12-1127174-01
February 1982

GERDA

General Test Specifications

Babcock & Wilcox
a McDermott company

GERDA General Test Specifications

B&W Doc. No. 12-1127174-01

February, 1982

595-8029-04-07-005

ABSTRACT

These General Test Specifications lay the groundwork for GERDA testing. The testing objective, general schedule, conduct, and administration are discussed. The types, format, and handling of results are described. Verification requirements and exceptions to the QA Specification (NPGD Spec. 09-1427-00) are addressed. Detailed test descriptions are deferred to subsequent test specification documents.

CONTENTS

TABLES

I. INTRODUCTION

These GERDA General Test Specifications form the basis for GERDA testing. The general test schedule, conduct, and administration are defined, section II. The content, format, and handling of results are described, section III. Verification requirements are addressed by noting exceptions to the NPGD QA Requirements, section IV. Detailed discussions of tests and variables are deferred to subsequent test specifications.

II. TESTS

II.1. Objective

The (GERDA) SBLOCA tests are being performed to generate data for code verification and/or code model development. These tests must provide sufficient and accurate documentation of at least the most significant loop conditions and interactions, within the testing schedule.

II.2. Schedule

II.2.A. Phases

The planned GERDA testing period extends from April, 1982 through mid-January, 1983, inclusive.[1,2] This nine and one-half month period is divided into three portions. The first weeks are relegated to "Phase 0" testing, for loop checkout and characterization. The middle period is for "Phase 1" basic variations, and the final period is for supplementary variations.

Phase 1 tests include only essential variations: They are planned to encompass the minimum testing which must be satisfactorily performed to address the test objectives as described in attachment 1 to the Tender[1] (and which are repeated herein in Appendix A). Time and budget permitting, it is intended to supplement these Phase 1 tests during the remainder of the allocated testing period.

The intent of this two-tier testing scheme is to ensure that all required tests are addressed within the allotted test period, at least with their most-significant combinations of test variables. Subsequent testing of the less-significant variations permits a more-informed selection of these conditions, repeats of tests found to be especially important, and perhaps some detailed conditions-variation to locate apparent threshold conditions. This two-tiered testing is especially tailored to the dual constraints of a fixed testing deadline and a comprehensive test scope.

II.2.B. Initial Tests

The initial loop tests will serve to characterize the system and to test its as-built performance. These tests have been labelled "Phase O" to differentiate them from the contractual test phase. The results of these tests will bear directly on subsequent interpretation of loop response, and on code modelling of the test facility, thus the verification requirements of section IV herein also govern these tests. The tests will be discussed in a separate writeup.

II.2.C. Phase 1 Tests

Eight tests are delineated in the SBLOCA Testing Program Contract[1]:

Outline of Proposed Experiments

A. AFW Characteristics

B. Secondary Blowdown and Refill

C. Condensing Primary w/o NCG (Steady State)

D. Condensing Primary w/NCG (Steady State)

E. Condensing Primary Transients (w/ & w/o NCG)

1. oscillations (primary pressure and level)
2. primary refill w/o HPV
3. primary refill 2/HPV

F. HPV Effects

G. Natural Circulation (Transient)

1. restart

2. primary phase transitions

H. Secondary Swell Behavior in BC Mode

The various tests have also been briefly described in the contract attachment 1 to the Tender[1], and are repeated herein as Appendix A.

These tests are more descriptively grouped according to SBLOCA phenomena, table II.1. Then regrouping to combine similar tests obtains the Phase 1 Test Outline, table II.2: The Transition From Forced Flow Into Natural Circulation (test IV of table II.1) is grouped with the Natural Circulation tests; and the Interruption of Natural Circulation and Transition Into the Boiler-Condenser Mode (test V of table II.1) is grouped with the Boiler-Condenser Mode tests. The resulting test outline and order of testing, table II.2, contains sixteen tests in five categories. Tests are sequenced to supply insight into subsequent tests and generally to increase in complexity.

II.2.D. Variables

The basic (Phase 1) variables are readily identified for each test, table II.3. Note that two variables which were listed in the Tender[1] are not included, viz. Primary Subcooling and Auxiliary Feedwater Temperature; both are perceived to be inconsequential compared to the (eighteen) selected variables. Primary Pressure, which was also cited in the Tender, is controlled with Secondary Pressure except when the primary is subcooled. Further discussions of variables are reserved for subsequent test-specification documents.

The test-variables matrix is not invariant, cf. Section II.3.A. below.

Loop modifications for testing include AFW nozzle exchanges, removal of the SG thermocouple strings and Pitot tubes, and perhaps installation and removal of conductivity probes and viewports (depending on their leakage and durability at test conditions). The supplementary SG instrumentation should be available for some of the variations of the first two Test Categories (Steam Generator and Natural Circulation). Thus portions of these tests should be run, the instrumentation removed, and then these tests should be completed. Similarly, "wetting" variations should be grouped to minimize AFW nozzle changes.

