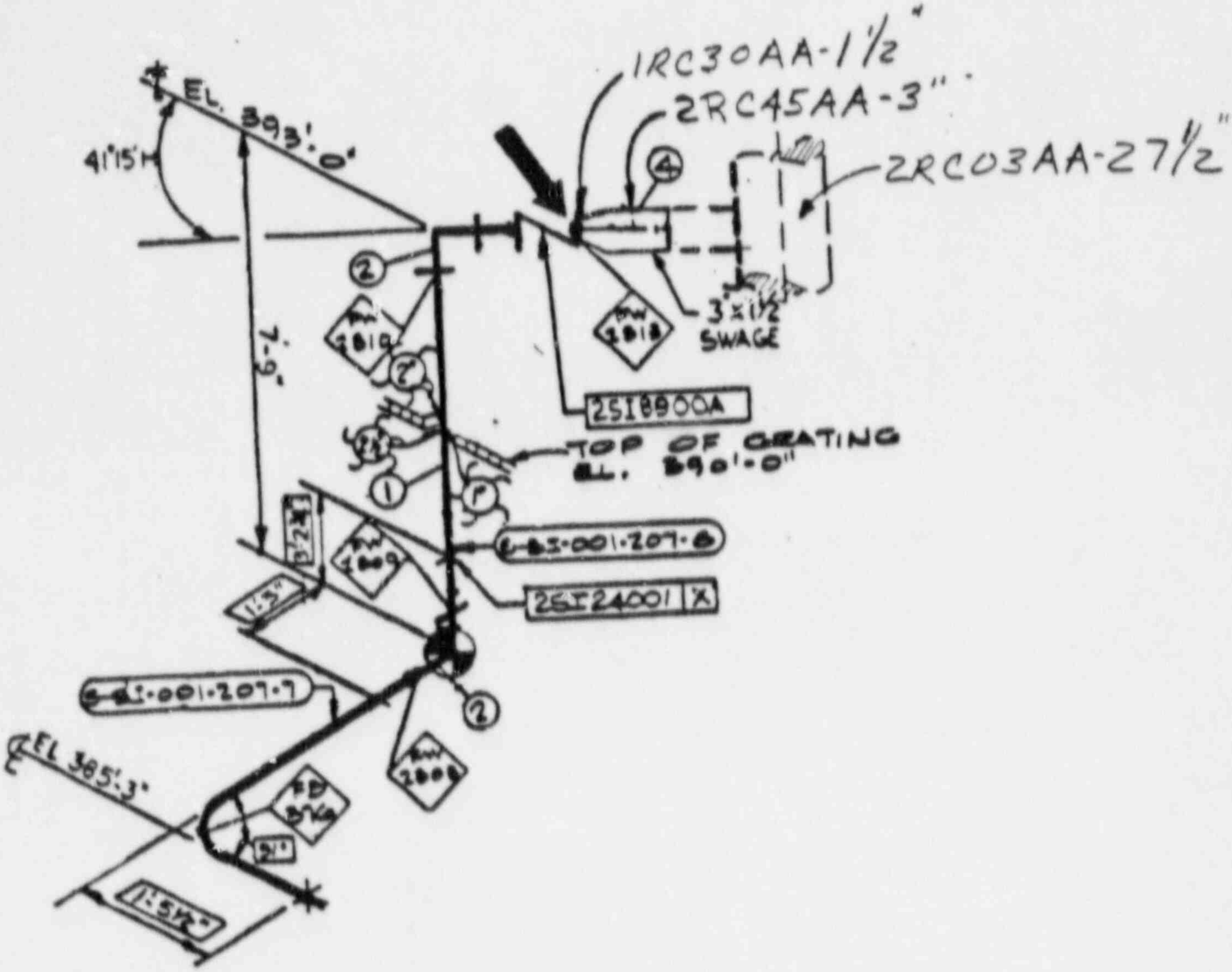
Reference: Isometric Drawing ICV03 Rev 4. (Sargent and Lundy)

