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COLLEGE OF APPLIED SCIENCE AND ENGINEERING

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Mr. Harold R. Denton
Chief, Technical Support Branch
United States Atomic Energy Commission
7920 Norfolk Avenue
Bethesda, Md.

Dear Harold:

Enclosed is one copy of my preliminary report on the Nine Mile situation entitled, "A Preliminary Report on a Meeting Concerning the Nine Mile Point Core Spray Nozzles and Related Piping Systems - May 1, 1970." You will note that this is primarily an account of the discussions of this meeting, relating only the specific points discussed and reserving comment until further evaluation has been performed by me.

It is my opinion that there are a few open areas which should be covered before a total evaluation and decisions can be made on the overall problem of the sensitized safe ends within BWR reactor systems. The following are my evaluation of these necessary points:

(1) The Collins finding of the existence of titanium carbonitrides in the thermal sleeve material of the East nozzle must be completely verified by a total chemistry analysis. If this material is truly 321, this would be the only possible way of making such a definite statement.

(2) It is my opinion that we will need much more information on the East Nozzle pipe and weld to definitely document the possibility of field stress relief as we and particularly Joe Collins suspect.

(3) It appears to me that it is important for us to know the total metallurgical findings as investigated by GE concerning their portion of the East Nozzle specimen. Any definite decisions by the AEC Regulatory Section might be very premature without this kind of information. The implication here lies primarily in the documentation of the extent of transgranular cracking. Joe Collins definitely verified the existence of such mode of cracking, but to date we do not know whether this is widespread or not. This means that the unknown here is whether or not one can expect concentrations of chloride in other portions of the piping system, and whether or not this will be an environment to be expected and contended with in the future. One may consider that a stagnant area such as this section was and the fact of a compressed or periodically compressed vapor phase and liquid phase may play an important part in the overall significance of the data obtained in this East core spray nozzle at Nine Mile Point.

(4) A very brief review on my part of the thermal sleeve design previously and currently being used in the core spray nozzle causes concern as to its capabilities of actually doing its job. This design is not adequately protecting the thick section of the pipe or the section change. This situation could result in large thermal stresses at this magnified thermal discontinuity. I have taken the liberty to discuss this with Dick Lofy, who feels in concert with me; and in addition, Joe Collins has commented that this could lend much meaning to the observation that cracks have tended to be axial, or, after initiating radially, tend to ultimately propagate in an axial manner.

(5) Lastly, I am still very undecided as to the merits or advantages or overlaying sensitized safe ends to improve their overall metallurgical-corrosion-mechanical capabilities. Probably one of the things that disturbs me the most is the lack of significant or germane information in regard to these characteristics of overlaid structures and their application to the existing problem. It has been observed that cast stainless steel structures contain 20% δ-ferrite and sometimes greater do not tend to exhibit stress corrosion characteristics. However, overlaid weld deposits of stainless steel like 308L will always contain less than 10% and usually very close to 5% δ-ferrite. In addition it is not improbable to expect occasional exposed sensitized surfaces which occur during the overlay process, allowing for the possibility of galvanic action.

The points presented above essentially indicate what I feel is necessary to be learned before the next major decisions can be made. The collection of this information may require my traveling to Richland, Washington to inspect the existing samples which have previously been analyzed or may require further analysis.

These final statements are what I feel may result in future applications. Present environments of nuclear reactors may be optimum or, in other words, the best one can hope for, such that materials and fabrication methods may be needed to allow compatibility with these environments to the extent that integrity is maintained. More specifically, if it is established that chlorine can normally exist in concentrations of the form found by Collins, then type 304 stainless steel which is unsensitized would not be an adequate material in the system. With the present sensitized 304 it is not clear what is the best technique for repairing this condition--overlaying or replacement. The overlaying process may very well indeed be quite adequate from many standpoints, but one of the materials that has not been considered greatly is a low carbon type 310 stainless steel, which provides increased alloying contents with respect to chromium and nickel. This material, which may tend to be slightly fissure-sensitive in the weld metal, would not be greatly susceptible to intergranular or transgranular stress corrosion attack, and would provide the necessary strengthening mechanism, which one may expect to lose when the low carbon 304 types are used. These comments should be considered premature until a little more thought is given to them. In addition, I do not believe that one should forget the economics of the situation, and the fact that the replacement

of these defective pieces may be just as economical as their cladding, particularly when one considers that in order to clad, the pipe must be half cut out of the system in the first place. Finally, high chlorine content residues and their concentrations requires that thought be given to other alloys which are non-ferrous in nature, i.e., Incoloy 800 and Inconel 600. I have seen literature which indicates that Inconel 600 is much more resistant to chlorine and oxygen-containing environments than Incoloy 800, but I have not been able to verify this with a cursory search of the literature recently. I believe it is relevant at this point to mention, at least, the experiences of LACBWR and the fact that their complete changeout was accomplished utilizing Inconel 600.

Finally, I feel that I should make some very brief comments as to the stress situation around the sensitized material and its effect on mode of cracking and crack propagation. It is my belief that the transgranular cracking observed on the East nozzle resulted from the reduced stress existing at this location and the chlorine content on the I.D. surface. Conversely, the intergranular cracking found on the West nozzle could be considered to be caused by the high stress condition here, of the order probably of the yield strength, and the high concentration of oxygen in the atmosphere around this situation. It is comforting, I believe, that most of these cracks found in this system and others have not been associated with the heat-affected zones of welds which have not been stress relieved or otherwise sensitized by furnace treatment. To me this indicates that field welds do not provide large enough areas of sensitized material to cause concern from a corrosion and cracking standpoint in the environments existing in BWR reactors. In addition some recent studies as to the residual stress around welds indicate that their magnitudes are the greatest and the rate of change of magnitudes are the greatest in the vicinity of the fusion line and can exist either in the heat affected zone side of the fusion line or the weld metal side of the fusion line. These stresses can be either compressive or tensile, and can approach and be almost equal to the yield strengths. Yet in no case have we found cracking near any fusion line of the weld which caused trouble to the operation of the plant. Therefore residual stress causes by welding and sensitization caused by welding does not seem to be a factor of our concern, and the implication here, from my standpoint, is that whether overlaying is used as a repair method or complete changeout is effected, the welding operation in either of these will not unduly harm the integrity of the piping system as repaired.

These statements , shown above, are my current thinking on the subjectof this letter and the attached report. While they may seem disjointed and confusing, this only results from the indecision and premature rambling which I find myself doing at this time. In any event, I hope these comments serve your current purpose and I will solidify my thoughts in the next few days such that more definite decisions can be arrived at.

Best personal regards,

R. G. Gilliland