II.3. Conduct

II.3.A. Control

The ARC Coordinator[1] is responsible for the coordination of ARC activities, including testing and loop control. He or his designated representative, usually the Shift Engineer, will control loop evolutions and will direct the actions of assigned and attending persons. Except in emergency circumstances, no equipment is to be altered in any way without the authorization of the controlling engineer.

The ARC controlling engineer must direct testing to achieve the contractual test goals within the allotted testing period. The Phase 1 tests attempt to embody these goals, and thus must be pursued unless otherwise indicated by previous testing experience and engineering judgement. Deviations from the test plan should have prior concurrence of the BBR Onsite Technical Representative. Additional or unplanned test points should be deferred to Phase 2 testing. Unplanned Phase 1 tests shall be conducted only with BBR approval, and after the preparation of abbreviated descriptions and procedures for such tests.

II.3.B. Emergencies

Emergency and abnormal loop conditions must be handled to safeguard personnel, and to minimize loop damage. Such events must be promptly reported to BBR and B&W-NPGD participants.

II.3.C. Invalid Measurements

Failed, sporadic, or otherwise questionable measurements must be noted at the beginning and end of each test, and upon their first occurrence.

The data-acquisition signal from invalid instruments should be replaced with a constant signal which unambiguously signifies an invalid measurement.

II.3.D. Log

Record loop evaluations and observations onsite, as they occur.

Notify BBR and B&W-NPGD Technical Representatives of emergency events, significant abnormal or unforeseen occurrences, and major equipment failures, as they occur. If the significance of an event is not clear, report the event.

II.4. Administration

II.4.A. Changes

Test plans including scope and schedule must be altered when so dictated by testing experience, cf. Section II.3.A. herein.

II.4.B. Acceptance

Test acceptance and satisfactory test completion is to be based on the simulation of the relevant loop conditions and interactions, with the acquisition of accurate descriptive data. Pre-test predictions and estimates of performance are test planning and control aids only; they do not bear on test acceptance.

II.4.C. Numbering

Tests points are numbered to clearly and simply denote test conditions. Each test number consists of six digits in three groups:

Group 1. The first two digits denote the test number, cf. tests numbered 1 through 16, table II.2.

Group 2. The third and fourth digits are sequential points within one test.

Group 3. The fifth and sixth digits identify the variables which are off-nominal. Variables will be numbered in the individual test-specification document.

Test points with more than two off-nominal variables are flagged by setting this group to 99.

Examples: "100000" denotes the Boiler Condenser Mode With Non-Condensibles Test point at nominal conditions. "121123" denotes test 12 (Refill Characterization and High Point Vent Effects) sequential point 11, with variables numbered 2 and 3 both at off-nominal conditions.

II.5. Instrumentation

Instrumentation is described in the current revision of the Functional Specifications.[3] Particular measurement requirements will be addressed in the appropriate test specifications.

TABLE II.1. PHASE 1 TESTS GROUPED BY SBLOCA PHENOMENA

I. STEAM GENERATOR HEAT TRANSFER

- 1.1 Steady-State With Forced Primary Circulation
- 1.2 Secondary-Side Transients (Boil-Off, Blowdown, Refill)
- 1.3 Auxiliary Feedwater Spray Effects
    - 1.3.1 With Forced Primary Flow
    - 1.3.2 With Natural Circulation

II. NATURAL CIRCULATION

- 2.1 Steady-State
- 2.2 Transition from a Stationary Isothermal Primary into Natural Circulation
- 2.3 Natural Circulation Cooldown During a SBLOCA

III. BOILER-CONDENSER MODE (STEADY-STATE)

- 3.1 Without Non-Condensible Gases (NCG)
- 3.2 With NCG

IV. TRANSITION FROM FORCED FLOW INTO NATURAL CIRCULATION

V. INTERRUPTION OF NATURAL CIRCULATION AND TRANSITION INTO THE BOILER-CONDENSER MODE

VI. REFILL AND TRANSITION INTO NATURAL CIRCULATION

- 6.1 Without High Point Venting
- 6.2 Effect of High Pressure Injection Distribution
- 6.3 Effect of LOCA Position
- 6.4 Effect of LOCA Size
- 6.5 Effect of High Pressure Injection (HPI) Redundancy
- 6.6 Effect of Non-Condensible Gases
- 6.7 Effect of Increasing Vent Capacity or Secondary-Side Level

VII. INTEGRAL TEST (COMPLETE SBLOCA TRANSIENT) - 6 PHASES

- Circulation
- Interruption of Circulation
- Boiler-Condenser Mode
- Refill
- Cooldown
- Depressurization

TABLE II.2. TEST OUTLINE

Phase 1 (basic variations) tests arranged by test categories and in the order of testing. Comparable contractual tests[1] are listed under "Tender".

