NUREG/IA-0072
AEEW-R2454

International Agreement Report

LOFT Input Dataset Reference Document for RELAP5 Validation Studies

Prepared by
J. C. Birchley

Winfrith Technology Centre
United Kingdom Atomic Energy Authority
Dorchester, Dorset, DT2 8DH
United Kingdom

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

April 1992

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

Available from

Superintendent of Documents
U.S. Government Printing Office
P.O. Box 37082
Washington, D.C. 20013-7082

and

National Technical Information Service
Springfield, VA 22161

NUREG/IA-0072
AEEW-R2454

International Agreement Report

LOFT Input Dataset Reference Document for RELAP5 Validation Studies

Prepared by
J. C. Birchley

Winfrith Technology Centre
United Kingdom Atomic Energy Authority
Dorchester, Dorset, DT2 8DH
United Kingdom

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

April 1992

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

NOTICE

This report is based on work performed under the sponsorship of the United Kingdom Atomic Energy Authority. The information in this report has been provided to the USNRC under the terms of the International Code Assessment and Application Program (ICAP) between the United States and the United Kingdom (Administrative Agreement - WH 36047 between the United States Nuclear Regulatory Commission and the United Kingdom Atomic Energy Authority Relating to Collaboration in the Field of Modelling of Loss of Coolant Accidents, February 1985). The United Kingdom has consented to the publication of this report as a USNRC document in order to allow the widest possible circulation among the reactor safety community. Neither the United States Government nor the United Kingdom or any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability of responsibility for any third party's use, or the results of such use, or any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

LOFT Input Dataset Reference Document for RELAP5 Validation Studies

J.C.Birchley

Summary

Analyses of LOFT experiment data are being carried out in order to validate the RELAP5 computer code for future application to PWR plant analysis. The dataset used in the analyses is based on the latest available information on the LOFT facility issued by the Idaho National Engineering Laboratory (INEL), operators of the LOFT experimental facility. The dataset was developed originally by INEL, for use with RELAP5/MOD1, to support planning and analysis of LOFT experiments. The MOD1 dataset was also used by CEGB Barnwood who subsequently converted the dataset to run with MOD2. The modifications included changes to the nodalisation to take advantage of the crossflow junction option at appropriate locations. Additional pipework representation was introduced for breaks in the intact (or active) loop. Further changes have been made by Winfrith following discussion of calculations performed by the CEGB and Winfrith. These concern the degree of noding in the steam generator, the fluid volume of the steam generator downcomer, and the location of the reactor vessel downcomer bypass path.

This document describes the dataset contents relating to the volume, junction, and heat slab data for the intact loop, reactor pressure vessel, broken loop, pressuriser, steam generator secondary, and ECC system. Also described are the control system for steady state initialisation, standard trip settings, and boundary conditions.

	NAME	SIGNATURE	POSITION	DATE
Lead Author	J. C. BIRCHLEY	J Birchley	Section Head / Project Officer	28 - 3 - 90
Checked	I. H. GIBSON	J Birchley for I. GIBSON	Group Head Head Tech. Area	28 - 3 - 90
Approved	J.C. BIRCHLEY	J Birchley	Project Officer	28 - 3 - 90

Reactor Physics Division
AEA Technology, Winfrith

January 1990

Contents

Tables

Figures

Acknowledgments

The author wishes to acknowledge the value of discussions with staff from the Central Electricity Generating Board (CEGB), Barnwood. A number of the figures used in the report [illegible] taken from Reference 3 (NUREG/CR-0247). The work was financed by the CEGB under the Thermal Reactor Agreement.

LOFT Input Dataset Reference Document for RELAP5 Validation Studies

1. Introduction

The RELAP5 computer code (Ref 1) has been chosen for independent assessment of small break LOCA and intact primary circuit faults for the Sizewell 'B' PWR. To provide confidence in RELAP5 as a suitable tool for this assessment, a series of validation studies is being carried out, via analyses of experimental data from rigs, from plant commissioning tests, and from unplanned plant transients that have occurred in the past. The cases being analysed have been chosen on the basis of the provision of data which address the important macroscopic phenomena that are likely to occur in those transients within the Sizewell 'B' design basis envelope, and are identified in Reference 2. The main sources of such data are the LOFT and LOBI integral test facilities.

This report describes the LOFT input dataset, based on the latest available information on the LOFT facility (Ref 3). The dataset used in the U.K. calculations is based on the input deck developed by INEL, and described in Reference 4. Section 2 of this report provides a brief description of the LOFT facility. Section 3 provides a detailed description of the dataset.

The LOFT experiments that have been/are being/will be analysed are:

- L9-1 Loss-of-feedwater with recovery via: (i) primary PORV; (ii) steam generator heat sink.
- L9-3 Loss-of-feedwater anticipated transient without trip (ATWT).
- L9-4 Loss of on and offsite power ATWT.
- LP-FW-1 Loss of main and auxiliary feedwater with recovery via primary feed and bleed.
- L3-5 Small (4 inch equivalent) cold leg break - pumps off
- L3-6 Small (4 inch equivalent) cold leg break - pumps on
- L5-1 Intermediate (10 inch equivalent) cold leg break - pumps on
- LP-SB-1 Small (3 inch equivalent) hot leg break - pumps off
- LP-SB-2 Small (3 inch equivalent) hot leg break - pumps on
- LP-SB-3 Small (2 inch equivalent) cold leg break - w/o HHSI, delayed pump trip

2. LOFT Facility Description

The LOFT facility was designed to model the nuclear and thermal-hydraulic phenomena which would take place in a loss-of-coolant accident (LOCA). The scaling philosophy adopted was to reduce the coolant volumes and flow areas for the components by the ratio of the LOFT core power (50 MW(th)) to that of a typical four-loop commercial PWR (3400 MW(th)). This was not completely achieved however, with the result that some of the components were oversized. In addition, the vertical scaling was not preserved with several components considerably shorter than their commercial PWR counterparts. Despite these shortcomings, the components in LOFT were functionally similar to those of a commercial PWR, and the transient simulations carried out in LOFT (Ref 3, for example), exhibited most of the phenomena that may be expected in a PWR LOCA or an intact primary circuit fault transient. In particular LOFT was at least an order of magnitude larger than most other integral facilities, and was unique among them in containing a nuclear core.

The main features of LOFT are summarised as follows:

i. A reactor vessel with an annular downcomer, a lower plenum, an upper plenum, and a nuclear core with lower and upper support structure.

ii. An intact (active) loop with an active steam generator, pressuriser, and two primary coolant pumps connected in parallel.

iii. A broken (test) loop containing pipework with resistance and elevation changes designed to simulate the steam generator and pump resistance, and two quick acting blowdown valve assemblies. (The steam generator and pump simulators were disconnected in several of the intact primary circuit fault transient experiments.)

   Despite the terminology "intact/broken loop", the majority of the small break LOCA experiments in LOFT were conducted with the break in the active loop.

iv. A blowdown suppression system consisting of a header, suppression tank and a spray system, to simulate the containment response to a LOCA.

v. An emergency core coolant (ECC) injection system consisting of two low head safety injection (LHSI) pumps, two high head safety injection (HHSI) pumps, and two accumulators, and the associated pipework.

The LOFT facility is depicted in Figures 1 through 7. Figures 1 and 2 show the primary coolant system (PCS); figures 3 through 5 show cutaways of the reactor vessel, the pressuriser, and the steam generator; figure 6 shows the secondary system, and figure 7 the ECC system.

2.1. RELAP5 Input Dataset Description

The input dataset described in the present document is based on the model developed by INEL for analyses of LOFT intact circuit fault and LOCA experiments using RELAP5/MOD1 (Ref 4). The MOD1 dataset was used by CEGB Barnwood for analysis of LOFT small break experiment LP-SB-3 (Ref 5), and was subsequently modified for further analyses of LOFT experiments LP-SB-3 (Ref 6), LP-SB-1 (Ref 7), LP-SB-2 (Ref 8), LP-FW-1 (Ref 9), and L9-4 (Ref 10), using MOD2. The version used for analysis of experiment LP-SB-2 constitutes the major part of the present model.

Modifications made by Barnwood are described in the above references but have not been formally documented. The input datasets are, however, archived. The modifications from the original dataset are essentially of four types:

i. Renoding of the reactor vessel in order to make use of the cross-flow junction option in MOD2. This enabled simplification of the noding for the connections between the loops and the reactor vessel. In particular, the intact and broken loop cold legs are connected to only a single fluid cell.

ii. Adjustments to provide closer representation of the hardware. This concerned, in particularly, the reactor vessel downcomer bypass flow paths (following discussion of sensitivity studies performed by Barnwood) and steam generator downcomer flow area. There is also supporting information information from INEL for these changes (referenced below).

iii. Subdivision of the lowest node in the steam generator boiler and tubes to provide better resolution of the fluid distribution during boildown of the steam generator in loss-of-feed transients.

iv. Inclusion of the intact loop hot leg and cold leg break geometry, ECCS, and broken loop SG and pump simulators (to be commented out when not applicable).

The RELAP5 input dataset for the LOFT facility consists of seven parts:

i. Intact loop components (100-199, 900-999)

ii. Reactor vessel components (200-299)

iii. Broken loop components (300-399)

iv. Pressuriser components (400-499)

v. Secondary coolant system components (500-599).

vi. ECC system components (600-699).

vii. Containment volume components (800-899)

Also represented are the internal heat structures in the reactor vessel and vessel wall, the pipework of the primary coolant system and the pressuriser, the conductors between the primary and secondary sides, and the secondary side shell.

During the course of the USNRC and OECD LOFT experiment programmes, the facility was configured in several different ways, to represent breaks of different size or location, etc. Certain sections of pipework were added or valved in or out accordingly. In any particular experiment only part of the whole configuration was used. In the interest of compactness, all of the configuration relevant to the validation of RELAP5 is represented in a single reference dataset. For calculation of any particular experiment, the representation for LOFT hardware that was not used is commented out.

Because the model is used for a range of transients compromises are made between economy of calculation and detail of representation. The degree of detail allows realistic simulation of small breaks (in which it is necessary to be able to track the level in the primary system and the reactor vessel), and transients such as loss of feedwater (where it is necessary to track the level in the steam generator). When the model was developed it was expected that similar noding would be used for all the transients, rather than seek run time economies by using different noding for different classes of transient. In making subsequent modifications involving the addition of further detail, the new model became, essentially, a new base deck. For example, the noding in the intact loop hot leg and cold leg was modified to include small BRANCH components at the locations of the connection to the break lines. The use of a small fluid volume at the break connection is recommended by INEL, although Barnwood had reported that the results were not significantly affected by the noding change. The new noding is retained for simplicity and to reduce the amount of input model maintenance, documentation, etc. In general, however, the size of the hydrodynamic volumes are specified such that all volumes have comparable flow length, within the constraints implied by the likely level of detail required. One of the values of length, flow area, and volume is always set to zero, so that this value is calculated by the code. If the hydraulic diameter is input as 0.0, then it also is calculated by the code, from the flow area.

The from/to volume number has the format - XXXNNMM - where XXX is the component number, NN is the volume number within the component, and MM = 00 for inlet, 01 for outlet. If the area for a junction is set to zero in the input deck, the smaller flow area of the adjacent volumes is used.

Figure 8 shows the nodalisation scheme used in the input dataset.

2.2. Intact Loop and pump injection systems

The connections of the intact loop to the reactor vessel and to the pressuriser surge line are included here. Also included in the description of the intact loop pipework are the primary coolant pump injection, and the break pipework from the intact loop.

2.2.1. Volume related data

The intact loop components, including the two primary coolant pumps and the primary side of the steam generator are identified in figure 10a,b,c, and the volume outlet elevations, in figure 10d. Table 1a describes the noding and details of the components. The pump inlet and outlet regions, the ECC connection, and the connection between the hot leg and pressuriser surge line are simulated as tees. A PIPE component comprising 10 fluid volumes is used to represent the steam generator tubes, with the lowermost section noded more finely than the remainder. Components 100, 105, 110, and 112 represent the hot leg, 114 and 116 the steam generator inlet and outlet plena, respectively, and 118 the crossover leg. A BRANCH component 120 simulates the tee at which the pipework divides to form the two parallel paths for the pumps. Pump number one is represented by components 125 and 130 for the pump suction and entry, 135 for the pump, and 140 and 145 for the outlet and discharge. Pump number two is represented in similar manner by components 155 and 160 (suction and entry), the PUMP component 165, and 170. A second BRANCH simulates the confluence of the pump discharges. Components 175, 180, 184 and 185 represent the cold leg.

2.2.2. Junction related data

Table 10b details the junction data for the intact loop. The two junctions at the pump suction tee which connect component 120 with 125 and 155 have half the flow area of component 170. Connection to the pressuriser spray line is represented by a junction from BRANCH component 150. The ECC connects to BRANCH component 185. Junctions 11401 and 11602 have smaller flow areas than the minimum flow area of the flow areas of the adjacent volumes, and are specified with the abrupt area change option, thus simulating the orifices installed in the steam generator inlet and outlet plena. The loss coefficients are adjusted to produce the correct pressure drop as specified in the LOFT System and Test Description (Ref. 3).

The LOFT configuration contains a number of pathways by which fluid can pass between the inlet and outlet nozzles without passing through the main flow paths within the reactor vessel. Some of these paths are lumped together in the RELAP5 input dataset in the form of a single pathway from the vessel inlet to the outlet, (sometimes referred to as the downcomer bypass).

Analyses have shown that the transient conditions, particularly following a small break LOCA, are sensitive not only to the size of the downcomer bypass but also to the elevation. In earlier versions of the input model, the downcomer bypass was represented as a path within the vessel itself, between the top of the inlet annulus and the top of the upper plenum, SNGLJUN component 208. Vessel bypass data given in Reference 11 indicate that the bulk of the downcomer bypass is at the elevation of the inlet and outlet nozzles, and that the pathway represented by junction 208 admits only a small fraction of the downcomer bypass flow. This is supported by sensitivity studies carried out in the analysis of experiment LP-SB-1 (Reference 11). The input lines for junction 208 are retained, for reference, as comments in the present input deck.

The downcomer bypass is represented by a junction from volume 185 to 100, with the flow area set to the cold leg area. The bypass flow rate is kept at 2.4 percent of the total loop flow. The form loss coefficient, determined from pressure drop considerations, is set to 7200.

The tee junctions for the pump inlet and outlet regions are specified as normal (i.e. not cross-flow) junctions. The ECC connection tee is simulated as a normal junction. The connections between the reactor vessel upper plenum and intact loop hot leg, and between the inlet annulus and cold leg are modelled using cross-flow junctions, with the vessel fluid volumes (and not the pipe volumes) specified as cross-flow. The cold leg also connect to the reactor vessel filler gap via a normal junction. The connection between the intact loop hot leg and pressuriser surge line is specified as a cross-flow junction, with the hot leg volume as cross-flow, and the modified entrainment model invoked.

The primary coolant pump injection is via TMDPJUN components 900 and 901, the coolant conditions defined by TMDPVOL components TMDPVOLs 910 and 911.

2.2.3. Heat slabs

Heat slabs are included for the steam generator tube walls and all the intact loop pipework, except the ECC line and the pump housing. The heat slab data are given in table 1c.

2.2.4. Break Configuration for Experiments LP-SB-1 and LP-SB-2

For hot leg break experiments LP-SB-1, SB-2 the noding for the intact loop hot leg is modified. A section of the hot leg, SNGLVOL component 104, is introduced in between 100 and 105. A crossflow SNGLJUN then connects component 104 to the SNGLVOL component 102 that represents the break line. The piping for the break line from the intact loop hot leg is represented by SNGLVOL component 102. The break itself is represented by the VALVE component 103. The lines of input corresponding to the hot leg break geometry are appended to the intact loop representation, and are commented out for experiments other than LP-SB-1 and SB-2. Multipliers of 0.93 and 0.81 are used for single and two phase break flows, respectively. However, multipliers of up to 1.2 had been used in some sensitivity studies carried out by Barnwood.

2.2.5. Break Configuration for Experiment LP-SB-3

For cold leg break experiment LP-SB-3 the a section of pipework is added to represent the break line and orifice. The break piping is represented by BRANCH components 181 and 182, the break orifice represented by VALVE component 183. Component 181 is connected to cold leg volume 184 by means of a cross flow junction. The lines of input corresponding to the cold leg break geometry are appended to the intact loop representation, and are commented out for experiments other than LP-SB-3. Multipliers of 0.93 and 0.81 are used for single and two phase break flows, respectively.

2.3. Reactor Vessel

The reactor vessel input data are based on Reference 1. Because of the complicated geometry of the reactor vessel, particularly in and around the core, simplifications have been made to represent the vessel with a degree of detail consistent with the remainder of the system.

2.3.1. Volume related data

The components representing the reactor vessel are identified in figure 11a,b,c,d, and the elevations of the volumes indicated in figure 11e. The volume data for the reactor vessel are described in table 2a.

Components 200, 202, and 205 simulate the inlet annulus. The downcomer and vessel filler gap are represented by ANNULUS components 210 and 223, respectively. Components 215 and 220 simulate the lower plenum and lower head. The volume containing the lower core support structure and flow diffuser plate is represented by component 225. Components 230 and 235 simulate the core and core bypass, respectively. Finer noding is used for the core than for most of the vessel, in order to provide sufficient resolution of the core fluid distribution during small break LOCAs in which core uncovery occurred. Component 240 represents the region containing the upper end boxes and the lower part of the upper core support structure. Component 245 represents the cross-flow region up to the level of the control rod guide structure. Components 250 and 251 simulate the upper flow skirt region and the dead end region of the fuel modules up to the level of the control rod drive housing, respectively. Components 252, 255, and 260 simulate, respectively, the upper plenum at the connection with the intact and broken loop hot legs, the lower part of the upper plenum above the level of the hot leg connections, and the dead end region at the top of the upper plenum. All the volumes are vertically oriented.

2.3.2. Junction related data

The geometric data for the junction related components in the reactor vessel are shown in table 2b. All the junctions within the vessel model are oriented vertically, and all BRANCHes in the vessel are one-dimensional. The connections between the inlet annulus and the intact and broken loop cold legs, and the upper plenum to the intact and broken loop hot legs are simulated using horizontal junctions, with the respective vessel components defined as cross-flow volumes for those junctions.

As stated in Section 2.1, the downcomer bypass is represented by a connection from the vessel inlet nozzle to outlet nozzle. However, the original path, junction 208, is retained for reference but is commented out in the present input deck. The junction areas in the core bypass volume, between the lower core support volume and upper end box/support volume, are specified to give approximately five percent flow. Details of the bypass path flow are given in Reference 11.

The pressure drop distribution in the vessel is not known in detail with accuracy. The additional loss coefficients in the reactor vessel are chosen to provide the correct total pressure drop across the vessel.

2.3.3. Heat slabs

The heat slab components in the vessel are shown in figure 11c. The following heat structures are used, as shown in figure 11d:

i. Vessel wall

ii. Vessel bottom

iii. Vessel filler blocks

iv. Core support barrel

v. Core lower support structure

vi. Flow skirt - core filler assembly

vii. Active core

viii. Upper core support structure

ix. Internals in upper plenum

x. Top plate

Two-sided heat structures are used to represent the vessel walls, bottom, top plate, and the upper sections of the fuel modules. The fuel rods, filler assemblies, support structures, flow skirt, and internals are modelled using one-sided heat structures. A detailed description of the geometric data for the heat structures is given in table 2c.

2.4. Broken loop

Figure 12a,b,c displays the broken loop geometric data, and figure 12d shows the volume outlet elevations. The broken loop. loop pipework is represented up to the isolation valves, with the steam generator and pump simulators not included since these sections were not used in the experiments analysed here The Reflood Assist Bypass System (RABS) consisted of an assembly comprising two parallel lines, each one valved (normally closed but admitting some flow through leakage). The lines connected at each end, via a tee, to a section of pipe. The pipe sections connected to the broken loop, one to the hot leg and one to the cold leg. To allow room for the RABS assembly, the pipe from the cold leg was elevated above the loop elevation, and connected vertically to the top of the cold leg pipe and horizontally to the hot leg.

2.4.1. Volume related data

PIPE component 350 represents the line to the cold leg break plane. PIPE component 315 represents the line to the hot leg break plane, and which comprises the steam generator and pump simulators. The dataset contains two sets of input lines, one set to be commented out depending on whether the simulators were used or not. For experiments in which the simulators were not used, fluid cells 315-3 through 315-12 are, in effect, commented out and the length of cell 315-2 increased to accommodate the additional length of straight pipe.

The RABS is simulated by two PIPE components (370 and 380). These are connected to BRANCH components 310 and 345 representing the broken loop hot leg and cold leg reducer sections. The line from the cold leg is at an elevation of 0.64 m.

The geometric data for the volumes are detailed in table 3a.

2.4.2. Junction related data

Table 3b describes the input data for the junctions in the broken loop. The loss coefficients are specified to give the correct pressure drop distribution. The junctions in the broken loop are normal, one-dimensional, and oriented horizontally with the exception of the RABS connections. The connection to the broken loop cold leg is oriented vertically and normal (i.e. not crossflow), while the hot leg connection is horizontal and crossflow. The PIPE sections of the RABS in the broken loop are connected to each other via a SNGLJUN (375) whose loss coefficients are specified so as to yield a flow of 1.4 percent of the full steady state flow. This represents the average flow through the (leaking) valve in the RABS, derived from steady state measurements of loop flow and temperature. The size of the bypass flow through the RABS, like the downcomer bypass, can have a significant effect on the thermal-hydraulic response in some transients. Unfortunately, the RABS flow is not known with certainty and, moreover, is believed to vary from experiment to experiment depending on how securely the valve reseats after it had been opened. (The RABS was normally tested before experiments were conducted). The flow resistance may be varied in some experiment simulations.

2.4.3. Heat slabs

The input data for the broken loop configuration includes heat slabs for the pipework for the broken loop hot and cold legs and RABS. The heat slab data are given in table 3c. The remarks pertaining to the whether the simulators were used apllies to the heat slabs, also.

2.4.4. Steam generator and pump simulators

The LOFT configuration includes a section of pipework designed to simulate the flow path from the broken loop hot leg to to cold leg break. The pipework includes the steam generator and pump simulators, which present flow resistances representative of large break LOCA [illegible] conditions, and elevation changes similar to those in the intact loop pipework. For several of the experiments, the simulators were moved aside and were replaced by a straight length of pipe leading to the break plane.

The pipework is represented by PIPE component 315, containing 12 fluid cells. Large loss coefficients are input to represent the flow resistance provided by orifice plates in the steam generator and pump sections of the pipe. The volume, junction and heat slab data are given in tables 3d, 3e, and 3f, respectively. Figure 12e displays the volumes and figure 12f the volume outlet elevations for the steam generator and pump simulators.

2.5. Pressuriser

The input data for the pressuriser are based on reference 1. The pressuriser is modelled in some detail in order to simulate the response to in- and out- surges and to flows through an open relief valve. The representation comprises 13 fluid volumes, 16 junctions, and 9 heat slabs.

2.5.1. Volume related data

Figure 13a,b,c identifies the components of the pressuriser, and figure 13d shows the volume outlet elevations. This part of the system includes the pressuriser surge line, which is represented by a SNGLVOL and a PIPE component (components 400 and 405, respectively) comprising three fluid volumes overall. The pressuriser tank is simulated using a PIPE component (415) consisting of seven fluid volumes. A BRANCH component (440) is used to represent the spray line, connected to the top of the pressuriser tank via a VALVE (445), and to the intact loop cold leg. The volume related data are given in table 4a.

2.5.2. *Junction related data*

Table 4b shows the junction related input data for the pressuriser. Component 410 is a SNGLJUN simulating the entry to the pressuriser. Component 420 is a BRANCH used to connect to three VALVE components which represent the Pilot Operated Relief Valve (PORV) (455), the Safety Relief Valve (SRV) (450), and a dummy valve used to control the pressure for the steady state. The areas of the PORV and SRV are specified to provide the correct relief flows. The spray line flow resistance is set to give the specified spray flow rate. The PORV, SRV and spray valves are represented by trip valves in the input model.

2.5.3. *Heat slabs*

The walls of the pressuriser are represented by heat structures, but the surge line does not have any heat structure representation. The pressuriser heaters were not used in those experiments being analysed and are not simulated in the input data. The heat slab data are given in table 4c.

2.6. Steam generator secondary

Data for the configuration of the steam generator secondary are not available in same degree of detail for for the rest of the system. Limited data are provided in reference 1, and some additional data are given in reference 10.

Unfortunately, there is no value given for the diameter of the boiler shroud. The original dataset assumes a value 1.289 m for the internal radius, which is used to calculate the boiler and downcomer flow areas and volumes. This value implies a distance of 0.035 m between the outermost tubes and the shroud, which is comparatively large compared with the tube pitch (0.0191 m). The dimensions used in the RELAP5 dataset have consistently resulted in an underestimate of the initial inventory by about 100 kg. A revised calculation of experiment L9-3 used a larger downcomer area corresponding to the internal diameter of the shroud set to 1.219 m, the diameter of the tube bundle. This gave better agreement for the estimated initial inventory but distorted the physical picture because the shroud would not, of course, have been in contact with the tubes.

In order to overcome the discrepancy in mass inventory, the following modification is made to the input dataset. A reduction in the shroud diameter to 1.2572 m is assumed which corresponds to a distance of 0.0191 m between the outermost tubes and the shroud inner wall, i.e. the same as the tube pitch. This value results in an increase in the downcomer area to 0.297 m2, and a reduction in the boiler flow area to 0.258 m2. The net effect is that the total volume in steam generator is not significantly changed, but during power operation (when the fluid in the boiler is two-phase), the liquid inventory, as calculated by RELAP5/MOD2, is increased by about 60 kg. This results in an inventory close to the quoted value at full power. It should be noted,however, that the inventory calculated by RELAP5/MOD2 depends also on the code models for interphase drag and subcooled void, and the flow resistance in the input dataset.

