THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

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To J. S. TULENKO - MANAGER, FUEL ENGINEERING

From R.V. DE MARS - CCTF LEADER
CORE CONDITION TASK FORCE

BOS 663.5

Cust.

File No. or Ref.

Subj. CURRENT ASSESSMENT OF CORE CONDITION 4/7/79 (1800)

Date 4-7-79 - 7:48 p.m.

This letter is cover one customer and one subject only.

ATTACHED IS THE CURRENT ASSESSMENT OF THE CORE CONDITION BASED ON INFORMATION AVAILABLE AS OF 4/7/79. MOST OF THE INFORMATION USED IN FORMING THIS ASSESSMENT, IS STILL PRELIMINARY AND REQUIRES VERIFICATION AND DOCUMENTATION. THE MOST SIGNIFICANT UNCERTAINTY IS THE TIME AND TEMPERATURE CONDITIONS PRESENT DURING THE CORE UNCOVERY.

THE CORE CONDITION TASK FORCE CONSIDERS THIS A PRELIMINARY BUT REALISTIC ESTIMATE BASED ON VARIOUS SOURCES OF INFORMATION INCLUDING INPUT FROM THE EPRI TASK FORCE ON FUEL DAMAGE ASSESSMENT.

AS FURTHER INFORMATION BECOMES AVAILABLE THE ASSESSMENT WILL BE UPDATED ACCORDINGLY.

RKK:dww

ATTACHMENT
CC: D.H. ROY
E.A. WOMACK
C.D. MORGAN
XC: CORE CONDITION TASK FORCE

INTRODUCTION

THE PHYSICAL CONDITION OF THE CORE IS BASED ON THE FOLLOWING POSTULATED SEQUENCE OF EVENTS. THE CORE WAS UNCOVERED ~11 FT DURING THE FIRST 15 MINUTES FOLLOWING THE SECOND PUMP TRIP. (SEE FIG. 1) THE CORE WAS THEN UNCOVERED 8 FT FOR 105 MINUTES. FOR THE REMAINDER OF THE TRANSIENT, THE CORE WAS ASSUMED TO BE QUASI-COVERED TO THE POINT THAT NO SIGNIFICANT OXIDATION OCCURRED. DURING THE INITIAL UNCOVERING, THE CLADDING WOULD FAIL NEAR THE TOP OF THE ROD DUE TO STRESS RUPTURE. DEPENDING ON THE HEATING RATES, THESE FAILURES WOULD HAVE OCCURRED BETWEEN ~1200-1650°F. THIS MAY PRECLUDE INITIAL FAILURE BY EUTECTIC FORMATION BETWEEN INCONEL GRID AND ZIRCALOY RODS. CLADDING STRAINS DUE TO HIGH-TEMPERATURE DEFORMATION PRIOR TO RUPTURE COULD APPROACH 35%. DURING THE HOLD TIME SUBSEQUENT TO THE RUPTURE, THE CLADDING OXIDIZED SEVERELY, FORMING ZIRCONIUM OXIDE AND RELEASING HYDROGEN GAS. THE DEGREE OF OXIDATION WILL VARY WITH THE POWER, HAVING BOTH AXIAL AND RADIAL DISTRIBUTION. THE DEGREE OF OXIDATION ALONG THE LENGTH OF A ROD COULD VARY FROM NEGLIGIBLE AT THE BOTTOM TO 100% AT THE HOTTEST REGION NEAR THE TOP OF THE ROD.

BASED ON EVALUATION AND INTREPRETATION OF AVAILABLE INFORMATION AS OF (4/7/79) IT IS POSTULATED THAT THE CURRENT CORE CONDITION IS:

1. FUEL ROD PRESSURE BOUNDARY

   APPROXIMATELY 90% OF THE FUEL RODS MAY HAVE PERFORATED CLADDING, ALLOWING RELEASE OF HELIUM AND VOLATILE FISSION PRODUCTS.

