NMPC Project 03-9425
MPM-USE-293515

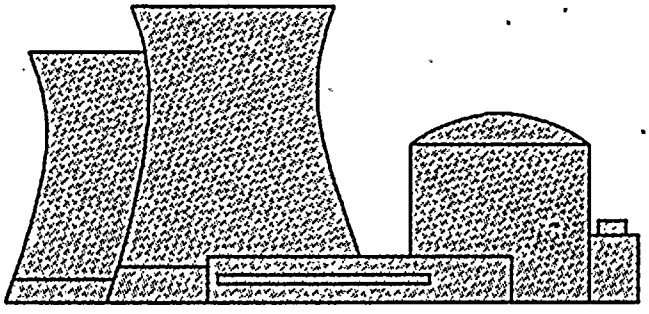
FINAL REPORT

entitled

NINE MILE POINT UNIT 1 BELTLINE PLATE

ORIENTATION DETERMINATION

MPM Research & Consulting



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February 19, 1993

1.0 Introduction

During a telephone conference on January 29, 1993, between NMPC Licensing, the NRC, and MPM Research & Consulting, the NRC requested that NMPC provide a drawing which clearly indicates the vessel plate rolling direction relative to the axis of the vessel. In addition, the NRC requested that the drawing contain the assumed flaw orientation for the ASME Appendix X analysis along with the surveillance specimen orientation. There are no written materials at NMPC or at MPM Research & Consulting which specify how the plates were placed in the vessel during fabrication. Therefore, MPM Research & Consulting proposed using the archive plate, currently stored at MPM Research & Consulting, to determine the direction of microstructural anisotropy, and thus determine the rolling direction relative to the vessel axis. The detailed scope of work is as follows:

- Machine microscopy specimens from the 1/4 thickness position of the archive plate.
- Perform light microscopy to determine grain and MnS inclusion anisotropy orientation relative to the vessel axis.
- Contact Lukens Steel to verify the ingot production procedures used in the mid-1960s are consistent with the orientation measurements.
- Prepare a drawing which satisfies the NRC request.

2.0 Microstructural Orientation

2.1 Lukens Fabrication Practice

MPM Research & Consulting contacted Lukens Steel and requested that Lukens describe the heavy section manufacturing procedures which were used when the NMP-1 vessel plates were fabricated. Plate G-8-3 was produced by Lukens Steel Co. and given the heat number P2130. The plate was cast into a rectangular ingot 72 inches high, by 101 inches wide, by 38 inches thick, with a total weight of approximately 39 tons. The ingot was rolled by Lukens as follows: spread or cross rolled to increase the transverse dimension (T) from 101 to 136 inches (a reduction of 26%); straightaway rolled to increase the length (L) by 3.5:1 from 72 to 252 inches (71% reduction). The plate was shipped to Combustion Engineering, Inc. (CEI) in the "as-rolled" condition with areal dimensions of L=251-7/8 inches (rolling direction) x T=135-3/4 inches (transverse direction). CEI roller- or otherwise bent the plate in the longitudinal or major rolling

direction (L), as can be seen from Figure 4 of their surveillance test program description [CE65]. This is consistent with the size of the plates in the as-built configuration and with the radius of curvature of the archive plate.

2.2 Metallographic Investigation

The archive plate has identifying marks engraved on the OD surface of the plate: "Test N G-8-3". This identification is also shown in Figure 5 of Reference [CE65] along with the rolling direction relative to the Charpy specimen axis. MPM Research & Consulting removed a section of Test N which was 8-1/2 inches in the assumed L direction x 11 inches in the assumed T direction. From this section, a 1-1/4 inch slab was cut for further studies at the quarter thickness as shown in Figure 2-1. To ensure that the orientation of the plate was maintained throughout the study, a metallographic section, L=1 inch x T=1/2 inch x S=1-1/4 inches, was cut from the slab and polished for metallographic examination of the L-S and T-S faces (Figure 2-1).

Micrographs from the as-polished L-S and T-S faces are shown in Figure 2-2 and 2-3. As shown in the figures, MnS inclusions (gray) appear extremely elongated in the assumed rolling direction L, and flattened in the thickness direction S, giving them an oval shape on the T-S face. Such shapes develop during rolling when the roughly spherical MnS inclusions, which are plastic at the rolling temperature, change shape in proportion to the change in shape of the plate; that is the MnS spheres are reduced in thickness S direction 79%, elongated 3.5:1 in the L direction, and spread 26% in the T direction. In addition to the MnS inclusions, dark spherical oxide inclusions were observed which are hard and do not plastically deform during rolling. The oxide inclusions tend to string out in planar arrays in the rolling L direction.

