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# International Agreement Report

# RELAP5/MOD3.2 Assessment Using GERDA Small Break Test, 1605AA

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## Abstract

The Small Break Loss of Coolant Accident (SBLOCA) Test Facility GERDA (Geradrohr Dampferzeuger Anlage) was designed to evaluate the post SBLOCA thermal-hydraulic events expected to occur in the German Mülheim-Kärlich plant. The scaled in volume 1:1 in height Test Facility was built and tested by B&W at the Alliance Research Centre (ARC) under contract of BBR (Brown Boveri Reaktor GmbH) now ABB Reaktor GmbH (Ref. /1/, /2/). The objective of the whole test program was to obtain detailed experimental data for the evaluation of single and composite SBLOCA phenomena and for the verification and the refinement of the analytical tools and models used to predict plant performance during SBLOCA transients.

This report presents the results of RELAP5/MOD3.2 assessment on the integral (composite) GERDA Test 1605AA which features a complete sequence of a 10 $cm^2$ Reactor Vessel Leak transient conducted on April 12th, 1983. The purpose of the assessment analysis was to determine whether the tested RELAP version can predict the major phenomena of this complex transient and to provide some useful information both to code developers and analysts for the application on SBLOCA transients in 'Once-Through-Steam-Generator' Plants.

The results of the post test calculations were compared to the test data. This comparison has shown that in general most of the important phenomena are predicted quite well. However differences in details such as timing of key sequences and some disagreements, such as over and under predictions of certain key parameters were observed. In general it was concluded from the comparison that the predictability of such complex transients, especially the BCM (boiler-condenser) phase, is fairly good. However there were several deficiencies discovered mainly in predicting OTSG behaviour, leak flow and the refill phase during SBLOCA in an OTSG plant. These finding should be used as a target for further fine tuning and enhancements of the code.

Additionally this report presents some base calculations identified as conditioning calculations of OTSG steady state and transient behaviour which is one of the essentials for the prediction of phenomena observed in the SBLOCA scenarios.

Finally a complete input listing of the RELAP5MOD3.2 GERDA model is included in appendix B.

The analysis presented here and the report is an inkind contribution to the CAMP contract.

## Abbreviations

| | |
|---|---|
| ABBR/BBR | ABB Reaktor GmbH |
| AFW | Auxiliary Feed Water |
| ARC | Alliance Research Centre, Ohio |
| B&W | Babcock & Wilcox |
| BCM | Boiling Condensing Mode (Phase of Transient, Heat Transfer) |
| CAMP | Code Assessment and Maintenance Program |
| CL | Cold Leg |
| DAS | Data Acquisition System |
| DC | Down Comer |
| FP | Full Power |
| FW | Feed Water |
| GERDA | Geradrohr Dampferzeuger Anlage<br>Straight-Tube Steam Generator Test Facility |
| HL/HLUB | Hot Leg / HL "inverted" Loop (U-) Bend (Candy Cane) |
| HPI | High Pressure Injection |
| HPV | High Point Vent (Hot Leg) |
| IEOTSG | Integral Economiser OTSG |
| KMK / MK | Mülheim-Kärlich Nuclear Power Plant |
| KWU | Kraftwerk Union |
| LOCA | Loss of Coolant Accident |
| NPP | Nuclear Power Plant |
| NSSS | Nuclear Steam Supply System |
| OTSG | Once Through Steam Generator |
| PKL | Primärkreislauf, Primary Coolant Loop Test Facility |
| PORV | Power operated Relief Valve |
| PRZ | Pressurizer |
| RPV | Reactor Pressure Vessel |
| PWR | Pressurized Water Reactor |
| RCS | Reactor Coolant System |
| RSK | Reaktorsicherheits Kommission (German Reactor Safety Board) |
| SBLOCA | Small Break LOCA |
| SG | Steam Generator |
| VV | Vent Valve |

# 1 Introduction

Since many years Small Break LOCA scenarios are in the centre of interest both for licensing bodies to understand the complex phenomena and learn about the accompanying risks and for code developers to increase the capabilities of licensing codes and to implement specific physical models and enhancements. The Probabilistic Risk Assessment activities in the US and Germany and especially the TMI-2 event in April 1979 raised quite a number of additional reactor safety questions in the early eighties mainly in the area of post-SBLOCA system performance. Particularly plants with the Hot-Leg-U-Bend Once-Through-Steam-Generator (HLUB-OTSG) configuration underwent thorough examinations. While in the US B&W had already built some nuclear power plants with OTSG in the seventies, in Germany only one plant of this type, Mülheim-Kärlich NPP was under construction since 1973 by a consortium of BBR and B&W.

Electrified by the TMI-2 problems and the regulations of the German Reactor Safety Board (RSK-LL) BBR consented to conduct experiments to remove the concerns about SBLOCA transient behaviour. As B&W already had some test rigs in ARC at that time, featuring mainly coupled Pressurizer and OTSG models used so far for code verification, BBR and B&W contractually agreed in 1981 to build an independent test loop for SBLOCA transients named GERDA, an acronym of Geradrohr Dampferzeuger Anlage which is German for OTSG plant (Ref. /1/, /2/). GERDA pretest prediction analyses were performed through spring 1982, characterisation tests mid of the year. SBLOCA testing was begun only a year and a half after contract award, and it extended from September 1982 through April 1983. In total 112 tests have been performed in two campaigns including characterisation tests used to determine loop characteristics and to exercise specific loop features such as instrumentation, vent valve actuation, cool down control and others. In the second phase SBLOCA scenarios were addressed in detail. This testing followed a progression from separate-effects to composite, integral-system testing. In this phase testing was performed in five categories: Steam Generator Heat Transfer, Natural Circulation, Boiler-Condenser Mode, Refill and Composite Tests (Ref. /3/).

For the RELAP5/MOD3.2 assessment presented in this report a composite integral test (Test 1605AA) was chosen which is a complete SBLOCA transient and which was performed on April 12th 1983. This test, selected as the nominal composite test, represents a 10 $cm^2$ Reactor Vessel break with 2 out of 4 HPI trains available. The test scenario covers the transient from leak initialisation, loop saturation, Boiling Condensing Mode (BCM) and primary refill. In this report a post-test analysis of test 1605AA applying RELAP5/MOD3.2 is presented. An overview and description of the GERDA Test Facility as well as of the test and the test conditions are provided. The RELAP input model of GERDA test 1605AA is described. The results of the calculations and the correspondence to the test phenomena are discussed and finally the conclusions and recommendations from this assessment are presented. An input listing (limited distribution) is attached in the appendix. The purpose of the presented analysis is to add experience to the CAMP community, applying RELAP to OTSG plant transients, and to serve as an inkind contribution to the Code Assessment and Maintenance Program.

## 2 Description of the GERDA Test Facility

The Small Break Loss of Coolant Accident Test Facility GERDA was designed to evaluate post SBLOCA thermal-hydraulic events for the 1300 MWe German Mülheim-Kärlich plant, which is based on a license of B&W's 205 NSSS design. A principal drawing of the primary loop of the 205 design is shown in Fig 2.1. The main difference to the typical B&W 177 plants like Rancho Seco or TMI (Fig. 2.2), apart from power level and core design, is the raised loop configuration and the Integral Economizer OTSG (IEOTSG). The typical OTSG has feed water preheating in the feed water downcomer by the admission of rated life steam flow from the tube bundle to the top of the downcomer through aspirator orifices. In the IEOTSG design the feed water enters the tube bundle section subcooled and is heated to saturation in the lower part of the SG. In this design the steam superheating is enhanced to 38 K at FP. The main SG characteristics of both designs, 177 and 205, is seen in Fig. 2.3. In view of modeling SG with RELAP the IEOTSG is simpler to model because of the absence of downcomer feed water preheating but more challenging with respect to thermal dynamics because of the complete set of heat transfer mechanisms and flow phenomena along the tubes (subcooled to superheated).

GERDA was built and tested by the B&W Utility Power Generator Division at the B&W Alliance Research Center, Ohio, under contract of BBR (Brown Boveri Reaktor GmbH) now ABB Reaktor GmbH. The Test Facility was intended to be primarily used to evaluate separate effects and integral system tests at scaled power levels between 1 to 5% . The objective of the whole test program was to obtain experimental data for the evaluation of all significant SBLOCA phenomena and for the verification and the refinement of the analytical models used to predict plant performance during SBLOCA transients. SBLOCA fluid behavior is typically buoyancy-driven in major transient phases, thus full elevation modeling was the main priority for scaling. The Test Facility therefore retains all MK elevations. Full elevations, of course, do not guarantee for all plant-typical post-SBLOCA phenomena. Therefore all governing important SBLOCA phenomena (e.g. HL 2-phase flow behavior) have to be preserved as a second scaling criteria. All components are scaled with respect to volume by the ratio of the steam generator tubes (32026/19=1685,6). Finally, loop irrecoverable losses are conserved by use of orifices to match original MK losses.

With this scaling philosophy piping size has been selected to preserve the (vapor) Froude number, and thus the ratio of inertial to buoyant fluid forces. This preserves flow regimes according to well known flow maps and flooding criteria. System pressure and temperatures are not limited in the Test Facility as in other facilities. The test configuration consists of a 1-by-1 model loop (the prototype plant KMK has 2 x 4 loops) which is approximately 95 feet (29 m) high and about 6 feet wide, see Fig. 2.4, including an electrically heated Core Simulator, 1 Hot Leg, a 19 tube model OTSG with full length tubes, 1 Cold Leg, and a Pressurizer. The prevalent power and volume scaling factor is 1685.6 and 1400 respectively, the model core power is limited to 178 KW corresponding to ~ 8% of nominal full power. The ratio of power and volume is 1.2 (1.1 for SEMISCALE 2A, 1.0 for LOBI). The scaling used for GERDA allows for similar time dependencies of the major events in the tests and the prototype plant.

Primary components include a rector vessel vent valve (VV), Pressurizer PORV or Safety Valves, High Point Vent (HPV), High-Pressure Injection (HPI) into the Cold Leg, controlled primary leaks, Auxiliary Feedwater (AFW), and a simulation of the MK 48-bar Steam Relief Valves and Cooldown Valves. No primary reactor coolant pump is included in the basic loop. A multi-purpose pump in a CL bypass line can be used to provide forced primary flow.

Some details of the test arrangement are shown in the following figures. In Fig. 2.5 the 19-Tube OTSG model is presented. It can be seen that additionally to the MK typical IEOTSG design an alternate steam/feedwater mixer is available for OTSG type 177 evaluations. One main phenomenon during BCM is the spillover of steam/water mixture from the HL via the HLUB into the upper plenum of the SG. The model HLUB (Fig. 2.6) is designed to preserve the spillover elevation and to guarantee that voids in the HLUB separate and accumulate at least as likely in the model as in the real plant. In Fig. 2.7 and 2.8 some other details of scaling and preserving of basic geometric dimensions are shown.

In addition to the customary pressure, temperature, level, and pressure-drop measurements, GERDA included HL optical ports, primary and secondary conductivity probes for level, and a CL acoustical (supersonic) flow meter to measure low natural-circulation flow rates. More than 300 parameters could be monitored simultaneously for each test by a heavy duty data acquisition system. Type and locations of instrumentation are given as an overview in Fig. 2.9 and in detail in Figs 2.10 and 2.11 . In appendix A (Table 2.1) a list of all instrumentation used for this test 1605AA is provided in order to be able to identify the parameters on the original data plots.

## 3 Description of Experiment 1605AA

GERDA test 1605AA was conducted on April 12th 1983 in the second phase of testing which addressed SBLOCA phenomena. The test series 16 belongs to category 5, composite effects test, i.e. complete SBLOCA transients. This test series investigated system interactions following SBLOCA. Leak size and location as well as HPI capacity were varied. The nominal sequence of events included draining, saturated spillover circulation, intermittent spillover, punctuated primary depressurisation, stalled primary flow, BCM, HPI flow greater than discharge flow, HLUB spillover by refill, and finally reactor vessel refill. The main interest focussed on the heat transfer from the core to the heat sink provided by the SG, especially in the BCM phase of the transient, and on system refill and integral system behaviour during cool down.

Composite test 1605AA investigates a scaled 10 $cm^2$ Reactor Vessel (RV) leak with two (2) scaled High Pressure Injections (HPI) Pumps. The transient was tested through refill and was intended as the nominal test for the other tests in this series.

At test initialization the primary system is subcooled at forced flow conditions. The primary pressure is 2170 psia, the Core outlet and the Hot Leg temperatures are at 605 F, Cold Leg temperatures are at 570 F. Saturation temperature and Pressurizer fluid temperatures are at 648 F, the PRZ level is 11 feet, the Surgeline metal temperature is approximately 625 F (heated from a scheduled pretest system drain evolution).

The core is powered at 5.2% of scaled full power (1% = 22.3 KW), Primary flow is 9% of scaled full flow (1% = 0,263 lbm/s), the Reactor Vessel Vent Valve (RV VV) is shut close. RVVV – bracketing temperatures are 570 F and 540 F, the RV Upper Plenum fluid temperature is 563 F. Loop flow resistance is nominal.

The Steam Generator (SG) Secondary is being maintained at 1150 psia (Tsat = 562 F) and 11 ft level. The steam flow orifice simulating two (2) 48-bar steam dump valves is installed. AFW (Auxiliary Feedwater) is being injected at 120 F using the lower-elevation (MK situation) and minimum-wetting nozzles. SG heat removal is 4,5% of full power, steam and feed flowrates are 3,3% of full flow (1% = 0,0263 lbm/sec). At 1024 on April 12, 1983 the Data Acquisition System (DAS) is activated; this defines zero time for the data plots and for the discussion following. The entire Test 1605AA sequence is summarized in Section 3.9, a detailed sequence of events can be found in table 3.1 in appendix A.

## 3.1 Initiation

The test is initiated in two steps, to approximate plant-typical conditions at and after loop saturation. Power level at DAS activation is 5.25 % of full power. The first group of initiating actions are taken between 2 and 3 minutes after DAS activation:

- Adjust core power to 4.4% of full power
- Trip and isolate the Primary forced circulation pump
- Open the 10 cm² RV leak
- De-energize the PRZ main heaters, and increase the PRZ guard heater bias
- Realign the VV controller to open/close the VV at +/- 0.005 psi Upper Plenum to Downcomer pressure difference.

The second group of initiating actions is taken at the approximate time of loop (HL U-Bend) fluid saturation. These actions, taken at approximately six (6) minutes, are:

- Realign the SG Secondary set points to obtain 48 bar (700 psia) steam pressure and "MK" level using two (2) simulated AFW pumps
- Actuate the core power ramp controller to simulate power decay; and
- Actuate two (2) simulated HPI pumps directed to the Cold Leg (pump-) Discharge (CLD) piping.

The MK SG level control scheme feeds to 26.7', then steams down to 25' without feed, in a repetitive band-control fashion. Manual feedrate adjustments are made to simulate prototypical AFW head-flow characteristics. The aforementioned initiating actions precipitate changes in virtually every loop parameter, as discussed in the following section.

## 3.2 Subcooled Draining, 2 to 6 Minutes

The Primary forced circulation pump trip at 2 minutes has an immediate effect and parallels the forced to natural circulation transient examined in previous tests. Primary flowrate decreases to ~ 2% by 3 minutes (Plot 9, plot numbering corresponds to original data plots ). With the core still powered (but decreased to 4.3% at 2 minutes, Plot 19), the core outlet fluid is heated increasingly with decreasing flow, attaining 620 F at 2 ½ minutes (Plot 111). As flow decreases, the SG heat removal rate decreases also to ~ 1.5% of full power by 2 ½ minutes. Secondary steam and flowrates are attenuated by minutes (Plot 12), the slight lag of feed attenuation cools the SG Secondary pool at the feed inlet by 10 F at 3 minutes (Plot 191); following feed reduction the SG Secondary pool approaches uniform temperatures by 5 minutes (Plot 191). The primary flow decrease also produces some cooler SG Primary outlet temperatures at 2 ½ minutes (Plots 132 and 26). The net fluid density effect of these flow-induced Primary temperature changes is a slight system fluid expansion, because the heated fluid volume exceeds the cooled one. Primary pressure peaks slightly at 2 ½ minutes (Plot 1), and PRZ Surgeline metal cools to 621 F by 3 minutes with the accompanying insurge flow (Plot 124).

Upon actuation of the VV on automatic (~0 dp) control at 3 minutes (Plot 16), the driving pressure difference is 0.15 psi and is decreasing (Plot 172) in response to the increasing natural circulation flowrate. The VV opens. The Downcomer flowrate immediately exceeds the Cold Leg flowrate (Plot 9) and the VV bracketing fluid temperatures immediately equalize and increase toward core outlet temperature, attaining 610 F at 3 minutes (Plot 171). The Downcomer fluid temperatures increase as the VV admits hotter fluid (Plot 151).

The Reactor Vessel leak is actuated at 2 ½ minutes (Plot 16). The RV leak flow attains 0.12 lbm/sec by 3 minutes (Plot 17). The PRZ Surgeline metal temperature increases with the outsurge due to draining, reaching 640 F at 3 ½ minutes (Plot 124). The Pressurizer inventory is depleted by 3 ½ minutes (Plot 4); the pressure falls rapidly (Plot 1) reaching 1700 psia by 5½ minutes. The Hot Leg Fluid temperatures increase dramatically from 3 to 5 ½ minutes, due to both the Primary flow reduction and the introduction of saturated PRZ fluid (Plot 121); At 4 ½ minutes the temperature probe HLTC02 at 9', just above the Surgeline connection to the HL, attains 622 F (Plot 121). The HL Conductivity Probes indicate HL voiding after 4 minutes (Plot 123). The HL metal temperatures respond rapidly (Plot 124); these temperatures at 34.5' have increased from 605 F to 618 F by 5 ½ minutes, and to 615 F by 6 minutes at 66'. At 5 minutes as the PRZ voids, the PRZ fluids, at saturation temperature, and the Surgeline metal temperature fall abruptly to the current HL fluid temperature, ~620 F (Plots 124 and 161).

The primary fluid temperature changes accompanying pump trip at 2 minutes have generated an increasing natural circulation driving force; the natural circulation flowrate peaks at 6% of full flow at 5 minutes (Plot 9). In response to this renewed flow, the SG heat removal has returned to ~5% (Plot 19). The SG Primary outlet and Cold Leg fluid temperatures returned to ~570 F between 5 and 6 minutes (Plots 26 and 132). At approximately 6 minutes, the Hot Leg and Primary saturation temperatures merge (Plots 102 and 121) and the HLUB saturates.

## 3.3 Saturated Spillover Circulation, 6 to 8 Minutes

At approximately 6 minutes, the HLUB (Hot Leg U-Bend) fluid is observed to saturate and the second group of initiating actions is taken: The SG Secondary control points are reset to 48 bar (700 psia) using 2 simulated dump valves and MK level controls 25' to 26.7' band control manually simulating the head-flow characteristics of 2 AFW pumps); core Power is ramped to simulate decay; and the two scaled HPI pumps directed to the Cold Leg Discharge piping are actuated.

The Steam Generator Secondary immediately responds to the control point changes. The feed and steam flowrates increase to 4 ½% and 3 ½% of full flow at 6 minutes (steam flow is choked) (Plot 12). The SG heat transfer rate increases to 5% of full power (Plot 19). Secondary steam pressure begins to decrease from 1150 psia, reaching the 700 psia control point by 9 minutes (Plot 1). The combination of Secondary steaming and pressure-retarded feeding suppresses the SG Secondary level change for these first minutes (Plot 4). But the increased feeding does lower the SG Secondary pool temperatures (Plot 191); the lower-elevation pool temperatures decrease from 560 F at 6 minutes to ~ 480 F at 8 minutes. The SG Primary Outlet and CL temperatures respond similarly, decreasing from 570 F at 6 minutes to 520 F at 8 minutes. The downstream Cold Leg temperatures (Temperature gauge CLTC04 and 05, Plot 151) begin to indicate HPI cooling, dropping to 505 F by 9 minutes. The HPI, actuated at 6 minutes, attains only 0,03 lbm/sec at this Primary pressure (Plot 17).

During these first two minutes of loop saturation, the Reactor Vessel stays approximately full, the HL upstream collapsed level is at the spillover elevation, but the HLUB downstream collapsed level begins to recede, reaching 63' at 8 minutes (Plot 4). With this saturated spillover circulation mechanism available, and with the system responding to the buoyancy effects caused by the temperature distribution, the primary flow attains a second natural circulation maximum value of ~5% of full flow at 8 minutes (Plot 9). But the primary liquid inventory is still decreasing rapidly due to the excess of leak over HPI flowrate (Plot 17), thus the HLUB upstream collapsed level begins to fall at 8 minutes (Plot 4).

## 3.4 Intermittent Circulation (8 to 22 Minutes)

At 8 minutes the HL upstream level begins to decrease, reaching 64' at 9 minutes (Plot 4). Primary Circulation is thus interrupted (Plot 9), the Primary repressurizes to 1750 psia at 9 minutes (Plot 1), and Secondary pressure reaches its 700 psia control value (Plot 1). Pressurizer level increases to ~10' upon this repressurization (Plot 4). Steam Generator heat transfer decreases with de-coupling (Plot 19). The upper HL Conductivity Probes reflect dryout (Plot 112).

The Reactor Vessel Upper Plenum saturates at ~11 minutes (Plot 111), and the downcomer and RV inlet fluid approach saturation (Plots 111 and 151). The Reactor Vessel level begins to drop with upper head voiding (Plot 4), reaching 0' at 11 minutes. This voiding transfers fluid up the Hot Leg, raising the HLUB upstream collapsed level to the spillover at 10 ½ minutes (Plot 4). The primary flow restarts (Plot 9), and the primary fluid temperatures respond accordingly (Plots 121, 131, 132 and 151). The SG steam flow increases (Plot 12), as does the SG heat transfer (Plot 19). The secondary steam dump valve simulation chokes and the secondary pressure momentarily increases (Plot 1). Primary system cooling, fluid contraction, and condensation are sufficient to depressurize the primary system back to 1700 psia (Plot 1). But the contraction plus the continuing loss of Primary fluid inventory again deplete the HLUB upstream level (Plot 4), interrupting primary circulation a second time.

Two subsequent HLUB spillover occur, at 16 and 22 minutes. They resemble the initial spillover, except that their corresponding HL upstream collapsed levels are progressively lower (Plot 4), at 65' and 63'. The spill over at 16 minutes occurs as the RV collapsed level drops from the region of the VV to that of the HL nozzle, the later spillover occurs as the RV, Downcomer, and Cold Leg void to -6'. The ensuing condensation of the CL and DC voids drops the HL upstream level to 40' (Plot 4) and intermittent spillover ceases.

The primary pressure is reduced at each spillover. It decreases from 1850 to 1700 psia at 22 minutes (Plot 1). The Steam Generator Secondary refills to the control zone by 20 minutes (Plot 4). The Pressurizer routinely refills with Primary pressurization and vice versa (Plot 4). The primary flowrate and the Steam Generator heat transfer rate peaks are observed with each spillover (Plot 9 and 19). Cold Leg fluid temperatures tend increasingly toward saturation with successive spillovers (Plot 26). Reactor Vessel Conductivity Probes record dryer conditions between circulation pulses, especially the upper CP's bracketing the VV (Plot 112). The Hot Leg and Steam Generator Outlet fluid temperatures reflect flow pulses by converging (Plots 121 and 132). At 22 minutes, the primary flow has again subsided (Plot 9) and the SG Secondary heat transfer is diminishing (Plot 19).

## 3.5 Stalled Flow, 22 to 35 Minutes

From 22 to 35 minutes, HL levels are generally subsiding (Plot 4), Primary and Secondary flows are miniscule (Plots 9 and 12), thus the core heat source is largely decoupled from the Steam Generator. Leak discharge energy approximates Core heat input (Plot 19), thus the Primary repressurizes only mildly, from 1700 to 1800 psia (Plot 1). HPI flowrate is reduced to 0,015 lbm/sec by this repressurization (Plot 17). Thus leak flow greatly exceeds HPI flow (Plot 17) and Cold Leg fluid temperatures either stratify (Plot 141) or follow the Downcomer and Core Inlet temperatures toward saturation (Plots 26 and 151).

Hot Leg and upper RV fluid temperatures remain saturated (Plots 111 and 121). HL and upper RV conductivity probes indicate decreasing moisture content (Plots 112 and 123). By 35 minutes the SG Primary Level approaches the Secondary level (Plot 4), the Primary system liquid inventory reaches a minimum of 45 % of full (Plot 105). The insurge accompanying Primary repressurization has raised PRZ level to 15' (Plot 4) and has increased Surgeline metal temperature to within 10 F of saturation (Plot 124). At 32 minutes the High Point Vent (HPV) is opened (Plot 16) and the SG Secondary is depressurized to obtain the prototypical 50 F/hour cooldown (Plot 1). Neither of these events has a major impact on the current transient behavior.

## 3.6 Boiler-Condenser Mode, 35 to 52 Minutes

At 35 minutes the SG Primary and Secondary levels are approximately equal (Plot 4) and Primary steam is condensed within the SG. The SG steam and feed flowrates increase to ~4% of full flow (Plot 12), and the SG heat removal attains 5% of full power (Plot 19).

The primary pressure is rapidly reduced by the condensation of Primary vapor. The Primary depressurization rate reaches 200 psi/min, the primary pressure decreases from 1600 psia to 630 psia (Plot 1), and the primary saturation temperature is reduced to 495 F (Plot 102). The influx of primary condensate (Plot 9) introduces colder fluid into the Downcomer (Plot 151). The Downcomer refills at 37 minutes, the Core collapsed liquid level increases from –5' to –3', and the Pressurizer drains with depressurization and with Primary inventory contraction (Plot 4). As the primary pressure decreases, the HPI flowrate increases exceeding the leak mass flowrate by 40 minutes and attaining 0,15 lbm/sec (Plot 17). The net Primary System liquid volume rate of change abruptly increases from - 0,2 to + 0,2 ft³/min. The increased HPI flowrate sporadically cools the CL upstream thermocouple (CLTC04, Plot 151).

Although the Primary system liquid inventory is increasing , the redistribution of this liquid towards lower elevations, with condensation of primary vapor decreases the moisture content of the higher Primary elevations. The Hot Leg fluid temperatures decrease with the primary saturation temperature. Then, successively with the decreasing liquid level in the HL, the HL fluid content remains superheated by as much as 70 F (Plot 121). The HLUB metal behaves similarly (Plot 123), but is 15 F hotter than the adjacent fluid. The highest HL Conductivity Probes indicate dry conditions. The Reactor Vessel Conductivity Probes indicate intermittent wetting while the CP below the HPI nozzle shows continuous wetting. The Reactor Vessel upper plenum fluid, like the upper HL fluid, is left superheated as primary saturation temperature decreases (Plot 111).

For the first time in the test, the RV upper plenum fluid temperature exceeds the other RV fluid temperatures.

The SG Secondary fluid temperatures respond to the increased SG heat transfer activity. The SG Secondary pressure increases to 1100 psia as the simulated steam dump valve chokes (Plot 1). The vapor region Secondary temperatures follow this saturation temperature increase (Plots 192 and 193). The SG Secondary pool temperatures decrease as feed is re-introduced (Plot 191).

By 50 minutes the SG Primary has been refilled to the SG Secondary level (Plot 4) and the condensing surface is recovered.

## 3.7 Hot Leg Refill, 55 to 110 Minutes

At 55 minutes the SG Primary condensing surface is totally re-wetted (Plot 4) and the Boiler-Condenser Mode of heat transfer is extinguished. The Steam Generator heat transfer drops to zero (Plot 19). The SG Secondary pool temperatures drift downward toward 250 F (Plot 191). The SG Secondary vapor temperatures parallel the (imposed) Secondary saturation temperature decrease, and abruptly decrease with the Primary SG temperatures as they de-superheat upon refill (Plots 191 and 193).

Post-BCM (Boiler-Condenser Mode) refill begins with 0,08 lbm/sec excess of HPI over the leak flow (Plot 17). HPI cooling is sufficient to condense the generated core steam, thus the Primary repressurizes only mildly, ~ 300 psi/hour (Plot 1). The HPI flowrate decreases correspondingly (Plot 17), from 0,15 to 0,11 lbm/sec. The Cold Leg temperature distribution indicates a generally fluid stratification (Plot 26), the temperature gauge CLTC04 just upstream of the HPI discharge point remains at the HPI fluid temperature of 90 F, for almost an hour. The downcomer and core inlet fluid temperatures gradually cool down, reaching 400 F by 100 minutes (Plots 111 and 121). With increasing pressure and decreasing leak fluid temperature, the leak flowrate increases from 0,07 lbm/sec to 0,09 lbm/sec by 100 minutes (Plot 17). Thus the excess of HPI over leak flow decreases from 0,08 lbm/sec to 0,03 lbm/sec at 100 minutes (Plot 17). The System refill rate decreases from 40% (of total system volume)/hour, to 25%/hour at 100 minutes (Plot 105). The HL refill rate is roughly 2/3 ft/min (Plot 4).

During refill the core outlet and VV fluid temperatures follow saturation, the RV upper plenum fluid slowly de-superheats (Plot 111). The RV Conductivity Probes indicate intermittent wetting (Plot 112). The HL fluid successively cools to saturation temperature with the passage of the liquid level. The HL CP's similarly indicate wetting in succession (Plot 123). The Hot Leg metal at 66' (Plot 124) remains at ~575 F until rewetted with HL level rise. The upper SG Primary fluid temperatures, like those of the HLUB upstream, successively approach to saturation as they are wetted (Plot 131); the lower SG Primary fluid temperatures are roughly constant at 300 F. The Surgeline metal is approximately 50 F subcooled (Plot 163) reflecting Surgeline heat losses; the PRZ fills to ~13' with gradual repressurization during system refill (Plot 4).

Scheduled 1.5 standard cubic feet NCG (Noncondensible gas) additions to the RV Lower Plenum at 73 and 130 minutes (Plot 16) perturb system conditions but have no major impact on the transient.

At 105 minutes the HLUB upstream piping has refilled to the spillover elevation. Spillover circulation ensues and the primary flowrate peaks at 7% (Plot 9). The SG is immediately recoupled, and the secondary flowrates increase to 5% of full flow (Plot 12). The SG heat transfer peaks at 2 ½% of full power (Plot 19), and the Secondary pressure increases momentarily by 70 psia (Plot 1). Spillover circulation generally contracts and subcools the Primary System fluid.

The primary pressure falls from 930 to 750 psia (Plot 1). The HL upstream level briefly subsides below the spillover elevation, then both the upstream and downstream HL piping fill (Plot 4). The Pressurizer empties with Primary depressurization (Plot 4). The average Primary System fluid specific energy decreases from 445 to 400 BTU/lbm. HPI fluid is swept into the Downcomer region by forward loop flow; Temperature gauge CLTC04 upstream of the HPI point increases in response to the warmer upstream CL and SG outlet fluid, CLTC05 downstream of the HPI point cools toward 200 F (Plot 26). The lower Downcomer and Core Inlet fluid temperatures are similarly decreasing (Plots 111 and 151). The core outlet fluid is subcooled for the first time since test initiation. This cold fluid also affects the HL temperatures (Plot 121), abruptly cooling the HL by ~100 F starting from the bottom of the HL.

## 3.8 System Refill, 110 Minutes and Beyond

At 112 minutes the HL-HPV discharge flowrate abruptly increases to 0,025 lbm/sec (Plot 17), signaling the completion of HL refill as liquid issues from the HPV. The system natural circulation driving force is slightly negative at that time; this counters the forward-flow tendencies of HPI fluid flowing to the RV leak, resulting in negligible system flow (Plot 9). The Secondary feed and steam flows subside following spillover circulation (Plot 12) and the Steam Generator is largely inactive (Plot 19). The Net System energy change is slightly negative, the major heat removal mechanism is leak-HPI cooling (Plot 19). The System fluid average specific energy is slowly increasing.

The HPI flowrate slightly exceeds the liquid discharge flowrate from the leak and the HPV (Plot 17). The Reactor Vessel and Pressurizer are gradually refilled (Plot 4). The Reactor Vessel Conductivity Probes successively indicate liquid-immersed conditions, starting from the lowest (below the HL nozzle) at 10 minutes to the highest (above the VV penetration) at 117 minutes (Plot 112). The RPV upper plenum and VV fluid temperatures indicate subcooled conditions from approximately 115 minutes.

At 117 minutes the continued cooling of the RPV and lower HL fluid yield a sufficiently negative system natural circulation driving head to trigger a brief pulse of reverse loop flow. This pulse is most discernible on the HL and SG Primary temperature traces (Plots 121 and 131). From then until 3 hours the loop is stagnant and loop temperatures vary little. The Core-VV-DC flow loop remains active, however. The Core power of 1,6% of full power (Plot 19) leads to 60 F RV fluid heat up (Plot 111) with 2% of full flow through the VV. The VV flow combines with the HPI from the CL Discharge (Plot 17) and flows either out of the leak or back to the Core Inlet.

After 3 hours, the RV is full, the PRZ has refilled to 17' (Plot 4), and the Primary system is filled up to 90%. At this time the HPI simulation is reduced from 2 to 1 scaled pumps, and testing is continued for another 13 minutes. The HPI flowrate decreases correspondingly at 180 minutes, and the leak flow exceeds HPI flow. The

Primary pressure decreases toward a revised new leak-HPI equilibrium point (Plot 1). The RPV and PRZ lose inventory (Plot 4), and the Surgeline metal heatup from 365 F to 490 F confirms the PRZ outsurge. The test is terminated with the HPI-change transient still in progress.

## 3.9 Synopsis

A 10 cm² Reactor Vessel leak with 2 HPI's has been tested from loop saturation to Primary refill. A broad range of system conditions has been encountered. A two-step initiation sequence was used to approximate plant conditions at saturation.

The System is initially subcooled in forced flow; the SG Secondary is initialized at high pressure and low level. Two minutes after Data Acquisition System activation (time zero), the core power is adjusted to the scaled value at the predicted time of loop saturation, The primary flow is transferred from forced to natural circulation, the 10 cm² RV leak is activated, the PRZ main heaters are de-energized, and the VV is transferred to automatic control.

From 2 to 6 minutes (after DAS activation) the loop flow subsides, then restarts in natural circulation; the Pressurizer drains; the primary pressure falls, and the HLUB fluid saturates. Saturation coincides with the second initiation step: The SG Secondary control pressure and level are reset, the Core power ramp is begun, and HPI is activated.

Although the system is saturated at 5 minutes and primary inventory is decreasing, saturated spillover persists until 8 minutes. At 8 minutes the HLUB upstream level begins to fall and primary circulation is interrupted. Steam Generator heat removal is lost, the Primary begins to pressurize, and the Core region fluid begins to void. This voiding raises the HL level, causing spillover circulation at 10 ½ minutes. But spillover causes heat removal in the SG and thus cooling and contraction of the Primary fluid; HL level is again decreased and spillover circulation is again interrupted. These periods of spillover circulation occur at 10 ½, 16, and 22 minutes. After 22 minutes Primary inventory is sufficiently reduced to preclude further HLUB spillover, and Primary flow is stalled (flow in the core-VV-Downcomer loop remains active).

From 22 to 35 minutes the Primary re-pressurizes mildly and Primary inventory continues to decrease. At 35 minutes the SG Primary liquid level drops below the Secondary level, exposing a condensing surface and triggering the BCM. The Primary is rapidly depressurized, the lower Primary elevations are largely quenched and refilled, and system refill begins at 40 minutes. The Steam Generator condensing surface is re-wetted by 55 minutes and system refill slows from 40% (of total volume) per hour to 25% per hour. The Primary re-pressurizes gradually during post-BCM refill. Upper-elevation (superheated) fluid and metal temperatures remain virtually constant until quenching starts by the rising liquid level.

Finally at 105 minutes the HLUB upstream piping has been refilled to the spillover elevation and primary circulation restarts. The Primary is rapidly depressurized and generally cooled and refilled by this spillover circulation. After the HL refill, the primary flow stalls, however the HPI cooling of the core region and the lower HL fluid density cause a flow-retarding buoyant force.

By 180 minutes the RV is refilled, and the Primary is 90% full of liquid. The Pressurizer level is 18' and is still increasing. All Primary components other than the PRZ are totally filled, subcooled, and at roughly constant temperatures. The natural circulation in the Primary loop has not restarted. A brief HPI-simulation change is appended to the test, then testing is terminated after 193 minutes.

# 4 RELAP5 MOD 3.2 Analysis of Test 1605AA

## 4.1 Code Description

The code used for the assessment calculations described by this report is the Mod3.2 version of RELAP5. This code has been developed within the USNRC Code Assessment and Maintenance program (CAMP) and is the internationally well known and state-of-the-art best-estimate thermal hydraulics code systems for the analysis of reactor transients. It is based on a non-homogeneous non-equilibrium model of a one dimensional two phase flow system. The code solves basically six field equations for the steam-water system including lots of constitutive models and correlations. The code also can handle non-condensables and other media. It uses partially implicit numerical schemes to achieve a high calculational speed. The code version used for the reported analyses was implemented under UNIX operating system on an IBM RS-6000 Workstation.

A comprehensive description of the code is given in Ref. /4/

## 4.2 Modeling Description

Figure 4.1 shows the nodalization to simulate the GERDA Test Facility and test 1605AA with the RELAP5 code. The model is geometrically based on an RELAP4 MOD 6 (BBR Version) model which originally was used in the eighties for Pre- and Posttest calculations of the GERDA tests however grossly reworked with respect to discretization and simulation details. The model consists of all major parts of the primary and secondary side of the test facility, in total of 77 RELAP components with 168 hydrodynamic Volumes, 171 Junctions and Valves and the Heat Structures adjacent to the piping and Volumes. A complete listing of the base case input set is listed in Appendix B.

The simulated sections of the Test Facility include the reactor vessel and core region, the pressurizer, the cold leg and hot leg, the "main coolant pump" and the 19 tube steam generator model. The core area of the RPV is represented by a pipe component subdivided in 6 Volumes, the lower 4 Volumes corresponding to the heated region containing 4 Heat Structures which simulate the three core simulator heaters. The upper 2 Volumes are not heated (Figure 2.7). The upper plenum and reactor vessel head are composed of two Branches and a Single Volume. GERDA's lower plenum is simulated with a Branch and a Pipe. This Pipe simulates the 4 small inlet pipes of the Test Facility's lower plenum.

The pressurizer model is based on the nodalization scheme developed for an ABBR RELAP5 MOD1 transient analysis model for the KMK plant and contains a pipe with a subdivision into 10 Volumes.

The head losses for the Main Coolant Pump simulation in GERDA are modeled with an upwards flowing Branch Volume and a Single Volume connected by a Valve component which is opened for natural circulation situations and in parallel to this valve a Time Dependent Junction to simulate forced flow situations, followed by a downward slanting Branch volume.

The most critical aspect of the GERDA model is the Steam Generator. The prototype IEOTSG Steam generator design, based on a license by Babcock & Wilcox, differs considerably from that of other vendors such as Combustion Engineering (CE), Siemens KWU or Westinghouse which employ a U-Tube type design. The OTSG is a counterflow steam generator which uses straight tubes. It is shown in Figure 2.3. The Hot and Cold Legs also differ markedly from U-Tube SG design PWR. The hot leg geometry includes a very tall vertical section which leads to an inverted U-bend and connects to the upper plenum of the OTSG (HLUB design) The primary fluid is distributed into more than 16000 tubes and unified at the bottom of the SG in the lower plenum. From there two Cold Legs connect to the Reactor Pressure Vessel, each furnished with one Main Coolant Pump similar in design to CE plants of the US. In the GERDA Test Facility two hot legs of the two SG loops are lumped into one loop thus lumping also the 4 cold legs into one.

To model the behavior of the OTSG is a quite demanding problem because of the complete spectrum of heat transfer phenomena arising between the tube walls and the secondary coolant (Ref. /5/, /6/, /7/). In the bottom region, heat transfer is to a subcooled liquid, then further up the tubes to a saturated liquid, and finally at the top to a superheated steam. Also the OTSG heat removal rate is very sensitive to the secondary-side liquid level, because the more inventory is present the more tube surface area is covered which can effectively transfer heat through boiling which is the most prominent heat transfer mechanism. As the liquid inventory and the length of the heat transfer regimes strongly influence the actual SG power, a good simulation of OTSG is a subject of thorough nodalization planning. In the past, several computer codes introduced so called 'moving boundaries' in OTSG simulations to overcome these problems. RELAP, however, is a discrete volume boundary type of code. It has some nice features to deal with discrete levels (e.g. in PRZ modeling) like vertical stratification or thermal front tracking which, however, cannot be applied here. In OTSG modeling a coarse nodalization crates discrete jumps in overall heat transfer, which causes the system to be even more sensitive to the secondary fluid inventory. This can lead to an unstable system. Increasing the number of axial nodes to create finer mesh intervals helps keep the system from oscillating wildly, provided these intervals are not too small, which again leads to instability. One economic aspect also has to be considered: fine discretizations tend to produce large computing efforts. An optimum can be found through sensitivity studies which have been done in the past very extensively and will not be reported here.

The GERDA SG model is based strongly upon a KMK model developed for RELAP5 MOD1 (ABBR Version) and is modeled for the MOD 3.2 version as two concentric pipes divided axially into 52 subvolumes, one for each foot in length of the original vertical pipe. The inlet and outlet plenum is modeled as a Single Volume at the top and a Branch at the bottom. For the RELAP5 model the hexagonal arrangement of the GERDA-SG shell was modeled by a circular shell with the same cross-sectional area and height as the original test arrangement. The primary side pipe is connected to the secondary side pipe by a Heat Structure with original heat transfer areas which simulates the primary side tube walls and provides the heat flow from the primary side to the secondary coolant. The Feedwater and AUX Feedwater systems parts are simulated by Time dependent Volumes, Time Dependent Junctions, Valves, a Single Volume and a Branch. The Feedwater is simulated for the purpose of simplification to enter directly into the bottom of the SG. Correspondingly the steam leaves the secondary side also simplified directly at the top. The original shell region of the prototype SG and the Feed Water inlet Downcomer is not simulated, because the influence on the LOCA transient is negligible in this case.

## 4.3 Conditioning Calculations

### 4.3.1 Steam Generator Steady-State Performance

The proof of quality of the input model and the stability of steady state performance especially of the OTSG model was achieved by a lot of conditioning calculations which have been performed in advance of the post test analyses. Some of them and the main results will be presented here.

Four separate calculations at steady state conditions were undertaken using a standalone RELAP5 input deck to test the performance of the GERDA-SG model before an integral model was tested. The initial conditions, temperatures, pressures, and mass flows were changed in each case to reflect the different power levels in the GERDA steam generator during steady state conditions. Testing standalone models to insure a correctly functioning SG is critical to the integral model, because without proper heat removal the overall system model will not achieve a steady state condition. The SG is as mentioned above the most crucial and complex part of the overall system.

Using known temperature distributions (from the old RELAP5/MOD1 inputs) for the KMK-SG model at 100%, 65%, 45%, and 15% total power and flow rates from GERDA steady state data, the initial conditions for the RELAP5/MOD3.2 GERDA-SG model were developed. For the KMK-SG a set of steady-state and transient measurements collected during start-up of the plant exist for comparison, see Tables 4.1 - 4.4. These values, due to the measuring techniques used, have an uncertainty of 3 K for the saturated region and ~6 K for the superheated region, which stems from an occasional water drop hitting the thermocouple causing an erroneous reading.

All of the test calculations were run up to 200 s to achieve a complete stationary, steady-state thermal hydraulic condition. In addition to the prototype data mentioned above, in Tables 4.1 - 4.4 comparative values are given of the GERDA facility, prior computer models used for design and analysis and the RELAP5/MOD 3.2 results for GERDA.

The general result of these exercises is that for the 100% SG-Power case stable conditions are obtained after a relatively short period. The data of the different sources compared in the Tables 4.1 - 4.4 are all relatively similar, with the exception of the SG inventory for which the RELAP5/MOD 3.2 GERDA model predicts values which are closer to the GERDA test data than the predictions of both older models and prior computations (Figure 4.2). The variation comes from the different geometries and from the extrapolated error going from 19 tubes to 16000. The RELAP5/MOD3.2 model simulates a circular outer shell while the actual GERDA facility SG shell is hexagonal. Steam superheat is about 2 K less than GERDA measurements and plant data but are 2 to 4 K better compared to the older calculational data which illuminates the efforts in code development since then (Figure 4.3).

For the 65% SG-Power case the secondary side mass inventory again is less than older calculational data But close to GERDA data. Steam superheat only differs about 1 K from GERDA data. For the 45% and 15% SG-Power level the secondary side steady-state mass inventory is very similar to known data, except that for the 15 % Power Level no GERDA data was available. It is noteworthy that the steam superheat is very close to the prototype data and only deviates by about 1 K from the GERDA data, which is a very good result with respect to the low rated power levels we have to deal with in the LOCA transient.

### 4.3.2 GERDA-1 Loop Model Steady-State

With a high degree of confidence in the steam generator model's proper functioning, it was integrated into the full RELAP5 model of the GERDA facility. The nodalization scheme can be seen in Figure 4.1 of Appendix A.. The model was then run at 7.5% full power for one SG till steady state conditions were achieved. Since the KMK plant has 2 SGs the GERDA data must be compared to the 15% full power data of the KMK plant. By multiplying the RELAP5 GERDA-Model results by the scaling factor (S = 1686) the appropriate values for comparison will result. The results of the integral run can be seen in Table 4.5 in appendix A. The computed data compares quite well as shown in the table.

From this steady-state conditioning calculations some modifications to the boundary conditions in the data set of the GERDA model have been made in order to achieve a steady state faster and in order to hit the initial starting parameters of the test.

## 4.4 Calculational Procedures

Prior to the Post test calculation steady state runs were performed with the rated power level of the test which was 5.25 %. The Post Test calculation was started with the initial parameters evaluated in these steady state calculations. Time zero in the test, which is 1024.12 on 12-April-83 is time zero of the calculation. This implies that the model is run at steady state conditions for 145 s with forced coolant flow modeled by the Time Dependent Junction 907. At 145 s the coolant flows was forced to cast down to zero flow in 5 seconds while opening Valve 906 to allow for natural circulation flow.

The PRZ main heaters and the PRZ guard heaters are not simulated, so no actions are taken here.

The leak of 10 $cm^2$ at the lower plenum of the Reactor Pressure Vessel modeled by Valve 905 is opened at 145 s. The rated core power is started to ramp down to 4,4 % of full power simulating a post shutdown situation at the time the leak is opened. At 355 s, when the LOCA signal 'System Pressure < 117 Bar' is generated the core power is continually ramped down based on the test data simulating decay heat.

From time zero to the time of the LOCA signal (355 s) a secondary side pressure control of 79 bar was maintained at a steam generator secondary water level which corresponds to non-LOCA post-trip situations. The steam generator is being fed in this time span by two Aux-Feedwater Pumps. At 355 s, upon the LOCA signal (which is the approximate time of loop (HLUB) fluid saturation) the SG Secondary set points were realigned to obtain 48 bar (700 psia) steam pressure and (Post-LOCA) level control of 8.4 - 9.0 m using two simulated AFW pumps. Additionally two simulated HPI pumps were activated to feed into the Cold Leg Discharge (CLD) piping.

The original KMK SG level control scheme feeds to 8,14 m, then steams down to 7,62 m without feed, in a repetitive band-control fashion. Additionally, during the GERDA test feedrate adjustments were made to simulate prototypical AFW head-flow characteristics. In the calculation these controls are simulated as automatic. The reason for the difference of the steam generator level control setpoints between test and calculation was an unsufficiently low heat transfer rate of the model at the lower SG secondary side water level. To correct this underprediction, the level setpoints were increased by about 0,8 m to the ones stated above.

As an operator action at 32 minutes the High Point Vent (HPV) is opened like in the test and the SG Secondary is depressurized to obtain the prototypical 50 F/hour (28 K/hour) cooldown.

Compared to the test RELAP5 predicted a leak mass flow which roughly was 25% to high in situations with considerably subcooled fluid. Therefor the 10 cm² RPV Bottom leak is modeled and simulated without any cross section reductions of the leak area up to 44 minutes into the transient which roughly is the time refill begins. At that time the leak mass flow in the calculation was reduced to the leak mass flow measured in the test, which is about 75% of the leak mass flow RELAP originally predicts.

In the test, as a scheduled action, 1,5 standard cubic feet NCG (Noncondensable gas) were added to the RV Lower Plenum at 73 and 130 minutes, which perturbed system conditions but had no major impact to the transient. The NCG addition was not simulated in the Post-Test calculation.

The test basically ended at 180 min when the primary system was filled up. The calculation ended at 200 min but comparisons to the test only were made up to 180 min (10000 s).

## 4.5 Results of Post-Test calculations and Comparison to the Test

The overall system responses and the most prominent parameters are shown in Figures 4.4 - 4.8. In Table 4.6 the timing of major phenomena as computed is compared to the test. Almost all of these phenomena are predicted well in sequence and timing. The most important phenomenon is the time when the LOCA signal is generated after the leak is opened and subsequently, when the LOCA actions are initiated, the onset of BCM, the duration of BCM and the refill of the Primary.

At 145 s the transient is initiated by opening the leak Valve 905. The RELAP5 system pressure at that time is a little bit higher than in the experiment (Fig. 4.4). The primary forced circulation was tripped by Time Dependent Junction 907 and natural circulation was allowed by opening Valve 908. The loop flow subsides for a short time and then recovers till the loop circulation is interrupted first at about 480 seconds (Fig. 4.10). Saturated HLUB spill over causes intermediate loop flow . At about 17 minutes the flow stagnates and after a last short spill over at 22 minutes and further the flow stagnates totally till the refill of the HL.

The Pressurizer is drained by 210 seconds in the test (Plot 4) and at 280 seconds in the calculation. Due to the leak the system pressure falls rapidly reaching 1700 psia (117 bar ) by 330 seconds in the test (Plot 1) and 356 seconds in the calculation (Fig. 4.4). Saturation is reached in the Primary at the same time. The LOCA signal activates the SG secondary control pressure of 48 bar and high SG level control setpoints. HPI is activated (Fig. 4.11) and the core power ramp is begun. In Figure 4.9 the core power as measured in the test is shown. The core power history from the test is input into the heater rods simulating the core in the RELAP analysis. The resultant heat flow from the heater rods to the coolant as calculated is shown in the same figure. At about 2000 s when the operator action, venting of HLUB and initiating cool down with 28 K/h, becomes effective the BCM, which starts at about the same time is substantially enhanced, the system experiences an immediate and significant depressurization and cool down. This results in a considerable power peaking and heat flow from the core to the coolant (Fig. 4.9). In the transient phases before the onset of BCM the short pulses of saturated spill over flow in the HLUB result in peaks of heat flow from core to water.

Although the system is saturated at about 5 minutes and the primary inventory is further decreasing, due to the leak flow which is still much higher than the HPI flow (Fig . 4.12), saturated continuous spillover persists until 8½ minutes (Fig. 4.10). At that time the HLUB upstream level begins to fall and primary circulation is interrupted for the first time and only a short period. The same situation can be observed in the test. The result of this interruption is that the Steam Generator heat removal is lost, the Primary begins to pressurize, and the Core region fluid begins to void. This voiding raises the HL level again, causing further spillover circulation cycles till the mass loss in the Primary is so big that no further spillover can persist for a longer time frame (Fig. 4.11). Each of these spillover cycles cause heat removal in the SG and thus cooling and contraction of the primary fluid. These periods of spillover circulation occur in the test as well as in the RELAP calculation as can be seen from Figures 4.4 and 4.5. After about 22 minutes primary inventory is sufficiently reduced both in the test and in the prediction to preclude further HLUB spillover, and primary flow is stalled. Despite stalled flow in the loop the internal loop in the RPV via the VV is still very active as shown in Figure 4.14.

The RELAP prediction of the VV flow especially from 3000 s to 6000 s seems to be much lower than the measured VV flow. The VV flow however is not a continuous one and plots tend to smooth by graphical integration. For that reason the VV flow as calculated by RELAP was integrated and compared to the integral VV mass flow from the test which was available as a calculated test parameter. The result is depicted In Figure 4.15. It is demonstrated that at least from 2000 s to 6000 s the VV mass flows integrally compare very well.

From 22 to 35 minutes the Primary re-pressurizes mildly in the test and some more in the calculation (Fig. 4.4). This difference is caused by a too low heat removal in the RELAP SG during that phase as compared to the test. At 35 minutes (2100 s) both in both the test and in the calculation the SG primary liquid level drops below the secondary level, which very well can be seen from Figure 4.8, exposing a condensing surface and triggering the BCM. The Primary is rapidly depressurized, HPI mass flow, within a short time period jumps to a new equilibrium flow rate (Fig. 4.11), the leak mass flow decreases due to the depression and the lower primary elevations are largely quenched and refilled. This can well be seen by the integrated mass flows of leak and HPI from Figure 4.13. Figure 4.8 additionally shows that the reactor vessel upper plenum drained completely to a minimum of about - 2 m (The reference elevation of 0 is the center of the VV, Fig. 2.7) which is about 1 m above the GERDA core simulator and is still above heated core of the prototype plant. In both the test and in the calculation the system begins to refill at about 40 minutes.

The comparison between the calculated refill rate to the test data also can be observed from Figure 4.7. The refill rate of the HL compares very well to the test, however the refill rate as calculated is retarded grossly by about 500 seconds, but reaches the modeled spillover level earlier than in the test (Fig 4.6). This delay of refill is caused by a too low HPI flow (Fig. 4.11) in the timeframe from 2000 s to 3500 s as compared to the test, whereas the leak flow of calculation and test is pretty much the identical (Fig. 4.13). This deviation of HPI flow can be explained by a lower heat removal capability of the RELAP5 SG as compared to the GERDA SG, with the consequence that the calculated system pressure is above the pressure measured in the test (Fig. 4.4).

During the refill the Steam Generator condensing surface is re-wetted after about 13 minutes into the BCM, which causes the refill of the SG tubes and of the downwards bound HL to slow. This effect is more pronounced in the calculation than in the test (Fig.4.7). At 6000 seconds into the transient the difference in time between test and calculation of reaching the same collapsed water level (e.g. the spill over elevation) is about 1000 seconds.