2. FUEL ROD STRUCTURAL INTEGRITY

   MANY OF THE INTERIOR FUEL ASSEMBLIES MAY VIRTUALLY HAVE NO RECOGNIZABLE FUEL ROD ARRAY BETWEEN THE UPPER END FITTING AND FIRST (TOP) INTERMEDIATE SPACER GRIDS. IN SOME ASSEMBLIES THIS CONDITION MAY EXIST TO A LESSER EXTENT AS FAR DOWN AS THE SECOND OR THIRD INTERMEDIATE GRIDS. MOST OF THE PERIPHERAL RODS AND THE LOWER PORTION OF MOST RODS WILL BE OXIDIZED BUT NOT TO AN EXTENT TO SIGNIFICANTLY AFFECT STRUCTURAL INTEGRITY.

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3. FUEL ASSEMBLY STRUCTURE

THE INTERMEDIATE INCONEL SPACER GRIDS SHOULD BE CLOSE TO THEIR ORIGINAL AXIAL POSITION. THE UPPER END GRID AND END FITTING IN MANY OF THE INTERIOR ASSEMBLIES MAY HAVE LITTLE STRUCTURAL SUPPORT. THE FIRST AND SECOND INTERMEDIATE SPACER GRIDS IN THESE INTERIOR ASSEMBLIES ARE LIKELY TO BE SUPPORTED AXIALLY FROM BELOW BY BADLY OXIDIZED GUIDE TUBES AND POSSIBLY FUEL RODS. THE REMAINING LOWER GRIDS ARE EXPECTED TO HAVE STRUCTURAL SUPPORT FROM THE DEGRADED BUT REMAINING GUIDE TUBES AND FUEL RODS.

4. ZIRCALOY COMPONENT MATERIAL CONDITION

THE ZIRCONIUM OXIDE (ZrO_2) PRODUCED BY THE OXIDATION OF THE ZIRCALOY COMPONENTS HAS RELATIVELY LOW DENSITY AND CAN RANGE IN FORM FROM SMALL PARTICLES OF A FEW MILS IN SIZE, TO IRREGULAR SHAPED FLAKES OF A FEW MILS IN THICKNESS AND UP TO A QUARTER INCH ON A SIDE, TO VIRTUALLY INTACT TUBULAR BUT FRAGILE SEGMENTS OF CLADDING. THE PARTICLES AND FLAKES ARE LIKELY TO BE MOBILE IN MOVING WATER. THESE PARTICLES CAN BE EXPECTED TO LODGE IN THE UPSTREAM SIDE OF ANY FLOW RESTRICTION SUCH AS SPACER GRIDS. GRAVITY MAY BE SUFFICIENT TO CAUSE THE LARGER ZIRCALOY AND ZrO_2 FRAGMENTS TO SETTLE OUT ON THE DOWNSTREAM OR UPPER SIDE OF SPACER GRIDS. THE QUANTITY OF ZrO_2 AND FRAGMENTED ZIRCALOY PRODUCED DURING THE PARTIAL CORE UNCOVERY IS LARGE. EXCEPT FOR SOME RODS IN PERIPHERAL ASSEMBLIES AND THE LOWER PORTION OF MOST RODS IN ALL ASSEMBLIES, THE TEMPERATURES PROJECTED FOR THE ZIRCALOY FUEL RODS WAS SUFFICIENT TO CAUSE SIGNIFICANT OXIDATION. THUS, THE MOBILITY, QUANTITY AND ORIGIN OF ZrO_2 IS SUCH THAT LOCAL FLOW BLOCKAGE COULD BE EXPECTED TO OCCUR IN ALMOST ANY LOCATION IN THE CORE. HOWEVER, THE MOST EXTENSIVE FLOW BLOCKAGE COULD BE EXPECTED IN THE UPPER CENTRAL PART OF THE CORE, WHERE THE ZrO_2 PARTICLES COULD FURTHER RESTRICT THE GENERAL FLOW RESTRICTION CAUSED BY THE HEAVIER FUEL PARTICLES AND FUEL ROD FRAGMENTS.