The data in reference 10, and the assumed and derived values for dimensions are summarised below.

Characteristic	Value	Units
Tube bundle diameter	1.219	m
Outside diameter of tubes	0.0127	m
Number of tubes	1845	
Tube pitch (from above)	0.0191	m
Assumed shroud inner diameter (based on tube pitch)	1.2572	m
Thickness of boiler shroud (from original dataset)	0.0127	m
Shroud external diameter = downcomer inner diameter	1.2826	m
External diameter of secondary shell	1.528	m
Thickness of secondary shell (from original dataset)	0.0528	m
Outer diameter of downcomer annulus (from above)	1.4224	m
Flow area of downcomer (from above)	0.2970	m2
Assumed shroud inner diameter (based on tube pitch)	1.2572	m
Area inside shroud (from above)	1.2414	m2
Outside diameter of tubes	0.0127	m
Number of tubes	1845	
Area occupied by tubes (from above)	0.4674	m2
Flow area of bundle in horizontal plane (from above)	0.7740	m2
Flow area in dataset (taking into account flow direction)	0.2580	m2
Mass inventory at full power	2041	kg

The steam generator secondary system, including the feedwater system and the components downstream of the MSCV are simulated by means of 21 fluid volumes, 21 junctions, and 15 heat slabs.

2.6.1. Volume related data

Figure 14a,b,c identifies the components in the steam generator secondary, and figure 14d indicates the volume outlet elevations. The steam generator secondary The volume data for the secondary coolant system are detailed in table 5a.

The boiler is represented by the PIPE component 515. The length of the flow path from volume 515-01 to 515-05 is greater than the elevation change because the fluid has to flow around the baffles inserted in the boiler. Smaller nodes are employed in the lower part of the boiler and downcomer (510), to make it possible to track the level in those volumes as the steam generator boils down following a loss of feedwater. The downcomer is simulated using the annulus component (510).

The separator is represented using the SEPARATR component 500. The quantity VOVER, the liquid fraction above which liquid carryover occurs, has the value 0.2. Carryunder occurs at a liquid fraction less than VUNDER, which has the value 0.0002. A small value was used for VUNDER in order to suppress the instability when steam is transported into the downcomer while there is still significant liquid present.

Liquid is returned from the separator to the region simulated by the SNGLVOL 505, and hence to the upper downcomer, represented by BRANCH component 508, where it mixes with the subcooled feedwater. The separator bypass is simulated by a SNGLVOL 502, which connects to the separator liquid return and to the lower part of the steam dome (520). The lower, and upper (525) parts of the steam dome are simulated using SNGLVOL components.

The steam main system is represented by a SNGLVOL components 530 and 541 for the sections of pipe before and after the steam control valve. The condenser and and volume connected to the steam bypass are simulated using the TMDPVOL components 542 and 546. steam dome are simulated using SNGLVOL components.

2.6.2. *Junction related data*

The junction related input data are shown in table 5b. The initial circulation rate and flow resistance in the steam generator are not known accurately. The loss coefficients have a bearing on the circulation ratio which, in turn, affects the inventory during steady state operation. Prior to increasing the downcomer area, sensitivity studies were performed in which the flow resistances were reduced in attempt to raise the circulation ratio and inventory. However, the inventory could not be increased satisfactorily via any plausible reductions, and the loss coefficients were reset to their original values.

The feedwater valve is simulated using the TMDPJUN 566. The steam flow control valve and steam bypass valve are simulated using VALVE components 540 and 545, respectively. The steam flow control valve, when closed, admits a small but noticeable leakage which is slightly different each time the valve closes. The leakage flow is generally in the range 0.05 to 0.1 kg/s.

2.6.3. *Heat slabs*

The heat slab input data for the steam generator are given in table 5c. The heat slabs represent the steam generator shell, and the shroud separating the downcomer and boiler regions. The steam generator tube walls are included in the description of the steam generator primary side.

2.7. ECC System

A SNGLVOL (605) is used to represent the ECC header, to which are connected the accumulator line, component 615, and the borated water storage tank (BWST). TMDPVOL components 625 and 620 represent the BWST and accumulator, respectively. The connection between the ECCS header and the intact loop cold leg (185) is via VALVE component 600. A second VALVE (610) connects the header with the accumulator pipe. The low and high head ECC pumps are represented by TMDPJUN components 630 and 640, respectively. The configuration is shown in figure 10, the volume and junction data are given in table 6a,b. The HHSI and LHSI flow rates are specified separately for each experiment. No heat structures are used in the input for the ECCS.

2.8. Containment system

The containment (or, strictly, the blowdown suppression tank) is represented by time dependent volumes 805, 810, 815, 820, and 825 which define the conditions downstream of the pressuriser PORV, SRV, intact loop hot leg break, intact loop cold leg break, and broken loop cold leg break, respectively. Only those components relevant to each experiment are used, the remainder are commented out.

3. Initial and Boundary Conditions

Some of quantities which define the initial and boundary conditions (e.g. the steam bypass valve set-points) can be considered as having standard values. In general, however the initial and boundary conditions vary from test to test.

The initial and boundary conditions are specified via the trip and control systems, and table data. For the initial conditions of a particular run, the primary system pressure, the primary loop mass flow rate, the core power, the secondary side downcomer level are set in the input deck to their required values. The initial state is achieved by means of a pseudo-steady state calculation in which those quantities (e.g. loop flow rate) which cannot be specified explicitly are achieved via the control system's action on some other quantity, in this case the pump speed. The boundary conditions for the transient calculation are specified directly.

3.1. Initial conditions

The initial primary system pressure is specified by means of a time dependent volume attached to the pressuriser. This volume controls the system pressure directly and is removed in transient calculation. In reality pressuriser sprays and heaters are deployed in the LOFT pressuriser, but these are not invoked in steady state calculations.

The initial core power is set to the measured or specified value, in the relevant heat structure card.

The mass flow rate is controlled via the pump speed, which is continually adjusted using a proportional-integral controller on the difference between the current flow rate and the required flow rate. This readily drives the flow rate to the required value, thus:

$$\omega_{new} = \omega_{old} - 0.2(\dot{m} - \dot{m}_{reqd}) - 0.1\int(\dot{m} - \dot{m}_{reqd})\,dt\,,$$

where the mass flow is evaluated at junction 18001 in the intact loop cold leg.

The steam generator pressure is controlled via the main steam control valve whose position, X, is adjusted using a proportional-integral controller on the steam line pressure, p, thus:

$$\dot{X} = 10^{-7}(p - p_{reqd}) + 5.10^{-10}\int(p - p_{reqd})\,dt$$

$$X = 0.9 + \int\dot{X}\,dt$$

The steam generator downcomer level is controlled via the feedwater flow which is itself controlled on the level and the steam flow, thus:

$$\dot{m}_{feed} = \dot{m}_{steam} - 20.0(level - level_{reqd})$$

Although the steam generator inventory is actually monitored via the level in the downcomer, there is some uncertainty over the relation between level and inventory. In particular, RELAP5/MOD2 tends to underpredict the inventory as a function of the level in steady state conditions. An overestimate of the level might be used in order to specify the initial inventory more accurately.

3.2. Boundary Conditions

The controllers for the initial conditions are disabled at the start of a transient calculation, and the trip and control logical, and the table data for the transient then become effective.

3.2.1. Trip settings

The trip logic used in LOFT experiments varies considerably from test to test, and a standard set of trips does not exist. However, certain of the trips are characteristic of the LOFT facility and are essentially test independent and may be considered as standard. However, although their operation is generally test independent, the setpoint values vary from test to test. The trip conditions in the reference dataset are:

i. Pumped ECC and accumulator -
(hot leg pressure)
HHSI on: 8.07 MPa
LHSI on: 1.03 MPa
Accum on: 4.14 MPa

ii. Pressuriser spray (except loss of offsite po
(hot leg pressure)
On: 15.32 MPa
Off: 15.16 MPa
The spray valve is modelled as a trip valve.

iii. Pressuriser PORV opening and closing (except loss of offsite power) -
(hot leg pressure)
Open: 16.20 MPa
Close: 16.00 MPa
The PORV is modelled as a trip valve.

iv. Pressuriser SRV opening and closing
(hot leg pressure)
Open: 17.24 MPa
Close: 16.46 MPa
The SRV is modelled as a trip valve.

v. Main steam control valve (when enabled)
(steam line pressure)
Open: 7.12 MPa
Stop opening: 6.98 MPa
Close: 6.50 MPa
Stop closing: 6.57 MPa
The control valve rate of opening/closing is 0.06/s.

vi. Steam bypass opening and closing (when MSCV disabled)
(steam line pressure)
Open. 6.50 MPa
Close: 6.35 MPa
The bypass valve rate of opening/closing is 0.143/s.

vii. Auxfeed on and off (following SI signal)
(SG level)

On: 2.1844 m
Off: 2.9464 m

viii. Scram, termination of main feed, and MSCV closure on SI signal (hot leg pressure)
Active: 14.28 MPa

The remaining trip logic and settings are experiment specific, indeed define the experiment. Such trips include break opening, scram, termination of main feed other than on SI signal, pump trip.

3.2.2. Heat sources and sinks

The heat input from the nuclear fuel is specified, during steady state, as a constant power. For transients involving scram, a decay heat table is generally specified based on tabulated data provided by INEL. For transients not involving scram, the power is calculated either by input of a supplied table for power against time, or by means of the point kinetics model in RELAP5/MOD2. Reactivity parameters, derived by INEL from physics calculations performed as part of the planning and safety analysis for LOFT ATWT sequences, are included in the input deck. The treatment of power generation using the kinetics model is described in Reference 13. The input lines for the reactivity model are commented out if the kinetics model is not used. The dimensions and enrichment of the LOFT core are different from that of a commercial PWR, with the result that the reactivity feedback roughly simulates a PWR core at the end of life (although the power shape and degree of irradiation are typical of beginning of life). The nominal full power of the LOFT core is 50 MW.

Heat losses to the environment are modelled by means of a constant ambient temperature and a set of fixed heat transfer coefficients from the outside walls of the primary system pipework, vessel, and pressuriser, and the steam generator. The htc's and the losses at normal operating temperature are as follows:

Ambient temperature = 311 K

Vessel and pipework	htc = 10.74 W/m**2K	loss = 174 kW
Pressuriser wall	htc = 3.019 W/m**2K	loss = 6 kW
Steam generator wall	htc = 3.385 W/m**2K	loss = 20 kW

The total heat loss of 200 kW is significant compared with decay heat levels for long transients.

3.2.3. Mass sources and sinks

Mass sources modelled in the input deck include the pumped ECC injection, the primary coolant pump injection, the feedwater and auxiliary feedwater systems. Each of these sources are modelled by time dependent volumes and junctions in conjunction with the trip and control systems, as described elsewhere in the present document. The charging system, although used prior to the start of each transient, is disabled during transients and is not modelled in the deck. There is no control, therefore, of the primary coolant mass inventory during steady state operation, and so the initial inventory has to be specified separately at the start of a steady state run.

Mass sinks are identified with the modelled break(s) during LOCA transients, with relief valve flows, and with the main steam and main steam bypass flow. The flow rate is determined from the upstream conditions, the valve or break area, the multiplier, using the RELAP5/MOD2 break flow model, (the downstream conditions being such that the flows are choked).

4. Conclusions

The LOFT input dataset described in this document for RELAP5/MOD2 represents the latest information available for the LOFT system, taking into account also results from analyses performed in the U.K. Modifications have been made, therefore, in accordance with analysis results.

The dataset includes representation of hardware and trip systems f… loss-of-coolant experiments and intact primary circuit transients, thereby keeping all the data in a single dataset.

5. References

1. "RELAP5/MOD2 Code Manual" NUREG/CR-4312, EGG-2396
   (December 1985) EG&G (Idaho), Inc.
2. "RELAP5/MOD2 Validation for Sizewell 'B' Application" PWR/THSG/P28 issue 2,
   (October 1988) I.L. Hirst
3. "LOFT System and Test Description (5.5-ft Nuclear Core LOCEs)" NUREG/CR-0247, TREE-1208
   (July 1978) D.L. Reeder
4. "LOFT Input Data Deck for RELAP5" EGG-LOFT-5199
   (July 1980) E.J. Kee, P.J. Schally, and L. Winters,
5. "Post test analysis of OECD LOFT experiment LP-SB-3 using RELAP5/MOD1" GD/PE-N/482,
   (February 1985) C. Harwood.
6. "RELAP5/MOD2 Calculation of OECD LOFT test LP-SB-3" GD/PE-N/535(Rev)
   (April 1986) G. Brown, and C. Harwood.
7. "RELAP5/MOD2 Calculations of OECD LOFT test LP-SB-1" GD/PE-N/544(Rev)
   (November 1986) P.C. Hall, and G. Brown.
8. "RELAP5/MOD2 Calculations of OECD LOFT test LP-SB-2" GD/PE-N/606(Rev)
   (December 1987) P.C. Hall.
9. "RELAP5/MOD2 Calculations of OECD LOFT test LP-FW-1" GD/PE-N/597
   (June 1988) M.G. Croxford, C. Harwood, and P.C. Hall.
10. "RELAP5/MOD2 Analysis of LOFT Experiment L9-4" GD/PE-N/721
    (December 1988) M.B. Keevill.
11. "Internal LOFT Reactor Vessel Core Bypass Flows" RE-A-81-011, USNRC-P394
    (November 1981) W.C. Jouse
12. "Dimensional Data - Steam Generator" Private Communication from INEL
13. "RELAP5/MOD2 analysis of LOFT Experiment L9-3" AEEW-R 2435
    (December 1988) J C Birchley

Table 1a Intact loop volume data

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
100	01	1.4458	0.06414*	0.09274	0.2858*	0.0	0.0	BRANCH	Core barrel, vessel nozzle
102	01	4.1275	0.000682	0.002815*	0.0295*	0.0	0.0	SNGLVOL	Break line, ID = 1.16 inch
104	01	0.286	0.06416*	0.01835	0.2858*	0.0	0.0	SNGLVOL	Break connection
105	01	1.0506	0.06414*	0.06739	0.2858*	0.0	0.0	BRANCH	Pipe to surge line, elbow
110	01	1.1061	0.05815*	0.064318	0.2721*	0.0	0.0	BRANCH	Pipe from surge line, venturi
112	01	1.3889	0.05378*	0.079697	0.2703*	0.0	0.0	PIPE	elbow, half of reducer
	02	0.70769	0.08190*	0.057961	0.3229*	0.246	0.246		Half of reducer
114	01	0.63	0.5122*	0.3227	0.0102	0.513	0.759	BRANCH	SG inlet plenum
115	01	0.5972	0.1513	0.09036*	0.01022	0.5972	1.3562	PIPE	SG tubes upside
	02	0.3048	0.1513	0.04611*	[illegible]	0.3048	1.6610		SG tubes upside
	03	0.6096	0.1513	0.09223*	[illegible]	0.6096	2.2706		SG tubes upside
	04	0.6096	0.1513	0.09223*	[illegible]	0.6096	2.8802		SG tubes upside
	05	0.4612	0.1513	0.06978*	0.01022	0.4612	3.3414		SG tubes U-bend
	06	0.4612	0.1513	0.06978*	0.01022	-0.4612	2.8802		SG tubes U-bend
	07	0.6096	0.1513	0.09223*	0.01022	-0.6096	2.2706		SG tubes downside
	08	0.6096	0.1513	0.09223*	0.01022	-0.6096	1.6610		SG tubes downside
	09	0.3048	0.1513	0.04611*	0.01022	-0.3048	1.3562		SG tubes downside
	10	0.5972	0.1513	0.09036*	0.01022	-0.5972	0.759		SG tubes downside
116	01	0.63	0.5318*	0.335	0.0102	-0.513	0.246	BRANCH	SG outlet plenum
118	01	0.547	0.07989*	0.0437	0.3189*	-0.498	-0.252	PIPE	52 degree elbow
	02	0.689	0.06705*	0.0462	0.2922*	-0.689	-0.941		Half of reducer
	03	0.550	0.0634	0.03544*	0.2841*	-0.356	-1.297		90 degree elbow
120	01	0.76	0.0634	0.04818*	0.2841*	0.0	-1.297	BRANCH	Pipe, inlet to pump suction

Table 1a Intact loop volume data (continued)

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
125	01	1.003	0.06112*	0.0613	0.2790*	0.521	-0.776	BRANCH	Half of pump suction, elbow
130	01	0.457	0.04136*	0.0189	0.2295*	0.457	-0.319	SNGLVOL	Half of reducer, PCP 1 inlet
135	01	2.7049*	0.0366	0.099	---	0.319	0.0	PUMP	PCP 1
140	01	0.502	0.0366	0.01837*	0.2159*	0.0	0.0	SNGLVOL	PCP 1 outlet pipe, elbow
145	01	[illegible]084	0.04494*	0.0633	0.2392*	0.0	0.0	BRANCH	Pipe, reducer, PCP outlet
150	01	0.4966	0.0634	0.03148*	0.2841*	0.0	0.0	BRANCH	Half of pump outlet
155	01	1.003	0.06111*	0.0613	0.2790*	0.521	-0.776	BRANCH	Half of pump suction, elbow
160	01	0.457	0.04136*	0.0189	0.2295*	0.457	-0.319	SNGLVOL	Half of reducer, PCP 2 inlet
165	01	2.7949*	0.0366	0.099	---	0.319	0.0	PUMP	PCP 2
170	01	0.514	0.0366	0.01881*	0.2159*	0.0	0.0	BRANCH	elbow, inlet of PCP outlet
175	01	0.559	0.0634	0.03544*	0.2841*	0.0	0.0	PIPE	90 degree elbow
	02	0.613	0.0634	0.03886*	0.2841*	0.0	0.0		Pipe section, elbow
180	01	1.01	0.06343*	0.06406	0.2842*	0.0	0.0	BRANCH	Pipe to ECC line

Table 1a Intact loop volume data (continued)

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
181	01	2.997	0.0006818	0.002043*	0.000549*	0.0	0.0	BRANCH	Break line ID=1.16 in horiz
182	01	0.806	0.0006818	0.000549*	0.000549*	-0.806	-0.806	BRANCH	Break line ID=1.16 in vertical
184	01	0.284	0.06356*	0.01805	0.2845*	0.0	0.0	SNGLVOL	Cold leg break connecting pipe
185	01	1.152	0.06379*	0.07349	0.2850*	0.0	0.0	BRANCH	Pipe from ECC line, nozzle
910	01	1.0	0.0035	0.0035*	0.00669*	0.0	0.0	TMDPVOL	PCP 1 injection volume
911	01	1.0	0.0035	0.0035*	0.00669*	0.0	0.0	TMDPVOL	PCP 2 injection volume

Table 1b Intact loop junction data

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
100	01	2520000	1000000	0.0634	000002	0.1	0.1	RPV nozzle intact loop hot leg
	02	1000100	1050000	0.06344*	000000	0.1	0.1	RPV nozzle to pressuriser tee
	03	1000000	1850100	0.06344*	000000	7200.0	7200.0	Bypass flow across nozzles
101	01	1040100	1020000	0.000682	100102	1.26	1.26	Break - junction with hot leg
103	01	1020100	8050000	0.0001266	000120	-0.93	-0.81	Break - valve ID = 0.5 inch
105	01	1050100	1100000	0.05815*	000000	0.12	0.12	Pressuriser tee hot leg side
	02	1040100	1050000	0.05815*	000000	0.0	0.0	Pressuriser tee RPV side
110	01	1100100	1120000	0.05738*	000000	0.15	0.15	Pressuriser tee SG side
112	01	1120100	1120200	0.05738*	010000	0.2	0.2	Hot leg pipe
114	01	1120100	1140000	0.0512	000100	0.0	0.0	Hot leg pipe to SG inlet plenum
	02	1140100	1150000	0.1513*	000100	0.0	0.0	SG inlet plenum to SG tubes
115	01	1150100	1150200	0.1513*	000000	0.0	0.0	
	02	1150200	1150300	0.1513*	000000	0.0	0.0	
	03	1150300	1150400	0.1513*	000000	0.0	0.0	
	04	1150400	1150500	0.1513*	000000	0.0	0.0	SG tubes
	05	1150500	1150600	0.1513*	000000	0.0	0.0	
	06	1150600	1150700	0.1513*	000000	0.0	0.0	
	07	1150700	1150800	0.1513*	000000	0.0	0.0	
	08	1150800	1150900	0.1513*	000000	0.0	0.0	
	09	1150900	1151000	0.1513*	000000	0.0	0.0	
116	01	1150100	1160000	0.1513*	000100	0.0	0.0	SG tubes to SG outlet plenum
	02	1160100	1180000	0.07989*	000100	0.0	0.0	SG outlet plenum outlet

0.0* Indicates input as 0.0 and value calculated by code.
Negative loss coefficients imply multipliers for single- and two-phase flow

Table 1b Intact loop junction data (continued)

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
118	01	1180100	1180200	0.06705*	000000	0.083	0.083	Crossover leg pipe
	02	1180200	1180300	0.0634*	000000	0.104	0.104	
120	01	1180100	1200000	0.0634*	000000	0.1	0.1	Pump suction tee inlet
	02	1200100	1250000	0.0317	000000	0.4	0.4	Pump suction outlet PCP 1 side
	03	1200100	1550000	0.0317	000000	0.4	0.4	Pump suction outlet PCP 2 side
125	01	1250100	1300000	0.04136*	000000	0.13	0.13	PCP 1 inlet pipe
135	01	1300100	1350000	0.0366*	000000	0.017	0.017	PCP 1 entry
	02	1350100	1400000	0.0366*	000000	0.05	0.05	PCP 1 exit
145	01	1400100	1450000	0.0366*	000000	0.0	0.0	PCP 1 discharge to discharge tee
	02	1450100	1500000	0.04494*	000000	0.1	0.1	PCP discharge tee PCP 1 side
150	01	1700100	1500000	0.0183	000000	0.1	0.1	PCP discharge tee PCP 2 side
	02	1500100	1750000	0.0634*	000000	0.0	0.0	PCP discharge tee outlet to ILCL
155	01	1550100	1600000	0.04136*	000000	0.13	0.13	PCP 2 inlet pipe
165	01	1600100	1650000	0.0366*	000000	0.017	0.017	PCP 2 entry
	02	1650100	1700000	0.0366*	000000	0.05	0.05	PCP 2 exit
175	01	1750100	1750200	0.0634*	000000	0.0	0.0	ILCL leg 45 degree bend
180	01	1750100	1800000	0.0634*	000000	0.0	0.0	Inlet to pump side of ECC tee
	02	1800100	1850000	0.0634*	000000	0.0	0.0	PCP side of ECC tee

0.0* Indicates input as 0.0 and value calculated by code.

Table 1b Intact loop junction data (continued)

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
181	01	1840100	1810000	0.0006818	001001	1.26	1.26	Break line connection tee
182	01	1810100	1820000	0.0006818	001000	1.26	1.26	Break line elbow connection
183	01	1820100	8350000	0.0000608	001200	-0.93	-0.81	Orifice - simulated 1.84in break
185	01	1850100	2020000	0.0634	000001	2.8	2.8	ECC tee connection to vessel
901	00	9100000	1400000	0.0035*	--	0.0	0.0	PCP 1 injection
902	00	9110000	1700000	0.0035*	--	0.0	0.0	PCP 2 injection

0.0* indicates input as 0.0 and value calculated by code.