In the test at 6300 seconds (105 minutes), the HL upwards bound piping has been refilled to the spillover elevation and primary circulation restarts. This effects the VV flow and the system pressure. The Primary is rapidly depressurized at 6300 seconds (Fig. 4.4) and the VV flow decreases (Fig. 4.14). The RPV is generally cooled very effectively (Fig 4.6) by this spillover circulation. The RELAP calculation predicts a fill up of the HL 200 s in advance to the test (Fig. 4.6). The subsequent core cooling is only half as effective as seen in the test. The reason is that, triggered by the fill up, RELAP predicts severe flow oscillations with parts of reverse flow in the loop (HL) and in the RPV and a significant increase of VV flow (Fig. 4.14, 4.21). This big VV flow causes the observed increase of lower and upper core temperatures at about 6200 s, shown in Figure 4.6. This increased VV flow of the RELAP calculation also can be seen in Figure 4.15

In the test, after HL refill, at 112 minutes (6720 s) the circulation of primary flow stalls, and VV flow increases very rapidly (Fig. 4.14, 4.15). The core region is only cooled via HPI and the internal RPV circulation flow. The core exit fluid temperature rises and the lower RPV plenum temperature falls (Fig 4.6). At 117 minutes (7000 s) the continued cooling of the RPV and lower HL fluid yield a sufficiently negative system natural circulation driving head to trigger a brief pulse of reverse loop flow. This pulse however is not seen very well in the test data but is reflected in the temperature readings shown in Figure 4.6. In the RELAP calculation on the contrary a negative pulse of reverse flow caused by a negative driving head is not observed.

After the reversed flow has ceased until the end of the transient the loop is stagnant and loop temperatures vary little. The Core-VV-DC flow loop remains active (Fig. 4.14) both in the test and the calculation.

The phenomena observed in the test during 6000 s and 8000 s are not too well predicted by the RELAP calculation. Very well predicted however is the final condition of the system at the end of the transient (10000 s), the trend in system pressure, the leak and HPI mass flow (see described modifications), the VV flow and the short period of circulation flow when the Hot Leg is filled up to the spillover level at 6100 s, at 6400 s and later at about 7000 s.

In the RELAP calculation the first fill up of the Hot Leg causes flow oscillations with the effect of a triggered VV flow. For a short time the HL level decreases again and backs up to the spillover elevation at 6400 s triggering again an immediate flow from the Hot Leg to the SG primary tubes, accompanied by severe flow oscillations (Fig 4.21). The fluid spilled over at 6400 s from the Hot Leg to the SG is saturated and has a much higher temperature than the fluid on the secondary side (Fig. 4.16). Nevertheless RELAP calculates a significant decrease of secondary side pressure at 6400 s which is strange. The opposite should be expected when hot water flows into the SG tubes. It should be mentioned that no feedwater was injected into the Secondary which could result in a sudden depressurization. The reason for this depressurization actually is a negative heat transfer from the secondary to the primary side as calculated by RELAP at 6400 s (Fig. 4.17). The root cause is not a flow of primary coolant backwards from the Cold leg into the bottom of the SG which also could result in a negative heat flux. Digging deeper into this phenomenon it can be found that the calculated negative heat flux causing the problem is mostly prominent in SG levels 19 through 36 (Fig. 4.18). The reason is a big secondary side heat transfer coefficient in that time frame between 6400 s and 6500 s as shown in Figure 4.19 for node 23 (primary noding, corresponding to node 30 on the secondary side). The reason why especially in that time frame such a big heat transfer is computed are severe flow oscillations that occur on the secondary side of the SG. From Figure 4.20 it is learned that before 6400s the Flow Regimes oscillate between Mist-Post-CHF and Mist-Pre-CHF with a relatively stable phase between 6400 s and 6500 s in the Annular-Mist regime. These instabilities at the SG secondary side are grossly responsible for the observed unrealistic heat transfer.

At about 6800 s, however, when the HLUB is filled from both sides, a considerable (positive) circulation flow is induced, again triggering a positive step of VV flow and causing a secondary pressure peak which at that time is expected and predicted well. This peak was also experienced in the test (Fig. 4.5). At about 6900 s of the calculation the primary flow again destabilizes and oscillates heavily causing considerable pressure spikes and substantial condensation effects in Volume 280 (RPV top plenum). This subsequently causes an unphysical immediate fill up of RPV top plenum at 116 min (Fig. 4.8). Consequently an instant drainage of the HLUB below the spill over elevation (Fig. 4.7) results. For another 500 s the circulation stalls again (Fig. 4.21). At 7500 s finally the HLUB is filled again, and natural circulation starts causing the second pressure peak on the Secondary. The Primary re-pressurizes gradually during post-BCM refill, both in the test and the calculation.

## 5 Conclusion

The GERDA Test Facility simulates post SBLOCA thermal-hydraulic events in OTSG plants of B&W 205 design. The integral (composite) Test 1605AA which features a complete sequence of a 10 $cm^2$ Reactor Vessel Leak transient conducted on April 12th, 1983 was used as data basis for assessment calculations with RELAP5/MOD3.2. The results of these post test calculations were compared to the test data. The comparison presented in this report has shown that in general the majority of the important phenomena are predicted well.

In detail it was found that the OTSG heat transfer capability was less than measured and the discharge leak flow rate between 2600 s and ~ 8000 s was about 25% to high compared to measured data. The other problems found analysing the RELAP results stem from flow oscillations which mostly are caused by a poor prediction of the transition from stagnant flow to natural circulation after refill of the primary system. The severe flow oscillations observed cause additional second order problems like pressure spikes, condensation in the RPV and triggering VV flow. These induced problems subsequently have immediate and significant influence on the overall system behaviour. Another problem was identified in the heat transfer on the secondary side of the Steam Generator. In the present case instabilities in the flow regime selection results in negative heat transfer. Once the observed disturbances are mastered, however, the comparison to the test shows that RELAP predicts a system behaviour which is very close to the tested scenario.

It was concluded from the comparison that the predictability especially for the BCM (Boiler-Condenser-Mode of Heat-Transfer) in general is fairly good. OTSG performance, especially the heat transfer models and logic for the selection of heat transfer regimes should be a target for further fine tuning and improvements. The refill problem and the root cause for the observed deficiencies and the flow oscillations should be eliminated.

## 6 References

/1/ G. Ahrens, G. Haury, K. Lahner, A. Schatz
Versuchsanlage GERDA für DWR mit Geradrohrdampferzeuger,
Atomwirtschaft, Atomtechnik, Nov. 1983

/2/ G. Ahrens, G. Haury, K. Lahner
BBR - Versuchsanlage GERDA zur Untersuchung von Kühlmittelverluststörfällen
mit kleinen Lecks im Primärkreis
Jahrestagung Kerntechnik '84, Tagungsbericht ISSN 0720-92207

/3/ R. Salm, S. Schwarz, D. Steinkamp
Ergebnisse der Notkühlversuche zu kleinen lecks an der BBR - Versuchsanlage GERDA
Jahrestagung Kerntechnik '84, Tagungsbericht ISSN 0720-92207

/4/ Idaho National Engineering Laboratory
RELAP5/MOD3 Code Manual
NUREG/CR-5535 INEL-95/0174 Vol. I-VII

/5/ Yassin A. Hassan (B&W)
Simulation of a 19-Tube Integral Economizer Once-Through Steam Generator Experiment
Using the TRAC-PF1 Code
Trans. Am. Nucl. Soc. ISSN 0003-018X (1985) v. 49, p 448-450
Annual meeting of the American Nuclear Society, Boston, MA (USA)

/6/ Yassin A. Hassan (Texas A&M University)
Assessment of boiling heat transfer correlations for Once-Through Steam Generators
Nuclear Technology, Vol. 81, June 1988, pp 446-450

/7/ Yassin A. Hassan, Omar Rais (Texas A&M University)
Two-Phase Flow Interfacial Drag for Once-Through Steam Generators
Nuclear Technology, Vol. 95, July 1991, pp 77-86

# 7 List of Figures and Tables

Figures

**Tables**



**Original Data Plots from GERDA Composite Test 1605AA**

| | |
|---|---|
| Plot 141 | Cold Leg Fluid Temperatures (0 - 60 min, 0 - 300 min) |
| Plot 151 | Down Comer Fluid Temperatures (0 - 60 min, 0 - 300 min) |
| Plot 161 | Pressurizer Fluid Temperatures (0 - 60 min, 0 - 300 min) |
| Plot 163 | Pressurizer Metal Temperatures (0 - 300 min) |
| Plot 171 | RVVV (VV) Fluid Temperature (0 - 60 min, 0 - 300 min) |
| Plot 172 | RVVV (VV) Pressure Difference (0 - 60 min, 0 - 300 min) |
| Plot 191 | SG Secondary Fluid Temperatures (0 - 60 min, 0 - 300 min) |
| Plot 192 | SG Secondary Fluid Temperatures (0 - 60 min, 0 - 300 min) |
| Plot 193 | SG Secondary Fluid Temperatures (0 - 60 min, 0 - 300 min) |

# APPENDIX A

## Figures and Tables

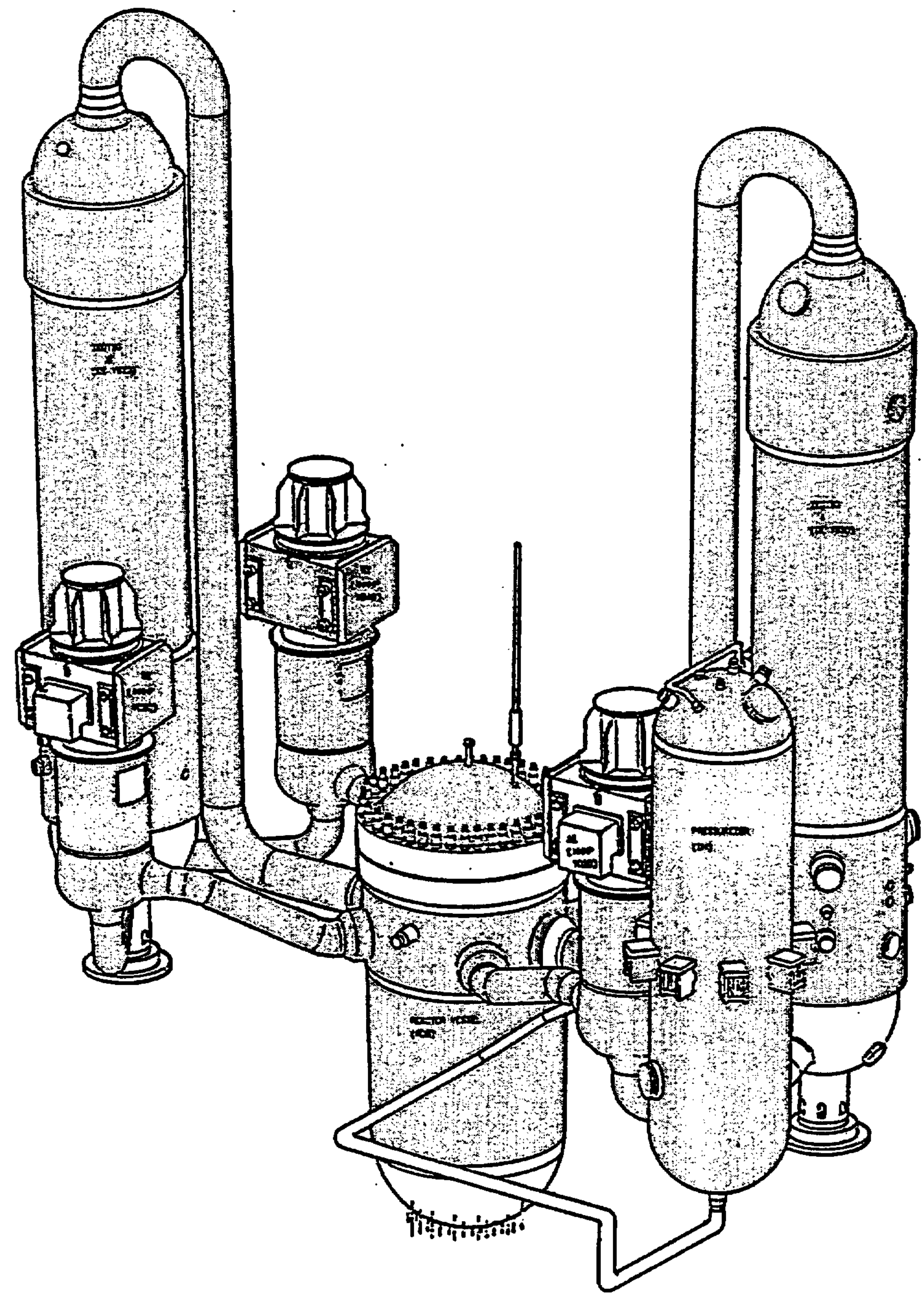


Figure 2.1 View of B&W 205-FA Design IEOTSG Plant

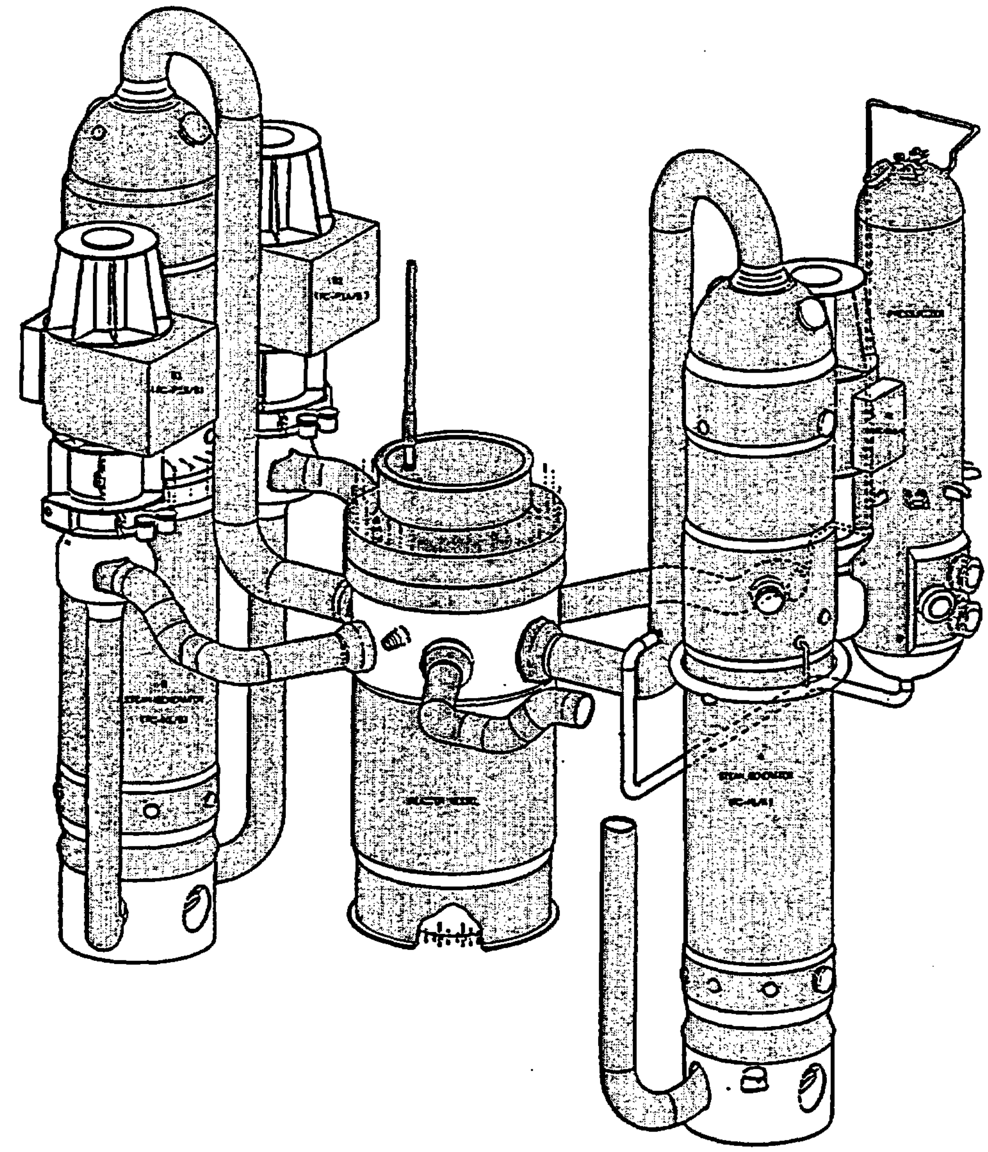
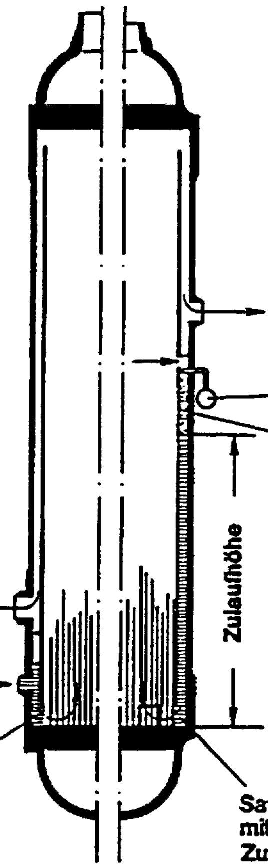


Figure 2.2 View of B&W 177-FA Design OTSG Plant




## Some specific data of OTSG and IEOTSG

| | | |
|---|---|---|
| Number of tubes | 15500 | 16000 |
| Length of tubes (m) | 15,88 | 15,88 |
| Diameter & wall thickness | same | |
| Coolant flow (kg/s) | 9200 | 10600 |
| Steam flow (kg/s) | 740 | 980 |
| Life steam pressure (bar) | 63 | 69 |
| Life steam temperature (C) | 313 | 321 |
| Steam superheating (C) | 34 | 38 |

Figure 2.3 Characteristic Data of OTSG type 177 and 205

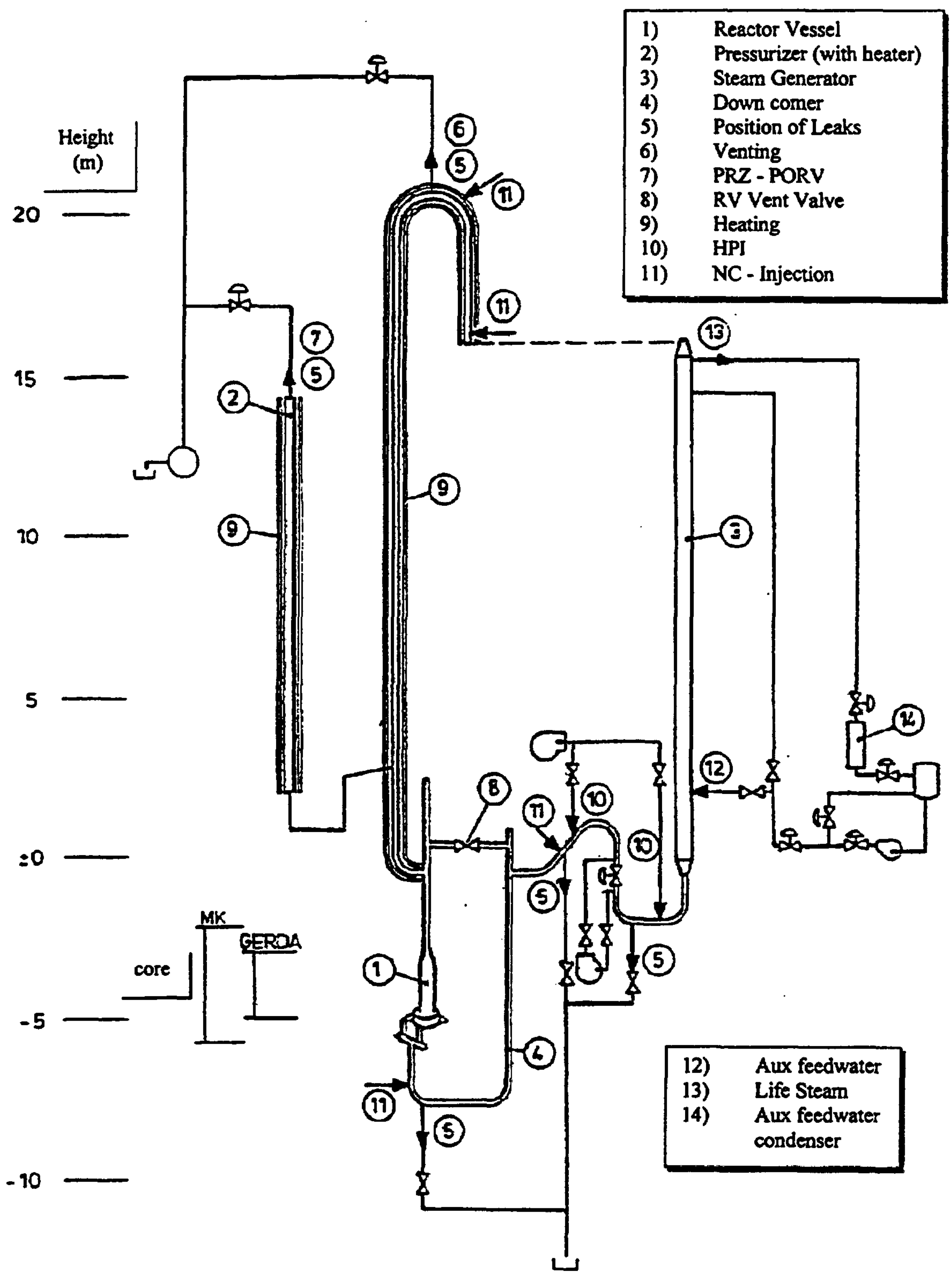



Figure 2.4 GERDA Test Facility

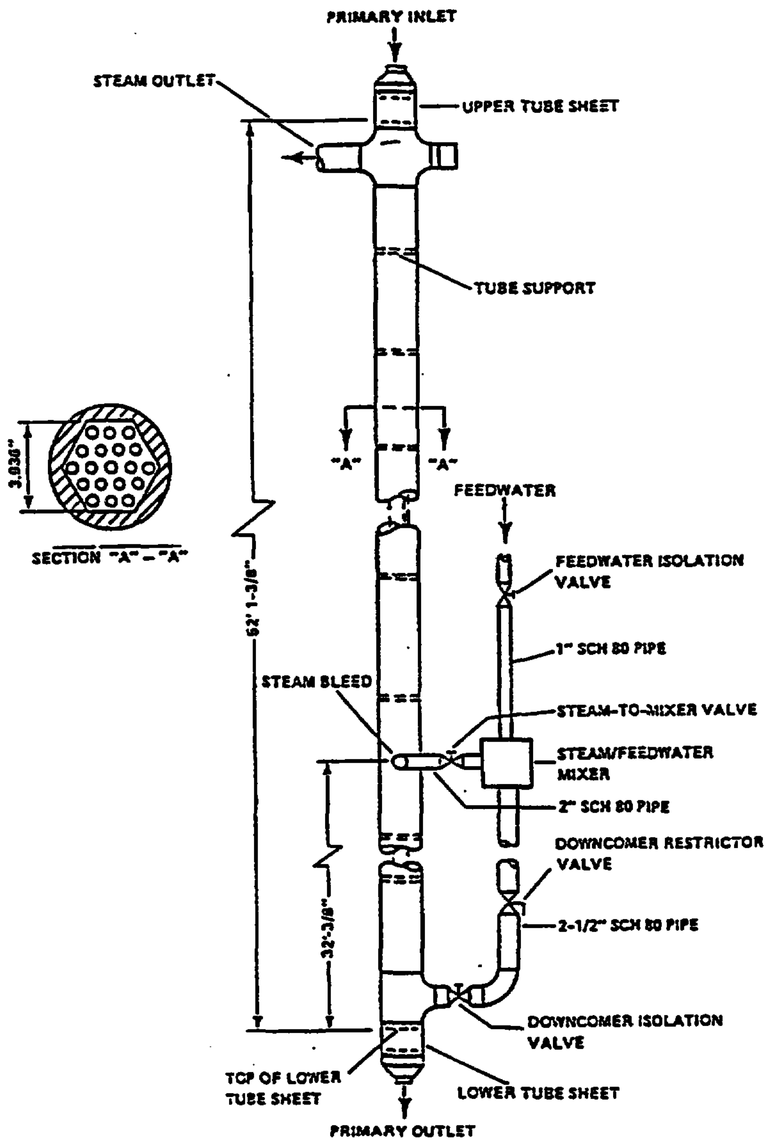



Figure 2.5 OTSG 19-Tube Bundle Test Section

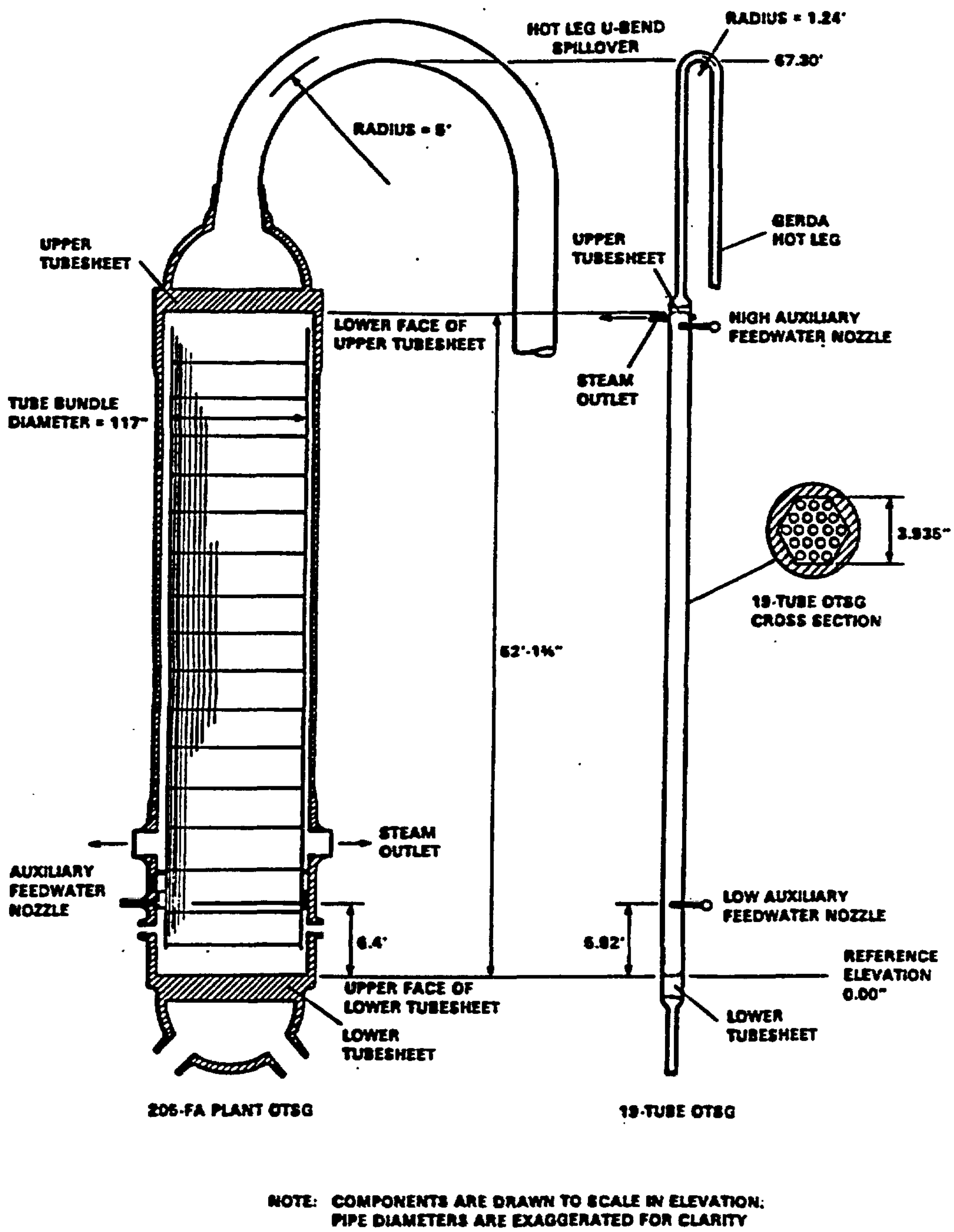



Figure 2.6 Comparison of Full-Size 205-FA Plant OTSG to 19-Tube OTSG in GERDA

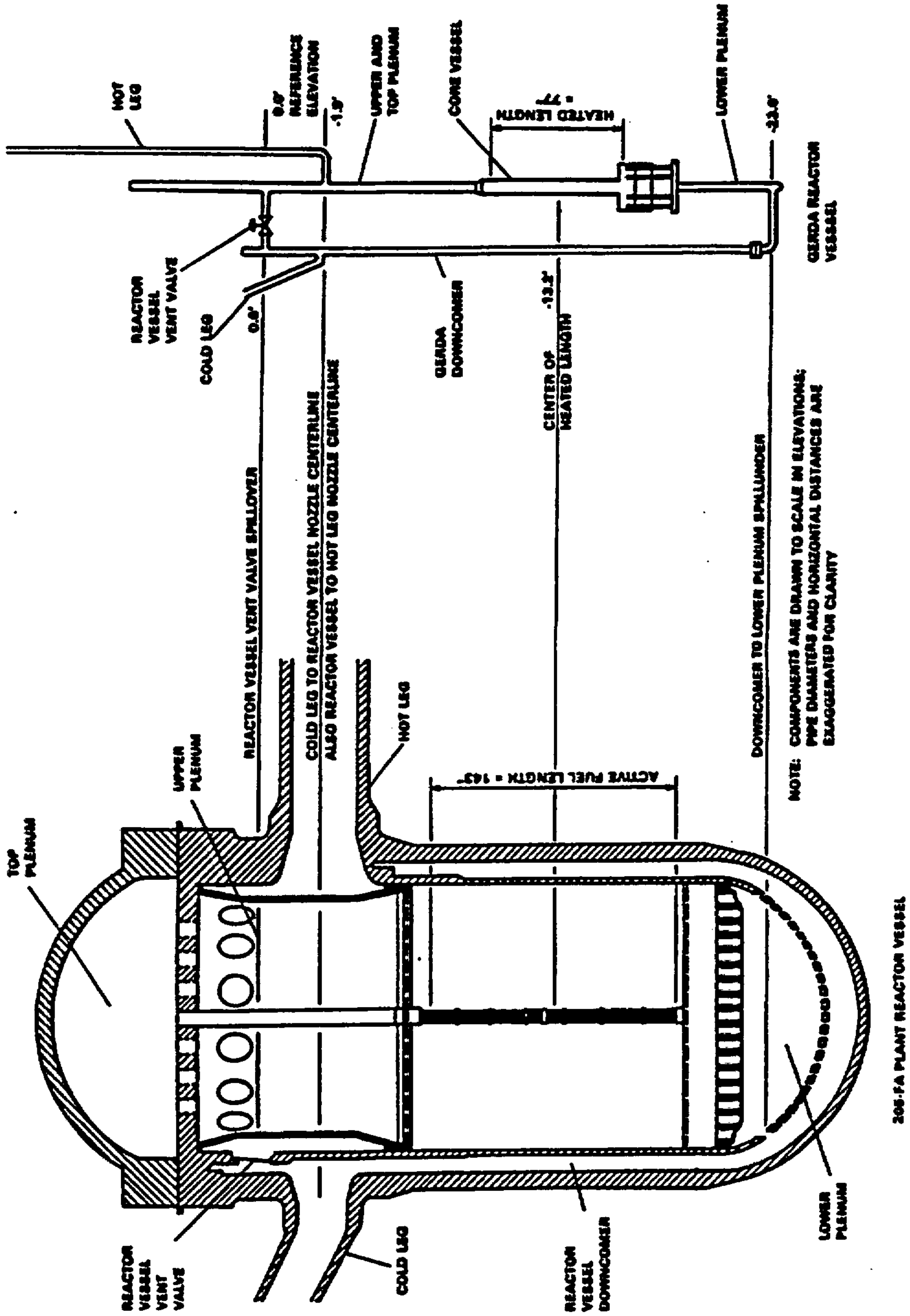



Figure 2.7 Comparison of Full-Size 205-FA Plant Reactor Vessel to GERDA Reactor Simulation

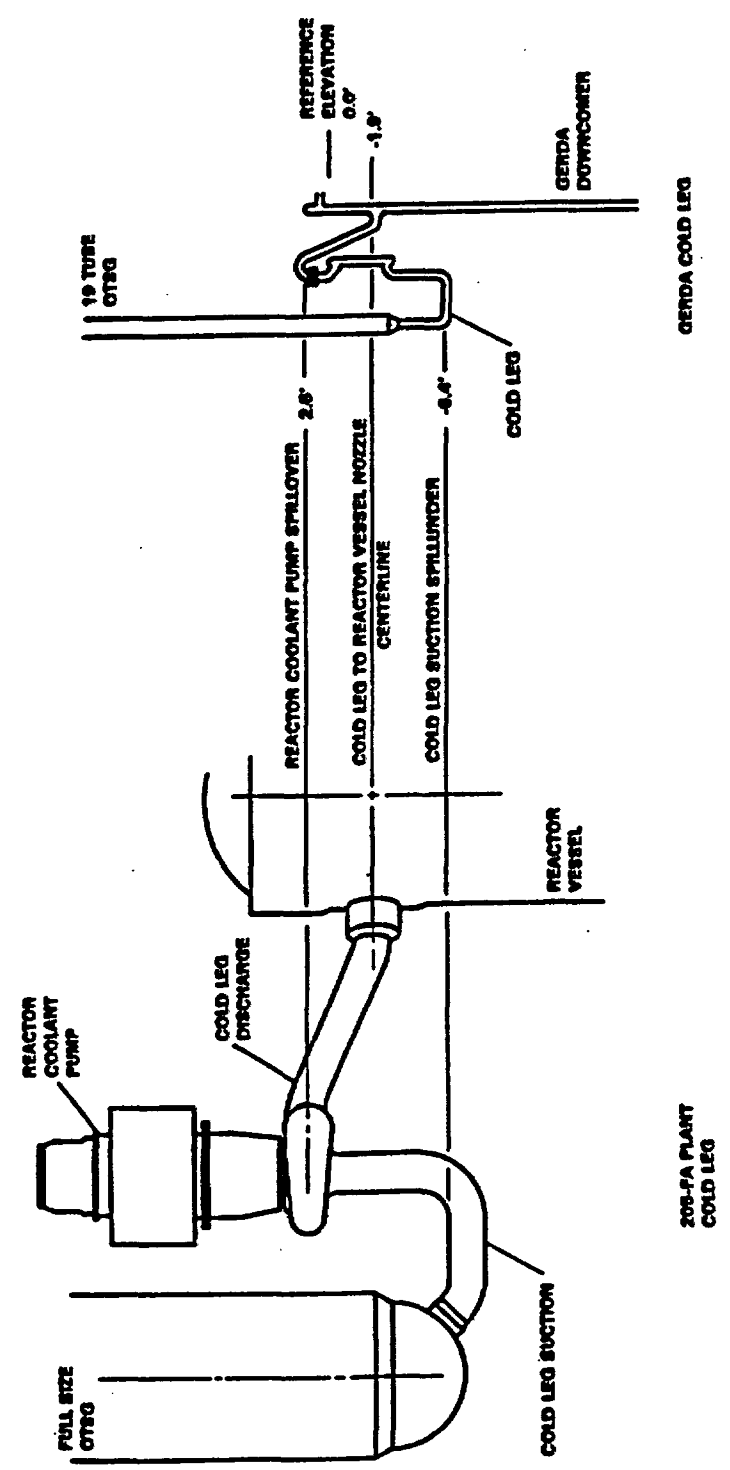



Figure 2.8 Comparison of Full-Size 205-FA Plant Cold Leg to GERDA Cold Leg

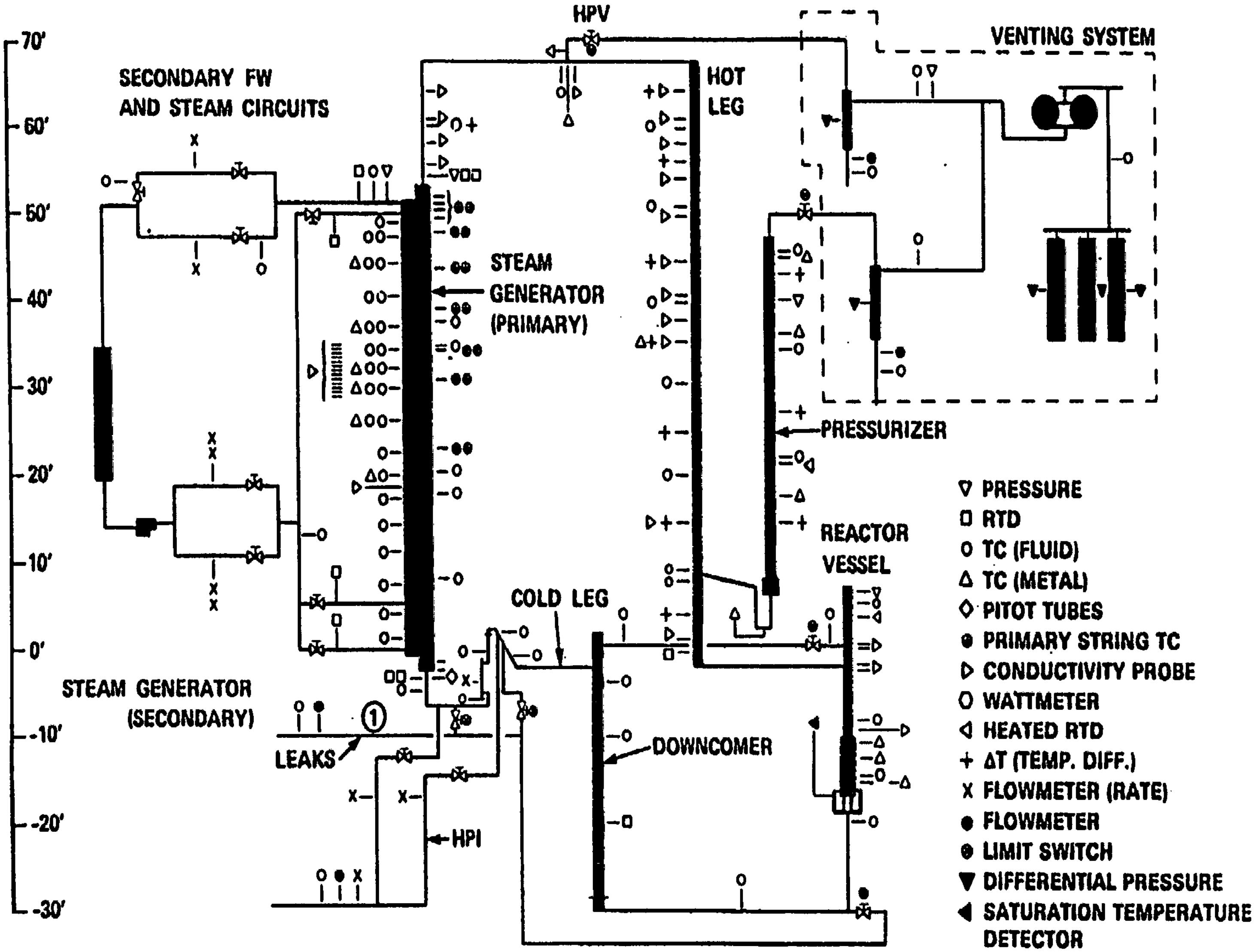



Figure 2.9 GERDA Instrumentation, Overview

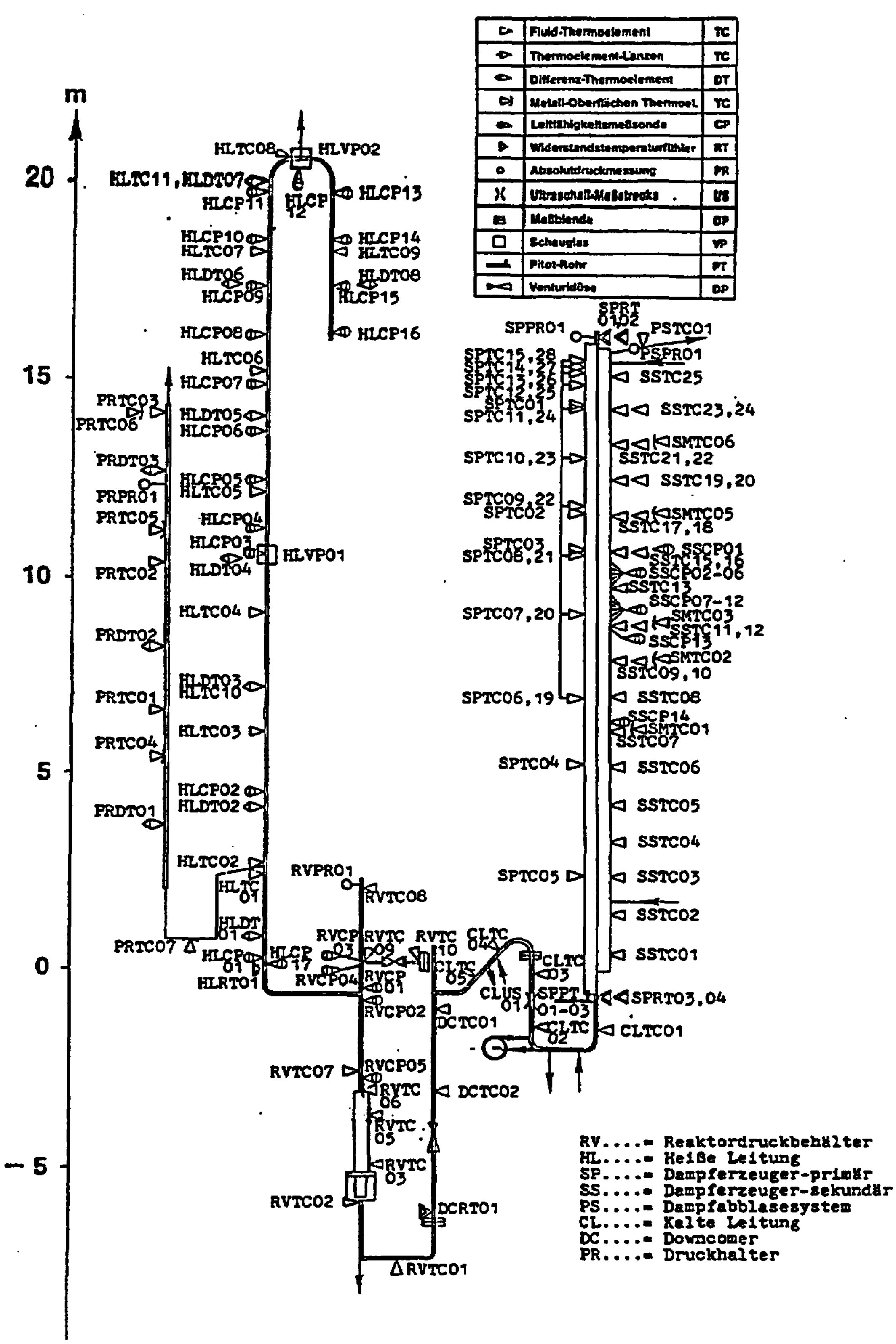



Figure 2.10 GERDA Instrumentation, Details

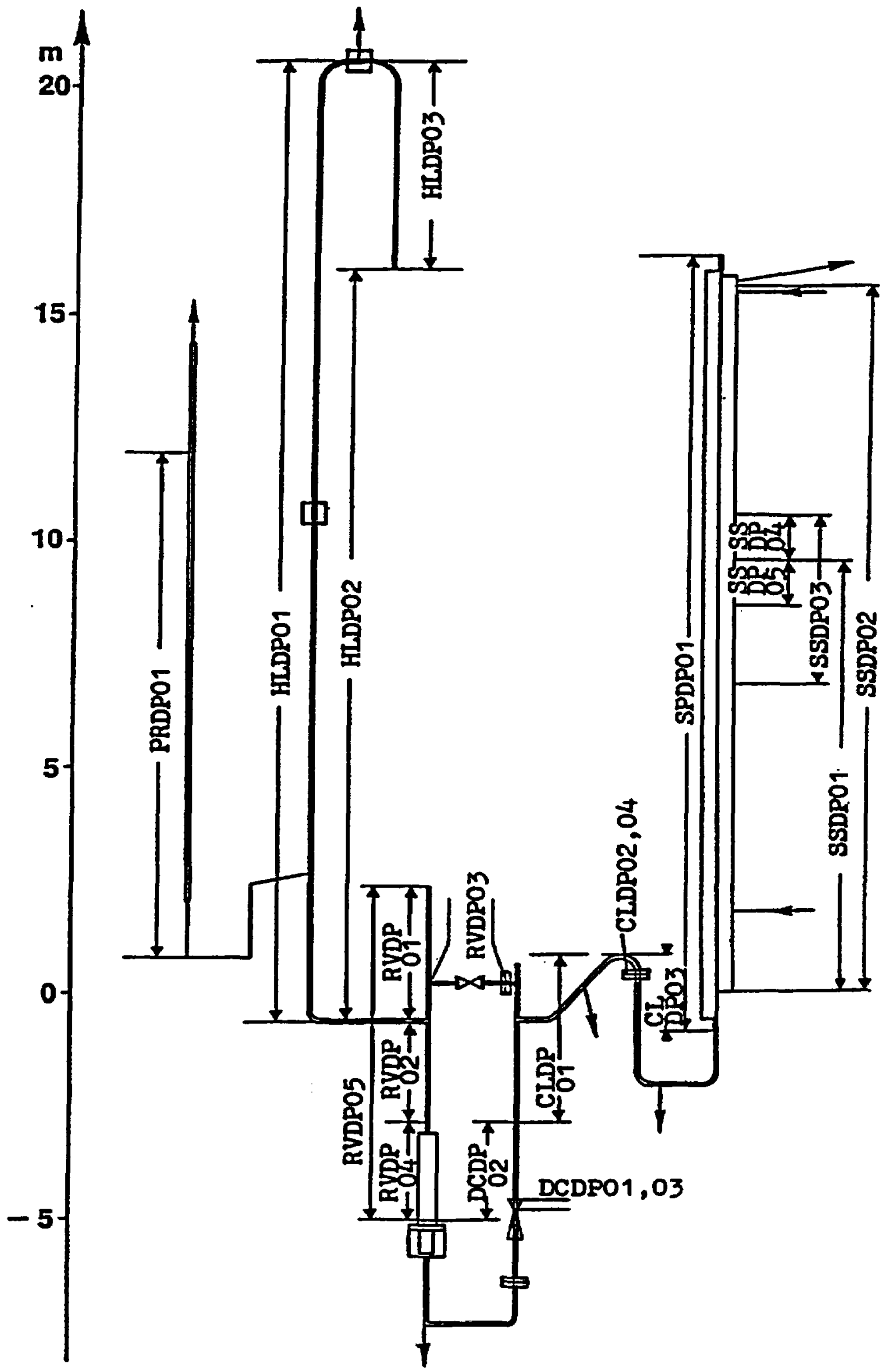



Figure 2.11 GERDA Instrumentation, Pressure Difference Measurements

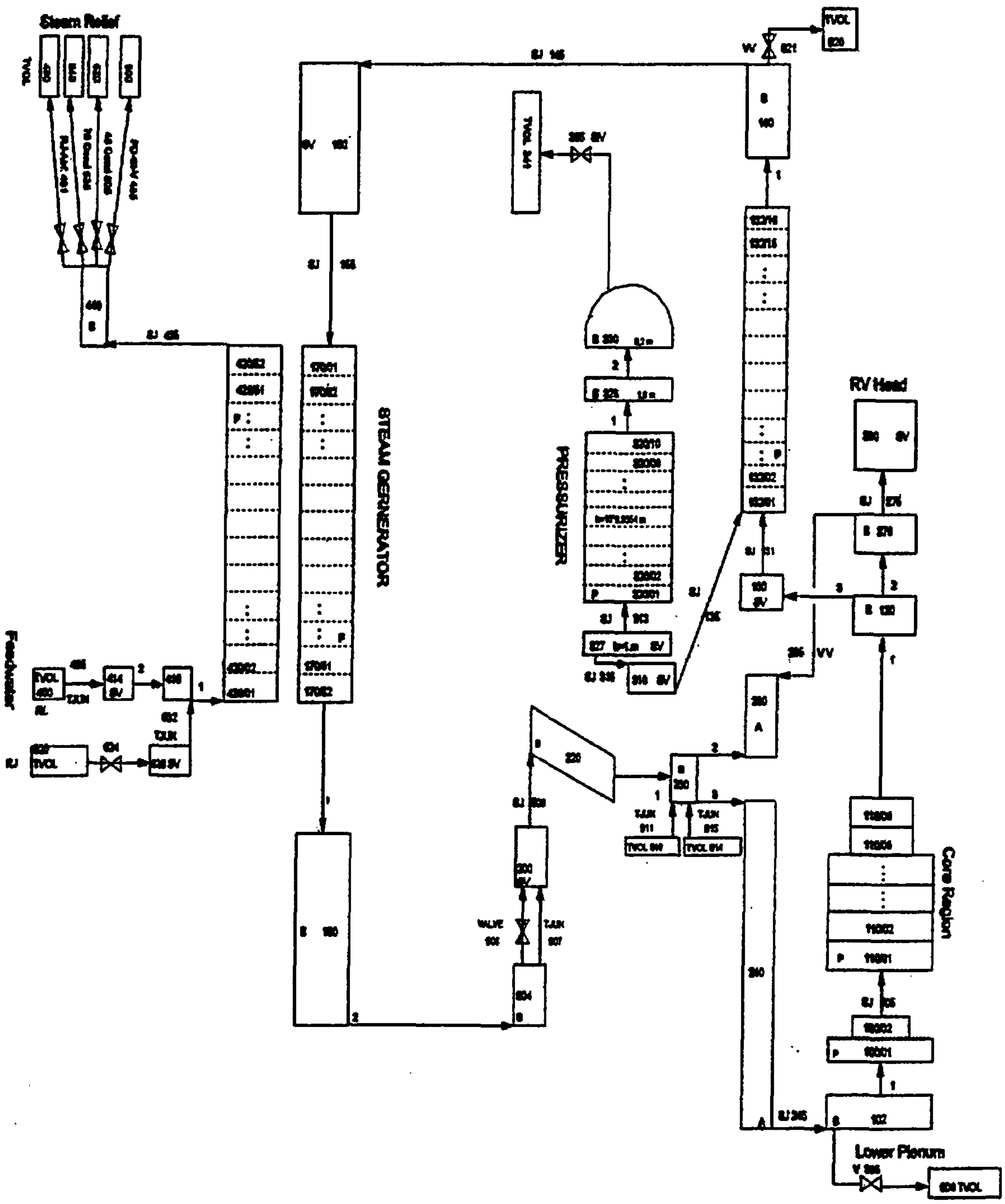



Figure 4.1 GERDA Nodalization Scheme for RELAP 5MOD3.2 Calculations of Test 1605AA