CATEGORY TEST	TENDER (cf. Appendix A. herein)
I. STEAM GENERATOR (SG) HEAT TRANSFER	
1. SG Characterization (steady state, forced flow).	
2. Auxiliary Feedwater (AFW) Effects in forced flow.	A
3. SG Transients (boiloff, blowdown, and refill).	B
4. AFW Effects in natural circulation.	A
II. NATURAL CIRCULATION (NC)	
5. NC Characterization.	
6. NC Transient: NC initiation in a stationary and isothermal system.	G.1
7. NC cooldown.	
8. NC Flow Transient: Establish NC following the interruption of forced flow.	
III. CONDENSING PRIMARY OR BOILER-CONDENSER MODE (BCM)	
9. BCM Characterization (steady state without non-condensible gases, NCG).	C
10. BCM With Non-Condensible Gases (steady state)	D
11. BC Transient: Establish BCM after the interruption of NC.	G.2,H
IV. REFILL TRANSIENTS AND TRANSITION INTO NC	E
12. Refill Characterization and HPV Effects	F
13. High Pressure Injection (HPI) effects on refill (Vary HPI distribution and redundancy).	

TEST	TENDER
14. I[illegible]k effects on refill (vary break size and location).	
15. NCG effects on refill.	
V. COMPOSITE EFFECTS	(ALL)
16. Complete SBLOCA Transient (including NC, interruption of NC, BCM, refill, cooldown, and depressurization).	

TABLE II.3. TEST VARIABLES

Basic (Phase 1 testing) variables are checked (✓). Irrelevant variables are X'd (X).
Unmarked variables are significant to the test, but are not included among the basic variations.

NO:	1	2	3	4	5	6	7	8	9	10	1	12	13	14	15	16	17	18		
VARIABLE:	PRIMARY Power	Flow (Free & Forced)	Level	HPV Capacity	HPI No.	HPI Eff'y.	RVVV Actuation	Leak Size	Leak Loc'n.	NCG Volume	Inj. Loc.	Species	SECONDARY AFW Control (Level)	Inj. Elev.	Wetting	Pressure	SG Δp-Rate	Initial ΔT	Number of Basic Variables	Test No.
I. STEAM GENERATOR HEAT TRANSFER.																				
			X	X	X	X	X	X	X	X	X	X						X		
1. SG Char'n	✓	✓											✓			✓			4	1.
2. SG Trans.													✓			✓	✓		3	2.
3. AFW-Forced													✓	✓	✓	✓			4	3.
4. AFW-Free													✓	✓	✓	✓			4	4.
II. NATURAL CIRCULATION.																				
			X							X	X	X								
5. NC Char'n	✓	✓					✓						✓			✓			5	5.
6. NC ΔT Trans.	✓	✓					✓						✓			✓		✓	6	6.
7. NC Cooldown	✓				✓			✓	✓							✓			5	7.
8. NC Flow Trans.	✓	✓					✓						✓			✓			5	8.
III. BOILER-CONDENSOR MODE.																				
				X													X	X		
9. BCM Char'n.	✓		✓				✓						✓			✓			5	9.
10. BCM w/NCG	✓		✓				✓			✓	✓	✓	✓			✓			8	10.
11. NC-to-BCM	✓				✓			✓	✓				✓	✓	✓	✓			8	11.
IV. REFILL TRANSIENTS.																				
																	X	X		
12. Char'n HPV	✓			✓									✓			✓			4	12.
13. HPI					✓	✓													2	13.
14. Break								✓	✓										2	14.
15. NCG										✓	✓	✓							3	15.
V. COMPOSITE EFFECTS																				
16. SBLOCA Trans.			X		✓			✓	✓									X	3	16.

III. RESULTS

III.1. Online Results

Online data will ordinarily use English units to facilitate test control; units should be selected and prefixed to obtain convenient magnitudes, i.e. 0.001 to 1000. Online plots will also use English units, reserving space for subsequent labelling by BBR.[4] Those plots not using time or dimensionless scales may, alternatively, be specified in normalized units, e.g. ΔT divided by maximum ΔT. Dimensionless plots are particularly appropriate for core power and loop flow (which are conveniently expressed as percent of full power or flow).

Online data and plots should be distributed for timely test interpretation and reporting, and retained for reference.

III.2. Data Files

III.2.A. Types

Each test will generate three types of files: An unalterable raw data file, a data conversion file, and a file of engineering data in English units. The ARC test coordinator or his designated representative is responsible for the generation, verification, revision, and maintenance of these files; test participants may access but not alter them.