Table 1c Intact loop heat slab data

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
60-001	CYL	11501	51501	562.36	1 - 8	Inconel	0.0051054	0.00634898
-002		11502	51502	562.36				
-003		11503	51503	1124.71				
-004		11504	51504	1124.71				
-005		11505	51505	849.063				
-006		11506	51505	849.063				
-007		11507	51504	1124.71				
-008		11508	51503	1124.71				
-009		11509	51502	562.36				
-010		11510	51501	562.36				
1001-001	CYL	10001	0	1.4458	1 - 5	S-Steel	0.142	0.178
-002		10401	0	0.2866				
-003		10501	0	1.0506				
-004		11001	0	1.06124				
-005		11201	0	1.38893				
-006		11802	0	0.68900				
-007		11803	0	0.55900				
-008		12001	0	0.76000				
-009		15001	0	0.49660				
-010		17501	0	0.55[illegible]00				
-012		17502	0	0.61300				
-012		18001	0	1.01000				
-013		18501	0	1.15200				
-014	LP-SB-3	18401	0	0.284				

Table 1c Intact loop heat slab data (continued)

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
1002-001	CYL	11202	0	0.70800	1 - 5	S-Steel	0.16250	0.20300
-002		11801	0	0.54700				
1003-001	CYL	12501	0	1.00000	1 - 5	C-Steel	0.10800	0.13650
-002		13001	0	0.45700				
-003		14001	0	0.50200				
-004		14501	0	1.40840				
-005		15001	0	1.00300				
-006		16001	0	0.45700				
-007		17001	0	0.51400				
1004-001	CYL	11401	0	0.25000	1 - 5	C-Steel	0.68580	0.77470
-002		11601	0	0.25000				

Table 2a Reactor vessel volume data

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
200	01	0.1874	0.268	0.05022*	0.172	0.1874	0.330	ANNULUS	Inlet annulus upper
202	01	0.2852	0.268	0.07643*	0.178	-0.2852	-0.1426	BRANCH	Inlet annulus middle
205	01	0.2814	0.268	0.07542*	0.172	-0.2814	-0.1426	ANNULUS	Inlet annulus lower
210	01	0.958	0.142	0.13604*	0.102	-0.958	-1.392	ANNULUS	Downcomer
	02	0.579	0.142	0.08221*	0.102	-0.579	-1.961		
	03	0.657	0.142	0.09329*	0.102	-0.657	-2.618		
	04	0.559	0.142	0.07938*	0.102	-0.559	-3.177		
	05	0.559	0.142	0.07938*	0.102	-0.559	-3.736		
	06	0.520	0.142	0.07384*	0.102	-0.520	-4.256		
215	01	0.360	0.740	0.2664*	0.97067*	-0.360	-4.616	BRANCH	Lower plenum upper
220	01	0.370	0.790	0.2923*	1.00293*	-0.370	-4.986	SNGLVOL	Lower plenum lower
223	01	1.382	0.02911	0.04023*	0.19252*	-1.382	-1.382	ANNULUS	Vessel filler gap
	02	1.236	0.02911	0.03598*	0.19252*	-1.236	-2.618		
	03	1.118	0.02911	0.03254*	0.19252*	-1.118	-3.736		
	04	1.250	0.02911	0.03639*	0.19252*	-1.250	-4.986		
225	01	0.520	0.250	0.13*	0.095	0.520	-3.736	BRANCH	Lower core support

Table 2a Reactor vessel volume data (continued)

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
230	01	0.2795	0.1705	0.04765*	0.012	0.2795	-3.4565	PIPE	Active core
	02	0.2795	0.1705	0.04765*	0.012	0.2795	-3.177		
	03	0.2795	0.1705	0.04765*	0.012	0.2795	-2.8975		
	04	0.2795	0.1705	0.04765*	0.012	0.2795	-2.618		
	05	0.2795	0.1705	0.04765*	0.012	0.2795	-2.3385		
	06	0.3775	0.1705	0.06437*	0.012	0.3775	-1.961		
235	01	0.559	0.015	0.00839*	0.003	0.559	-3.177	PIPE	Core bypass
	02	0.559	0.015	0.00839*	0.003	0.559	-2.618		
	03	0.657	0.015	0.00989*	0.003	0.657	-1.961		
240	01	0.559	0.297	0.16602*	0.145	0.559	-1.402	BRANCH	Upper end box center/support
245	01	0.559	0.297	0.16602*	0.145	0.559	-0.843	BRANCH	Upper support X-flow
250	01	0.7004	0.114	0.07985*	0.131	0.7004	-0.1426	BRANCH	Upper flow skirt vol
251	01	0.700	0.183	0.1281*	0.214	0.700	-0.1426	SNGLVOL	Dead end fuel modules
252	01	0.2852	0.201	0.05732*	0.5059*	0.2852	1426	BRANCH	Upper plenum lower
255	01	0.7114	0.288	0.20488*	0.6055*	0.7114	0.854	BRANCH	Upper plenum bottom
260	01	0.712	0.244	0.1737*	0.5574*	0.712	1.566	SNGLVOL	Upper plenum top

* Indicates input as 0.0 - value calculated by code

Table 2b Reactor vessel junction data

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
202	01	202000	2000000	0.268*	000000	0.0	0.0	Inlet [illegible]nlus upper to middle
	02	2020100	2050000	0.268*	000000	0.0	0.0	Inlet a[illegible]lus middle to lower
206	00	2050100	2100600	0.142*	000000	0.0	0.0	Inlet annulus to downcomer
210	01	2100100	2100200	0.142*	000000	0.0	0.0	
	02	2100200	2100300	0.142*	000000	0.0	0.0	
	03	2100300	2100400	0.142*	000000	0.0	0.0	Vessel downcomer
	04	2100400	2100500	0.142*	000000	0.0	0.0	
	05	2100500	2100600	0.142*	000000	0.0	0.0	
215	01	2100100	2150000	0.142*	000000	2.0	2.0	Downcomer to lower plenum
	02	2150100	2200000	8.74*	000000	0.005	0.005	Lower plenum to lower head
	03	2150000	2250000	0.15	000000	1.5	1.5	Lower plenum to lower support
222	00	1850100	2230000	0.02911*	000000	52.0	52.0	Cold leg to vessel filler gap
223		2230100	2230200	0.02911*	000000	0.0	0.0	
	0[illegible]	2230200	2230300	0.02911*	000000	0.0	0.0	vessel filler gap
	03	2230300	2230400	0.02911*	000000	0.0	0.0	
224	00	2230100	2200100	0.02911*	000000	45.0	45.0	Filler gap to lower head

* Indicates input as 0.0 and value calculated by code.

Table 2b Reactor vessel junction data (continued)

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
225	01	2250100	2300000	0.0975	000000	1.5	1.5	Core entry
	02	2250100	2350000	0.015*	000000	21.0	21.0	Core bypass entry
230	01	2300100	2300200	0.1705*	000000	0.0	0.0	
	02	2300200	2300300	0.1440*	003000	0.66	0.66	
	03	2300300	2300400	0.1705*	000000	0.0	0.0	Core
	04	2300400	2300500	0.1440*	000000	0.66	0.66	
	05	2300500	2300600	0.1705*	000000	0.0	0.0	
235	01	2350100	2350200	0.015*	000000	0.0	0.0	
	02	2350200	2350300	0.015*	000000	0.0	0.0	Core bypass
240	01	2300100	2400000	0.120	000000	1.5	1.5	Core exit
	02	2350100	2400000	0.015*	000000	21.0	21.0	Core bypass exit
245	01	2400100	2450000	0.297*	000000	0.0	0.0	Upper support structure
	02	2450100	2510000	0.183*	000000	0.0	0.0	
250	01	2450100	2500000	0.114*	000000	0.0	0.0	Upper support structure
252	01	2520100	2550000	0.201*	000000	0.006	0.006	Upper plenum lower to bottom
	01	2520600	2500100	0.114*	000000	0.003	0.003	Upper structure to upper plenum
255	01	2550100	2600300	0.244*	000000	0.03	0.03	Upper plenum bottom to top

* Indicates input as 0.0 and value calculated by code.

Table 2c Reactor vessel heat slab data

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
2000-001	CYL	20001	0	0.1874	1 - 5	S-Steel	0.5080	0.7264
-002		20201	0	0.2852				
2001-001	CYL	0	20001	0.187	1 - 5	S-Steel	0.381	0.419
-002		0	20201	0.285				
-003		0	20501	0.281				
-004		0	21001	0.958				
-005		0	21002	0.579				
-006		0	21003	0.657				
-007		0	21004	0.559				
-008		0	21005	0.559				
-009		0	21006	0.520				
2050-001	CYL	20501	22301	0.2814	1 - 5	S-Steel	0.5010	0.7264
2100-001	CYL	21001	22301	0.958	1 - 5	S-Steel	0.4700	0.7264
-002		21002	22302	0.579				
-003		21003	22302	0.657				
-004		21004	22303	0.559				
-005		21005	22303	0.559				
-006		21006	22304	0.520				
-007		21501	22304	0.360				
-008		22001	22304	0.370				
2200-001	RECT	22001	0	1.680	1 - 5	C-Steel	0.0	0.092
2231-001	CYL	22301	0	1.382	1 - 5	C-Steel	0.7328	0.8725
-002		22302	0	0.802				
2232-001	CYL	22302	0	0.434	1 - 5	C-Steel	0.7328	0.8247
-002		22303	0	1.118				
-003		22304	0	1.250				

Table 2c Reactor vessel heat slab data (continued)

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
2250-001	CYL	22501	0	0.5200	1 - 5	S-Steel	0.300	0.380
-002		23001	0	0.2795				
-003		23002	0	0.2795				
-004		23003	0	0.2795				
-005		23004	0	0.2795				
-006		23005	0	0.2795				
-007		23006	0	0.3775				
-008		24001	0	0.5590				
-009		24501	0	0.5590				
-010		25001	0	0.8430				
2251-001	CYL	22501	0	0.520	1 - 5	S-Steel	0.282	0.300
2300-001	CYL	0	23001	363.35	1 - 6	UO2	0.0	0.004647
					7	Gap	0.004647	0.004742
					8 - 10	Zircaloy	0.004742	0.005359
-002		0	23002	363.35	1 - 6	UO2	0.0	0.004647
					7	Gap	0.004647	0.004742
					8 - 10	Zircaloy	0.004742	0.005359
-003		0	23003	363.35	1 - 6	UO2	0.0	0.004647
					7	Gap	0.004647	0.004742
					8 - 10	Zircaloy	0.004742	0.005359
-004		0	23004	363.35	1 - 6	UO2	0.0	0.004647
					7	Gap	0.004647	0.004742
					8 - 10	Zircaloy	0.004742	0.005359
-005		0	23005	363.35	1 - 6	UO2	0.0	0.004647
					7	Gap	0.004647	0.004742
					8 - 10	Zircaloy	0.004742	0.005359
-006		0	23006	363.35	1 - 6	UO2	0.0	0.004647
					7	Gap	0.004647	0.004742
					8 - 10	Zircaloy	0.004742	0.005359

Table 2c Reactor vessel heat slab data (continued)

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
2400-001	CYL	24001	0	0.559	1 - 5	S-Steel	0.282	0.310
-002		24501	0	0.559				
2510-001	RECT	25001	25101	1.800	1 - 5	S-Steel	0.0	0.010
2551-001	RECT	25201	0	0.300	1 - 5	S-Steel	0.0	0.005
-002		25501	0	0.700				
-003		26001	0	1.000				
2552-001	CYL	25501	0	0.854	1 - 5	C-Steel	0.381	0.474
2601-001	CYL	26001	0	0.712	1 - 5	C-Steel	0.381	0.728
2602-001	RECT	26001	0	0.712	1 - 5	C-Steel	0.0	0.474

Table 3a Broken loop volume data

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
300	01	0.876	0.0634	0.05554*	0.2841*	0.0	0.0	BRANCH	Vessel nozzle BLHL
305	01	0.698	0.0634	0.04425*	0.2841*	0.0	0.0	BRANCH	BLHL to RABS tee
310	01	1.5001	0.0452*	0.06785	0.24[illegible]	0.0	0.0	BRANCH	BLHL contraction
315	01	0.488	0.01109*	0.00541	0.1188*	0.0	0.0	PIPE	Pipe to isolation valve
	02	1.6085	0.0483*	0.0777	0.248*	0.0	0.0		
335	01	0.7495	0.0634	0.04752*	0.2841*	0.0	0.0	BRANCH	Vessel nozzle BLCL
340	01	0.698	0.0634	0.04425*	0.2841*	0.0	0.0	BRANCH	BLCL to RABS tee
345	01	0.974	0.0634	0.06175*	0.2841*	0.0	0.0	BRANCH	BLCL contraction
350	01	0.0488	0.01109*	0.00541	0.3758*	0.0	0.0	PIPE	Pipe to isolation valve
	02	1.6085	0.0483*	0.0777	0.2480*	0.0	0.0		
370	01	0.7190*	0.0388	0.0279	0.2223*	0.64	0.64	PIPE	RABS - BLCL side
	02	1.8041*	0.0388	0.0700	0.2223*	0.0	0.64		
	03	1.5013*	0.0776	0.1165	0.3143*	0.0	0.64		
380	01	1.1791*	0.0776	0.0915	0.3143*	0.0	0.64	PIPE	RABS - BLHL side
	02	1.2371*	0.0388	0.0480	0.2223*	-0.64	0.0		
	03	1.2603*	0.0388	0.0489	0.2223*	0.0	0.0		

* Indicates input as 0.0 - value calculated by code

Table 3b Broken loop junction data

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
300	01	2520100	3000000	0.0634	000002	0.0	0.0	Broken loop hot leg nozzle
	02	3000100	3050000	0.0634*	000000	0.1	0.1	BLHL nozzle connection to pipe
305	01	3050100	3100000	0.04523*	000000	0.1	0.1	BLHL connection to RABS tee
310	01	3800100	3100000	0.0388	000001	0.84	0.84	RABL tee to RABL pipe - HL side
	02	3100100	3150000	0.008365	000100	0.0	0.0	RABL tee to BLHL contraction
315	01	3150100	3150200	0.01109	000100	0.0	0.0	BLHL contraction junction - HL
335	01	2020100	3350000	0.0634	000002	1.0	1.0	Broken loop cold leg nozzle
	02	3350100	3400000	0.0634*	000000	0.1	0.1	BLCL nozzle connection to pipe
340	01	3400100	3450000	0.0634*	000000	0.1	0.1	BLCL connection to RABL tee
345	01	3450000	3700000	0.0388	010000	0.84	0.84	RABL tee to RABL pipe - CL side
350	01	3500100	3500200	0.01109	000100	0.0	0.0	BLCL contraction junction - CL
370	01	3700100	3700200	0.0388	000000	0.28	0.28	RABL pipe junction - CL side
	02	3700200	3700300	0.0388	000000	0.84	0.84	
375	01	3700100	3800000	0.0776*	003000	14000.0	14000.0	RABL valve
380	01	3800100	3800200	0.0388	000000	0.84	0.84	RABS pipe junction - CL side
	02	3800200	3800300	0.0388	000000	0.28	0.28	

* Indicates input as 0.0 and value calculated by code.

Table 3c Broken loop heat slab data

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
3000-001	CYL	30001	0	0.876	1 - 5	S-Steel	0.142	0.178
-002		30501	0	0.698				
-003		31001	0	1.424				
3151-001	CYL	31501	0	0.488	1 - 5	S-Steel	0.055	0.178
3152-001	CYL	31502	0	1.6085	1 - 5	S-Steel	0.0865	0.1095
3350-001	CYL	33501	0	0.7495	1 - 5	S-Steel	0.142	0.178
-002		33502	0	0.6980	1 - 5	S-Steel		
-003		33503	0	0.9740	1 - 5	S-Steel		
3501-001	CYL	35001	0	0.488	1 - 5	S-Steel	0.055	0.178
3502-001	CYL	35002	0	1.6085	1 - 5	S-Steel	0.0865	0.1095
3700-001	CYL	37001	0	0.7251	1 - 5	S-Steel	0.111	0.1365
-002		37002	0	1.8200				
-003		37003	0	2.9055				
-004		38001	0	2.2898				
-005		38002	0	1.2331				
-006		38003	0	1.1065				

Table 3d Broken loop volume data (for tests using SG and pump simulators)

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
[illegible]	01	0.367768	0.00836*	0.0030767	0.1032*	0.127	0.127	PIPE	Line to SG simulator
	02	0.552201	0.00847*	0.0046762	0.1038*	0.552201	0.679201		Line to SG simulator
	03	0.993378	0.08663*	0.0860554	0.3321*	0.993978	1.673179		SG simulator upside
	04	0.993378	0.08663*	0.0860554	0.124	0.993978	2.667157		SG simulator upside
	05	0.849744	0.10563*	0.0897552	0.3667*	0.457202	3.124359		SG simulator top
	06	0.849744	0.10563*	0.0897552	0.3667*	-0.457202	2.667157		SG simulator top
	07	0.993378	0.08663*	0.0860554	0.124	-0.993978	1.673179		SG simulator downside
	08	0.993378	0.08663*	0.0860554	0.3321*	-0.993978	0.679201		SG simulator downside
	09	1.37135	0.01329*	0.0182303	0.1301*	-1.37135	-0.692149		Pump suction downside
	10	1.365029	0.04005*	0.0546687	0.2258*	-0.520701	-1.21285		Pump suction bottom
	11	1.674812	0.01090*	0.0182489	0.1178*	1.212851	0.0		Pump suction upside
	12	0.545209	0.05195*	0.0283241	0.2572*	0.0	0.0		Pump simulator

* Indicates input as 0.0 - value calculated by code

Table 3e Broken loop junction data (for test using SG and pump simulators)

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
315	01	3150100	3150200	0.008365	000000	0.2	0.2	
	02	3150200	3150300	0.008365	000100	0.0	0.0	
	03	3150300	3150400	0.032603	000000	93.9	93.9	
	04	3150400	3150500	0.032603	000000	93.9	93.9	
	05	3150500	3150600	0.105626	000000	0.4	0.4	
	06	3150600	3150700	0.032603	000000	93.9	93.9	
	07	3150700	3150800	0.032603	000000	93.9	93.9	
	08	3150800	3150900	0.008365	000100	0.0	0.0	
	09	3150900	3151000	0.008365	000000	0.2	0.2	
	10	3151000	3151100	0.008365	000000	4.1	4.1	
	11	3151100	3151200	0.004640	000100	0.4	0.4	

* Indicates input as 0.0 and value calculated by code.

Table 3f Broken loop heat slab data (for tests using SG and pump simulators)

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
3151-001	CYL	31501	0	0.3678	1 - 5	S-Steel	0.055	0.178
-002		31502	0	0.5522				
-003		31503	0	0.9940				
-004		31504	0	0.9940				
-005		31505	0	0.8497				
-006		31506	0	0.8497				
-007		31507	0	0.9940				
-008		31508	0	0.9940				
-009		31509	0	1.3714				
-010		31510	0	1.3650				
-011		31511	0	1.6748				
-012		31512	0	0.5452				

Table 4a Pressuriser volume data

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
400	01	2.300	0.00145	0.00334*	0.04297*	0.540	0.540	SNGLVOL	Pzr surge line - PCS side
405	01	2.300	0.0145	0.00334*	0.04297*	0.300	0.840	PIPE	Pressuriser surge line
	02	2.300	0.0145	0.00334*	0.04297*	0.300	1.140		
415	01	0.1815	0.3769*	0.0684	0.6927*	0.1815	1.3215	PIPE	Pressuriser vessel
	02	0.1524	0.5499*	0.0838	0.8367*	0.1524	1.4739		
	03	0.3967	0.5653	0.2243*	0.8484*	0.3967	1.8706		
	04	0.5289	0.5653	0.2990*	0.8484*	0.5289	2.3995		
	05	0.3967	0.5653	0.2243*	0.8484*	0.3967	2.7962		
	06	0.1943	0.3767*	0.0732	0.6926*	0.1943	2.9905		
	07	0.1029	0.1380*	0.0142	0.4192*	0.1029	3.0934		
420	01	0.1029	0.1380*	0.0142	0.4192*	0.1029	3.1963	BRANCH	Pressuriser top
430	01	1.0	1.0	1.0*	1.1284*	0.0	3.0934	TMDPVOL	Dummy volume
440	01	6.322	0.000336	0.00213*	0.0207*	3.0934	3.0934	BRANCH	Pressuriser spray
805	01	1.0	0.1*	0.1	0.3568*	0.0	3.1963	TMDPVOL	Containment from SRV
810	01	1.0	0.1*	0.1	0.3568*	0.0	3.1963	TMDPVOL	Containment from PORV

* Indicates input as 0.0 - value calculated by code

Table 4b Pressuriser junction data

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
401	00	1100030	4000000	0.00145*	110002	0.93	0.93	ILHL to surge line connection
402	00	4000100	4050000	0.00145*	000000	0.93	0.93	Surge line pipe junction
405	01	4050100	4050200	0.00145	000000	0.0	0.0	Surge line pipe junction
410	00	4050100	4150000	0.00145*	000000	0.93	0.93	Surge line connection to pzr
415	01	4150100	4150200	0.3769*	000000	0.0	0.0	Pressuriser vessel junction
	02	4150200	4150300	0.5499*	000000	0.0	0.0	Pressuriser vessel junction
	03	4150300	4150400	0.5653*	000000	0.0	0.0	Pressuriser vessel junction
	04	4150400	4150500	0.5653*	000000	0.0	0.0	Pressuriser vessel junction
	05	4150500	4150600	0.3767*	000000	0.0	0.0	Pressuriser vessel junction
	06	4150700	4150700	0.1380*	000000	0.0	0.0	Pressuriser vessel junction
420	01	4150100	4200000	0.1380*	000000	0.0	0.0	Pzr vessel to top connection
431	00	4300000	4230000	0.1380*	000000	0.0	0.0	Dummy volume to pressuriser
440	01	1500000	4400000	0.0003363	000000	0.0	0.0	ILCL connection to spray line
445	00	4400100	4150100	0.0003345	000000	0.0	0.0	Pressuriser spray valve
450	00	4200100	8050000	0.0000156	000100	0.0	0.0	Safety relief valve
455	00	4200100	8100000	0.0000134	000100	0.0	0.0	Pilot operated relief valve

* Indicates input as 0.0 and value calculated by code.

Table 4c Pressuriser heat slab data

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
4152-001	CYL	41501	0	0.1815	1 - 5	C-Steel	0.42291	0.49911
-002		41502	0	0.1524				
-003		41503	0	0.3967				
-004		41504	0	0.5289				
-005		41505	0	0.3967				
-006		41506	0	0.1943				
4153-001	CYL	41507	0	0.1029	1 - 5	C-Steel	0.2032	0.3683
-002		42001	0	0.1029				
4201-001	RECT	42001	0	0.130	1 - 5	C-Steel	0.0	0.18415

Table 5a *Steam generator secondary volume data*

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
500	01	0.4445	0.3063	0.1362*	0.6245*	0.444	5.1469	SEPARATR	Primary separator
502	01	0.4445	2.212	0.9832*	1.6782*	0.444	5.1469	SNGLVOL	Separator bypass
505	01	1.2131	1.2241*	1.4850	1.9048	-1.2131	3.4898	BRANCH	Separator liquid outlet volume
508	01	0.6096	0.3626*	0.22107	0.16397	-0.6096	2.8802	BRANCH	Feed inlet, upper downcomer
510	01	0.6096	0.2970	0.1811*	0.10793	-0.6096	2.2706	ANNULUS	Steam generator downcomer
	02	0.6096	0.2970	0.1811*	0.10793	-0.6096	1.6610		
	03	0.6096	0.2970	0.1811*	0.10793	-0.6096	1.0514		
515	01	0.9144	0.2580	0.2359*	0.0234	0.3048	1.3562	PIPE	Steam generator boiler
	02	0.9144	0.2580	0.2359*	0.0234	0.3048	1.6610		
	03	1.8288	0.2580	0.4718*	0.0234	0.6096	2.2706		
	04	1.8288	0.2580	0.4718*	0.0234	0.6096	2.8802		
	05	1.8288	0.2580	0.4718*	0.0234	0.6096	3.4898		
	06	1.2131	0.306294	0.3716*	0.5962	1.2131	4.7029		
520	01	0.7180	0.27871	0.2001*	1.0827	0.718	5.8649	BRANCH	Lower part of steam dome
525	01	0.7620	1.5886	1.2105*	0.64417	0.762	6.5269	BRANCH	Upper part of steam dome
530	01	25.074	0.04635	1.1622*	0.2429*	0.0	6.5269	SNGLVOL	Steam line to MSCV
541	01	54.44	0.06557	3.5696*	0.2889*	0.0	6.5269	BRANCH	Steam line downstream of MSCV
542	01	17.67	0.21677	3.8303*	0.02	0.0	6.5269	TMDPVOL	Air cooled condenser
546	01	17.67	0.21677	3.8303*	0.02	0.0	6.5269	TMDPVOL	Steam bypass line
565	01	3.048	29.810	90.8609*	6.1608*	0.0	3.4898	TMDPVOL	Feedwater tank
568	01	3.048	29.810	90.8609*	6.6108*	0.0	3.4898	TMDPVOL	Auxiliary feedwater tank

Table 5b Steam generator secondary junction data

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag efvcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
500	01	5000100	5200000	0.3063	001000	0.37	0.37	Separator steam offtake
	02	5000000	5050000	0.14024	001000	0.0	0.0	Separator liquid drain
	03	5150100	5000000	0.29187	001000	4.404	4.304	Separator entry from riser
505	01	5050100	5080000	0.3626*	000100	0.0	0.0	Liquid drain to downcomer
	02	5050000	5020000	1.2241*	000100	0.0	0.0	Connection to separator bypass
508	01	5080100	5100000	0.297*	000100	0.0	0.0	Entry to downcomer
510	01	5100100	5100200	0.297	000000	0.0	0.0	Downcomer pipe junction
	02	5100200	5100300	0.297	000000	0.0	0.0	
513	00	5100100	5150000	0.258	000100	17.5	17.5	Downcomer to riser
515	01	5150100	5150200	0.258	000100	2.0	2.0	Steam generator riser junction
	02	5150200	5150300	0.258	000100	2.0	2.0	
	03	5150300	5150400	0.258	000100	4.05	4.05	
	04	5150400	5150500	0.258	000100	4.05	4.05	
	05	5150500	5150600	0.258	000100	4.05	4.05	
520	01	5200100	5250000	0.2787*	000100	0.0	0.0	Steam dome lower to upper
	02	5020100	5200000	0.2787*	000100	0.0	0.0	Separator bypass to steam dome
525	01	5250100	5300000	0.0464*	000100	0.8	0.8	Steam exit to steam line
540	00	5300100	5410000	0.003370	000110	0.0	0.0	Main steam control valve
541	01	5410100	5420000	0.06557*	000100	0.0	0.0	Steam line outlet to condenser
545	00	5300100	5460000	0.00032	000110	0.0	0.0	Steam bypass valve
566	00	5650000	5080000	0.05	-	0.0	0.0	Feedwater inlet flow
569	00	5680000	5080000	0.05	-	0.0	0.0	Auxiliary feedwater inlet flow

Table 5c Steam generator secondary heat slab data

Heat Structure Number	Geometry Type	Left Boundary Volume	Right Boundary Volume	Area/Length /Factor (m2/m/m0)	Interval Number	Material	Left Boundary (m)	Right Boundary (m)
5000-001	CYL	50201	50001	0.85127 L	1 - 4	C-Steel	0.3048	0.3143
				0.8778 R				
-002		51506	50501	2.51199 L				
				2.59028 R				
5100-001	CYL	51505	50801	0.64635	1 - 4	C-Steel	0.6445	0.6572
-002		51504	51001	2.46858 L				
				2.51723 R				
-003		51503	51002	2.46858 L				
				2.51723 R				
-004		51502	51003	1.23429 L				
				1.2[illegible]362 R				
-005		51501	51003	1.23429 L				
				1.25862 R				
5250-001	CYL	52501	0	0.76238	1 - 5	C-Steel	0.7112	0.76397
-002		52001	0	0.7520				
-003		50001	0	0.4445				
-004		50501	0	1.2131				
-005		50801	0	0.6096				
-006		51001	0	0.6096				
-007		51002	0	0.6096				
-008		51003	0	0.6096				

Table 6a ECC Systems volume data

Comp Num	Vol Num	Length (m)	Area (m2)	Volume (m3)	Hyd Diam (m)	Elev Change (m)	Elev Outlet (m)	Comp Type	Description
605	01	5.0148	0.00599	0.03003*	0.0873*	3.307	0.0	SNGLVOL	ECCS header
615	01	25.9972	0.01567*	0.4075	0.1413*	0.0	-3.307	SNGLVOL	Accumulator pipe
620	01	3.0393	1.2485*	3.7946	1.2608*	3.0393	0.1803	ACCUM	Accumulator tank
		3.3226	0.01864	0.06193	0.281*	0.448	-2.859		Accumulator standpipe and line
625	01	5.0	20.44	102.2*	5.1015*	5.0	-3.307	TMDPVOL	Borated water storage tank LPI

* Indicates input as 0.0 and value calculated by code.