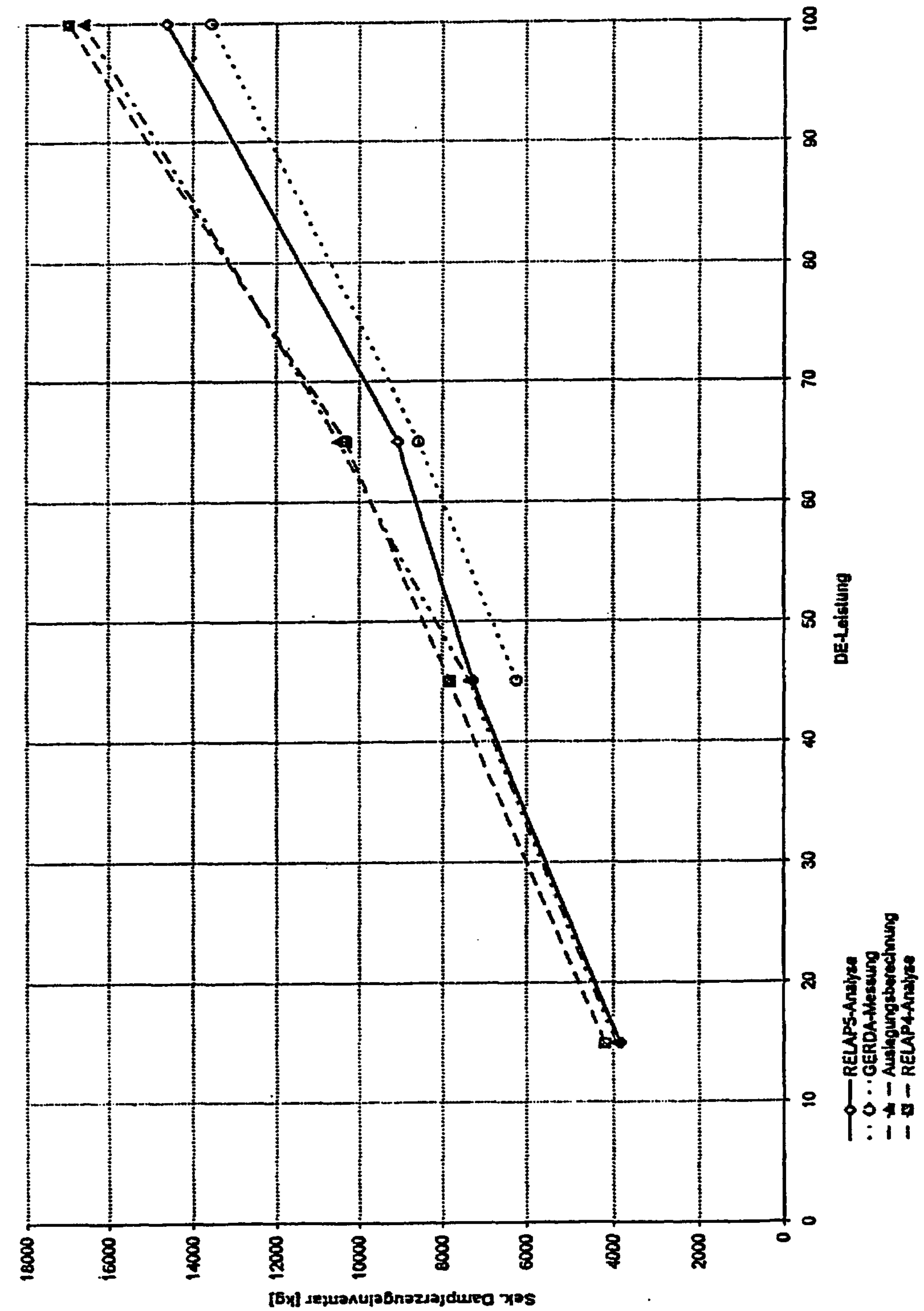



Figure 4.2 OTSG Secondary Side Inventory as Function of Rated Power

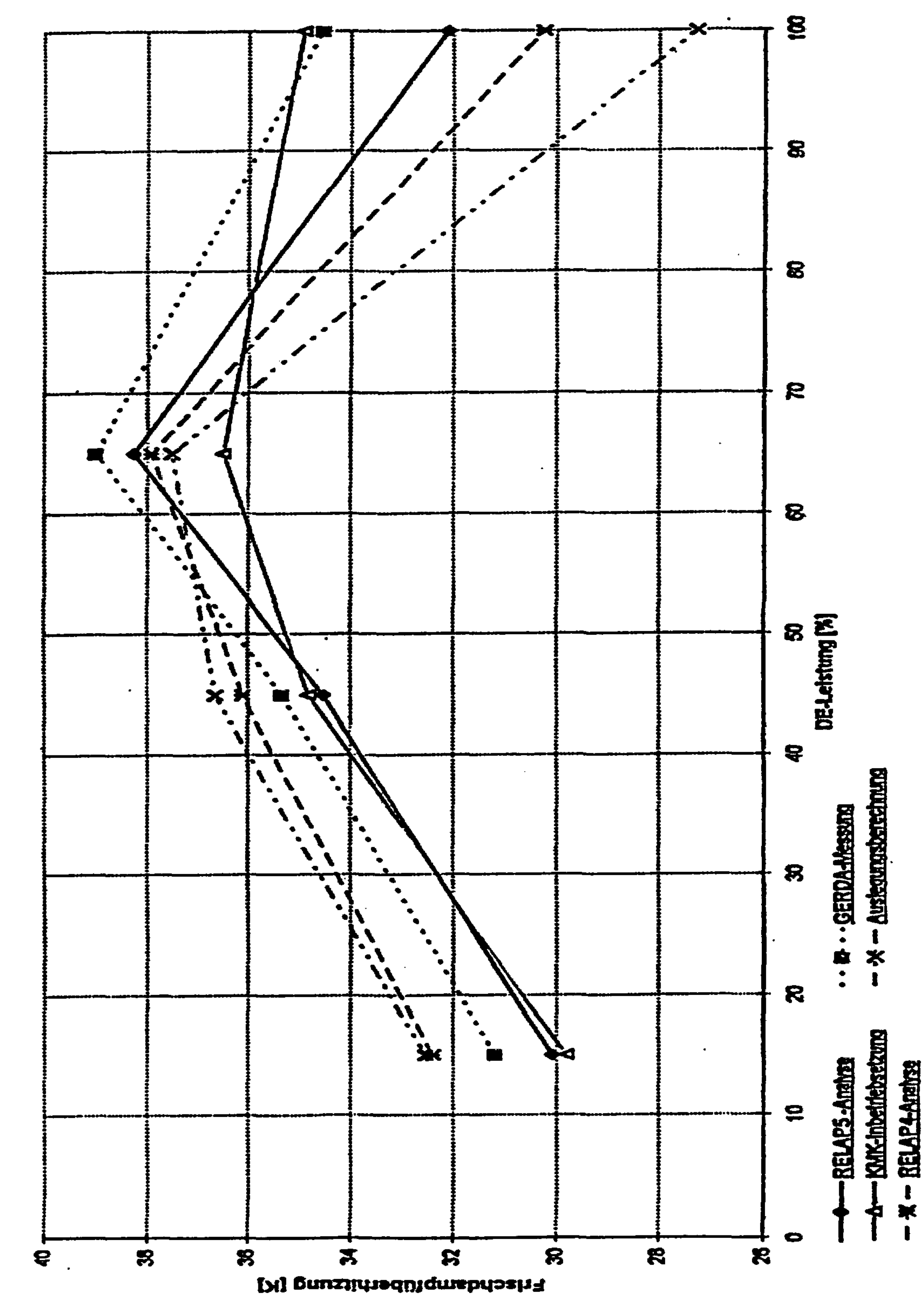



Figure 4.3 OTSG Secondary Steam Superheating as Function of Rated Power

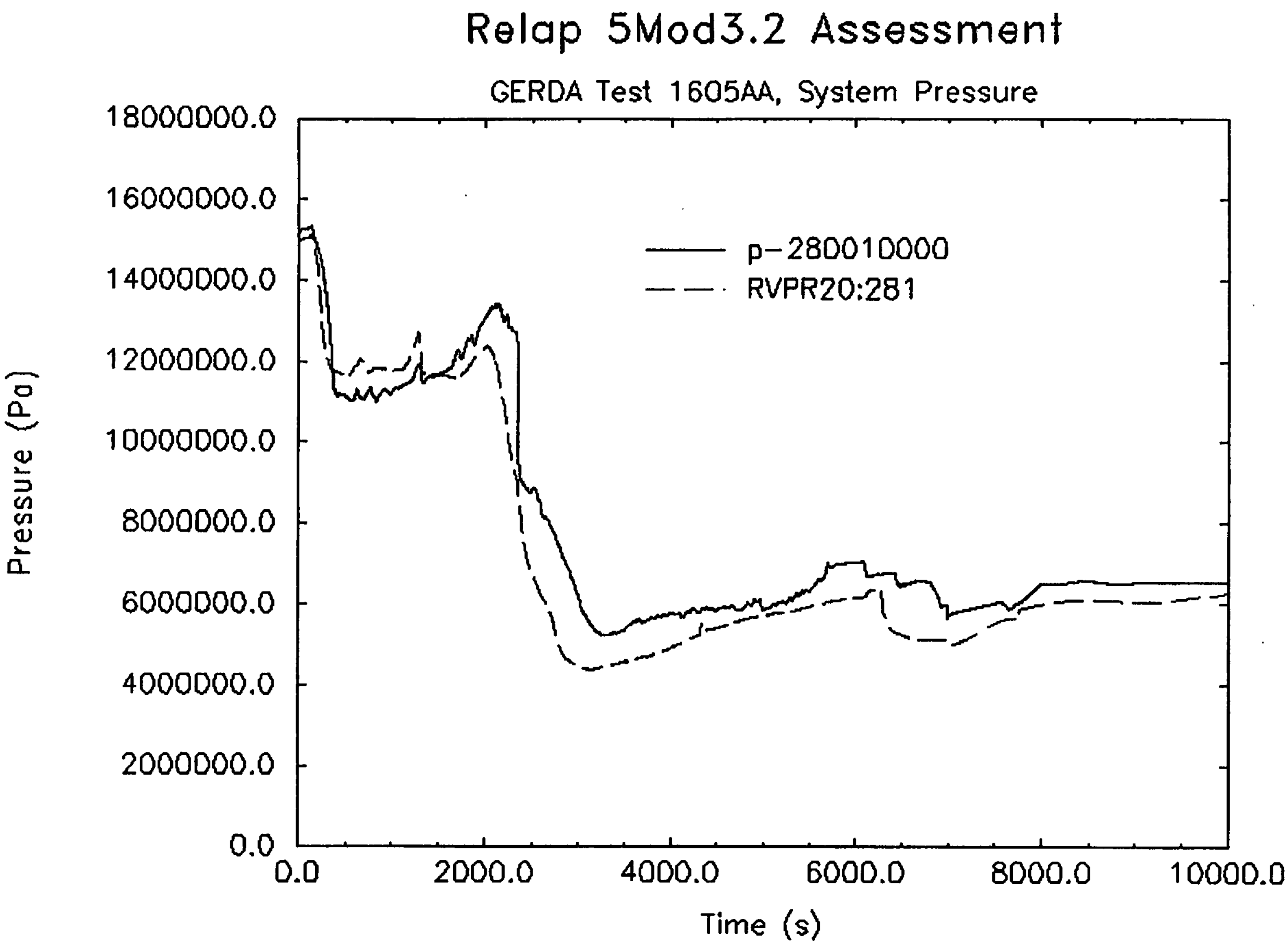



Figure 4.4 Comparison of Measured and Calculated Primary Pressure

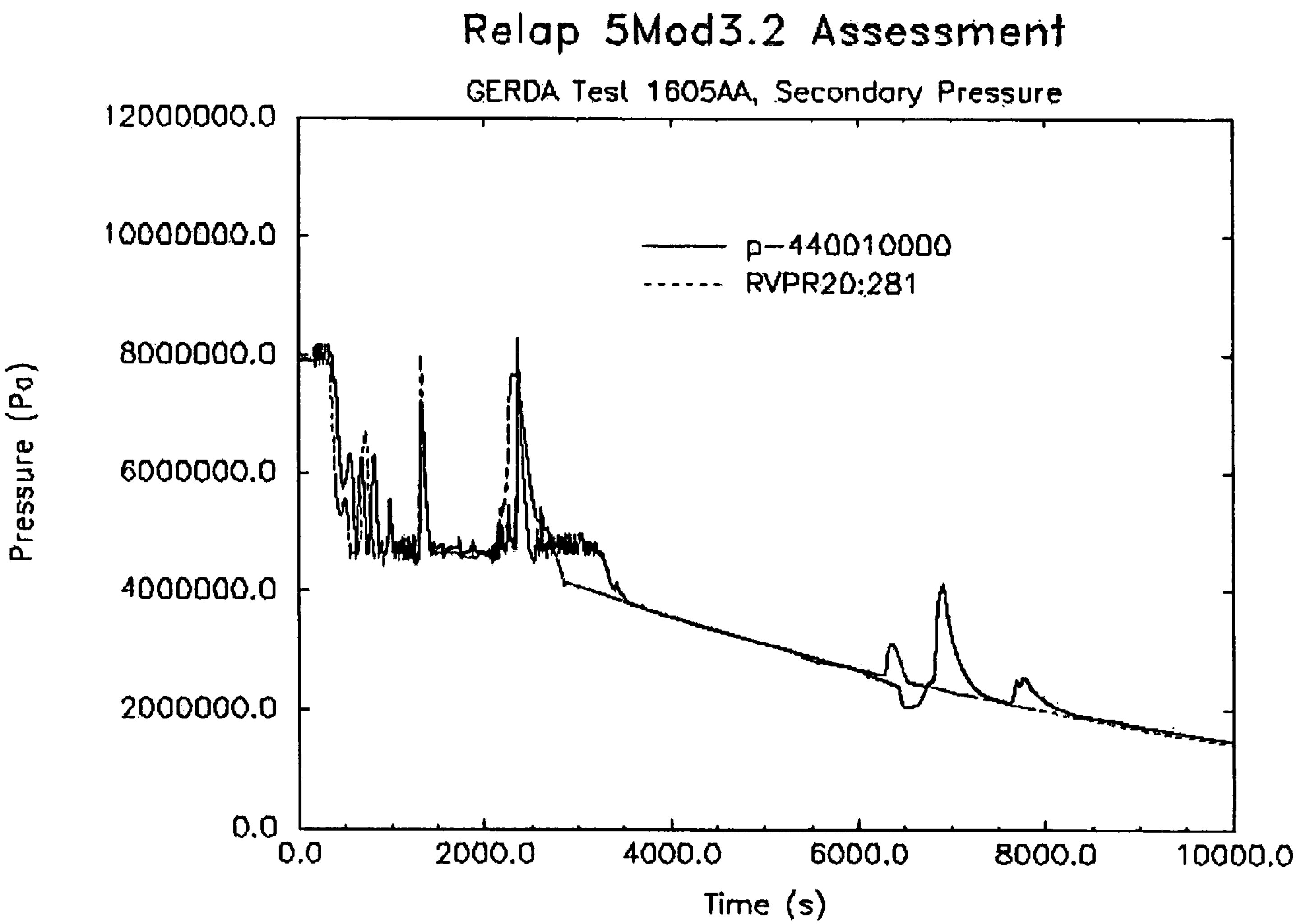



Figure 4.5 Comparison of Measured and Calculated SG Steam Pressure

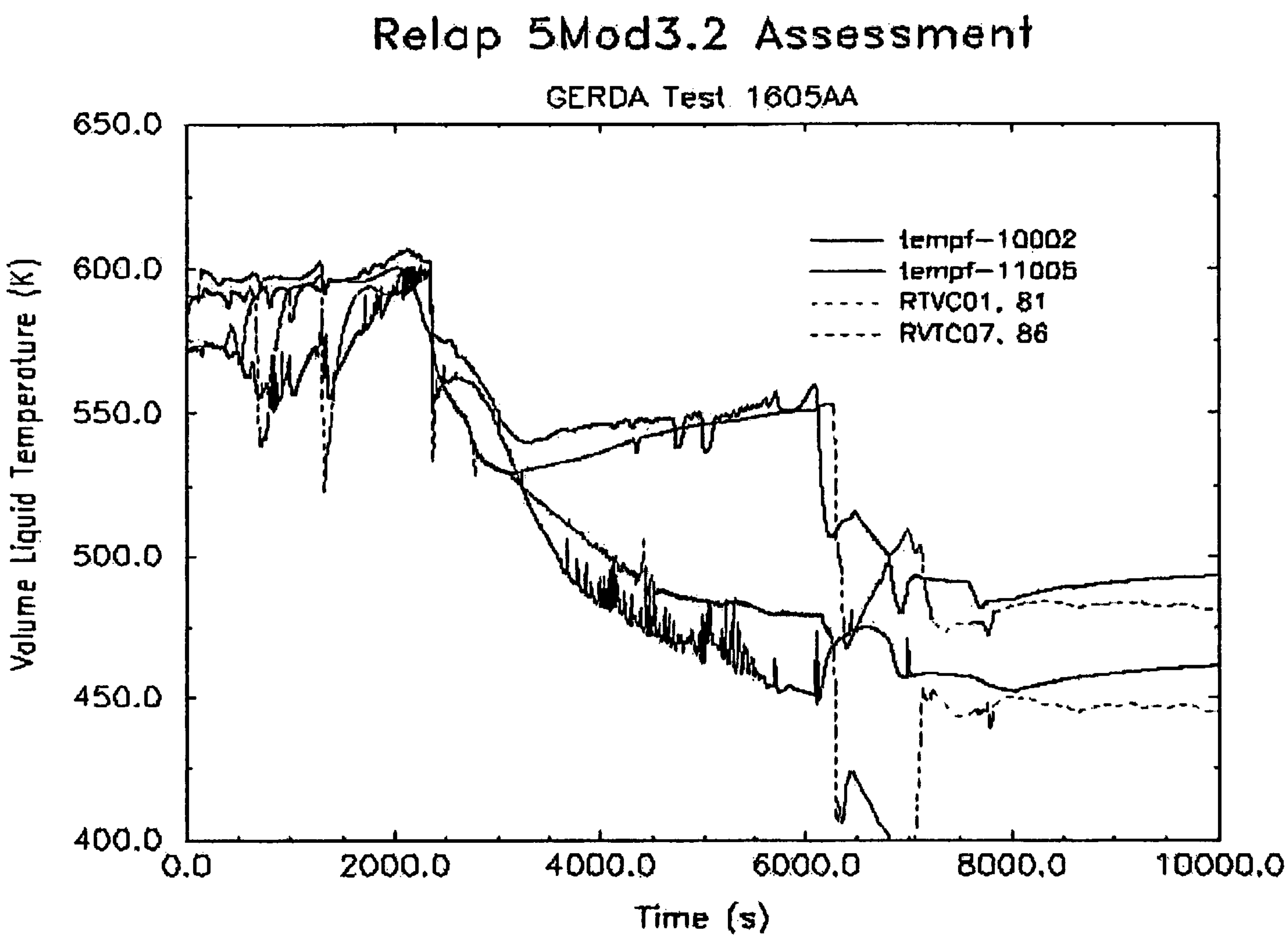



Figure 4.6 Comparison of Measured and Calculated Core Intel and Outlet Temperature

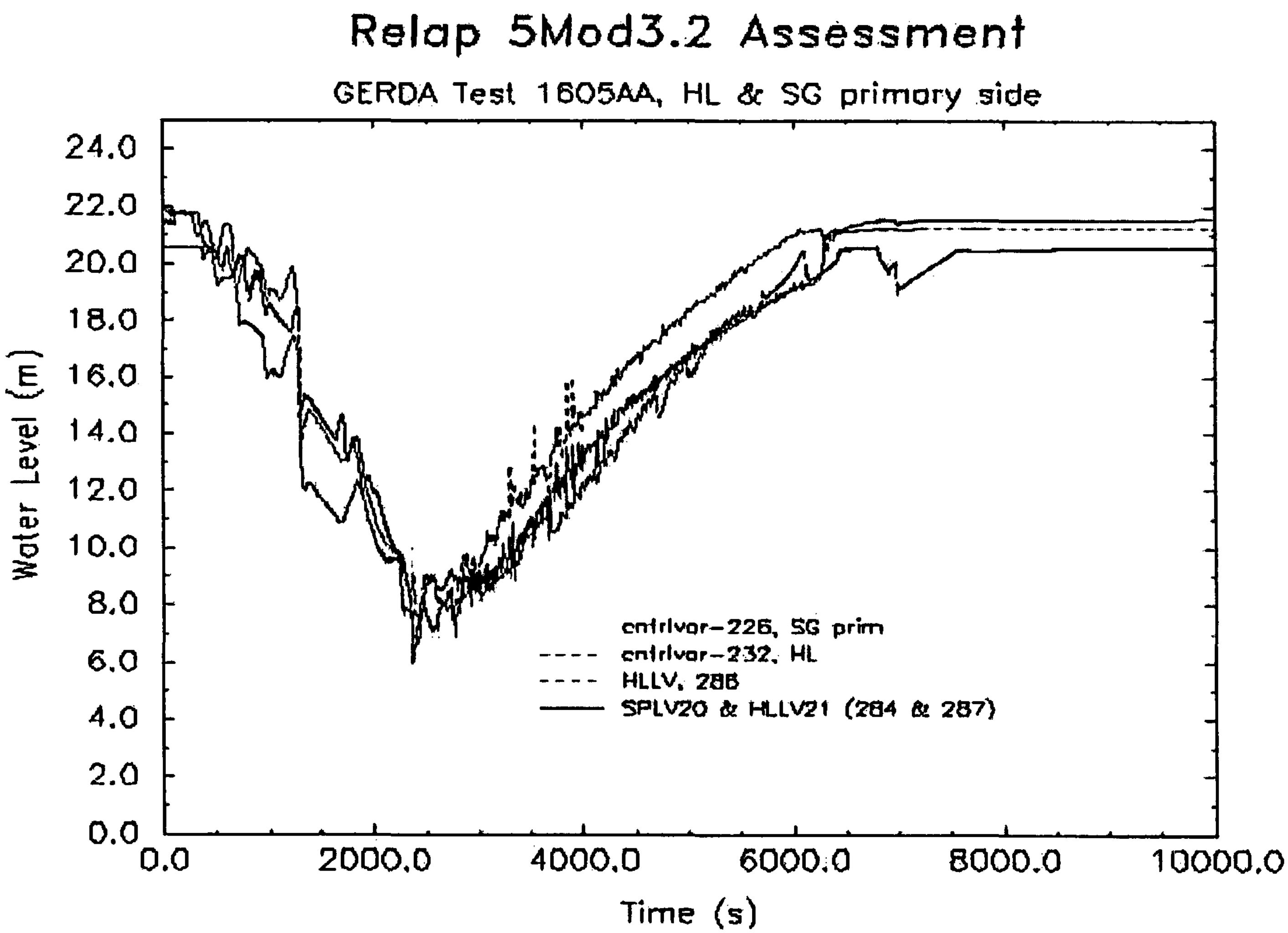



Figure 4.7 Comparison of Measured and Calculated Hot Leg and SG Primary Water Level

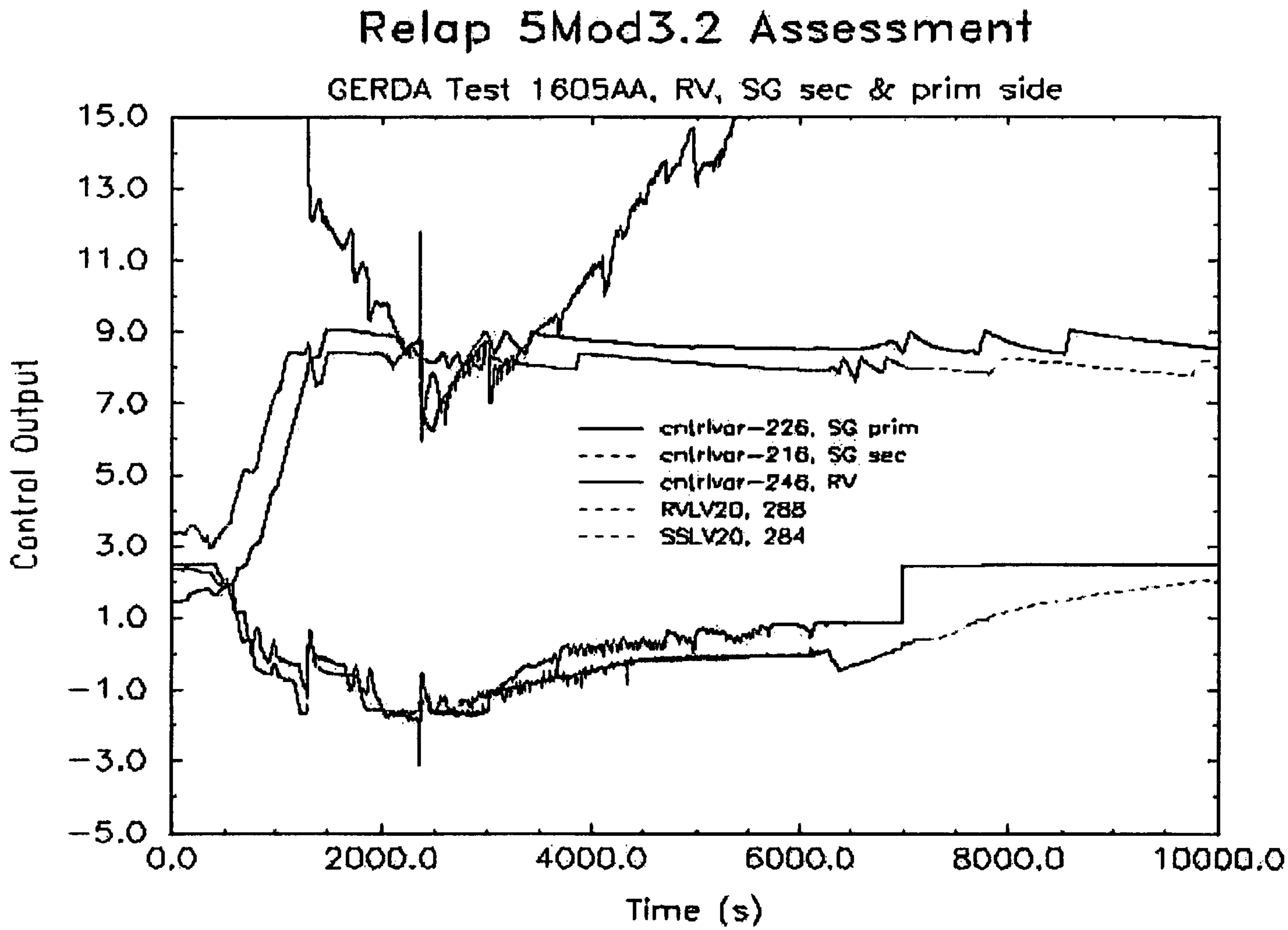



Figure 4.8 Comparison of Measured and Calculated SG Secondary and RV Water Level

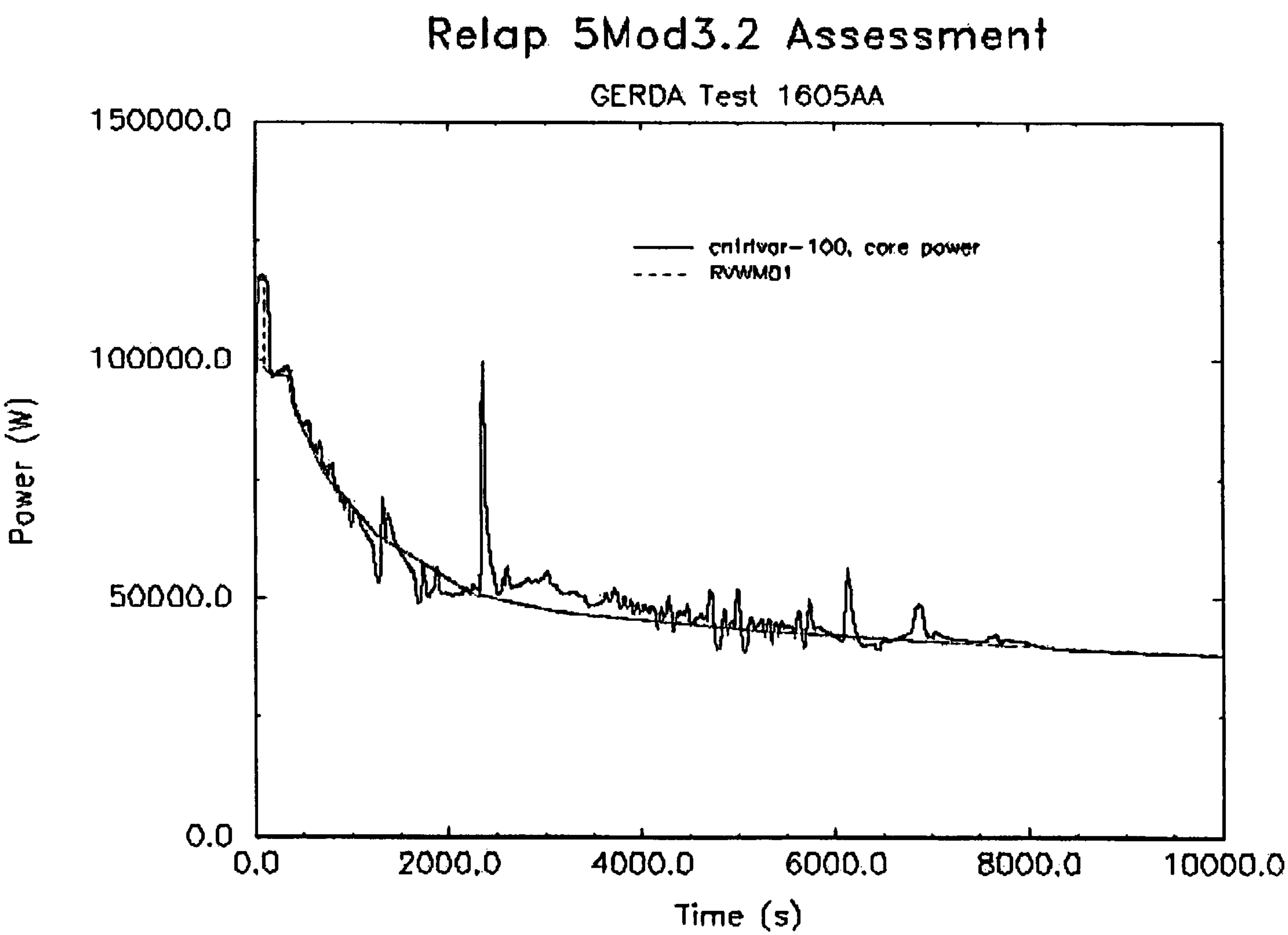



Figure 4.9 Comparison of Measured and Calculated Core Power

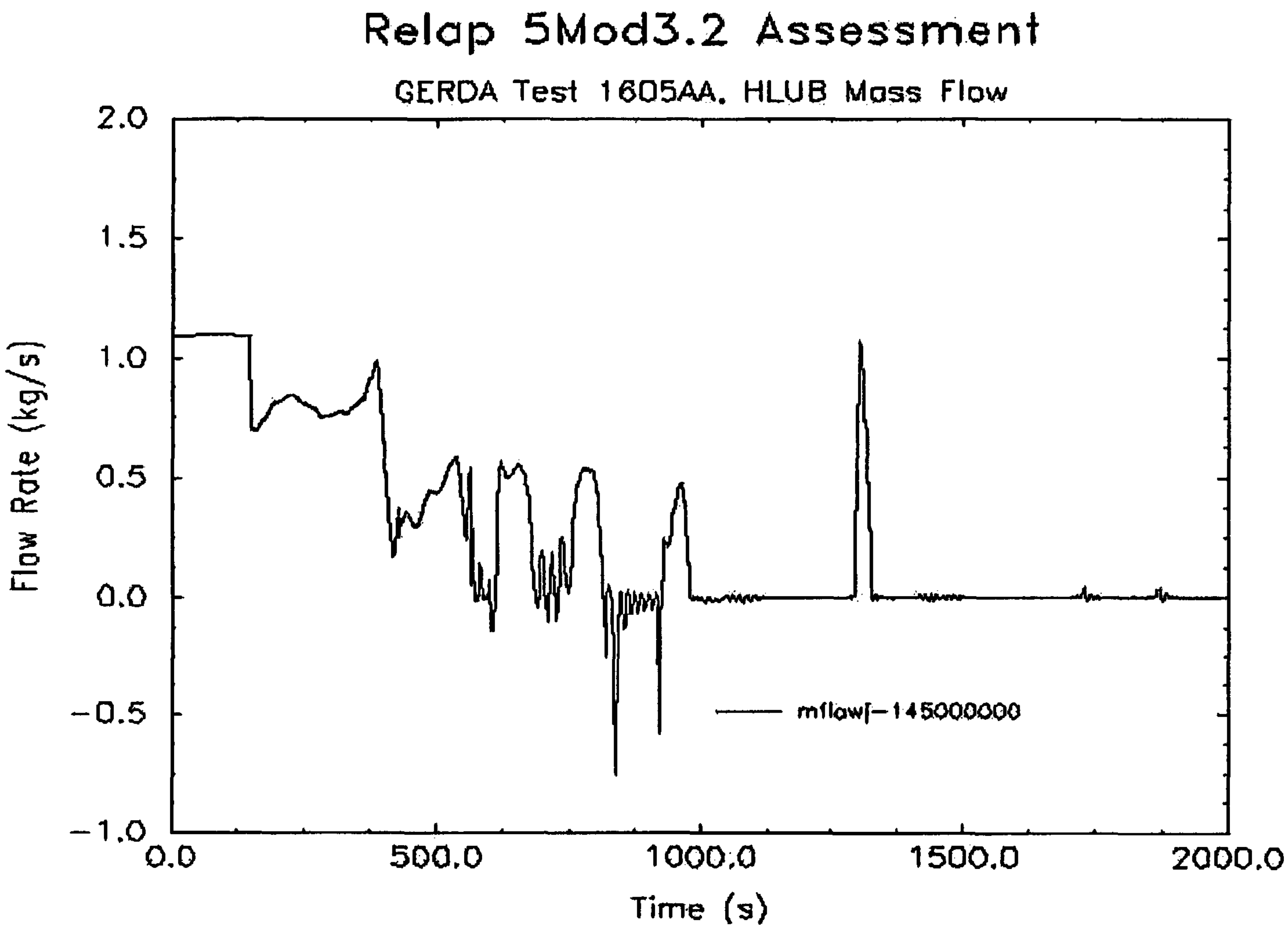



Figure 4.10 RELAP5 MOD 3.2 Prediction of Mass Flow in HLUB

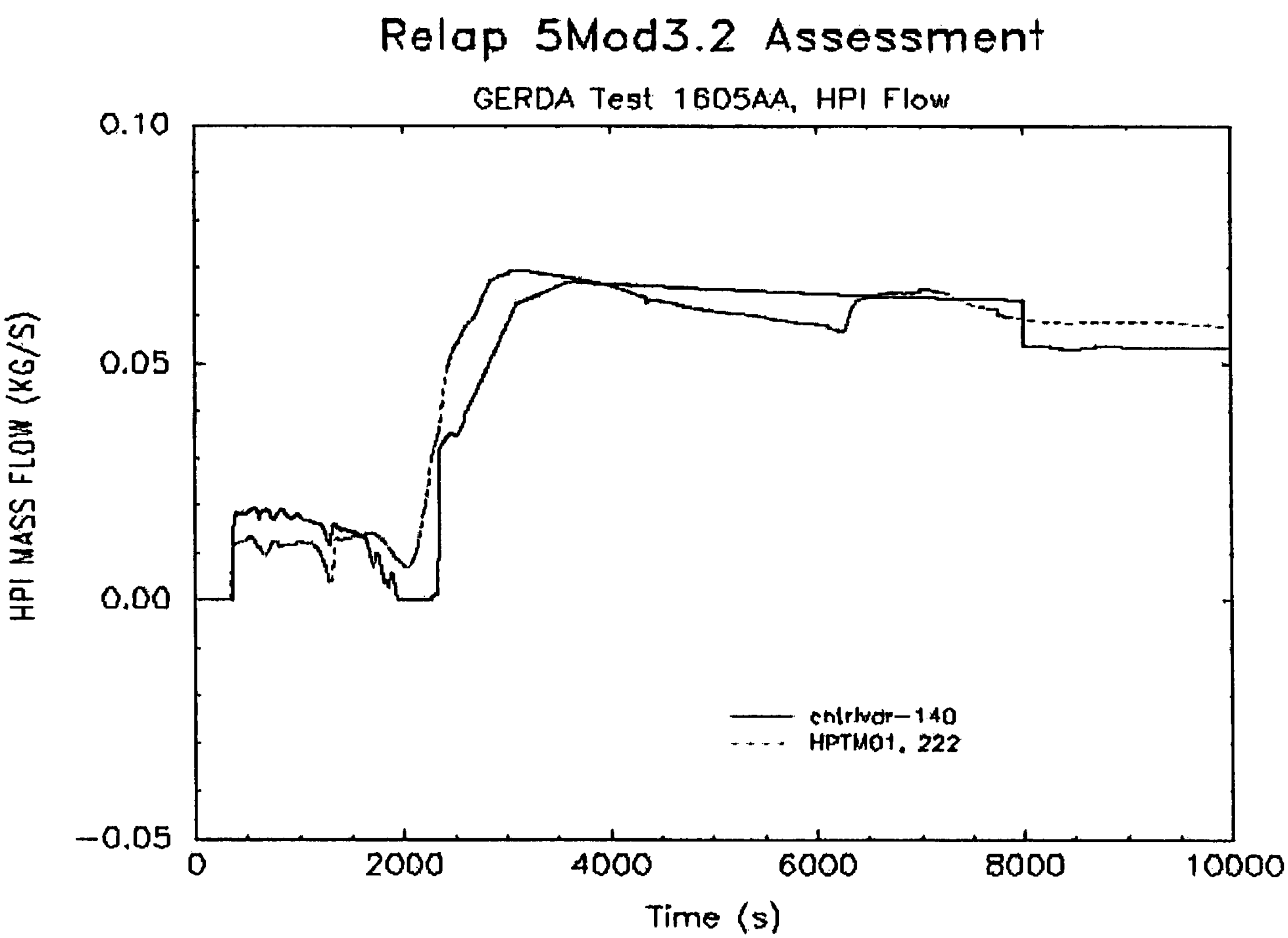



Figure 4.11 Comparison of Measured and Calculated HPI Mass Flow

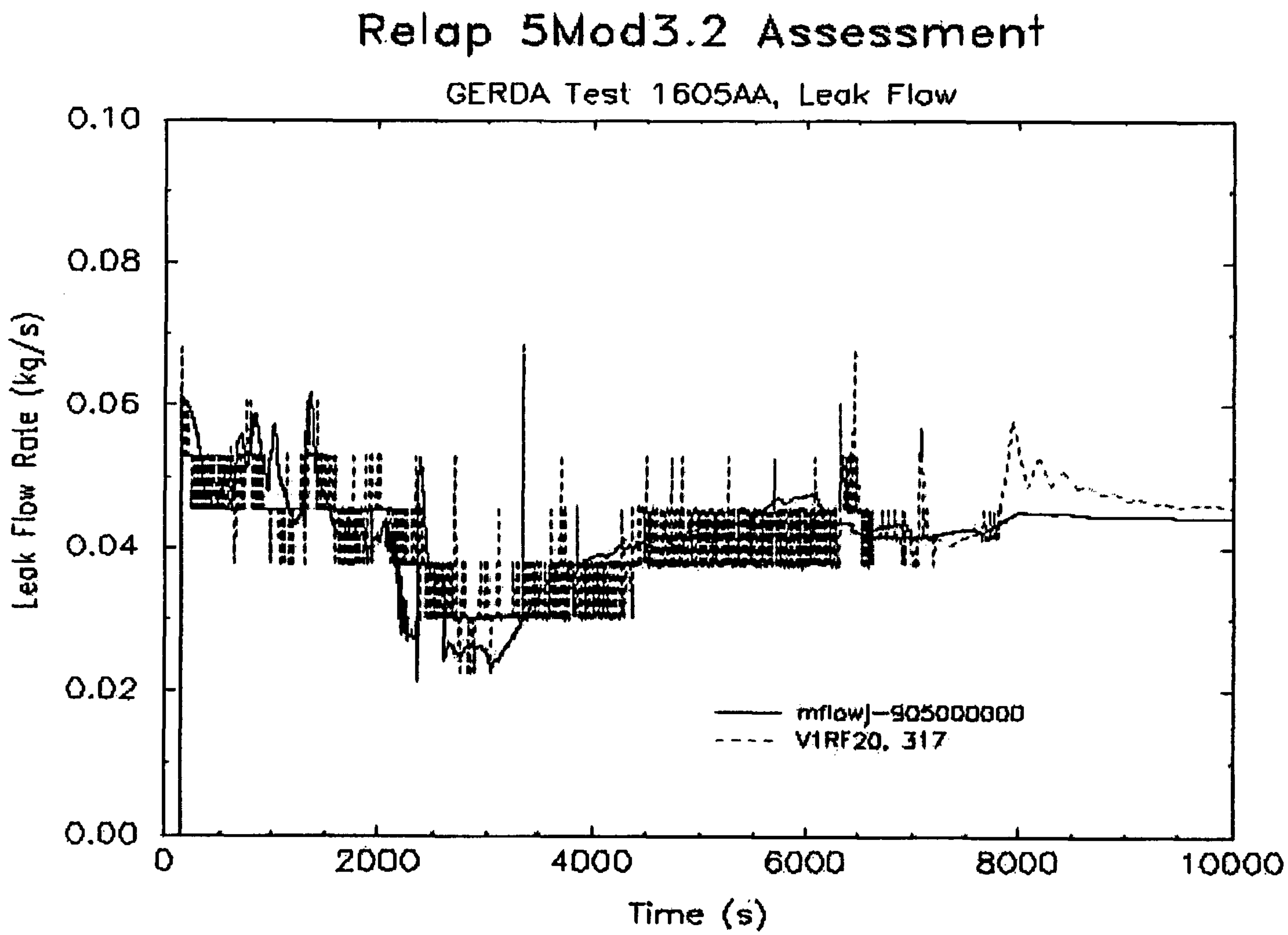



Figure 4.12 Comparison of Measured and Calculated Leak Mass Flow

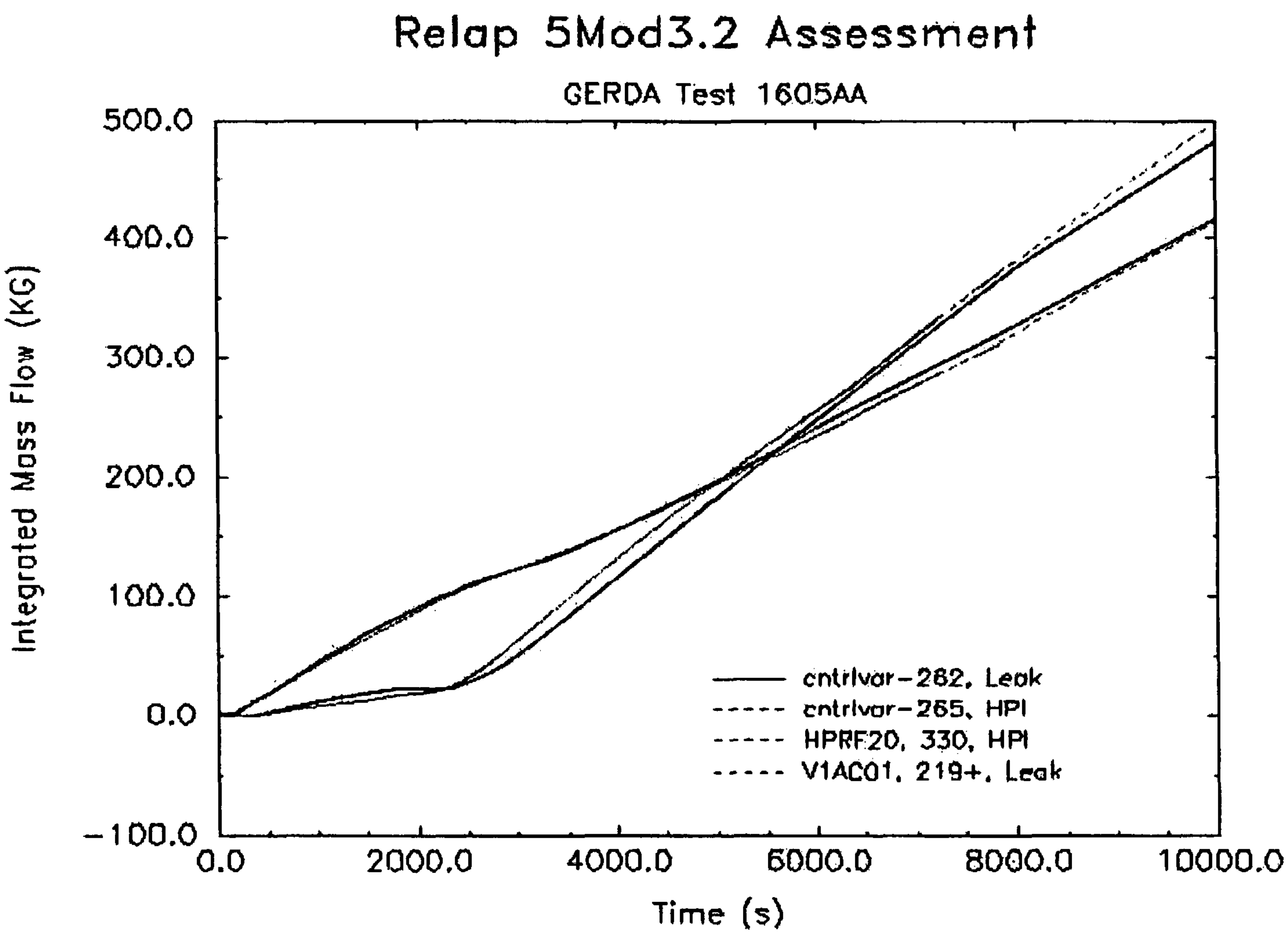



Figure 4.13 Comparison of Measured and Calculated Integrated Mass Flow of HPI and Leak

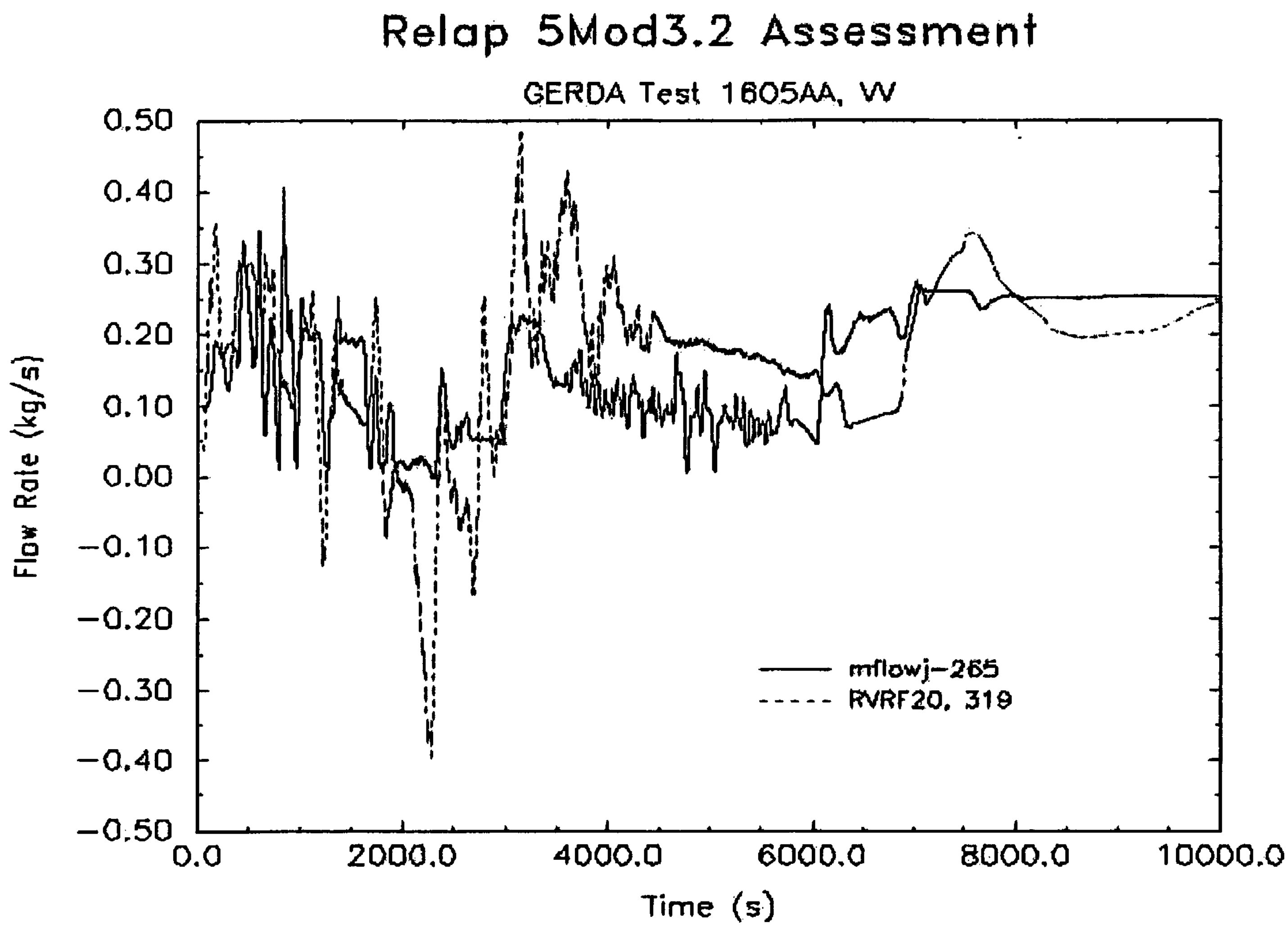



Figure 4.14 Comparison of Measured and Calculated Vent Valve Mass Flow

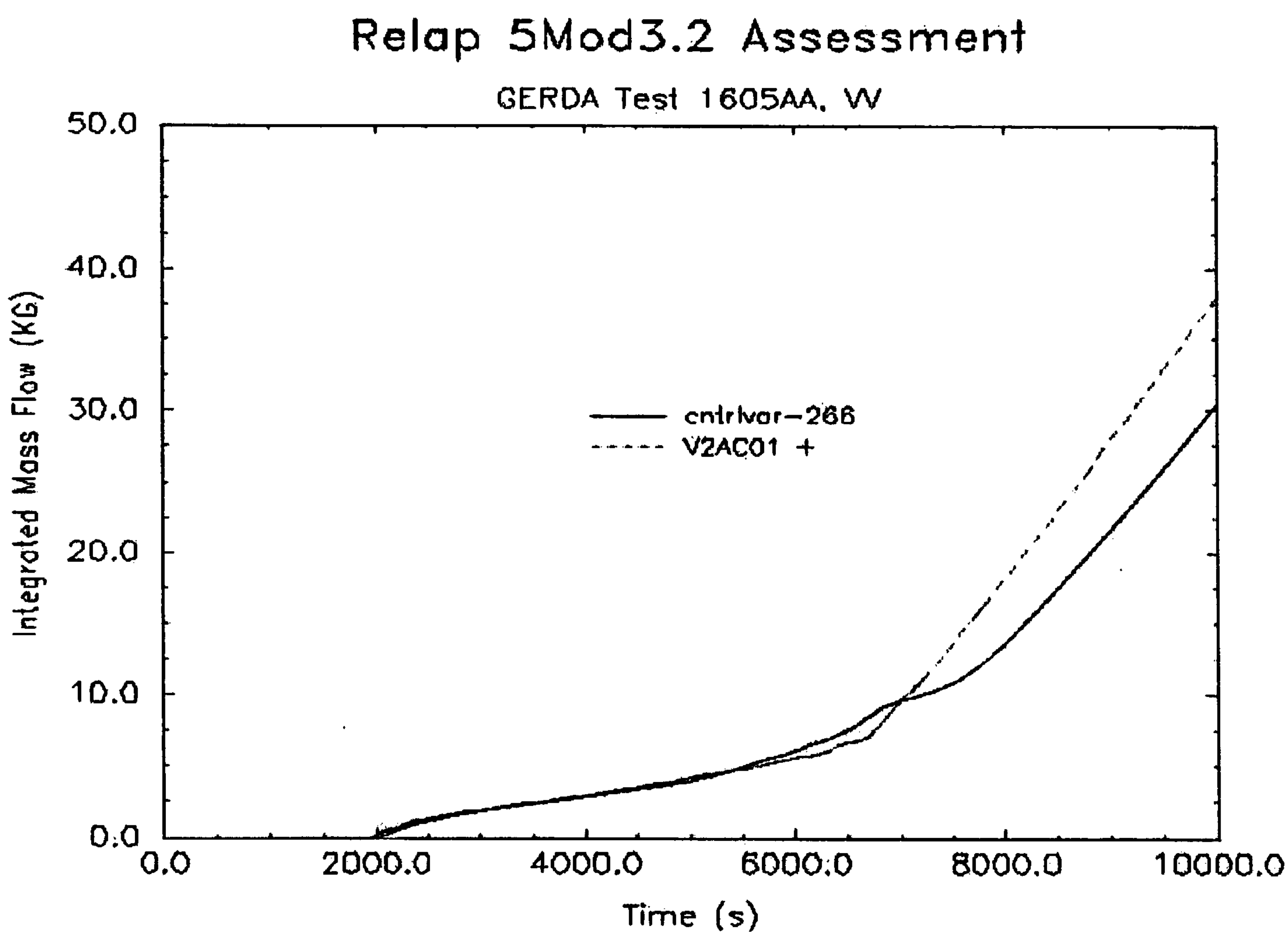



Figure 4.15 Comparison of Measured and Calculated Integrated Vent Valve Mass Flow

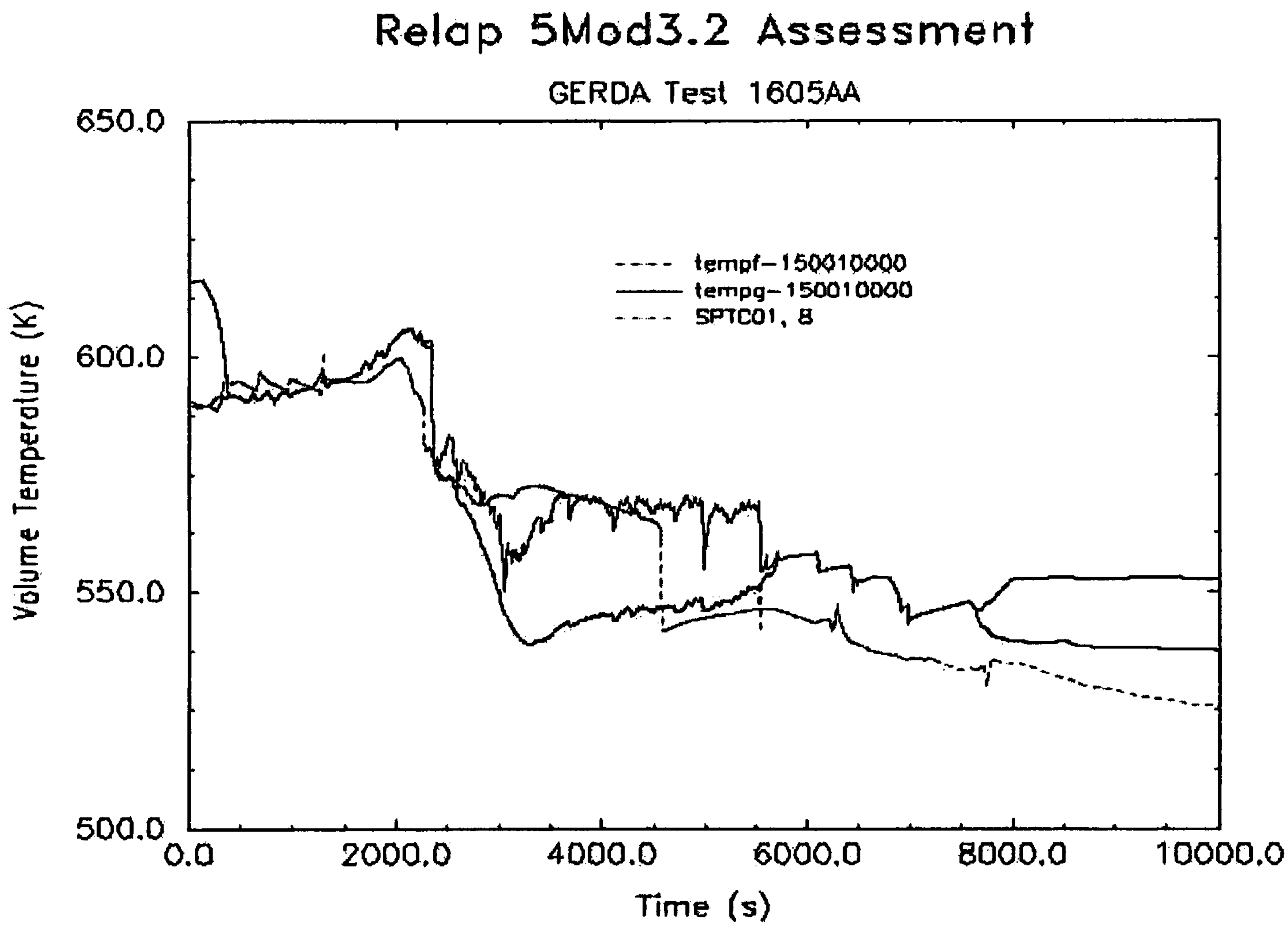



Figure 4.16 Comparison of Measured and Calculated Temperatures in HLUB Downwards bend Piping