III.2.B. Format

III.2.B.(1). Units

Unit selections should be made to obtain convenient magnitudes of converted readings, i.e. from 0.001 to 1000. Unit selections should be kept as uniform as possible among the like measurements (i.e., all pressures in psia). Unit selections for a given measurement should also be kept constant among all the tests and test points. Deviations from either practice must be carefully recorded and reported.

Inter-system unit conversion are provided for reference in Appendix B. (Engineering data will be supplied only in English units).

III.2.B(2). Order

The data files in engineering units should be ordered by increasing real test time. Then the files read: Time "t," all measurements at time "t"; time "t + Δt," all measurements at time "t + Δt"; and so on. The number and order of entries (at each time) must be fixed throughout a test, and should be fixed for all tests and test points. The first entry of each file should identify the test point. The units, and number and order of entries at each time, must also be keyed if they vary among the data records.

The order of data within each time-entry should remain constant for all entries and all test points; this order should roughly correspond to decreasing significance (e.g., primary loop measurements, then secondary loop measurements, followed by loop boundary system and ancillary system measurements). Within this arrangement, data from like measurements should be grouped (i.e., all levels, all temperatures, all pressure, etc.). Blank or invalid measurements must be unambiguously flagged.

III.2.B(3). Field

The smallest tens place of each data field should reflect instrument sensitivity. (This level of sensitivity does not usually correspond to absolute accuracy). For example, a thermocouple reading the equivalent of 503.179 F, but sensitive to ±0.1 F, would be entered in a field having one decimal place as "503.2" F. Oversize data fields carrying meaningless digits are to be universally avoided.

III.2.C. Identification

Data file identification should be keyed to the test point identifier. Additional heading entries should indicate: The verification status of the data (determined by the ARC test coordinator), the file version number, and the approximate test beginning and end times and dates. (Because the day precedes the month in the European system, it is suggested that the month be identified by abbreviation rather than by number; also, use the twenty-four hour system, i.e. use "1600" to denote 4 p.m.).

III.2.D. Transmission

Blocks of raw test data will periodically be transmitted to the ARC VAX computer. The VAX will generate processed data files which will be taped for storage at ARC. A duplicate tape of each engineering data file will be sent to NPGD by shuttle for mounting on the CDC. Data users thus may access the files using two techniques: Relatively small blocks of data may be gathered on the VAX and transmitted electronically to the CDC for early access; and the complete data file may be accessed after the tape has been assimilated into the CDC tape library.

III.2.E. Maintenance

The ARC test coordinator is responsible for the maintenance, revision, and retention of the files of test data. All data files should be kept current and accessible at least for the duration of the testing contract.

Only one set of files should exist for each test. Revision of any data file should trigger the revision of all files for the affected date point(s), and the deletion of the superceded files.

File status should be reported by ARC as revisions occur. All existing and deleted files should be identified by test point(s), file revision number and date, and reason for revision.

III.3. Reports

Test results are to be reported in two forms: Quick-Look Reports following each (basic, or phase 1) test, and a Final Report summarizing the entire program. The Quick-Loop Reports will be prepared by NPGD (within two months of the subject tests), but will be based on the Summary Data Packages supplied by ARC (within two weeks of the completion of the subject tests).[2]

The Summary Data Package should contain: Identification of the test described, testing dates and conditions, and testing abnormalities if any; (a copy of) the control room logs; reproducible online data sheets and graphs; and identification of the checked data files pertaining to these tests. Interpretations of results and observations are encouraged but are not required. Control room logs must be annotated and complete. Any original test documentation will be returned to ARC for retention, immediately after preparation of the corresponding Quick-Look Report.

IV. FORMAL VERIFICATION

Formal verification of this test program is based on NPGD Specification 09-1427-00, "Quality Assurance Requirements for Research and Development."[5] The applicability of this document is discussed below.

IV.1. Organization, QA Program

Sections 1 and 2 of the Specification apply.

IV.2. Design Control

NPGD has performed design calculations for customer review.[6] Therefore Section 3 of the Specification does not apply and ARC should not include detailed design calculations in the technical plant, although ARC (informal) verification of the design is encouraged.

IV.3. Procurement Document Control

Section 4 of the Specification applies.

IV.4. Instructions, Procedures, and Drawings

Section 5 of the Specification applies, except that technical (test) procedures may be revised by the ARC coordinator or his representative, and implemented immediately without the review stipulated in Subsection 5.2 of the Specification. Control of testing revisions has been described in Section II.3.A. herein.

IV.5. Document Control

Specification Section 6 applies, except that testing may proceed prior to review of the revised plans and/or procedures, as described above in paragraph IV.4.

IV.6. Control of Purchases, Components, and Special Processes

Specification Sections 7 through 9 apply.