Table 6b ECC Systems junction data

Comp Num	Jun Num	Volume number From	Volume number To	Area (m2)	Junction Flag evcahs	Loss coefficient Forward	Loss coefficient Reverse	Description
600	00	6050100	1850000	0.00599*	001110	0.935	0.935	ECCS control valve
610	00	6150100	6050000	0.00599*	001000	6.278	6.278	Accumulator valve
630	00	6250000	6050000	0.00599*	000000	0.0	0.0	LPIS junction from BWST
640	00	6250000	6050000	0.00599*	000000	0.0	0.0	HPIS junction from BWST

0.0* Indicates input as 0.0 and value calculated by code.

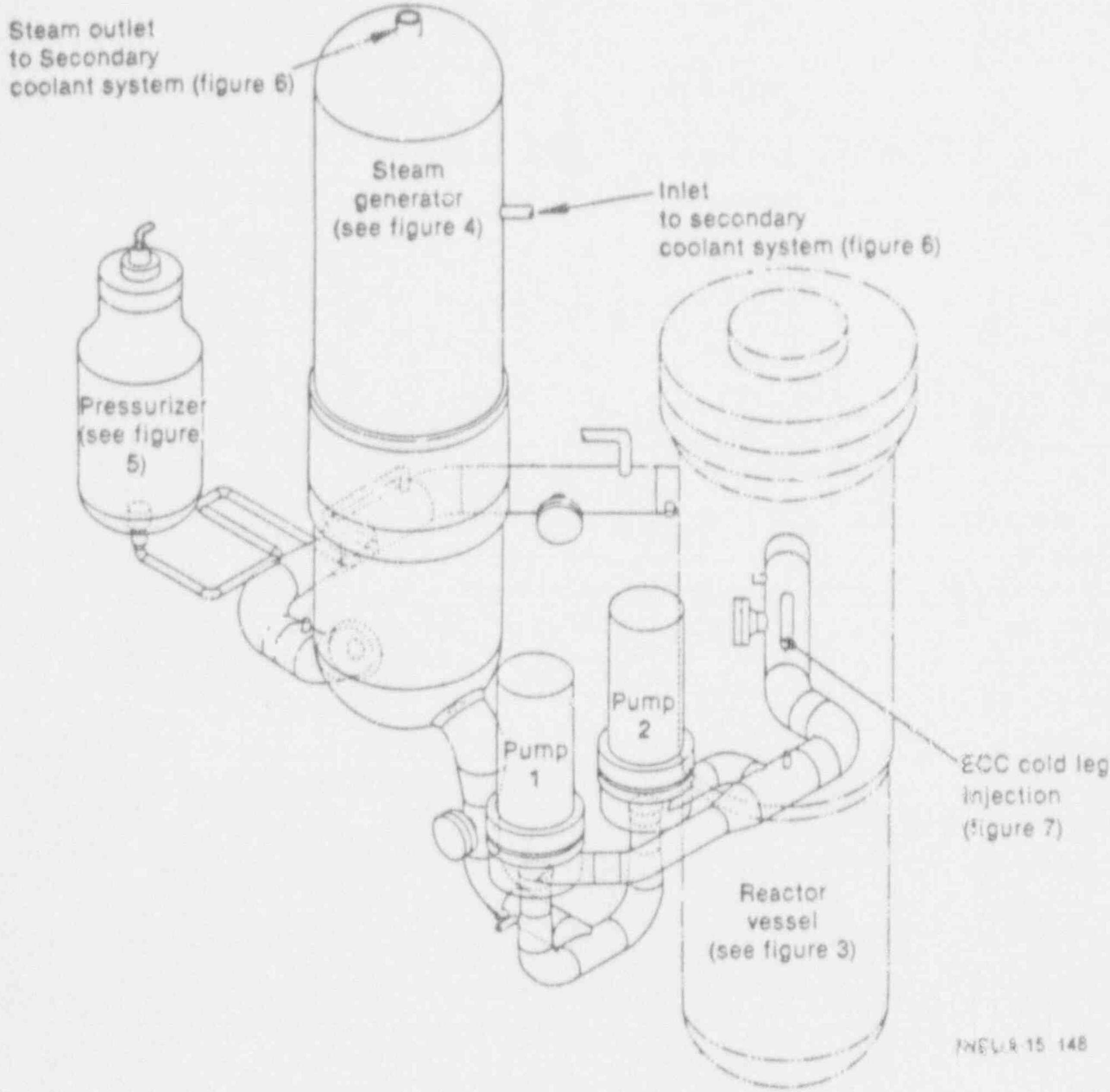
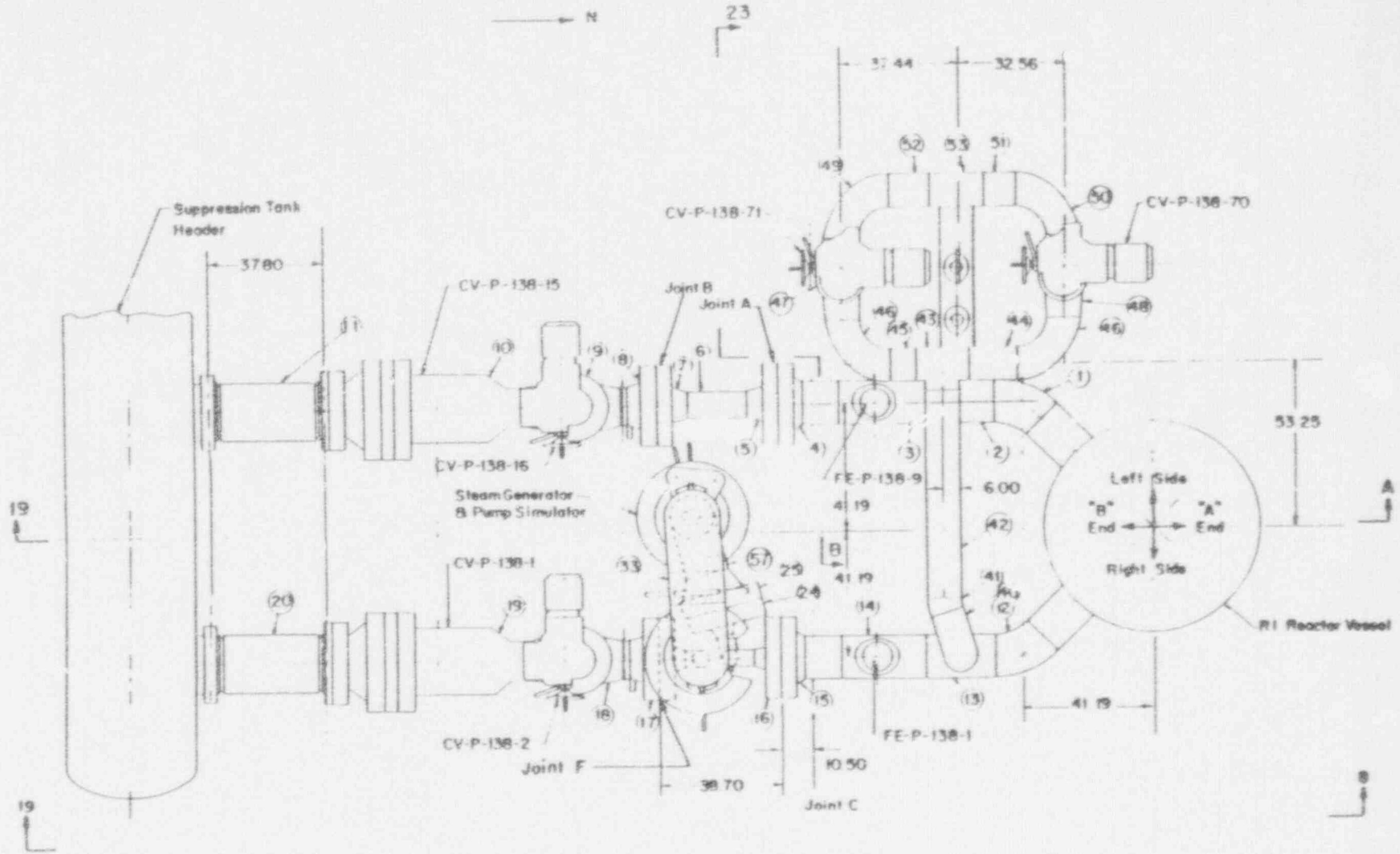


Figure 1. LOFT System--intact loop.



PLAN 14-A

Figure 2: LOFT System - Broken Loop

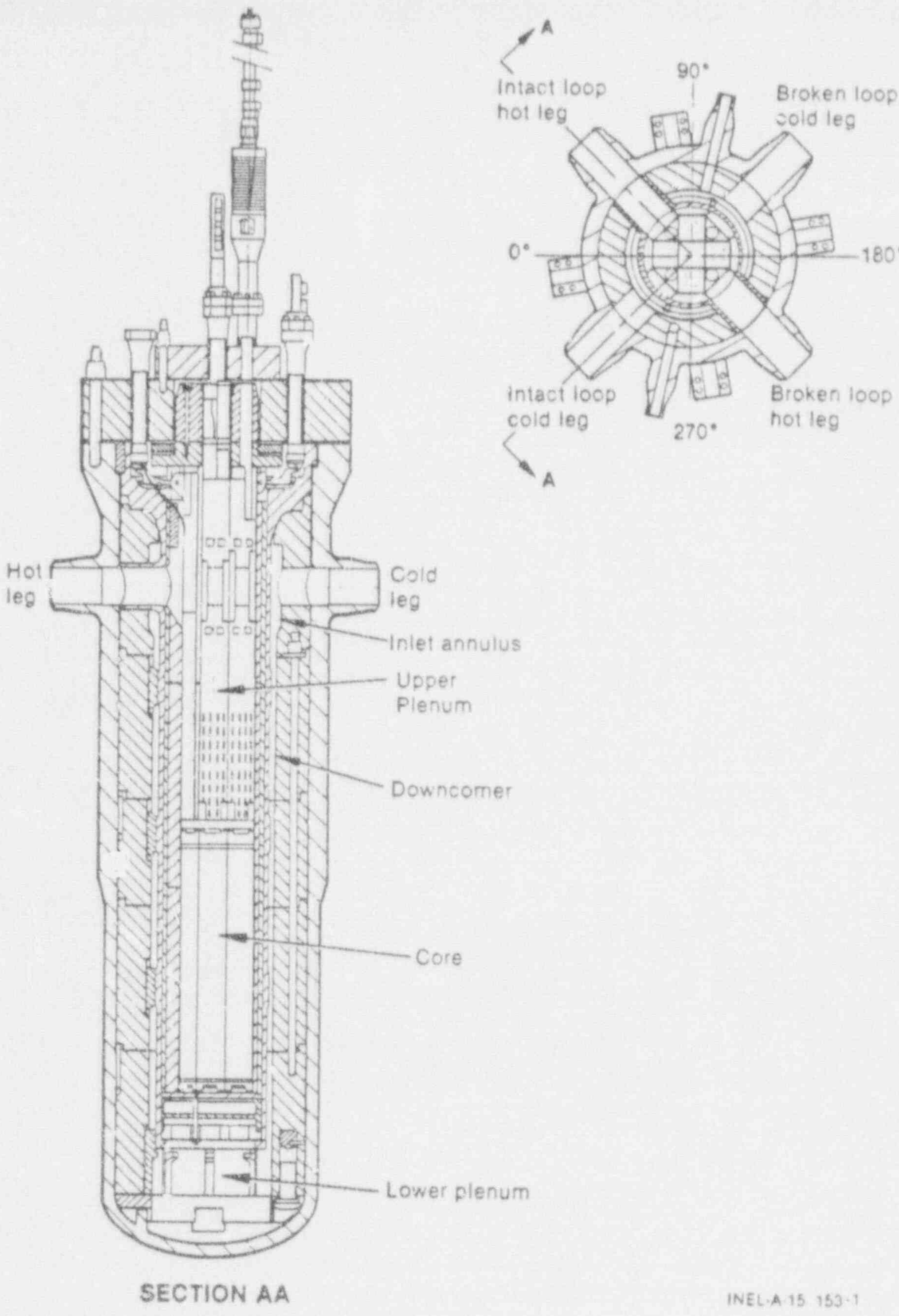


Figure 3. LOFT System--reactor vessel.

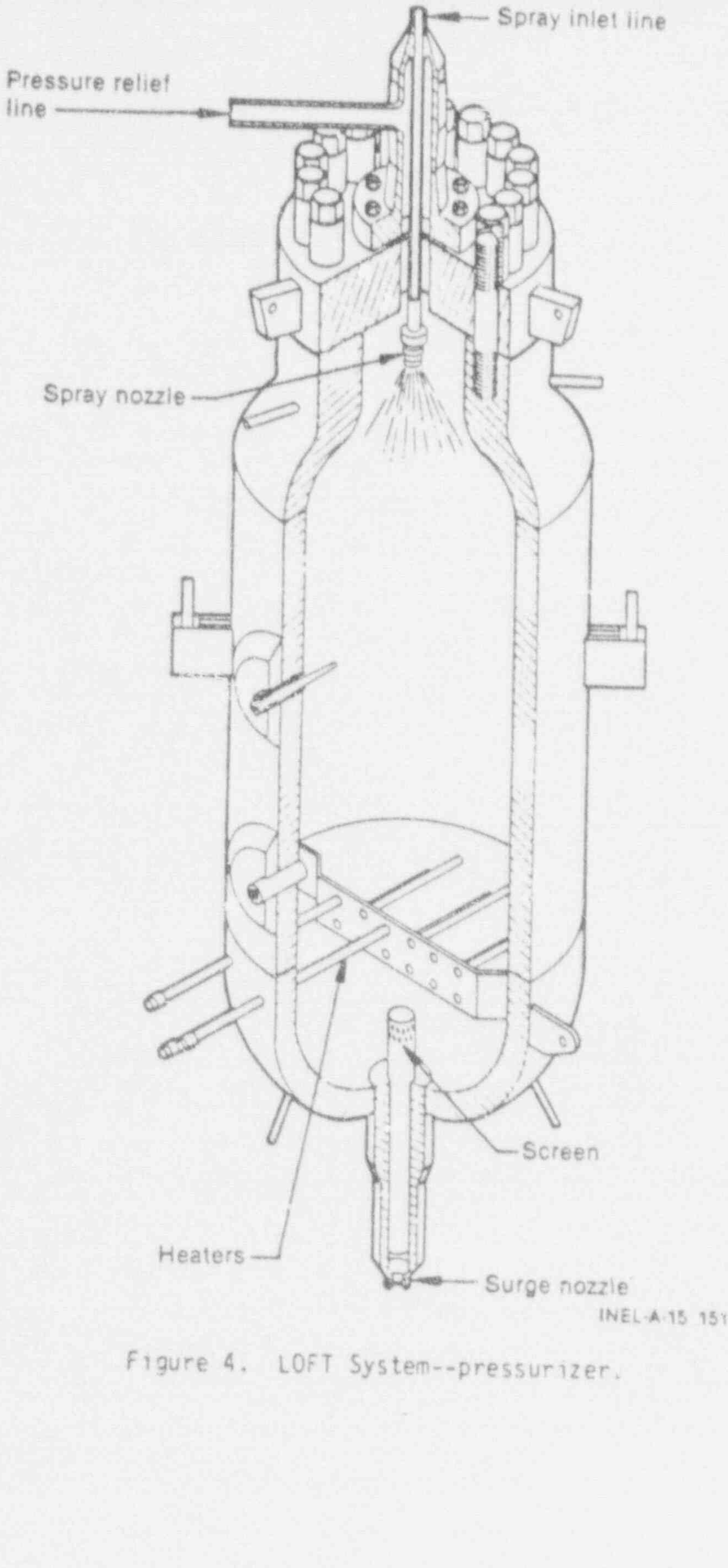


Figure 4. LOFT System--pressurizer.

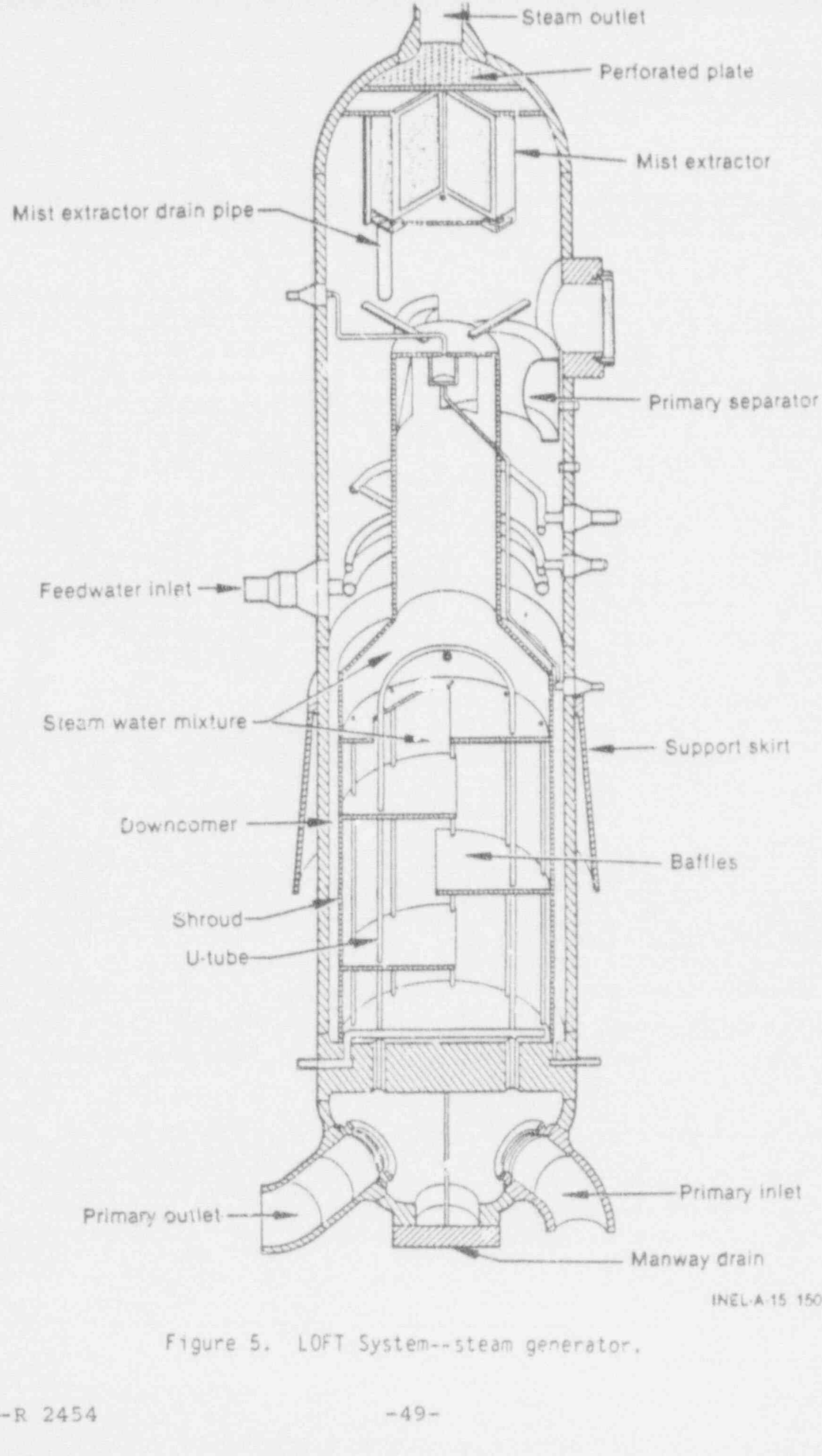


Figure 5. LOFT System--steam generator.

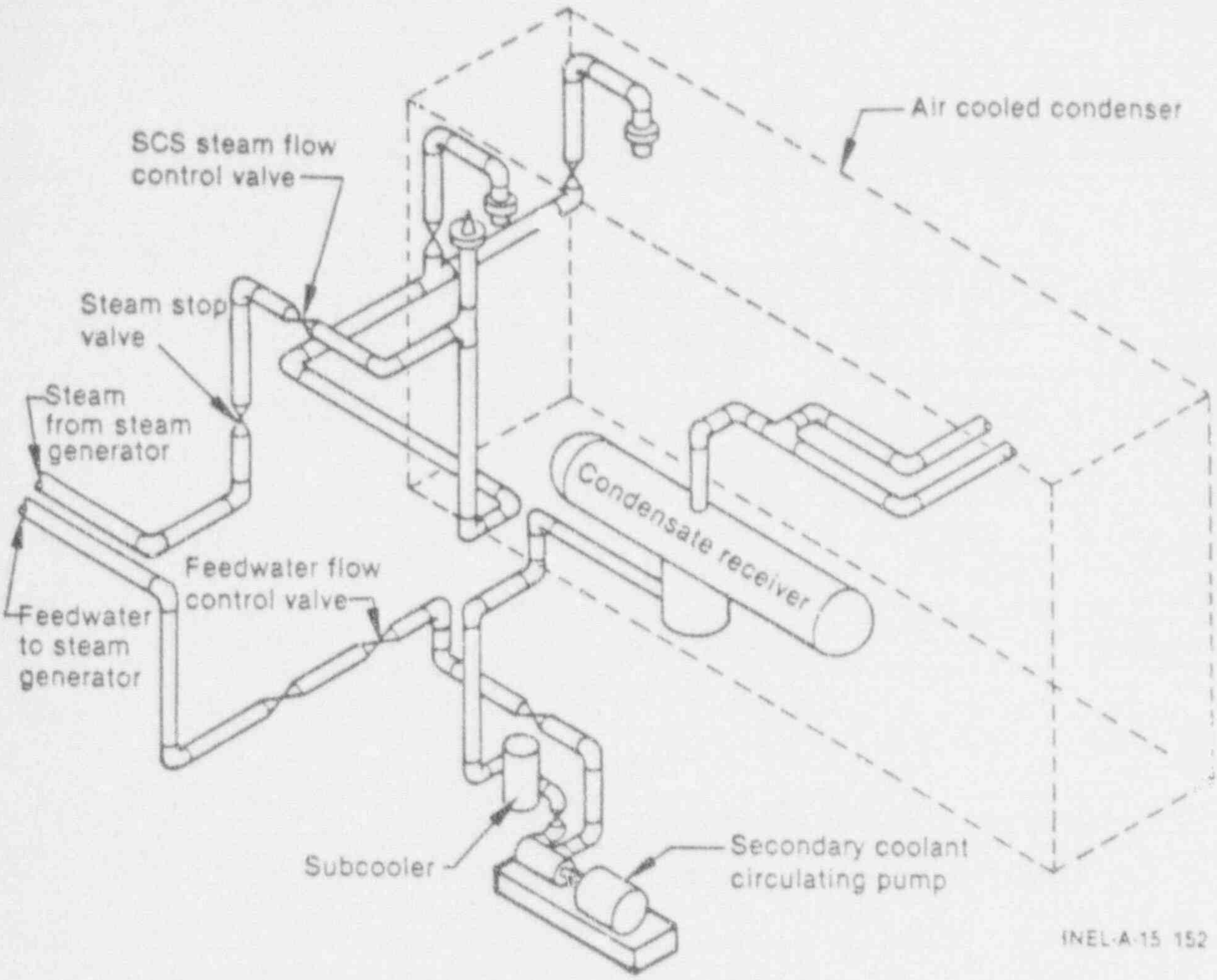


Figure 6. LOFT System--secondary side.