5. FUEL (UO_2) CONDITION

THE FUEL RELEASED FROM THE DETERIORATED CLADDING IS VERY DENSE. THE ORIGINAL SIZE OF PELLETS IS APPROXIMATELY 3/8 INCH IN DIAMETER BY 5/8 INCH LONG. UNDER IRRADIATION, THERMAL STRESSES CAUSE THE PELLETS TO BREAK UP INTO FRAGMENTS GENERALLY RANGING IN SIZE FROM 1/16 INCH TO 1/4 INCH ON A SIDE. DURING A TRANSIENT AND THE PERIOD FOLLOWING, THE FLOWING WATER AND STEAM CAN BE EXPECTED TO CAUSE SOME FUEL EROSION, WHICH WILL PRODUCE VERY

SMALL PARTICLES WHICH CAN BE SUSPENDED IN MOVING WATER.

IN THE CENTER ASSEMBLIES, IT IS LIKELY THAT MOST OF THE FUEL HAS BEEN RELEASED FROM THE RODS BETWEEN THE END FITTING AND THE SECOND OR THIRD INTERMEDIATE GRIDS. BASED ON THE UNDERSTANDING THAT THE FLOW IN THE CORE IS SEVERELY BLOCKED, THE FUEL FRAGMENTS HAVE SETTLED ON TO THE INTERMEDIATE GRIDS. LOCAL FLOW PERTURBATIONS CAN MOVE PELLET FRAGMENTS THROUGHOUT THE SYSTEM. FUEL FROM THE UPPER LEVEL MAY HAVE SETTLED DOWN THROUGH THE TOP INTERMEDIATE SPACER GRID TO THE SECOND LEVEL AND LOWER LEVELS TO A LESSER EXTENT. THERE IS SOME REMOTE POSSIBILITY THAT THE STRUCTURE SUPPORTING THE FIRST TWO INTERMEDIATE GRIDS IN THE CENTER FEW ASSEMBLIES MAY COLLAPSE, CAUSING THE TOP 5 FT OF FUEL TO SETTLE ON THE THIRD INTERMEDIATE GRID. THE FUEL FRAGMENTS WOULD LIKELY BE MIXED IN WITH SOME REMAINING ZIRCALOY ROD FRAGMENTS. THE SPACE BETWEEN FRAGMENTS COULD BE FILLED WITH WATER, STEAM, ZrO_2, OR SOME COMBINATION THEREOF. THE LARGE QUANTITY OF SMALL ZrO_2 PARTICLES COULD CAUSE SOME LOCALIZED FLOW BLOCKAGE TO PREVENT FULL COVERAGE WITH WATER. THE PRESENCE OF SOME TUBULAR SEGMENTS COULD ALLOW LOCAL FLOW CHANNELING AND ATTENDANT "JETTING".