IV.7. Inspection

Specification Section 10 applies, except that as-built dimensions shall not be measured or recorded. Rather, as-installed loop dimensions shall be measured as described in the Functional Specifications[3] and recorded; heated loop elevations shall be measured and recorded during the initial loop heatup; and loop volumes shall be measured and recorded during the initial loop-checkout tests.

IV.8. Test Control

Specification Section 11 applies except that the ARC test coordinator or his representative may direct testing which is not in conformance with the written test procedure, as described herein in Section II.3.A. The "acceptance criteria" of Specification[5] Section 11, 1(h) is to be based on the completion of testing at the prescribed (or revised) conditions with adequate and accurate descriptive data, not on a comparison of test performance to test predictions.

IV.9. Test Equipment, Handling

Specification Section 12 applies, Specification Section 13 is not applicable.

IV.10. Status

Specification Section 14 applies.

IV.11. Noncomformance

Specification Section 15 applies, except that reports of noncomformance during testing shall be made to the BBR representative as well as to B&W-NPGD.

IV.12. Corrective Action

Specification Section 16 applies.

IV.13. Quality Assurance Records

Specification Section 17 applies. All records, including data banks, must be retained at least until the completion of the contract.

IV.14. Audits, Correction Action

Specification Sections 18 and 19 apply.

REFERENCES

1. "Small Break Loss-of-Coolant Accident (SBLOCA) Testing Program - A tender prepared for Brown Boveri Reaktor Gmbh," B&W Doc. No. 08019-015 Rev. 3 (10 Feb. 1981).

2. "Composite Program Plan for SBLOCA Testing Program," B&W Doc. No. 12-1123165-01 (7 July 1981).

3. "Small Break Loss-of-Coolant Accident (SBLOCA) Loop Functional Specifications,: (Rev. 1) B&W ARC (July, 1981).

4. "SBLOCA - Testing - SI Units," G. Ahrens telecopy MEG-020 (Sept., 1981).

5. "Quality Assurance Requirements for Research and Development," B&W NPGD Specification 09-1427-00, Contract No. NSS-205, Customer: Standard Plant Design (released 27 Oct. 1975).

6. "GERDA Design Requirements," B&W Doc. No. 12-1123163-01 (Rev. 1), (June, 1981).

APPENDIX A. TEST PHASES

Source: "Small Break Loss-of-Coolant Accident (SBLOCA) Testing Program -- A Tender Prepared for Brown Boveri Reaktor GmbH," B&W Doc. No. 08019-015, Rev. 3, (February 10, 1981).

A. AFW Characteristics

(1) Background: Plant AFW wets approximately 2-4% of the tubes, around the OTSG periphery. The resulting three-dimensional flow and heat-transfer profiles may significantly affect OTSG heat transfer and stability with AFW injection.

The 19-tube model OTSG is largely a one-dimensional device. The dependence of model performance on AFW-injection profiles may be investigated by using two injection configurations, one for minimum and one for maximum wetting (as well as the high and low injection elevations of the 177 and 205 plants).

Model AFW nozzles for these bracketing injection profiles will be selected in bench-scale tests.

(2) Objective: Determine steady-state model OTSG heat transfer with bracketing AFW injection profiles.

(3) Configuration: Bracketing AFW injection nozzles, high and low injection elevations (single-phase primary).

(4) Variables: AFW injection configuration, rate, and temperature; and primary power and flow.

(5) Measurements: Primary fluid temperature profiles within the OTSG tubes.

(6) Notes: (a) Primary flow may be reduced to enhance primary fluid temperature changes; avoid the turbulent-

to-laminar flow transition.

(b) Model the highest of the 177LL AFW injection elevations (approximately 14" below the UTS).

B. Secondary Blowdown and Refill

(1) Description: With low power, secure secondary feed; after secondary steam pressure begins to decrease, reinitiate feed (using various AFW configurations, or main feed). Investigate the influence of RCP coastdown by testing at several primary flowrates.

(2) Objective: Determine OTSG heat transfer during blowdown and refill.

(3) Vary: Initial power, primary flowrate and subcooling, and secondary inventory; FW mode and rate, including AFW configuration; and initial pressure upon refilling.

(4) Measure: Transient second inventory and axial temperature profiles (use temperatures for level indication).

(5) Note: Consider reducing initial primary to increase initial secondary level.

C. Condensing Primary w/o NCG (Steady State)

(1) Objective: Determine (steady state) OTSG heat transfer with a condensing primary.

(2) Configuration: Both (177 and 205) AFW injection elevations must be available.

(3) Vary: Core power, primary pressure, primary (or secondary) level, feed temperature, and primary natural circulation flowrate (perhaps by a variable restriction).

(4) Measure: Primary and secondary level, (low) primary natural circulation flowrate and secondary froth height.