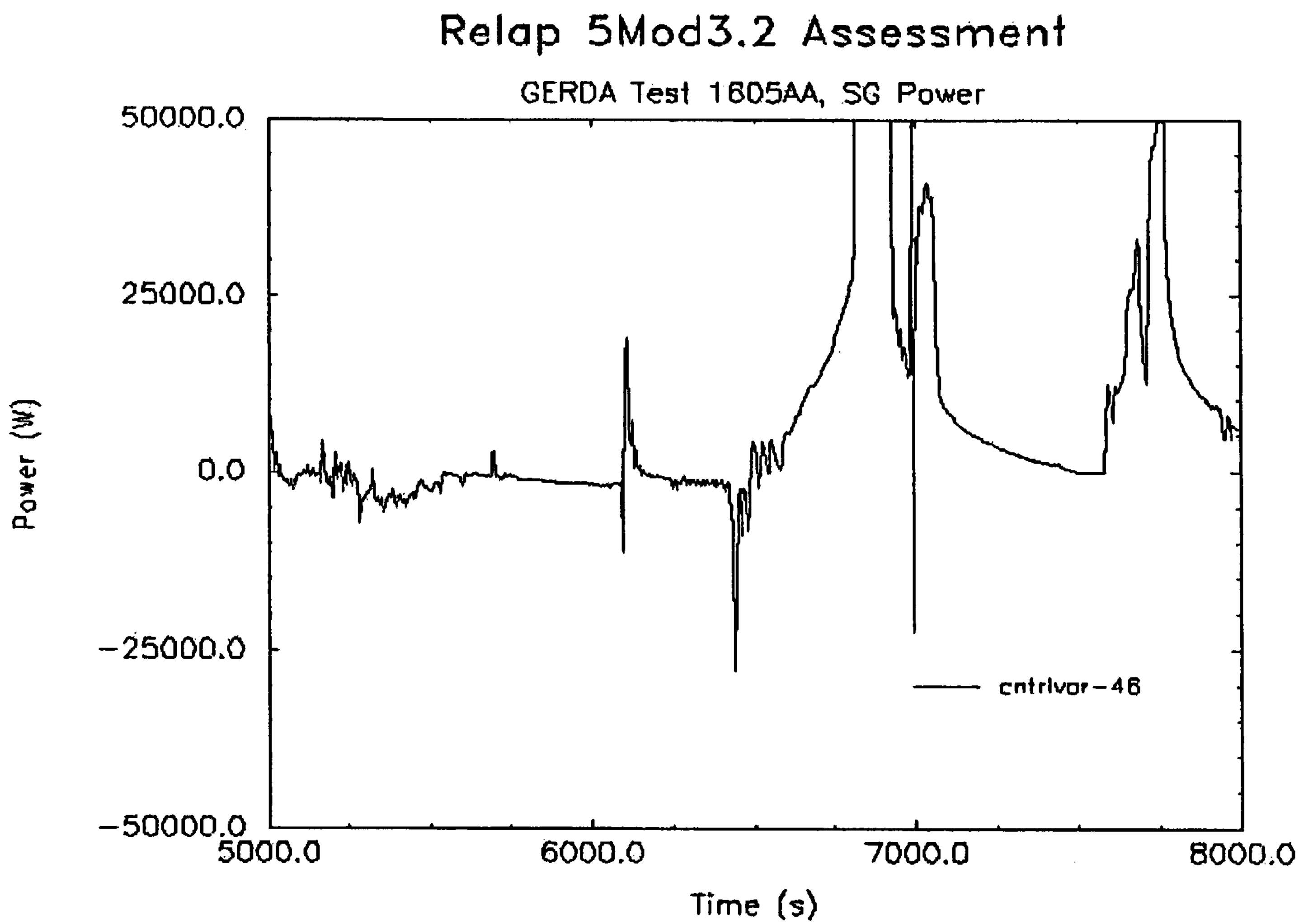



Figure 4.17 RELAP5 MOD 3.2 Prediction of SG Power, 5000 s - 8000 s

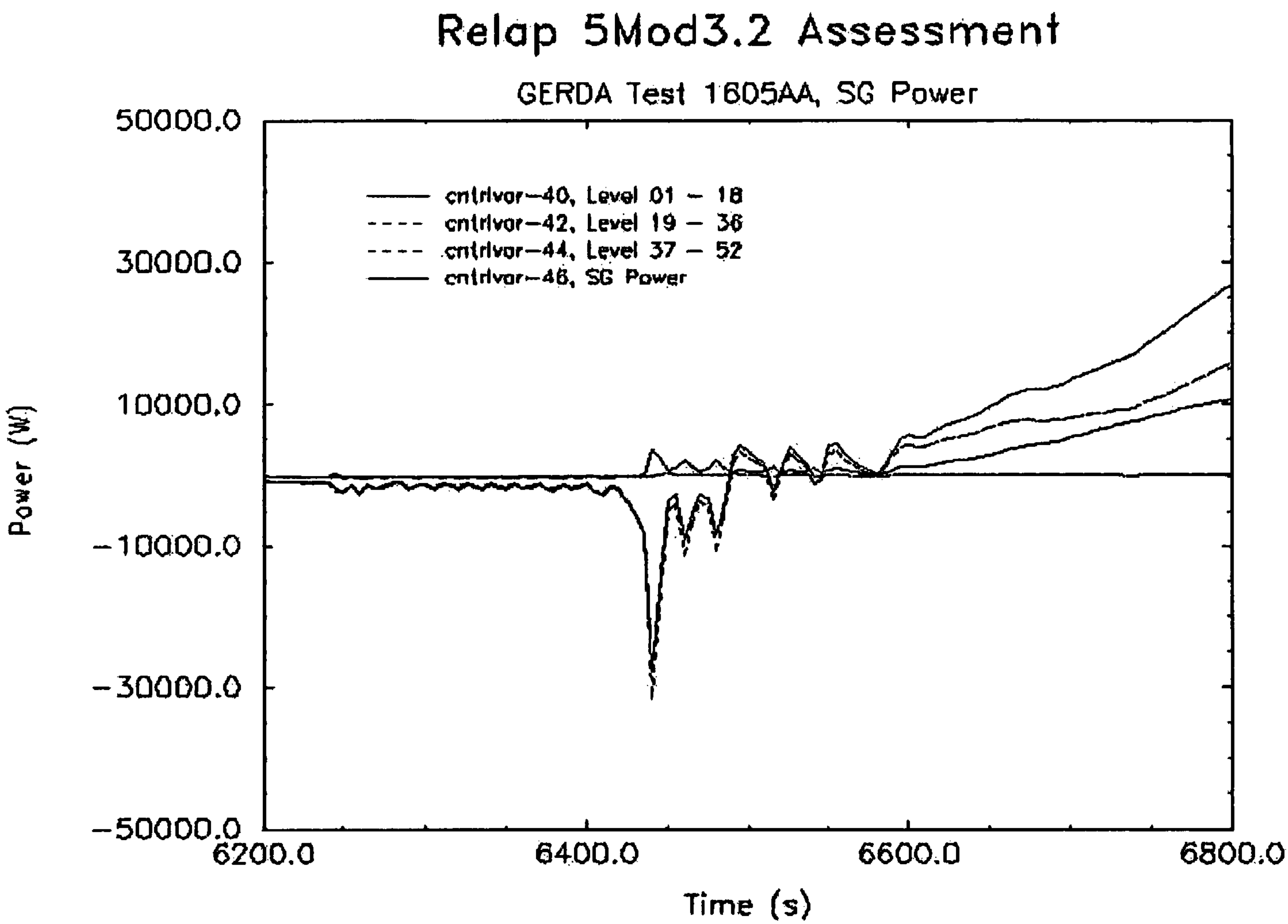



Figure 4.18 RELAP5 MOD 3.2 Prediction of SG Power, Details from 6200 s - 6800 s

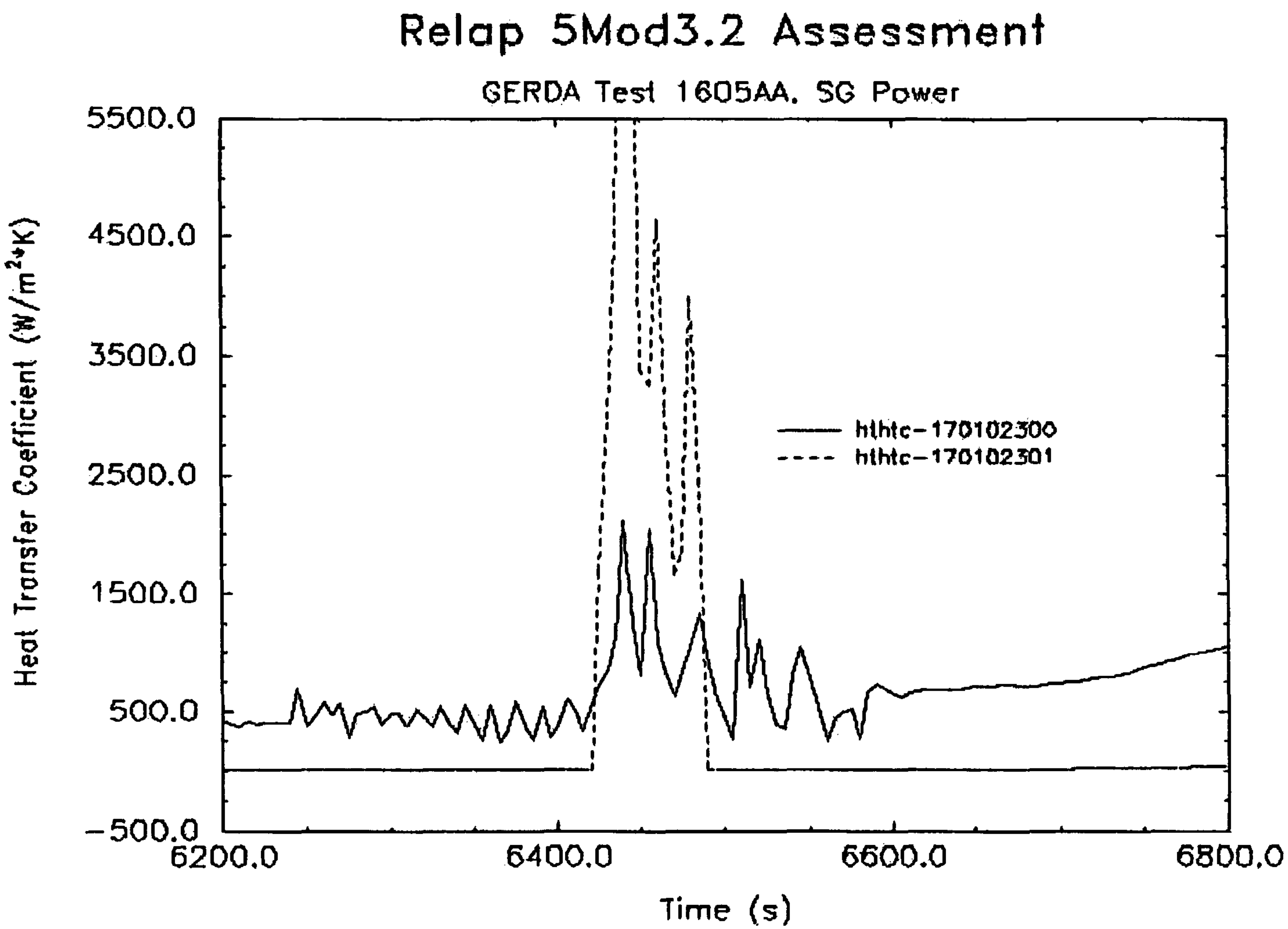



Figure 4.19 RELAP5 MOD 3.2 Prediction of SG HT Coeff. in Prim. Node 23, 6200 s - 6800 s

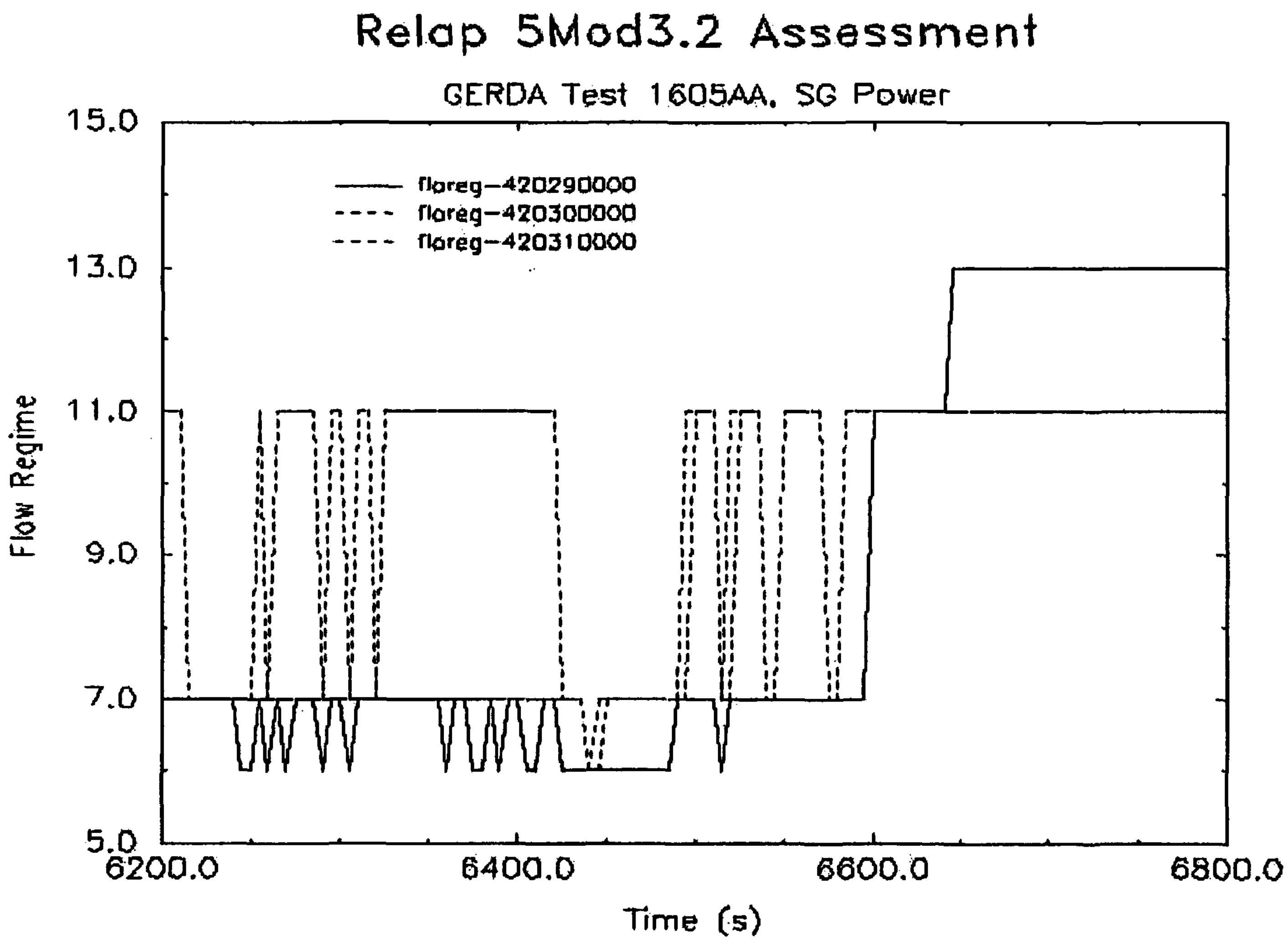



Figure 4.20 RELAP5 MOD 3.2 Prediction of Secondary Flow Regimes, Details form 6200 s - 6800 s

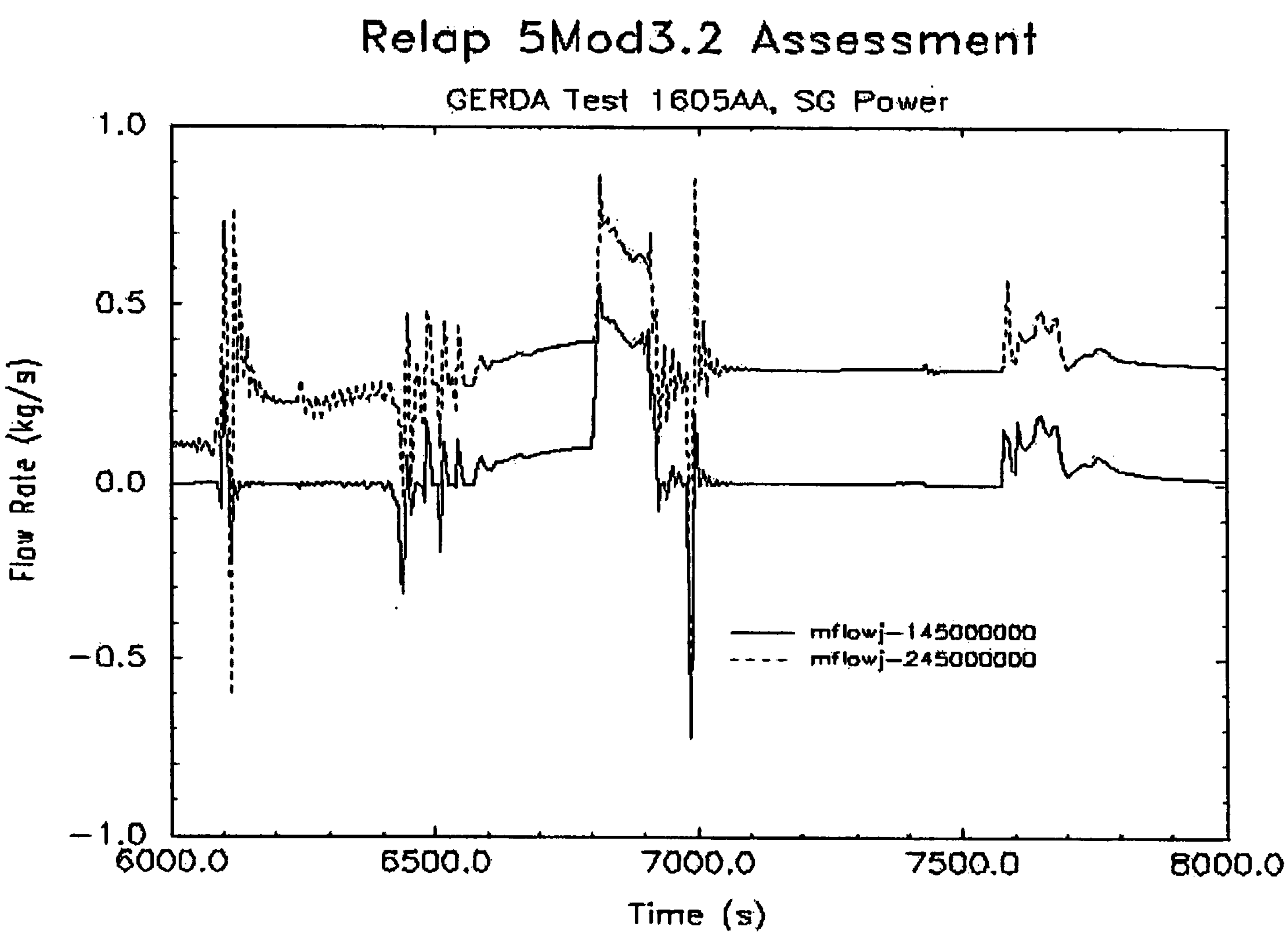



Figure 4.21 RELAP5 MOD 3.2 Prediction of HLUB and RPV-Downcomer Mass Flow Rates, 5000 s - 8000 s

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 1 | SPPR01 | PSIA | | | |
| 2 | SPDP01 | PSI | | | |
| 3 | SPLV01 | PSI | | | |
| 4 | SPRT01 | DEG F | 3 SGP SG PRIMRY | 3 RTD FLUID RTD | +53.10 |
| 5 | SPRT02 | DEG F | 3 SGP SG PRIMRY | 3 RTD FLUID RTD | +53.10 |
| 6 | SPRT03 | DEG F | 3 SGP SG PRIMRY | 3 RTD FLUID RTD | -2.80 |
| 7 | SPRT04 | DEG F | 3 SGP SG PRIMRY | 3 RTD FLUID RTD | -2.90 |
| 8 | SPTC01 | DEG F | 3 SGP SG PRIMRY | 2 FTC FLUID TEMP | +47.10 |
| 9 | SPTC02 | DEG F | 3 SGP SG PRIMRY | 2 FTC FLUID TEMP | +38.20 |
| 10 | SPTC03 | DEG F | 3 SGP SG PRIMRY | 2 FTC FLUID TEMP | +35.30 |
| 11 | SPTC04 | DEG F | 3 SGP SG PRIMRY | 2 FTC FLUID TEMP | +17.30 |
| 12 | SPTC05 | DEG F | 3 SGP SG PRIMRY | 2 FTC FLUID TEMP | +8.10 |
| 13 | SPTC06 | DEG F | | | |
| 14 | SPTC07 | DEG F | | | |
| 15 | SPTC08 | DEG F | | | |
| 16 | SPTC09 | DEG F | | | |
| 17 | SPTC10 | DEG F | | | |
| 18 | SPTC11 | DEG F | | | |
| 19 | SPTC12 | DEG F | | | |
| 20 | SPTC13 | DEG F | | | |
| 21 | SPTC14 | DEG F | | | |
| 22 | SPTC15 | DEG F | | | |
| 23 | DCDP03 | PSI | | | |
| 24 | DCLV03 | PSI | | | |
| 25 | DCOR03 | LBM/HR | | | |
| 26 | SPTC19 | DEG F | | | |
| 27 | SPTC20 | DEG F | | | |
| 28 | SPTC21 | DEG F | | | |
| 29 | SPTC22 | DEG F | | | |
| 30 | SPTC23 | DEG F | | | |
| 31 | SPTC24 | DEG F | | | |
| 32 | SPTC25 | DEG F | | | |
| 33 | SPTC26 | DEG F | | | |
| 34 | SPTC27 | DEG F | | | |
| 35 | SPTC28 | DEG F | | | |
| 36 | SPPT01 | PSI | | | |
| 37 | SPPT02 | PSI | | | |
| 38 | SPPT03 | PSI | | | |
| 39 | SPPT04 | LBM/HR | | | |
| 40 | SPPT05 | LBM/HR | | | |
| 41 | SPPT06 | LBM/HR | | | |
| 42 | SSTC25 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +49.80 |
| 43 | SSTC24 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +47.00 |
| 44 | SSTC23 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +47.00 |
| 45 | SSTC22 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +44.20 |
| 46 | SSTC21 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +44.20 |
| 47 | SSTC20 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +41.20 |
| 48 | SSTC19 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +41.20 |
| 49 | SSTC18 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +38.20 |
| 50 | SSTC17 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +38.20 |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 51 | SSTC16 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +35.30 |
| 52 | SSTC15 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +35.30 |
| 53 | SSTC13 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +32.30 |
| 54 | SSTC12 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +29.20 |
| 55 | SSTC11 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +29.20 |
| 56 | SSTC10 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +26.30 |
| 57 | SSTC09 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +26.30 |
| 58 | SSTC08 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +23.10 |
| 59 | SSTC07 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +20.10 |
| 60 | SSTC06 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +17.30 |
| 61 | SSTC05 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +14.10 |
| 62 | SSTC04 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +11.10 |
| 63 | SSTC03 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +8.10 |
| 64 | SSTC02 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +4.90 |
| 65 | SSTC01 | DEG F | 22 SGS SG SECOND | 2 FTC FLUID TEMP | +1.50 |
| 66 | SSDP01 | PSI | | | |
| 67 | SSLV01 | PSI | | | |
| 68 | SSDP02 | PSI | | | |
| 69 | SSLV02 | PSI | | | |
| 70 | SSDP03 | PSI | | | |
| 71 | SSLV03 | PSI | | | |
| 72 | SSDP04 | PSI | | | |
| 73 | SSLV04 | PSI | | | |
| 74 | SSDP05 | PSI | | | |
| 75 | SSLV05 | PSI | | | |
| 76 | SMTC06 | DEG F | | | |
| 77 | SMTC05 | DEG F | 22 SGS SG SECOND | 25 MTC METAL TC | +38.20 |
| 78 | SMTC03 | DEG F | 22 SGS SG SECOND | 25 MTC METAL TC | +29.20 |
| 79 | SMTC02 | DEG F | 22 SGS SG SECOND | 25 MTC METAL TC | +26.30 |
| 80 | SMTC01 | DEG F | 22 SGS SG SECOND | 25 MTC METAL TC | +20.10 |
| 81 | RVTC01 | DEG F | 1 RV CORE VESL | 2 FTC FLUID TEMP | -23.70 |
| 82 | RVTC02 | DEG F | 1 RV CORE VESL | 2 FTC FLUID TEMP | -19.10 |
| 83 | RVTC03 | DEG F | 1 RV CORE VESL | 25 MTC METAL TC | -16.00 |
| 84 | RVTC05 | DEG F | 1 RV CORE VESL | 25 MTC METAL TC | -11.90 |
| 85 | RVTC06 | DEG F | 1 RV CORE VESL | 25 MTC METAL TC | -9.90 |
| 86 | RVTC07 | DEG F | 1 RV CORE VESL | 2 FTC FLUID TEMP | -8.30 |
| 87 | RVTC08 | DEG F | 1 RV CORE VESL | 2 FTC FLUID TEMP | +6.80 |
| 88 | RVTC09 | DEG F | 7 RVV R.V.V.V. | 2 FTC FLUID TEMP | +0.60 |
| 89 | RVTC10 | DEG F | 7 RVV R.V.V.V. | 2 FTC FLUID TEMP | +0.60 |
| 90 | RVWM01 | KWATT | 1 RV CORE VESL | 7 Q POWER [%FP] | -13.20 |
| 91 | RVDP01 | PSI | | | |
| 92 | RVLV01 | PSI | | | |
| 93 | RVDP02 | PSI | | | |
| 94 | RVLV02 | PSI | | | |
| 95 | RVDP03 | PSI | 3 RVV R.V.V.V. | 8 DP PRES.DIFF | +0.60 |
| 96 | RVDP04 | PSI | | | |
| 97 | RVLV04 | PSI | | | |
| 98 | RVDP05 | PSI | | | |
| 99 | RVLV05 | PSI | | | |
| 100 | RVPR01 | PSIA | | | |
| | | | | | |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA, Continued

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 101 | PRDT01 | DEG F | 6 PR PRESURIZR | 10 DT INSUL. DT | +12.20 |
| 102 | PRDT02 | DEG F | 6 PR PRESURIZR | 10 DT INSUL. DT | +27.10 |
| 103 | PRDT03 | DEG F | 6 PR PRESURIZR | 10 DT INSUL. DT | +42.80 |
| 104 | PRTC01 | DEG F | 6 PR PRESURIZR | 2 FTC FLUID TEMP | +21.90 |
| 105 | PRTC02 | DEG F | 6 PR PRESURIZR | 2 FTC FLUID TEMP | +34.20 |
| 106 | PRTC03 | DEG F | | | |
| 107 | PRTC04 | DEG F | 6 PR PRESURIZR | 25 MTC METAL TC | +18.00 |
| 108 | PRTC05 | DEG F | 6 PR PRESURIZR | 25 MTC METAL TC | +36.80 |
| 109 | PRTC06 | DEG F | 6 PR PRESURIZR | 25 MTC METAL TC | +46.50 |
| 110 | PRPR01 | PSIA | | | |
| 111 | PRDP01 | PSI | | | |
| 112 | PRLV01 | PSI | | | |
| 113 | HPTC01 | DEG F | 10 HPI HP INJECT | 2 FTC FLUID TEMP | -999.00 |
| 114 | CLTC01 | DEG F | 4 CL COLD LEG | 2 FTC FLUID TEMP | -4.70 |
| 115 | CLTC02 | DEG F | 4 CL COLD LEG | 2 FTC FLUID TEMP | -4.50 |
| 116 | CLTC03 | DEG F | 4 CL COLD LEG | 2 FTC FLUID TEMP | -0.10 |
| 117 | CLTC04 | DEG F | 4 CL COLD LEG | 2 FTC FLUID TEMP | +1.80 |
| 118 | CLTC05 | DEG F | 4 CL COLD LEG | 2 FTC FLUID TEMP | -0.50 |
| 119 | CLDP01 | PSI | | | |
| 120 | CLLV01 | PSI | | | |
| 121 | CLOR02 | LBM/HR | | | |
| 122 | CLDP02 | PSI | | | |
| 123 | CLDP03 | PSI | | | |
| 124 | CLLV03 | PSI | | | |
| 125 | DCTC01 | DEG F | 5 DC DOWNCOMER | 2 FTC FLUID TEMP | -3.20 |
| 126 | DCTC02 | DEG F | 5 DC DOWNCOMER | 2 FTC FLUID TEMP | -10.00 |
| 127 | DCRT01 | DEG F | 5 DC DOWNC=MER | 3 RTD FLUID RTD | -20.00 |
| 128 | DCOR01 | LBM/HR | | | |
| 129 | DCDP01 | PSI | | | |
| 130 | DCDP02 | PSI | | | |
| 131 | DCLV02 | PSI | | | |
| 132 | V1TC01 | DEG F | 11 V1 1-PH VENT | 2 FTC FLUID TEMP | -999.00 |
| 133 | V2TC01 | DEG F | 12 V2 2-PH VENT | 2 FTC FLUID TEMP | -999.00 |
| 134 | V2TC02 | DEG F | 12 V2 2-PH VENT | 2 FTC FLUID TEMP | -999.00 |
| 135 | V2TC03 | DEG F | 12 V2 2-PH VENT | 2 FTC FLUID TEMP | -999.00 |
| 136 | V2TC04 | DEG F | 12 V2 2-PH VENT | 2 FTC FLUID TEMP | -999.00 |
| 137 | V2PR01 | PSIA | 12 V2 2-PH VENT | 1 P PRESSURE | -999.00 |
| 138 | V2DP01 | PSIA | | | |
| 139 | V2LV01 | PSIA | | | |
| 140 | V2DP02 | PSIA | | | |
| 141 | V2LV02 | PSIA | | | |
| 142 | V2DP03 | PSIA | | | |
| 143 | V2LV03 | PSIA | | | |
| 144 | V2DP04 | PSIA | | | |
| 145 | V2LV04 | PSIA | | | |
| 146 | V2DP05 | PSIA | | | |
| 147 | V2LV05 | PSIA | | | |
| 148 | V2RF01 | FT**3 | 12 V2 2-PH VENT | 18 VOL NCG VOL | -999.00 |
| 149 | HLRT01 | DEG F | 2 HL HOT LEG | 3 RTD FLUID RTD | 0.00 |
| 150 | HLTC01 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +8.10 |
| | | | | | |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA, Continued

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 151 | HLTC02 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +9.10 |
| 152 | HLTC03 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +20.00 |
| 153 | HLTC04 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +30.00 |
| 154 | HLTC05 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +40.00 |
| 155 | HLTC06 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +50.00 |
| 156 | HLTC07 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +60.00 |
| 157 | HLTC08 | DEG F | 2 HL HOT LEG | 2 FTC FLUID TEMP | +67.40 |
| 158 | HLTC09 | DEG F | 3 SGP SG PRIMRY | 2 FTC FLUID TEMP | +59.90 |
| 159 | HLDT01 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +2.80 |
| 160 | HLDT02 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +12.80 |
| 161 | HLDT03 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +23.80 |
| 162 | HLDT04 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +34.50 |
| 163 | HLDT05 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +46.20 |
| 164 | HLDT06 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +57.20 |
| 165 | HLDT07 | DEG F | 2 HL HOT LEG | 10 DT INSUL. DT | +65.90 |
| 166 | HLDT08 | DEG F | 3 SG SG PRIMRY | 10 DT INSUL. DT | +57.20 |
| 167 | HLDP01 | PSI | | | |
| 168 | HLLV01 | PSI | | | |
| 169 | HLDP02 | PSI | | | |
| 170 | HLLV02 | PSI | | | |
| 171 | HLDP03 | PSI | | | |
| 172 | HLLV03 | PSI | | | |
| 173 | SPDP01 | PSI | | | |
| 174 | SFOR01 | LBM/HR | | | |
| 175 | SFDP02 | PSI | | | |
| 176 | SFOR02 | LBM/HR | | | |
| 177 | SFDP03 | PSI | | | |
| 178 | SFOR03 | LBM/HR | | | |
| 179 | SFDP04 | PSI | | | |
| 180 | SFOR04 | LBM/HR | | | |
| 181 | PSPR01 | PSIA | | | |
| 182 | PSTC01 | DEG F | | | |
| 183 | PSTC04 | DEG F | | | |
| 184 | PSPC05 | DEG F | | | |
| 185 | PSRT01 | DEG F | | | |
| 186 | PSDP01 | PSI | | | |
| 187 | PSOR01 | LBM/HR | | | |
| 188 | PSDP02 | PSI | | | |
| 189 | PSOR04 | LBM/HR | | | |
| 190 | PSDP03 | PSI | | | |
| 191 | PSOR03 | LBM/HR | | | |
| 192 | PSDP04 | PSI | | | |
| 193 | PSOR04 | LBM/HR | | | |
| 194 | FPRT01 | DEG F | | | |
| 195 | FPRT02 | DEG F | | | |
| 196 | FPRT03 | DEG F | | | |
| 197 | FPTC01 | DEG F | | | |
| 198 | GATC01 | DEG F | 14 GA GAS ADD | 2 FTC FLUID TEMP | -999.00 |
| 199 | GATC02 | DEG F | 14 GA GAS ADD | 2 FTC FLUID TEMP | +67.40 |
| 200 | GATC03 | DEG F | 14 GA GAS ADD | 2 FTC FLUID TEMP | +54.50 |
| | | | | | |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA, Continued

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 201 | GATC04 | DEG F | 14 GA GAS ADD | 2 FTC FLUID TEMP | +1.00 |
| 202 | GATC05 | DEG F | 14 GA GAS ADD | 2 FTC FLUID TEMP | -22.00 |
| 203 | GAPR01 | PSI | 14 GA GAS ADD | 1 P PRESSURE | -999.00 |
| 204 | GSTC01 | DEG F | 15 GA GAS SAMPL | 2 FTC FLUID TEMP | +67.50 |
| 205 | GSTC02 | DEG F | 15 GA GAS SAMPL | 2 FTC FLUID TEMP | +59.00 |
| 206 | GSTC03 | DEG F | 15 GA GAS SAMPL | 2 FTC FLUID TEMP | +53.50 |
| 207 | GSTC04 | DEG F | 15 GA GAS SAMPL | 2 FTC FLUID TEMP | +7.70 |
| 208 | GSPR01 | PSI | 15 GA GAS SAMPL | 1 P PRESSURE | +67.50 |
| 209 | GSPR02 | PSI | 15 GA GAS SAMPL | 1 P PRESSURE | +59.00 |
| 210 | GSPR03 | PSI | 15 GA GAS SAMPL | 1 P PRESSURE | +53.50 |
| 211 | GSPR04 | PSI | 15 GA GAS SAMPL | 1 P PRESSURE | +7.70 |
| 212 | MSTC01 | DEG F | | | |
| 213 | MSTC02 | DEG F | | | |
| 214 | MSTC03 | DEG F | | | |
| 215 | MSRF01 | VOLTS | | | |
| 216 | MSRF02 | VOLTS | | | |
| 217 | MSRF03 | VOLTS | | | |
| 218 | HPAC01 | GAL | 10 HPI HP INJECT | 19 ACC ACCD. FLOW | -999.00 |
| 219 | V1AC01 | GAL | 11 V1 1-PH VENT | 19 ACC ACCD. FLOW | -999.00 |
| 220 | V2AC01 | GAL | 12 V2 2-PH VENT | 19 ACC ACCD. FLOW | -999.00 |
| 221 | V2AC02 | GAL | | | |
| 222 | HPTM01 | LBM/HR | 10 HPI HP INJECT | 13 TMF TURB. FLOW | -999.00 |
| 223 | HPTM02 | LBM/HR | 10 HPI HP INJECT | 13 TMF TURB. FLOW | -999.00 |
| 224 | HPTM03 | LBM/HR | 10 HPI HP INJECT | 13 TMF TURB. FLOW | -999.00 |
| 225 | SFTM01 | LBM/HR | | | |
| 226 | SFTM02 | LBM/HR | | | |
| 227 | CLUS01 | GPM | 4 CL COLD LEG | 5 USF U.S.FLOW | -999.00 |
| 228 | DCOR20 | LBM/HR | 5 DC DOWNCOMER | 6 ORF HEADFLOW [%] | -999.00 |
| 229 | RVLS01 | OPN/CL | 7 RVV R.V.V.V. | 28 LIM LIMIT SW | +0.60 |
| 230 | V1LS01 | OPN/CL | 11 V1 1-PH VENT | 28 LIM LIMIT SW | -999.00 |
| 231 | V1LS02 | OPN/CL | 11 V1 1-PH VENT | 28 LIM LIMIT SW | -999.00 |
| 232 | V1LS03 | OPN/CL | 11 V1 1-PH VENT | 28 LIM LIMIT SW | -999.00 |
| 233 | V2LS01 | OPN/CL | 12 V2 2-PH VENT | 28 LIM LIMIT SW | -999.00 |
| 234 | V2LS03 | OPN/CL | 12 V2 2-PH VENT | 28 LIM LIMIT SW | -999.00 |
| 235 | GALS01 | OPN/CL | 14 GA GAS ADD | 28 LIM LIMIT SW | +67.50 |
| 236 | GALS02 | OPN/CL | 14 GA GAS ADD | 28 LIM LIMIT SW | +54.50 |
| 237 | GALS03 | OPN/CL | 14 GA GAS ADD | 28 LIM LIMIT SW | +1.00 |
| 238 | GALS04 | OPN/CL | 14 GA GAS ADD | 28 LIM LIMIT SW | -22.00 |
| 239 | SSCP01 | WT/DRY | | | |
| 240 | SSCP02 | WT/DRY | | | |
| 241 | SSCP03 | WT/DRY | | | |
| 242 | SSCP04 | WT/DRY | | | |
| 243 | SSCP05 | WT/DRY | | | |
| 244 | SSCP06 | WT/DRY | | | |
| 245 | SSCP07 | WT/DRY | | | |
| 246 | SSCP08 | WT/DRY | | | |
| 247 | SSCP09 | WT/DRY | | | |
| 248 | SSCP10 | WT/DRY | | | |
| 249 | SSCP11 | WT/DRY | | | |
| 250 | SSCP12 | WT/DRY | 22 SGS SG SECOND | 16 CP CONDCTVTY | +29.50 |
| | | | | | |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA, Continued

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 251 | SSCP13 | WT/DRY | 22 SGS SG SECOND | 16 CP CONDCTVTY | +29.00 |
| 252 | SSCP14 | WT/DRY | 22 SGS SG SECOND | 23 RCP REF. C. P. | +21.00 |
| 253 | RVCP01 | WT/DRY | 1 RV CORE VESL | 16 CP CONDCTVTY | -1.40 |
| 254 | RVCP02 | WT/DRY | 1 RV CORE VESL | 16 CP CONDCTVTY | -2.40 |
| 255 | RVCP03 | WT/DRY | 1 RV CORE VESL | 16 CP CONDCTVTY | +0.70 |
| 256 | RVCP04 | WT/DRY | 1 RV CORE VESL | 16 CP CONDCTVTY | +0.60 |
| 257 | RVCP01 | WT/DRY | | | |
| 258 | HLCP01 | WT/DRY | | | |
| 259 | HLCP02 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +15.00 |
| 260 | HLCP03 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +35.00 |
| 261 | HLCP04 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +37.00 |
| 262 | HLCP05 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +41.00 |
| 263 | HLCP06 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +45.00 |
| 264 | HLCP07 | WT/DRY | | | |
| 265 | HLCP08 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +53.00 |
| 266 | HLCP09 | WT/DRY | | | |
| 267 | HLCP10 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +61.00 |
| 268 | HLCP11 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +65.00 |
| 269 | HLCP12 | WT/DRY | 2 HL HOT LEG | 16 CP CONDCTVTY | +67.20 |
| 270 | HLCP13 | WT/DRY | | | |
| 271 | HLCP14 | WT/DRY | 3 SGP SG PRIMRY | 16 CP CONDCTVTY | +60.90 |
| 272 | HLCP15 | WT/DRY | | | |
| 273 | HLCP16 | WT/DRY | | | |
| 274 | HLCP17 | WT/DRY | | | |
| 275 | CLUS02 | OPN/CL | 4 CL COLD LEG | 29 ETC MISCELLAN | -999.00 |
| 276 | CLOR20 | LBM/HR | 4 CL COLD LEG | 6 ORF HEADFLOW [%] | -999.00 |
| 277 | CLLV02 | PSI | | | |
| 278 | DCLV01 | PSI | | | |
| 279 | SPPR20 | PSI | 3 SGP SG PRIMRY | 30 KPR CORRD.PR | +53.10 |
| 280 | PRPR20 | PSI | 6 PR PRESURIZR | 30 KPR CORRD.PR | +40.50 |
| 281 | RVPR20 | PSI | 1 RV CORE VESL | 30 KPR CORRD.PR | +7.10 |
| 282 | PSPR20 | PSI | 23 STM SEC.STEAM | 30 KPR CORRD.PR | -999.00 |
| 283 | PRLV20 | FT | 6 PR PRESURIZR | 31 KLV COLLD.LVL | +2.50 |
| 284 | SPLV20 | FT | 3 SGP SG PRIMRY | 31 KLV COLLD.LVL | -2.80 |
| 285 | SSLV20 | FT | 22 SGS SG SECOND | 31 KLV COLLD.LVL | 0.00 |
| 286 | HLLV20 | FT | 2 HL HOT LEG | 31 KLV COLLD.LVL | -1.90 |
| 287 | HLLV21 | FT | 3 SGP SG PRIMRY | 31 KLV COLLD.LVL | +53.00 |
| 288 | RVLV20 | FT | 1 RV CORE VESL | 31 KLV COLLD.LVL | -16.10 |
| 289 | SSCP20 | FT | 22 SGS SG SECOND | 32 KCP UP.WET.CP | 0.00 |
| 290 | HLCP20 | FT | | | |
| 291 | HLCP21 | FT | | | |
| 292 | RVCP20 | FT | | | |
| 293 | PSOR20 | LBM/HR | 23 STM SEC.STEAM | 33 KOR CALC. FLOW | -999.00 |
| 294 | SFOR20 | LBM/HR | 21 AFW AUX. FEED | 2 FTC FLUID TEMP | -999.00 |
| 295 | SFRF01 | DEG F | 21 AFW AUX. FEED | 33 KOR CALC. FLOW | -999.00 |
| 296 | RVRT03 | DEG F | | | |
| 297 | RVHR02 | DEG F | | | |
| 298 | RVRF02 | VOLTS | | | |
| 299 | RVRT02 | DEG F | | | |
| 300 | RVLS04 | WT/DRY | | | |
| | | | | | |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA, Continued

| No | Measurement | Unit | System | Instrument | Location,ft |
|---|---|---|---|---|---|
| 301 | RVLS05 | OPN/CL | | | |
| 302 | RVHR01 | VOLTS | | | |
| 303 | RVRF01 | VOLTS | | | |
| 304 | RVRT01 | DEG F | | | |
| 305 | RVLS02 | WT/DRY | | | |
| 306 | RVLS03 | OPN/CL | | | |
| 307 | PRHR01 | VOLTS | | | |
| 308 | PRRF01 | VOLTS | | | |
| 309 | PRRT01 | DEG F | | | |
| 310 | PRLS01 | WT/DRY | | | |
| 311 | PRLS02 | OPN/CL | | | |
| 312 | HLHR01 | VOLTS | | | |
| 313 | HLRF01 | VOLTS | | | |
| 314 | HLRT02 | DEG F | | | |
| 315 | HLLS01 | WT/DRY | | | |
| 316 | HLLS02 | OPN/CL | | | |
| 317 | V1RF20 | LBM/HR | 11 V1 1-PH VENT | 38 FLO CALC.FLOW | -999.00 |
| 318 | V2RF20 | LBM/HR | 12 V2 2-PH VENT | 38 FLO CALC.FLOW | -999.00 |
| 319 | RVRF20 | LBM/HR | 7 RVV R.V.V.V. | 33 KORCALC.FLOW [%] | +0.60 |
| 320 | CLDP04 | PSI | | | |
| 321 | CLLV04 | PSI | | | |
| 322 | CLOR04 | LBM/HR | | | |
| 323 | RVLS01 | OPN/CL | | | |
| 324 | RVLS06 | OPN/CL | | | |
| 325 | PRTC07 | DEG F | 6 PR PRESURIZR | 25 MTC METAL TC | +2.60 |
| 326 | HLTC10 | DEG F | 2 HL HOT LEG | 25 MTC METAL TC | +33.90 |
| 327 | HLTC11 | DEG F | 2 HL HOT LEG | 25 MTC METAL TC | +65.50 |
| 328 | CLLV20 | FT | | | |
| 329 | CLLV21 | FT | | | |

Table 2.1 Instrumentation used in Composite GERDA Test 1605AA, Continued

# Chronology of Test 1605AA

## (Selected Events From Operators Log and Data Legend File)

| TIME | EVENT |
|---|---|
| 1025 | Reduced core power to 97.4 KW (54.1 %); Power Controller to auto / cascade; Trip forced circulation pump; Close pump discharge and suction valves; RVVV open manual; Open RV leak (10 cm2); PR main heaters off; PR guard heaters on. |
| 1027 | HPI activated after reaching TSAT; Steam pressure on constant control 700 psia. |
| 1030 | MK' level control activated. |
| 1031 | HLUB viewport voided. |
| 1033 | PR refilling; PR level 12 %; RV level 83 %; CLDP02 (Cold Leg orifice differential pressure) in service. |
| 1035 | Steam valve chokes; Steam pressure increasing adjust SFCV-03 AFW valve). |
| 1037 | Water at HLUB; PR level decreasing 10 %; RV level 62 %; 35' HL viewport showing many bubbles. |
| 1040 | Steam pressure increased then decreased; HLUB voided. |
| 1043 | 'MK' injection off. |
| 1044 | Steam pressure = 672 psia; THOT = 617.7 F; TCOLD = 440 F; Core power = 62 KW. |
| 1045 | RVVV short-cycled once; 35 ft HL viewport vent black from void mixture; zeroed CLDP02 & DCDP01 (downcomer orifice differential pressure). |
| 1048 | SGS steam pressure = 693 psia; THOT = 611.1 F; TCOLD = 454 F; RV level = 59 %; PR level = 13 %; TSAT = 612.7 F; RV pressure = 1693 psia; Downcomer Temperature = 586.9 F; Core power = 61 KW; Downcomer Flow = 915 lbm/hr. |
| 1056 | HPV open. |
| 1059 | PR level = 25 %; RV level = 43 %; RV pressure = 1767 psia; 35 ft HL viewport is black from void mixture. |
| 1102 | RVVV short-cycled; SGS steam pressure increased to 1100 psia; Steam valve choked; Primary level < secondary level; PR voided. |
| 1104 | Water level below 35 ft HL viewport; PR level = 0 %; RV level = 44 %; HPI flow = 0.106 lbm/sec; RV leak = 0.073 lbm/sec. |
| 1110 | CLDP01 (downcomer liquid level differential pressure probe) and DCDP01 voltage output is changing rapidly over entire range. |

Table 3.1 Detailed Sequence of Events of Composite GERDA Test 1605AA

| | |
|---|---|
| 1111 | Downcomer temperature is saturated. |
| 1118 | Primary levels are recovering; SGS steam pressure = 583 psia; THOT = 573.6 F; TCOLD = 316.7 F; Downcomer temperature = 485.1 F; Primary TSAT = 494 F; RV core power = 47 KW. |
| 1120 | Observe small and large bubbles at the 35 ft HL viewport; The small bubbles appear periodic at a frequency of 2 sec. |
| 1122 | PR level = 11 %; RV level = 57 %. |
| 1124 | RVVV short cycled once. |
| 1127 | Primary loop continues to fill; PR level = 14 %; RV level = 60 %; RV pressure = 691 psia; SGS steam pressure = 528 psia; TSAT = 501.6 F; Downcomer temperature = 450.4 F; Core power = 45.7 F KW; Water level above the 35 ft HL viewport. |
| 1136 | Added 1.47 SCF (standard cubic feet) of N2 to the RV; Gas addition pressure = 1711 psia; Primary pressure = 736 psia; RV and Pr (levels) spiked when gas added. |
| 1140 | The PR and RV level oscillations have greatly decreased. |
| 1142 | The primary loop continues to refill. PR level = 18 %; RV level = 67 %; RV pressure = 806 psia; SGS steam pressure = 471 psia (controller = 486 psia); TSAT = 519.8 F; Downcomer temperature = 414.1 F; HPI flowrate = 0.136 lbm/sec; RV leak rate = 0.091 lbm/sec. |
| 1156 | PR level = 22 %; RV level = 68 %. |
| 1204 | PR level = 23 %; RV level = 68 %; TSAT = 530.9 F; Downcomer temperature = 402.9; HPI flow rate = 0.128 lbm/sec; RV leak rate = 0.117 lbm/sec. |
| 1209 | Water observed at HLUB viewport; PR level decreasing rapidly; RV level increasing; Secondary pressure increased 50 - 100 psia. |
| 1210 | Water below HLUB viewport. |
| 1213 | Water observed at HLUB viewport; PR level decreased from 5 to 0 %; RV pressure decreased to 740 psia. |
| 1225 | A third spillover may have occurred as indicated by the PR and RV level response. |
| 1233 | Added 1.50 SCF (standard cubic feet) of N2 to the RV; Gas addition pressure = 1794.7 psia; Primary pressure = 799 psia; RV level = 88 %; HL full. |
| 1254 | The upper head thermocouple (RVTC08) indicated 10 F subcooled; The RV level is 21.5 ft (23.1 ft is full); This discrepancy in elevation is apparently being caused by the last gas addition which has collected in the upper section of the RV. |
| 1258 | RV level = 21.9 ft. |
| 1305 | RV level = 22.4 ft. |

Table 3.1 Detailed Sequence of Events of Composite GERDA Test 1605AA, Continued

| | |
|---|---|
| 1310 | RV level = 22.7 ft; PR level = 38 %; RVTC08 = 507 F; Primary TSAT = 533.4 F. |
| 1317 | RV level = 23 ft. |
| 1321 | SGS steam pressure controller reached 200 psia. |
| 1323 | Switched from 2 to 1 HPI pump; PR level = 38 % (decreasing). |
| 1325 | PR level = 26 % (decreasing). |
| 1330 | PR level = 14 % (decreasing). |
| 1332 | PR level = 8 % (decreasing). |
| 1333 | PR level = 0 %; Some bubbles observed at 35 ft HL viewport. |
| 1335 | PR level = 0 %; RV level = 94 %. |
| 1337 | End of test point. |

Table 3.1 Detailed Sequence of Events of Composite GERDA Test 1605AA, Continued

Table 4.1 OTSG at 100% Rated Power, Comparative Data

| | Parameter | Computed Values | | | Measured Values | |
|---|---|---|---|---|---|---|
| | | RELAP5 MOD3.2 | Design-Computation | RELAP5/ MOD1-EUR2ABB | KMK | ARC |
| P | Inlet Temperature | 602.15 K | 602.15 K | 602.15 K | 601.5 K | 601.38 K |
| R | Outlet Temperature | 569.94 K | 570.15 K | 570.12 K | 570.7 K | 568.87 K |
| I | Pressure SG-Inlet | 151 bar | 151.00 bar | 151.01 bar | 151.3 bar * | 154.68 bar |
| M | Pressure SG-Outlet | 149.36 bar | 149.60 bar | 149.74 bar | --- | 153.94 bar |
| . | Mass Flow Rate | 9981.12 kg/s | 9984 kg/s | 9984 kg/s | 10552 kg/s | 10061 kg/s |
| | Power | 1913.9 MW | 1893.5 MW | 1904.2 MW | 1924.3 MW | 1918.5 MW |
| | Inlet Temperature | 510.04 K | 510.05 K | 510.01 K | 505.0 K | 510.63 K |
| | Outlet Temperature | 590.64 K | 586.25 K | 588.84 K | 593.6 K | 593.26 K |
| S | Temp.- Superheated | 32.09 K | 27.27 K | 30.23 K | 34.9 K | 34.54 K |
| E | Pressure SG-Inlet | 70.68 bar | 70.97 bar | 70.58 bar | -- | 70.7 bar |
| C | Pressure SG-Outlet | 69.59 bar | 69.96 bar | 69.58 bar | 68.3 bar | 69.7 bar |
| . | Mass Flow Rate | 1013.29 kg/s | 1014.0 kg/s | 1014.0 kg/s | 980.4 kg/s | 1010.6 kg/s |
| | Power | 1913.8 MW | 1893.5 MW | 1913.2 MW | 1886.5 MW | 1911.5 MW |
| | SG-Inventory | 14614 kg | 16590 kg | 16957 kg | -- | 13561 kg ** |

* Pressure in Pressurizer
** 15351 kg incl. steam

Table 4.2 OTSG at 65% Rated Power, Comparative Data, RELAP, KMK and GERDA

| | Parameter | Computed | | Values | Measured | Values |
|---|---|---|---|---|---|---|
| | | RELAP5 MOD3.2 | Design-Computation | RELAP5/ MOD1-EUR2ABB | KMK | ARC |
| P | Inlet Temperature | 596.75 K | 596.75 K | 596.75 K | 597.2 K | 600.35 K |
| R | Outlet Temperature | 575.56 K | 575.55 K | 575.66 K | 575.1 K | 568.87 K |
| I | Pressure SG-Inlet | 150.98 bar | 151.00 bar | 150.98 bar | 150.8 bar * | --- |
| M | Pressure SG-Outlet | 149.49 bar | 149.60 bar | 149.74 bar | --- | --- |
| . | Mass Flow Rate | 9863.1 kg/s | 9861 kg/s | 9861 kg/s | 10431 kg/s | 9637 kg/s |
| | Power | 1233.80 MW | 1230.8 MW | 1232.1 MW | 1359.4 MW | --- |
| | Inlet Temperature | 488.18 K | 488.18 K | 488.18 K | 485.7 K | 484.96 K |
| | Outlet Temperature | 595.51 K | 594.90 K | 595.26 K | 593.8 K | 599.16 K |
| S | Temp.-Superheated | 38.25 K | 37.51 K | 37.92 K | 36.5 K | 38.99 K |
| E | Pressure SG-Inlet | 68.91 bar | 68.93 bar | 68.85 bar | -- | -- |
| C | Pressure SG-Outlet | 68.28 bar | 68.34 bar | 68.28 bar | 67.9 bar | 71.2 bar |
| . | Mass Flow Rate | 613.53 kg/s | 613.6 kg/s | 613.6 kg/s | 636.0 kg/s | 646.1 kg/s |
| | Power | 1233.79 W | 1230.8 MW | 1232.1 MW | 1281.4 MW | 1308.3 MW |
| | SG-Inventory | 9061.32 kg | 10510 kg | 10320 kg | -- | 8567 kg** |

