MT-SME-424(88)
Rev. 2

INDIAN POINT UNIT 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 Indian Point Unit 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 items 1 and 2 of Bulletin 88-08, "Actions Requested" for the Indian Point Unit 2.

(a) 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".

(b) Determination of locations for nondestructive examination to "provide assurance that there are no existing flaws".

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 susceptable 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 [illegible] review to determine unisolable sections of piping (item (a) of Sc[illegible] documented in attachment 1. In this evaluation the unisolable pi[illegible] been defined as the piping from the reactor coolant system to the f[illegible] valve in the auxiliary piping under consideration.

It is concluded that portions of the following auxiliary lines in the Indian Point Unit 2 plant must be considered under Bulletin 88-08:

- o Normal Charging
- o Alternate Charging
- o Auxiliary Spray

The safety injection lines are not subject to stratification because of the high head safety injection system which has a shut off head below the RCS pressure. The determination of locations for nondestructive examination (item (b) of Scope) is documented in attachment 2. It is concluded that the locations identified in figure 1 need to be nondestructively examined under Bulletin 88-08.

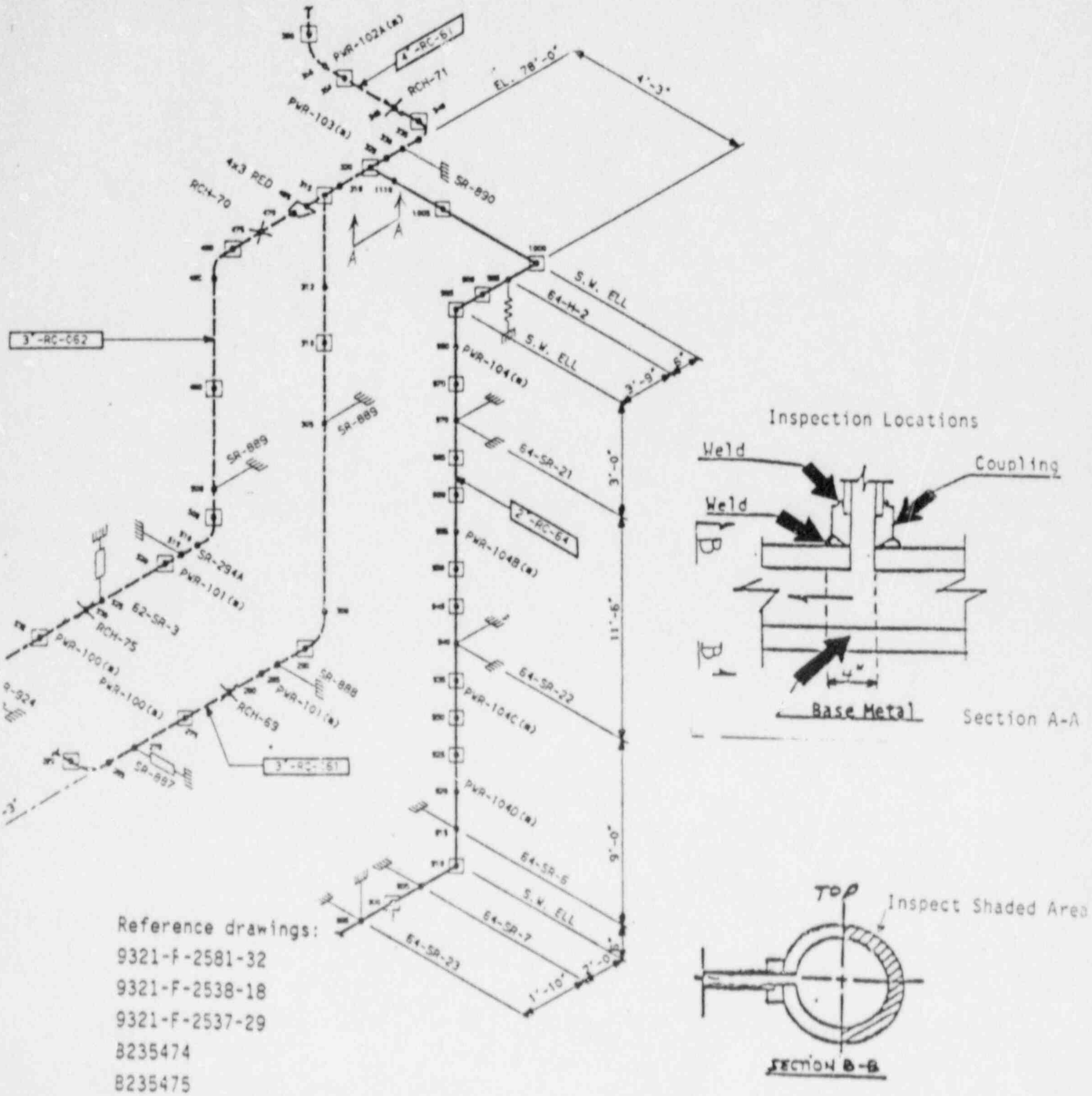
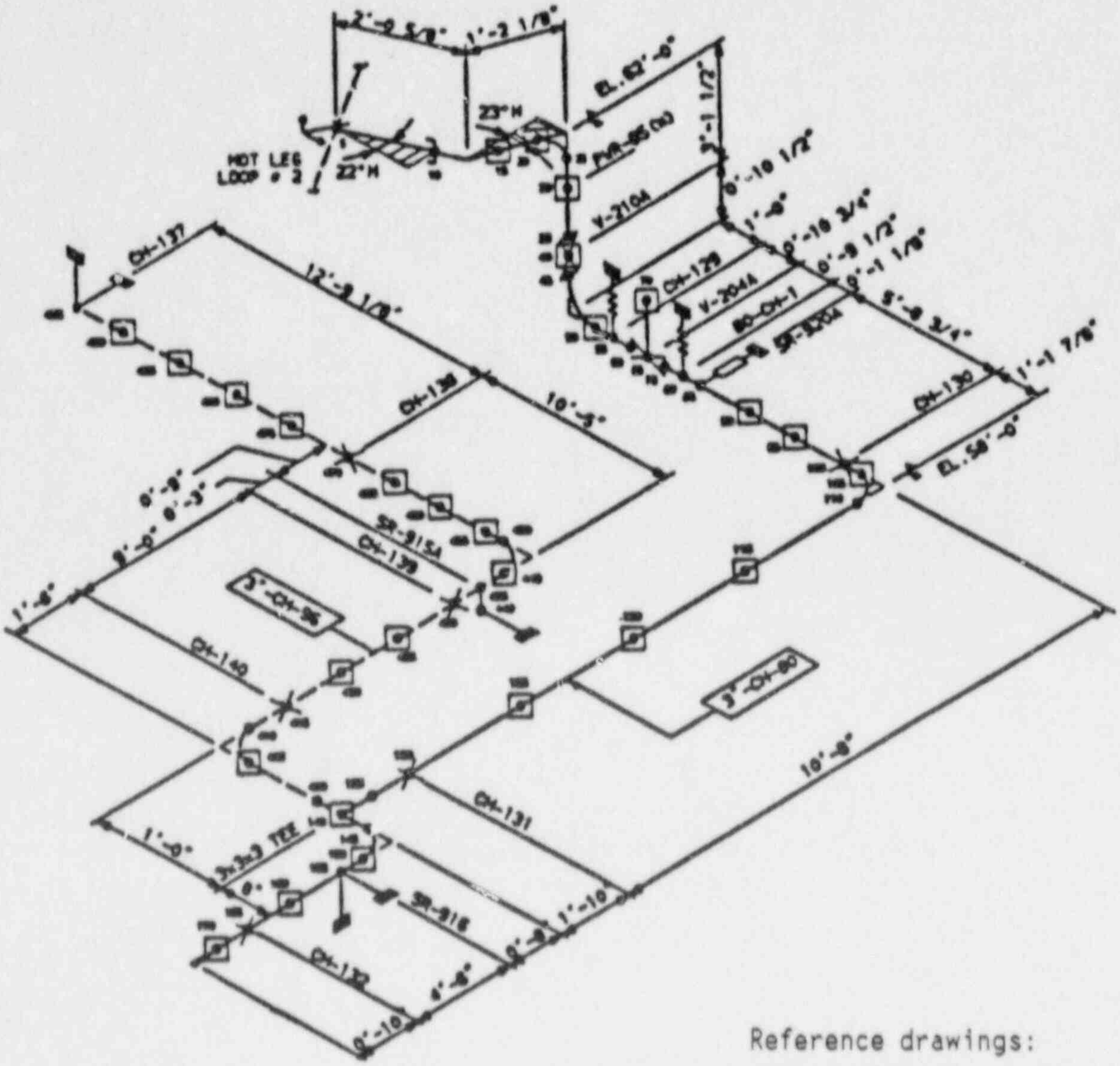


