RCS NATURAL CIRCULATION IN A PWR STATION BLACKOUT ACCIDENT - AN APPLICATION OF NRC MECHANISTIC CODES

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ABSTRACT

This paper discusses the phenomenon of reactor coolant system (RCS) natural circulation in a PWR station blackout accident with the loss of all AC power and auxiliary feedwater (the TMLB' accident). Existing and future studies performed for the industry and the Nuclear Regulatory Commission (NRC) are summarized in the paper.

During the core uncovery and core melt period of the high-pressure TMLB' accident, multi-dimensional natural circulation of gas flow (steam and other gas such as hydrogen and fission products) is likely to exist in the uncovered core and the upper plenum above. Meanwhile, counter-current gas flow may also exist in the hot leg piping except during the opening of a power-operated relief valve (PORV) or safety relief valve (SRV) on the pressurizer. As a result, some of the core decay heat is transferred to the upper plenum structures and ex-vessel piping and components, and the RCS pressure boundary may be heated to high temperature to challenge structural integrity.

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FOURTEENTH WATER REACTOR SAFETY
INFORMATION MEETING

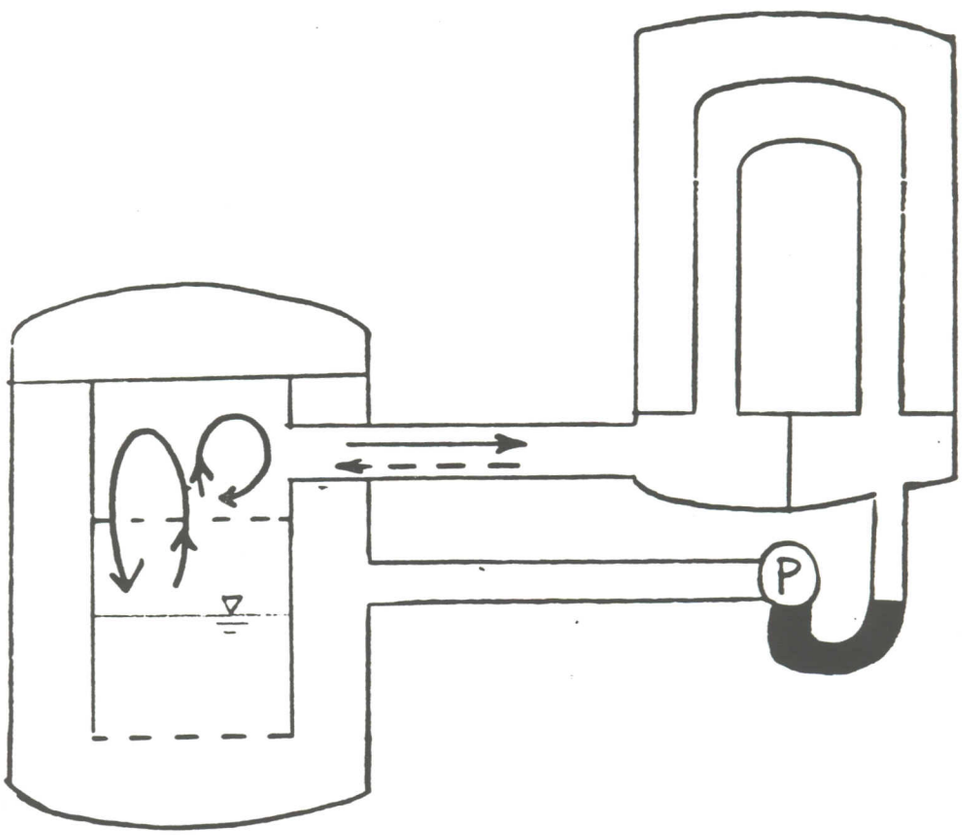
GAITHERSBURG, MARYLAND

OCTOBER 29, 1986

INTRODUCTION

- A PWR STATION BLACKOUT ACCIDENT WITH THE LOSS OF ALL AC POWER AND AUXILIARY FEEDWATER (TMLB' ACCIDENT):
  - STEAM GENERATORS BOIL DRY AND REMAIN DRY
  - NO ECCS INJECTION OR PUMP OPERATION
  - NO CONTAINMENT SPRAY
- DURING THE CORE UNCOVERY AND CORE MELT PERIOD OF THE TMLB' ACCIDENT, MULTI-DIMENSIONAL NATURAL CIRCULATION OF GAS FLOW IS LIKELY TO EXIST IN THE UNCOVERED CORE AND THE UPPER PLENUM ABOVE. COUNTER-CURRENT GAS FLOW MAY ALSO EXIST IN THE HOT LEG PIPING EXCEPT DURING THE OPENING OF A PORV OR SRV.
- BECAUSE OF THE NATURAL CIRCULATION FLOW, THE RCS PRESSURE BOUNDARY MAY BE HEATED TO HIGH TEMPERATURE TO CHALLENGE STRUCTURAL INTEGRITY.

RCS NATURAL CIRCULATION



IMPACT STATEMENT

- LOCATION, SIZE, AND TIMING OF PRESSURE BOUNDARY FAILURE

  - WILL THE FAILURE OCCUR LONG BEFORE VESSEL LOWER HEAD FAILURE TO PRECLUDE DIRECT HEATING THAT MAY CHALLENGE CONTAINMENT INTEGRITY ?

  - WILL STEAM GENERATOR TUBE RUPTURE OCCUR AND LEAD TO FISSION PRODUCT BYPASS OF THE CONTAINMENT ?

- FISSION PRODUCT RETENTION AND REVAPORIZATION

- HYDROGEN GENERATION

- RECOMMENDED OPERATOR ACTIONS TO MITIGATE AND RECOVER THE ACCIDENT

REVIEW OF ANALYTICAL AND EXPERIMENTAL STUDIES ON RCS NATURAL CIRCULATION IN THE TMLB' ACCIDENT

- EPRI :
  - CORMLT CALCULATIONS
  - CALCULATIONS OF THE INTEGRATED CODE (CORMLT-PSAAC-RAFT)
  - 1/7-SCALE WESTINGHOUSE EXPERIMENTS USING SF6 AND WATER

- IDCOR : MAAP CALCULATIONS

- NRC :
  - MELPROG CALCULATIONS
  - MELPROG/TRAC CALCULATIONS
  - MELPROG/TRAC VALIDATION USING WESTINGHOUSE DATA, TMI-2 PLANT DATA, OTHER FUEL DAMAGE EXPERIMENTS
  - COMPARATIVE SCDAP/RELAP5 CALCULATIONS
  - SUPPORTIVE COMMIX CALCULATIONS (INTACT CORE, GAS FLOW)
  - COMPARATIVE TRAC-PF1 AND COBRA-NC CALCULATIONS (INTACT CORE), SCOPING STUDY, HAND CALCULATIONS
  - STRUCTURAL RUPTURE ANALYSIS

CONCLUSION

PRELIMINARY ANALYSES INDICATE THAT THE RCS PRESSURE BOUNDARY MAY FAIL LONG BEFORE THE VESSEL LOWER HEAD FAILURE. AS A RESULT, HIGH-PRESSURE MELT EJECTION TO CHALLENGE CONTAINMENT INTEGRITY MAY NOT OCCUR. HOWEVER, ADDITIONAL ANALYSES AND DATA ARE NEEDED TO CONFIRM THIS CONCLUSION.