* Pressure in Pressurizer
** 10604 kg incl. steam

Table 4.3 OTSG at 45% Rated Power, Comparative Data, RELAP, KMK and GERDA

| | | Computed | Values | | Measured | Values |
|---|---|---|---|---|---|---|
| | Parameter | RELAP5 MOD3.2 | Design-Computation | RELAP5/ MOD1-EUR2ABB | KMK | ARC |
| P | Inlet Temperature | 593.55 K | 593.55 K | 593.57 K | 593.7 K | 596.38 K |
| R | Outlet Temperature | 578.85 K | 578.75 K | 578.86 K | 579.0 K | 580.96 K |
| I | Pressure SG-Inlet | 151.00 bar | 151.00 bar | 150.95 bar | 150.6 bar * | --- |
| M | Pressure SG-Outlet | 149.17 bar | 149.60 bar | 149.74 bar | --- | --- |
| . | Mass Flow Rate | 9812.52 kg/s | 9806 kg/s | 9806 kg/s | 10343 kg/s | 9623 kg/s |
| | Power | 849.77 MW | 852.07 MW | 851.66 MW | 895.5 MW | --- |
| | Inlet Temperature | 474.73 K | 474.70 K | 474.70 K | 482.1 K | 473.50 K |
| | Outlet Temperature | 593.06 K | 593.45 K | 592.70 K | 591.4 K | 596.05 K |
| S | Temp.- Superheated | 34.52 K | 36.66 K | 36.11 K | 34.81 K | 35.31 K |
| E | Pressure SG-Inlet | 69.97 bar | 68.10 bar | 67.87 bar | -- | -- |
| C | Pressure SG-Outlet | 69.59 bar | 67.73 bar | 67.53 bar | 67.4 bar | 71.8 bar |
| . | Mass Flow Rate | 412.9 kg/s | 412.9 kg/s | 412.9 kg/s | 439.3 kg/s | 457.6 kg/s |
| | Power | 849.75 MW | 852.07 MW | 851.66 MW | 852.07 MW | 944.1 MW |
| | SG-Inventory | 7276.7 kg | 7370 kg | 7836 kg | -- | 6238 kg** |

* Pressure in Pressurizer
** 8309 kg incl. steam

Table 4.4 OTSG at 15% Rated Power, Comparative Data, RELAP, KMK and GERDA

| | Parameter | Computed RELAP5 MOD3.2 | Computed Design-Computation | Values RELAP5/ MOD1-EUR2ABB | Measured KMK | Values ARC |
|---|---|---|---|---|---|---|
| P | Inlet Temperature | 588.66 K | 588.66 K | 588.68 K | 588.6 K | 591.87 K |
| R | Outlet Temperature | 583.64 K | 583.64 K | 583.71 K | 583.6 K | 586.87 K. |
| I | Pressure SG-Inlet | 151.00 bar | 151.00 bar | 150.87 bar | 151.8 bar * | --- |
| M | Pressure SG-Outlet | 149.18 bar | 149.60 bar | 149.73 bar | --- | --- |
| . | Mass Flow Rate | 9694.5 kg/s | 9697 kg/s | 9697 kg/s | 10261 kg/s | 9509 kg/s |
| | Power | 282.79 MW | 284.03 MW | 283.99 MW | 300.7 MW | --- |
| | Inlet Temperature | 473.19 K | 473.15 K | 473.15 K | 482.2 K | 473.20 K |
| | Outlet Temperature | 588.61 K | 588.85 K | 588.66 K | 585.7 K | 591.43 K |
| S | Temp.- Superheated | 30.07 K | 32.53 K | 32.40 K | 29.8 K | 31.17 K |
| E | Pressure SG-Inlet | 69.72 bar | 67.38 bar | 67.31 bar | -- | -- |
| C | Pressure SG-Outlet | 69.59 bar | 67.26 bar | 67.20 bar | 66.8 bar | 71.4 bar |
| . | Mass Flow Rate | 138.08 kg/s | 138.1 kg/s | 138.1 kg/s | 143.8 kg/s | 151.7 kg/s |
| | Power | 282.79 MW | 284.03 MW | 283.99 MW | 288.57 MW | 310.9 MW |
| | SG-Inventory | 3843.93 kg | 3939 kg | 4174 kg | -- | -- |

* Pressure in Pressurizer

| | Parameter | Computed Values: RELAP5 MOD3.2 Stand-Alone SG Model 15% F.P. = 7.5% F.P. / SG | Computed Values: GERDA RELAP5/MOD3.2 Integral Model, 7.5% F.P. (Lumped SG) | Measured Values: KMK Values, 15% F.P. | Measured Values: ARC-Values (GERDA), 7.5% F.P. |
|---|---|---|---|---|---|
| P | Inlet Temperature | 588.66 K | 591.17 K | 588.6 K | 591.87 K |
| R | Outlet Temperature | 583.64 K | 554.85 K ** | 583.6 K | 586.87 K |
| I | Pressure SG-Inlet | 151.00 bar | 146.77 bar | 151.8 bar * | --- |
| M | Pressure SG-Outlet | 149.18 bar | 148.05 bar | --- | --- |
| . | Mass Flow Rate | 9694.5 kg/s | 1411.58 kg/s ** | 10261 kg/s | 9509 kg/s |
| | Power | 282.79 MW | 283.98 MW | 300.7 MW | --- |
| | Inlet Temperature | 473.19 K | 473.15 K | 482.2 K | 473.20 K |
| | Outlet Temperature | 588.61 K | 588.78 K | 585.7 K | 591.43 K |
| S | Temp.- Superheated | 30.07 K | 32.25K | 29.8 K | 31.17 K |
| E | Pressure SG-Inlet | 69.72 bar | 67,37 bar | -- | -- |
| C | Pressure SG-Outlet | 69.59 bar | 67.26 bar | 66.8 bar | 71.4 bar |
| . | Mass Flow Rate | 138.08 kg/s | 138.10 kg/s | 143.8 kg/s | 151.7 kg/s |
| | Power | 282.79 MW | 283.99 MW | 288.57 MW | 310.9 MW |
| | SG-Inventory | 3844 kg | 3355 kg | -- | -- |

* Pressure in Pressurizer
** Nat. Circ. Flow

Table 4.5 Integral Loop OTSG at 7,5% Rated Power, Comparative Data, RELAP, KMK and GERDA

| Event | GERDA | RELAP 5 MOD 3.2 |
|---|---|---|
| 10 % Leak at RPV Bottom | 145 Seconds | 145 Seconds |
| PRZ empties | 210 Seconds | 280 Seconds |
| LOCA Signal, 'System Pressure < 117 Bar' | 330 Seconds | 356 Seconds |
| 1. Interruption of Circulation Flow | 8 Minutes | ~ 8,5 Minutes |
| Total Stall of Primary Flow | > 22 Minutes | 17 Minutes (1. Time) and > 22 Minutes |
| BCM starts | 35 Minutes | ~ 35 Minutes |
| Refill starts | 40 Minutes | ~ 40 Minutes |
| BCM ends | 52 Minutes | ~ 56 Minutes |
| HPI Flow > Leak Flow | 84,5 Minutes | 93 Minutes |
| HLUB filled to Spill over Elevation | 105 Minutes | ~106,5 Minutes (Hot Leg) 120 Minutes (SG Piping) |
| RV (Top Head) filled | 180 Minutes | > 116 Minutes (see Ch. 4.5) |

Table 4.6 Timing of Major Phenomena, Comparison of RELAP5 and GERDA

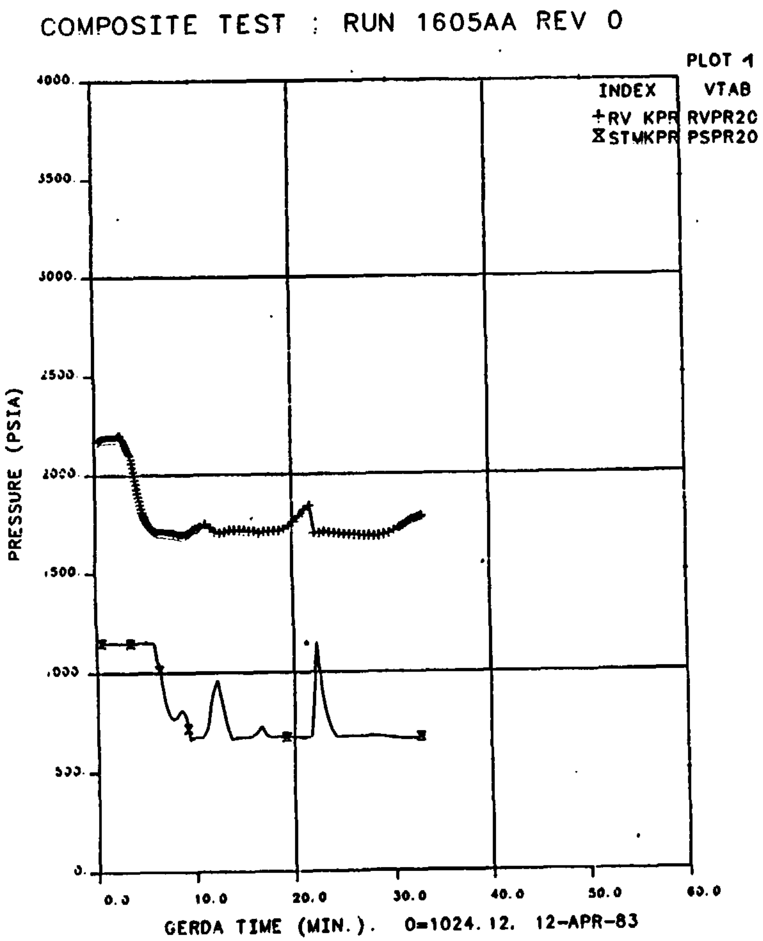
# APPENDIX B

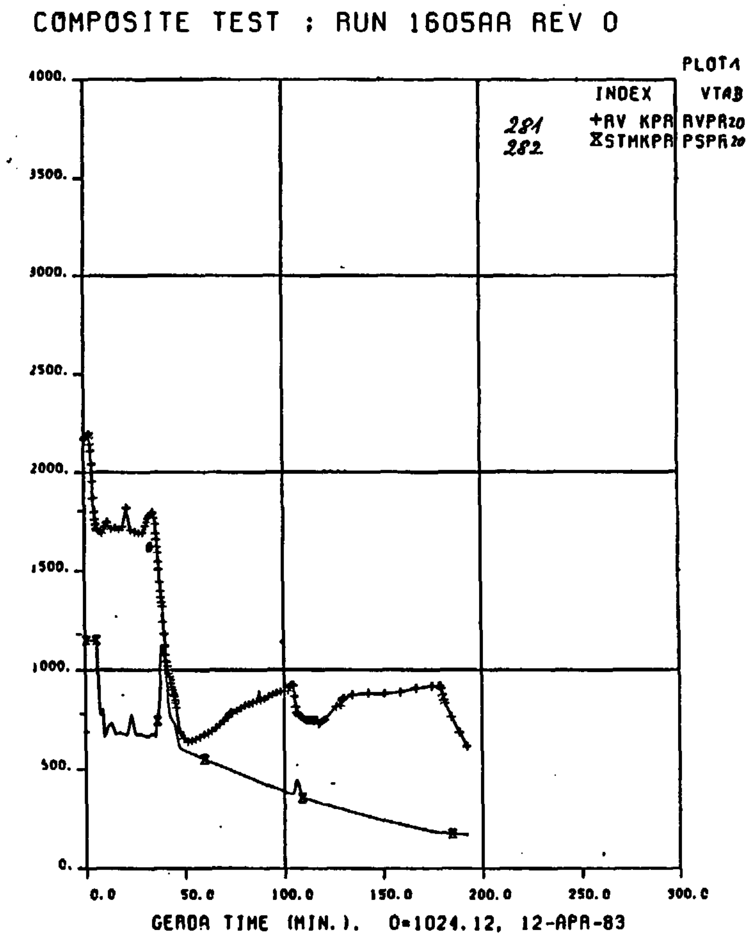
**Original Data Plots from GERDA Composite Test 1605AA**

**RELAP5 MOD 3.2 Input Deck for the GERDA Test 1605AA Post Test Calculation**

**RELAP5 MOD 3.2 Restart Input Deck**

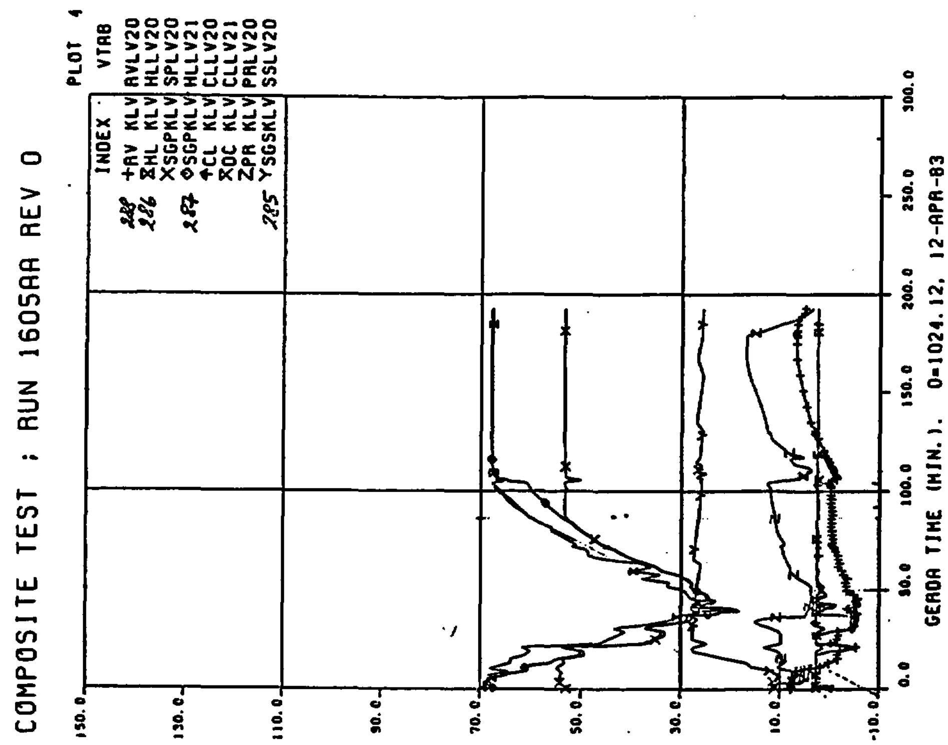
## Original Data Plots from GERDA Composite Test 1605AA

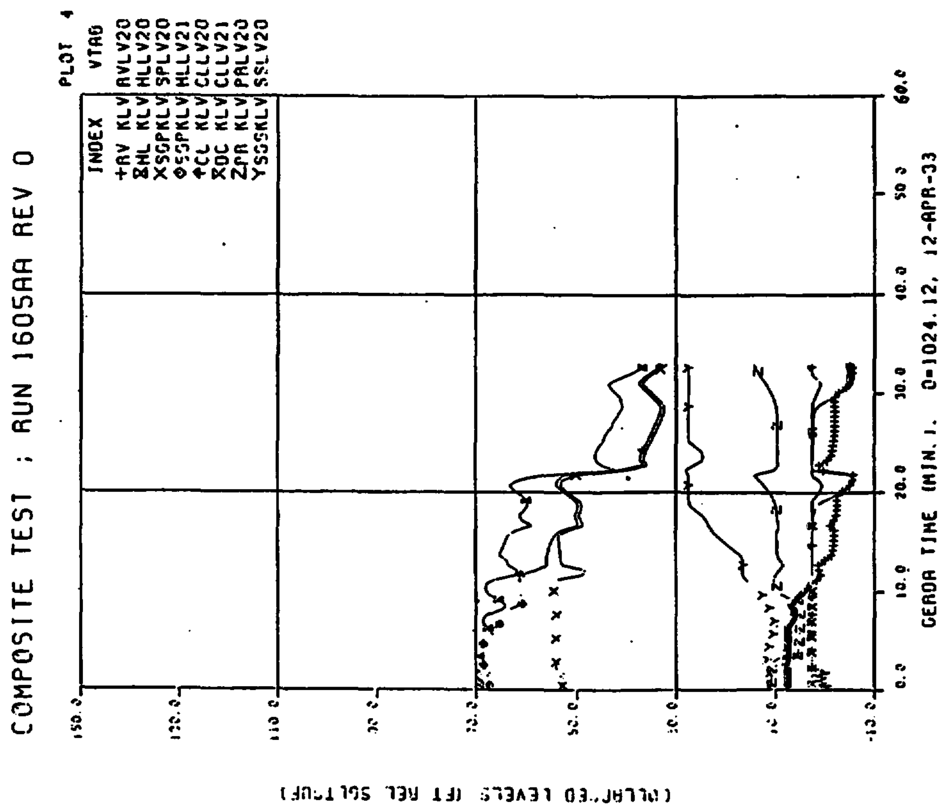



Plot 1 System Pressure (0 - 60 min, 0 - 300 min)

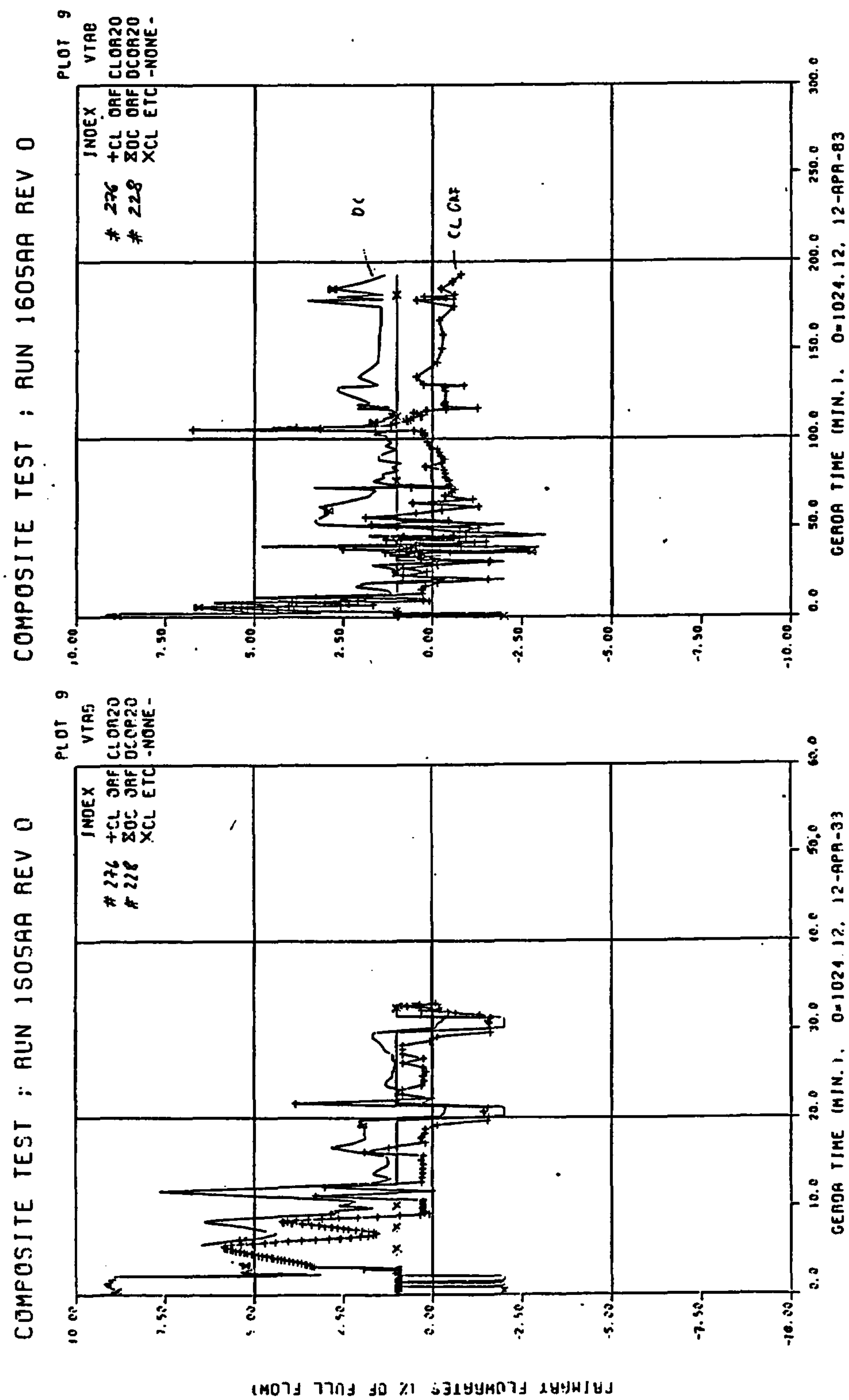
## Original Data Plots from GERDA Composite Test 1605AA



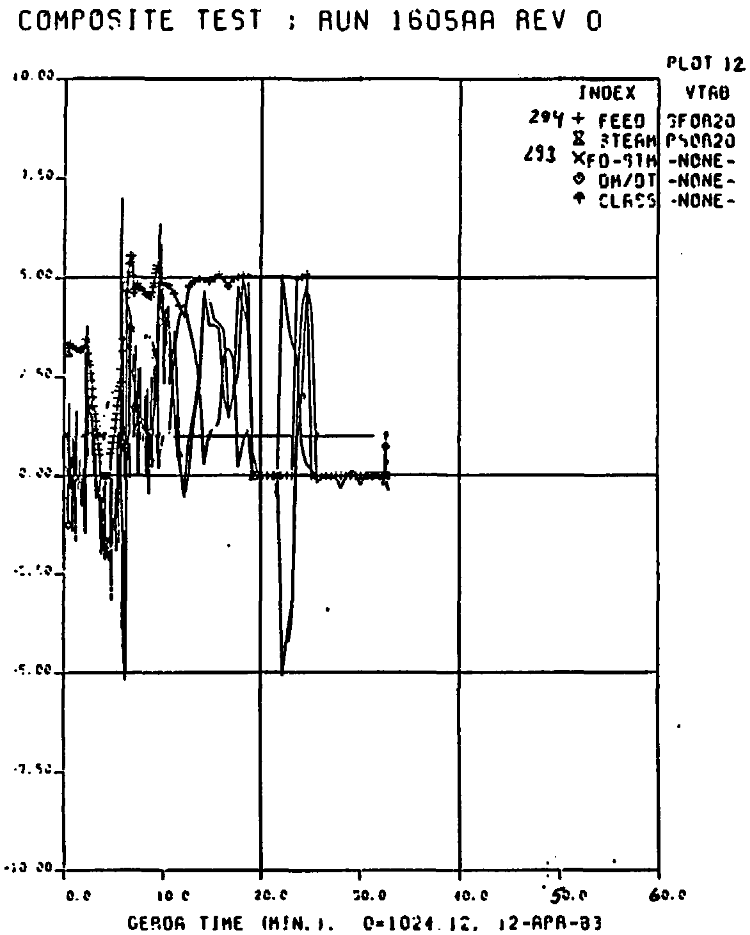

Plot 4 Collapsed Levels (0 - 60 min, 0 - 300 min)

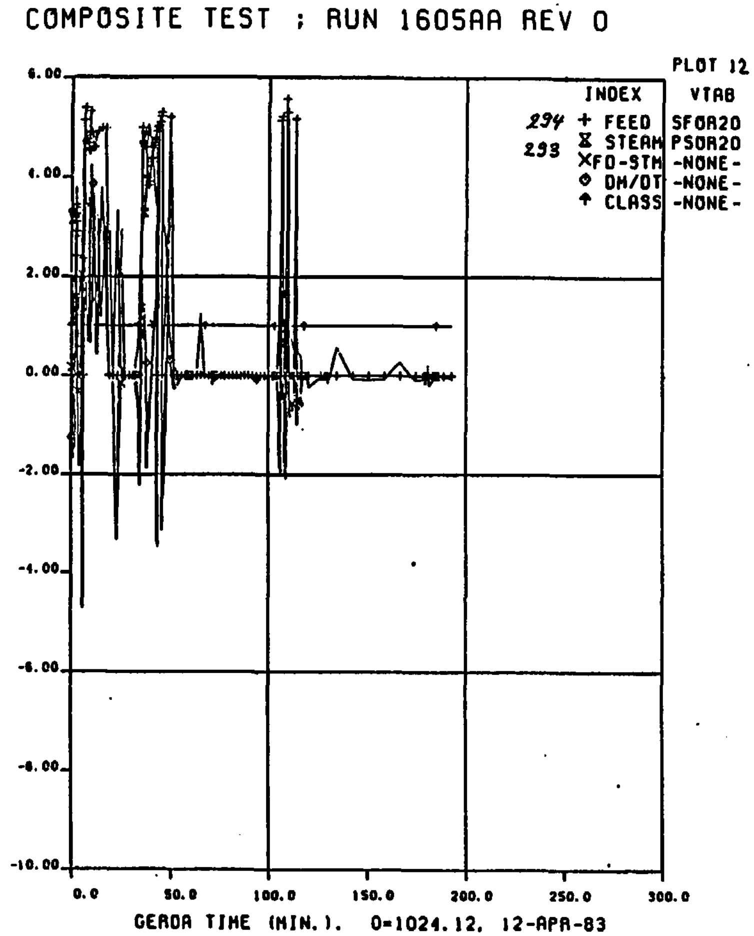
## Original Data Plots from GERDA Composite Test 1605AA




Plot 9 Primary Flow rates (0 - 60 min, 0 - 300 min)

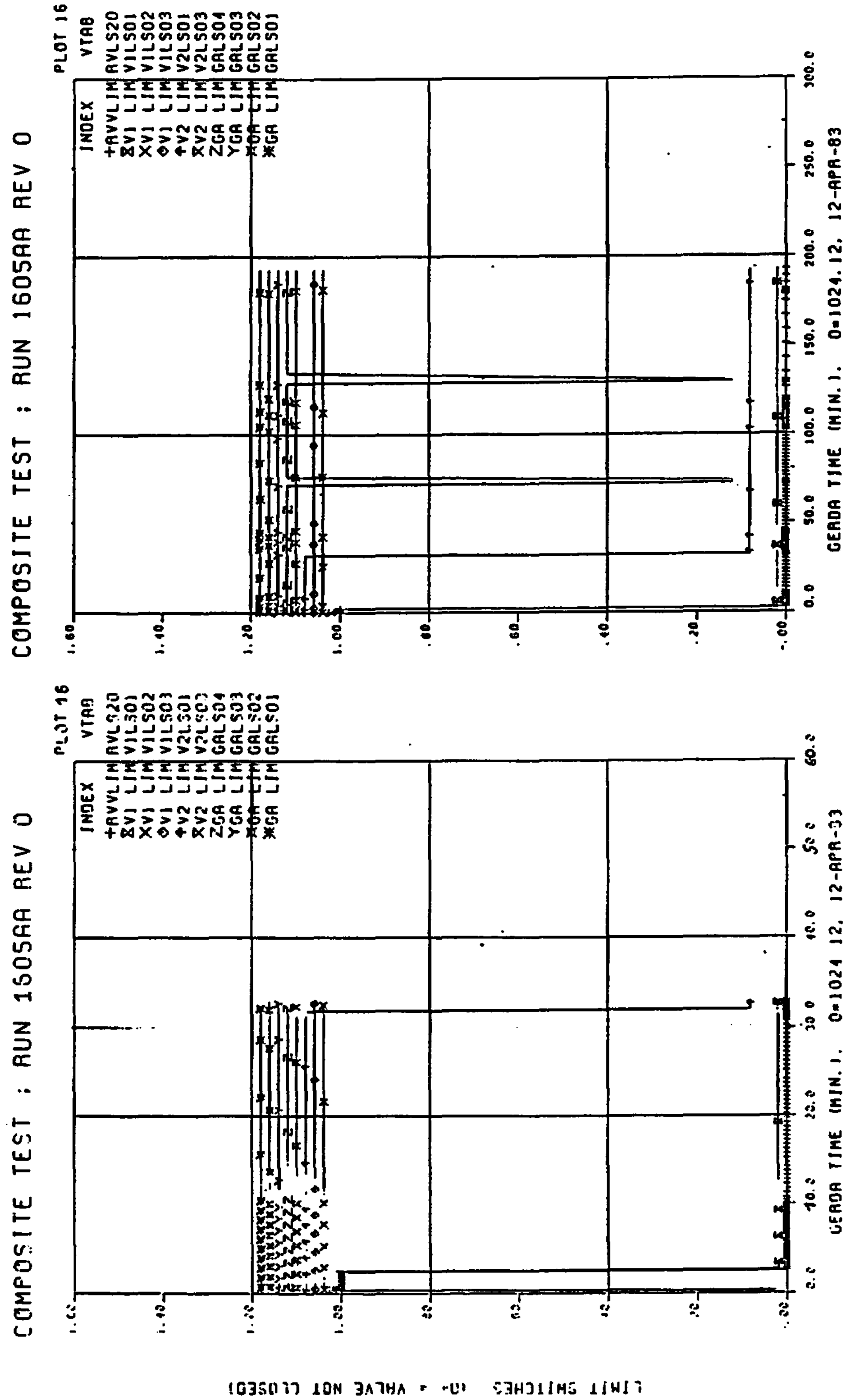
## Original Data Plots from GERDA Composite Test 1605AA



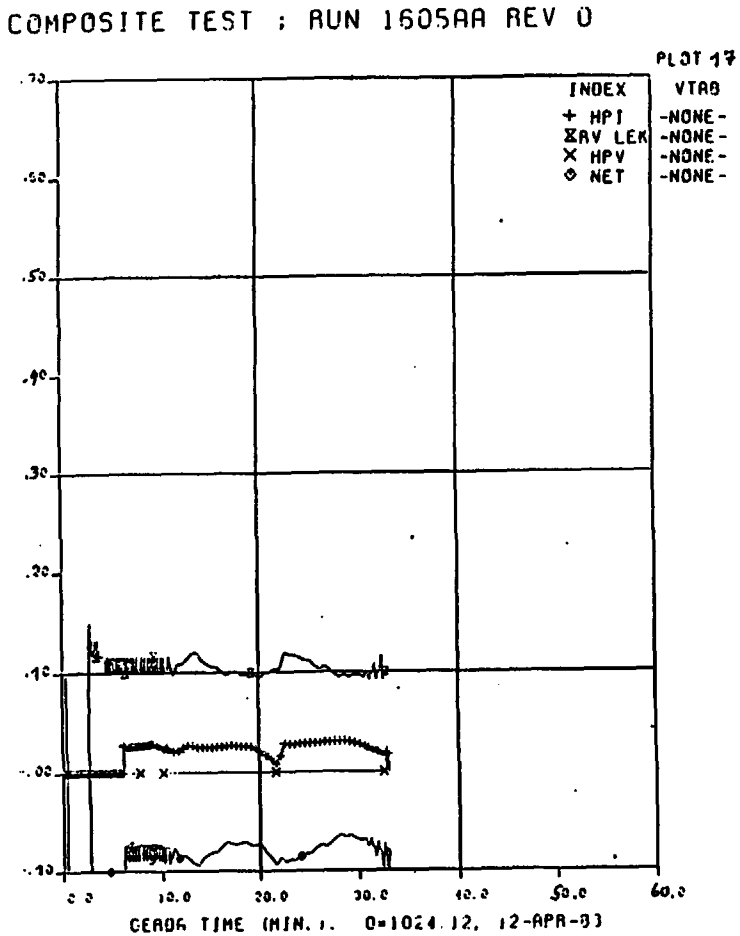

Plot 12 Secondary Flow rates (0 - 60 min, 0 - 300 min)

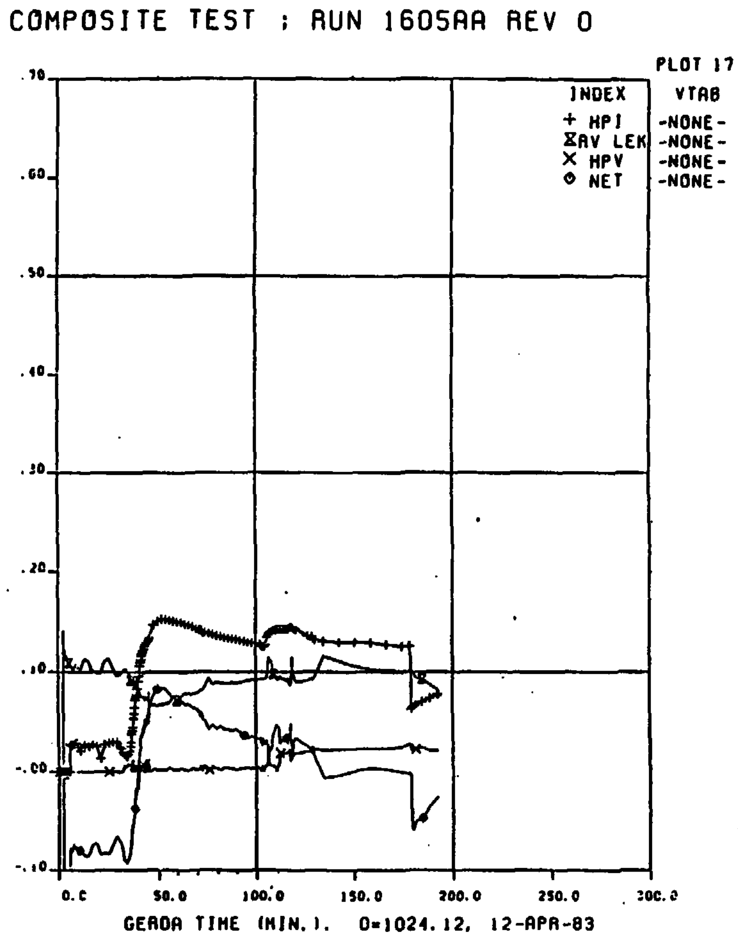
## Original Data Plots from GERDA Composite Test 1605AA




Plot 16 Limit Switches of Valves (0 - 60 min, 0 - 300 min)

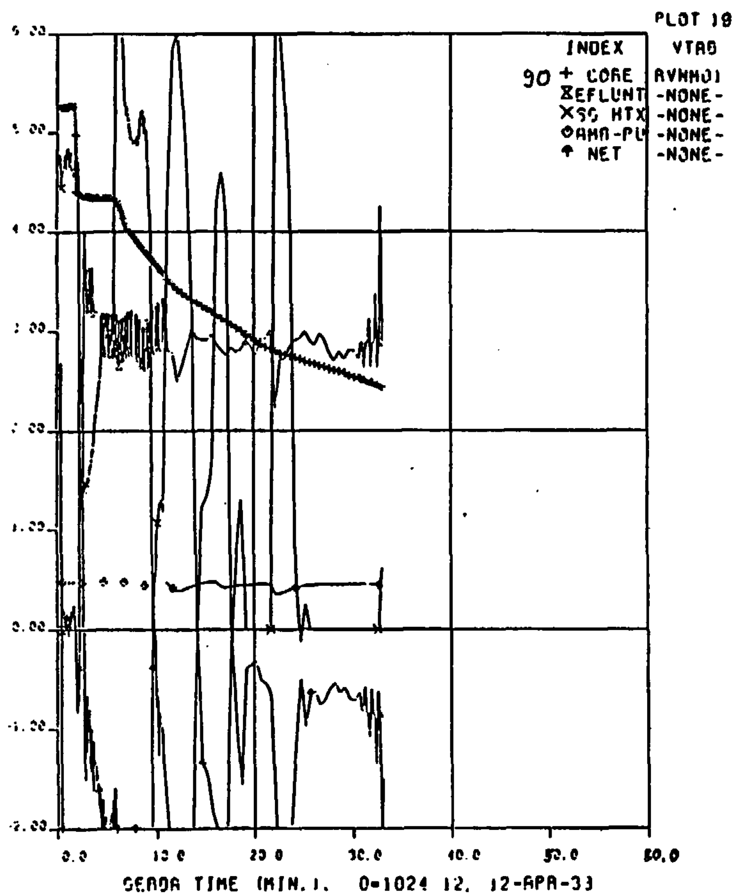
Original Data Plots from GERDA Composite Test 1605AA

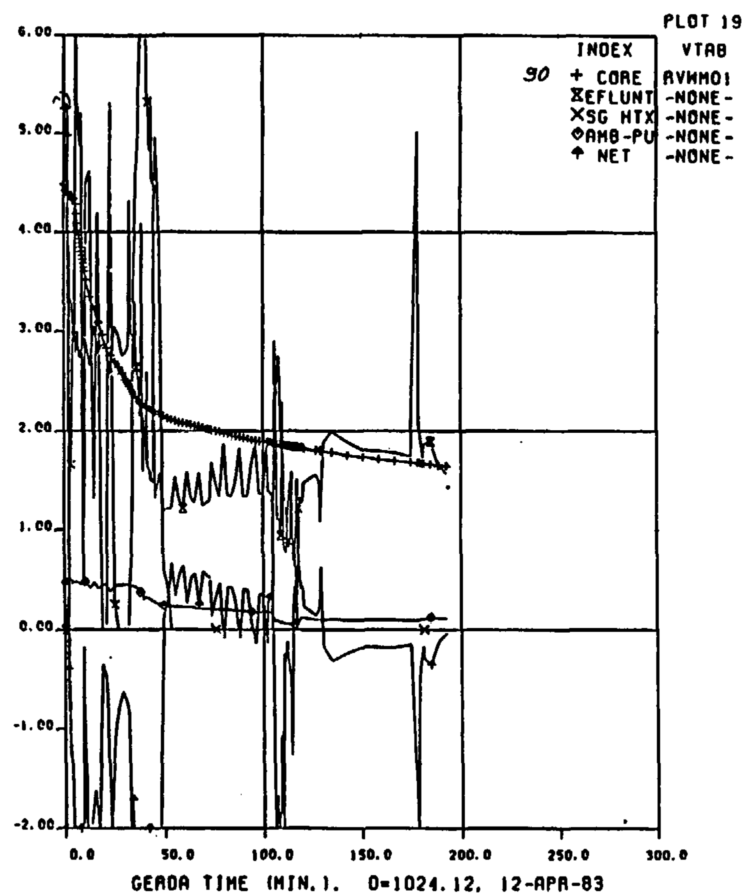



Plot 17 Primary Mass Balance (0 - 60 min, 0 - 300 min)

## Original Data Plots from GERDA Composite Test 1605AA

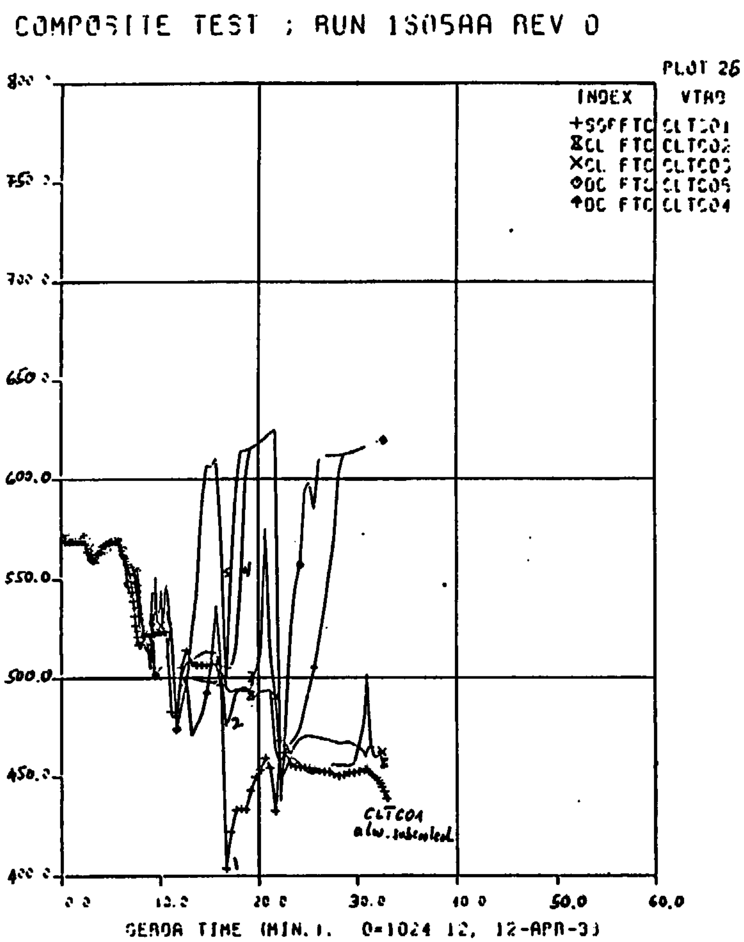


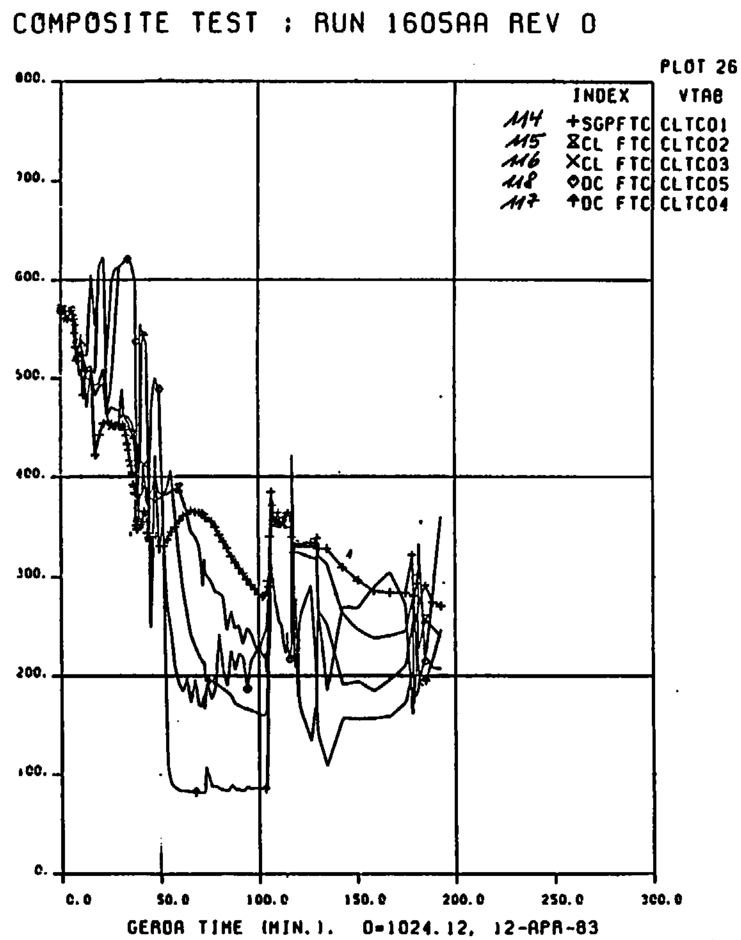




Plot 19

Primary Energy Balance (0 - 60 min, 0 - 300 min)

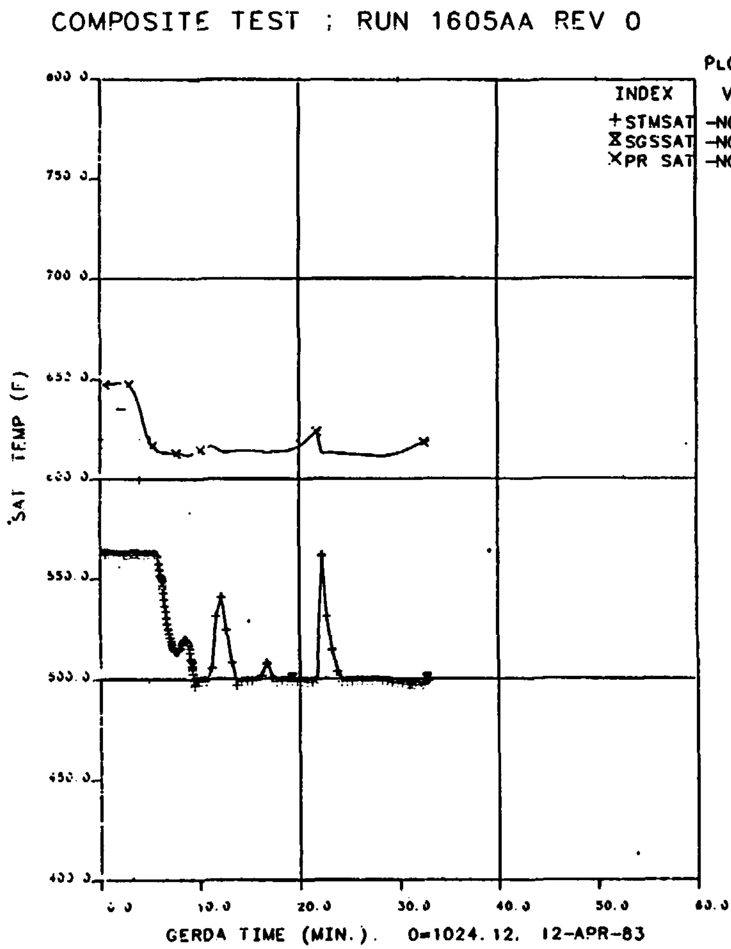
## Original Data Plots from GERDA Composite Test 1605AA

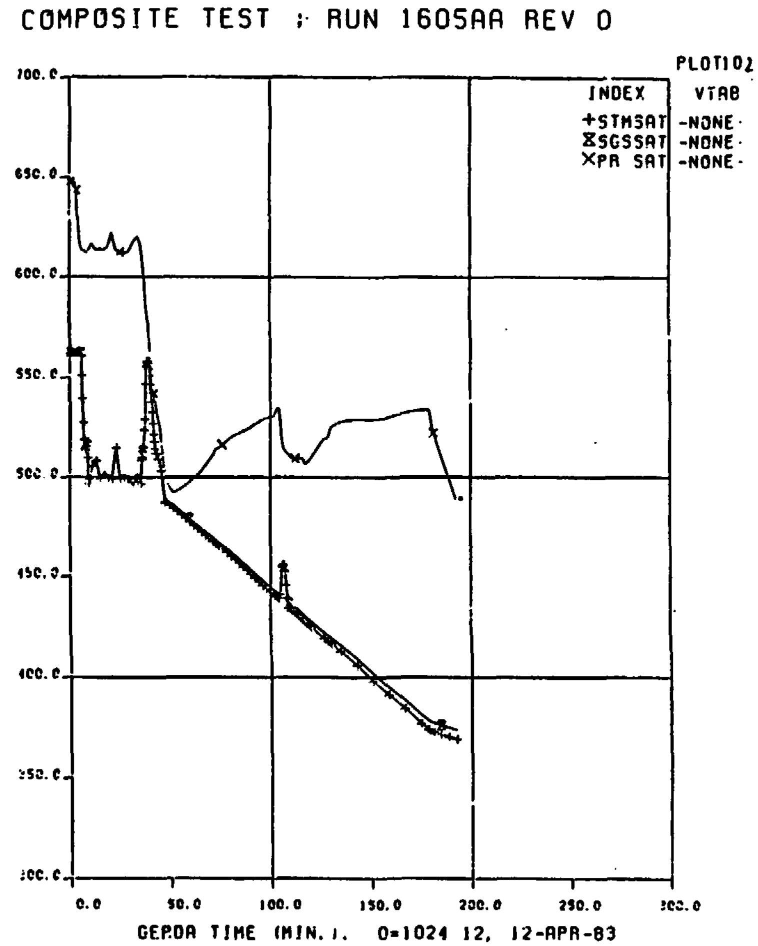



Plot 26 Cold Leg Temperature (0 - 60 min, 0 - 300 min)

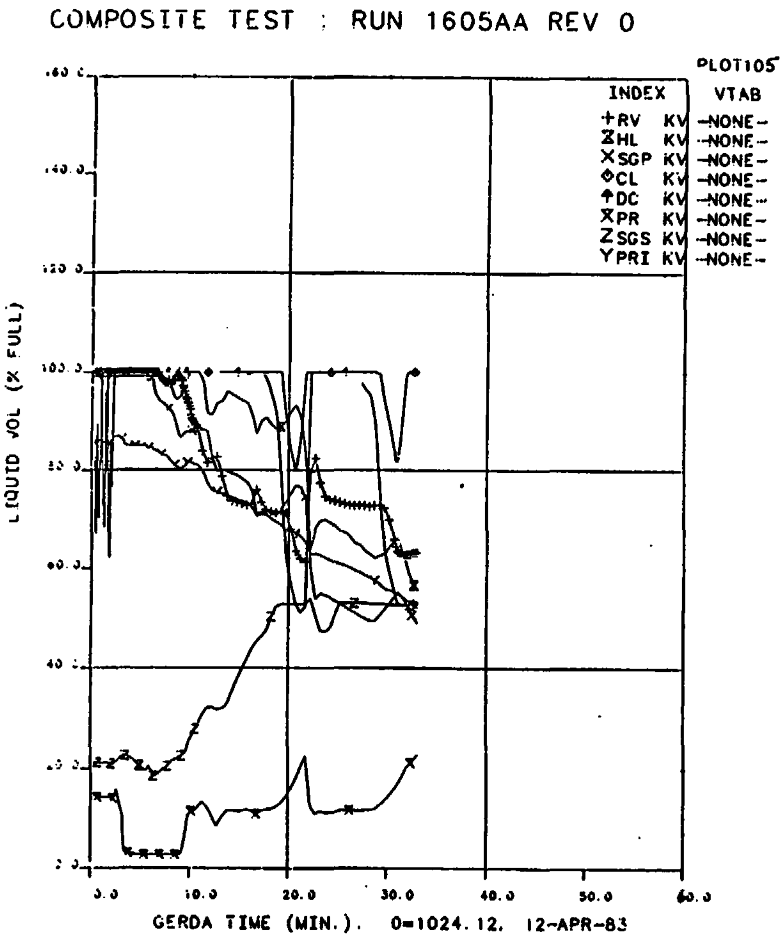
## Original Data Plots from GERDA Composite Test 1605AA

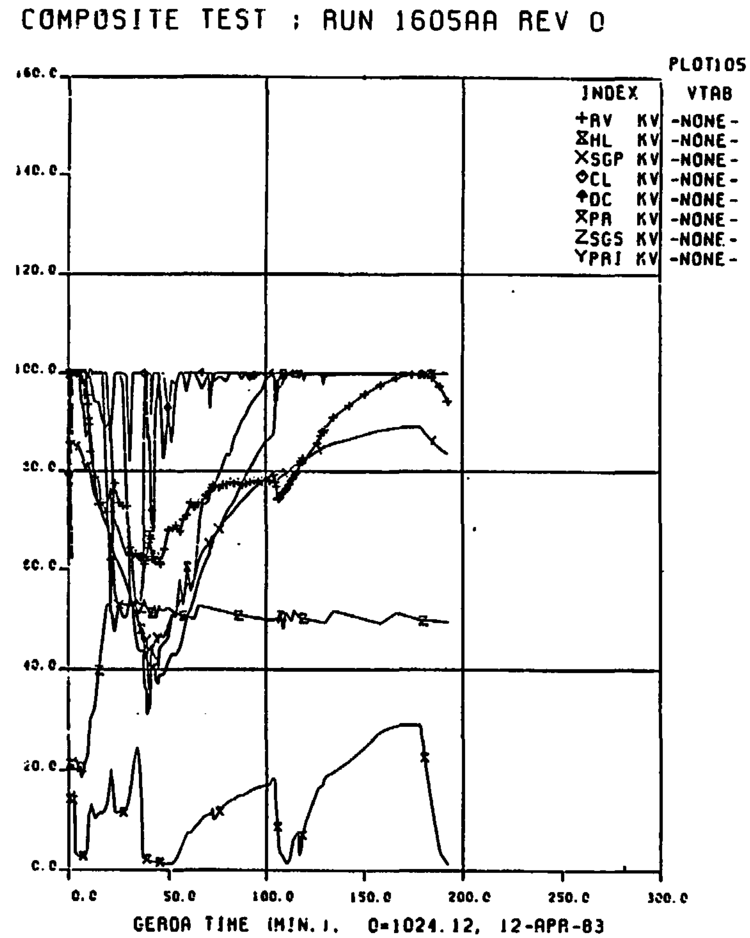



Plot 102 Saturation Temperatures (0 - 60 min, 0 - 300 min)

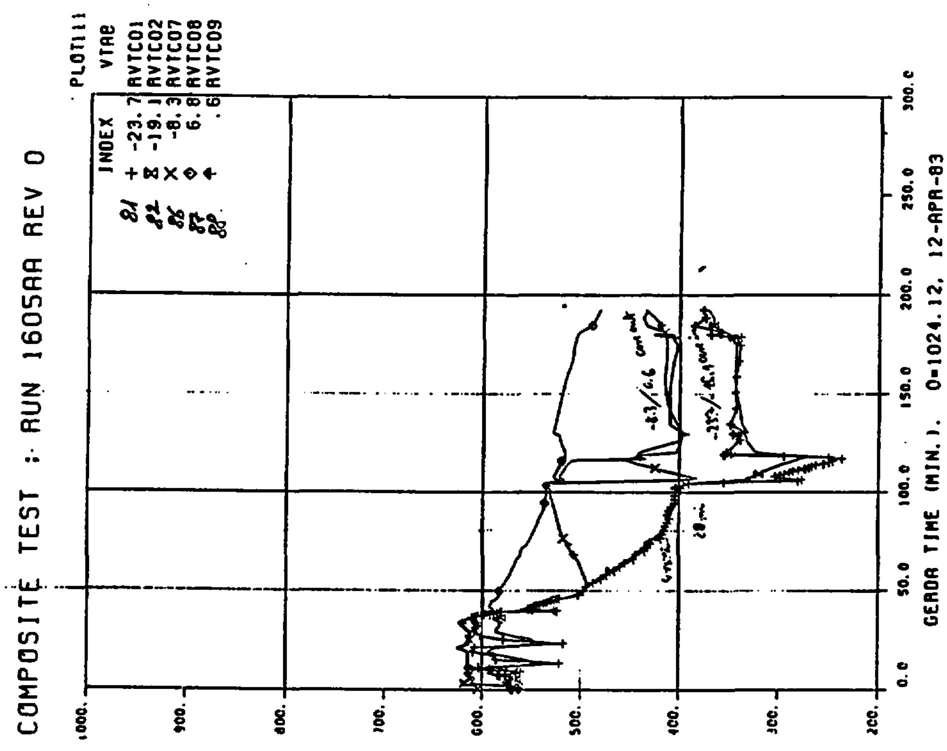
## Original Data Plots from GERDA Composite Test 1605AA