Figure 1. Auxiliary Spray Line (Line 064 and 061)

Inspections Not Required



Reference drawings:
9321-F-2581-32
9321-F-2582-17

Figure 2. Charging Line (Number 080)

ATTACHMENT 1

NRC BULLETIN 88-08 EVALUATION FOR INDIAN POINT UNIT NO. 2

SYSTEMS REVIEW

In general, this phenomenon of thermal fatigue of unisolable piping connected to the RCS, as described in the NRC Bulletin 88-08, can occur whenever the connected piping is isolated by a leaking isolation valve and the pressure upstream of the leaking valve is greater than the RCS pressure (2250 psig nominal), and the temperature of the fluid is significantly cooler than the RCS temperatures. The only pressure source available in the Indian Point Plant which fits this criteria is the normal charging system. During normal conditions, the pressure at the discharge of the charging pumps is approximately 2385 psig.

Our review identified all flow paths between the discharge of the charging pumps to the RCS. Lines identified included the auxiliary spray line, and the charging line to Loop 2 hot leg. The following is a review of each line.

1. Auxiliary Spray Line (Line # 5

   Figure 1-1 depicts the CVCS auxiliary spray line connection to the main spray lines, and to the pressurizer for Indian Point Station Unit 2. During normal operations, the auxiliary spray line is isolated by closure of valve 212. Valve 212 is a two inch air operated globe isolation valve (2-ID58R) which is designed to open when pressure under the seat exceeds the reactor coolant pressure by approximately 200 psi to provide pressure relief for the tube side of the regenerative heat exchanger if letdown is initiated on the shell side when the tube side is isolated. The differential pressure across the valve is estimated to be approximately 55.0 psid, under normal conditions. The check valve 211 (2-C58) is a two inch lift check valve.

A small amount of in-leakage from the high pressure charging line through valve 212 would result in eventual leakage of the fluid volume between valves 212 and the check valve 211 into the RCS, and the cracking pressure of the check valve would create a cyclic phenomena by periodically burping fluid as pressure builds up between the isolation valve and the check valve, due to the leakage.

The temperature upstream of valves 211 and 212 is approximately 495°F based on the regenerative heat exchanger tube side outlet temperature. Point E on figure 1-1 represents the junction of the CVCS auxiliary spray line with the main spray lines (Line #61). The temperature at point E is maintained at approximately cold leg temperature of 543°F by the 1 gpm spray flow. Note that some cooldown due to heat loss typically occurs in the main spray line from the cold leg spray scoop to point E. Based on the nominal low temperature alarm for the spray line, specified in the PLS document, temperature at point E is expected to be greater than 500°F.

From figure 1-1, it is seen that there are cold traps between the heat exchanger and point A, and between points B and C. Even if the line is insulated, the water will very likely be cool before it reaches the isolation valve 212 and check valve 211.

Similarly, there is another cold trap downstream the check valve 211, between the valve and point D, hence the fluid downstream of the check valve 211 can be expected to be cool, close to the containment ambient conditions (approximately 120°F). Depending on the amount of cooling taking place upstream and downstream of the check valve, there may be leakage from a hot source into a colder environment with a potential stratification.

