MASS AND ENERGY

RELEASE

- REACTOR PRESSURE VESSEL
- VESSEL AND INTERNALS HEAT TRANSFER
- BLOWDOWN FLOW RATE
- TOTAL DECAY POWER

JSP-1
5/31

MASS AND ENERGY RELEASE

INTRODUCTION

- MODEL DESCRIPTION
- APPLIED TO MARK II LONG TERM POOL TEMPERATURE ANALYSIS
- SAME MODEL AS USED BY
  - FSAR's
  - MARK I
  - MARK III

REACTOR PRESSURE VESSEL

- SINGLE THERMODYNAMIC NODE
- COLLAPSED LIQUID LEVEL
- SATURATED FLUID
- MASS AND ENERGY BOOK KEEPING

STANDARD MODEL FOR CONTAINMENT ANALYSIS

REACTOR PRESSURE VESSEL

- MASS CONSERVATION

$$\Sigma W_{OUT} - \Sigma W_{IN} + \frac{DM}{DT} = 0$$

- ENERGY CONSERVATION

$$\Sigma (HW)_{OUT} - \Sigma (HW)_{IN} - \Sigma Q + \frac{DU}{DT} = 0$$

- EQUATION OF STATE

$P = F(V,U)$ (1967 ASME)

$U = U_F + XU_{FG}$