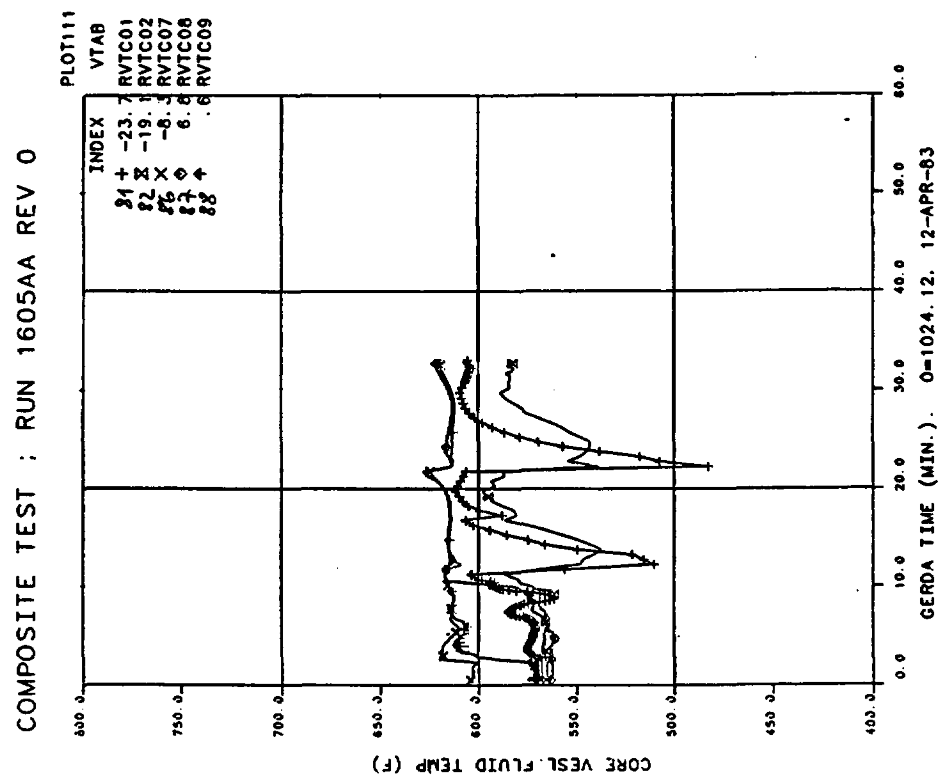



Plot 105 Liquid Volume (0 - 60 min, 0 - 300 min)

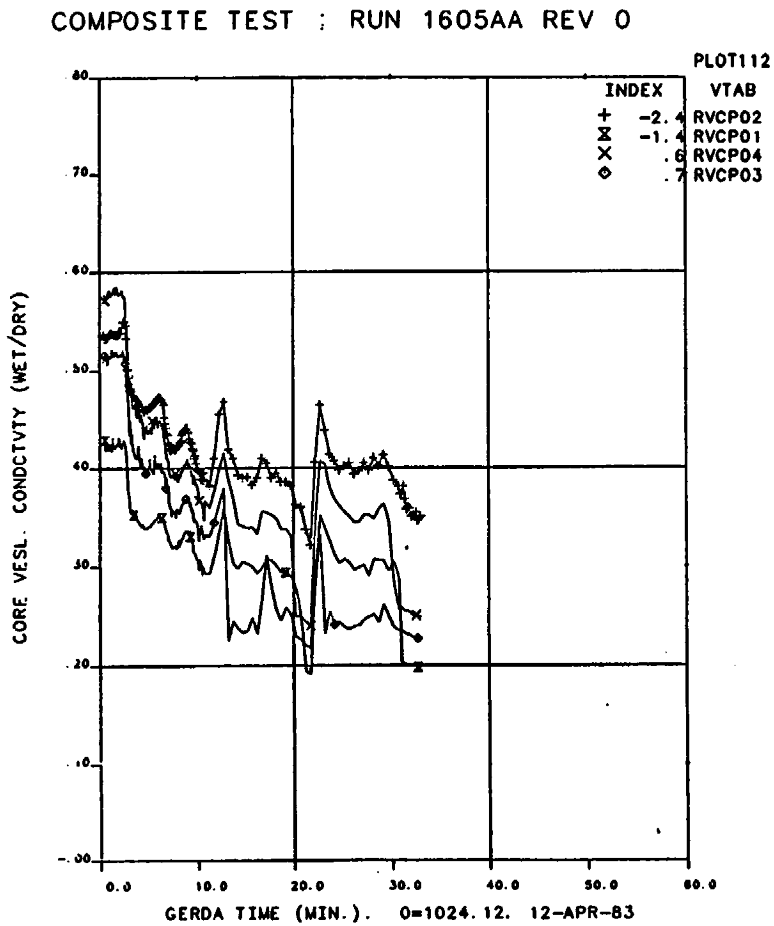
**Original Data Plots from GERDA Composite Test 1605AA**

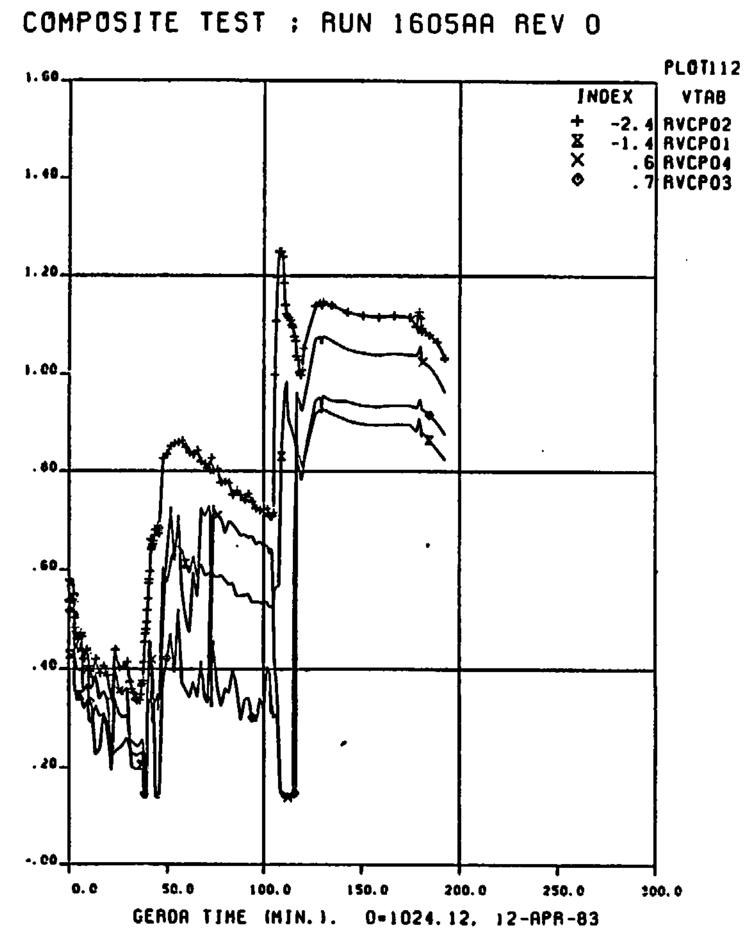



Plot 111 Core Vessel Fluid Temperatures (0 - 60 min, 0 - 300 min)

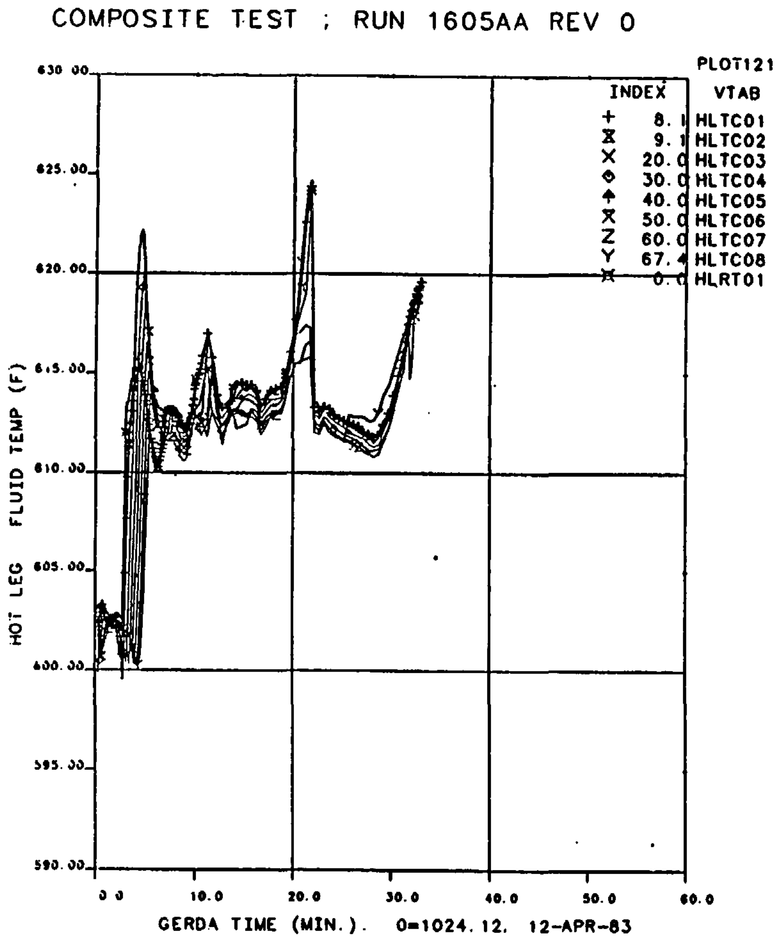
## Original Data Plots from GERDA Composite Test 1605AA

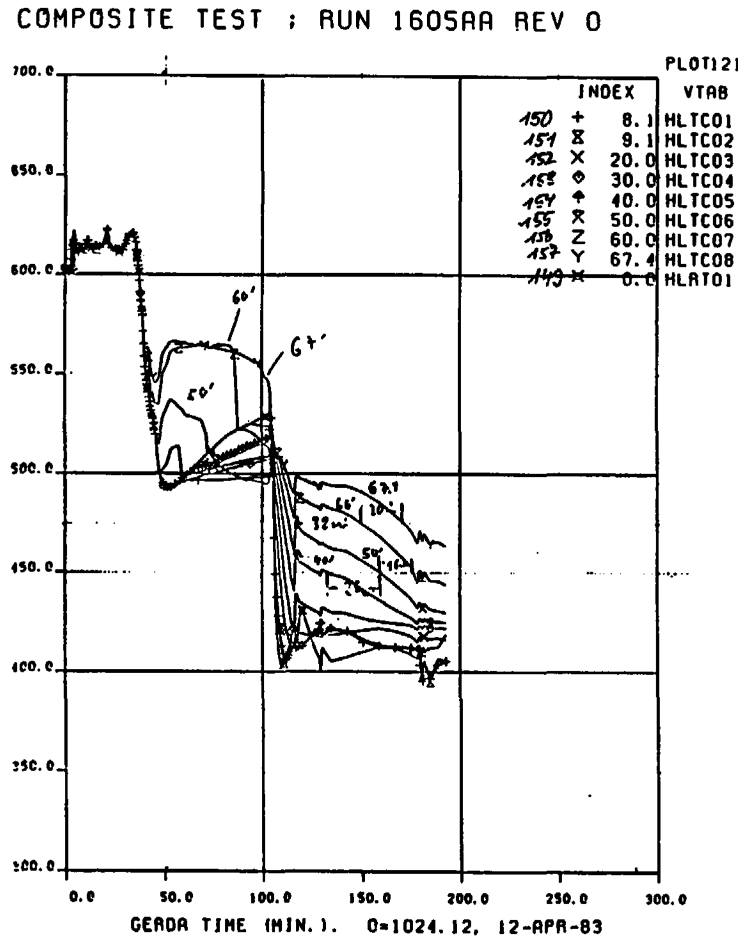



Plot 112 Core Vessel Conductivities (0 - 60 min, 0 - 300 min)

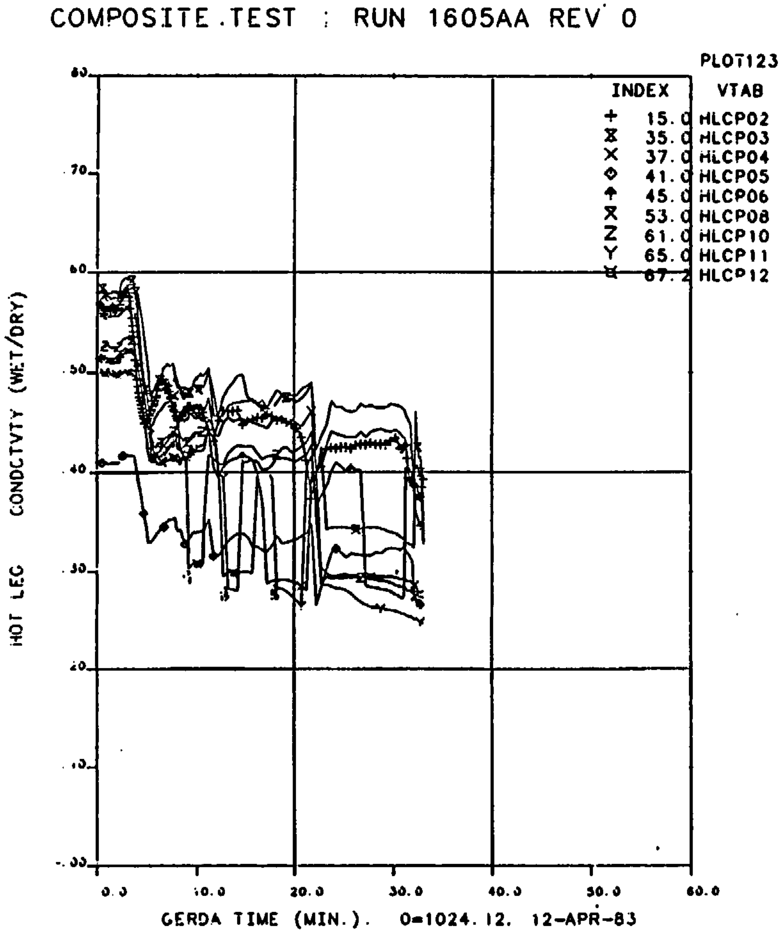
## Original Data Plots from GERDA Composite Test 1605AA

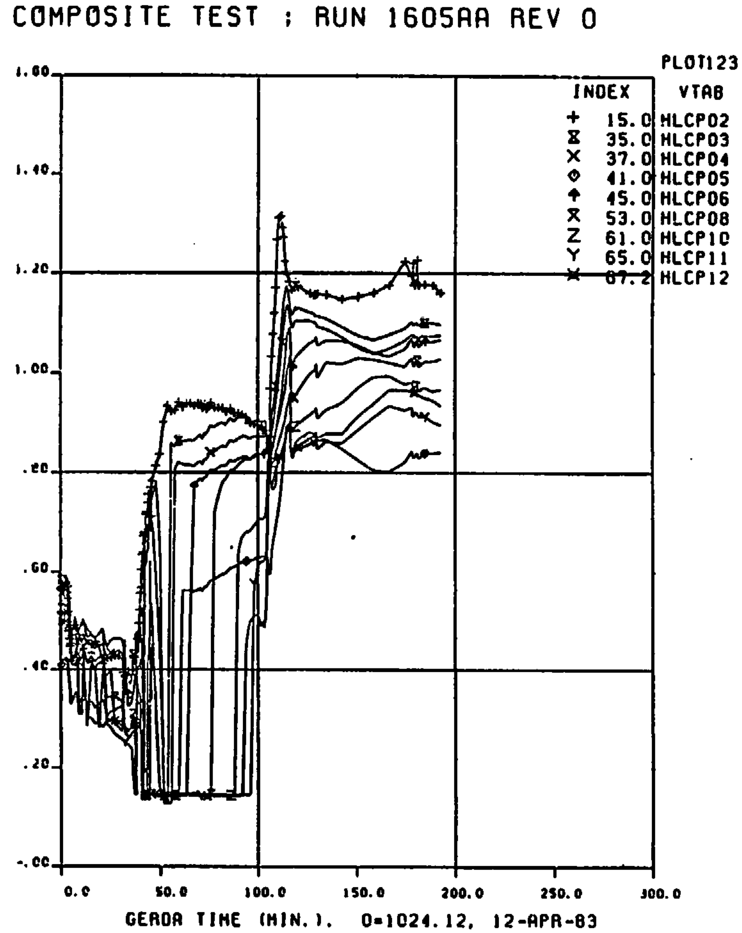



Plot 121 Hot Leg Fluid Temperatures (0 - 60 min, 0 - 300 min)

Original Data Plots from GERDA Composite Test 1605AA



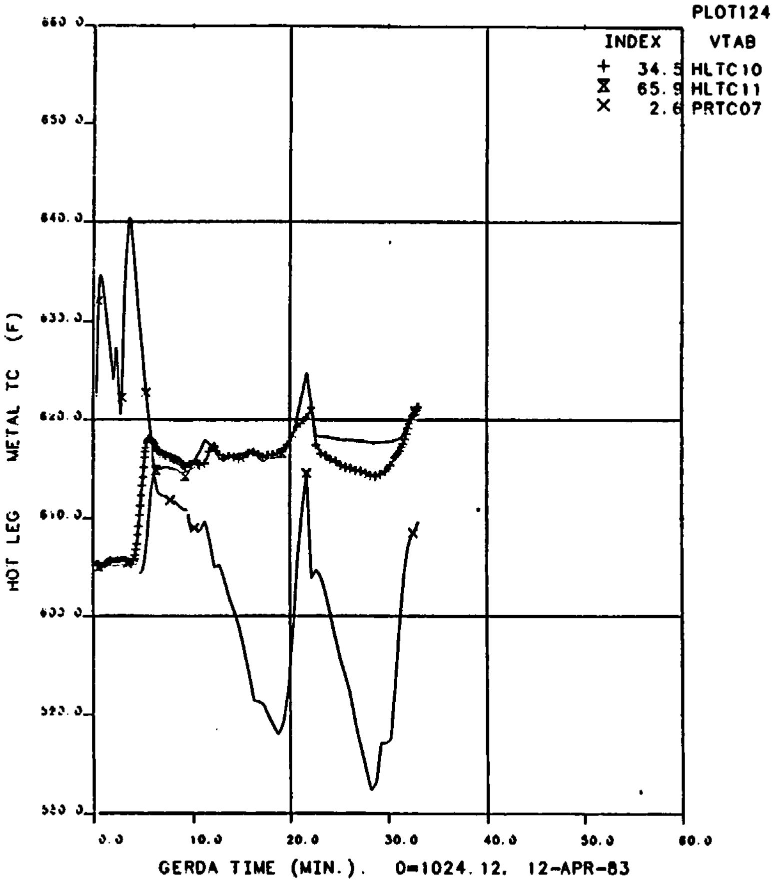




Plot 123

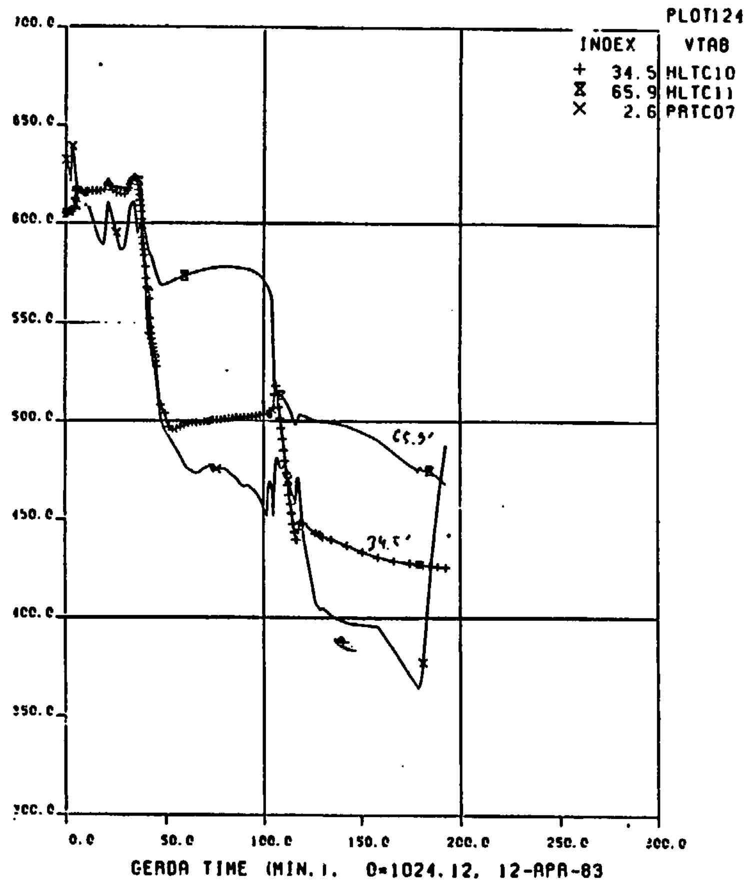
Hot Leg Conductivities (0 - 60 min, 0 - 300 min)

**Original Data Plots from GERDA Composite Test 1605AA**

COMPOSITE TEST ; RUN 1605AA REV 0

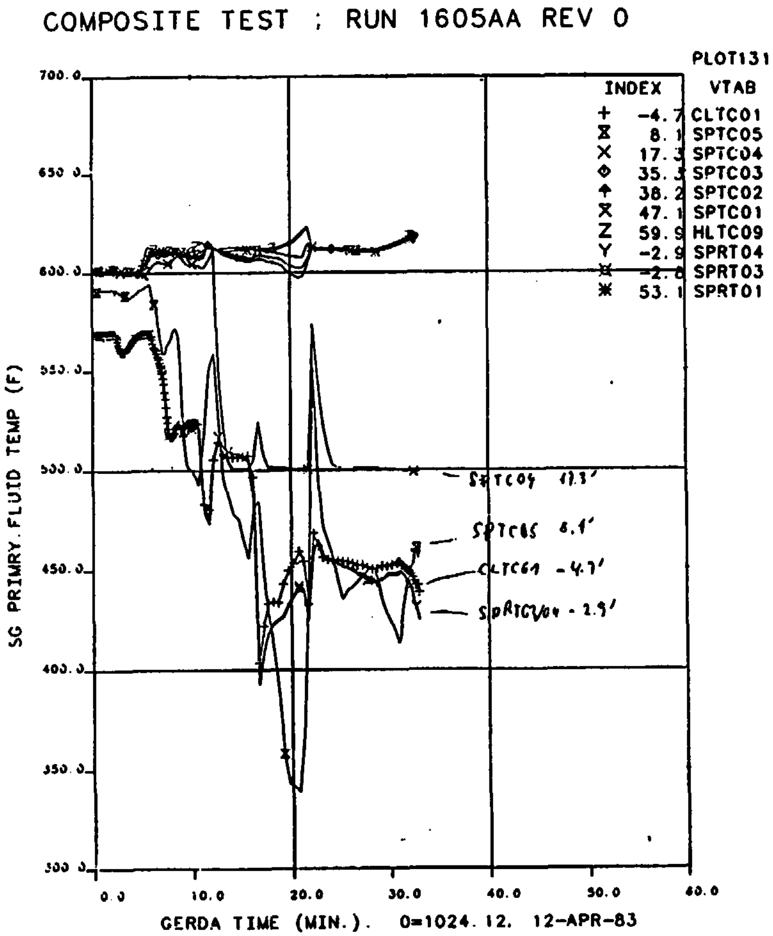


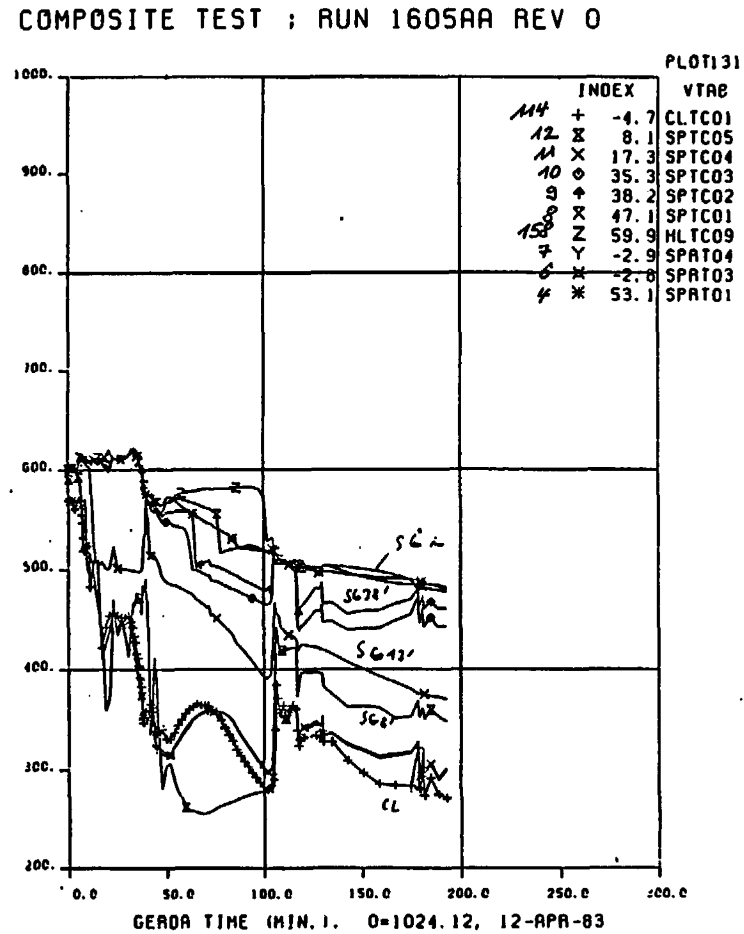

COMPOSITE TEST : RUN 1605AA REV 0




Plot 124 Hot Leg Metal Temperatures (0 - 60 min, 0 - 300 min)

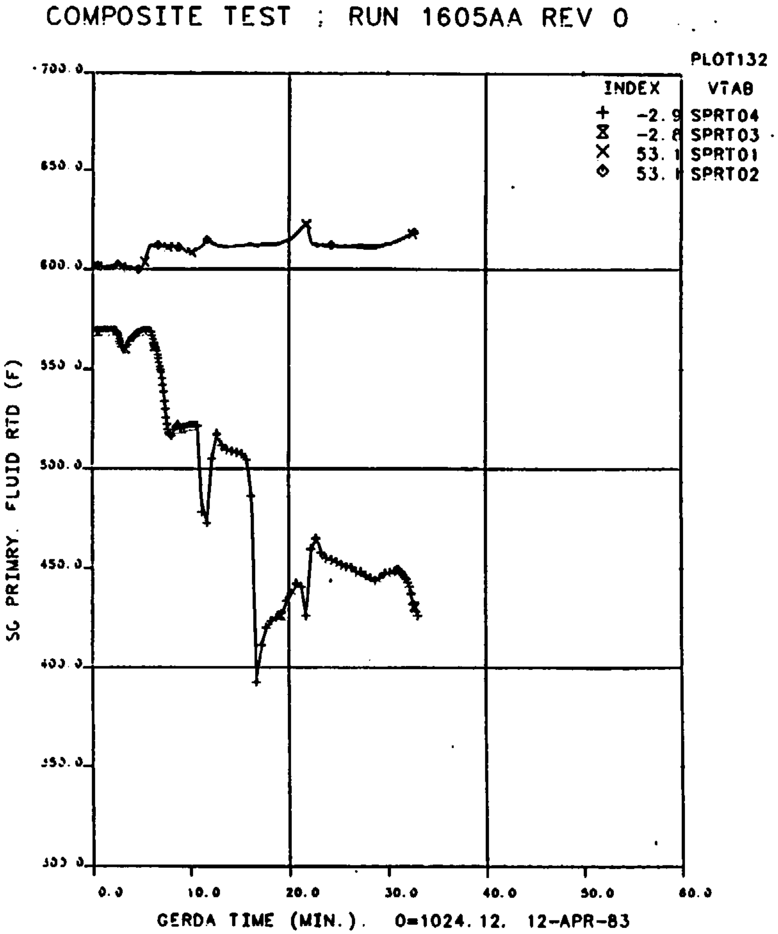
# Original Data Plots from GERDA Composite Test 1605AA

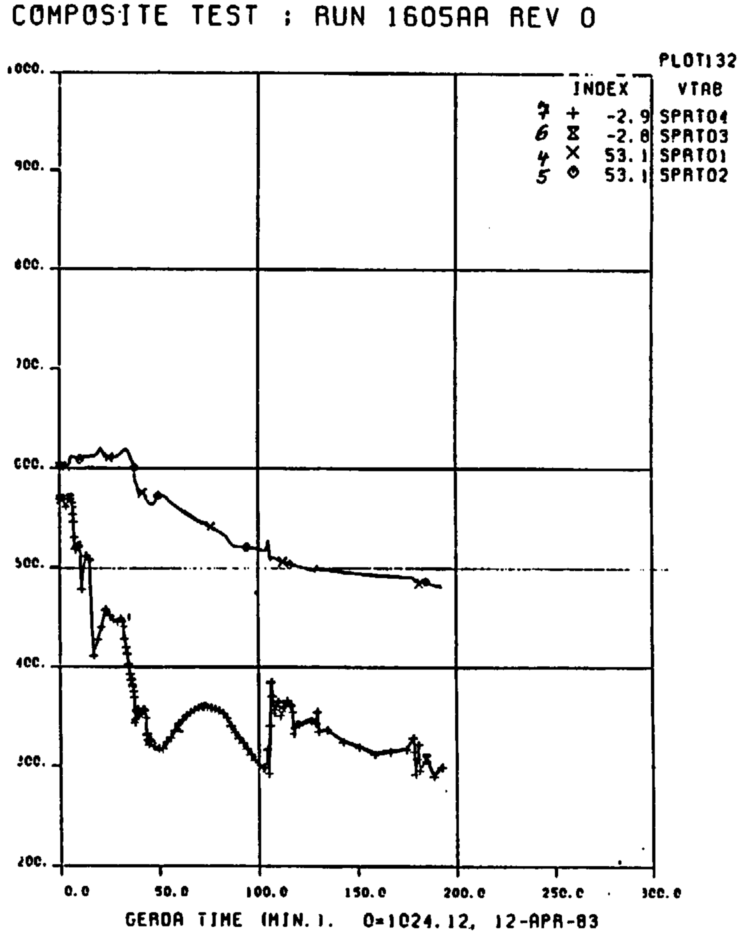



Plot 131 SG Primary Fluid Temperatures (0 - 60 min, 0 - 300 min)

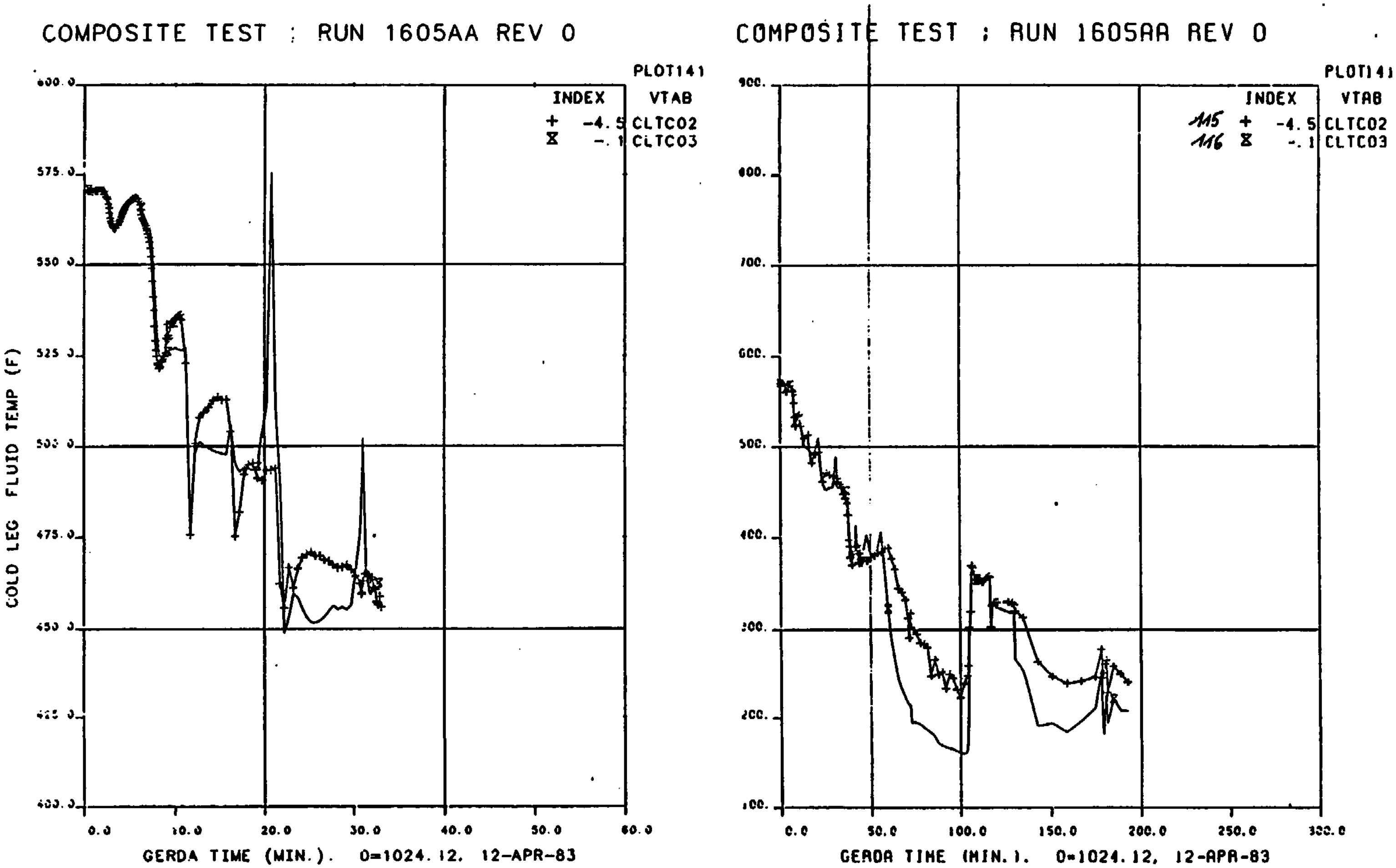
## Original Data Plots from GERDA Composite Test 1605AA



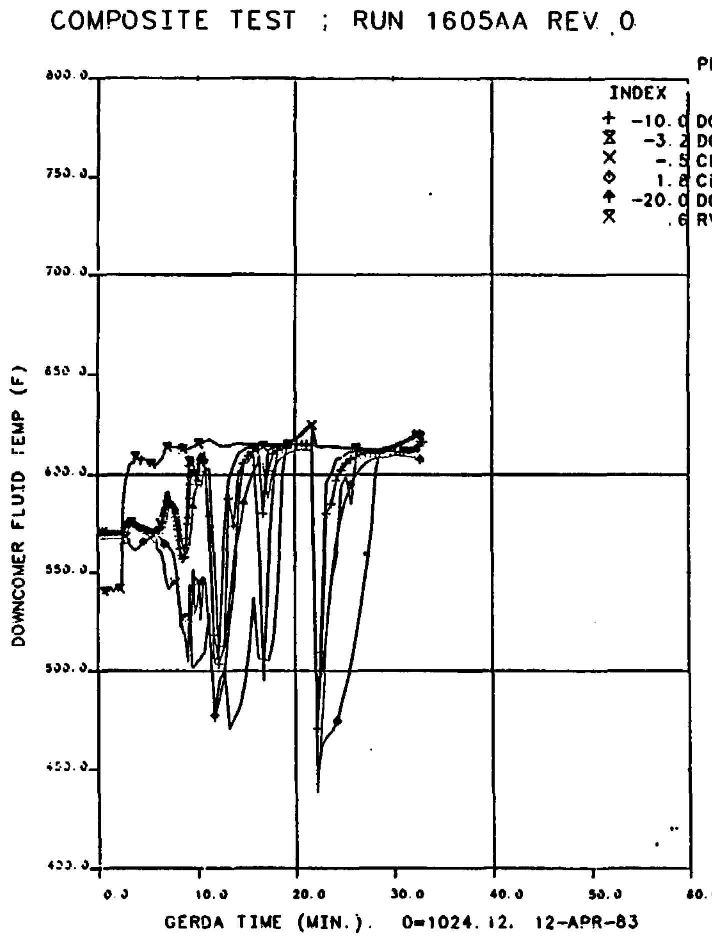

Plot 132 SG Primary Fluid RTD Temperatures (0 - 60 min, 0 - 300 min)

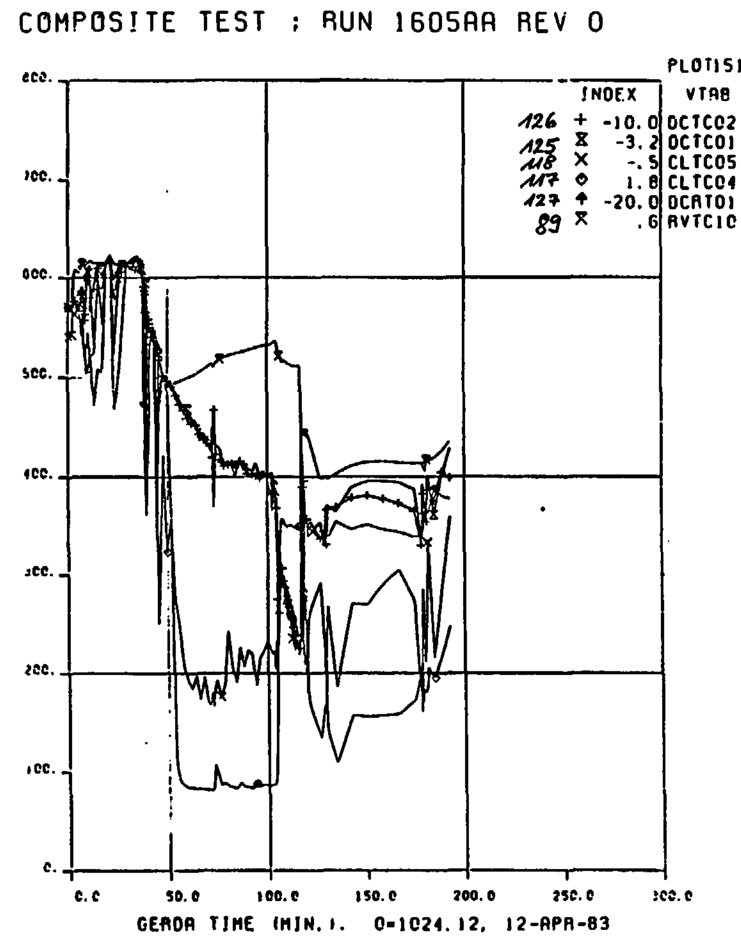
# Original Data Plots from GERDA Composite Test 1605AA




Plot 141 Cold Leg Fluid Temperatures (0 - 60 min, 0 - 300 min)

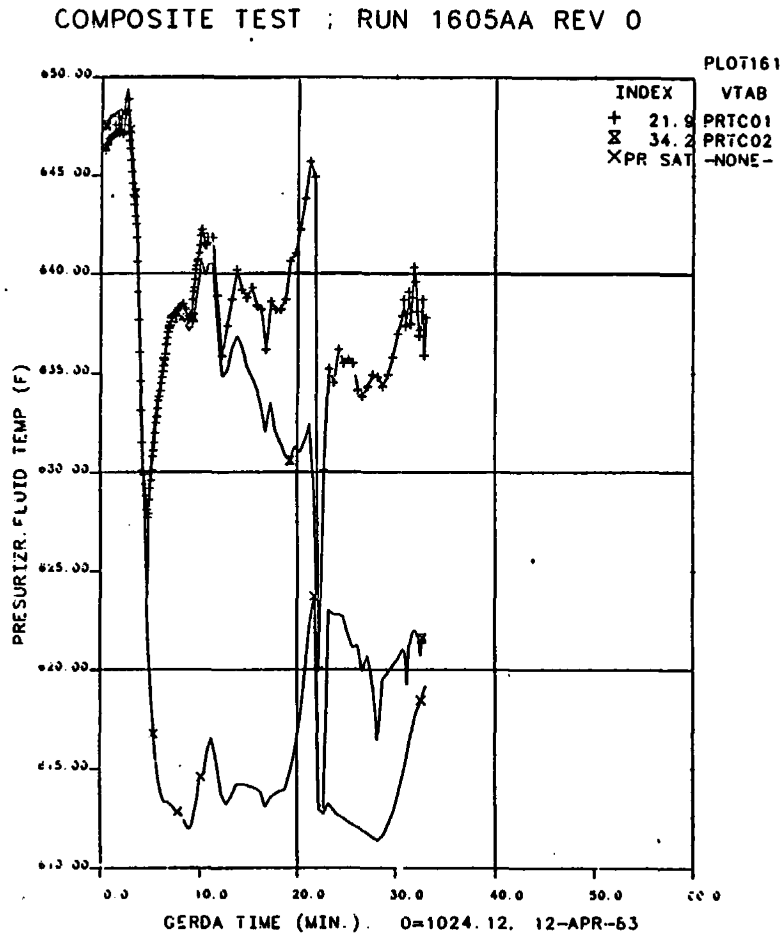
# Original Data Plots from GERDA Composite Test 1605AA

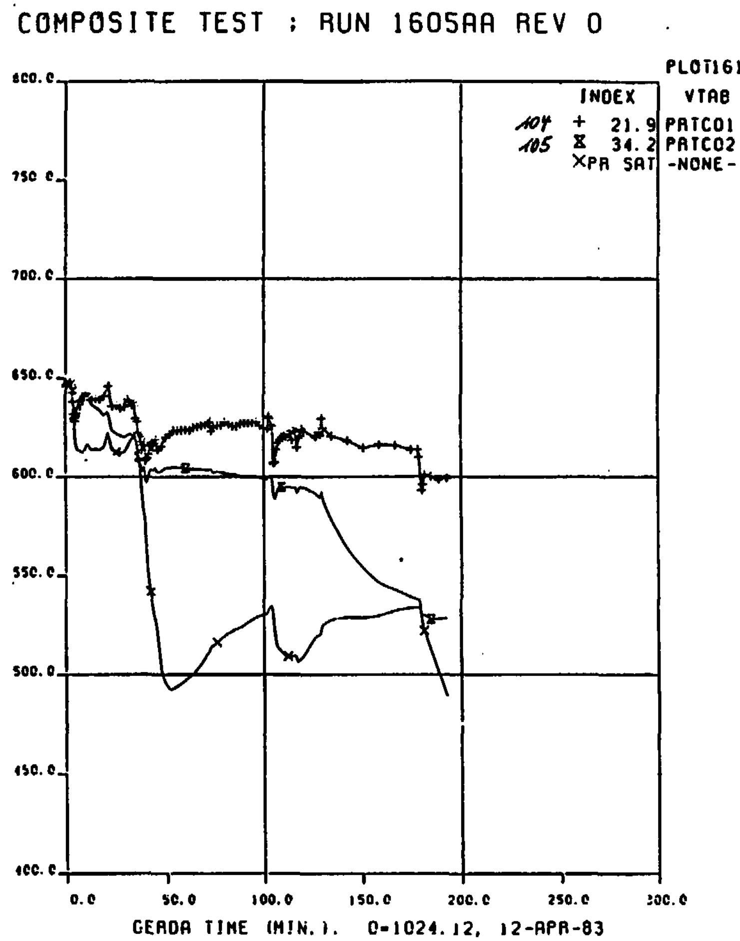



Plot 151 Down Comer Fluid Temperatures (0 - 60 min, 0 - 300 min)

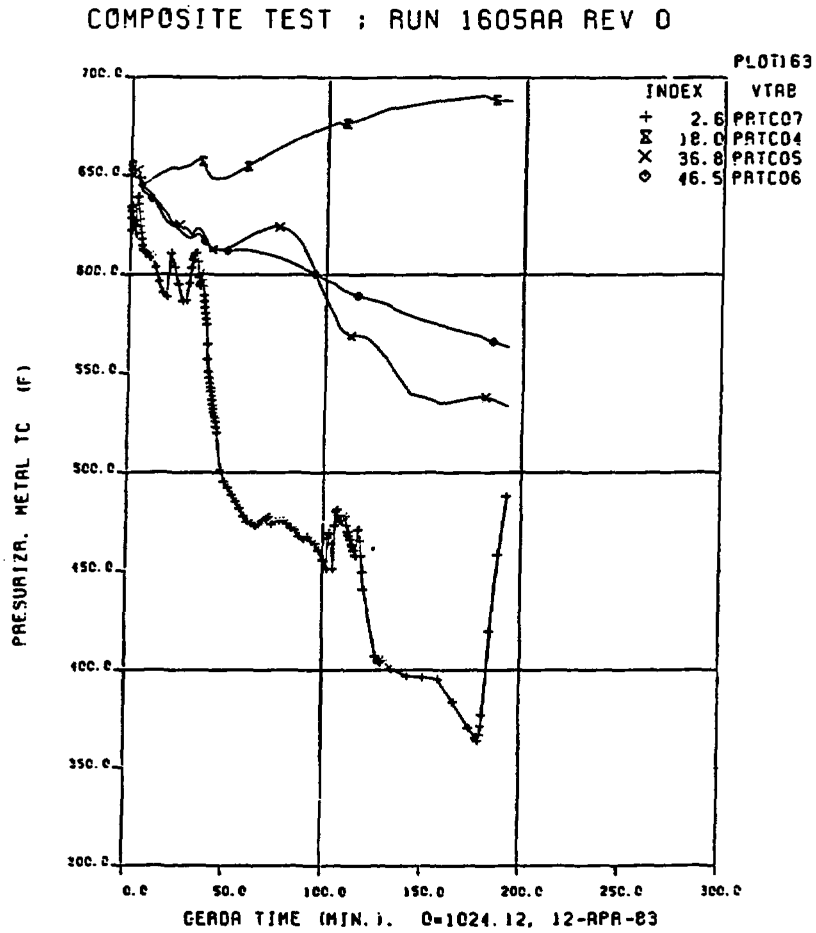
## Original Data Plots from GERDA Composite Test 1605AA



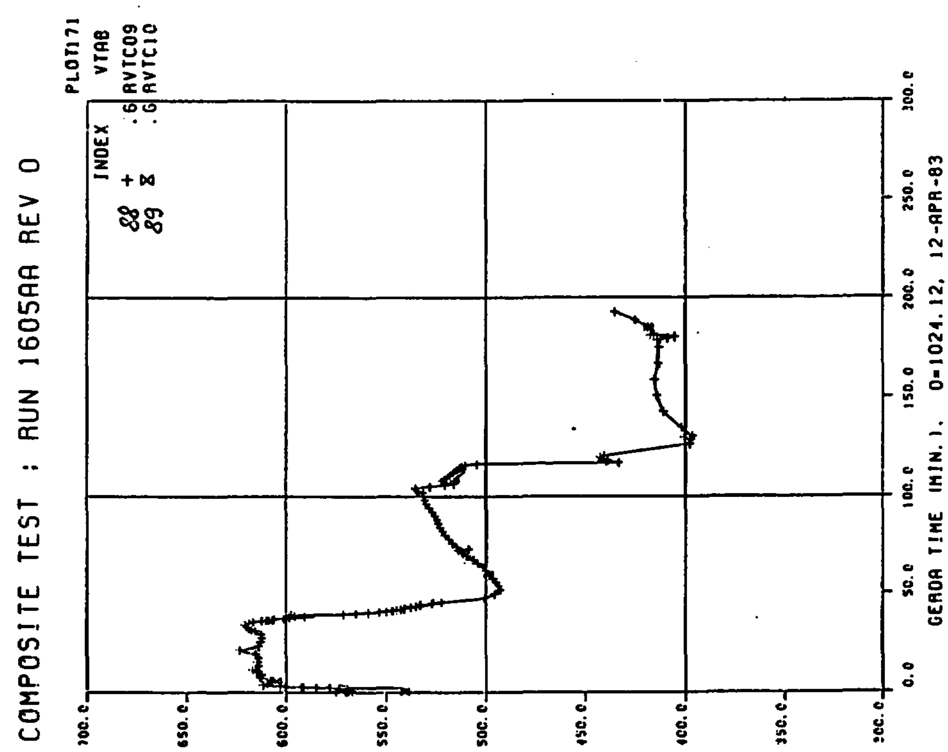

Plot 161 Pressurizer Fluid Temperatures (0 - 60 min, 0 - 300 min)

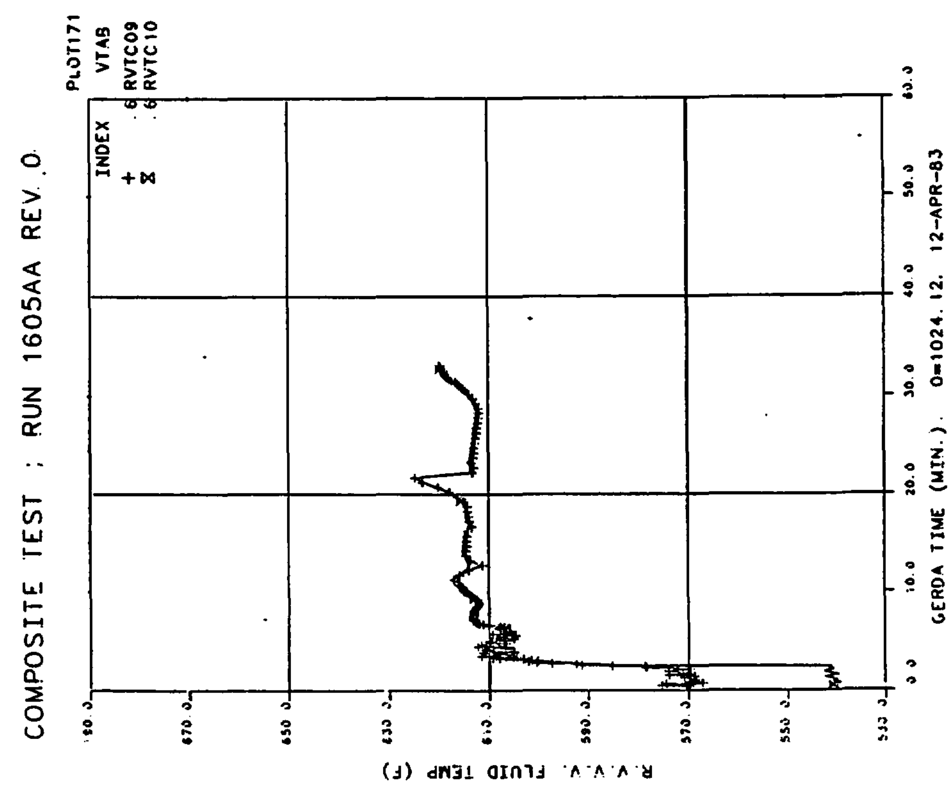
## Original Data Plots from GERDA Composite Test 1605AA




Plot 163 Pressurizer Metal Temperatures (0 - 300 min)

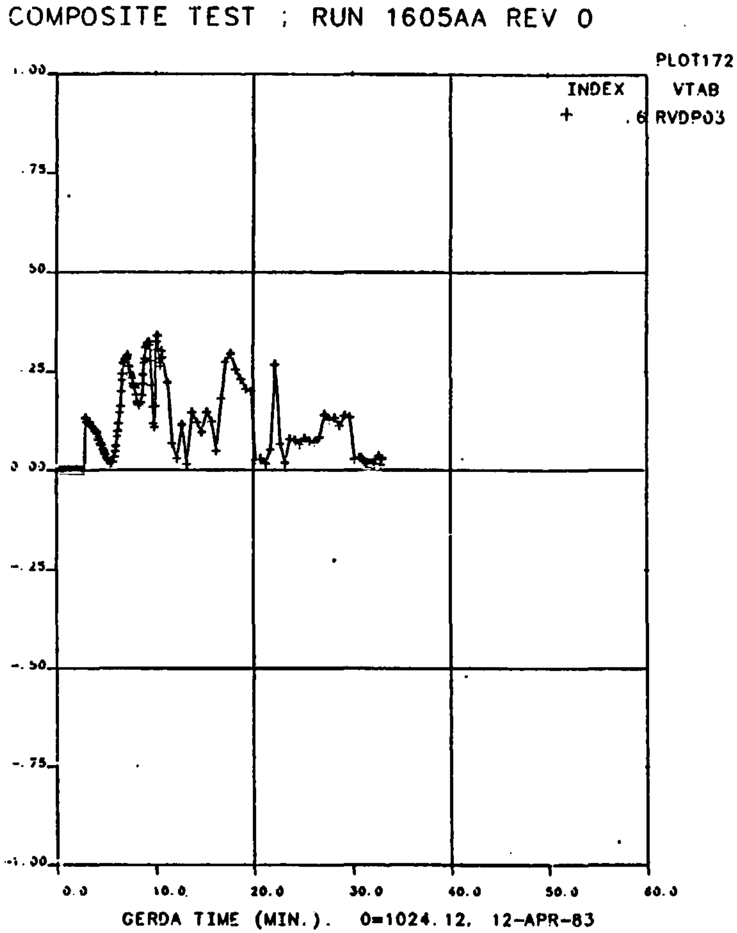
**Original Data Plots from GERDA Composite Test 1605AA**