The span of piping between regenerative heat exchanger and the check valve is large. Also the span of piping between point E (figure 1-1) and the check valve is large (with a large vertical span of 24'). Therefore, the fluid is expected to be in thermal equilibrium on either side of the check valve and the most likely piping segment of concern is the 8.5' horizontal segment at location E. In this segment the location for high thermal stress would be at the entrance to the main spray line.

Check valve 211 forms the RCS pressure boundary. Cracks upstream of 211 are considered in the isolable portion of the piping system. Cracks downstream of 211 are considered to be in the unisolable portion.

2. Charging Line to Loop 2 Hot Leg (Line # 80)

There are two charging paths provided in Indian Point Station Unit 2. The first path is the normal charging path to the cold leg of Loop 1. The second path is an additional charging path to the hot leg of Loop 2. This path can be used if the normal charging path is not available. However, based on the plant operating experience, the normal charging path (Line # 95) is always in use for the charging operations and is never isolated, hence, there is no potential for thermal cycling in this line.

The only charging line potentially subjected to the mechanism described in the NRC Bulletin No. 88-08 is Line # 80, the charging line to the hot leg of Loop 2.

Figure 1-2 depicts the CVCS charging line to Loop 2 hot leg, for Indian Point Station Unit 2. During normal operations, this line is isolated by closure of valve 204A which is a three inch air operated globe isolation valve (3-ID58DP). The differential pressure across the valve is estimated to be approximately 53 psid, under normal conditions.

The check valve 210A (3-C58) is a three inch swing type check valve. A small amount of in-leakage from the high pressure charging line through valve 204A would result in eventual leakage of the fluid volume between valves 204A and the check valve 210A into the RCS.

Under the normal charging conditions the temperature of the charging flow around the valve 204A is expected to be less than or equal to 495°F, the regenerative heat exchanger tube side outlet temperature. The temperature of the fluid downstream of the check valve 210A is expected to be close to 596°F by virtue of its location near the RCS hot leg.

There is a very short distance of piping between the valves 204A and 210A (approximately 1.7 feet) and as a result, the cooling in the leaking fluid will be negligible in this section of piping.

Note that the check valve 210A is located on a vertical section of piping. Any cool leakage through the isolation valve 204A and eventually through the check valve 210A will mix with the hot fluid in the vertical section downstream of the check valve before it reaches the horizontal section, and therefore, will minimize the possibility of thermal stratification and cyclic fatigue in the unisolable section of piping downstream of the check valve.

FIGURE 1-1: Line #64 and #61 Schematic
(Auxiliary Spray Line)

Reference Drawings:

9321-F-2581-32
9321-F-2538-18
9321-F-2537-29
B235474
B235475

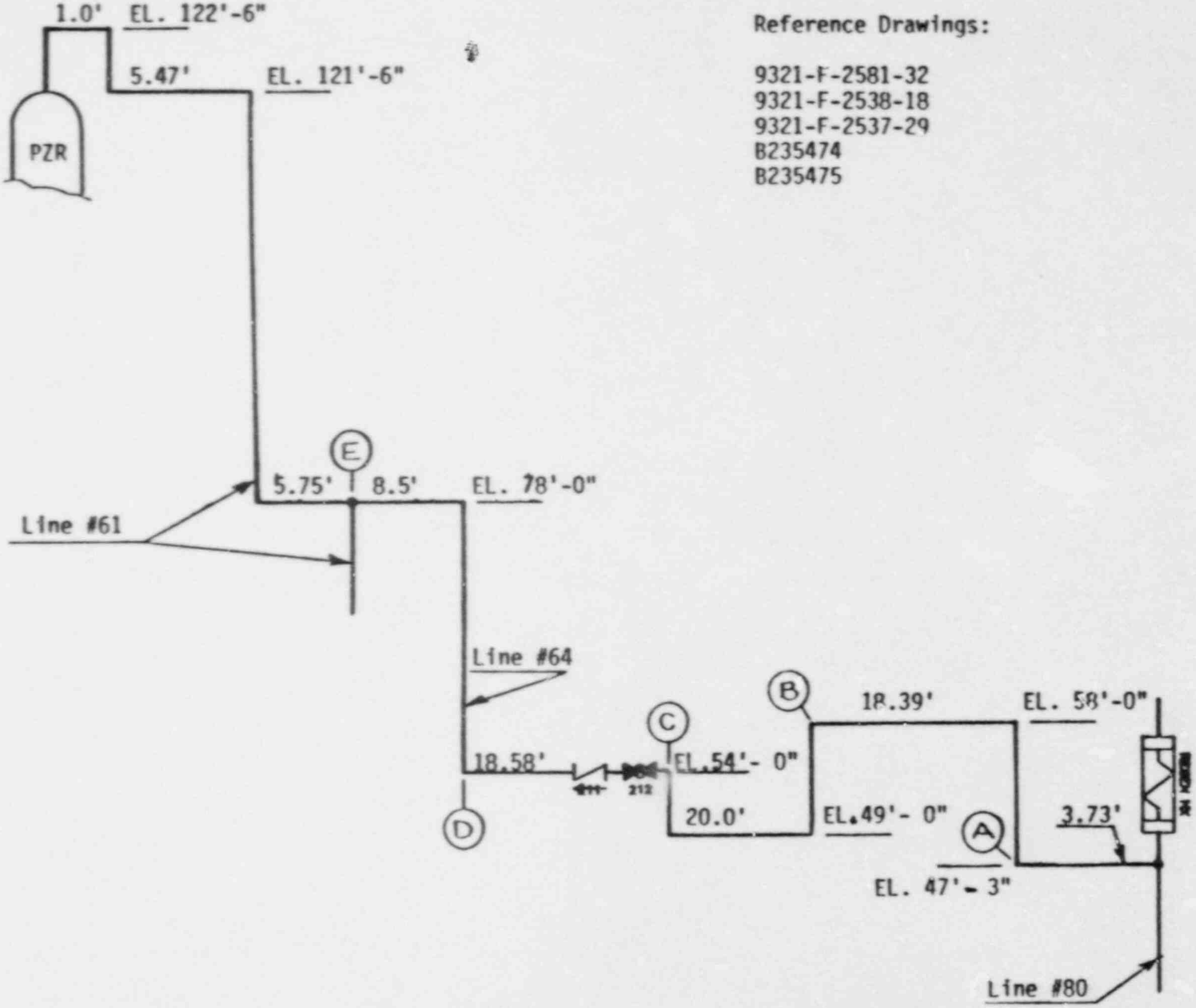
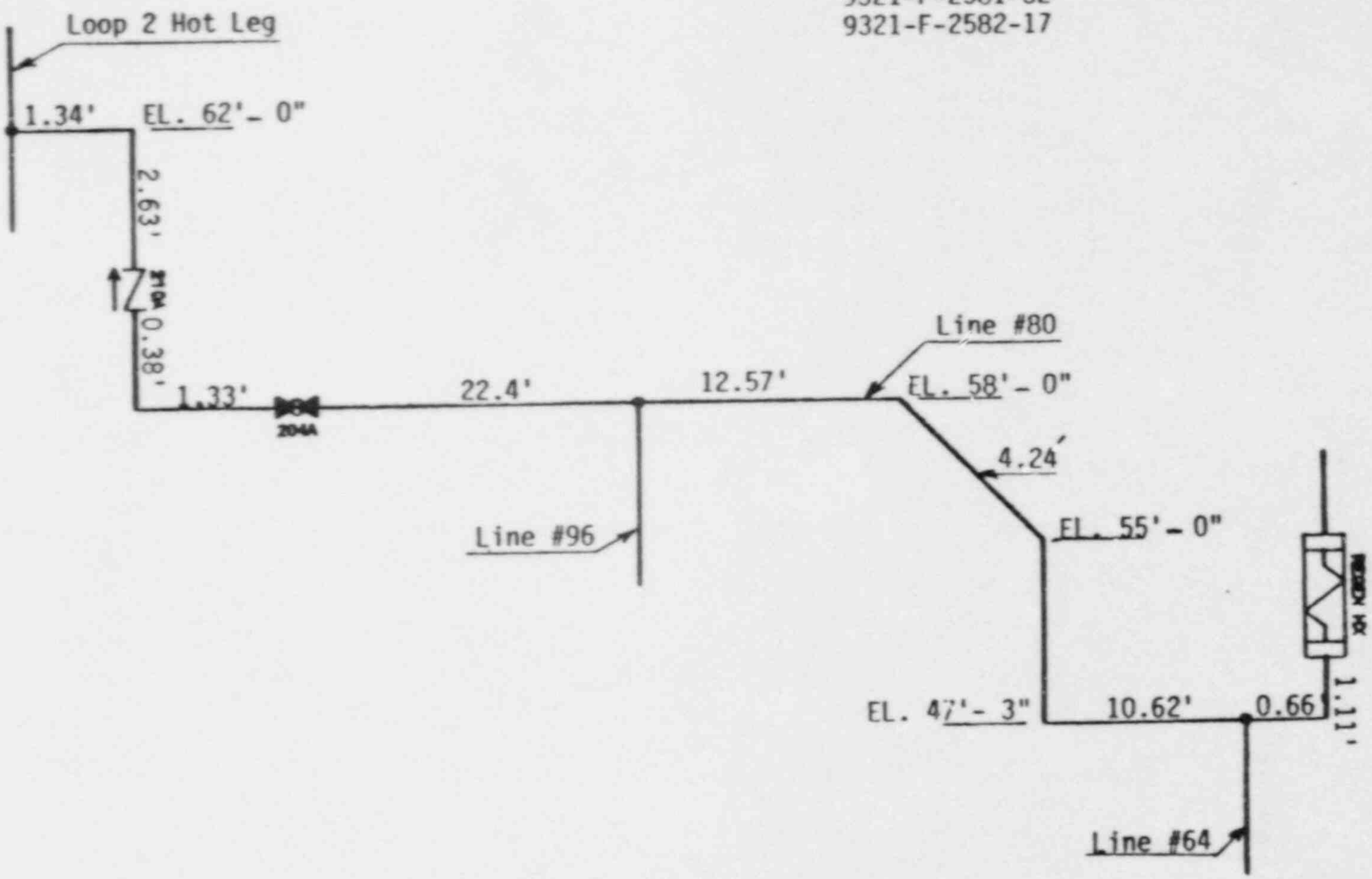