$V = V_F + XV_{FG}$

NOMENCLATURE

W = MASS FLOW RATE, LBM/SEC

M = MASS, LBM

$\frac{D}{DT}$ = DERIVATIVE WITH RESPECT TO TIME, SEC^{-1}

H = ENTHALPY, BTU/LBM

Q = ENERGY ADDITION RATE, BTU/SEC

U = INTERNAL ENERGY, BTU

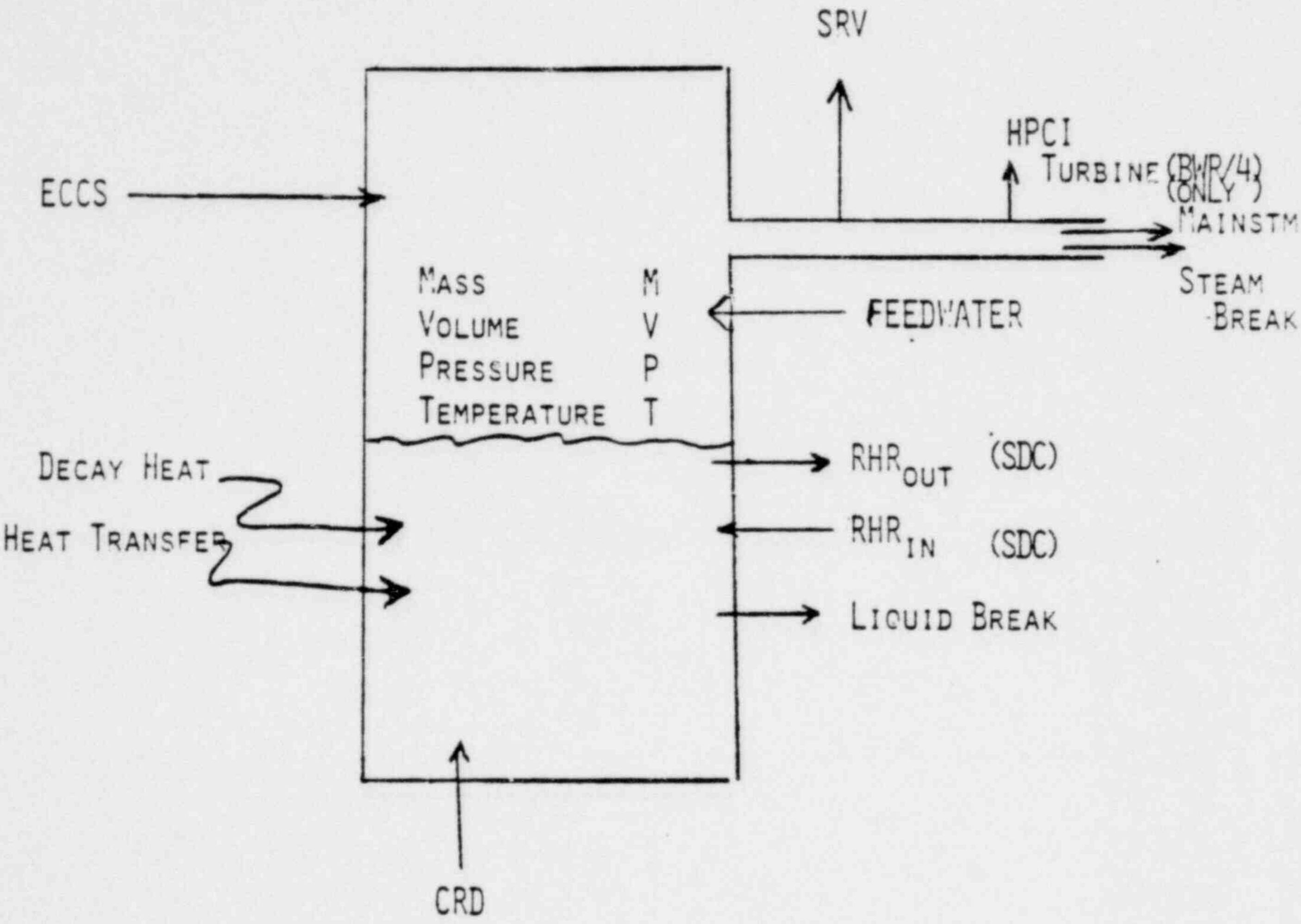
P = PRESSURE, PSIA

U = SPECIFIC INTERNAL ENERGY, BTU/LBM

V = SPECIFIC VOLUME, FT^3/LBM

X = QUALITY

REACTOR PRESSURE VESSEL



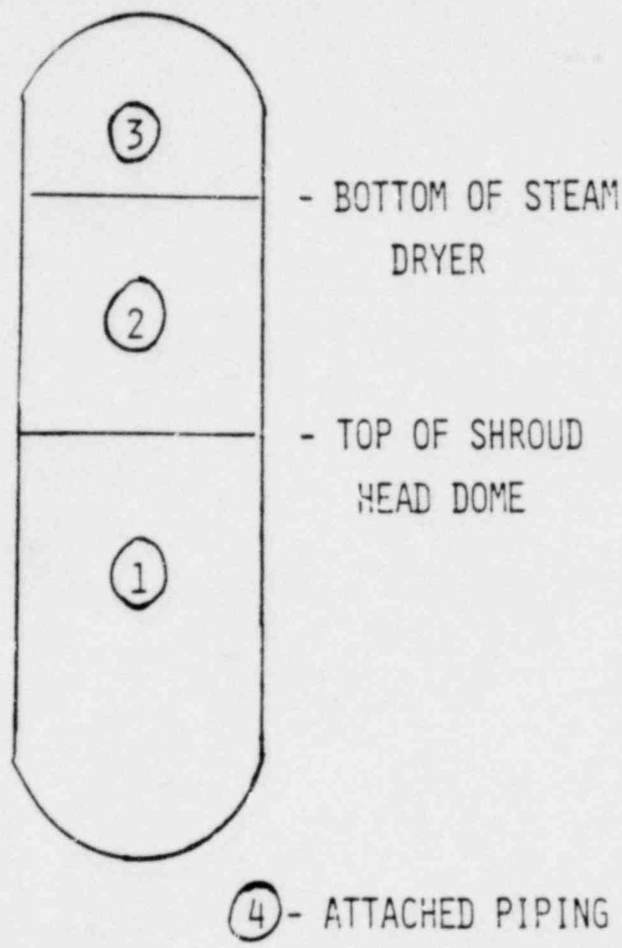
VESSEL AND INTERNALS HEAT TRANSFER

- GENERALIZED HEAT TRANSFER MODEL
  - AREA, HEAT CAPACITY, ELEVATION, AND INTERNAL RESISTANCE DESCRIBE EACH HEAT CAPACITANCE NODE
  - CONVECTIVE HEAT TRANSFER COEFFICIENT DEPENDANT UPON FLUID STATE
    - SATURATED STEAM
    - SATURATED LIQUID
  - ENERGY BOOK KEEPING FOR EACH HEAT CAPACITANCE NODE

