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One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

September 13, 1985

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: LaSalle County Station Units 1 and 2
Application of Mechanical Stress
Improvement Process (MSIP)
NRC Docket Nos. 50-373 and 50-374

Reference: July 19, 1985 letter from H. L. Massin
to H. R. Denton.

Dear Mr. Denton:

The referenced letter submitted our request to the NRC to review the application of MSIP on LaSalle Unit 1 to obtain credit equivalent to Induction Heating Stress Improvement (IHSI) relative to inservice inspection requirements. In the process of that review, the NRC was informed of our independent evaluation and requested a copy of its results and conclusions.

Attached is a copy of the final summary letter from Structural Integrity Associates, Inc. documenting the results of their evaluation. This information supplements the referenced submittal and Commonwealth Edison requests continued NRC technical review. Although we will not be performing MSIP on LaSalle Unit 1 during the first refueling outage, we are pursuing its use on remaining untreated welds on LaSalle Unit 2 and following piping replacement on Dresden Unit 3.

Please direct any questions you may have concerning this matter to this office.

One signed original and ten (10) copies of this letter are provided for your use.

Very truly yours,

H. L. Massin
Nuclear Licensing Administrator

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Attachments

cc: Resident Inspector - LSCS
A. Bournia - NRR
Robert Bosnak, Acting Deputy Director, Engineering Division - USNRC
B. D. Liaw, Chief, Materials Engineering Branch - USNRC

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STRUCTURAL INTEGRITY ASSOCIATES, INC.

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August 26, 1985
PCR-85-084

Mr. Robert Janecek
Commonwealth Edison Company
One First National Plaza
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Subject: MSIP Independent Review

Dear Bob:

Per your request, Structural Integrity (SI) has independently reviewed the Mechanical Stress Improvement Process (MSIP) described in documents given to CECo by Westinghouse Electric Corporation and O'Donnell & Associates, Inc. Documents reviewed are listed in Attachment 1. In addition to these documents, finite element modeling and pipe test results were discussed via telephone with O'Donnell & Associates. Our review has been updated to include a recent letter from Bill O'Donnell to B. D. Liaw of the U.S. NRC summarizing his thoughts on the process, and more recent tests and analyses performed to optimize the control parameters.

Our conclusion remains unchanged from our prior review, i.e. the basic concept of MSIP appears to be both valid and useful. The concept consists of modifying the residual stress distribution at pipe weldments by mechanically squeezing the pipe on one or both sides of a circumferential pipe weld to cause plasticity in the welded region. The plastic flow redistributes the stresses, leaving the pipe inside surface in the welded region under hoop and axial compression.

Like Induction Heating Stress Improvement (IHSI), MSIP is identified as a residual stress improvement technique, but along with application differences there are some fundamental differences between the IHSI and MSIP processes, as illustrated in attached Figure 1. With IHSI, large thermal stresses are produced in the weld region which cause the material near the inside surface of the weld to yield in tension (IHSI - Heating in Figure 1). Removal of the thermal load results in reversal of the stress state which puts the inside surface in compression (IHSI - Cooling in Figure 1). During MSIP, on the other hand, the material near the weld inside surface is loaded directly in compression, up to and beyond yield (MSIP - Loading in Figure 1). There is some relaxation upon removal of the MSIP load (MSIP - Unloading in Figure 1), however with proper choice of control parameters, the MSIP process has been shown in both tests and analyses conducted by O'Donnell & Associates, to leave substantial compressive residual stress at the weld inside surface.

These fundamental differences in concept result in both pros and cons of MSIP as compared to IHSI as an IGSCC remedy for BWR piping. The occurrence of large tensile stresses at the pipe inside surface during IHSI application can open cracks (if present) which may not completely close with load reversal. On the other hand, the use of only applied compressive stresses in MSIP is not expected to open pre-existing cracks or discontinuities, and thus MSIP has less potential to do further damage to already degraded piping. However, this may also be somewhat of a disadvantage of MSIP, given the rather large uncertainties which exist in ultrasonic examination for IGSCC in stainless steel piping. IHSI has been seen in some instances to enhance ultrasonic detectability, while with MSIP, large or deep defects would have a greater chance of going undetected.

It has also been argued, by O'Donnell and Associates, that MSIP raises the material compressive yield strength through cold work, thereby making it theoretically possible to obtain higher compressive residual stress than IHSI, which cold works the material in tension, thus reducing the compressive yield strength due to Kimematic hardening/Bauschinger effects. As illustrated schematically in Figure 1, however, this effect is not considered to be significant by SI, and is probably more than compensated for by the relaxation of residual stress that occurs during the MSIP unloading, which effect is not present in IHSI. The above argument is somewhat academic, however, since residual stress measurements for both processes indicate the ability to achieve, with proper controls, residual stresses well above the non-strain hardened yield strength of the material.