Figure B. Alternate Charging Line (CVCS), Byron/Braidwood



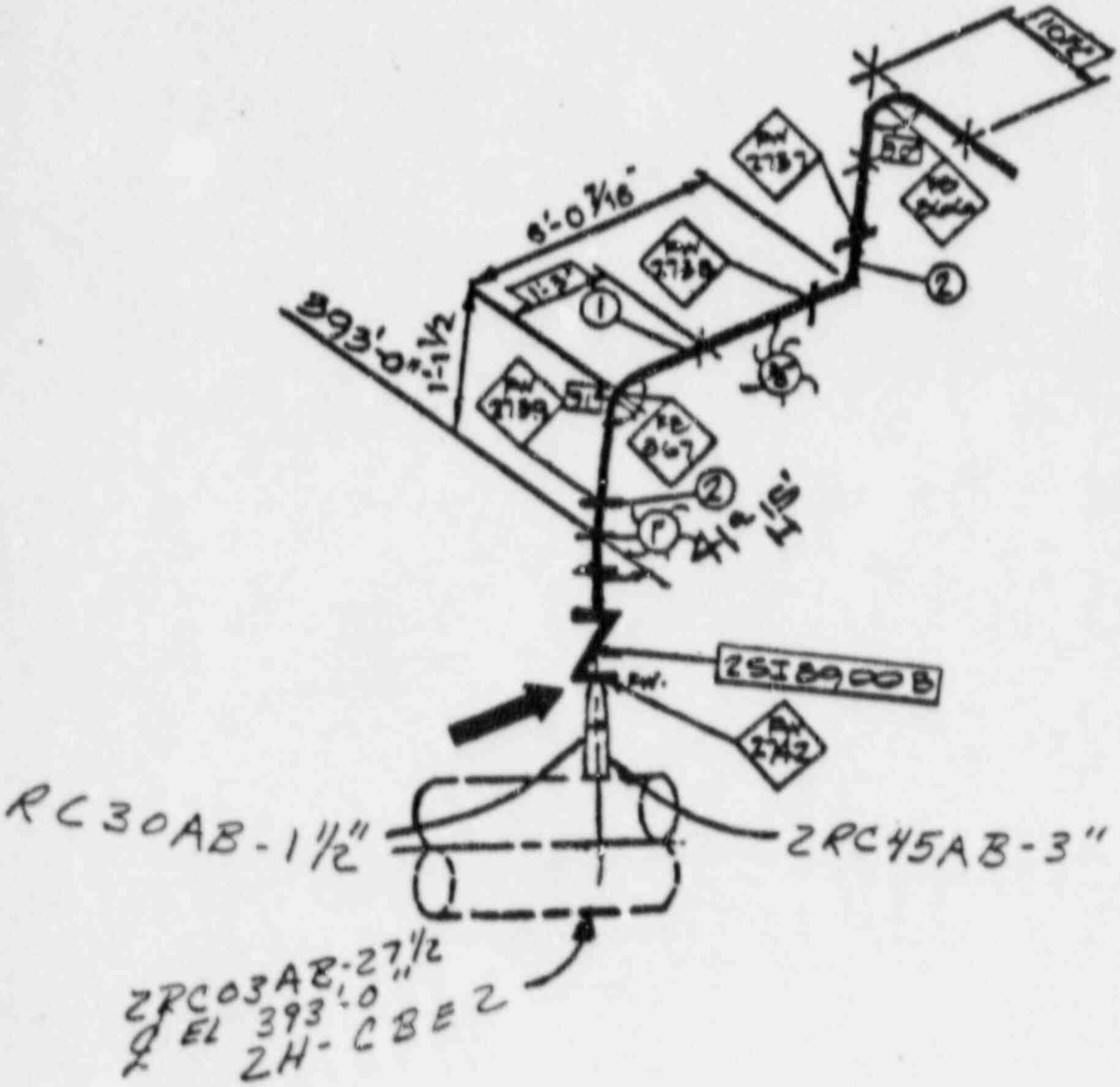
Reference: Isometric Drawing IC-RY-5 Rev B. (Sargent and Lundy)