D. Condensing Primary w/NCG (Steady State)

(1) Objective: Determine S/S OTSG heat transfer with a condensing primary and noncondensibles. (Configuration as in C)

(2) Vary: (C plus) amount and species of NCG injected, injection location, and (optionally) injection rate.

(3) Measure: (C plus) gas-phase NCG concentrations (gross measurements at top of HLUB and top of core), and (optionally) NCG injection rate.

E. Condensing Primary Transients (w/ and w/o NCG)

E.1 Oscillations (primary pressure and level)

1. Background: As the primary phase-interface level in the OTSG approaches the secondary level, condensation may abruptly lower primary pressure, thus increasing the HPI rate, particularly on low-head-HPI plants (MK, DB1). The increased HPI injection may cause primary level to increase, shutting off OTSG condensation and ultimately repressurizing the primary. These primary pressure level pulsations may continue until the decreasing core decay heat level is insufficient to cause repressurization.

2. Objective: Investigate primary BC (boiler-condensor) - mode oscillations.

3. Configuration: HPI and two-elevation AFW must be available. HPI discharge pressure readings must be available at the HPI pump controls (to permit simulation of plant HPI Q(p) characteristics). Measurable and controllable

leak paths are required.

4. Vary: System mass inventory rate of change (HPI less leak rate); leak location, core power, and NCG concentrations.

5. Measure: Leak and HPI flows, NCG concentration, and secondary level swell.

6. Notes: (a) Leaks might be located at the bottom of the reactor vessel, or at the top of the HLUB or in the cold leg.

   (b) HPI fluid temperature should be ambient, 40 to 120° F.

   (c) The MK HPI pump Q(p) characteristics will be simulated.

E.2 Primary Refill w/o HPV

1. Background: Primary refill w/o HPV depends on interphase heat transfer in the primary, to depressurize the primary and permit HPI injection, particularly in the low-head-HPI plants.

2. Objective: Investigate primary system refill w/o HPV.

3. Configuration: Leak location as in E.1.

4. Vary: HPI characteristics, leak rate and location, initial primary pressure, and AFW injection elevations.

5. Measure: Primary level, and leak and HPI flow rates.

6. Note: Plant HPI characteristics will be approximated in model testing.

E.3 Primary Refill w/HPV

1. Background: HPV should greatly augment primary refill, cf.E.2.

E.3 Primary Refill w/HPV (cont.)

2. Objective: Investigate primary refill w/HPV.
3. Configuration: The HPV lines must be "oversized", but with rate-control (metering) valves, to permit HPV-rate variation.
4. Vary: as in E.2, plus HPV operating procedure. HPV should be actuated as directed in the operator guidelines, as it appears optimum during testing, and as it appears apparently undesirable (to investigate the influence of inadvertent operation).
5. Measure: (as in E.2, plus) HPV fluid and NCG flow rates.

F. HPV Effects

1. Background: HPV operating procedures are being developed; preliminary B&W procedures utilize HPV to counteract gross NCG generation from fuel rod cladding reaction, and to facilitate primary refill. This HPV-effects test may be used to develop additional HPV uses.
   In addition to the general HPV-refill performance addressed in E.3, HPV may initiate primary oscillations; with HPV, the primary level increase may decrease primary condensation, thus allowing primary pressure to rise (much as in the Oscillation test, E.1).
2. Objectives: Investigate HPV effects.
3. Vary: HPV rate, initial primary level and pressure.
4. Measure: HPV fluid and NCG rates, transient primary level and pressure.

G. Natural Circulation (Transient)

G.1 Restart

1. Background: Natural circulation is hypothesized to stall for a variety of reasons. The time delay and system stability during natural circulation restart are of interest.

2. Description: Stall and restart natural circulation using one or more of the following techniques:

   a. With primary and secondary initially stalled and w/o imposed heat transfer, energize the model core.

   b. From low power natural circulation steaming, secure feed until primary stalls, then reinitiate feed.

   c. From low power natural circulation steaming, secure secondary steaming and decrease core power, and use HPI as necessary to accentuate the thermal inversion; then reinitiate secondary steaming.

   d. As in G.2 Primary Phase Transitions, continue decreasing primary level until HLUB spillover stops (w/o primary condensation); then actuate HPI.

   e. Inject a gross amount of NCG into the HLUB, with the primary in a BC mode; (restart w/ and w/o HPV).

3. Objective: Characterize the restart of natural circulation.

4. Configuration: Component elevations are significant in this test.

5. Vary: NCG concentration, and stalling and restart controlling variables. (i.e., vary core power in (2.a.).

6. Measure: Low primary natural circulation flowrate, primary fluid temperatures in the hot leg and cold leg piping, and level in the hot leg.