These observations confirm that the assumed rolling direction shown on CEI Figure 5 of Reference [CE65] is correct. Therefore, based on metallographic examination, it is clear that the principle rolling direction is in the vessel circumferential direction.

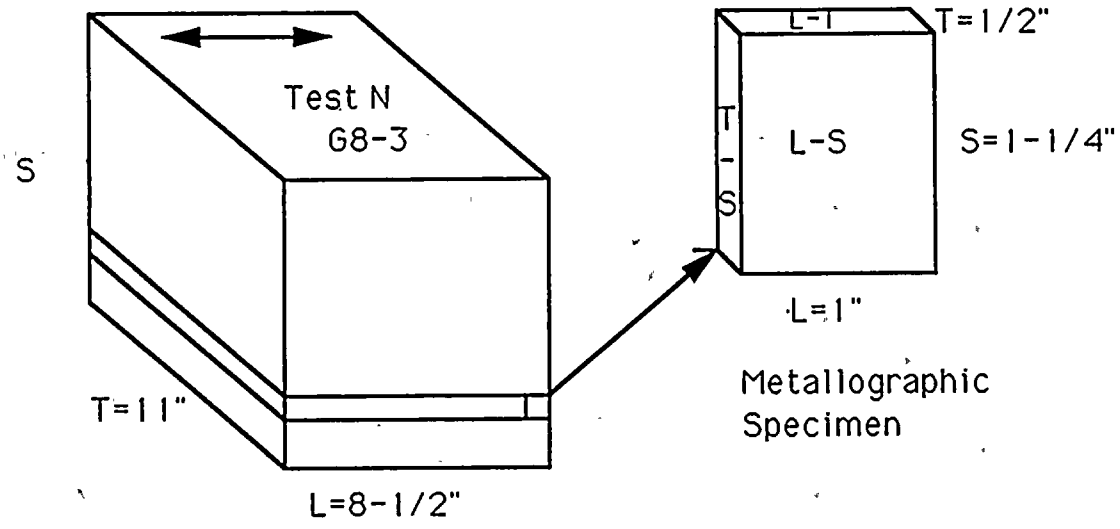


Figure 2-1

Orientation of Metallographic Section

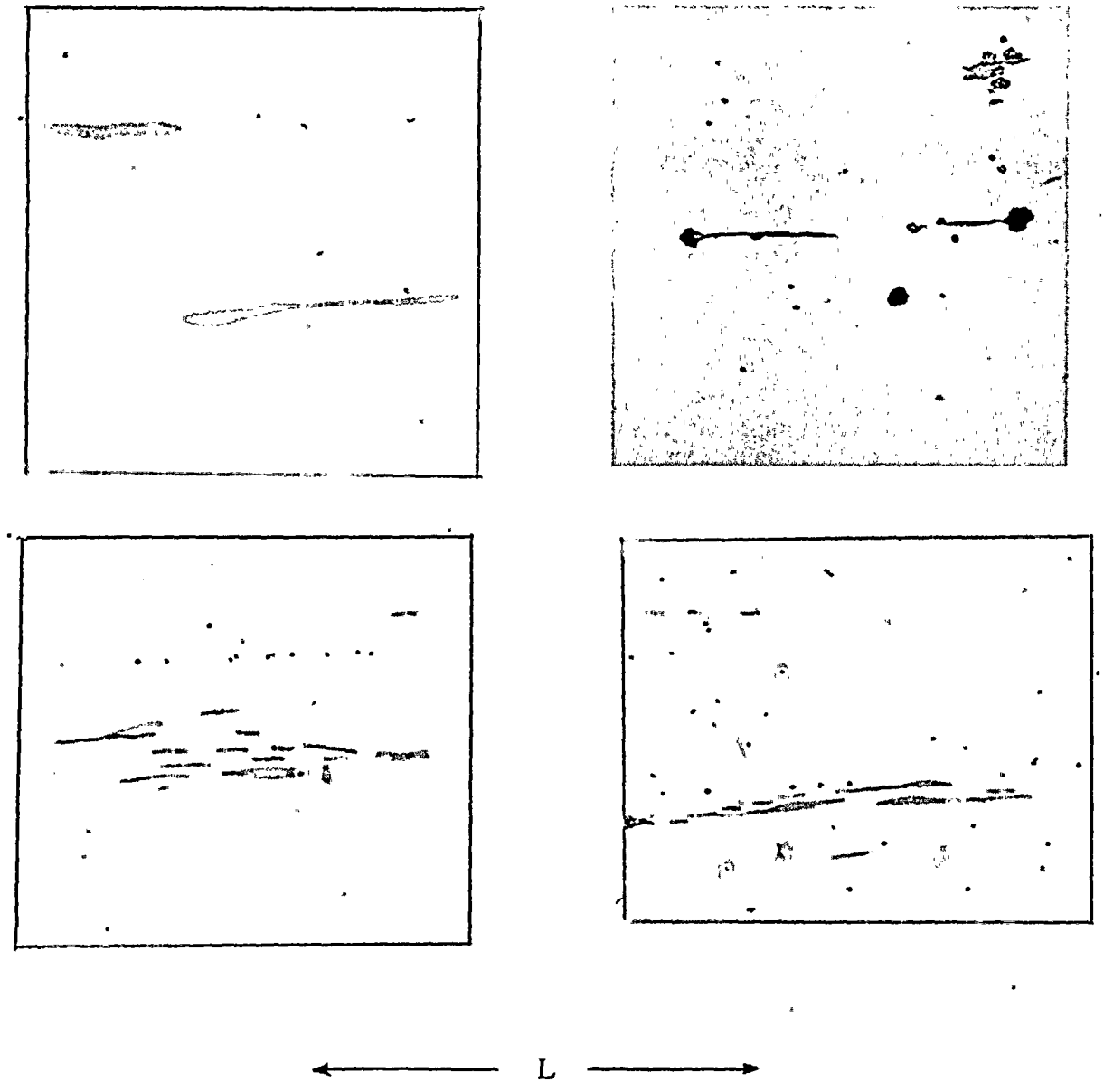


Figure 2-2

Mn-S Stringers Parallel to the Principle Rolling Direction
Viewed on the L-S Face (200x Magnification)