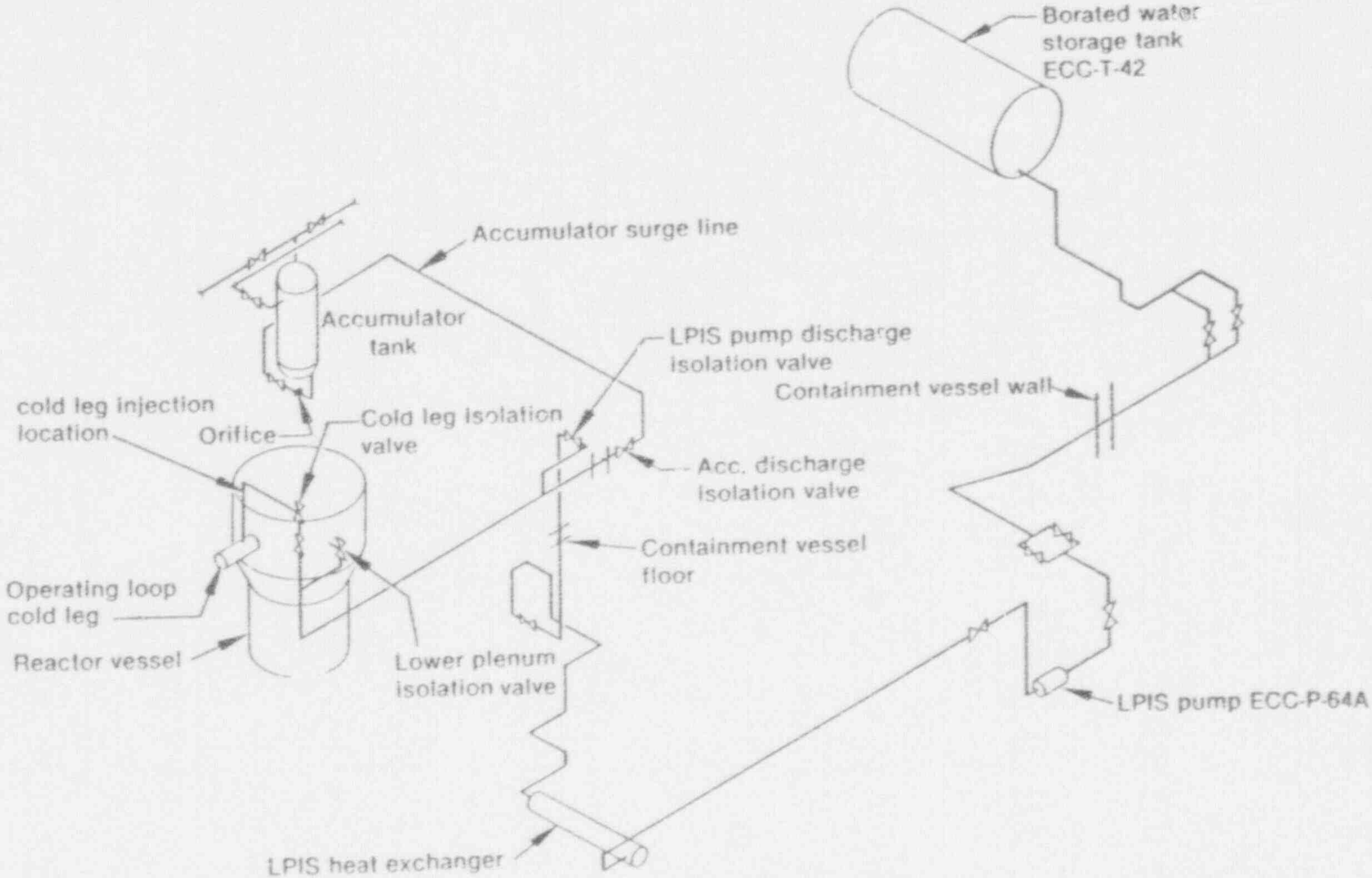


Figure 7. LOFT System--ECC.