G.2 Primary Phase Transitions

1. Background: Primary natural circulation may occur with single phase flow, mixed or homogeneous two phase flow, and with separated phases. The transient cooldown performance with these various flow modes, and during the transition among modes, must be ascertained.

2. Objective: Determine system performance during the transition among the modes of natural circulation.

3. Configuration: Thermal center elevations, and component elevations to a lesser extent, are significant to this test; suitable model piping is also significant.

4. Vary: Initial power, pressure, and leak rate; HPI characteristics; and secondary level and AFW flowrates.

5. Measure: Primary natural circulation flowrate; primary fluid levels in the reactor vessel, pressurizer, and steam generator; primary fluid temperatures in the hot leg and cold leg; secondary level. Video tape recordings of flow phenomena in the hot leg (through two viewing parts during selected portions of the test).

G.2 Primary Phase Transition (cont.)

6. Note: Plant HPI characteristics should be available for model simulation.

H. Secondary Swell Behavior in BC Mode

1. Background: As decreasing liquid level approaches that of the secondary, primary condensation increases abruptly, increasing primary-to-secondary heat transfer, and increasing secondary froth level; thus an increased tube length is available for condensation, and the process may be self-amplifying.

   This test may be conducted with G.2., Primary Phase Transitions.

2. Objective: Investigate secondary level swell at the onset of primary condensation.

3. Vary: Primary leak rate and power, AFW-injection elevation. (optional: NCG concentration).

4. Measure: Transient secondary level and temperature profiles.

APPENDIX B. UNIT CONVERSIONS

Unit equivalents are listed for three systems: "English" (or USCS, the U. S. Customary System), "SI" (The International System of Units), and Technical ("Technisches Maßsystem"). These are the systems indexed on the BBC-distributed unit conversions table. The English, SI, and Technical equivalents are listed in the same format for each quantity to be converted. For example, the first entry, length, indicates that 1 ft (English) is equivalent to 0. 3048m (SI and Technical); the next line is simply the inverse, i.e. 1m = 3.281 ft.

All entries have been checked against the Conversion and Equivalency Tables (pp. 1-44 through 1-54) of Marks' Standard Handbook for Mechanical Engineers, Theodore Baumeister (ed.), Eighth Edition, McGraw-Hill (1978). "BBC" and "Marks" differ slightly on the Technical-system (mmHg) equivalent of 1 bar pressure (SI). Marks gives 750.1 mmHg, BBC lists 750.0, but the other BBC table entries obtain 750.1 by back calculation; thus the entry has been truncated to "750."

The meaning of each unit abbreviation is listed after the conversion table. Certain units deserving special consideration are described below.

at: This Technical-system unit of pressure, 1 at = 14.22 psi, should not be confused with the usual value of standard atmospheric pressure, 14.696 psi.

mWs: This Technical-system unit of pressure refers to meters of water, Marks' gives these water conditions at 15° C and g = 9.80665 m/s^2.

t: This unit of mass in the Technical-system is equivalent to 2204.6 lbm, contrasted to a "short" ton of 2000 lbm.

kpm: This unit of energy in the Technical-system is equivalent to a kilogram-force through one meter.

psh: This unit of energy in the Technical-system is a metric horsepower-hour, according to Marks.

kpm/s: This unit of power in the Technical-system is equivalent to a kilogram-force through one meter, per second.

PS: This unit of power in the Technical-system is a metric horsepower, according to Marks.

EQUIVALENTS

QUANTITY	English	=	SI	=	Technical
Length	ft		m		m
	1		0.3048		0.3048
	3.281		1		1
Area	ft^2		m^2		m^2
	1		0.0929		0.0929
	10.76		1		1
Pressure	psi		bar		at
	1		0.06895		0.0703
	14.50		1		1.02
	14.22		0.9807		1
	in. water		bar		mWS
	1		0.00249		0.0254
	401.5		1		10.2
	39.37		0.09807		1
	in. Hg		bar		mmHg
	1		0.03386		25.4
	29.53		1		750
	0.03937		0.00133		1

Quantity	English =	SI =	Technical
Enthalpy	Btu/lb_m	$\frac{kJ}{kg}$	$\frac{kcal}{kg}$
	1	2.326	0.5556
	0.4299	1	0.2389
	1.800	4.187	1
Mass	lb_m	kg	t
	1	0.454	0.000454
	2.205	1	0.001
	2205	1000	1
Specific Volume	ft^3/lb_m	$\frac{m^3}{kg}$	$\frac{m^3}{kg}$
	1	0.06243	0.06243
	16.02	1	1
Specific Heat	$\frac{Btu}{lb_m F}$	$\frac{kJ}{kg\ K}$	$\frac{kcal}{kg\ C}$
	1	4.187	1.000
	0.2389	1	0.2389
	1.000	4.187	1
Mass Flowrate	$lb_{m/s}$	$\frac{kg}{s}$	t/h
	1	0.4536	1.633
	2.205	1	3.6
	0.6124	0.2778	1