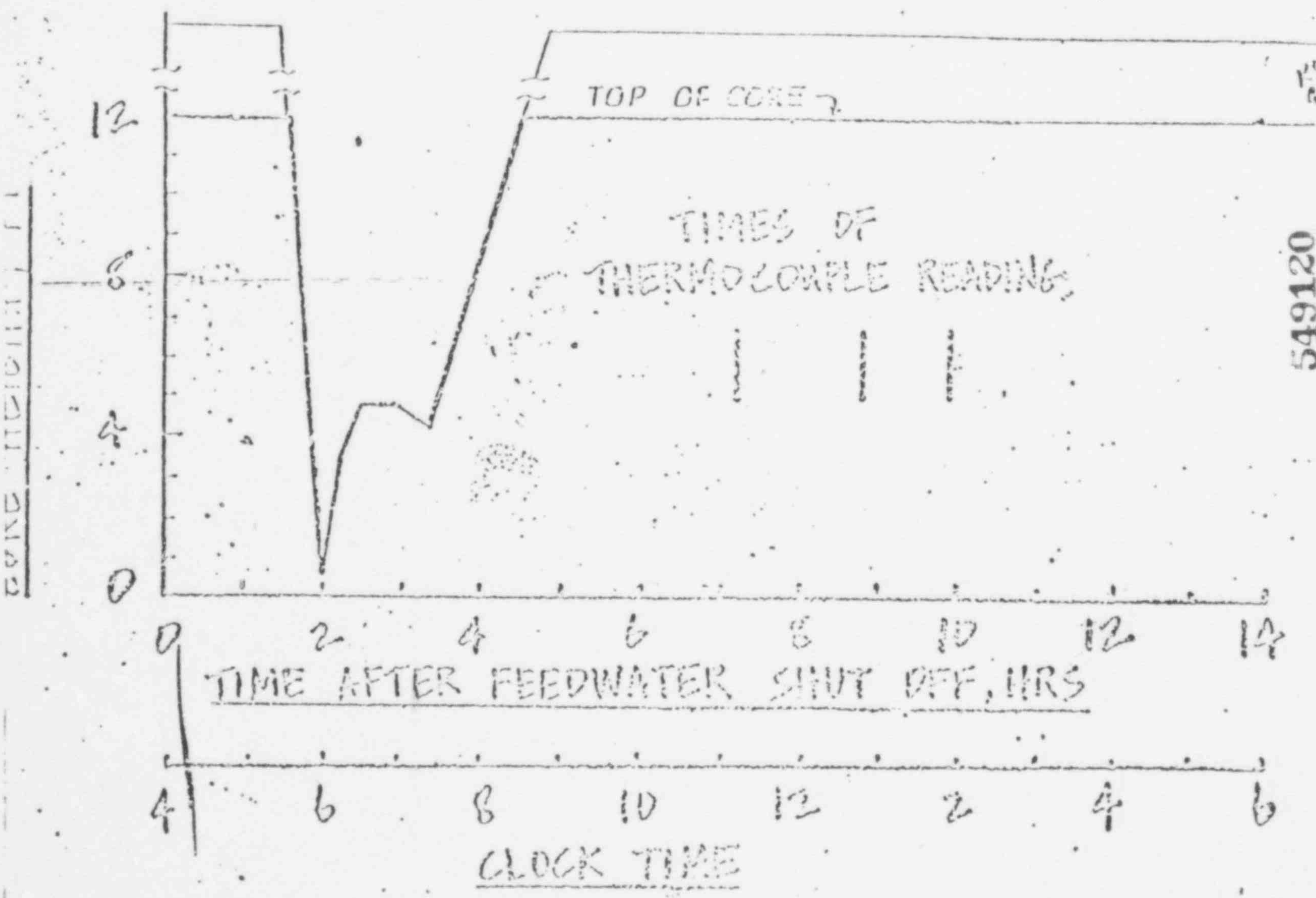
6. POTENTIAL STABILITY OF CORE CONDITION

THE POSSIBILITY OF CONTINUED STRUCTURAL DEGRADATION REQUIRES FURTHER EVALUATION. FLOW BLOCKAGE IS LIKELY WHICH CAN CAUSE LOCALIZED BOILING. WHEN LOCALIZED BOILING EXISTS, A FURTHER REDUCTION IN SYSTEM PRESSURE WILL INCREASE THE AREA OF BOILING AND RAISE THE TEMPERATURE OF CLADDING IN THE AFFECTED AREA. IF THE TEMPERATURE OF ANY ZIRCALOY COMPONENT EXCEEDS 1000°F, ACCELERATED OXIDATION WILL ADD TO THE GENERATION OF HYDROGEN AND CAUSE FURTHER DEGRADATION OF THE CORE STRUCTURE.

7. DISTRIBUTION OF FUEL AND ZrO_2 IN SYSTEM

IT IS VERY LIKELY THAT PARTICLES OF ZrO_2 AND UO_2 ARE CIRCULATING THROUGHOUT THE PRIMARY SYSTEM AND MAY SETTLE OUT IN STAGNANT AREAS.

ESTIMATED CORE COOLANT LEVEL



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SUBJECT NO. 3