FIGURE 1-2: Line #80 Schematic
(Charging Line to Loop 2 Hot Leg)

Reference Drawings:

9321-F-2581-32
9321-F-2582-17



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ATTACHMENT 2

BULLETIN 88-08 EVALUATION

INSPECTION LOCATIONS - INDIAN POINT UNIT 2

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 has been 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

$T(o)$ = temperature at position x=0, the hot location

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 2 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:

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

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 figure 1. 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. Auxiliary Spray Line

   The welds and components in the vicinity of the 2 inch branch connection to the main sprayline are recommended for inspection as shown in figure 1. The base metal in the main spray piping near the branch outlet is also recommended for inspection due to the potential for leakage impingement on this component during low spray flow conditions.

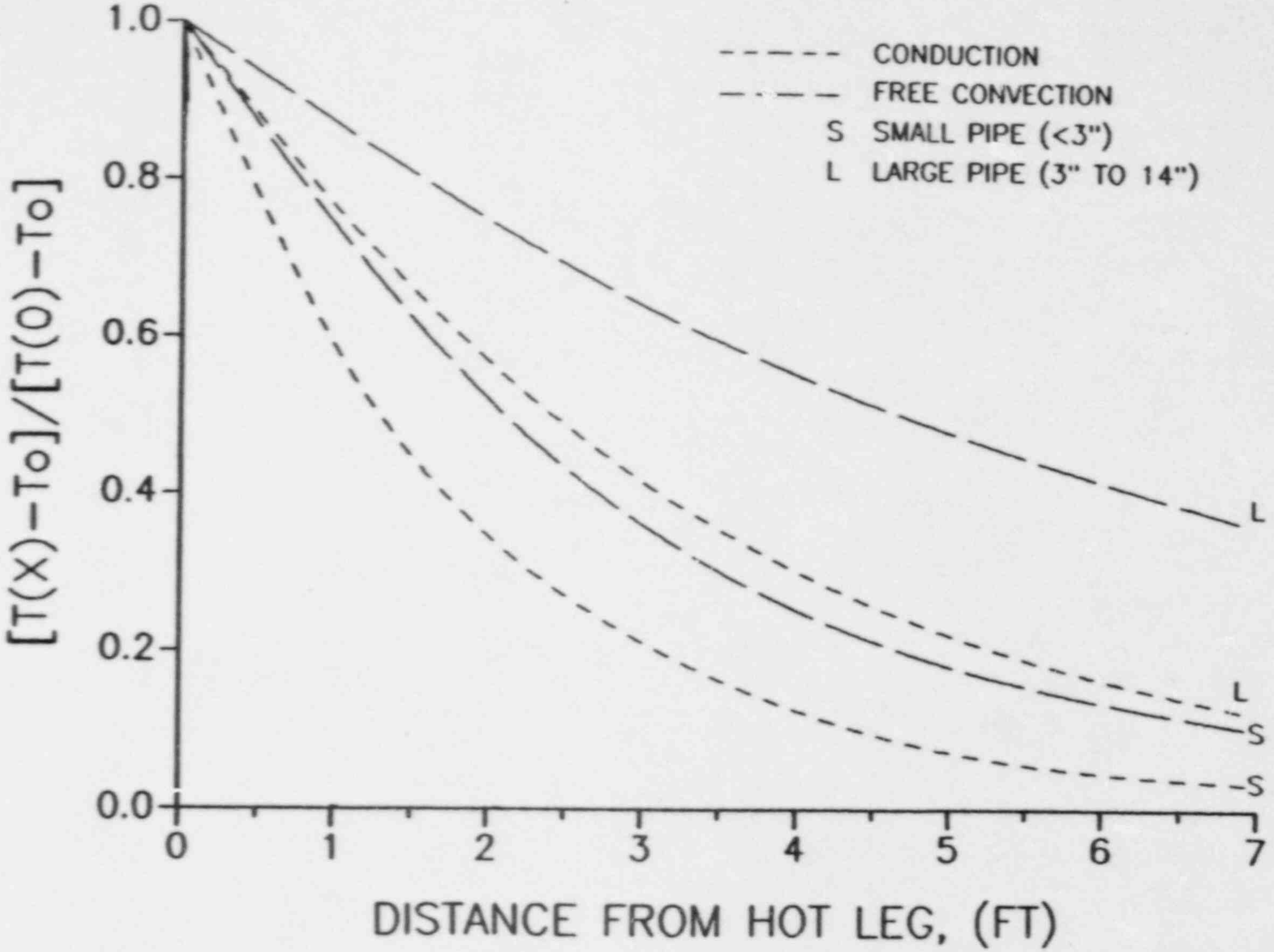
b. Alternate Charging Line (Line 080)

Our review of the charging line (line #80) indicates that the location identified in figure 2 is susceptible to high stresses resulting from thermal cycling only in the event of relatively large quantities of leakage through the valve 210-A. For small leakages, reasonable mixing will occur in the vertical leg containing the check valve 210-A, which will mitigate the impact of thermal cycling. Overall the likelihood of high stresses resulting from thermal cycling is small at this location. Therefore, a nondestructive examination is not required to be performed at this location.

c. Normal Charging Line (line 96)

The normal charging line (line 096) is always in use and is never isolated, hence there is no potential for thermal cycling, and no inspections are required.

FIGURE 2-1



EFFECT OF MOLECULAR CONDUCTION AND FREE CONVECTION ON AXIAL TEMPERATURE DISTRIBUTION