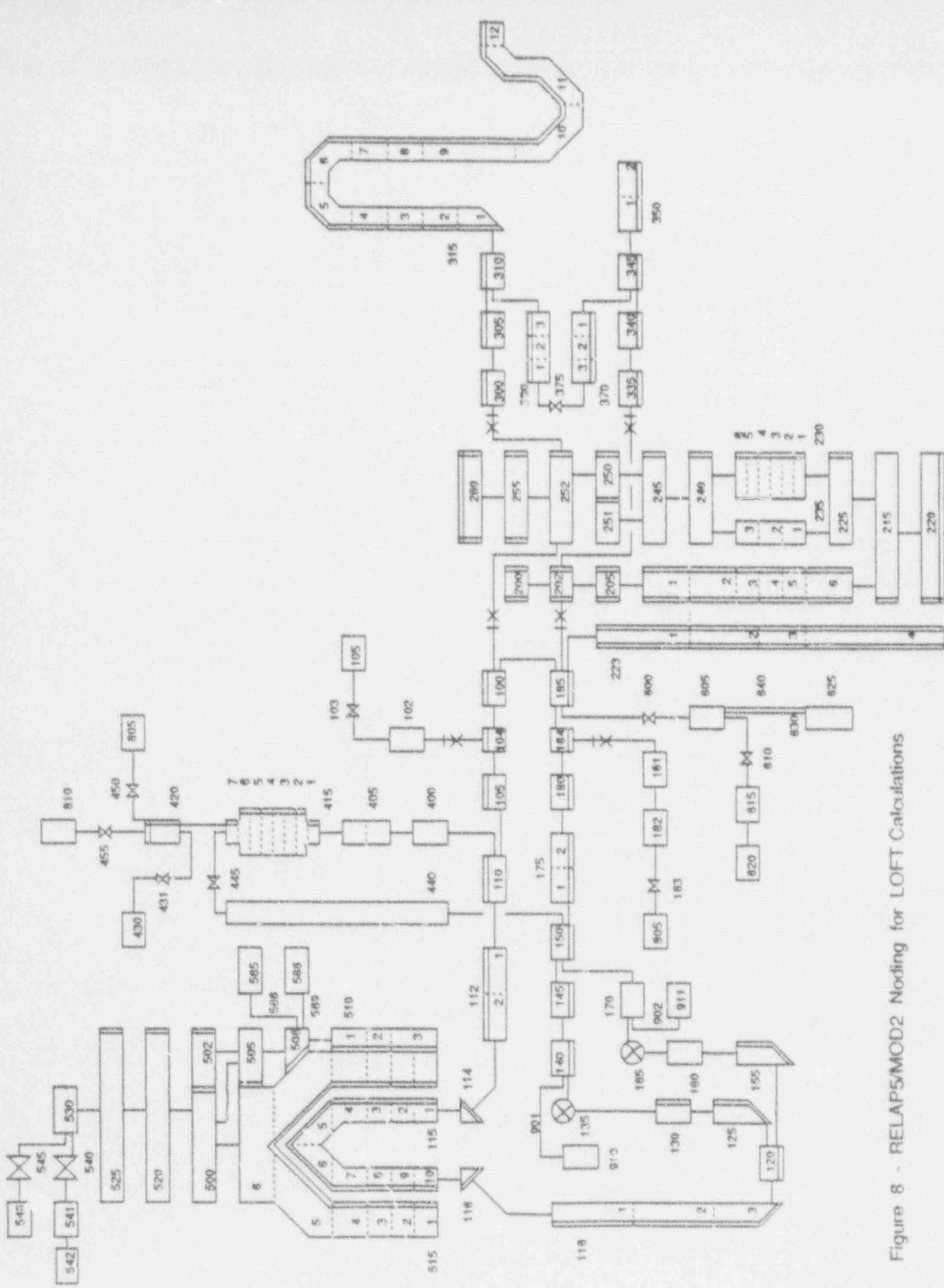


Figure 8 - RELAP5/MOD2 Noding for LOFT Calculations

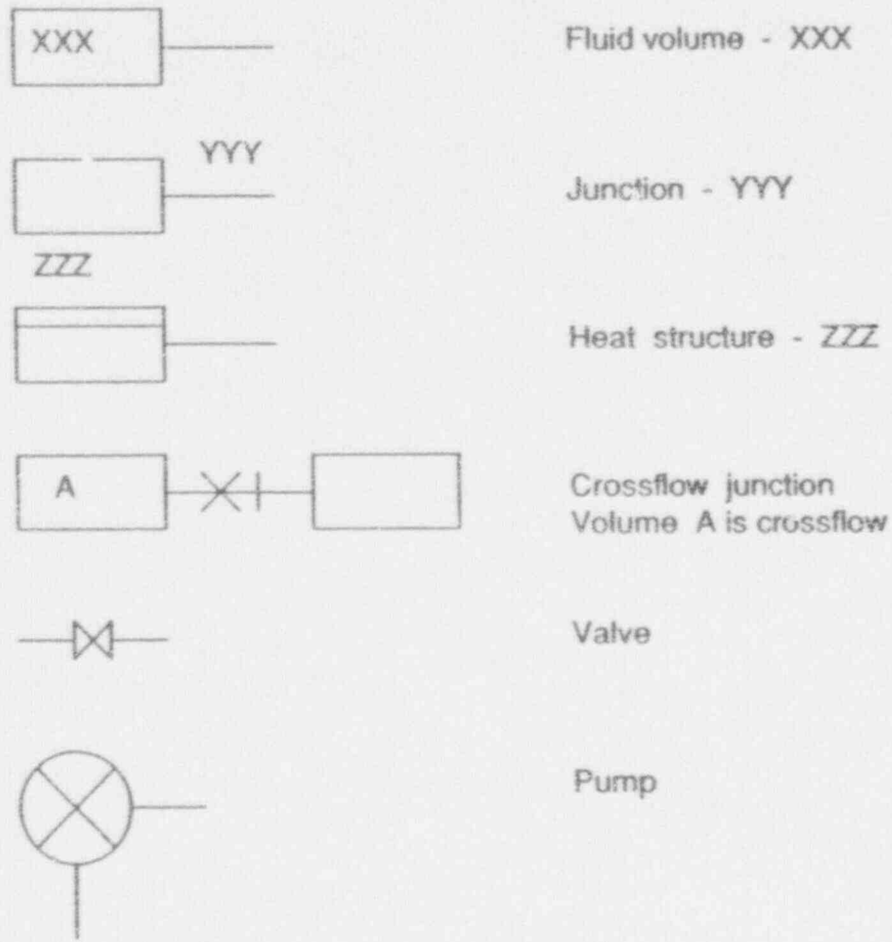


Figure 9 - Key to noding symbols

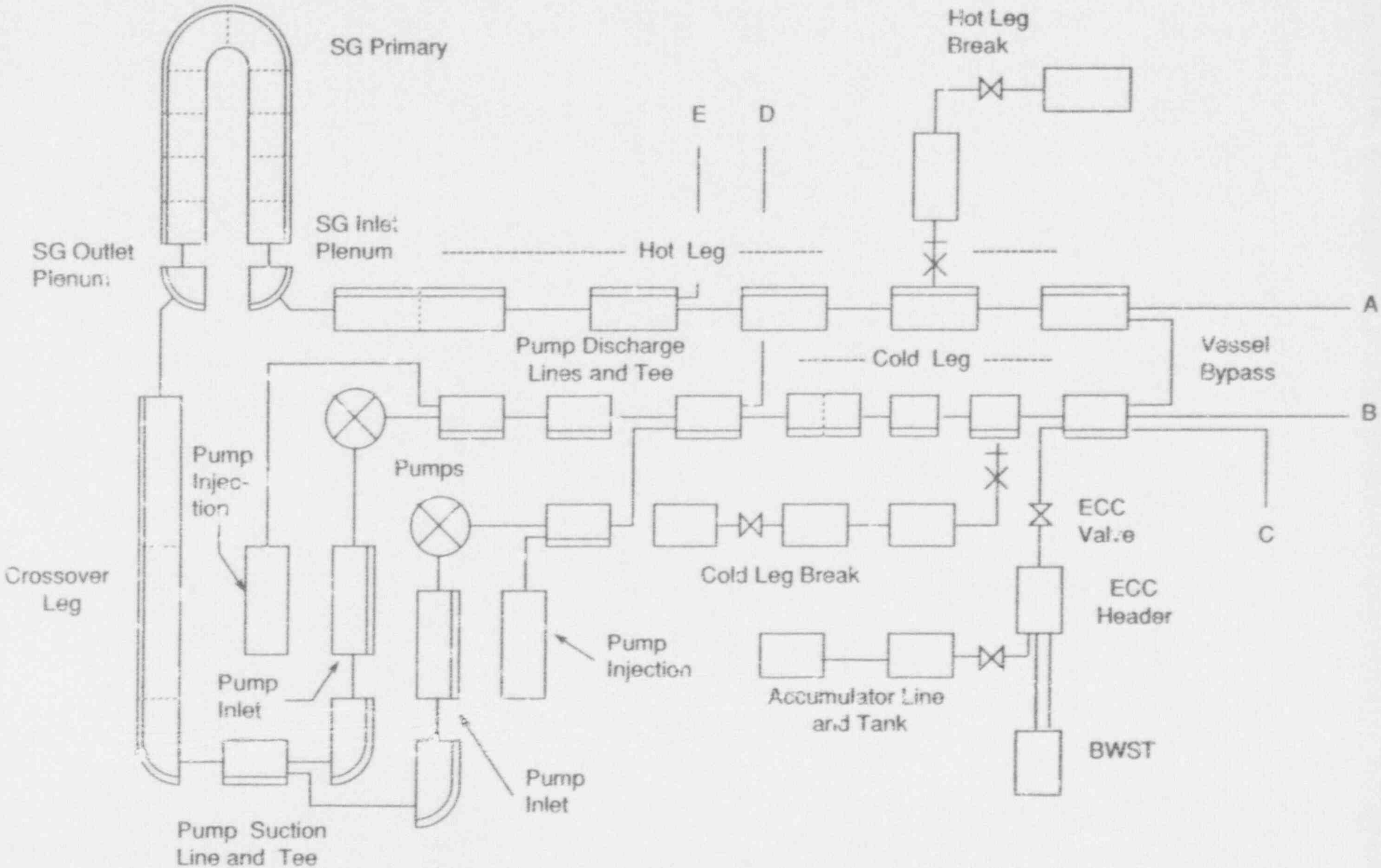


Figure 10 a Intact loop - description of components

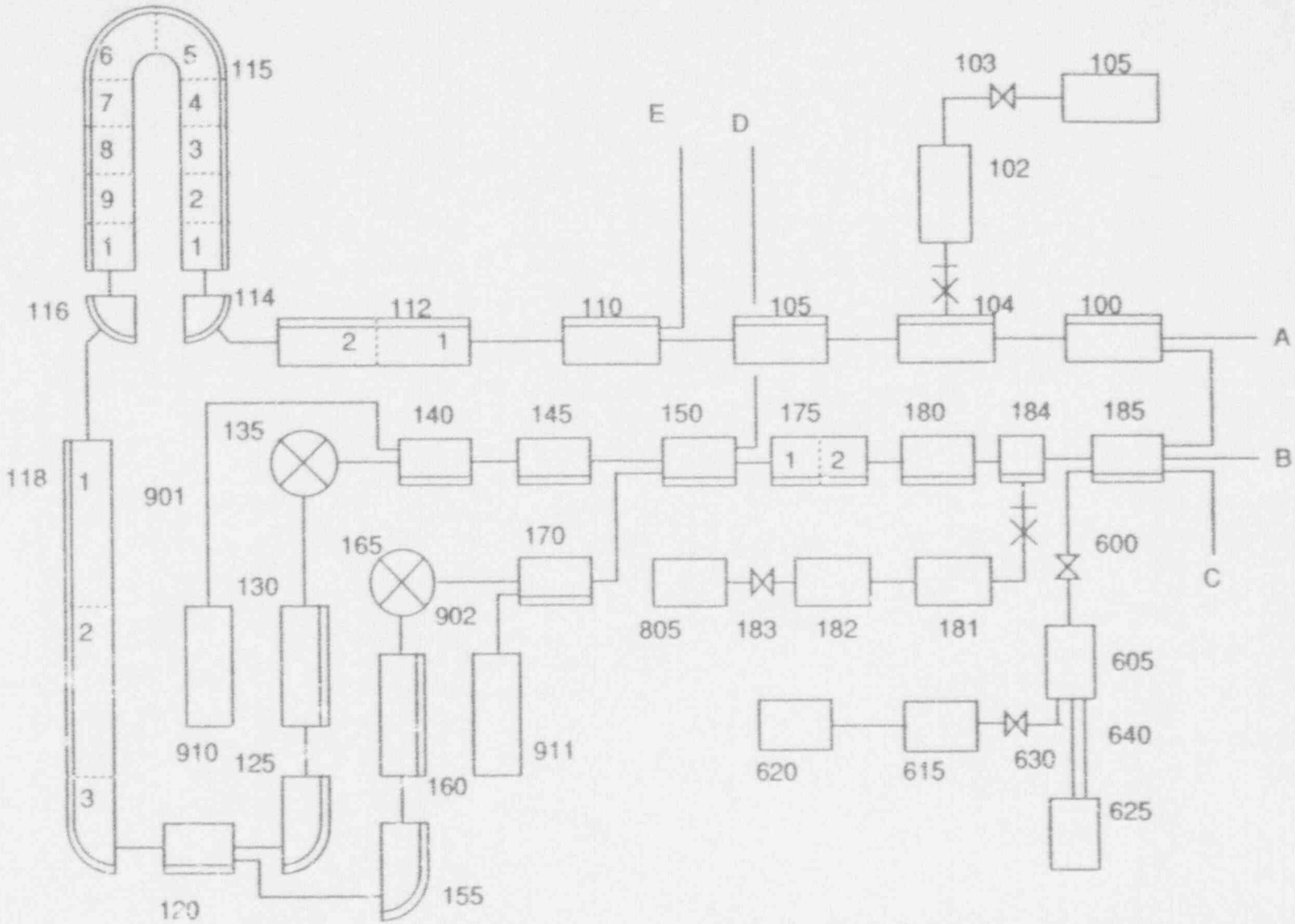


Figure 10 b Intact loop - noding of components

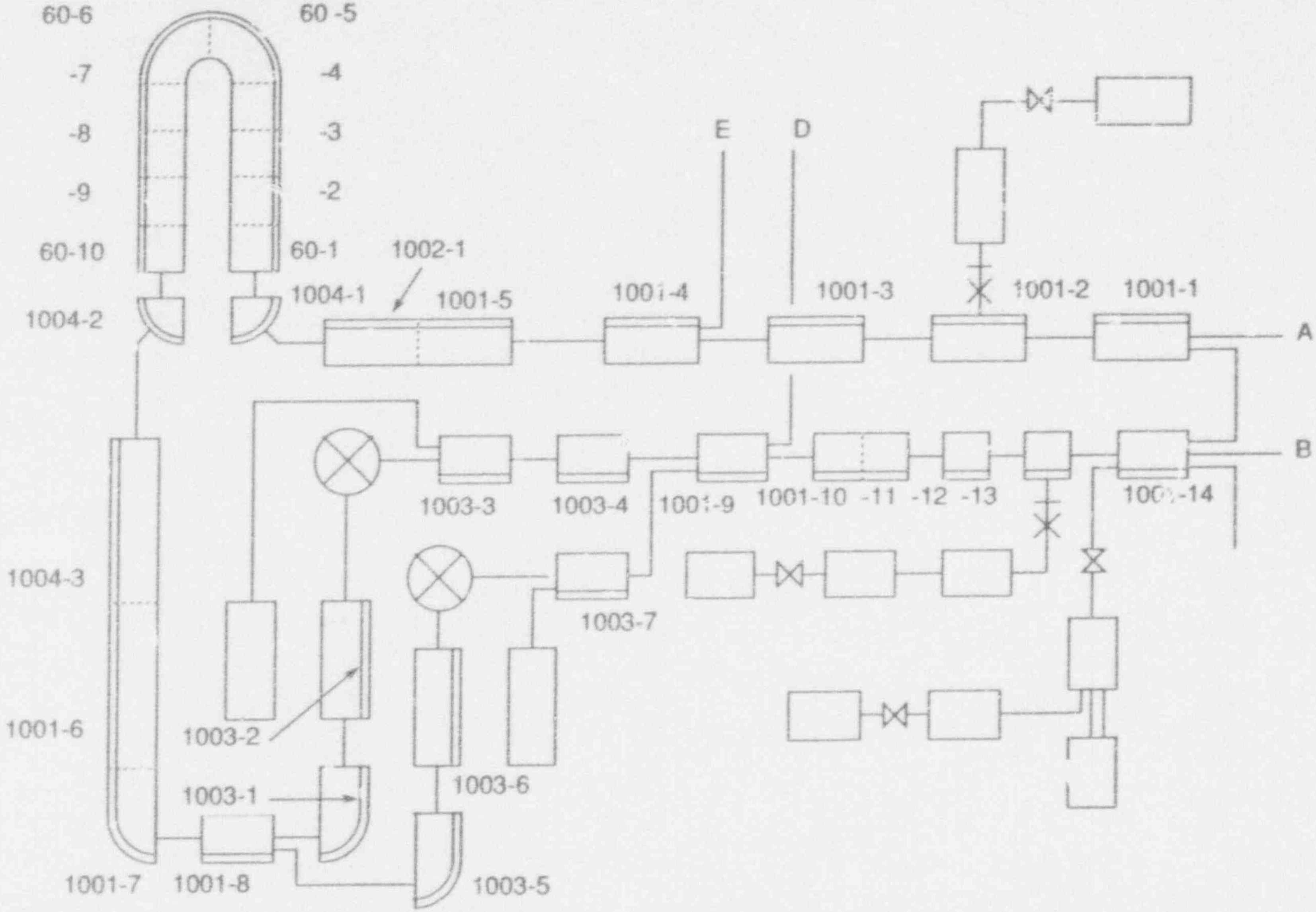


Figure 10 c Intact loop - noding of heat slabs

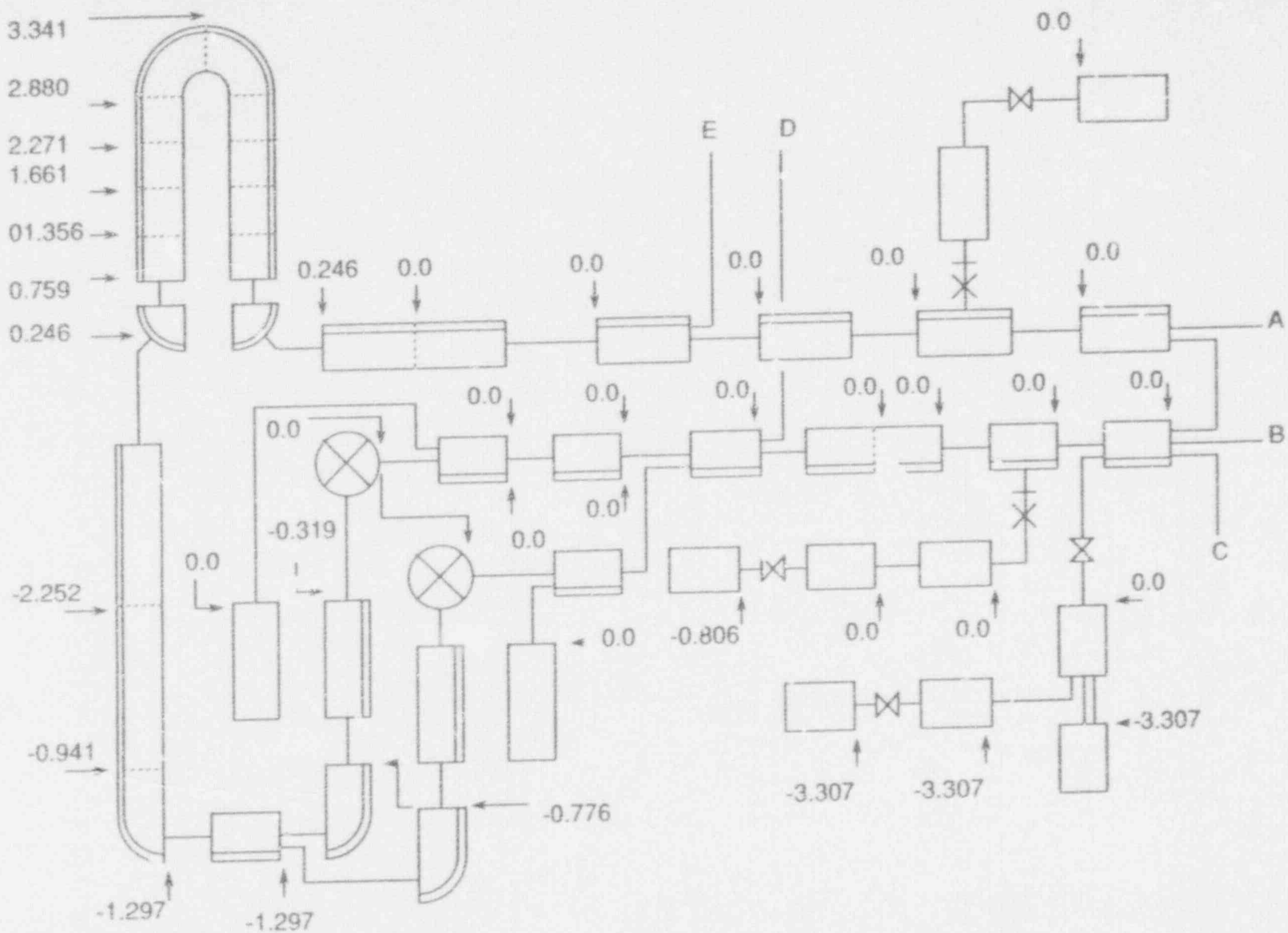


Figure 10 d Intact loop - volume outlet elevations

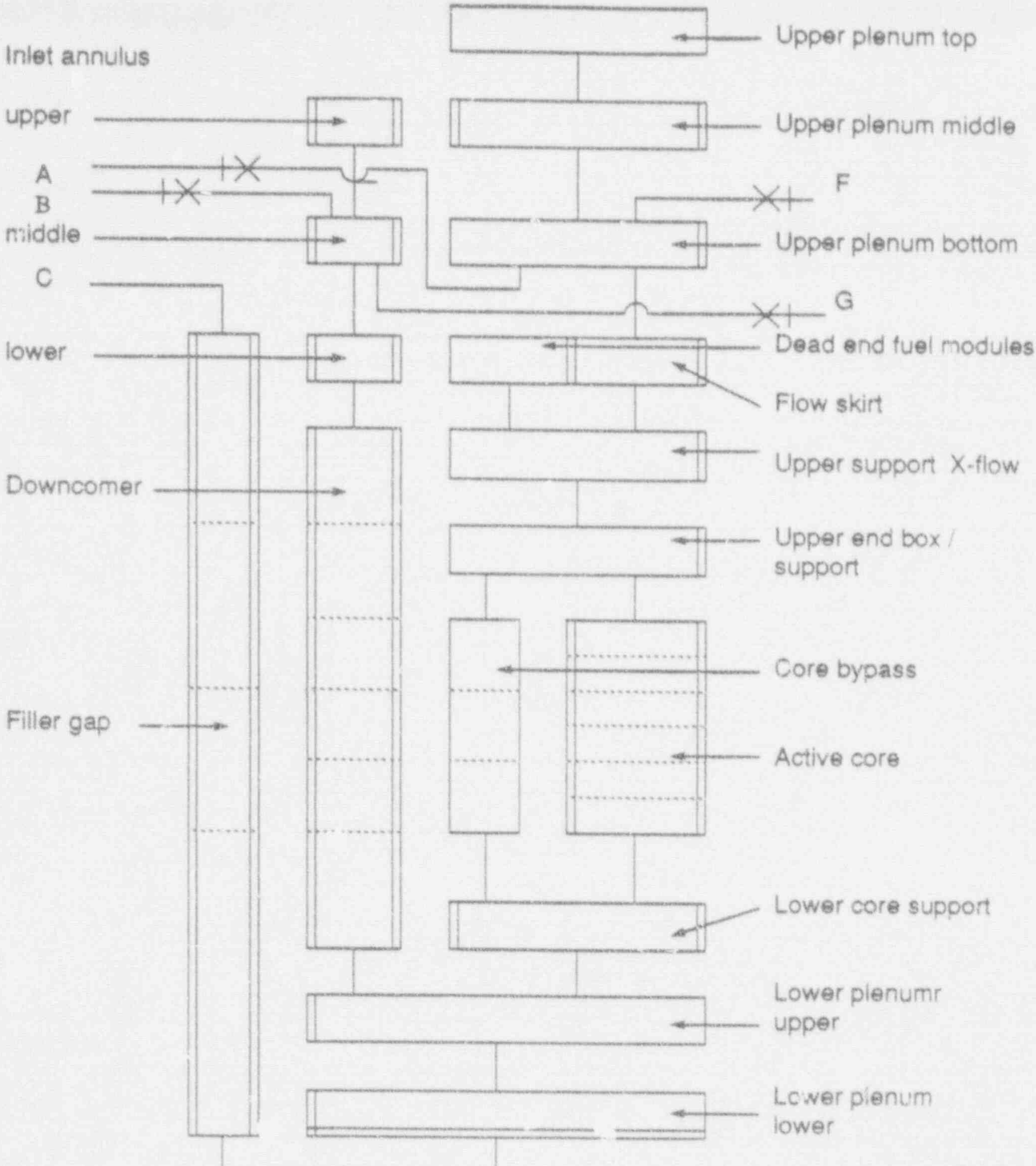


Figure 11a Reactor Vessel - description of components

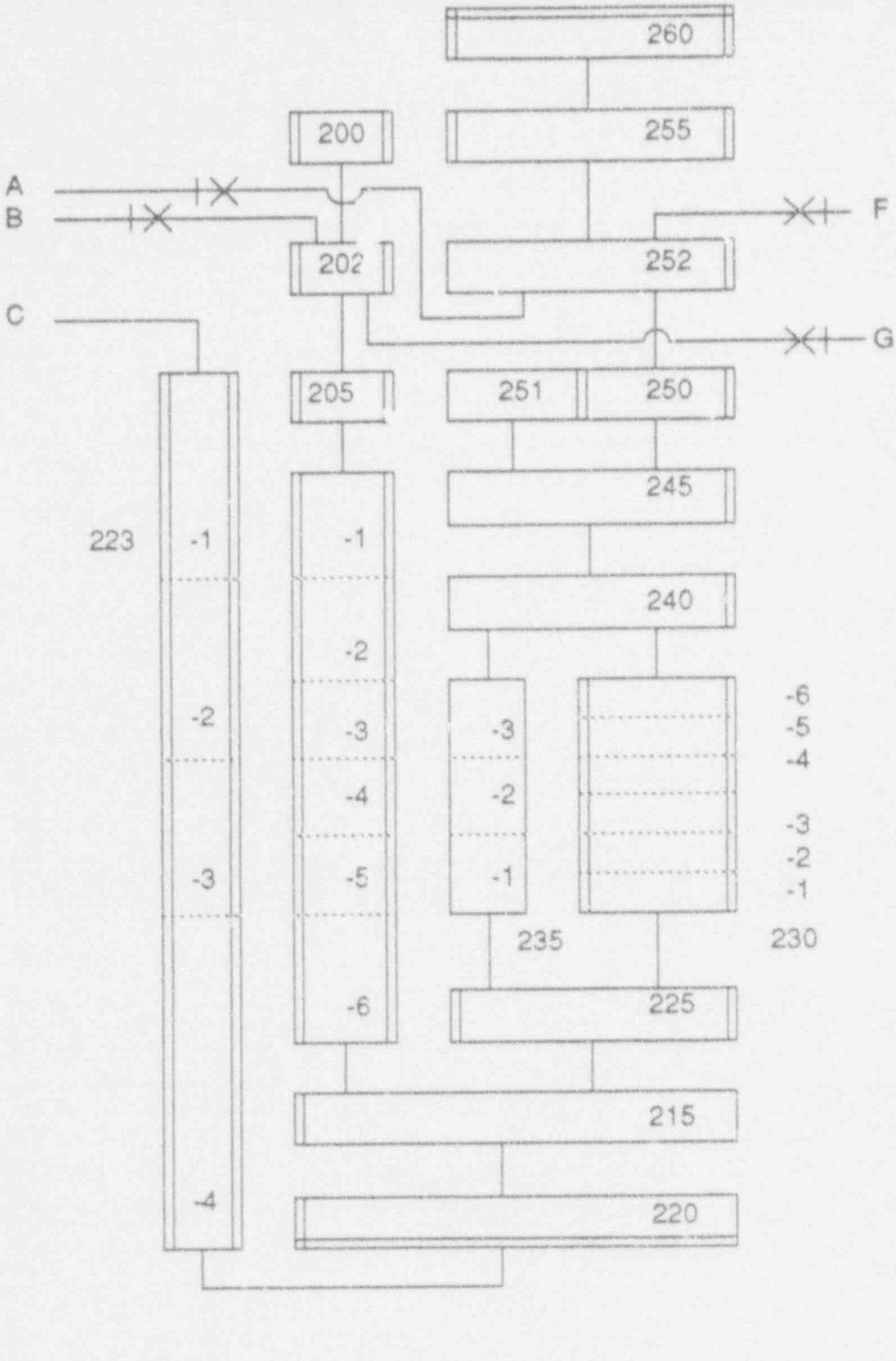


Figure 11 b Reactor vessel - noding of components

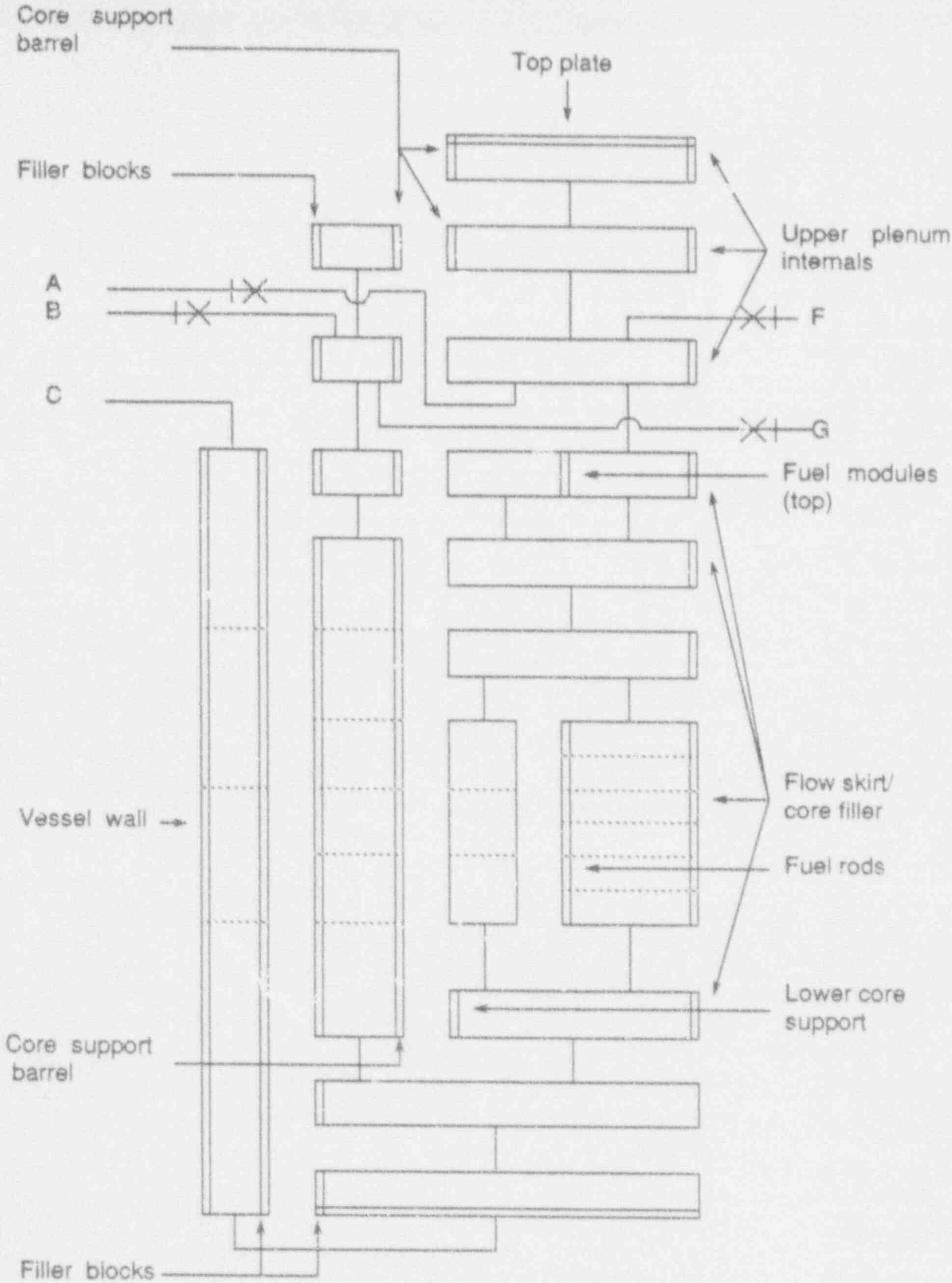


Figure 11c Reactor vessel - description of heat slabs

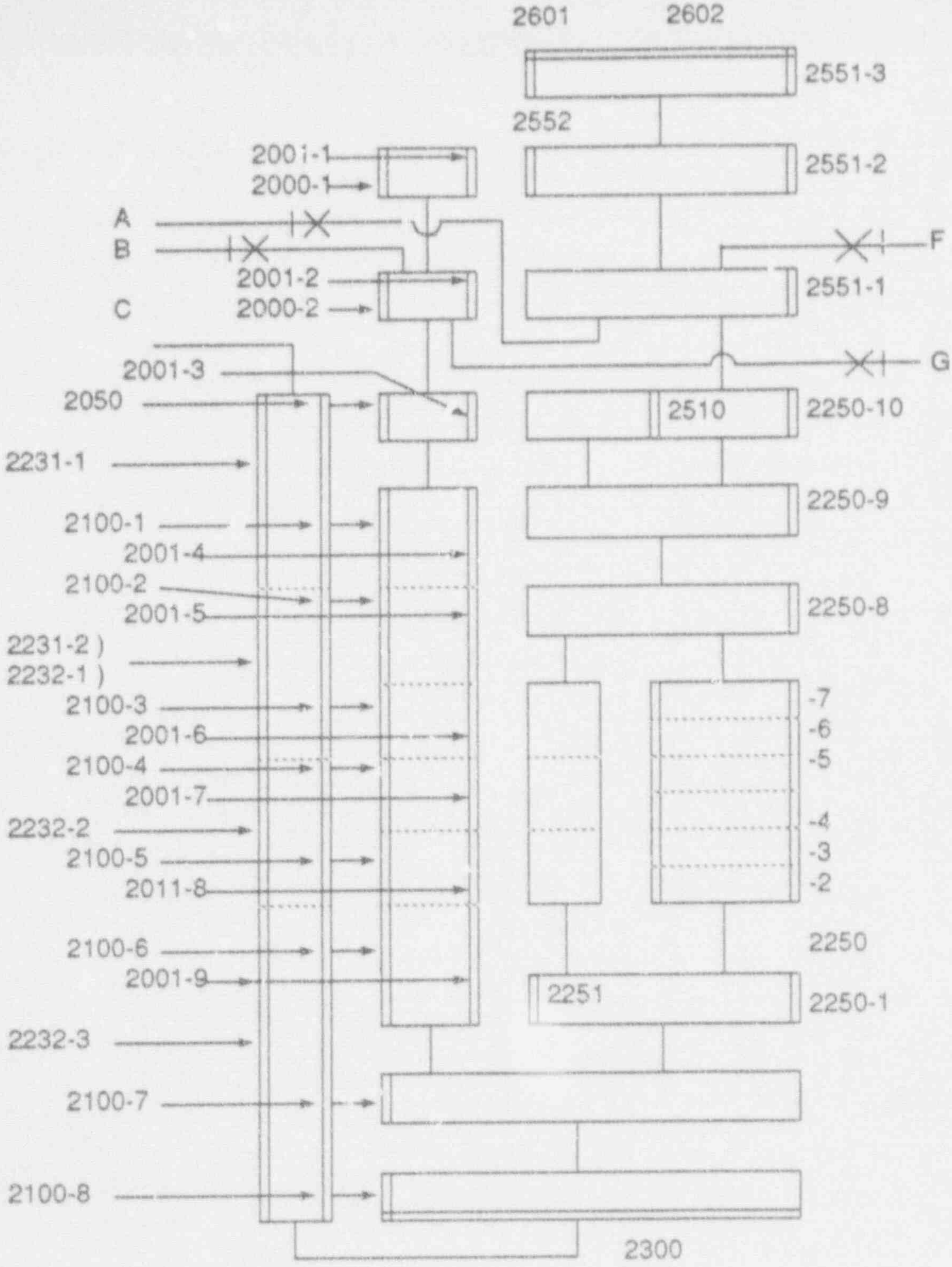


Figure 11 d Reactor vessel - numbering of heat slabs

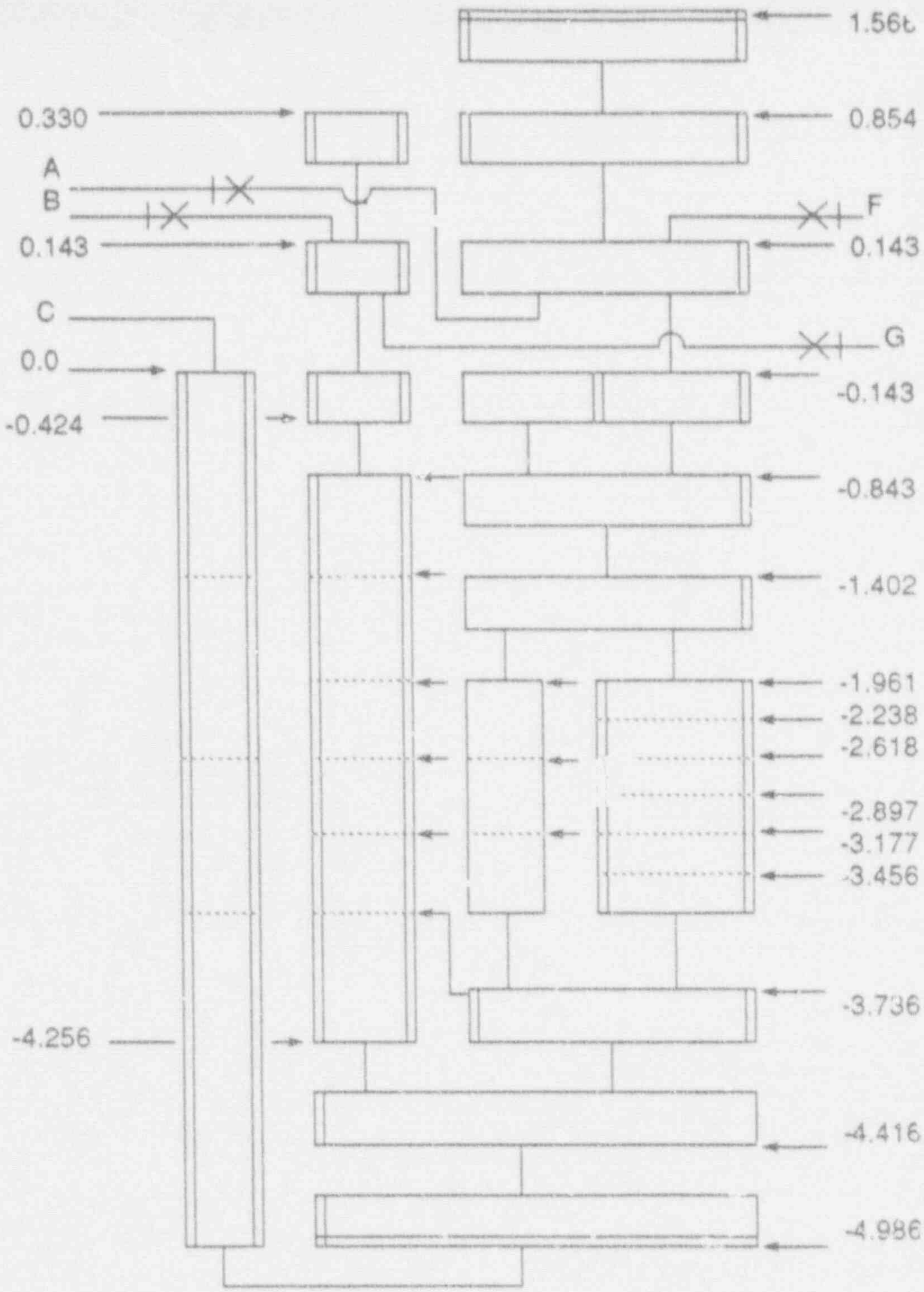


Figure 11 e Reactor vessel - volume outlet elevations

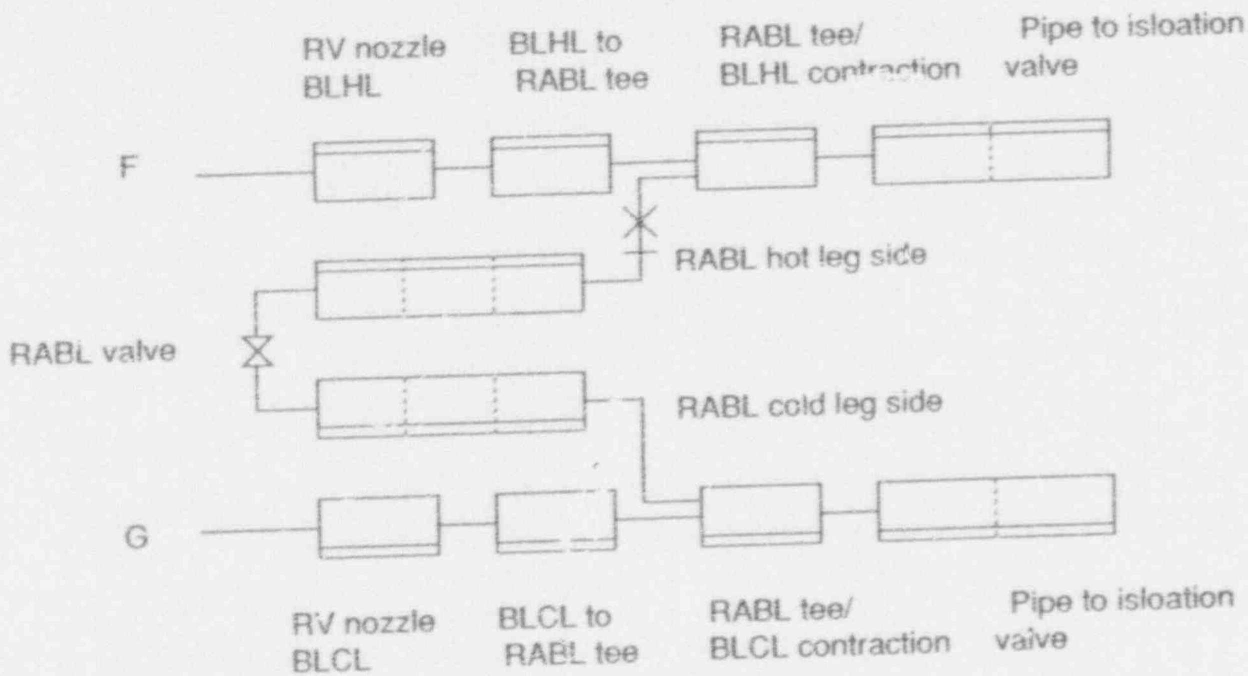


Figure 12 a Broken loop (without simulators) - description of components

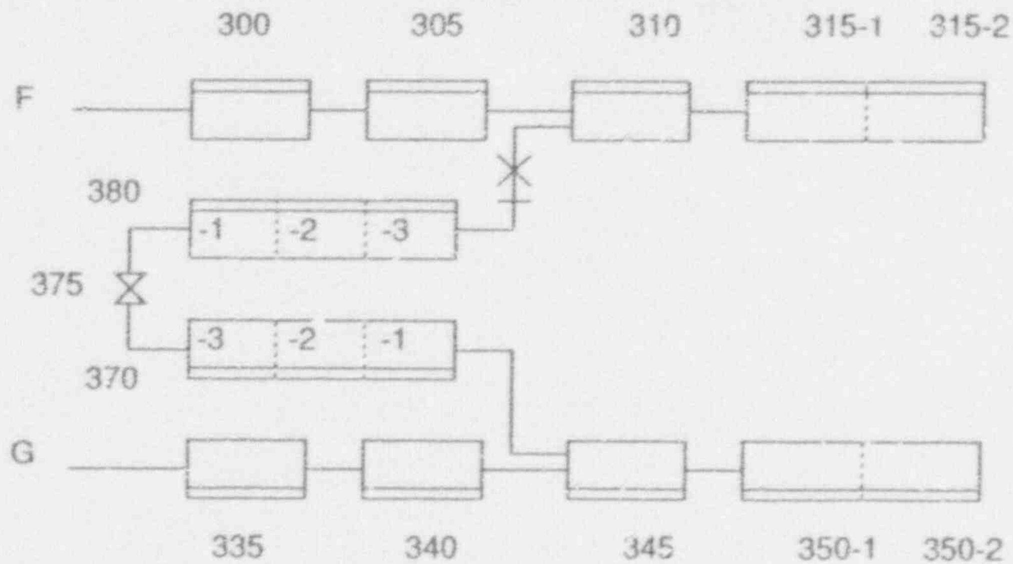


Figure 12 b Broken loop (without simulators) noding of components

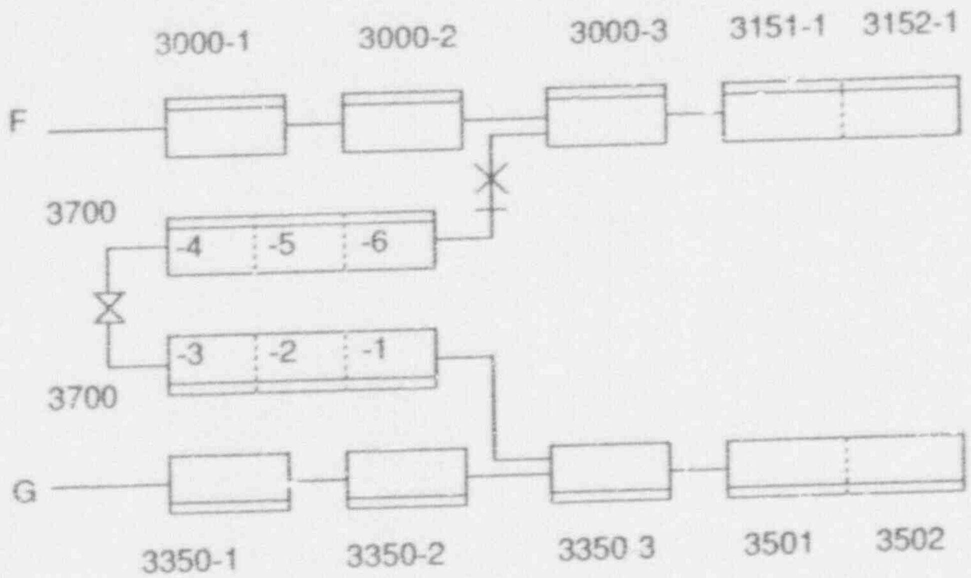


Figure 12 c Broken loop (without simulators) - noding of heat slabs

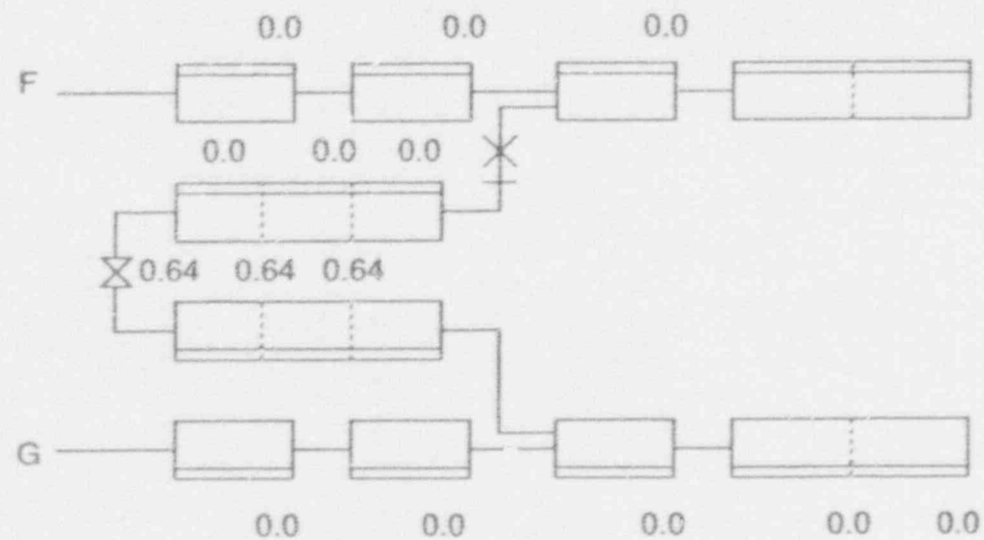


Figure 12 d Broken loop (without simulators) - volume outlet elevations

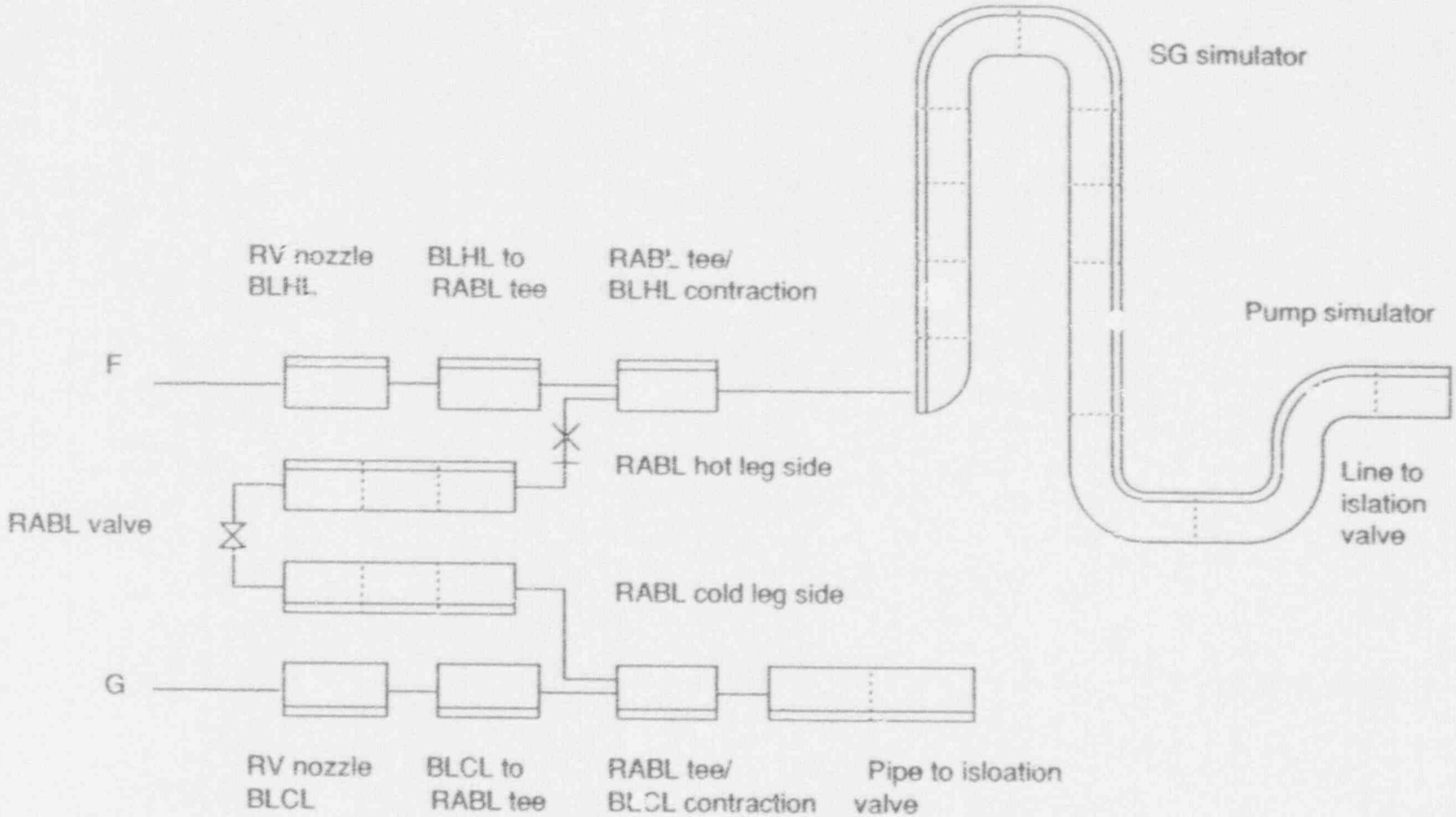


Figure 12 e Broken loop (with simulators) - description of components

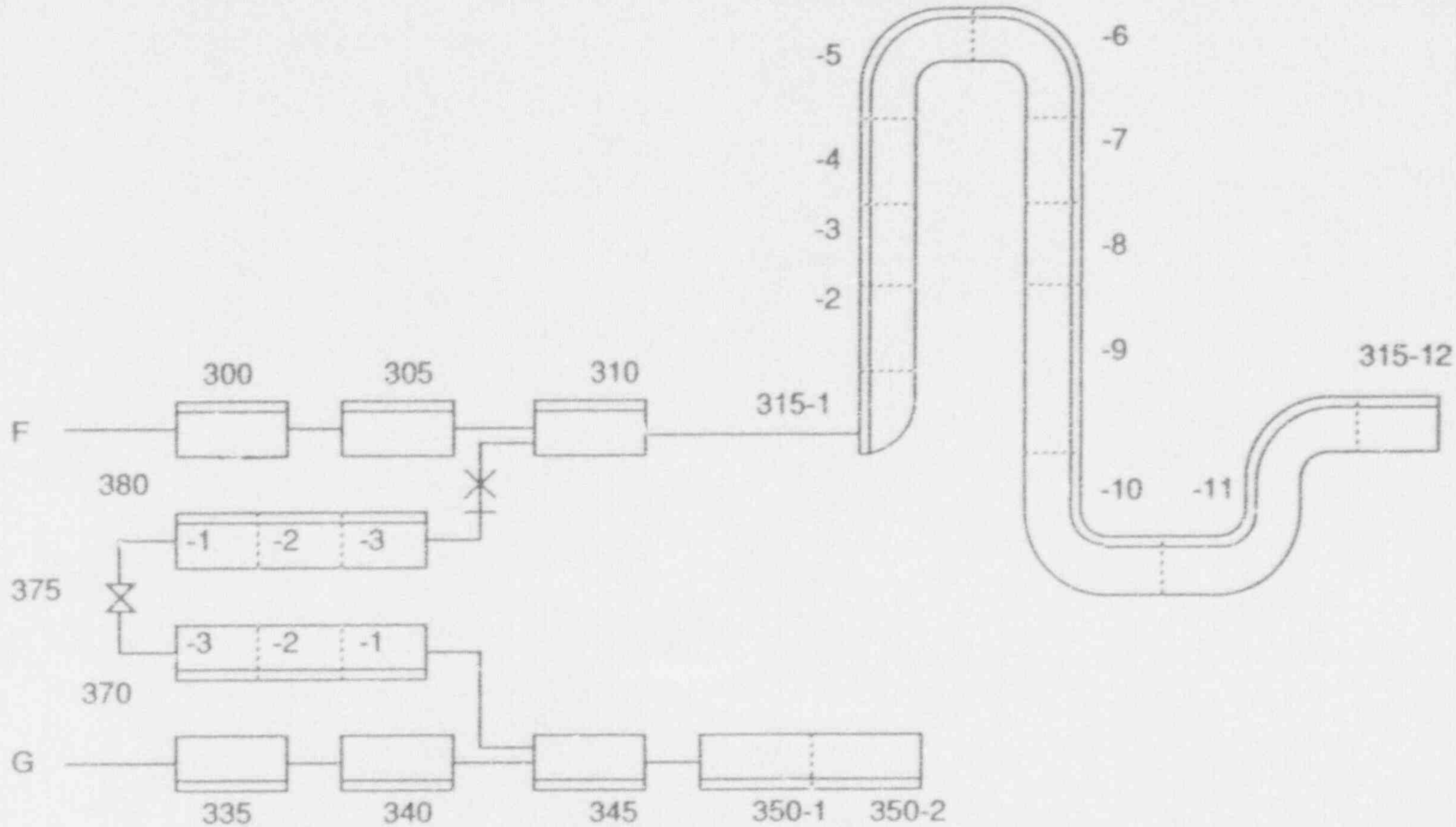


Figure 12 f Broken loop (with simulators) noding of components

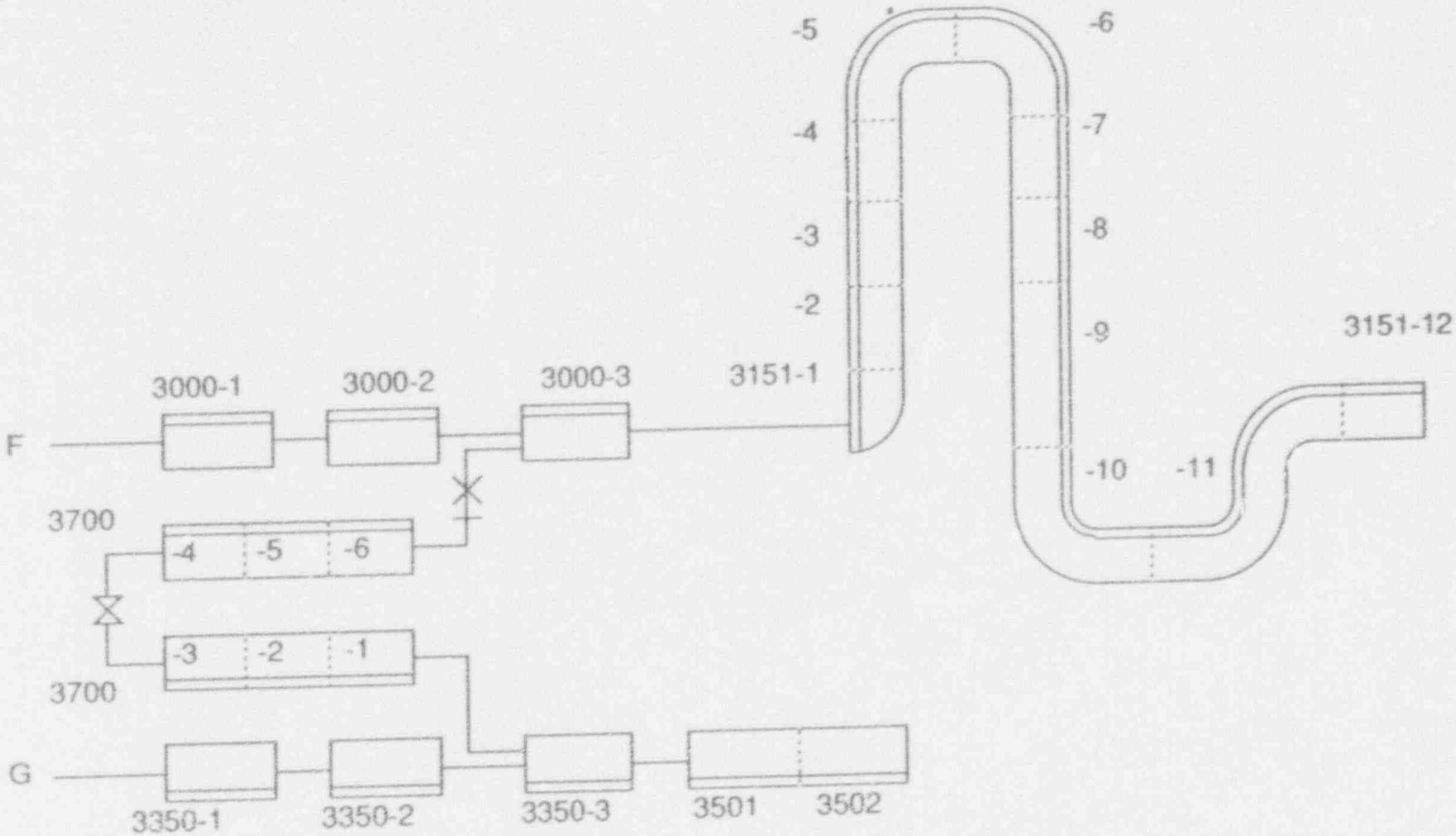


Figure 12 g Broken loop (with simulators) - noding of heat slabs

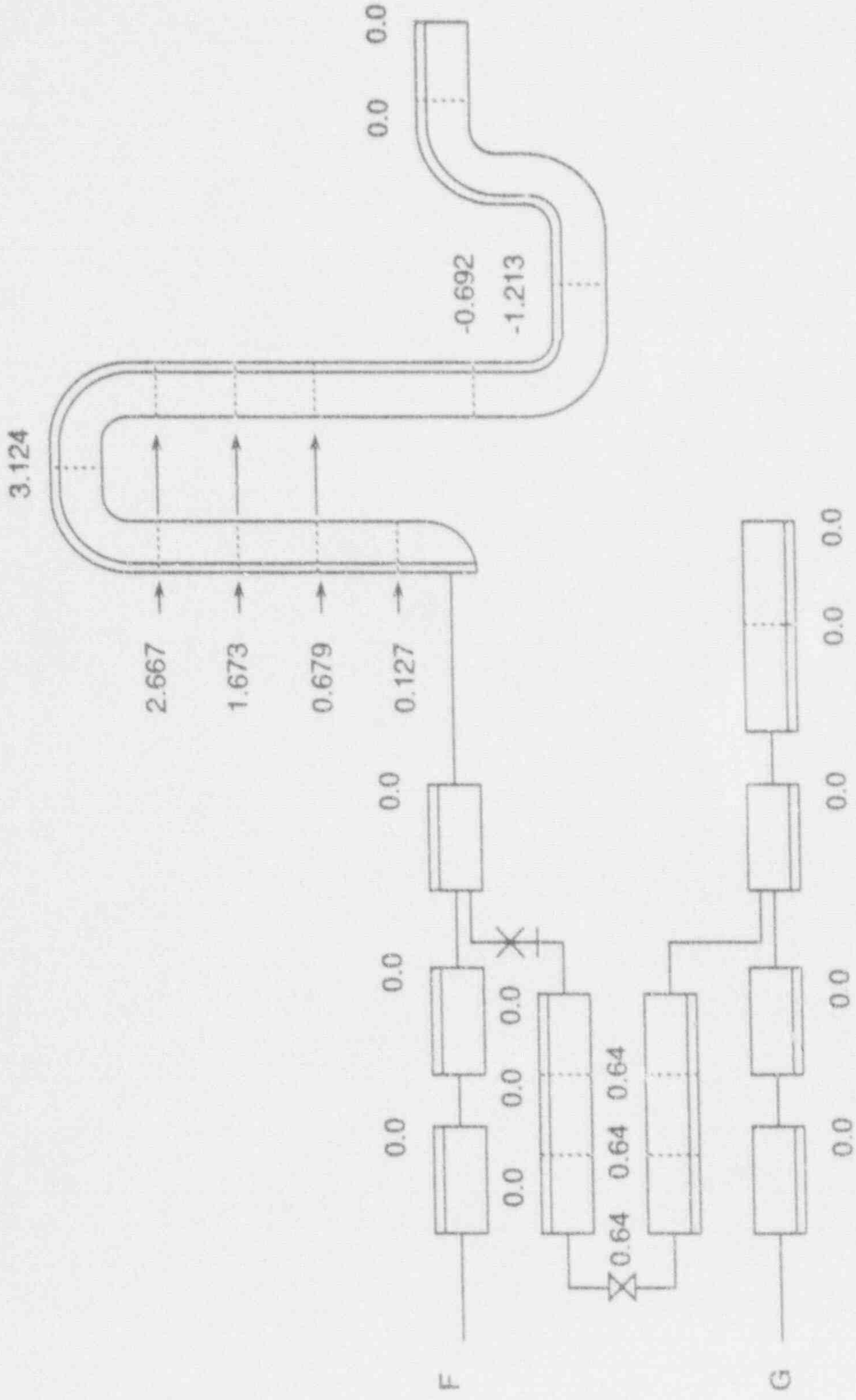


Figure 12 h Broken loop (with simulators) - volume outlet elevations

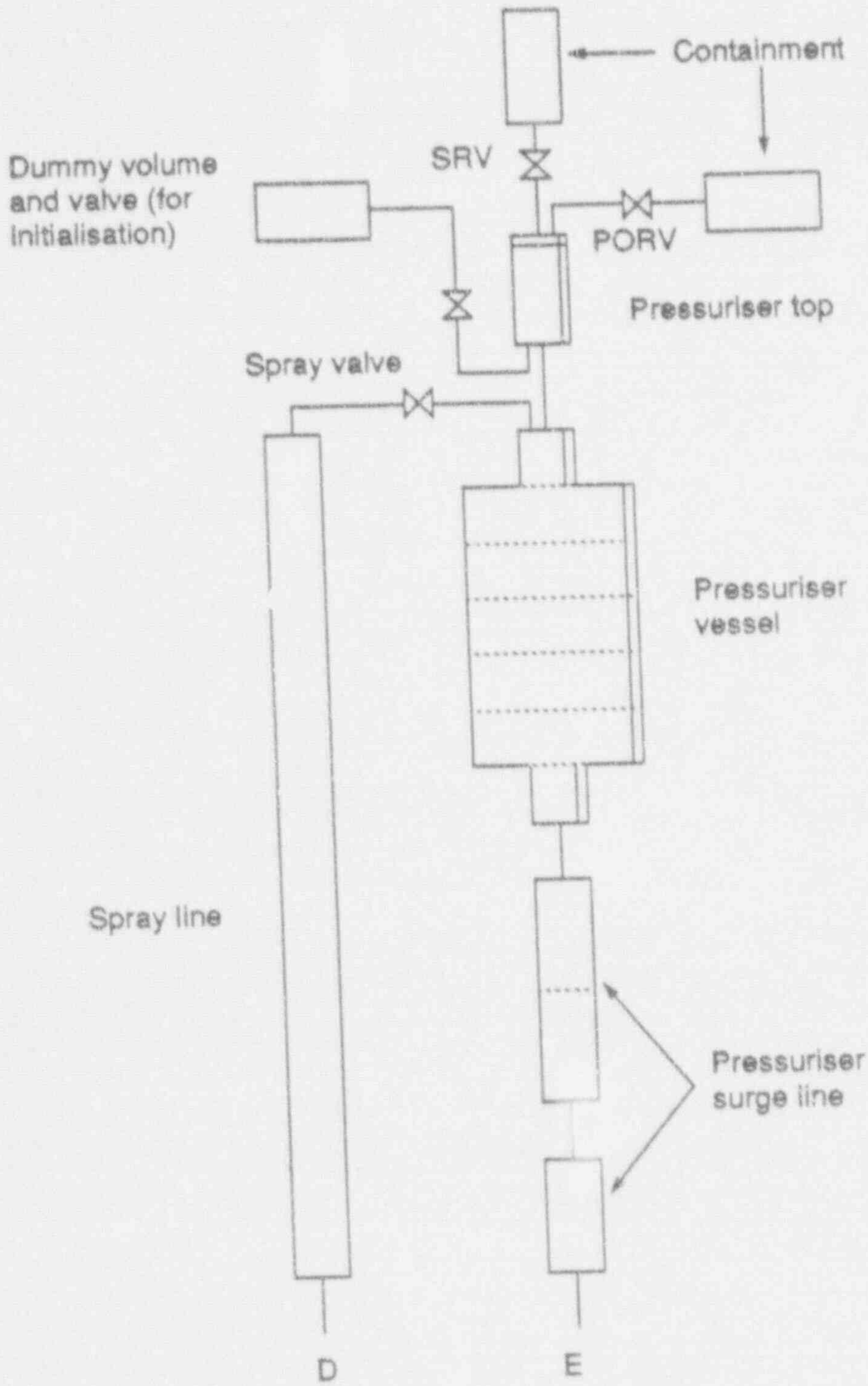


Figure 13 a Pressuriser system - description of components

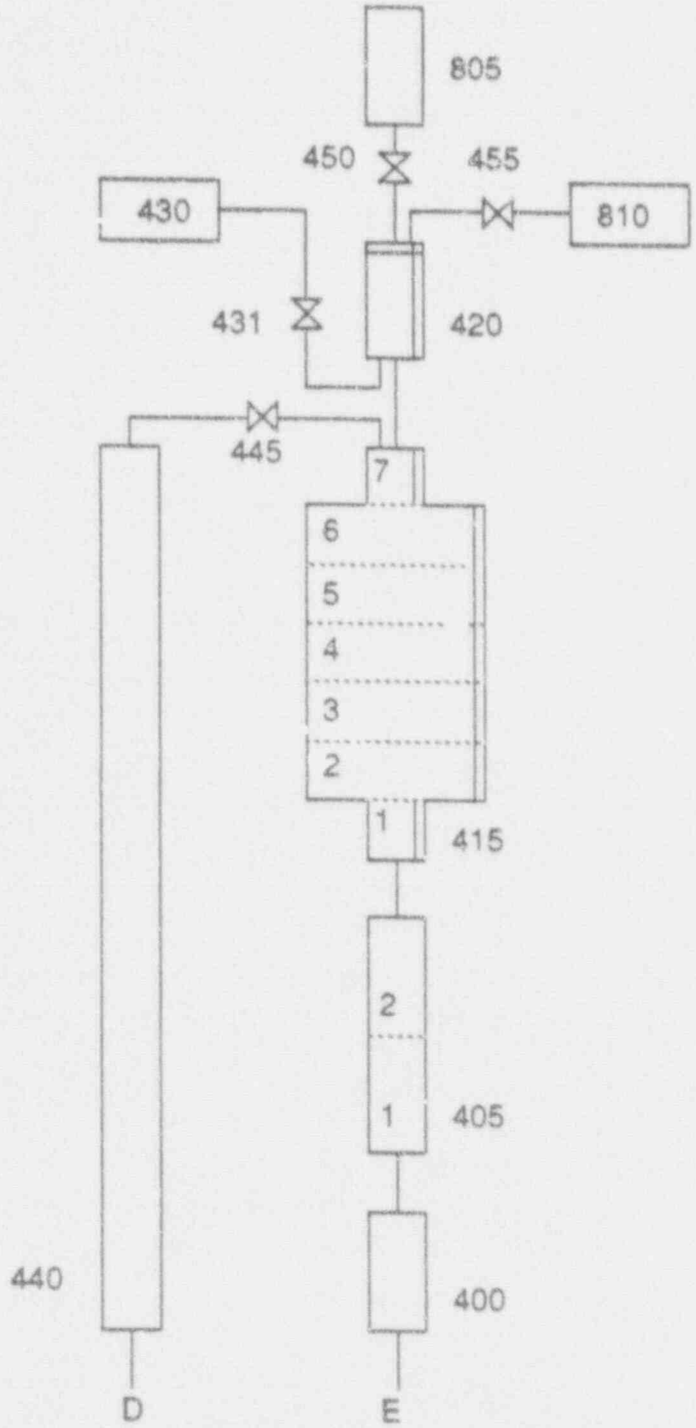


Figure 13 b Pressuriser system - noding of components

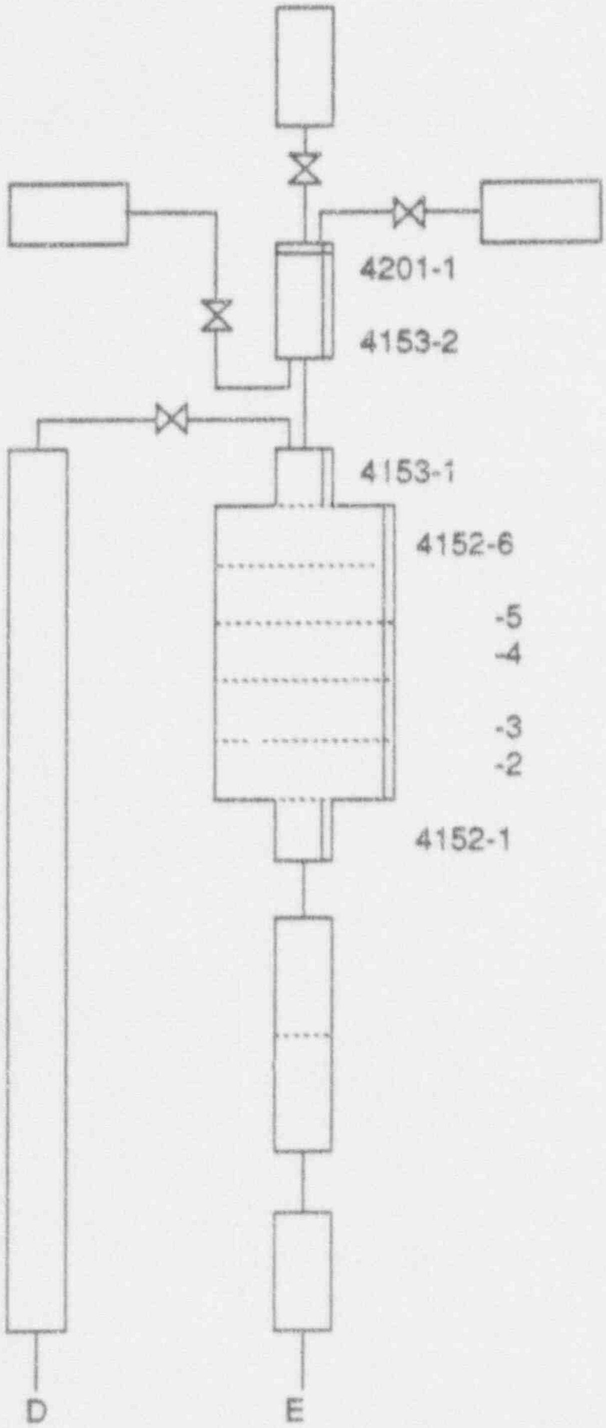


Figure 13 c Pressuriser system - noding of heat slabs

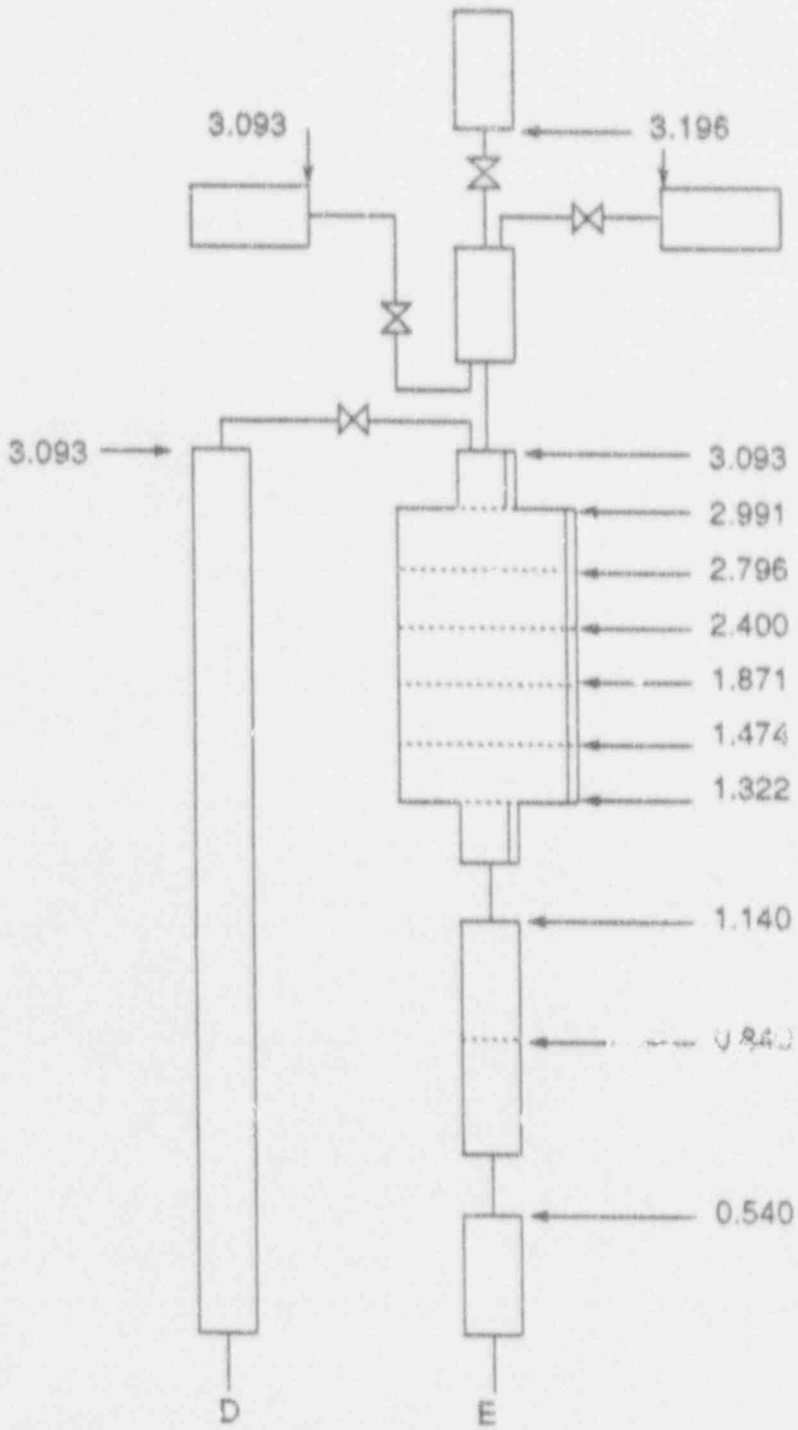


Figure 13 d Pressuriser system - volume outlet elevations

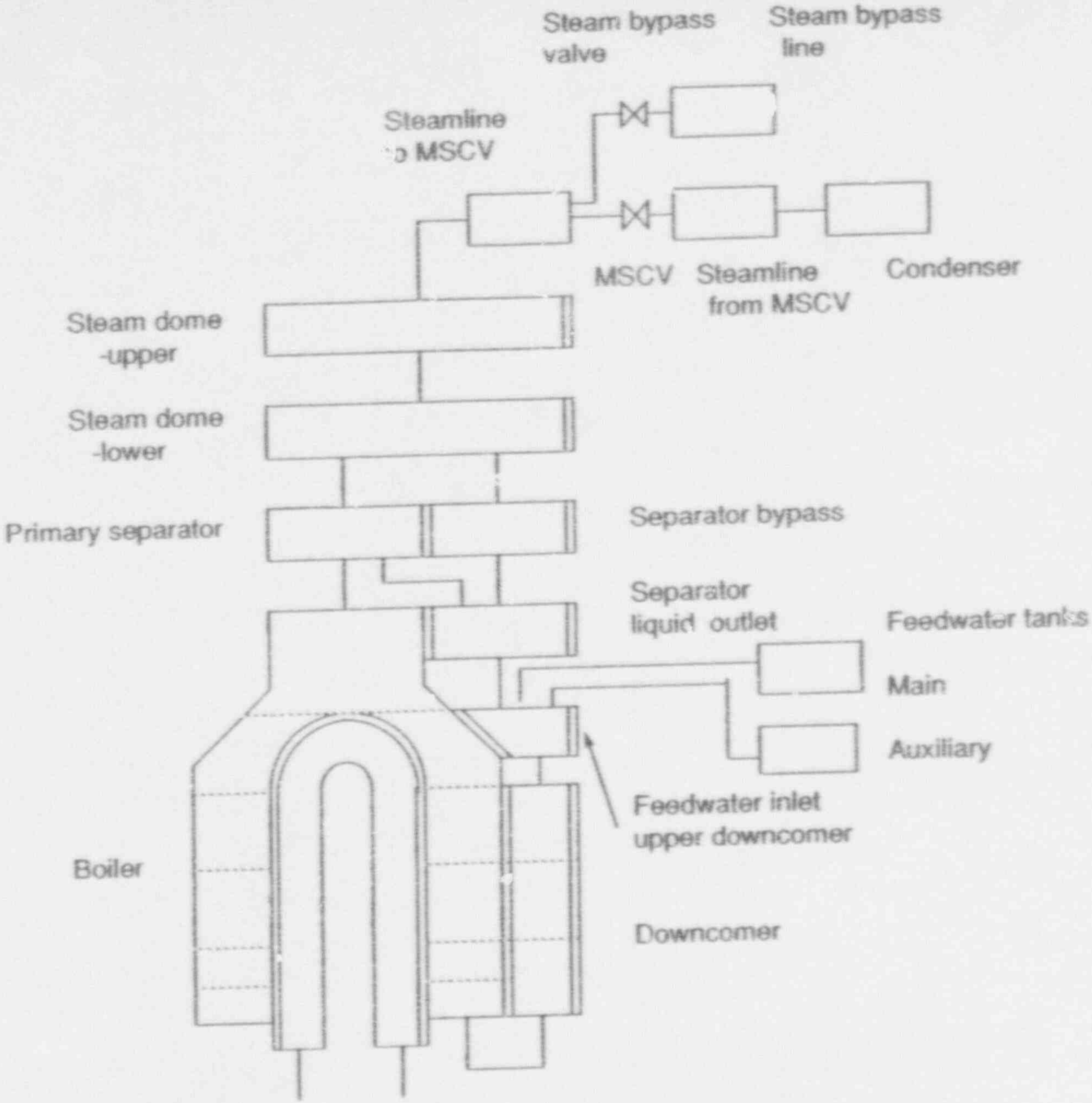