The subject of process control is also worthy of mention in this review. It is argued in the above referenced O'Donnell letter to B. D. Liaw, that the process is inherently easier to control and verify than IHSI. The basic MSIP control parameter is pipe circumferential strain under the loading fixture(s). By first measuring pipe circumference and then using shims to preset gaps between the two halves of the loading fixture(s), the amount of circumferential strain imposed during loading can be controlled, and it is argued that sensitivity of results to this parameter, as well as to tool location is within easily achievable tolerances. Also attractive is the fact that the effectiveness of application can be verified by measuring the circumference after application, versus IHSI which leaves no physically observable measure of treatment.

These process control advantages also appear, in concept, to be both valid and useful. However, we have not yet seen a systematic study of the sensitivity of MSIP to a number of potential variables which could be of real significance in field applications. Some specific areas which we feel need to be addressed were identified in our prior review letters. Some of these have been addressed since our prior review, and have been incorporated in this review. However, we still have not seen data on the following potentially significant effects:

- Pipe Size - Particularly larger pipes which IHSI experience has shown to be harder to treat successfully.

- Through-wall Stress Gradient - All experimental residual stress data have been surface measurements. Through-wall gradient predictions are based on analysis only.

- Variability in Original Pipe Weld - Mismatch has been addressed, but to our knowledge, the following variables have not:
  - Piping ovality and flat spots
  - Built up weld crowns
  - Component geometry on the opposite side of one-sided treatment
  - Existing cold work due to the original butt weld

- Work Hardening - The new optimized process parameters appear to induce higher strains in the vicinity of the tool (1.5% to 2%), in order to achieve greater benefits at the weldment. As discussed at length previously, these strains and attendant tensile residual stresses do raise some questions regarding potential IGSCC sensitivity at these locations.

- MSIP of Existing Cracks and Defects - To our knowledge MSIP has not been applied experimentally, nor have analyses been run, for already cracked pipes.

The above issues are not intended as a criticism of the MSIP process or its developer. To the contrary, O'Donnell and Associates are to be commended for producing a great deal of data in a short period of time, and based on the results observed to date, the process has real potential to become a new and improved technology. However, based on our somewhat limited review, it appears that additional data still need to be generated on process variability, limits of applicability, control parameters, and acceptance criteria in order to produce fully documented, field-ready application specifications such as exist for IHSI. We hope that our review has been helpful in focusing on the most critical of these needs, and we would be happy to participate in or review any future efforts as you deem appropriate.

In summary, we believe that application of MSIP to BWR piping should improve the stress state near welds. The amount of improvement is likely to match that of IHSI. With further optimization of the process through investigation of controlling parameters and development of application guidelines and acceptance criteria, it may be quite effective for many applications.

Sincerely,

A J Giannuzzi for
P. C. Riccardella

A J Giannuzzi
A. J. Giannuzzi

T L Gerber
T. L. Gerber

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att.

STRUCTURAL INTEGRITY ASSOCIATES, INC.

ATTACHMENT 1

MSIP Documents Reviewed by SI

1. "Mechanical Stress Improvement Process," Presentation to CECo, February 19, 1985.

2. "Mechanical Stress Improvement Process Initial Confirmatory Tests of 12" Weld," Final Report, February 28, 1985.

3. "Mechanical Stress Improvement Process-Description and Review of Analysis Results," April 1985.

4. "Mechanical Stress Improvement Process-Process Update," Presentation to CECo, May 15, 1985.

5. "Mechanical Stress Improvement Process (white paper).

6. "IHSI Preliminary Fatigue Analysis," May 28, 1985.

7. O'Donnell & Associates, Inc. drawings: 5870-112-105, 106, 107.

8. O'Donnell & Associates, Inc., Mechanical Stress Improvement Process - Vermont Yankee Confirmatory Test.

9. J. A. Jones Applied Research Company letter to O'Donnell Associates, Magnesium Chloride Testing of MSIP Treated Pipe with Two Weldments, July 30, 1985.

10. O'Donnell & Associates, Inc. Mechanical Stress Improvement Process. July 23, 1985.

11. O'Donnell & Associates, Inc. Letter, W. J. O'Donnell to B. D. Liaw, U.S. NRC, "Mechanical Stress Improvement (MSIP) Additional Technical Detail, August 12, 1985.

STRUCTURAL INTEGRITY ASSOCIATES, INC.

Figure 1. Conceptual Illustration of Differences Between IHSI and MSIP Stress Improvement Processes