UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 15 1982

MEMORANDUM FOR: [redacted] D. LaFleur, Jr., Assistant Director for International Cooperation, IP
W. V. Johnston, Assistant Director for Materials & Qualifications Engineering, DE
R. W. Houston, Assistant Director for Radiation Protection, DSI
J. P. Knight, Assistant Director for Components and Structures Engineering, DE
L. R. Rubenstein, Assistant Director for Core and Plant Systems Branch, DSI
T. P. Speis, Assistant Director for Reactor Safety, DSI

FROM: R. L. Tedesco, Assistant Director for Licensing, DL

SUBJECT: IAEA RECOMMENDATIONS ON KRSKO FEEDWATER SYSTEM MODIFICATIONS

Enclosed for your information and review is a summary of the initial recommendations by the IAEA Safety Mission. The purpose of the IAEA Safety Mission was to discuss the proposed modifications to the KRSKO plant resulting from the recent steam generator tube vibration problems on Westinghouse plants and to offer comments and advice. I represented the NRC on the IAEA Safety Mission and had the benefit of the initial comments developed by the NRR reviewers.

Robert L. Tedesco, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

cc: G. Lainas
W. Kane
T. Marsh
T. Quay
E. Rossi
J. Rajan
B. Singh
L. Frank
C. Liang
P. Ting
T. Ippolito
R. Mattson

J
06/10/82

MISSION OBJECTIVES

Steam generator tube vibration is a concern in the operation of recent Westinghouse designed nuclear power plants, including the Krško plant. This concern has led to a proposal at Krško to modify the feedwater system before continuation of the start-up programme. The purpose of the Mission was to discuss the current situation, particularly with regard to safety, with members of authorities and Krško plant staff members. In particular, the Mission was asked to give comments and advice on:

- proposed feedwater system modification, including changes in the control system,
- guidance for resumed operation of Krško with regard to the steam generator tube vibration problem,
- necessary documentation, evaluation and review to accept further operation of the plant as modified.

RECOMMENDATIONS

The Mission has had the benefit of reviewing various design studies covering the proposed modification to the D-4 Krško steam generator. In addition, the Mission has met with the representatives of the Government, the utility and the Westinghouse Company to further discuss the proposed design modifications. On the basis of its study, the Mission has developed a number of recommendations that are set forth in this section of the report. It believes that due consideration should be given to these recommendations and appropriate actions taken prior to plant start-up following modifications that will be made in the feedwater system. It is to be noted that the recommendations presented relate to the Krško plant and do not necessarily apply to other similar plants without further evaluation.

RECOMMENDATION NO. 1

The Mission recommends that the basis used to establish the 70% Main Feedwater flow through the S/G preheater section should be better developed in more quantitative terms; i.e. relating feedwater flow rates

to vibration frequencies, amplitudes and, in particular, wear rates.

DISCUSSION

Westinghouse representatives at the meeting held on June 8, 1982, at the Krsko site discussed some recent test results obtained from internal instrumentation installed on the D-4 Krško steam generators. The data showed that some minor vibration effects occured on the recordings already at power level of about 50%. At 75% some modest acceleration and vibration amplitudes were apparent. Westinghouse has not yet determined whether a correlation of tube wear with the test data could be made. The acceptability of the proposed feedwater system changes rests mainly upon the assumption that no damaging tube vibrations occur in the 70% range. The Mission believes that a more deterministic correlation should be made to better ensure the acceptability of the proposed 70% flow limit In addition, estimates of margin should also be developed to establish conservative permissible upper limits for the proposed initial operating programme. Additional test results are necessary to qualify the acceptance of extended operation at the proposed 70% main feedwater flow limit. *

The basis for the operation with 70% flow through the preheater section results from the internal instrumentation in the Krško plant and that no 'detrimental impact' occured. A review should be made to ensure that the chosen tube constitutes a conservative sample so that no detrimental vibration exists in other tubes. In addition, consideration should be given to the completeness of the model tests performed with D-4 type S/G.

Regardless of the lack of criteria, it is, however, the opinion of the Mission that the Krško plant, from S/G tube wear point of view, can be safely operated for limited periods, pending further confirmatory studies and ECT at the proposed operating conditions.

RECOMMENDATION NO. 2

The proposed modification of the feedwater system is extensive. The Mission recommends that the independent design reviews of this modification be completed on a timely basis. The review should include mechanical and thermo-hydraulic aspects as well as those relating to control and protection system modifications.

* Hose Such results would be useful in developing future tube plugging limits in accordance with R.G. 1.

DISCUSSION

The Mission believes that it would be prudent to have the advice of an independent design review of the proposed design modifications to the steam generator, external piping, valves and safety systems. This independent review should deal with selected design aspects to provide added assurance of the overall adequacy of the proposed modifications. Included in such a study would be the concern of vibration of the intermediate deck plate due to the increased auxiliary nozzle flow injection. The Mission believes that the design review may be made in conjunction with initial plant operation but should be completed as a prerequisite for acceptance of the modification as a permanent solution.

Reduced flow through the preheater section (from 100% to 70% flow) may lead to increased steam formation at the bottom part of the preheater. The Mission was informed that the vendor did not expect any water hammer hazard to develop as a result of increased steam generation. A criterion was quoted under which no net vapour formation should occur in the four first passes of the preheater. This criterion would also be met at the reduced flow operation.

The reduced flow could also result in sludge deposition at SG tube-to-baffle plate intersections. Again, the vendor's evaluation showed that sufficient flow velocities are maintained to prevent sludge deposition.