Figure C. Auxiliary Spray Line for Byron/Braidwood



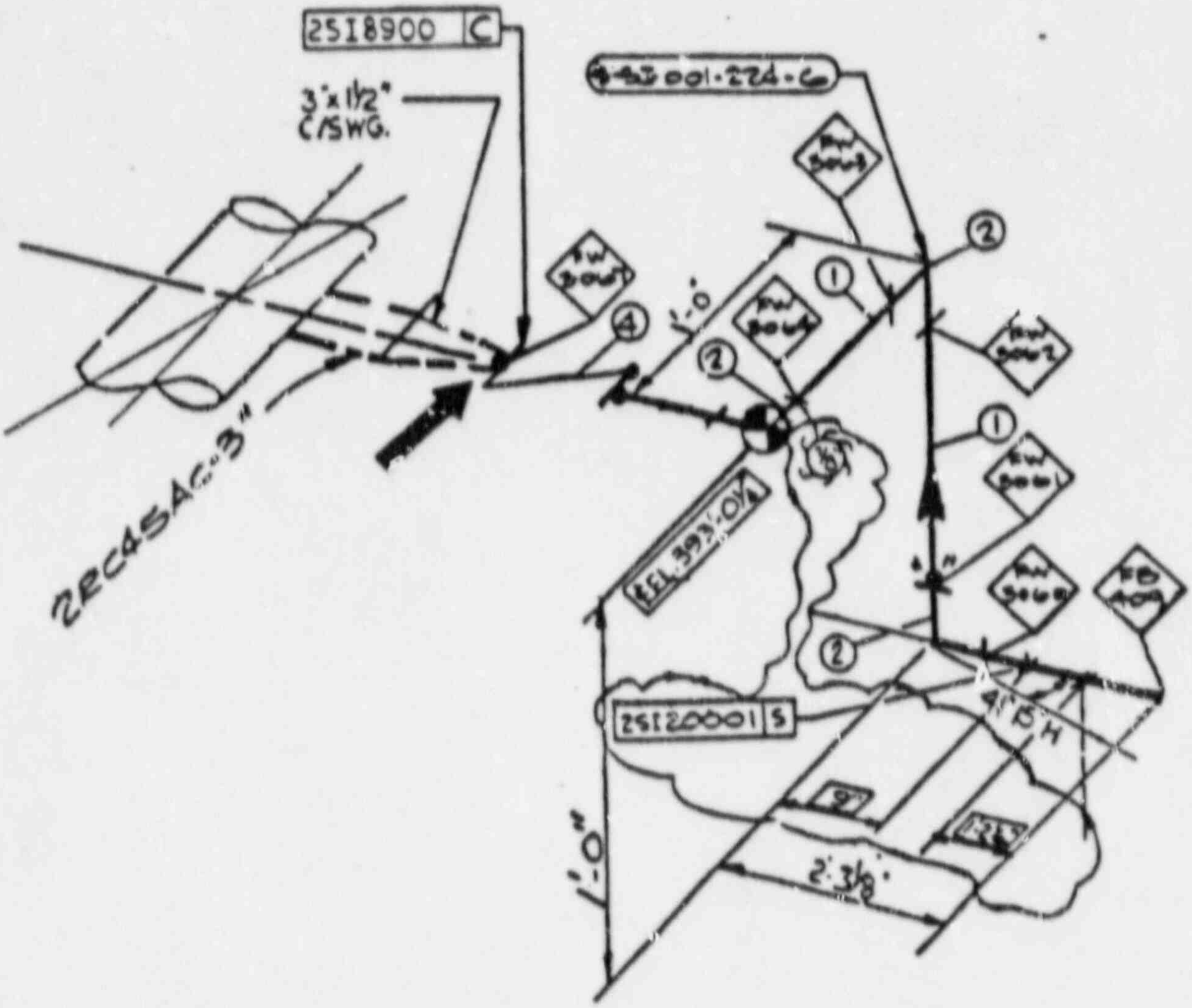
Reference: Isometric Drawing M-2539 Rev A. (Sargent and Lundy, page 13 of 19)