Quantity	English	=	SI	=	Technical
Volumetric Flowrate	ft^3/s		m^3/s		m^3/s
	1		0.02832		0.02832
	35.31		1		1
Energy (or work)	$ft\text{-}lb_f$		Nm		kpm
	1		1.356		0.1383
	0.7376		1		0.102
	7.233		9.807		1
	BTU		kJ		kcal
	1		1.055		0.252
	0.9478		1		0.2389
	3.968		4.187		1
	hp-hr		kWh		PSh
	1		0.7457		1.014
	1.341		1		1.36
	0.9863		0.7355		1
Power	$ft\ lb_f/s$		Nm/s = watt		kpm/s
	1		1.356		0.1383
	0.7376		1		0.102
	7.233		9.807		1

Quantity	English	=	SI	=	Technical
Power (Cont'd)	hp		kW		PS
	1		0.7457		1.014
	1.341		1		1.36
	0.9863		0.7355		1
	BTU/h		J/S		kcal/h
	1		0.2931		0.252
	3412		1000 = (1 kw)		859.8
	3.968		1.163		1
Thermal Conductivity	$\frac{BTU}{h\ ft\ F}$		$\frac{J}{m\ s\ K}$		$\frac{kcal}{m\ h\ C}$
	1		1.731		1.488
	0.5778		1		0.8598
	0.672		1.163		1
Heat Transfer Coefficient	$\frac{BTU}{h\ ft^2 F}$		$\frac{J}{m^2 s\ K}$		$\frac{kcal}{m^2 h\ C}$
	1		5.678		4.883
	0.1762		1		0.8598
	0.205		1.163		1

UNIT ABBREV.	QUANTITY	SYSTEM E	SI	T	MEANING
at	pressure			X	Atmosphere
bar	pressure		X		Bar
BTU	energy	X			British Thermal Unit
BTU/h	power	X			BTU per hour
BTU/hftF	thermal conductivity	X			BTU per hour-feet-degree F
BTU/hft^{2}F	Heat Transfer Coefficient	X			BTU per hour-feet squared-degree F
BTU/lb$_m$	enthalpy	X			BTU per pound (mass)
BTU/lb$_m$F	specific heat	X			BTU per pound (mass)-degree F
ft	length	X			Feet
ft^2	area	X			Feet squared
ftlb$_f$	energy	X			Foot-pound (force)
ftlb$_f$/s	power	X			Foot-pound (force)/second
ft^3/lb$_m$	specific volume	X			Feet cubed per pound (mass)
ft^3/s	volumetric flowrate	X			Feet cubed per second
hp	power	X			Horsepower
hp-hr	energy	X			Horsepower-hour
in. Water	pressure	X			Inches of water
in. Hg	pressure	X			Inches of mercury
J/s	power		X		Joule per second
J/msK	thermal conductivity		X		J per meter-second-degree K
J/m^{2}sK	heat transfer coefficient		X		J per meter squared second-degree K

UNIT ABBREV.	QUANTITY	SYSTEM E	SI	T	MEANING
kcal	energy			X	Kilo-calorie
kcal/h	power			X	kcal per hour
kcal/kg	enthalpy			X	kcal per kilogram
kcal/kgC	specific heat			X	kcal per kg-degree C
kcal/mhC	thermal conductivity			X	kcal per meter-hour-degree C
$kcal/m^2hC$	heat transfer coefficient			X	kcal per meter squared-hour-degree C
kJ	energy		X		Kilo-Joule
kJ/kg	enthalpy		X		KJ per kilogram
kJ/kgK	specific heat		X		KJ per kilogram-degree K
kpm	energy			X	The equivalent of a kilogram (force) through one meter
kpm/s	power			X	kpm per second
kW	power		X		Kilo-watt
kWh	energy		X		KW - hour
lb_m	mass	X			Pound (mass)
lbm/s	mass flowrate	X			lbm per second
m	length		X	X	meter
m^2	area		X	X	meter squared
m^3/kg	specific volume		X	X	meter cubed per kilogram
m^3/s	volumetric flowrate		X	X	meter cubed per second
mmHg	pressure			X	milimeters of mercury
mWS	pressure			X	meters of water

UNIT ABBREV.	QUANTITY	SYSTEM E	SYSTEM SI	SYSTEM T	MEANING
Nm	energy		X		Newton-meters
Nm/s	power		X		Nm per second (= one watt)
psi	pressure	X			pounds (force) per square inch
PS	power			X	A metric horse-power, according to Marks
t	mass			X	metric tons
t/h	mass flowrate			X	t per hour