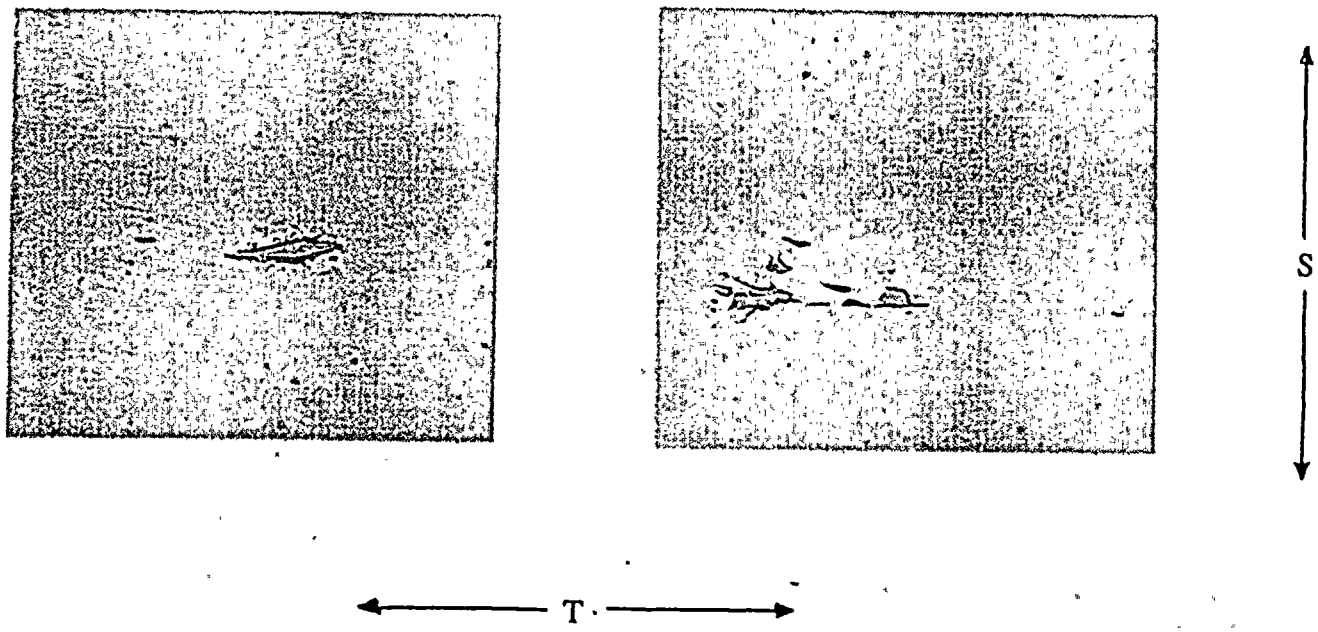


Figure 2-3

Mn-S Stringers Viewed End-on On the T-S Face (200x Magnification)

3.0 Mechanical Behavior Trend

Reference [MA91] contains all of the mechanical behavior data currently available on the NMP-1 beltline materials. The archive plate G-8-3 material was Charpy tested in both the L-T and T-L orientations. These data are shown in Figures 3-1 and 3-2. The test specimens were prepared under the assumption that the principle rolling direction corresponds to the circumferential direction. As expected, the T-L orientation yields a significantly lower upper shelf energy.