Figure D. Cold Leg Safety Injectinn Line A, Byron/Braidwood plants



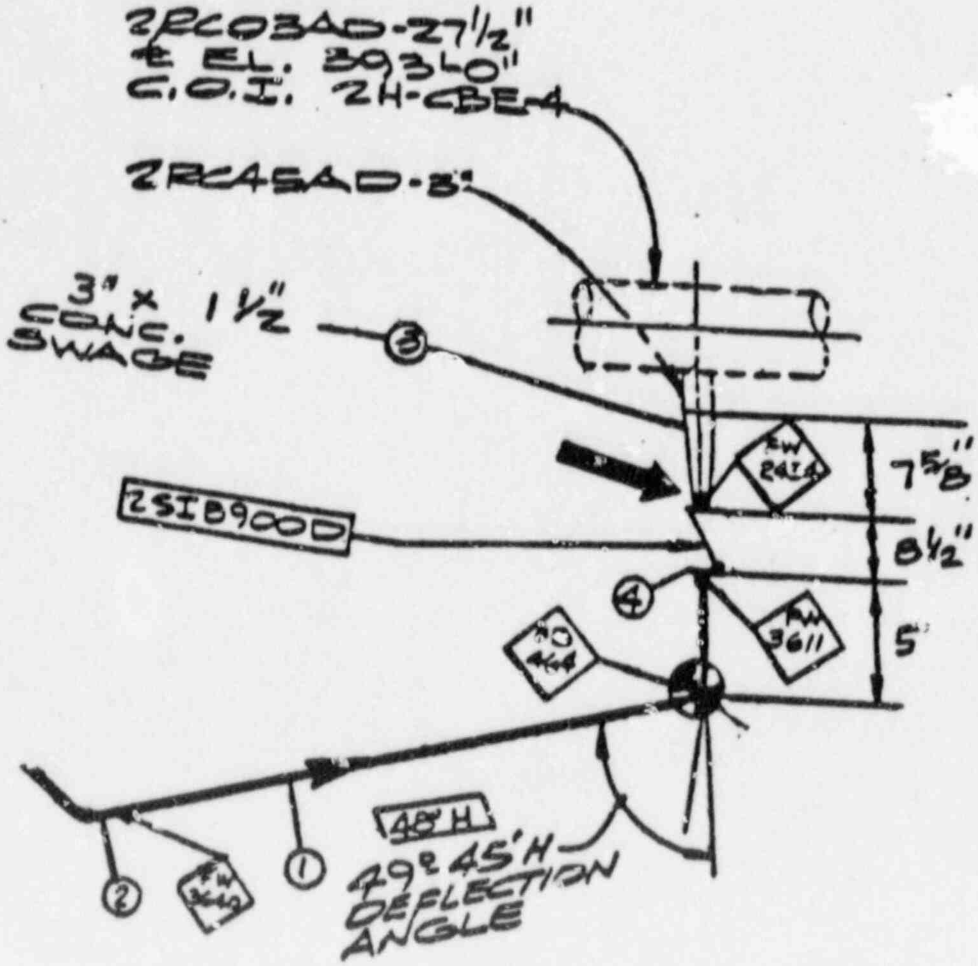
Reference: Isometric Drawing M-2539-C Rev A. (Sargent and Lundy, page 10 of 19)

Figure E. Cold Leg Safety Injection Line B, Byron and Braidwood Units



Referance: Isometric Drawing M-2539-C Rev A. (Sargent and Lundy, page 16 of 19)

Figure F. Cold Leg [illegible], Injection Line C, Byron and Braidwood Units



Reference: Isometric Drawing M-2539-C Rev A. (Sargent and Lundy, page 18 of 19)

Figure G. Cold Lag Safety Injection Line D, Byron and Braidwood Units

ATTACHMENT 1
BULLETIN 88-08 EVALUATION
INSPECTION LOCATIONS

1.0 METHODOLOGY

Attachment 1 identifies unisolable sections of piping connected to the RCS which can be subjected to large thermal stresses induced by leaking valves and that were not evaluated in the design analysis of the piping.

Within these systems, a thermal and stress review is performed, and documented in this attachment, to identify the locations of maximum potential stress for nondestructive examination.

a. The base line temperature (no leakage flow) of the unisolable piping is defined based on piping layout.

   The base line temperature in the dead leg (no leakage flow) for a well insulated pipe can be represented by the conduction and/or free convection relationship:

$$\frac{T(x) - T_o}{T(o) - T_o} = \exp\left[- (UP/k_{eff}A)^{1/2}\ x\right]$$

where x = axial position from hot fluid source

$T(x)$ = temperature at axial position x

T_o = ambient temperature

k_{eff} = effective thermal conductivity (e.g. E.R.G. Eckert, Heat and Mass transfer, McGraw-Hill, 1959, for free convection)

U = net thermal resistance between fluid and ambient

P = pipe wetted perimeter

A = cross-sectional flow

Base line temperatures are calculated for several nominal pipe sizes, schedule 160 wall and 2-inch calcium silicate insulation, with a 100 degree F ambient temperature.

Free convection and conduction are shown separately in figure 2-1 for 3" NPS and smaller piping.

The free convection curves would apply to vertical legs with the hot fluid source at the bottom. The molecular conduction curves would apply to vertical legs with the hot fluid source at the top ("cold trap") or horizontal legs.

b. The leakage flow is conservatively assumed to be at ambient temperature.

For a small leakage flow into a pipe with stagnant water, the axial temperature can be estimated by the relationship:

$$\frac{T(x) - T_o}{T(o) - T_o} = \exp [- (UP/\dot{m}Cp) x]$$

where $\dot{m}$ = leakage mass flow rate

C_p = fluid specific heat

This estimate shows that for small leakage (.01 gpm) the leakage flow temperature will tend to decrease to close to ambient temperature over a length of approximately 10 feet. It is therefore conservative to assume that the leakage flow is at ambient.

c. The leakage flow is conservatively assumed to stratify and not mix with the hot dead leg fluid, except in vertical segments of pipe.