Figure 14 a Secondary system - description of components

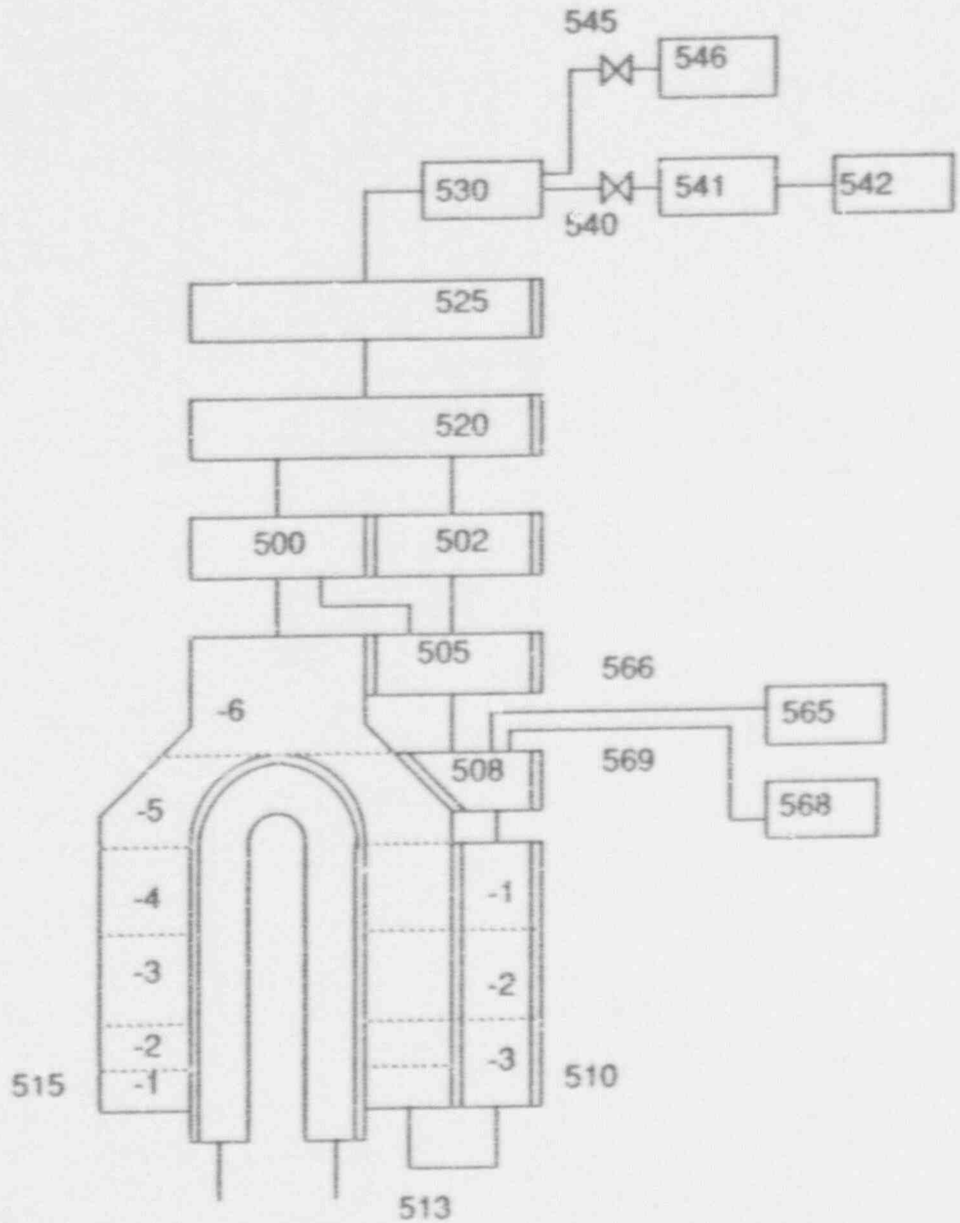


Figure 14 b Secondary system - noding of components

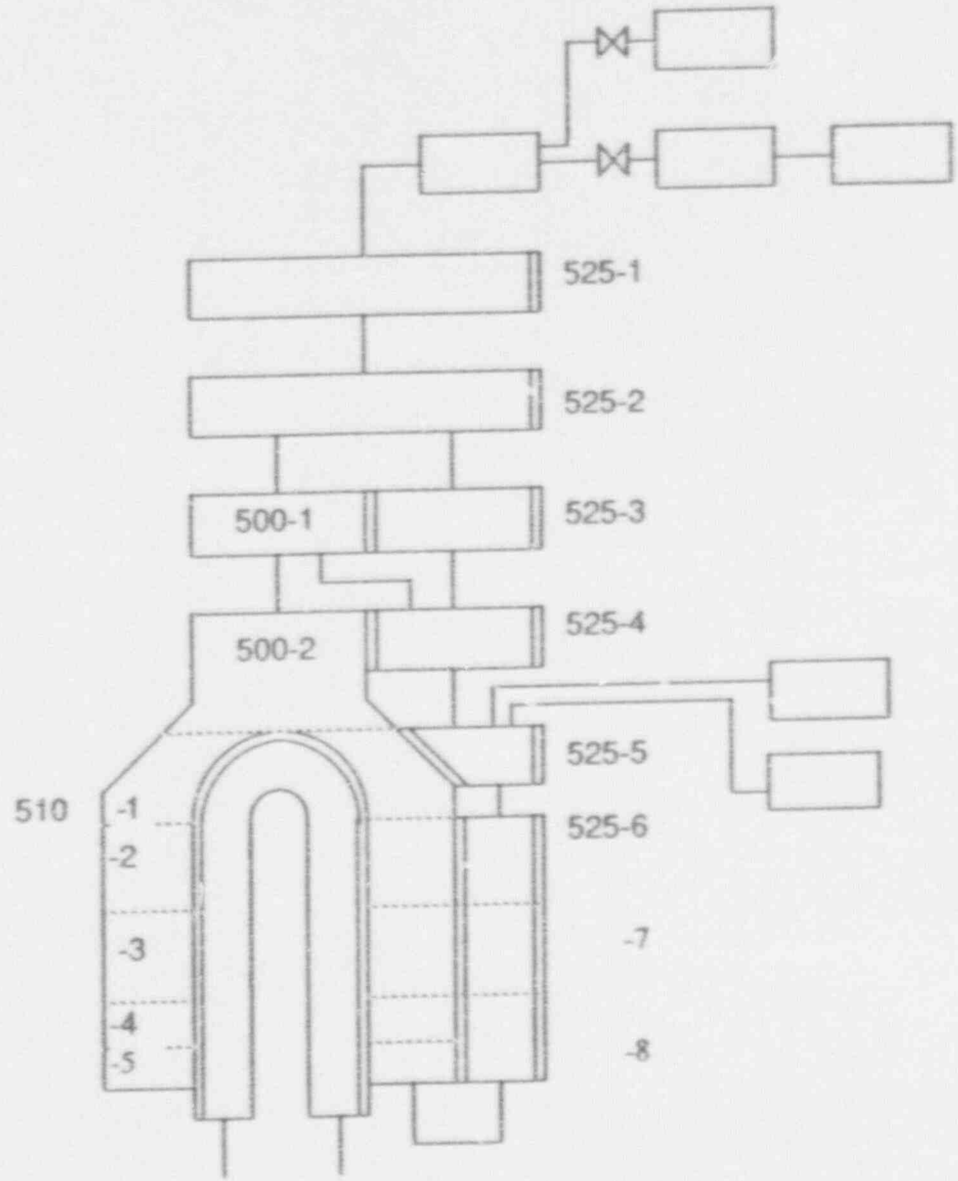


Figure 14 c Secondary system - noding of heat slabs

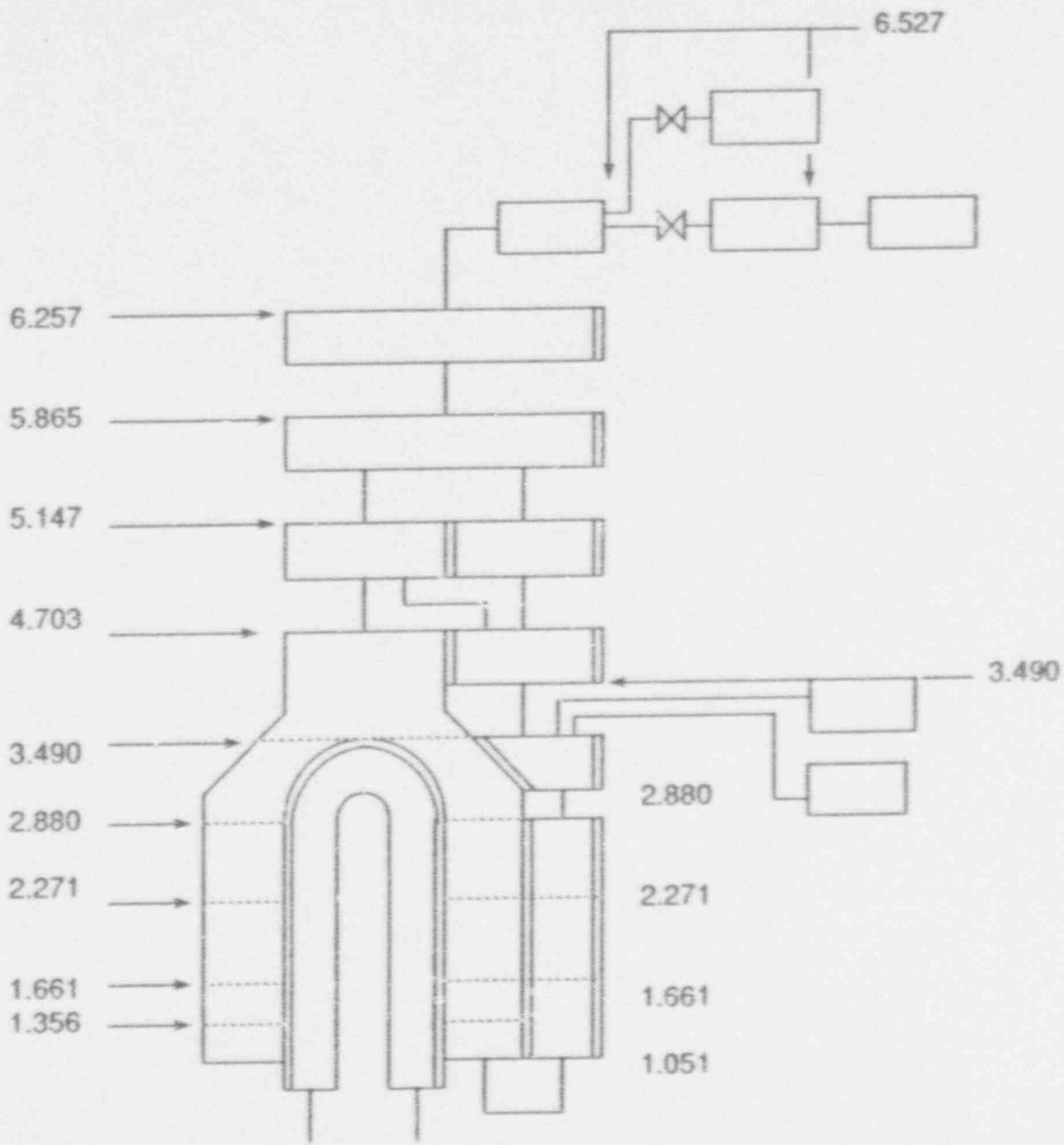


Figure 14 d Secondary system - volume outlet elevations

DISTRIBUTION

WINFRITH TECHNOLOGY CENTRE, DORCHESTER, DORSET, DT2 8DH

Mr A J Briggs		226/B21
Dr A T D Butland		343/B41
Dr I H Gibson		236/A32
Dr J C Birchley	(4)	230/A32
Mr A J Smethurst		234/A32
Mr G J Ward		239/A32
Dr S Kinnersly		203/A32
Mr J Sherwin		245/A32
Mr I Brittain		201/A32
Dr C G Richards		260/A32
Mr R O'Mahoney		263/A32
Mrs S Newbon		232/A32
Dr W M Bryce		262/A32
Mr J Fell		1 Melstock Avenue, Dorcheter, Dorset

NUCLEAR ELECTRIC, BARNETT WAY, BARNWOOD, GLOUCESTER, GL4 7RS

Mr N A J Butt
Mr I L Hirst
Mr P C Hall
Dr K H Ardron

NUCLEAR ELECTRIC, BERKELEY NUCLEAR LABORATORIES, BERKELEY, GLOUCESTER, GL13 9PB

Dr J Young

NUCLEAR POWER TECHNOLOGY AND ENVIRONMENT CENTRE, KELVIN AVENUE, LEATHERHEAD, SURREY

Mr M W E Coney
Dr J Putney

NUCLEAR ELECTRIC, MARCHWOOD ENGINEERING LABORATORIES, SOUTHAMPTON, SO4 4ZB

Mr B Chojnowski

INFORMATION TECHNOLOGY DIRECTORATE, 85 PARK STREET, LONDON, SE1

Mr L Wilson
Mr G France

NUCLEAR ELECTRIC, LAUD HOUSE, 18 WARWICK LANE, LONDON, EC4 4EB

Mr J R Harrison
Dr P R Farmer
Mr A L Willetts
Dr F Evans

NUCLEAR ELECTRIC, PWR PROJECTS GROUP, BOOTHS HALL, CHELFORD ROAD, KNUTSFORD, CHESHIRE, WA16 8QZ

Mr P Chappall
Mr P Lightfoot

UKAEA, SAFETY AND RERLIABILITY DIRECTORATE, WIGSHAW LANE, CULCHETH, WARRINGTON, CHESHIRE,

Mr J G Moore
Mr R Cox

UKAEA, C35, 329, AERE HARWELL, OXFORDSHIRE, OX11 0RA

Dr D Hicks
Dr G F Hewitt

SOUTH OF SCOTLAND ELECTRICITY BOARD, CATHCART HOUSE, INVERLAIR AVENUE, GLASGOW, SCOTLAND

Mr J R P Eaton

NATIONAL NUCLEAR CORPORATION, BOOTHS HALL, CHELFORD ROAD, KNUTSFORD, CHESHIRE, WA16 8QZ

Mr K T Routledge
Mr A Maccabee
Reports Library (4)

NUCLEAR INSTALLATIONS INSPECTORATE, HEALTH AND SAFETY EXECUTIVE, ST PETERS HOUSE, STANLEY PRECINCT, BALLIOL ROAD, BOOTLE, L20 3LZ

Dr S A Harbison
Mr J F Campbell
Mr C Potter

UNITED STATES NUCLEAR REGULATORY COMMISSION, 5650 NICHOLSON LANE, ROCKVILLE, MD 20814, USA

Mr D Bessette (4)
Dr L Shotkin

EG&G (IDAHO) INC, PO BOX 1625, IDAHO FALLS, ID 83415, USA

Mr G E Wilson
Mr G W Johnsen
Mr T R Charlton
Dr W L Weaver