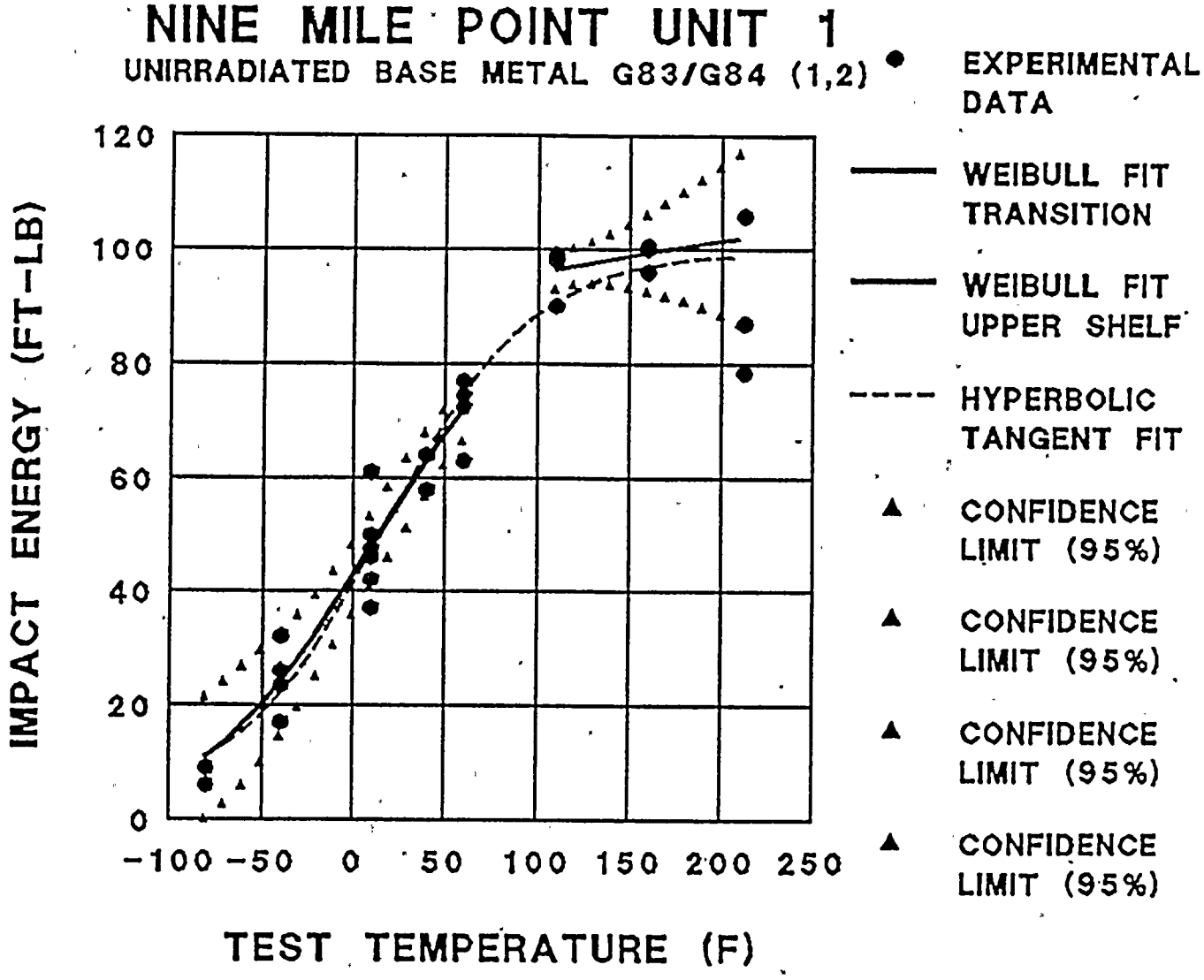


Figure 3-1

Unirradiated Plate G-8-3 Charpy Data for the L-T Orientation

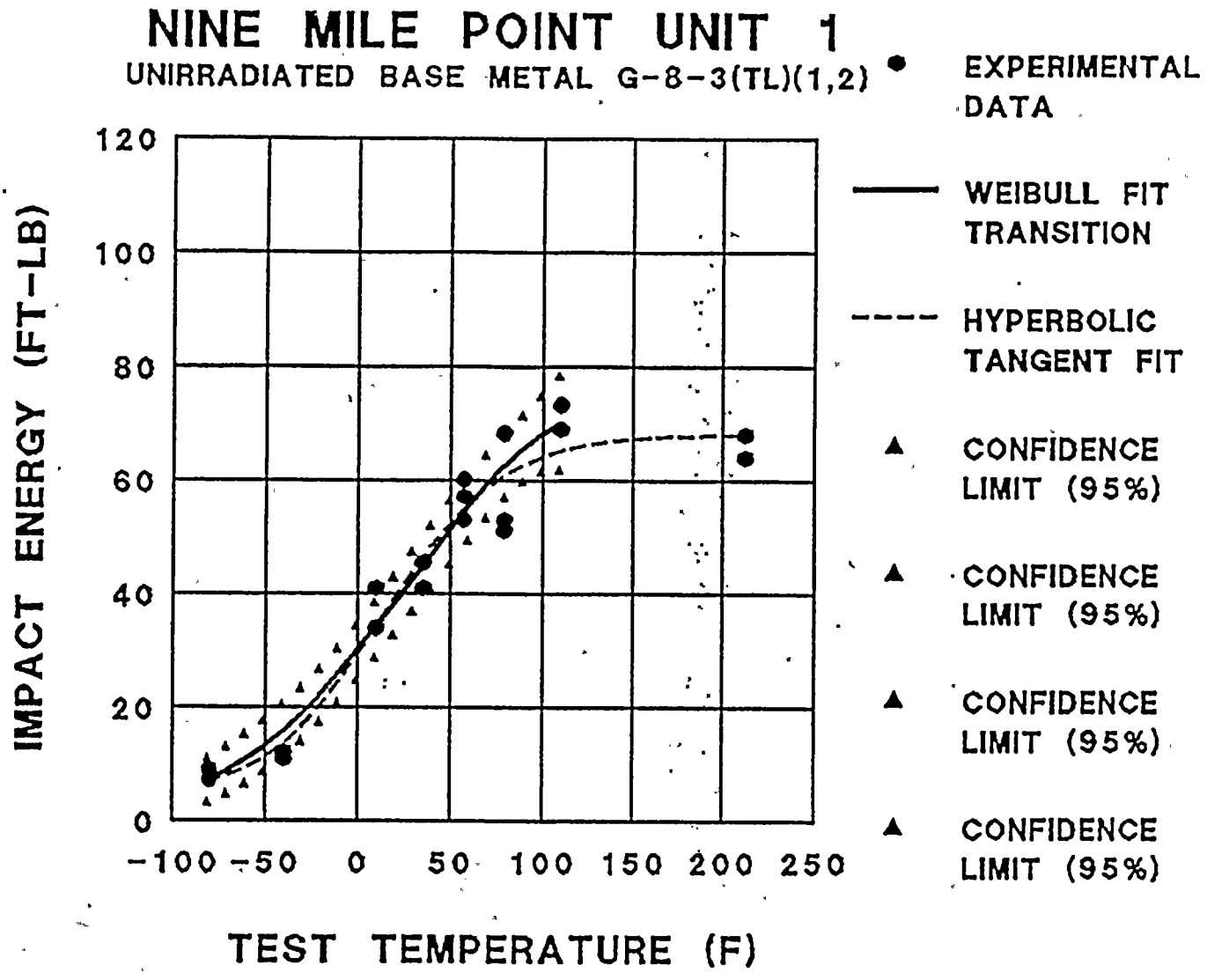


Figure 3-2

Unirradiated Plate G-8-3 Charpy Data for the T-L Orientation

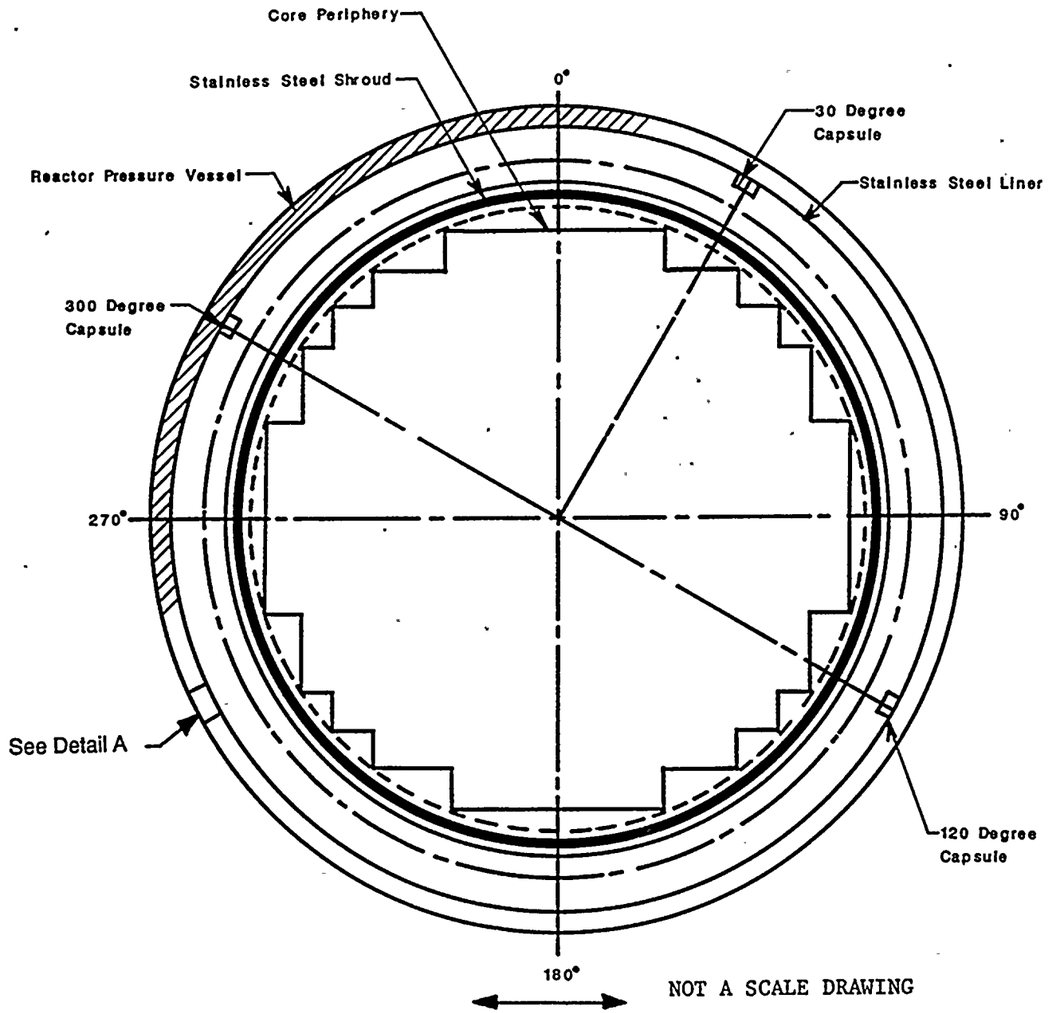
4.0 Conclusion

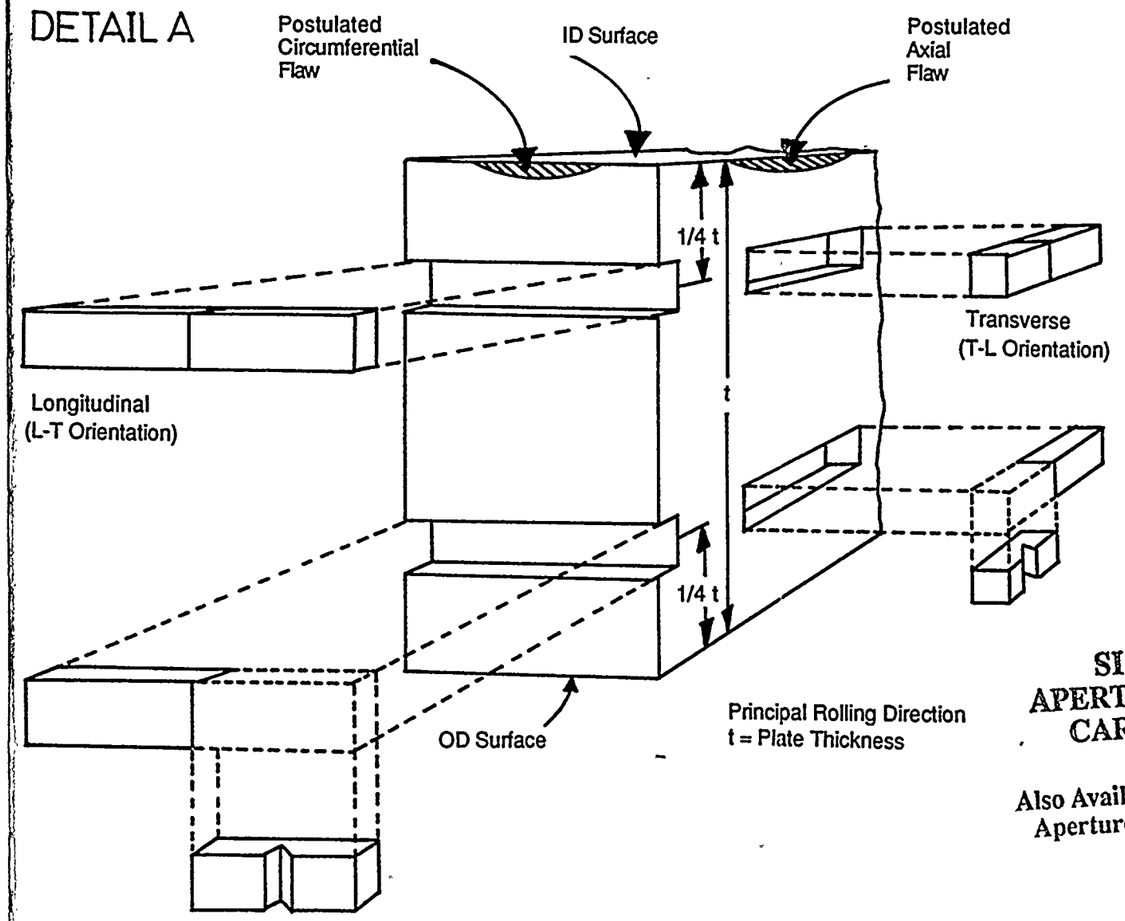
Based on the microstructural examination, discussions with Lukens steel, the mechanical behavior trends, and review of the plant documentation, it has been conclusively determined that the principle rolling direction is in the vessel circumferential direction. The rolling direction, Charpy specimen orientation relative to the rolling direction, and the postulated flaw orientation used in the ASME Appendix X analysis are shown in the attached drawing number MPM-NMP1-001.

5.0 References

[CE65] Combustion Engineering, "Surveillance Test Program for Niagara Mohawk Reactor Vessel", Contract 164, Rev. 2, 4/20/64.

[MA91] Manahan, M.P., "Nine Mile Point Unit 1 Surveillance Capsule Program", NMEL-90001, January 4, 1991.





SI APERTURE CARD

Also Available On Aperture Card

9303040241-01

Signature	Date	MPM Research & Consulting 915 Pike Street Box 840 Lemont, PA 16851-0840		
Drawn By David Rahmane	2/17/93	NINE MILE POINT UNIT 1 FRACTURE SPECIMEN ORIENTATION		
Design Appd. M.S. Morahan, Jr.	2/19/93			
Project Appd. M.S. Morahan, Jr.	2/19/93	Scale n/a	Dwg. No. MPM-NMP1-001	Rev. 0