The stratification was confirmed from plant measurements of leakage flow and can be expected based on low flow rates (large Richardson number).

d. Pipe sections of maximum temperature gradient (top to bottom) and temperature fluctuations (cycling of leakage flow) are determined.

e. Within pipe sections locations of largest stress concentration are identified for non-destructive examination.

2.0 RESULTS OF ASSESSMENT FOR INSPECTION LOCATIONS

Based on the methodology described above, the locations of maximum potential ΔT and most susceptible to fatigue are identified in figures A through G. These locations are recommended for NDE per Bulletin 88-08. Relevant details on selection of location pertaining to the identified system are provided below. Per supplement 1 of Bulletin 88-08 the component of maximum anticipated fatigue loadings is selected for base metal evaluation. Otherwise, only weld locations are specified as the stress concentration at these points will generally maximize the fatigue affects.

The welds of the reactor coolant loop nozzle do not require inspection due to sufficient mixing resulting from flow in the main coolant piping.

a. Normal and Alternate Charging Lines (CVCS)

These systems are shown in Figures A and B. Based on the evaluation given on page 2, no inspection is deemed necessary.

b. Auxiliary Spray Line

The two inch sockolet weld at the RCS piping connection is recomm [illegible] inspection. The [illegible]se metal in the main spray piping near the b[illegible] outlet is recommended for inspection, due to the potential for le[illegible] impingement on this component during low spray conditions, as shown in figure C.

c. Safety Injection Loop A

As shown in figure D, the downstream weld (FW 2813) of valve 2SI8900A is recommended for inspection. The RCS nozzle safe end weld is not recommended for inspection because turbulent flow in the main loop will sweep the water out of this area, causing complete mixing.

d. Safety Injection Loop B

As shown in figure E, the downstream weld (FW 2742) of valve 2SI8900B is recommended for inspection. The RCS nozzle safe end is not recommended for inspection because turbulent flow in the main loop will sweep the water out of this area, causing complete mixing.