STANDARD MODEL FOR CONTAINMENT ANALYSIS

VESSEL AND INTERNALS HEAT TRANSFER

TYPICAL HEAT CAPACITANCE NODES



BLOWDOWN FLOW RATE

- USED TO CALCULATE SRV OR BREAK FLOW
- MOODY SLIP FLOW MODEL USED
- BREAK FLOW ENTHALPY SET BY EXIT ELEVATION AND COLLAPSED LIQUID LEVEL
  - SATURATED STEAM
  - TWO-PHASE MIXTURE
  - SATURATED LIQUID

PREVIOUSLY DOCUMENTED IN NEDO-20533, "MARK III PRESSURE SUPPRESSION CONTAINMENT SYSTEM ANALYTIC MODEL," JUNE 1974

TOTAL POWER DECAY

- DETERMINED FROM
  - INITIAL REACTOR POWER
  - NORMALIZED POWER DECAY CURVE
- COMPONENTS OF NORMALIZED POWER DECAY
  1. ANS5 20/10 POWER DECAY
     - FISSION PRODUCT POWER
     - HEAVY ELEMENT POWER
  2. FUEL RELAXATION (SENSIBLE HEAT)
  3. PRE-SHUTDOWN/DELAYED NEUTRON FISSION
- NO METAL-WATER REACTION FOR "WHITE PAPER" EVENTS

TOTAL POWER DECAY

FISSION PRODUCT AND HEAVY ELEMENT POWER COMPONENT

- FROM ANS STANDARD OCT '73 (ANS5 20/10)
- INFINITE IRRADIATION AT MAX POWER
- FISSION PRODUCT POWER MULTIPLIER

  1.2 FOR FIRST 10^3 SEC

  1.1 FOR 10^3 TO 10^9 SEC

- SAME AS USED BY ECCS

TOTAL POWER DECAY

FUEL RELAXATION ENERGY COMPONENT

- FULL POWER TO COLD SHUTDOWN
- EQUIVALENT TO 8 FULL POWER SECONDS
- ECCS CORE HEATUP CALCULATION BASIS
  - INITIAL VALUE ZERO
  - PEAKS AT ~10 SEC
  - FALLS TO ZERO IN ~60 SEC

TOTAL POWER DECAY

PRE-SHUTDOWN/DELAYED NEUTRON FISSION COMPONENT

- ACCOUNTS FOR
  - FINITE SCRAM TIME
  - DELAYED NEUTRONS
- FROM GESSAR CURVE FOR ISOLATION
  - GESSAR 1976, FIGURE 15.1.4-1

TOTAL POWER DECAY

COMPONENTS

TIME	ANS5 20/10	FUEL RELAXATION	PRE-SHUTDOWN	TOTAL
0	.0839	0	1.0	1.084
0.1	.0839	.0231	1.0	1.107
1.	.0779	.1948	.60	.8727
2.	.0737	.3288	.10	.5025
4.	.0692	.4631	.07	.6073
10.	.0629	.4222	.04	.5251
20	.0569	.1544	.02	.2313
40	.0504	.0103	.01	.0707
100	.0426	0	0	.0426
200	.0358	0	0	.0358
400	.0309	0	0	.0309
10^3	.0245	0	0	.0245
10^4	.0120	0	0	.0120
10^5	.00624	0	0	.00624

SUMMARY

- VESSEL CONDITIONS FROM MASS AND ENERGY CONSERVATION
- VESSEL AND INTERNALS HEAT TRANSFER
- BREAK AND SRV FLOWS FROM MOODY SLIP MODEL
- TOTAL POWER DECAY INCLUDING ANS5 20/10
- MODELS USED FOR POOL TEMPERATURE ANALYSIS ARE STANDARD CONTAINMENT ANALYSIS MODELS