UKAEA LIBRARIES

Dounreay	(4)
Harwell	(2)
Risley	(4)
Springfields	(2)
Windscale	(2)
Winfrith	(6)

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC. Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG/IA-0072
AEEW-R2454

2. TITLE AND SUBTITLE

LOFT Input Dataset Reference Document for RELAP5 Validation Studies

3. DATE REPORT PUBLISHED
MONTH: April YEAR: 1992

4. FIN OR GRANT NUMBER
A4682

5. AUTHOR(S)

J. C. Birchley

6. TYPE OF REPORT
Technical

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION — NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Winfrith Technology Centre
United Kingdom Atomic Energy Authority
Dorchester, Dorset, DT2 8DH
United Kingdom

9. SPONSORING ORGANIZATION — NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

Analyses of LOFT experiment data are being carried out in order to validate the RELAP5 computer code for future application to PWR plant analysis. The MOD1 dataset was also used by CEGB Barnwood who subsequently converted the dataset to run with MOD2. The modifications included changes to the nodalisation to take advantage of the crossflow junction option at appropriate locations. Additional pipework representation was introduced for breaks in the intact (or active) loop. Further changes have been made by Winfrith following discussion of calculations performed by the CEGB and Winfrith. These concern the degree of noding in the steam generator, the fluid volume of the steam generator downcomer, and the location of the reactor vessel downcomer bypass path. This document describes the dataset contents relating to the volume, junction, and heat slab data for the intact loop, reactor pressure vessel, broken loop, steam generator secondary, and ECC system. Also described are the control system for steady state initialization, standard trip settings and boundary conditions.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

LOFT, RELAP5, Validation Studies

13. AVAILABILITY STATEMENT
Unlimited

14. SECURITY CLASSIFICATION
(This Page) Unclassified
(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE

NRC FORM 335 (2-89)

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

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

SPECIAL FOURTH CLASS RATE
POSTAGE AND FEES PAID
USNRC
PERMIT NO. G-67

120555139531 1 1AN1CI
US NRC-OADM
DIV FOIA & PUBLICATIONS SVCS
TPS-PDR-NUREG
P-211
WASHINGTON DC 20555