It is the Mission's opinion that these concerns justify careful monitoring during initial start-up and subsequent plant operation. Results from model tests in Sweden have shown extremely high and instable flow velocities after the main feedwater restrictor nozzle in the D-3 type steam generator. For this reason, the Mission would recommend that the exchange of this restrictor by a multi-venturi nozzle restrictor should be considered in order to reduce the velocities and to provide a more uniform flow distribution into the downcomer channel. This should ensure a steady flow entrance to the preheater tube-bank.

RECOMMENDATION NO. 3

The Mission recommends that careful consideration be given to ensure that there would be no adverse interactions between the control and safety features of the Feedwater Systems.

DISCUSSION

The proposed modifications include changes to the reactor protection system, the feedwater control system and the auxiliary control system. The effects of such changes with regard to possible adverse system interactions should be fully understood, especially under transient and accident modes and at various flow conditions. Of particular concern would be the effect of the proposed changes on overcooling transients, transients involving switchovers (e.g. load rejections), and other such events included in Chapter 15 FSAR analyses. Further, no adverse failures in the control system should preclude the operation of any safety function.

The proposed modification includes deletion of the steam/feedwater flow mismatch trip. Westinghouse informed the Mission that no credit has been taken for this trip in the safety analysis of the plant. The Mission was also informed by telephone on June 10, 1982, that US NRC has accepted the deletion of this trip as a generic change.

RECOMMENDATION NO. 4

The Mission recommends that an operating program be established to specify permissible operating modes at various main feedwater flow rates through the main nozzle and allowed short term operation at rates above 70 %. The initial operating program should include a definite operating time limit at 70 % flow until the next ECT is to be performed.

DISCUSSION

At the meeting held on June 8, 1982 at the Krško site, it was not apparent that operating limits had been fully evaluated. Permissible operation at 70 % flow for a specified time period prior to the next ECT inspection should be established prior to plant restart, in addition, off-normal conditions wherein flow in the preheater could exceed 70 % should be evaluated. This includes consideration of a maximum limit, permissible times for anyone event or number of events where 70 % flow would be exceeded.

The merits of a flow alarm versus a passive device for limiting flow should be evaluated especially with regard to excess feedwater transients.

RECOMMENDATION NO. 5

The Mission recommends that as additonal information becomes available from the Krsko and other ongoing related programmes, the proposed modification and operationg program should be reevaluated and programatic changes be made as appropriate.

DISCUSSION

As in any program of the type being investigated at Krsko, due attention must be given to the utilization of any new understanding or information that may become available. It is evident that the utility needs additional information from Westinghouse due to its involvement with other similar plants. This information would serve to help the utility to better assess the full impact on the operation of the Krsko nuclear power plant. Every effort should be made to provide such information as it becomes available.

In addition, the state government authorities are encouraged to establish good contacts with the authorities in the countries with D-2, D-3 and D-4 steam generators.

RECOMMENDATION NO. 6

The Mission recommends that prior to operation in the proposed mode, a comprehensive start-up testing programme should be established. Tests during the start-up phase should be performed to confirm predictions. In addition, operator training should be conducted prior to operation in the proposed mode, to account properly for the modified operating procedures.

DISCUSSION

Clearly the proposed changes to the operation of Krsko involve new demands on the part of the operator to properly respond to plant changes. This is especially true in the ranges where flow changes and flow-split occurs. Westinghouse should provide technical bases for system operations to establish the start-up test programme. The results of previous tests should be evaluated. Subsequently, proper detailed operating procedures should be prepared, reviewed and approved prior to plant start-up for the new operating modes. In addition, control system stability and the possible change in the potential for adverse water hammer in the pre-heater and auxiliary piping position of the feedwater system should be investigated and procedures verified to deal with such events.

RECOMMENDATION NO. 7

The Mission recommends that the new operating characteristics in the preheater section with the revised flow-split be evaluated to assure that no adverse changes will occur in thermal and hydraulic design basis for the D-4 steam generator.

DISCUSSION

Further studies are needed regarding the flow distributions in the D-4 steam generator. Better understanding is needed about the flow through the auxiliary feedwater nozzle and how it may affect main feedwater flow at various power levels. A restudy of affected aspects of Chapter 15 FSAR analyses should be performed to ensure that no adverse affects result from the proposed modification. This study should include due consideration to both transient and accident conditions including set-point determinations. The consequences of using the auxiliary feedwater piping and nozzle should be evaluated using conservative assumptions of auxiliary feedwater flow and temperatures considering critical system malfunction.

It must be understood that the modifications will result in a small decrease in plant thermal efficiency. In this context, the Mission was informed about plans to increase primary coolant average temperature by approximately $1.5^{o}F$ in order to improve thermal efficiency. It is the Mission's view that such a change may have far-reaching implications in the area of safety analysis and should therefore not be attempted until consequences of other modifications have been reviewed, and operation of the plant as modified has progressed satisfactorily.

RECOMMENDATION NO. 8

The Misison recognizes the wide-spread impact of the modifications on the Krsko plant. Accordingly, careful attention must be given to the quality assurance (QA) aspects associated with all the changes being made to ensure that the modifications have been made in accordance with the stated objectives for plant operation.

DISCUSSION

Recent experience at other nuclear facilities involving plant design and construction activities have shown the need for establishing an adequate Quality Assurance programme to ensure that proper design verification and plant modifications are carried out according to stated objectives in the FSAR as ammended. Similar concern is applicable to the modifications being proposed at the Krsko plant for the feedwater system. The utility should ensure the adequacy of their QA programme so that the proposed changes may be implemented in the intended manner. This involves such activities as design control and plant-walk down to ensure proper implementation of the required changes prior to operation. In addition, QA for operation should be included to cover appropriate operational aspects.