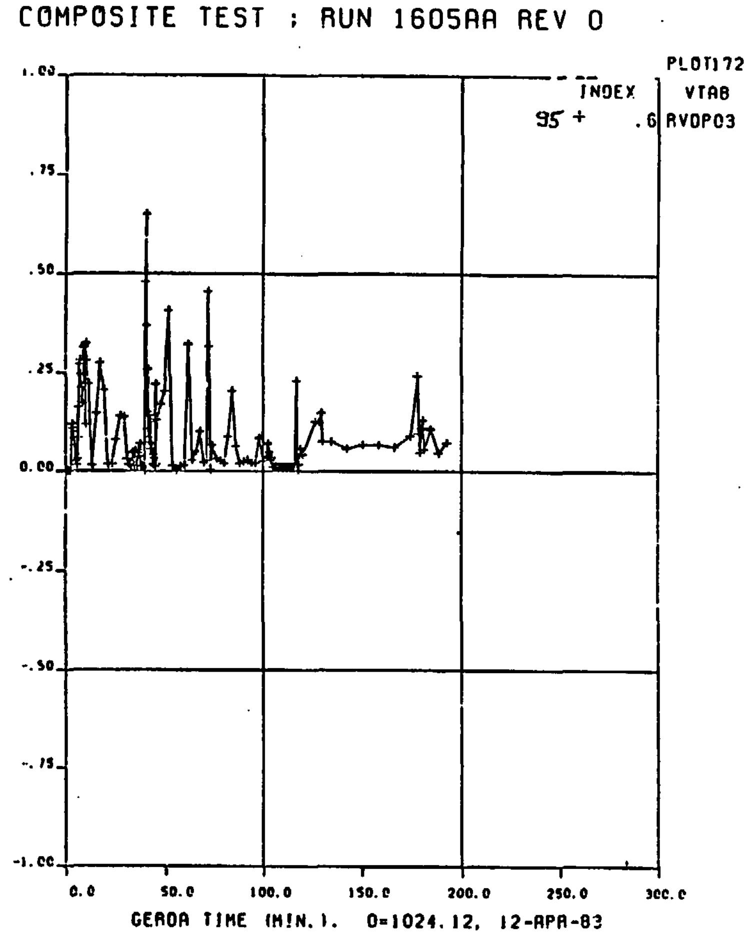



Plot 171 RVVV (VV) Fluid Temperature (0 - 60 min, 0 - 300 min)

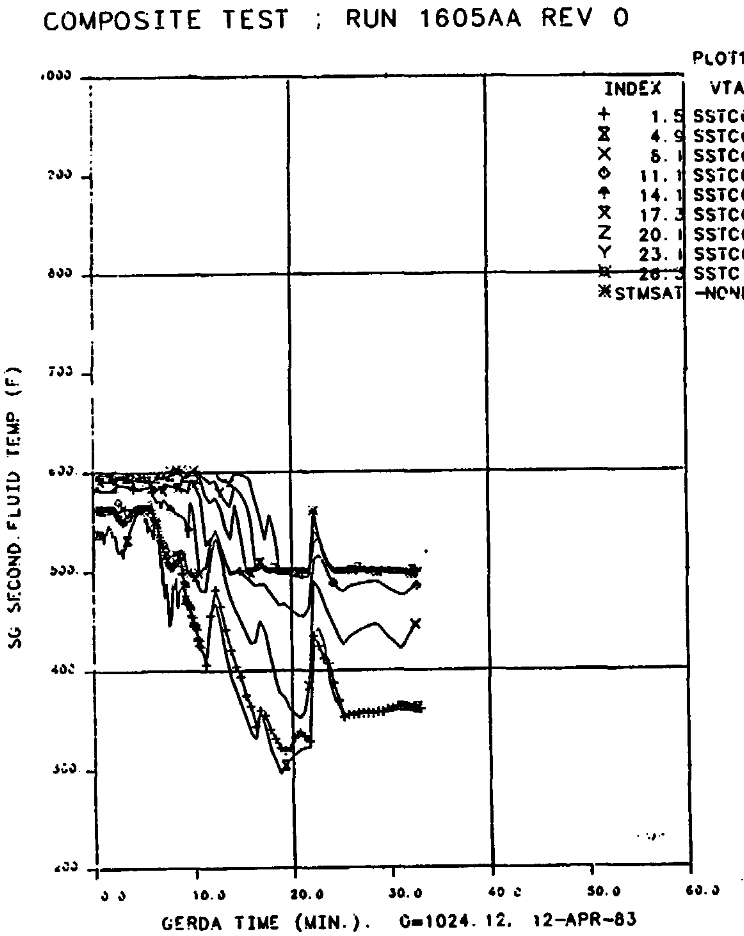
## Original Data Plots from GERDA Composite Test 1605AA

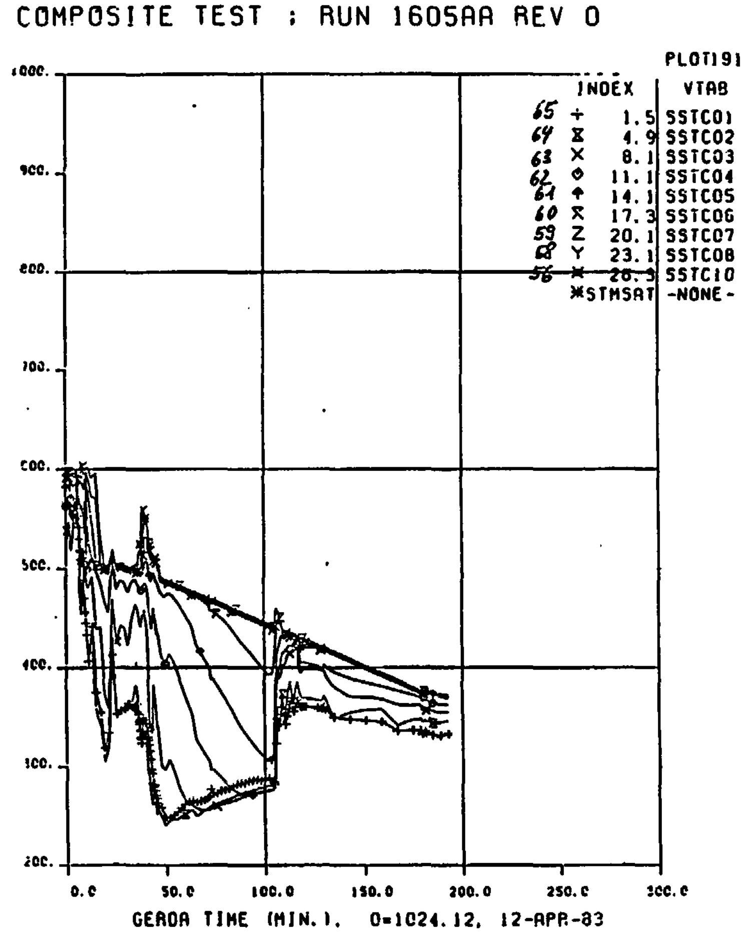



Plot 172 RVVV (W) Pressure Difference (0 - 60 min, 0 - 300 min)

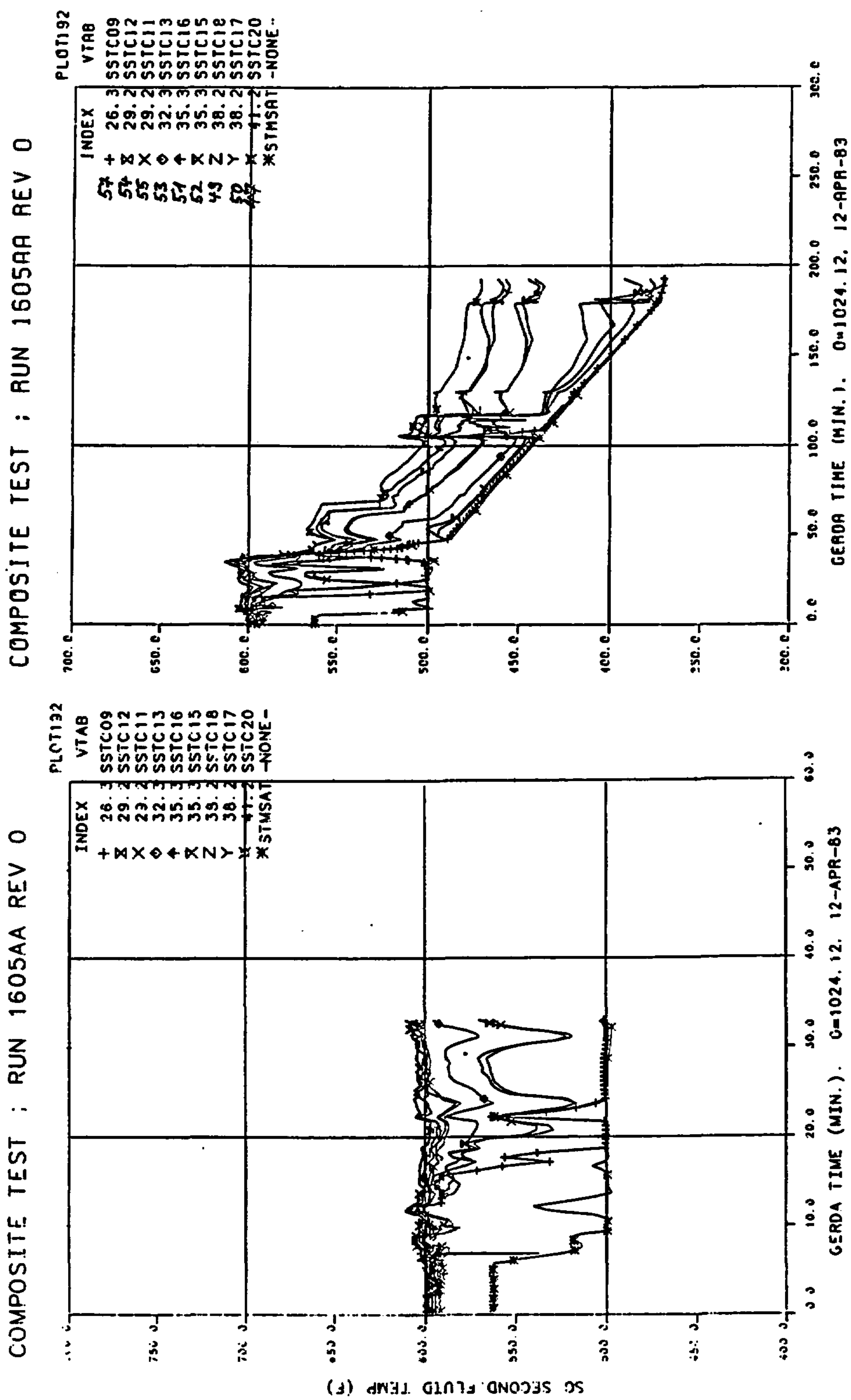
Original Data Plots from GERDA Composite Test 1605AA



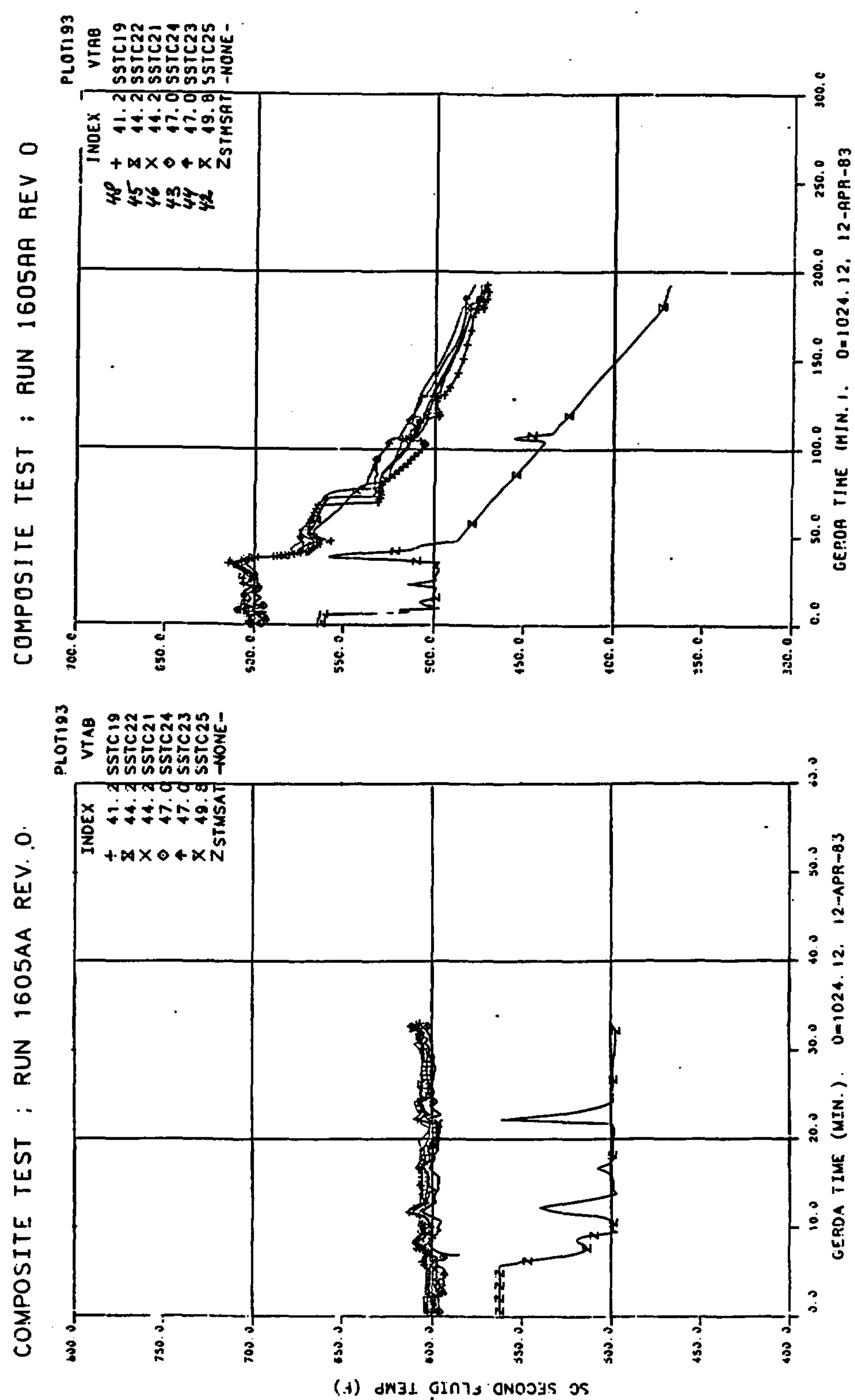

Plot 191 SG Secondary Fluid Temperatures (0 - 60 min, 0 - 300 min)

## Original Data Plots from GERDA Composite Test 1605AA




Plot 192 SG Secondary Fluid Temperatures (0 - 60 min, 0 - 300 min)

## Original Data Plots from GERDA Composite Test 1605AA




Plot 193 SG Secondary Fluid Temperatures (0 - 60 min, 0 - 300 min)