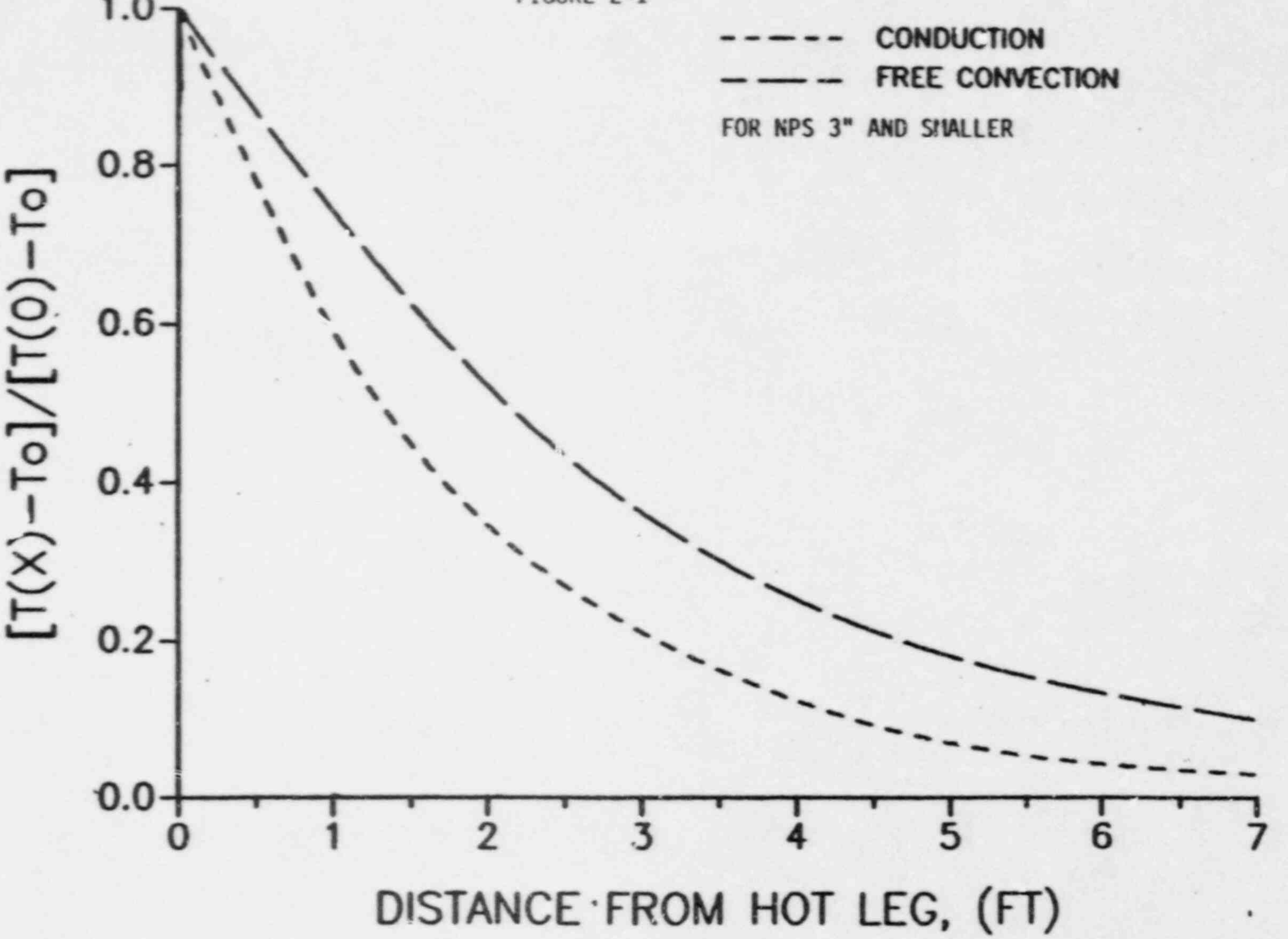
e. Safety Injection Loop C

As shown in figure F, the downstream weld (FW 3067) of valve 2SI8900C is recommended for inspection. The RCS nozzle safe end is not recommended for inspection because turbulent flow in the main loop will sweep the water out of this area, causing complete mixing.

f. Safety Injection Loop D

As shown in figure G, the downstream weld (FW 2434) of valve 2SI8900D is recommended for inspection. The RCS nozzle safe end is not recommended for inspection because turbulent flow in the main loop will sweep the water out of this area, causing complete mixing.

FIGURE 2-1



EFFECT OF MOLECULAR CONDUCTION AND FREE CONVECTION ON AXIAL TEMPERATURE DISTRIBUTION

Smaller Diameter Lines (less than 4 inches)

As a result of the NRC bulletin 88-08, a number of smaller diameter pipes are now requiring inspection. It should be noted that these lines were not designed for such inspections, and some locations may require advanced volumetric inspection techniques. Volumetric inspection can be either ultrasonic testing or radiographic testing.

1. Ultrasonic testing may involve use of miniature or specialized transducers with specific procedures for examining the volume of interest.

2. Radiographic techniques should be considered when unusual component geometry or large areas require inspection. These techniques should be qualified to ensure that proper coverage of the component volume of concern. Access for positioning the radioactive source is also an important consideration.

In some cases, it may be practical to use a combination of radiographic and ultrasonic testing techniques.

If any indications or suspect indications are detected during the above examinations, it is recommended that supplemental radiographic examination of that weld be performed.

ATTACHMENT 2

INSPECTION GUIDELINES

Larger Diameter Lines (4 to 6 inch)

Based on the examinations performed at Farley Unit 2 on the six(6) inch schedule 160 safety injection lines. the following supplemental examinations were able to detect the through-wall indication in the Farley Unit 2 line.

Perform the ASME Section XI UT examinations augmented to the specifications required for the safety injection line welds. These examinations should consist of:

Performing a 45 degree refracted shear wave examination using a 2.25 MHz 0.5 to 0.25 inch diameter transducer, calibrating out to a one and one-half vee exam for all of the above welds.

Performing an additional 60 degree refracted shear wave examination using a 0.50 to 0.25 inch diameter, 1.5 MHz transducer, calibrating out to a one and one-half vee exam for all of the above welds.

Scanning sensitivities should be at 14 dB above reference sensitivity with a noise level of less than 10% full screen height for the 45 and 60 degree exams. If the noise level exceeds the above limit, reduce the scanning sensitivity in one dB increments until the noise level drops to below the above level, and record this reduction on the applicable data sheet.

Record and evaluate all indications that traveled in time, are not attributed to component geometry and have an amplitude of greater than or equal to 20% of the distance amplitude correction curved.