## RELAP5 MOD 3.2 Input Deck for the GERDA Test 1605AA Post Test Calculation

```
* relap5 / mod3.2
*
*                   analysendeck: abx.inp
*                   datum :23.04.98
*                   analysendeck: abgeleitet von gdr53bwk.inp
*
*                   Leck 100%
*                   VV-Hoehe
*                   DE-Level 9 m
*                   RJ 100%
*                   HP 100%
*                   VV-Fläche 2.59 cm^2  und K = 1.45
*                   K-Faktor (FP909) = 0.0
*
*                   skalierungsfaktor bezogen auf die gesamtanlage:
*                   s = 2 x de-rohre(kmk) / de-rohre(gerda)
*                     = 2 x 16013        / 19      =   1686
*
*                   mit diesem faktor werden skaliert:
*                   die nachzerfallsleistung und die einspeise- und ab-
*                   blasemassenströme
*
=   title
*
100  new transnt
101  run
* --------------------------101 inp-chk
* -------------------------- 102 si  british
* --------------------------103 0   *restart nummer
104  ncmpress
105  5.0   6.0
110  air
201    150.0  1.0-8  0.25   7    20   80  600
202    600.0  1.0-8  0.25   7     2  800  4000
203   3000.0  1.0-8  0.25   7    10  800  4000
204  12000.0  1.0-8  0.25   7    20  800  4000
* ==========================================================================
*
* ========================= trips ========================================
* trip für ende der stationären rechnung
501  time  0  ge  timeof  538     145.0  1   * Zeit aus Versuch 1605AA
*
* --------------------------------------------------------------------------
*
502 time  0  gt  null  0  145.0  1
*
*
513 time   0    gt null 0  1.+6 1 *immer falsch
*
* ------ öffnen der heissen entlüftungen, loop 1 und 2
504  time  0  gt timeof  501  1855.0   1   * loop 1
*
505  p  440010000  gt null  0  82.0+5  n
506  p  440010000  lt null  0  79.5+5  n
*
509  time  0  ge  timeof  505  0.8  n
510  time  0  ge  timeof  509  0.2  n
*
511  time  0  ge  timeof  506  0.8  n
512  time  0  ge  timeof  511  0.2  n
```

```
*
* ------ oeffnungs- und schliessdruecke f. 48 u. 79 bar-ventile ----------
*
524  p  440010000  gt null  0  48.0+5  n *oeffnen 48 bar-ventil de ii
525  p  440010000  lt null  0  47.4+5  n *schliessen 48 bar-ventil de ii
*
526  p  440010000  gt null  0  79.0+5  n *oeffnen 79 bar-ventil de i
527  p  440010000  lt null  0  78.4+5  n *schliessen 79 bar-ventil de i
*
550 time 0 ge timeof 689 3.00 n *oeffnungstotzeit 48 bar-vent. de ii
551 time 0 ge timeof 550 3.00 n *oeffnungsstellzeit 48 bar-vent. de ii
593 time 0 ge timeof 525 3.00 n *schliesstotzeit 48 bar-vent. de ii
594 time 0 ge timeof 593 3.00 n *schliesstellzeit 48 bar-vent. de ii
*
514 time 0 ge timeof 688 3.00 n *oeffnungstotzeit 79 bar-vent. de i
515 time 0 ge timeof 514 3.00 n *oeffnungsstellzeit 79 bar-vent. de i
516 time 0 ge timeof 527 3.00 n *schliesstotzeit 79 bar-vent. de i
517 time 0 ge timeof 516 3.00 n *schliesstellzeit 79 bar-vent. de i
*

552  cntrlvar  290  gt  null  0  0.0  n
553  cntrlvar  290  lt  null  0  0.0  n
546  time  0  ge  timeof  698  3.0  n  *™ffnungstotzeit  abfahren del
547  time  0  ge  timeof  546  3.0  n  *™ffnungsstellzeit abfahren del
528  time  0  ge  timeof  553  3.0  n  *schlieátotzeit abfahren del
529  time  0  ge  timeof  528  3.0  n  *schlieátotzeit abfahren del
*
*
* --------------- 'immer wahr'-trip -------------------------------------
*
538 time  0  lt  null  0  1.0+6  1 * trip, der immer 'wahr' ist
*
* ----------------------------------------------------------------------
*
* ----- oeffnen + schliessen anhand kollabierter wasserstaende
*              im dampferzeuger fuer rj und rx
*
540 cntrlvar  216  lt  null  0  8.4    n *oeffnen rj-einsp. de ,10t
541 cntrlvar  216  gt  null  0  9.0    n *schliessen rj-einsp. de ,12t
542 cntrlvar  216  lt  null  0  8.4    n *oeffnen rj-einsp. de , 8t
543 cntrlvar  216  gt  null  0  9.0    n *schliessen rj-eins. de ,10t
*
548  time  0  gt timeof  501  1655.0   1 *zeitverz"gerung abfahren mit 28 k/h
*
*580  cntrlvar  70  gt  null  0   10000000.0  n  * "ffnen vent valves,
station„r
*581  cntrlvar  70  lt  null  0   0.0  n  * schlieáen vent valves, station„r
580  cntrlvar  70  gt  null  0    34.3  n  * "ffnen vent valves, aus 1605aa
581  cntrlvar  70  lt  null  0   -34.3  n  * schlieáen vent valves, 1605aa
576  time   0   ge   timeof  580   2.0  n  * "ffnungstotzeit vent valves
577  time   0   ge   timeof  576   2.0  n  * "ffnungsstellzeit vent valves
578  time   0   ge   timeof  581   2.0  n  * schlieástellzeit vent valves
579  time   0   ge   timeof  578   2.0  n  * schlieátotzeit vent valves
*
* ----------------  reaktorschutz-trips  --------------------------------
*
*
582 p    140010000 lt null 0 117.00+5  1 *hkm-druck hot leg 1 sehr tief->
kuvest
585  time 0 gt timeof 592  0.0  1  *13.15 s zeitverz. tj ( notstromfall )
*585  time 0 gt timeof 592 13.15 1  *13.15 s zeitverz. tj ( notstromfall )
*
591 time 0 gt timeof 501 0.0    1 *0.9 s  zeitverzoegerung sekst
*591 time 0 gt timeof 501 0.9    1 *0.9 s  zeitverzoegerung sekst
```

```
592 time 0 gt timeof 582 0.0   1 *0.9 s  zeitverzoegerung kuvest
*592 time 0 gt timeof 582 0.9   1 *0.9 s  zeitverzoegerung kuvest
*****593 time 0 gt timeof 663 120.9  1 *120.9 s  zeitverzoegerung noss loop 1
*****594 time 0 gt timeof 664 120.9  1 *120.9 s  zeitverzoegerung noss lopp 2
*
*
596 time 0 gt timeof 591  0.0  1  *5.5 s zeitverzoegerung start rj-red. i
*596 time 0 gt timeof 591  16.5  1  *5.5 s zeitverzoegerung start rj-red. i
*
597 time 0 gt timeof 592 16.5  1 *13.5 s zeitverzoegerung start rj-red.ii
*597 time 0 gt timeof 592 24.5  1 * 24.5 s -    "    -   bei notstromfall
*
*
598 time 0 gt timeof 592 0.0  1 *zeitverz. freischalt. 48 bar-v.
*598 time 0 gt timeof 592 36.5 1 *zeitverz. freischalt. 48 bar-v.
*       bei erreichen von kuvest (trip 598 wird true)
*       tripkarten 540 bis 543 austauschen (rj-regelung
*       von 10/12t auf 28/30t setzen)
*
*
599 time 0 gt timeof 591  0.0  1 *zeitverz. freischalt. 79 bar-v. bei
notstrom
*599 time 0 gt timeof 591  26.5 1 *zeitverz. freischalt. 79 bar-v. bei
notstrom
*599 time 0 gt timeof 591 10.0 1 *zeitverz. freischalt. 79 bar-v.
*
*
*
*
* ======================  logische trips  =================================
*
*
648  576  and  -577  n   * "ffnungstrip vent valves
649  578  and  -579  n   * schlieátrip vent valves
*
* -----------------------  regelung rj -----------------------------------
*
*    regelung rj-einspeisung in de i
670  -672  and  540  n *grenzwerte 540 und 541 ohne verzoegerungen
671   672  and -541  n
672   670  or   671  n *schaltung rj-red. de i
673   672  and  596  n *schaltung nur, wenn sekst oder kuvest ausgeloest
*
*    regelung rj-einspeisung in de ii
674  -676  and  542  n *grenzwerte 542 und 543 ohne verzoegerungen
675   676  and -543  n
676   674  or   675  n *schaltung rj-red. de ii
677   676  and  597  n *schaltung nur, wenn sekst oder kuvest ausgeloest
678  -673  and  538  n *komplement zu 673
679  -677  and  538  n *komplement zu 677
*
*
*
680  514  and  -515  n * oeffnen 79 bar ventil de i
681  516  and  -517  n * schliessen 79 bar ventil de i
682  550  and  -551  n * oeffnen 48 bar ventil de ii
683  593  and  -594  n * schliessen 48 bar ventil de ii
688  526  and   599  n * oeffnen 79 bar ventil de i nach kuvest
689  524  and   598  n * oeffnen 48 bar ventil de ii nach kuvest
*
*
690  546  and  -547  n * ™ffnen abfahren del
691  528  and  -529  n * schliessen abfahren del
698  552  and   548  n * ™ffnen abfahrstrang del nach 1800 s
```

```
*
694   509   and   -510   n
695   511   and   -512   n
*
*
*
*
* ===========================================================================
*                          eingabe der komponenten
* ===========================================================================
*
*
* ==== eingabe reaktordruckbehalter =======================================
*
*
*    komponente 102
1020000  vsslbtm   branch
1020001  1  1
1020101  0.00345117  0.2  0.  0. 90.0  0.2  2.0-5 0.0 0000000
1020200  3  1.53295+07   571.760
1021101  102010000  100000000  0.001446  0.0  0.0  0001000
1021201  1.0967        0.0  0.0
*
*
*    komponente 905
*    break valve
9050000  break   valve
*        f = 0.001 m^2  (10 cm^2)
*        f-gerda = 0.001/1686 = 0.0000005931 m^2
*9050101  102000000  906000000   0.0000005338  0.0  0.0  0000100  1.0  1.0
1.0
9050101  102000000  906000000   0.0000005931  0.0  0.0  0000100  1.0  1.0
1.0
9050201  1  0.  0. 0.
9050300  mtrvlv
9050301  501  513  66.67  0.  0
*
9060000  tha  tmdpvol
9060101  100.0  0.0 400.0   0.  0.  0.  0.  0.  0000011
9060200  4
9060201  0.      1.+5     293.00   1.
9060202  1.+6    1.+5     293.00   1.

*    komponente 100
*    unteres plenum rdg
1000000  unt.ple  pipe
1000001  2
1000101  0.00345117  1  7.267504-4  2
1000301  1.92        1      0.375   2
1000601  90.0                       2
1000801  2.0-5       0              2
1000901  0.0         0.0            1
1001001  0000000                    2
1001101  0001000                    1
1001201  3    1.53219+07    571.758   0.0  0.0  0.0  1
1001202  3    1.53120+07    571.754   0.0  0.0  0.0  2
1001300  1
1001301  1.0967      0.0   0   1
*
*
*    komponente 105
*    verbindung zw untplm und core
1050000  untplm  sngljun
1050101  100010000  110000000  0.0136361  0.  0.  0001000  1.0  1.0  1.0
```

```
1050201  1  1.0967      0.  0.
*
*
*    komponente 110
*    rdg / core
1100000  core   pipe
1100001  6
1100101  0.0136361 4  0.0059892 6
1100301  0.4875    4  1.091     6
1100601  90.0                   6
1100801  2.0-5     0            6
1100901  0.        0.           5
1101001  0000000                6
1101101  0001000                5
1101201  3   1.53103+07      576.589     0.0  0.0  0.0  1
1101202  3   1.53069+07      581.345     0.0  0.0  0.0  2
1101203  3   1.53036+07      585.917     0.0  0.0  0.0  3
1101204  3   1.53003+07      590.459     0.0  0.0  0.0  4
1101205  3   1.52949+07      590.461     0.0  0.0  0.0  5
1101206  3   1.52876+07      590.458     0.0  0.0  0.0  6
1101300  1
1101301  1.0967       0.0   0   5
*
*
*    komponente 120
*    rdg hoehe auslaufstutzen
1200000  coreaus  branch
1200001  3  1
1200101  0.0059892  0.2  0  0  90.0  0.2  2.0-5  0  0000000
1200200  3   1.52832+07   590.456
1201101  110010000  120000000   0.007495    0.    0.    0001000
1202101  120010000  270000000   0.007495    0.    0.    0001000
1203101  120010000  130000000   0.0017466  4.296 5.36   0001000
1201201  1.0967       0.  0.
1202201  0.  0.  0.
1203201  1.0967       0.  0.
*
*
*    komponente 270
*    rdg oberes plenum unterer teil
2700000  rdgobpl   branch
2700001  0  1
2700101  0.0059892 1.470 0. 0. 90. 1.470 1.6-6 0  0000000
2700200  3  1.52776+07   590.818
*
*
*    komponente 265
*    ueberstroemvorrichtungen
2650000  vv         valve
*        f = 0.7948 m^2
*        f-gerda = 0.7948/1686 = 0.0004714 m^2
*        K-Wert wurde aus Versuch 1605AA abgeleitet
2650101  270010000  260010000  0.000259 1.45  1.0+9  0000100  1.0  1.0  1.0
2650201  1  0.  0.  0.
2650300  mtrvlv
2650301  648  649 0.5  0  0
*
*
*    komponente 275
*    verbindung zw ob plm 1+2 teil
2750000  obplm  sngljun
2750101  270010000  280000000  0.0059892  0.  0.  0001000  1.0  1.0  1.0
2750201  1  0.0  0.  0.
*
```

```
*
*    komponente 280
*    rdg ob plm,ob teil
2800000  rdgobplm  snglvol
2800101  0.0059892  1.6345  0  0  90.  1.6345 1.6-6  0.  0000000
2800200  3   1.52672+07  590.818
*
*
*
* ===== eingabe heisser strang ============================================
*
*
*    komponente 130
*    hot leg : rdg bis vor oberem kruemmer 1.teil loop i
1300000  hotle1  snglvol
1300101  0.003599 2.480  0  0 90.0  2.480     2.0-5  0.0  0000000
1300200  3   1.52729+07   590.451
*
*
*    komponente 131
*    verbindung: 130 und 132
1310000  hotverb sngljun
1310101  130010000  132000000  0.003599  0.255  0.255 0001000 1.0  1.0  1.0
1310201  1    1.0967       0.   0.
*
*
*    komponente 132
*    hot leg : 2. teil mit abzweig zum druckhalter loop i
1320000  hotle1   pipe
1320001  16
1320101  0.003599        16
1320301  0.9746885       16
1320601  90.0            16
1320801  2.0-5  0.0      16
1320901  0.0  0.0        15
1321001  0000000         16
1321101  0001000         15
1321201  3   1.52612+07    590.447    0.0    0.0    0.0   1
1321202  3   1.52546+07    590.443    0.0    0.0    0.0   2
1321203  3   1.52481+07    590.440    0.0    0.0    0.0   3
1321204  3   1.52415+07    590.437    0.0    0.0    0.0   4
1321205  3   1.52349+07    590.434    0.0    0.0    0.0   5
1321206  3   1.52283+07    590.430    0.0    0.0    0.0   6
1321207  3   1.52218+07    590.427    0.0    0.0    0.0   7
1321208  3   1.52152+07    590.424    0.0    0.0    0.0   8
1321209  3   1.52086+07    590.421    0.0    0.0    0.0   9
1321210  3   1.52020+07    590.417    0.0    0.0    0.0  10
1321211  3   1.51954+07    590.414    0.0    0.0    0.0  11
1321212  3   1.51889+07    590.411    0.0    0.0    0.0  12
1321213  3   1.51823+07    590.408    0.0    0.0    0.0  13
1321214  3   1.51757+07    590.404    0.0    0.0    0.0  14
1321215  3   1.51691+07    590.401    0.0    0.0    0.0  15
1321216  3   1.51626+07    590.398    0.0    0.0    0.0  16
1321300  1
1321301  1.0967       0  0  15
*
*
*    komponente 135
*    verbindung: hot leg und druckhalter
1350000  pressjun  sngljun
1350101  310000000  132000000 0.000172 144.89 144.89  0001000 1.0  1.0  1.0
1350201  1   0.0    0.0   0.
*
*
```

```
*
*    komponente 140
*    oberer kruemmer bis zum hoechsten punkt loop i
1400000  hipoint   branch
1400001  1   1
1400101  0.003523  3.271  0  0  90.0 3.271    2.0-5 0.0  0000000
1400200  3  1.51482+07   590.391
1401101  132010000 140000000  0.003599  0.255  0.255 0001000
1401201  1.0967      0.   0.
*
*     komponente 921
*     heisse entlüftungsleitung (loop 1)
*     flächenanpassung aus gbra 027402, 21.12.93, kohler
*     flächenanpassung fachbesprechnungsbericht k-648 vom 17.08.81
*     begutachtung des ya- und yp-systems  (g-5829)
*
9210000  vv        valve
*        f = 0.0002 m^2 (2 ventile)
*        f-gerda = 0.0002/1686 = 0.0000001186
*        Durchmesser-Gerda = 0,05 cm
*        Gerda-Magnetband: 3 cm^2
*9210101  140010000  920000000   0.0000001779  0.0  1.+9  0000100  1.0  1.0
 1.0
*9210101  140010000  920000000   0.0000001963  0.0  1.+9  0000100  1.0  1.0
 1.0
9210101  140010000  920000000   0.0000001186  0.0  1.+9  0000100  1.0  1.0
1.0
9210201  1  0.  0.  0.
9210300  mtrvlv
9210301  504  513  0.5  0  0
*
*   komponente 920   containment
*
9200000 contain  tmdpvol
9200101 1.+6  1.+6  0.  0.  0.  0.  0.  0.  11
9200200 4
*             time       press        temp
9200201       0.         1.+5         293.   1.
9200202       1.+6       1.+5         293.   1.
*
*
*    komponente 145
*    vebindung : kruemmerteile am hoechsten punkt hot leg loop i
1450000  bogen  sngljun
1450101  140010000  150000000  0.003599  0.255  0.255 0001000 1.0  1.0  1.0
1450201  1    1.0967      0.   0.
*
*
*    komponente 150
*    oberer kruemmer : hoechster punkt bis einlass de loop i
1500000  inlsgl   snglvol
1500101  0.003761  4.691  0  0 -90.0  -4.691 2.0-5 0.0  0000000
1500200  3   1.51529+07   590.395
*
*
*    komponente 155
*    verbindung : hot leg -> einlass de loop i
1550000  hlinsgl  sngljun
1550101  150010000  170000000  0.0029655  0.99  1.139 0001000 1.0  1.0  1.0
1550201  1   1.0967        0.   0.
*
* ==== eingabe primaerteil dampferzeuger ==================================
*
* ---komponenten des primaerstranges----------------
```

```
*
*
*    komponente 170
*    heizrohre loop i
1700000  del  pipe
1700001  52
1700101  0.002964           52
1700301  0.305386           52
1700601  -90.0              52
1700801   3.2-6  0.014094   52
1700901   0.06  0.06        51
1701001   0000000           52
1701101   0001000           51
1701201  3  1.51695+07      590.404    0.0    0.0    0.0    1
1701202  3  1.51715+07      590.405    0.0    0.0    0.0    2
1701203  3  1.51735+07      590.406    0.0    0.0    0.0    3
1701204  3  1.51755+07      590.407    0.0    0.0    0.0    4
1701205  3  1.51776+07      590.408    0.0    0.0    0.0    5
1701206  3  1.51796+07      590.409    0.0    0.0    0.0    6
1701207  3  1.51816+07      590.410    0.0    0.0    0.0    7
1701208  3  1.51836+07      590.411    0.0    0.0    0.0    8
1701209  3  1.51856+07      590.412    0.0    0.0    0.0    9
1701210  3  1.51876+07      590.413    0.0    0.0    0.0   10
1701211  3  1.51896+07      590.414    0.0    0.0    0.0   11
1701212  3  1.51916+07      590.414    0.0    0.0    0.0   12
1701213  3  1.51936+07      590.415    0.0    0.0    0.0   13
1701214  3  1.51956+07      590.416    0.0    0.0    0.0   14
1701215  3  1.51976+07      590.416    0.0    0.0    0.0   15
1701216  3  1.51996+07      590.417    0.0    0.0    0.0   16
1701217  3  1.52016+07      590.417    0.0    0.0    0.0   17
1701218  3  1.52036+07      590.418    0.0    0.0    0.0   18
1701219  3  1.52056+07      590.418    0.0    0.0    0.0   19
1701220  3  1.52076+07      590.417    0.0    0.0    0.0   20
1701221  3  1.52096+07      590.417    0.0    0.0    0.0   21
1701222  3  1.52116+07      590.416    0.0    0.0    0.0   22
1701223  3  1.52136+07      590.415    0.0    0.0    0.0   23
1701224  3  1.52156+07      590.413    0.0    0.0    0.0   24
1701225  3  1.52176+07      590.411    0.0    0.0    0.0   25
1701226  3  1.52196+07      590.408    0.0    0.0    0.0   26
1701227  3  1.52216+07      590.405    0.0    0.0    0.0   27
1701228  3  1.52237+07      590.401    0.0    0.0    0.0   28
1701229  3  1.52257+07      590.395    0.0    0.0    0.0   29
1701230  3  1.52277+07      590.389    0.0    0.0    0.0   30
1701231  3  1.52297+07      590.381    0.0    0.0    0.0   31
1701232  3  1.52317+07      590.371    0.0    0.0    0.0   32
1701233  3  1.52337+07      590.359    0.0    0.0    0.0   33
1701234  3  1.52357+07      590.345    0.0    0.0    0.0   34
1701235  3  1.52377+07      590.328    0.0    0.0    0.0   35
1701236  3  1.52397+07      590.308    0.0    0.0    0.0   36
1701237  3  1.52417+07      590.283    0.0    0.0    0.0   37
1701238  3  1.52437+07      590.254    0.0    0.0    0.0   38
1701239  3  1.52457+07      590.218    0.0    0.0    0.0   39
1701240  3  1.52477+07      590.175    0.0    0.0    0.0   40
1701241  3  1.52497+07      590.123    0.0    0.0    0.0   41
1701242  3  1.52517+07      590.060    0.0    0.0    0.0   42
1701243  3  1.52537+07      589.985    0.0    0.0    0.0   43
1701244  3  1.52557+07      589.890    0.0    0.0    0.0   44
1701245  3  1.52578+07      589.776    0.0    0.0    0.0   45
1701246  3  1.52598+07      588.518    0.0    0.0    0.0   46
1701247  3  1.52618+07      585.622    0.0    0.0    0.0   47
1701248  3  1.52639+07      583.055    0.0    0.0    0.0   48
1701249  3  1.52659+07      580.881    0.0    0.0    0.0   49
1701250  3  1.52680+07      578.987    0.0    0.0    0.0   50
1701251  3  1.52701+07      577.109    0.0    0.0    0.0   51
```

```
1701252  3  1.52722+07     571.733    0.0    0.0    0.0  52
1701300   1
1701301   1.0967   0  0 51
*
*
*    komponente 180
*    unteres plm del loop i
1800000  lowplm1  branch
1800001  2  1
1800101  0.003655 2.169 0. 0. -90. -2.169 3.2-6 0.0 0000000
1800200  3  1.52810+07     571.737
1801101  170010000  180000000  0.0029654  0.747   0.598   0001000
1802101  180010000  904000000  0.003493   1.183   1.183   0001000
1801201  1.0967       0. 0.
1802201  1.0967       0. 0.
*
*
* ==== eingabe sekundaerteil dampferzeuger ===========================
*
*    komponente 420
*    sec de loop i
4200000  secde1    pipe
4200001  52
4200101  0.004777         52
4200301  0.305386         52
4200601  90.0             52
4200801  3.2-6  0.015622 52
4200901  2.5   2.5        51
4201001  0000000          52
4201101  0001000          51
4201201   3  7.91540+06   494.050     0.0       0.0    0.0          1
4201202   3  7.91299+06   547.753     0.0       0.0    0.0          2
4201203   1               566.551     0.00700   0.0    0.0    0.0   3
4201204   1               567.316     0.01876   0.0    0.0    0.0   4
4201205   1               567.307     0.03337   0.0    0.0    0.0   5
4201206   1               567.301     0.03499   0.0    0.0    0.0   6
4201207   1               567.288     0.61103   0.0    0.0    0.0   7
4201208   3  7.90519+06   572.077     0.0       0.0    0.0          8
4201209   3  7.90506+06   574.876     0.0       0.0    0.0          9
4201210   3  7.90494+06   577.226     0.0       0.0    0.0         10
4201211   3  7.90482+06   579.202     0.0       0.0    0.0         11
4201212   3  7.90470+06   580.940     0.0       0.0    0.0         12
4201213   3  7.90458+06   582.454     0.0       0.0    0.0         13
4201214   3  7.90446+06   583.722     0.0       0.0    0.0         14
4201215   3  7.90434+06   584.784     0.0       0.0    0.0         15
4201216   3  7.90422+06   585.676     0.0       0.0    0.0         16
4201217   3  7.90411+06   586.424     0.0       0.0    0.0         17
4201218   3  7.90399+06   587.054     0.0       0.0    0.0         18
4201219   3  7.90387+06   587.583     0.0       0.0    0.0         19
4201220   3  7.90376+06   588.029     0.0       0.0    0.0         20
4201221   3  7.90364+06   588.404     0.0       0.0    0.0         21
4201222   3  7.90352+06   588.720     0.0       0.0    0.0         22
4201223   3  7.90341+06   588.986     0.0       0.0    0.0         23
4201224   3  7.90329+06   589.211     0.0       0.0    0.0         24
4201225   3  7.90318+06   589.400     0.0       0.0    0.0         25
4201226   3  7.90306+06   589.560     0.0       0.0    0.0         26
4201227   3  7.90295+06   589.694     0.0       0.0    0.0         27
4201228   3  7.90283+06   589.807     0.0       0.0    0.0         28
4201229   3  7.90272+06   589.903     0.0       0.0    0.0         29
4201230   3  7.90260+06   589.983     0.0       0.0    0.0         30
4201231   3  7.90249+06   590.054     0.0       0.0    0.0         31
4201232   3  7.90237+06   590.113     0.0       0.0    0.0         32
4201233   3  7.90226+06   590.163     0.0       0.0    0.0         33
4201234   3  7.90214+06   590.204     0.0       0.0    0.0         34
```

```
4201235   3  7.90203+06   590.239    0.0      0.0   0.0         35
4201236   3  7.90191+06   590.267    0.0      0.0   0.0         36
4201237   3  7.90180+06   590.291    0.0      0.0   0.0         37
4201238   3  7.90168+06   590.311    0.0      0.0   0.0         38
4201239   3  7.90157+06   590.327    0.0      0.0   0.0         39
4201240   3  7.90145+06   590.340    0.0      0.0   0.0         40
4201241   3  7.90134+06   590.352    0.0      0.0   0.0         41
4201242   3  7.90122+06   590.361    0.0      0.0   0.0         42
4201243   3  7.90111+06   590.368    0.0      0.0   0.0         43
4201244   3  7.90099+06   590.374    0.0      0.0   0.0         44
4201245   3  7.90088+06   590.379    0.0      0.0   0.0         45
4201246   3  7.90076+06   590.383    0.0      0.0   0.0         46
4201247   3  7.90065+06   590.386    0.0      0.0   0.0         47
4201248   3  7.90053+06   590.388    0.0      0.0   0.0         48
4201249   3  7.90042+06   590.390    0.0      0.0   0.0         49
4201250   3  7.90030+06   590.391    0.0      0.0   0.0         50
4201251   3  7.90019+06   590.392    0.0      0.0   0.0         51
4201252   3  7.90007+06   590.393    0.0      0.0   0.0         52
4201300  1
4201301  0.0      0.0      0   51
4201401  0.020914 0 1.0  1.0 51
*
*
*
*    komponete 425
*
*        f = 2 x 2.1244 = 4.2488 mý (2 de)
*        f-gerda = 4.2488/1686 = 0.002520
4250000  dwncrl   sngljun
4250101  420010000 440000000 0.00252 0.0  0.0  0001000 1.0  1.0  1.0
4250201  1 0.0  0.0       0
*
*
*
*    komponente 440
4400000  bmsoivl   branch
4400001  0
4400101  0.00252  5.0   0.0 0.0 0.0 0.0 6.-5 0.0  0000000
4400200  3 7.90001+06    590.393
*
*
*    komponente 445
4450000  msoivl       valve
4450101  440010000  470000000  0.00252  1.15  1.15  0001100  1.0  1.0  1.0
4450201  1  0.  0.04464      0.
4450300  mtrvlv
4450301  513 502 0.0666   1.0  0
*
*    komponente 470
4700000  turbine  tmdpvol
4700101  500.0  500.   0.  0.  0.  0.  0.  0.  0000011
4700200  4
4700201  0.0    7.90000+06    520.920   1.
4700202  1.+6   7.90000+06    520.920   1.
*
*
*     komponente 480
*     temperaturabsenkung 28 k/h
4800000  con48del  tmdpvol
4800101  500.0  500. 0.   0.  0.  0.  0.  0.  0000011
4800200  1
*        time       temp     x
4800201  0.0        533.81   1.0
4800202  1800.0     533.81   1.0
```

```
4800203  22456.0   373.15   1.0
4800204  100000.0  373.15   1.0
*
*     komponente 481
* druckreduzierstation loop i
4810000  con48del        valve
*        fläche:  0.007 m^2 (2 ventile)
*        f-gerda = 0.007/1686 = 0.00000415 m^2
4810101  440010000  480000000   0.00000415 0.  1.+9  0001100  1.0  1.0  1.0
4810201  1  0.  0.  0.
4810300  mtrvlv
4810301  690  691  0.3333  0.  0
*
*
*     komponente 485
* fd-sicherheitsventile (2 ventile) loop i
4850000  fd-si-vl        valve
*                  flaeche angepasst an durchsatz
*        fläche:  4 x 0.03916 m^2 (4 ventile)
*        f-gerda = 4 x 0.03916/1686 = 0.0000929 m^2
4850101  440010000  500000000  0.0000929  0.  0.  0001100  1.0  1.0  1.0
4850201  1  0.  0.  0.
4850300  mtrvlv
4850301  694  695  5.0  0.0  0
*
*    komponente 500
*    atmosphaere
5000000  atmos     tmdpvol
5000101  1.+6  1.+6   0.  0.  0.  0.  0.  0.  0000011
5000200  4
*        time     press    temp
5000201  0.0      1.+5     293.00 1.
5000202  1.+5     1.+5     293.00 1.
*
*     komponente 505
* 48 bar condenser valves (2) loop i
5050000  con48del        valve
*                  flaeche angepasst an durchsatz
*        fläche: 0.007 m^2 (2 ventile)
*        f-gerda = 0.007/1686 = 0.00000415 m^2
*        Vergleich mit gemessener Gerda-Kurve - Vergr"äerung der Fläche um
10%
5050101  440010000  520000000   0.00000457  0.  0.  0000100  1.0  1.0  1.0
5050201  1  0.  0.  0.
5050300  mtrvlv
5050301  682  683  0.3333  0.  0
*
*    komponente 520
*    atmosphaere
5200000  atmos     tmdpvol
5200101  1.+6  1.+6   0.  0.  0.  0.  0.  0.  0000011
5200200  4
*        time     press    temp
5200201  0.0      1.+5     293.00 1.
5200202  1.+5     1.+5     293.00 1.
*
*     komponente 525
* 79 bar condenser valves (2) loop i
5250000  con79del        valve
*                  flaeche angepasst an durchsatz
*        fläche: 0.0042 m^2  (2 ventile)
*        f-gerda = 0.0042/1686 = 0.00000249 m^2
5250101  440010000  540000000    0.00000349  0.  0.  0000100  1.0  1.0  1.0
*5250101  440010000  540000000    0.00000249  0.  0.  0000100  1.0  1.0  1.0
```

```
5250201  1  0.   0.   0.
5250300  mtrvlv
5250301  680  681  0.3333  0.  0
*
*    komponente 540
*    atmosphaere
5400000  atmos     tmdpvol
5400101  1.+6 1.+6   0.    0.   0.   0.   0.   0.   0000011
5400200  4
*        time     press     temp
5400201  0.0      1.+5      293.00 1.
5400202  1.+5     1.+5      293.00 1.
*
*
*
* ---- hauptspeisewasserversorgung --------------------
*
*
*    komponente 400
*    einlauf
4000000  einlaufl   tmdpvol
4000101  100.0  0. 400.   0  0  0  0  0  0000011
4000200  3
*        time     press      temp
4000201  0.0     7.928+6        321.93
4000202  1.+6    7.928+6        321.93
*
*
*    komponente 405
*    verbindung
*        fläche: 0.146 m^2 (2 de)
*        f-gerda = 0.146/1686 = 0.0000866 m^2
4050000  hspwl    tmdpjun
4050101  400000000  414000000  0.0000866
4050200   1
4050201   0.0    0.0         0  0
4050202   5.0    0.0230      0  0
4050203   10.0   0.0375      0  0
4050204   20.0   0.0425      0  0
4050205   30.0   0.0441      0  0
4050206  145.0   0.0441      0  0
4050207  160.0   0.0         0  0
4050208   1.+6   0.0         0  0
*
*
*    komponente 414
*    speisewasserringraum rl-einspeisung loop i
4140000  downl   snglvol
4140101  0.0000866  1.0  0.  0.  0.  0.0  3.2-6  0.0  0000000
4140200  3  7.91713+6       321.93
*
*
*    komponente 410
*    downcomer rj/rx-einpeisung loop i
4100000  rjrxdcrl    branch
4100001  2  1
4100101  0.0000866  1.0  0.  0.   0.  0.0  3.2-6  0.0  0000000
4100200  3   7.91673+6       321.93
4101101  410010000  420000000  0.0000866   0.0  1.+9  0001000
4102101  414010000  410000000  0.0000866   0.0  1.+9  0001000
4101201  0.0              0.  0.
4102201  0.0              0.  0.
*
*
```

```
*
*
* ---------- notspeisewasserversorgung -----------------------------------
*
*
*    komponente 620
*    rj-vorlagebehaelter (1 behaelter) loop i
6200000  rj-tank2   tmdpvol
6200101  100.0  0. 400.   0.   0.   0.   0.   0.   0000011
6200200  3
*        time     press    temp
6200201  0.0      1.00+5   321.93
6200202  1.+5     1.00+5   321.93
*
*
*
*    komponente .624
*    rj - einspeiseventil loop i
6240000  rjvent2    valve
*                   flaeche angepasst an durchsatz
*        fläche: 2 x 0.00785 m^2 (2 ventile)
*        f-gerda = 2 x 0.007850/1686 = 0.00000931 m^2
6240101  620000000   628000000   0.00000931  0.0  0.0  0001100  1.0  1.0  1.0
6240201  1   0.0   0.0   0.0
6240300  mtrvlv
6240301  673   678  0.1818   0.0  * 0.03333
*6240301  677   679   0.1818   0.0  * 0.03333
*
*
*    komponente 628
*    rj - einspeiseleitung loop i
6280000  rj-ltg2   snglvol
*                  flaeche angepasst an durchsatz
6280101  0.00000931  2.0  0.   0.   0.   0.   0.   0.1  00
6280200  3  1.0+5  321.93
*
*
*    komponente 632
*    notspeisewassereinspeisung (1 rj-pumpe) loop i
6320000  notspw2      tmdpjun
*                  flaeche angepasst an durchsatz
6320101  628010000  410000000  0.00000931
6320200  1  538  cntrlvar  225
6320201     0.        0.       0.      0.
6320202   300.      300.       0.      0.
*
*
* ===== eingabe kalte straenge bis hkmp ================================
*
*
*    komponente 904
9040000  coldleg   branch
9040001  0  1
9040101  0.006184 0.467 0. 0. 90.0 0.467 2.0-5 0.0 0000000
9040200  3 1.52870+07   571.74
*
*
*     komponente 907
*     verbindung komp 904 und 200
9070000  coldleg   tmdpjun
9070101  904010000 200000000 0.002752
9070200  1
9070201  0.0       1.0967      0.  0
9070202  145.0     1.0967      0.  0
```

```
9070203  150.0     0.0         0.  0
9070204  100000.   0.0         0.  0
*
*9070000  coldleg   sngljun
*9070101  904010000 200000000 0.003599 0.02033 0.03367 0001000 1.0 1.0 1.0
*9070201  1   1.0918     0.  0
*
*
*    komponente 908
9080000  coldleg     valve
9080101  904010000  200000000  0.002752    0.0  0.0 0001100  1.0  1.0  1.0
9080201  1  0.  0. 0.
9080300  mtrvlv
9080301  501  513  66.67  0.  0
*
*    komponente 200
*    cold leg bis hkmp loop i
2000000  coldleg   branch
2000001  0  1
2000101  0.002752  2.408  0  0  90.0 2.408  2.0-5 0.0  0000000
2000200  3   1.52801+07   571.738
*
*
*    komponente 909
*    verbindung komp 200 und 290
9090000  coldleg   sngljun
9090101  200010000 220000000 0.002752    0.0     0.0     0001000 1.0  1.0
1.0
*9090101  200010000 220000000 0.002752  200.0     0.0     0001000 1.0  1.0
1.0
9090201  1    1.0967     0.  0
*
* ===== druckseitige kalte straeÄnge ====================================
*
*
*    komponente 220
*    auslass hkp bis einlass downcomer loop i
2200000  cld   branch
2200001  0   1
2200101  0.00349314  1.383 0 0  -64.27  -1.246  2.0-5  0.0  0000000
2200200  3    1.52759+07   571.737
*
*
*    komponente 230
*    druckleitung pumpe ->oberer und unterer downcomer
2300000  branch1   branch
2300001  3   1
2300101  0.00349314  0.2  0  0  90.0  0.20  2.0-5  0.0  0000000
2300200  3    1.52811+07   571.739
2301101  220010000  230010000  0.00349314 0.0   0.0    0001000
2302101  230010000  260000000  0.          0.0   0.0    0001000
2303101  230000000  240000000  0.0034932  5.23  5.23   0001000
2301201  1.0967     0  0
2302201  0.0    0  0
2303201  1.0967     0  0
*
*
*    komponente 260
*    oberer downcomer
2600000  updown    annulus
2600001  1
2600101  0.002671        1
2600301  1.235           1
2600601  90.0            1
```

```
2600801  1.60-6  0.0  1
2601001  00000000       1
2601201  3   1.49624+07   571.98     0.0  0.0  0.0  1
*
*
*    komponente 240
*    unterer downcomer
2400000  lowdown   annulus
2400001  10
2400101  0.00234392      10
2400301  0.6862          10
2400601  -90.0           10
2400801  1.6-6  0.0      10
2400901  0.0   0.0        9
2401001  0000000         10
2401101  0001000          9
2401201  3   1.52838+07   571.740    0.0  0.0  0.0   1
2401202  3   1.52887+07   571.742    0.0  0.0  0.0   2
2401203  3   1.52936+07   571.744    0.0  0.0  0.0   3
2401204  3   1.52964+07   571.747    0.0  0.0  0.0   4
2401205  3   1.53033+07   571.749    0.0  0.0  0.0   5
2401206  3   1.53082+07   571.751    0.0  0.0  0.0   6
2401207  3   1.53131+07   571.753    0.0  0.0  0.0   7
2401208  3   1.53180+07   571.755    0.0  0.0  0.0   8
2401209  3   1.53228+07   571.757    0.0  0.0  0.0   9
2401210  3   1.53277+07   571.759    0.0  0.0  0.0  10
2401300  1
2401301  1.0967  0.0  0  9
*
*
*    komponente 245
*    vebindung : zw downcommer und lower plenum
2450000  dwuntplm  sngljun
2450101  240010000 102000000 0.0014465 0. 0. 0001000 1.0  1.0  1.0
2450201  1    1.0967        0.   0.
*
*
*         kernnotkuehlung
*
*
*
*     komponente 910
*     1 borwasserbecken
9100000  bwb   tmdpvol
9100101  100.  0.  400.   0. 0. 0. 0. 0. 0000011
9100200   3
*              time     press    temp
9100201        0.       1.+5     296.5
9100202        1.+6     1.+5     296.5
*
* komponente 911
* hp injection am ringraum
*  fläche: 0.0707 m^2 / 1686 = 0.0000419
9110000 hpi   tmdpjun
9110101 910000000 230000000 0.0000419
9110200 1 585  p  230010000
*              press        flow(1 hpi)          (2 hpi)
9110201        -1.0         0.0         0. 0.   * 150.26    0. 0.
9110202          0.         0.044561    0. 0.   * 150.26    0. 0.
9110203          4.90+5     0.043906    0. 0.   * 148.05    0. 0.
9110204         19.61+5     0.040629    0. 0.   * 137.      0. 0.
9110205         39.23+5     0.036041    0. 0.   * 121.53    0. 0.
9110206         58.84+5     0.029816    0. 0.   * 100.54    0. 0.
9110207         78.46+5     0.020644    0. 0.   *  69.61    0. 0.
```

```
9110208          98.07+5    0.014090    0. 0.    *  47.51    0. 0.
9110209         117.68+5    0.006880    0. 0.    *  23.2     0. 0.
9110210         128.47+5        0.0     0. 0.    *   0.      0. 0.
*
*
*     komponente 914
*     1 borwasserbecken
9140000  bwb    tmdpvol
9140101  100.   0.   400.   0. 0. 0. 0. 0. 0000011
9140200   3
*               time     press     temp
9140201         0.       1.+5      296.5
9140202         1.+6     1.+5      296.5
*
* komponente 915
* hp injection ins kalte bein
9150000 hpi   tmdpjun
9150101 914000000 230000000 0.0000419
9150200 1 585  p  230010000
*
*               press        flow(1 hpi)          (2 hpi)
9150201         -1.0         0.0          0. 0.    * 150.26    0. 0.
9150202          0.          0.044561     0. 0.    * 150.26    0. 0.
9150203           4.90+5     0.043906     0. 0.    * 148.05    0. 0.
9150204          19.61+5     0.040629     0. 0.    * 137.      0. 0.
9150205          39.23+5     0.036041     0. 0.    * 121.53    0. 0.
9150206          58.84+5     0.029816     0. 0.    * 100.54    0. 0.
9150207          78.46+5     0.020644     0. 0.    *  69.61    0. 0.
9150208          98.07+5     0.014090     0. 0.    *  47.51    0. 0.
9150209         117.68+5     0.006880     0. 0.    *  23.2     0. 0.
9150210         128.47+5         0.0      0. 0.    *   0.      0. 0.
*
*
*
*
* ===== eingabe des druckhalters ======================================
*
*
*    komponente 310   surge-leitung
*
3100000  surge snglvol
*3100101  0.003741 1.0 0 0  0.0  0.0 1.6-6 0.0 0000000
3100101  0.003741 1.0 0 0 90.0  1.0 1.6-6 0.0 0000000
3100200  2  152.646e+5  0.0
*
*    komponente 315   verbindung surge-dh
*
3150000  su-dh sngljun
3150101  327000000 310010000 0.003741 0.0  0.0  0001000  1.0  1.0  1.0
3150201  1 0.0 0.0 0.0
*
*    komponente 327   druckhalter unten
*
3270000  dh1  snglvol
3270101  0.003741  1.0  0.0  0.0  90.0  1.0  1.6e-6  0.0  0000000
3270200  2  152.616e+5  0.0
*
*    komponente 313   verbindung 327 - 320
*
3130000  dh2  sngljun
3130101  327010000 320000000 0.003740 0.0 0.0 0001000 1. 1.
3130201  1 0.0 0.0 0.0
*
*    komponente 320   druckhalter hauptteil
```

```
*
3200000  dh3  pipe
3200001  10                   * anzahl der volumen
3200101  0.003741   10        * stroemungsquerschnitt
3200301  0.9154     10        * laenge des volumens
3200601  90.0       10        * winkel
3200801  1.6-6  0.0 10        * wandrauhigkeit und hydraulischer durchnesser
3201001  0000000    10
3201101  0001000     9
*           druck      dampfgehalt
3201201  2  152.559e+5      0.0      0.0     0.0   0.0  1
3201202  2  152.526e+5      0.0      0.0     0.0   0.0  2
3201203  2  152.514e+5      0.14     0.0     0.0   0.0  3
3201204  2  152.505e+5      1.0      0.0     0.0   0.0  4
3201205  2  152.497e+5      1.0      0.0     0.0   0.0  5
3201206  2  152.488e+5      1.0      0.0     0.0   0.0  6
3201207  2  152.479e+5      1.0      0.0     0.0   0.0  7
3201208  2  152.470e+5      1.0      0.0     0.0   0.0  8
3201209  2  152.462e+5      1.0      0.0     0.0   0.0  9
3201210  2  152.453e+5      1.0      0.0     0.0   0.0 10
3201300  1
3201301  0.  0.  0   9
*
*    komponente 325 dampfraum 1.456 m
*
3250000  dh4  branch
3250001  2  1
3250101  0.003741  1.0  0.0  0.0  90.0  1.0  1.6-6  0.0    0000000
3250200  2  152.444e+5  1.0
3251101  320010000  325000000  0.003741  0.0  0.0  0001000
3252101  325010000  330000000  0.003741  0.0  0.0  0001000
3251201  0.0  0.0  0.0
3252201  0.0  0.0  0.0
*
*    komponente 330   oberster dampfraum dh 0.388 m
*
3300000  dh5   branch
3300001  0   1
3300101  0.003741  0.2  0.0  0.0  90.0  0.2  1.6e-6  0.0  0000000
3300200  2  152.438e+05  1.0
*
*
*    komponente 365   2 sicherheitsventile
*      fläche: 2 x 0.002694 m^2 / 1686 = 0.0000032
3650000  dh-si-v   valve
3650101  330010000 341000000 0.0000032  1. 1.  0001100  1.0  1.0  1.0
3650201  1 0.0 0.0 0
3650300  mtrvlv
3650301  513 538  5.0  0 0
*
*    komponente 341   containment
*
3410000  contain  tmdpvol
3410101  100.0  0. 400.  0. 0. 0. 0. 0. 0000011
3410200  4
*        time        press        temp
3410201  0.          1.+5         293.   1.
3410202  1.+6        1.+5         293.   1.
*
*
* ======= ende druckhalter eingabe der komponenten ======================
*
* ======================================================================
*                         ende der komponenteneingabe
```

```
* ===================================================================
*
*
* ===================================================================
*                          eingabe der heatslabs
* ===================================================================
*
* ------------------- rdb -------------------------------------------
*
*      komponente 1001
* +++ R4 N1S1 NODE 1 METAL SLAB-2 IN. SCH160 PIPE --- 150011
*
11001000  1  8  2  1  0.029261
11001100  0  1
11001101  2  0.040416    5  0.1166165
11001201  006 2       003  7
11001301  0  7
11001400  0
11001401  571.758   8
11001501  100010000  0  1  0  0.32637   1
11001601      0      0  0  0  1.30071   1  * 1.3006
11001701  0  0  0  0  1
11001801  0.0 100.0  100.0  0.0  0.0  0.0  0.0 1.0  1
*      komponente 1002
*  +++ R4 N1S2 LP 1 INCH XXS PIPE  ---  150021
*
11002000  1  8  2  1  0.048158
11002100  0  1
11002101  2  0.0656234    5  0.1418234
11002201  006  2       003  7
11002301  0  7
11002400  0
11002401  571.754   8
11002501  100020000  0  1  0  0.184227   1
11002601      0      0  0  0  0.5425412  1 *.54295
11002701  0  0  0  0  1
11002801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1003
*   +++ R4 N1S3 LP 1.25 INCH SCH160 PIPE  --- 150031
*
11003000  1  8  2  1  0.043672
11003100  0  1
11003101  2  0.0496824    5  0.125882
11003201  006  2       003  7
11003301  0  7
11003400  0
11003401  571.758   8
11003501  100010000  0  1  0  0.30342   1
11003601      0      0  0  0  0.87459   1 * 0.90306
11003701  0  0  0  0  1
11003801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1101
*  +++  R4 N2S1 NODE 2 CV Metal Slab-6 In. SCH160 PIPE --- 150041
*
11101000  1  8  2  1  0.06523
11101100  0  1
11101101  2  0.083363    5  0.184861
11101201  006  2       003  7
11101301  0  7
11101400  0
11101401  571.758   8
11101501  110010000  0  1  0  0.90441   1
```

```
11101601      0       0  0  0  2.563087  1  *  2.5628
11101701  0  0  0  0  1
11101801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1102
*  +++  R4 N2S2 CV Bottom Head  ---  150051
*
11102000  1  8  2  1  0.0762
11102100  0  1
11102101  2  0.25786    5  0.35936
11102201  006  2       003  7
11102301  0  7
11102400  0
11102401  590.456   8
11102501  120010000  0  1  0  0.07144   1
11102601      0       0  0  0  0.3369118 1  *  0.33696
11102701  0  0  0  0  1
11102801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 2701
*  +++  R4 N2S3 Node 2 UP and TP Metal Slab  ---  150061
*
12701000  1  8  2  1  0.0445
12701100  0  1
12701101  2  0.058339    5  0.159837
12701201  006  2       003  7
12701301  0  7
12701400  0
12701401  590.818   8
12701501  270010000  0  1  0  1.39187   1
12701601      0       0  0  0  4.999378  1  *5.0007
12701701  0  0  0  0  1
12701801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1103
*  +++  R4  N2S4 Heater Rod Supports  ---  150071
*
11103000  1  5  2  1  0.0
11103100  0  1
11103101  4  0.0074676
11103201  006  4
11103301  0  4
11103400  0
11103401  590.818   5
11103501      0       0  0  0  0.0      1
11103601  280010000  0  1  0  0.35963  1
11103701  0  0  0  0  1
11103901  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1104
*  +++  R4 N2S5 Heater Rods  --- 150081
*
11104000  1  8  2  1  0.0
11104100  0  1
11104101  2  0.0113081   5  0.01588
11104201  002  2  006  7
11104301  0  7
11104400  0
11104401  590.818   8
11104501      0       0  0  0  0.0      1
11104601  280010000  0  1  0  0.58529  1
11104701  0  0  0  0  1
11104901  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
```

```
*       komponente 1301
*  +++  R4 NODE 3 Hot Leg Pipe ---  150091
*
11301000  1  8  2  1  0.034424
11301100  0  1
11301101  2  0.045781    5  0.05849
11301201  006  2        004  7
11301301  0  7
11301400  0
11301401  590.451   8
11301501  130010000  0  1  1  2.48       1
11301601      0      0  0  1  2.48       1
*11301601      0      0  0  0  6.62855  1  *0.0
11301701  0  0  0  0  1
11301801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*       komponente 1321
*  +++  R4 NODE 3 Hot Leg Pipe ---  150091
*
11321000  16  8  2  1  0.034424
11321100  0  1
11321101  2  0.045781    5  0.05849
11321201  006  2        004  7
11321301  0.  7
11321400  0
11321401  590.42   1
11321402  590.42   2
11321403  590.42   3
11321404  590.42   4
11321405  590.42   5
11321406  590.42   6
11321407  590.42   7
11321408  590.42   8
11321501  132010000  0  1  1  0.9746885  16
11321601      0      0  0  1  0.9746885  16
*11321601      0      0  0  0  6.62855  16  *0.0      1
11321701  0  0  0  0  16
11321801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 16
*
*       komponente 1401
*  +++  R4 NODE 4 Hot Leg Pipe  ---  150101
*
11401000  1  8  2  1  0.035357
11401100  0  1
11401101  2  0.046695  5  0.05941
11401201  006  2        004  7
11401301  0  7
11401400  0
11401401  590.391   8
11401501  140010000  0  1  0  0.69128   1
11401601      0      0  0  0  1.16155   1  *0.0      1
11401701  0  0  0  0  1
11401801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*       komponente 1501
*  +++  R4 N5S1 Hot Leg Pipe ---  150111
*
11501000  1  8  2  1  0.034747
11501100  0  1
11501101  2  0.04624    5  0.058948
11501201  006  2        004  7
11501301  0  7
11501400  0
11501401  590.395   8
```

```
11501501  150010000  0  1  0  0.96935   1
11501601      0      0  0  0  1.644494  1  *0.0       1
11501701  0  0  0  0  1
11501801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1502
*  +++  R4  N5S2 SG Inlet Plenum  ---  150121
*
11502000  1  8  2  1  0.04755
11502100  0  1
11502101  2  0.06135624    5  0.162855
11502201  006  2       003  7
11502301  0  7
11502400  0
11502401  590.395   8
11502501  150010000  0  1  0  0.049164   1
11502601      0      0  0  0  0.1683828  1  *0.0       1
11502701  0  0  0  0  1
11502801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1503
*  +++  R4  N5S3 SG Upper Tubesheets  ---  150131
*
11503000  1  8  2  1  0.00704
11503100  0  1
11503101  7  0.033756
11503201  006  7
11503301  0  7
11503400  0
11503401  590.395   8
11503501  150010000  0  1  0  0.009058   1
11503601      0      0  0  0  0.04343208 1  *0.0       1
11503701  0  0  0  0  1
11503801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
**
*      komponente 1801
*  +++  R4  N10S1 Lower Tubesheets  ---  150301
*
11801000  1  8  2  1  0.00704
11801100  0  1
11801101  7  0.033756
11801201  006  7
11801301  0  7
11801400  0
11801401  571.737    8
11801501  180010000  0  1  0  0.03268   1
11801601      0      0  0  0  0.156697  1  * 0.0
11801701  0  0  0  0  1
11801801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 1802
*  +++  R4  N10S2  SG  Outlet Plenum  ---  150311
*
11802000  1  8  2  1  0.04755
11802100  0  1
11802101  2  0.061356    5  0.162855
11802201  006  2       003  7
11802301  0  7
11802400  0
11802401  571.737    8
11802501  180010000  0  1  0  0.049164   1
11802601      0      0  0  0  0.1683828  1  *0.00       1
11802701  0  0  0  0  1
11802801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
```

```
*
*      komponente 1803
*  +++  R4  N10S3 Cold Leg Suction Pipe  ---  150331
*
11803000  1  8  2  1  0.03749
11803100  0  1
11803101  2  0.049682    5  0.12588
11803201  006  2       003  7
11803301  0  7
11803400  0
11803401  571.737    8
11803501  180010000  0  1  0  0.31959   1
11803601      0      0  0  0  1.073086  1  *0.16834
11803701  0  0  0  0  1
11803801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 9041
*  +++  R4  NODE 11 Cold Leg Suction Pipe --- 150211
*
19041000  1  8  2  1  0.058217
19041100  0  1
19041101  2  0.071933    5  0.14813
19041201  006  2       003  7
19041301  0  7
19041400  0
19041401  571.74    8
19041501  904010000  0  1  0  0.159329   1
19041601      0      0  0  0  0.405404   1  *0.0        1
19041701  0  0  0  0  1
19041801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
**
*      komponente 2001
*  +++  R4 NODE 12 RCP  ---  150221
*
12001000  1  8  2  1  0.03353
12001100  0  1
12001101  2  0.0567842    5  0.1329842
12001201  006  2       003  7
12001301  0  7
12001400  0
12001401  571.738    8
12001501  200010000  0  1  0  0.50567   1
12001601      0      0  0  0  2.00555   1  *2.01061
12001701  0  0  0  0  1
12001801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 2201
*  +++  R4 NODE 13 Cold Leg Discharge Pipe  ---  150231
*
12201000  1  8  2  1  0.036881
12201100  0  1
12201101  2  0.048768    5  0.124968
12201201  006  2       003  7
12201301  0  7
12201400  0
12201401  571.737    8
12201501  220010000  0  1  0  0.335566   1
12201601      0      0  0  0  1.13703565 1  *1.137133
12201701  0  0  0  0  1
12201801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
**
*      komponente 2301
*  +++  R4 NODE 13 Cold Leg Discharge Pipe  ---  150231
*
```

```
12301000  1  8  2  1  0.036881
12301100  0  1
12301101  2  0.048768    5  0.124968
12301201  006  2       003  7
12301301  0  7
12301400  0
12301401  571.739    8
12301501  230010000  0  1  0  0.335566   1
12301601      0      0  0  0  1.13703565 1  *1.137133
12301701  0  0  0  0  1
12301801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
***
*      komponente 2401
*  +++  R4 NODE 17 LDC Metal  ---  150271
*
*12401000  1  8  2  1  0.028407
*12401100  0  1
*12401101  2  0.0416966   5  0.1178966
*12401201  006  2       003  7
*12401301  0  7
*12401400  0
*12401401  533.55   8
*12401501  240010000  0  1  0  1.84235   1
*12401601      0      0  0  0  7.6462421 1  *4.91608
*12401701  0  0  0  0  1
*12401801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 2601
*  +++  R4 NODE 16 UDC Metal  ---  150261
*
12601000  1  8  2  1  0.028438
12601100  0  1
12601101  2  0.0385572    5  0.1147572
12601201  006  2       003  7
12601301  0  7
12601400  0
12601401  571.98    8
12601501  260010000  0  1  0  0.220738   1
12601601      0      0  0  0  0.890754   1  *0.0
12601701  0  0  0  0  1
12601801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
*
*      komponente 4201
*  +++  R4 NODE 14 SG Shell Metal ---  150251
*
14201000  1  8  2  1  0.055169
14201100  0  1
14201101  2  0.072756    5  0.174254
14201201  005  2       003  7
14201301  0  7
14201400  0
14201401  590.393    8
14201501  420010000  0  1  0  1.4751795   1
14201601      0      0  0  0  4.6594270   1  *4.66299
14201701  0  0  0  0  1
14201801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1

*      komponente 3201
*  +++  R4 N18S1 PZR Metal  ---  150281
*
13201000  1  8  2  1  0.033528
13201100  0  1
13201101  2  0.044775    5  0.057485
13201201  006  2       004  7
```

```
13201301  0  7
13201400  0
13201401  616.6   8
13201501  320010000  0  1  0  2.59413   1
13201601      0      0  0  0  4.447732  1  *0.0       1
13201701  0  0  0  0  1
13201801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
**
*      komponente 13202
*  +++  R4 N18S2 PZR Surgeline Metal  ---  150291
*
13202000  1  8  2  1  0.074676
13202100  0  1
13202101  2  0.079919    5  0.092629
13202201  006  2       004  7
13202301  0  7
13202400  0
13202401  616.6   8
13202501  320010000  0  1  0  0.28586   1
13202601      0      0  0  0  0.3545841 1  *0.0       1
13202701  0  0  0  0  1
13202801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0 1
**
*
*
*
*
*    komponente 1701
*    waermeplatten an den heizrohren loop i
11701000  52  2  2  1  0.007047
11701100  0  1
11701101  1  0.007559
11701201  001  1
11701301  0.0  1
11701400 -1
11701401   590.40      590.40
11701402   590.40      590.40
11701403   590.41      590.41
11701404   590.41      590.41
11701405   590.41      590.41
11701406   590.41      590.41
11701407   590.41      590.41
11701408   590.41      590.41
11701409   590.41      590.41
11701410   590.41      590.41
11701411   590.41      590.41
11701412   590.41      590.41
11701413   590.41      590.41
11701414   590.41      590.41
11701415   590.41      590.41
11701416   590.41      590.41
11701417   590.41      590.41
11701418   590.41      590.41
11701419   590.41      590.41
11701420   590.41      590.41
11701421   590.41      590.41
11701422   590.41      590.41
11701423   590.40      590.40
11701424   590.40      590.40
11701425   590.40      590.39
11701426   590.39      590.39
11701427   590.38      590.38
11701428   590.38      590.37
11701429   590.37      590.36
```

```
11701430   590.35       590.35
11701431   590.34       590.33
11701432   590.32       590.31
11701433   590.30       590.29
11701434   590.27       590.26
11701435   590.24       590.23
11701436   590.21       590.19
11701437   590.16       590.15
11701438   590.11       590.09
11701439   590.05       590.02
11701440   589.97       589.94
11701441   589.88       589.84
11701442   589.77       589.72
11701443   589.63       589.58
11701444   589.47       589.41
11701445   589.26       589.19
11701446   582.96       582.14
11701447   572.73       570.84
11701448   571.56       569.89
11701449   571.10       569.69
11701450   570.68       569.48
11701451   569.04       567.88
11701452   548.45       545.08
11701501  170010000  10000  101  1  5.802334   52
11701602  420520000 -10000  111  0  0.275580   52
11701701  0         0       0  0          52
11701801  0.0  100.0  100.0  0.0  0.0  0.0  0.0  1.0  52
11701900  1
11701901  0.015622  100.0  100.0  0.0  0.0  0.0  0.0  1.0
+         0.305386  1.10   1.0   52
*
*
12401000   10   8   2   1   0.028407
12401100    0   1
12401101    2   0.0416966    5    0.1178966
12401201    006  2    003    7
12401301    0    7
12401400    0
12401401    573.55   8
12401501    240010000    0    1    0  0.184235    10
12401601       0         0    0    0  0.76462421  10
12401701    0      0     0     0   10
12401801    0.0   100.  100.  0.  0.  0.  0.  1.0  10
* ===== eingabe der heatslabs fuer den kern ============================
*
* --- eingabe der heizstaebe -------------------------
*
*     komponente  1 321  heizstabgruppe 1
13210000  1  4  2  1  0.0
13210100  0  1
13210101  3  0.01
13210201  006  3
13210301  1.0  3
13210400  -1
13210401  692.37  684.52  660.74  620.28
13210501      0      0  0  0  0.0      1
13210601  110010000  0  1  0  0.1      1
13210701  31   1.0   0    0            1
13210900  1
13210901  0.03277 100.0  100.0  0.0  0.0  0.0  0.0  1.0
+         0.03277    1.1   1.0   1
*
*     komponente  1 322  heizstabgruppe 2
13220000  1  4  2  1  0.0
```

```
13220100  0  1
13220101  3  0.01
13220201  006  3
13220301  1.0  3
13220400  -1
13220401  692.51  684.66  660.88  620.42
13220501     0       0  0  0   0.0     1
13220601  110020000  0  1  0   0.1     1
13220701  32   1.0   0     0           1
13220900  1
13220901  0.03277 100.0  100.0  0.0  0.0  0.0  0.0  1.0
+         0.03277    1.1   1.0   1
*
*     komponente  1 323  heizstabgruppe 3
13230000  1  4  2  1  0.0
13230100  0  1
13230101  3  0.01
13230201  006  3
13230301  1.0  3
13230400  -1
13230401  692.63  684.78  661.00  620.54
13230501     0       0  0  0   0.0     1
13230601  110030000  0  1  0   0.1     1
13230701  33   1.0   0     0           1
13230900  1
13230901  0.03277 100.0  100.0  0.0  0.0  0.0  0.0  1.0
+         0.03277    1.1   1.0   1
*
*     komponente  1 324  heizstabgruppe 4
13240000  1  4  2  1  0.0
13240100  0  1
13240101  3  0.01
13240201  006  3
13240301  1.0  3
13240400  -1
13240401  692.75  684.90  661.12  620.67
13240501     0       0  0  0   0.0     1
13240601  110040000  0  1  0   0.1     1
13240701  34   1.0   0     0           1
13240900  1
13240901  0.03277 100.0  100.0  0.0  0.0  0.0  0.0  1.0
+         0.03277    1.1   1.0   1
*
*
*
* ---- eingabe der thermischen eigenschaften der waermestrukturen ----
*
*      tabelle 001: thermische daten f□r sg-tubes
*                   waermeleitf„higkeit sg-tubes [w/m-k]
20100100  tbl/fctn  1  1
20100101  273.15  15.0277     338.70  15.3595     366.48  15.7316
*20100101  310.93  15.0277     338.70  15.3595     366.48  15.7316
20100102  394.26  16.1336     422.04  16.5567     449.81  16.9930
20100103  477.59  17.4362     505.37  17.8814     533.15  18.3248
20100104  560.93  18.7640     588.70  19.1980     616.48  19.6270
20100105  644.26  20.0526     672.04  20.4777     699.81  20.9066
20100106  727.59  21.3448
*
*      spezifische waermekapazitaet sg-tubes [j/m**3-k]
20100151  273.15  3.7874+6    338.70  3.8546+6    366.48  3.9137+6
*20100151  310.93  3.7874+6    338.70  3.8546+6    366.48  3.9137+6
20100152  394.26  3.9663+6    422.04  4.0141+6    449.81  4.0584+6
20100153  477.59  4.1004+6    505.37  4.1411+6    533.15  4.1817+6
20100154  560.93  4.2227+6    588.70  4.2648+6    616.48  4.3083+6
```

```
20100155  644.26  4.3536+6    672.04  4.4008+6    699.81  4.4499+6
20100156  727.59  4.5006+6
*
*     tabelle 002 : thermische daten von mgo
*     waermeleitfaehigkeit [w/m-k]
20100200  tbl/fctn   1   -1
20100201  310.93   3.98084    810.93   3.98084
*
*      spezifische waermekapazitaet [j/m**3-k]
20100251  3.520952+6   3.520952+6
*
*
*     tabelle 003 : thermische daten von j-m thermo-2 (general insulation)
*     waermeleitfaehigkeit [w/m-k]
20100300  tbl/fctn  1    1
20100301  273.15    .055386      422.04   .062309      533.15   .074424
*20100301  310.93    .055386      422.04   .062309      533.15   .074424
20100302  644.26    .090002      700.00   .090002
*
*      spezifische waermekapazitaet [j/m**3-k]
20100351   273.15  2.17964+5    810.93   2.17964+5
*
*     tabelle 004 : thermische daten von kaowool fiber,
*                   (guard-heating control insulation)
*     waermeleitfaehigkeit [w/m-k]
20100400  tbl/fctn   1   -1
20100401  310.93   .050193    477.59   .050193    588.70   .072694
20100402  700.00   .072694

*     spezifische waermekapazitaet [j/m**3-k]
20100451  6.8407+4   6.8407+4   6.8407+4   6.8407+4
*
*     tabelle 005 : thermische daten von mild steel
*     waermeleitfaehigkeit [w/m-k]
20100500  tbl/fctn  1   -1
20100501   293.15  44.197708    373.15  44.197708    473.15  43.034611
20100502   573.15  41.871513    673.15  39.545318    773.15  38.382220
*
*     spezifische waermekapazitaet [j/(m**3-k]
20100551  3.614844+6  3.943466+6  4.272088+6  4.272088+6  4.929333+6
20100552  5.257955+6
*
*
*      tabelle 006: thermische daten von stainless steel
*                   waermeleitf„higkeit [w/m-k]
20100600  tbl/fctn  1  -1
20100601  310.93  15.82574    366.48  16.54646    394.26  16.90682
20100602  422.04  17.26718    449.82  17.62754    477.59  17.98790
20100603  505.37  18.34826    533.15  18.70862    560.93  19.06899
20100604  588.70  19.42934    644.26  20.15007    699.82  20.87079
20100605  755.37  21.59151    810.93  22.31223    894.26  23.39331
20100606  977.59  24.47439   1060.93  25.55547   1144.26  26.63655
20100607 1227.59  27.71763   1366.48  29.51943
*
*      spezifische waermekapazitaet sg-tubes [j/m**3-k]
20100651  3.969300+6   4.063506+6   4.109475+6   4.154688+6
20100652  4.199145+6   4.242846+6   4.285790+6   4.327979+6
20100653  4.369412+6   4.410088+6   4.489174+6   4.565236+6
20100654  4.638273+6   4.708286+6   4.807636+6   4.900182+6
20100655  4.985924+6   5.064861+6   5.136995+6   5.242097+6
*
*
*                 leistungsdaten fuer die kernheizung
*
```

```
*       Daten aus Versuch 1605AA vom 12.04.83
*
*       tabelle 31  heizgruppe 1
20203100  power  538
20203101       0.0       0.0
20203102       1.0     29.28+3
20203103     145.0     29.28+3
20203104     150.0     24.59+3
20203105     175.2     24.20+3
20203106     334.8     24.20+3
20203107     375.0     23.20+3
20203108     415.2     22.31+3
20203109     454.8     21.86+3
20203110     555.0     20.75+3
20203111     685.2     19.35+3
20203112     805.2     18.33+3
20203113    1045.2     17.07+3
20203114    1405.2     15.34+3
20203115    1645.2     14.61+3
20203116    1885.2     13.89+3
20203117    2085.0     13.22+3
20203118    2205.0     12.83+3
20203119    2710.2     12.27+3
20203120    3235.2     11.71+3
20203121    4299.0     11.27+3
20203122    5299.2     10.76+3
20203123    7020.0     10.21+3
20203124    9142.0      9.65+3
20203125   11362.8      9.20+3
*
*
*       tabelle 32  heizgruppe 2
20203200  power  538
20203201       0.0       0.0
20203202       1.0     29.28+3
20203203     145.0     29.28+3
20203204     150.0     24.59+3
20203205     175.2     24.20+3
20203206     334.8     24.20+3
20203207     375.0     23.20+3
20203208     415.2     22.31+3
20203209     454.8     21.86+3
20203210     555.0     20.75+3
20203211     685.2     19.35+3
20203212     805.2     18.33+3
20203213    1045.2     17.07+3
20203214    1405.2     15.34+3
20203215    1645.2     14.61+3
20203216    1885.2     13.89+3
20203217    2085.0     13.22+3
20203218    2205.0     12.83+3
20203219    2710.2     12.27+3
20203220    3235.2     11.71+3
20203221    4299.0     11.27+3
20203222    5299.2     10.76+3
20203223    7020.0     10.21+3
20203224    9142.0      9.65+3
20203225   11362.8      9.20+3
**      tabelle 33  heizgruppe 3
20203300  power  538
20203301       0.0       0.0
20203302       1.0     29.28+3
20203303     145.0     29.28+3
20203304     150.0     24.59+3
```

```
20203305    175.2     24.20+3
20203306    334.8     24.20+3
20203307    375.0     23.20+3
20203308    415.2     22.31+3
20203309    454.8     21.86+3
20203310    555.0     20.75+3
20203311    685.2     19.35+3
20203312    805.2     18.33+3
20203313   1045.2     17.07+3
20203314   1405.2     15.34+3
20203315   1645.2     14.61+3
20203316   1885.2     13.89+3
20203317   2085.0     13.22+3
20203318   2205.0     12.83+3
20203319   2710.2     12.27+3
20203320   3235.2     11.71+3
20203321   4299.0     11.27+3
20203322   5299.2     10.76+3
20203323   7020.0     10.21+3
20203324   9142.0      9.65+3
20203325  11362.8      9.20+3
**
*     tabelle 34  heizgruppe 4
20203400  power  538
20203401      0.0      0.0
20203402      1.0     29.28+3
20203403    145.0     29.28+3
20203404    150.0     24.59+3
20203405    175.2     24.20+3
20203406    334.8     24.20+3
20203407    375.0     23.20+3
20203408    415.2     22.31+3
20203409    454.8     21.86+3
20203410    555.0     20.75+3
20203411    685.2     19.35+3
20203412    805.2     18.33+3
20203413   1045.2     17.07+3
20203414   1405.2     15.34+3
20203415   1645.2     14.61+3
20203416   1885.2     13.89+3
20203417   2085.0     13.22+3
20203418   2205.0     12.83+3
20203419   2710.2     12.27+3
20203420   3235.2     11.71+3
20203421   4299.0     11.27+3
20203422   5299.2     10.76+3
20203423   7020.0     10.21+3
20203424   9142.0      9.65+3
20203425  11362.8      9.20+3
*
*
* ================= tabellen fuer einspeisecharakteristiken rj/rx ========
*                   ( durchfluss = f(gegendruck) )
*
*
*            es ist kein rj-bypass simuliert!
*
*
*
*     tabelle 100
*     rj - einspeiseventil loop i
*                   2 systeme        2 systeme
20210000    power
20210001     -1.        0.
```

```
20210002     0.      0.064914       *109.445
20210003    13.8+5   0.060961       *102.78
20210004    34.5+5   0.055368        *93.335
20210005    50.0+5   0.050415        *85.
20210006    55.2+5   0.049099        *82.78
20210007    65.5+5   0.045472        *76.665
20210008    75.5+5   0.041189        *69.445
20210009    86.2+5   0.035258        *59.445
20210010   100.0+5    0.
*
*     tabelle 120
*     rj - einspeiseventil loop i
*                  1 system        2 systeme
20212000   power
20212001    -1.       0.
20212002     0.      0.064914       *109.445
20212003    13.8+5   0.060961       *102.78
20212004    34.5+5   0.055368        *93.335
20212005    50.0+5   0.050415        *85.
20212006    55.2+5   0.049099        *82.78
20212007    65.5+5   0.045472        *76.665
20212008    75.5+5   0.041189        *69.445
20212009    86.2+5   0.035258        *59.445
20212010   100.0+5    0.
*
*
*
* ========================================================================
*                berechnung von kontrollvariablen
* ========================================================================
*
*     berechnung des kollabierten wasserstandes im druckhalter
*
20503000 dh-level  sum   1.0   0.0  1
20503001 0.0  0.9154 voidf 320010000  0.9154 voidf 320020000
20503002      0.9154 voidf 320030000  0.9154 voidf 320040000
20503003      0.9154 voidf 320050000  0.9154 voidf 320060000
20503004      0.9154 voidf 320070000  0.9154 voidf 320080000
20503005      0.9154 voidf 320090000  0.9154 voidf 320100000
20503006      1.0    voidf 325010000  1.0    voidf 327010000
20503007      0.2    voidf 330010000
*
*
*      berechnung der vom sekundaerkreis aufgenommenen waerme
*
20504000   qzuskl1  sum  1.0  0.0  1
20504001   0.0    1.0 q 420010000   1.0 q 420020000   1.0 q 420030000
20504002          1.0 q 420040000   1.0 q 420050000   1.0 q 420060000
20504003          1.0 q 420070000   1.0 q 420080000   1.0 q 420090000
20504004          1.0 q 420100000   1.0 q 420110000   1.0 q 420120000
20504005          1.0 q 420130000   1.0 q 420140000   1.0 q 420150000
20504006          1.0 q 420160000   1.0 q 420170000   1.0 q 420180000
20504200   qzuskl2  sum  1.0  0.0  1
20504201   0.0    1.0 q 420190000   1.0 q 420200000   1.0 q 420210000
20504202          1.0 q 420220000   1.0 q 420230000   1.0 q 420240000
20504203          1.0 q 420250000   1.0 q 420260000   1.0 q 420270000
20504204          1.0 q 420280000   1.0 q 420290000   1.0 q 420300000
20504205          1.0 q 420310000   1.0 q 420320000   1.0 q 420330000
20504206          1.0 q 420340000   1.0 q 420350000   1.0 q 420360000
20504400   qzuskl3  sum  1.0  0.0  1
20504401   0.0    1.0 q 420370000   1.0 q 420380000   1.0 q 420390000
20504402          1.0 q 420400000   1.0 q 420410000   1.0 q 420420000
20504403          1.0 q 420430000   1.0 q 420440000   1.0 q 420450000
20504404          1.0 q 420460000   1.0 q 420470000   1.0 q 420480000
```

```
20504405         1.0 q 420490000   1.0 q 420500000   1.0 q 420510000
20504406         1.0 q 420520000
*
20504600  qzutot   sum  1.0  0.0  1
20504601  0.0  1.0  cntrlvar 40 1.0 cntrlvar 42 1.0 cntrlvar 44
*-------------------------------------------------------------------
*
*      berechnung der vom primaerkreis abgegebenen waerme
*
20505000  qabpkl1  sum  1.0  0.0  1
20505001  0.0    1.0 q 170010000   1.0 q 170020000   1.0 q 170030000
20505002         1.0 q 170040000   1.0 q 170050000   1.0 q 170060000
20505003         1.0 q 170070000   1.0 q 170080000   1.0 q 170090000
20505004         1.0 q 170100000   1.0 q 170110000   1.0 q 170120000
20505005         1.0 q 170130000   1.0 q 170140000   1.0 q 170150000
20505006         1.0 q 170160000   1.0 q 170170000   1.0 q 170180000
20505200  qabpkl2  sum  1.0  0.0  1
20505201  0.0    1.0 q 170190000   1.0 q 170200000   1.0 q 170210000
20505202         1.0 q 170220000   1.0 q 170230000   1.0 q 170240000
20505203         1.0 q 170250000   1.0 q 170260000   1.0 q 170270000
20505204         1.0 q 170280000   1.0 q 170290000   1.0 q 170300000
20505205         1.0 q 170310000   1.0 q 170320000   1.0 q 170330000
20505206         1.0 q 170340000   1.0 q 170350000   1.0 q 170360000
20505400  qabpkl3  sum  1.0  0.0  1
20505401  0.0    1.0 q 170370000   1.0 q 170380000   1.0 q 170390000
20505402         1.0 q 170400000   1.0 q 170410000   1.0 q 170420000
20505403         1.0 q 170430000   1.0 q 170440000   1.0 q 170450000
20505404         1.0 q 170460000   1.0 q 170470000   1.0 q 170480000
20505405         1.0 q 170490000   1.0 q 170500000   1.0 q 170510000
20505406         1.0 q 170520000
*
20505600  qabtot   sum  1.0  0.0  1
20505601  0.0  1.0  cntrlvar 50 1.0 cntrlvar 52 1.0 cntrlvar 54
*
*      berechnung des inventars im dampferzeuger
*
*      de i
20511000  delmass1  sum  0.001459  0.0  1
20511001  0.0 1.0 rho 420010000 1.0 rho 420020000 1.0 rho 420030000
20511002      1.0 rho 420040000 1.0 rho 420050000 1.0 rho 420060000
20511003      1.0 rho 420070000 1.0 rho 420080000 1.0 rho 420090000
20511004      1.0 rho 420100000 1.0 rho 420110000 1.0 rho 420120000
20511005      1.0 rho 420130000 1.0 rho 420140000 1.0 rho 420150000
20511006      1.0 rho 420160000 1.0 rho 420170000 1.0 rho 420180000
20511200  delmass2  sum  0.001459  0.0  1
20511201  0.0 1.0 rho 420190000 1.0 rho 420200000 1.0 rho 420210000
20511202      1.0 rho 420220000 1.0 rho 420230000 1.0 rho 420240000
20511203      1.0 rho 420250000 1.0 rho 420260000 1.0 rho 420270000
20511204      1.0 rho 420280000 1.0 rho 420290000 1.0 rho 420300000
20511205      1.0 rho 420310000 1.0 rho 420320000 1.0 rho 420330000
20511206      1.0 rho 420340000 1.0 rho 420350000 1.0 rho 420360000
20511400  delmass3  sum  0.001459  0.0  1
20511401  0.0 1.0 rho 420370000 1.0 rho 420380000 1.0 rho 420390000
20511402      1.0 rho 420400000 1.0 rho 420410000 1.0 rho 420420000
20511403      1.0 rho 420430000 1.0 rho 420440000 1.0 rho 420450000
20511404      1.0 rho 420460000 1.0 rho 420470000 1.0 rho 420480000
20511405      1.0 rho 420490000 1.0 rho 420500000 1.0 rho 420510000
20511406      1.0 rho 420520000
*
20511600  demasse   sum  1.0  0.0  1
20511601  0.0  1.0  cntrlvar 110 1.0 cntrlvar 112 1.0 cntrlvar 114
*
*      berechnung des wasserstandes im dampferzeuger - sek.
*
```

```
*      de i
20521000  delevel1  sum  0.305386   0.0 1
20521001  0.0 1.0 voidf 420010000 1.0 voidf 420020000 1.0 voidf 420030000
20521002      1.0 voidf 420040000 1.0 voidf 420050000 1.0 voidf 420060000
20521003      1.0 voidf 420070000 1.0 voidf 420080000 1.0 voidf 420090000
20521004      1.0 voidf 420100000 1.0 voidf 420110000 1.0 voidf 420120000
20521005      1.0 voidf 420130000 1.0 voidf 420140000 1.0 voidf 420150000
20521006      1.0 voidf 420160000 1.0 voidf 420170000 1.0 voidf 420180000
20521200  delevel2  sum  0.305386  0.0  1
20521201  0.0 1.0 voidf 420190000 1.0 voidf 420200000 1.0 voidf 420210000
20521202      1.0 voidf 420220000 1.0 voidf 420230000 1.0 voidf 420240000
20521203      1.0 voidf 420250000 1.0 voidf 420260000 1.0 voidf 420270000
20521204      1.0 voidf 420280000 1.0 voidf 420290000 1.0 voidf 420300000
20521205      1.0 voidf 420310000 1.0 voidf 420320000 1.0 voidf 420330000
20521206      1.0 voidf 420340000 1.0 voidf 420350000 1.0 voidf 420360000
20521400  delevel3  sum  0.305386  0.0  1
20521401  0.0 1.0 voidf 420370000 1.0 voidf 420380000 1.0 voidf 420390000
20521402      1.0 voidf 420400000 1.0 voidf 420410000 1.0 voidf 420420000
20521403      1.0 voidf 420430000 1.0 voidf 420440000 1.0 voidf 420450000
20521404      1.0 voidf 420460000 1.0 voidf 420470000 1.0 voidf 420480000
20521405      1.0 voidf 420490000 1.0 voidf 420500000 1.0 voidf 420510000
20521406      1.0 voidf 420520000
*
20521600  delevel   sum  1.0  0.0  1
20521601  0.0  1.0  cntrlvar 210 1.0 cntrlvar 212 1.0 cntrlvar 214
*
*
*      berechnung des wasserstandes im dampferzeuger - prim.
*
*      de i
20522100  delevel1  sum  0.305386   0.0 1
20522101  0.0 1.0 voidf 170010000 1.0 voidf 170020000 1.0 voidf 170030000
20522102      1.0 voidf 170040000 1.0 voidf 170050000 1.0 voidf 170060000
20522103      1.0 voidf 170070000 1.0 voidf 170080000 1.0 voidf 170090000
20522104      1.0 voidf 170100000 1.0 voidf 170110000 1.0 voidf 170120000
20522105      1.0 voidf 170130000 1.0 voidf 170140000 1.0 voidf 170150000
20522106      1.0 voidf 170160000 1.0 voidf 170170000 1.0 voidf 170180000
20522200  delevel2  sum  0.305386  0.0  1
20522201  0.0 1.0 voidf 170190000 1.0 voidf 170200000 1.0 voidf 170210000
20522202      1.0 voidf 170220000 1.0 voidf 170230000 1.0 voidf 170240000
20522203      1.0 voidf 170250000 1.0 voidf 170260000 1.0 voidf 170270000
20522204      1.0 voidf 170280000 1.0 voidf 170290000 1.0 voidf 170300000
20522205      1.0 voidf 170310000 1.0 voidf 170320000 1.0 voidf 170330000
20522206      1.0 voidf 170340000 1.0 voidf 170350000 1.0 voidf 170360000
20522400  delevel3  sum  0.305386  0.0  1
20522401  0.0 1.0 voidf 170370000 1.0 voidf 170380000 1.0 voidf 170390000
20522402      1.0 voidf 170400000 1.0 voidf 170410000 1.0 voidf 170420000
20522403      1.0 voidf 170430000 1.0 voidf 170440000 1.0 voidf 170450000
20522404      1.0 voidf 170460000 1.0 voidf 170470000 1.0 voidf 170480000
20522405      1.0 voidf 170490000 1.0 voidf 170500000 1.0 voidf 170510000
20522406      1.0 voidf 170520000
*
20522600  delevel   sum  1.0  0.0  1
20522601  0.0  1.0  cntrlvar 221 1.0 cntrlvar 222 1.0 cntrlvar 224
20522602       4.691  voidf  150010000
*
*      berechnung des wasserstandes im heiáen bein
*
20523000  hllevel1  sum  0.9746885  0.0 1
20523001  0.0 1.0 voidf 132010000 1.0 voidf 132020000 1.0 voidf 132030000
20523002      1.0 voidf 132040000 1.0 voidf 132050000 1.0 voidf 132060000
20523003      1.0 voidf 132070000 1.0 voidf 132080000 1.0 voidf 132090000
20523004      1.0 voidf 132100000 1.0 voidf 132110000 1.0 voidf 132120000
20523005      1.0 voidf 132130000 1.0 voidf 132140000 1.0 voidf 132150000
```

```
20523006      1.0 voidf 132160000
*
20523200  hllevel   sum  1.0  0.0  1
20523201  -0.775004  1.0     cntrlvar 230  3.271   voidf 140010000
20523202          2.480  voidf  130010000
*
*      berechnung des wasserstandes im kernbereich
*
20524000  colevell  sum  1.0        0.0  1
20524001  0.0  0.2      voidf  102010000  1.92     voidf  100010000
20524002       0.375    voidf  100020000  0.4875   voidf  110010000
20524003       0.4875   voidf  110020000  0.4875   voidf  110030000
20524004       0.4875   voidf  110040000  1.091    voidf  110050000
20524005       1.091    voidf  110060000  0.2      voidf  120010000
*
20524200  colevell  sum  1.0        0.0  1
20524201  -7.445  1.0  cntrlvar 240
*
20524300  colevell  sum  1.0        0.0  1
20524301  0.0  1.470    voidf  270010000
*
20524400  delevel   sum  1.0  0.0  1
20524401  0.0  1.0  cntrlvar 242 1.0 cntrlvar 243

20524500  colevell  sum  1.0        0.0  1
20524501  0.0  1.6345   voidf  280010000
*
20524600  delevel   sum  1.0  0.0  1
20524601  0.0  1.0  cntrlvar 244 1.0 cntrlvar 245

20514000  mflow     sum  1.0   0.0   1
20514001  0.0  1.0  mflowj  911000000  1.0  mflowj  915000000
*
*      berechnung druckabfall ueber dem core
*
*20506000  dpcore    sum  1.0   0.0   1
*20506001  0.0  1.0  p  110010000     -1.0  p  110060000
*
*      berechnung druckabfall ueber vv
*
20507000  dpvv      sum  1.0   0.0   1
20507001  0.0  1.0  p  270010000     -1.0  p  260010000
*
*
20526100    vv-mf   integral   1.0   0.0   1
20526101    mflowj   265000000
*
20526200  leck-mf   integral   1.0   0.0   1
20526201    mflowj   905000000
*
20526300    hp-mf   integral   1.0   0.0   1
20526301    mflowj   911000000
*
20526400    hp-mf   integral   1.0   0.0   1
20526401    mflowj   915000000
*
20526500    hp-mf   sum        1.0   0.0   1
20526501    0.0  1.0  cntrlvar  263  1.0  cntrlvar  264
*
20526600    hp-mf   integral   1.0   0.0   1
20526601    mflowj   921000000

20550000    hp-mf   integral   1.0   0.0   1
20550001      cntrlvar  100
```

```
*
20550100    hp-mf   integral   1.0   0.0   1
20550101      cntrlvar   46
*
20550200    hp-mf   sum        1.0   0.0   1
20550201    0.0  1.0  mflowj  905000000
*
20550300    hp-mf   sum        1.0   0.0   1
20550301    0.0  1.0  mflowj  911000000  1.0 mflowj  915000000
*
20550400    hp-mf   sum        1.0   0.0   1
20550401    0.0  1.0  mflowj  921000000
*
* -------------------------------------------------------------------------
*
*     berechnung der leistungszufuhr durch die heat slabs im druckhalter
*
20507700  qzu01      sum  1.0   0.0   1
20507701 0.0  1.0 q 320010000  1.0 q 320020000  1.0 q 320030000
20507702      1.0 q 320040000  1.0 q 320050000  1.0 q 320060000
20507703      1.0 q 320070000  1.0 q 320080000  1.0 q 320090000
20507704      1.0 q 320100000
*
20507900  qzu03      sum  1.0   0.0   1
20507901  0.0   1.0 q 325010000  1.0 q 327010000
20507902        1.0 q 330010000
*
20508000  qzudhhs      sum  1.0   0.0   1
20508001  0.0  1.0 cntrlvar 77    1.0 cntrlvar 79
*
* -------------------------------------------------------------------------
*
*     zugefuehrte energie core
*
20510000  qzucor sum  1.0  0.0  1
20510010  0.0 1.0 q 110010000  1.0 q 110020000  1.0 q 110030000
20510011      1.0 q 110040000
*
20509100  qzucor sum  1.0  0.0  1
20509110  0.0 1.0 q 110010000
*
20509200  qzucor sum  1.0  0.0  1
20509210  0.0 1.0 q 110020000
*
20509300  qzucor sum  1.0  0.0  1
20509310  0.0 1.0 q 110030000
*
20509400  qzucor sum  1.0  0.0  1
20509410  0.0 1.0 q 110040000
*
* -------------------------------------------------------------------------
*
*
*     eingestroemte masse in den reaktorkern
*
20526700  rein-mf  integral  1.0  0.0  1
20526701  mflowj  105000000
*
* ----------------------------------------------------------------------
*
*     ausgestroemte masse aus dem reaktorkern
*
20526800  reout-mf  integral  1.0  0.0  1
20526801  mflowj  120010000
```

```
*
20526900  kern-mf  sum  1.0  0.0  1
20526901  0.0   1.0  cntrlvar  267   -1.0  cntrlvar  268
*
*  temperaturabsenkung  - 28 k/h
20529000  deltap  sum  1.0  0.0  1
20529001  0.0  1.0  p  440010000  -1.0  p  480010000
*
*
* -----------------------------------------------------------------------
*
*  berechnung der einspeiseraten von rj und rx
*
*
* ------------------------- rj loop i ----------------------------------
*
*20520000  funcrj1  function  1.0  0.0  1
*20520001    p   420070000    100
*
*20520500  durchrj1   mult    1.0  0.0  1
*20520501  cntrlvar  200      vlvarea  604
*
* ------------------------- rj loop ii ---------------------------------
*
*20521000  funcrj2  function  1.0  0.0  1
*20521001    p   422070000    110
*
*20521500  durchrj2   mult    1.0  0.0  1
*20521501  cntrlvar  210      vlvarea  606
*
* --------------------rj + rx loop i ----------------------------------
*
20522000  funcrx1  function  1.0  0.0  1
20522001    p   420070000    120
*
20522500  durchrx1   mult    1.0  0.0  1
20522501  cntrlvar  220      vlvarea  624
*
* -------------------rj + rx loop ii ---------------------------------
*
*20523000  funcrx2  function  1.0  0.0  1
*20523001    p   422070000    130
*
*20523500  durchrx2   mult    1.0  0.0  1
*20523501  cntrlvar  230      vlvarea  626
*
*-----------------------------------------------------------------------
. end of case
```

# RELAP5 MOD 3.2 Input Deck for the GERDA Test 1605AA Post Test Restart Calculation

```
* relap5/mod3.2
=   title
*
*              Inputfile: abx4.inp
*              Datum: 28.04.98
*
*              Leckfläche: 75% ab 2600 s
*              Hochdruckeinspeisung als Funktion der Zeit, aus ABX.INP
*
100   restart transnt
101   run
103   11824     ncmpress
*103   602     ncmpress
105  5.0  6.0
201     200.0  1.0-8  0.25   7   2   800   800
202    2000.0  1.0-8  0.25   7   4   800   800
203    4000.0  1.0-8  0.25   7  20  4000  4000
204    8000.0  1.0-8  0.25   7  20  4000  4000
205   12000.0  1.0-8  0.25   7  20  4000  4000
*
9050000   break valve
9050101   102000000  906000000   0.0000004448  0.0  0.0  0000100  1.0  1.0
1.0
9050201   1  0.035  0.  0.
9050300   mtrvlv
9050301   501  513  66.67  1.  0
*
9110000  hpi  tmdpjun
9110101  910000000  230000000  0.0000419
9110200  1
9110201  2600.0    0.0195   0    0
9110202  3100.0    0.0312   0    0
9110203  3600.0    0.0335   0    0
9110204  6600.0    0.0320   0    0
9110205  9700.0    0.0312   0    0
9110206 11300.0    0.0310   0    0
9110207 12000.0    0.0315   0    0
*
9150000  hpi  tmdpjun
9150101  914000000  230000000  0.0000419
9150200  1
9150201  2600.0    0.0195   0    0
9150202  3100.0    0.0312   0    0
9150203  3600.0    0.0335   0    0
9150204  6600.0    0.0320   0    0
9150205  9700.0    0.0312   0    0
9150206 11300.0    0.0310   0    0
9150207 12000.0    0.0315   0    0
*
. end of case
```

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**10. SUPPLEMENTARY NOTES**

**11. ABSTRACT** *(200 words or less)*

This report presents the results of RELAP5/MOD3.2 assessment on the integral (composite) GERDA Test 1605 AA which features a complete sequence of a 10 cm2 Reactor Vessel Leak transient conducted on April 12, 1983. The purpose of the assessment analysis was to determine whether the tested RELAP version can predict the major phenomena of this complex transient and to provide some useful information both to code developers and analysts for the application on SBLOCA transients in 'Once-Through-Steam-Generator' Plants. The Small Break Loss of Coolant Accident (SBLOCA) Test Facility GERDA (Geradrohr Dampferzeuger Anlage) was designed to evaluate the post SBLOCA thermal-hydraulic events expected to occur in the German Mulheim-Karlich plant. The scaled in volume 1:1 in height Test Facility was built and tested by B&W at the Alliance Research Centre (ARC) under contract of BBR (Brown Boveri Reaktor GmbH) now ABB Reaktor GmbH. The objective of the whole test program was to obtain detailed experimental data for the evaluation of single and composite SBLOCA phenomena and for the verification and refinement of the analytical tools and models used to predict plant performance during SBLOCA transients. Additionally, this report presents some base calculations identified as conditioning calculations of OTSG stready state and transient behaviour which is one of the essentials for the prediction of phenomena observed in the SBLOCA scenarios.

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

RELAP5/MOD3.2
GERDA
Small Break Loss of Coolant Accident

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