Non-Proprietary Version of Request for Additional Information (RAI)
ESBWR Pre-Application Review
General Electric Company

General Questions related to the SBWR and ESBWR test reports

334. In the PANDA M-series and P-Series test reports, it is stated that with few exceptions the tests began at about one hour after the reactor scram. For some tests the initial core power was either below (e.g., Test P3) or above (Tests P2 and M7) the equivalent decay power at one hour after the reactor scram as discussed below.

Based on the SBWR decay heat power at one hour after the scram, the equivalent PANDA core power is 1.06 megawatts (MW) (or 1.056 MW as reported on page 22 of ALPHA-606, "PANDA Facility, Test Program and Data Base General Description"). Therefore, the initial core power of a PANDA M-series test should be set at about 1.06 MW if the test is to begin equivalently at one hour after the SBWR scram.

Based on the ESBWR decay heat power at one hour after the scram, the equivalent PANDA core power is 1.07 MW. This is calculated below with a PANDA scaling factor of [[ ]] and a decay heat power at [[ ]] of the full power (based on an ORIGEN calculation for a 10-by-10 boiling water reactor (BWR) fuel bundle at [[ ]]).

([[ ]] = 1.07 MW (or = 1.19 MW if using [[ ]] as the scale for PANDA)

Therefore, the initial core power of a PANDA P-series test for ESBWR should be at 1.07 MW (as a minimum) if the test is to begin equivalently at one hour after the scram. Note that PANDA M-series tests for the SBWR and P-series tests for the ESBWR have practically the same core power (namely, 1.07 MW vs. 1.06 MW), if the scale of PANDA is proved to be [[ ]] of the ESBWR.

Please describe how the core power was calculated and provide a table to list the initial core power and its equivalent time after the reactor scram for all PANDA M-series and P-series tests. If additional power was added to offset heat loss (or some power was subtracted for other reason), a statement should be made to this effect. Please list other initial test conditions in the same table (e.g., similar to the GIRAFFE table on p. 2-106 of NEDC-32606P, "SBWR Testing Summary Report").

335. It appears that the initial passive containment cooling system (PCCS) vent submergence was set at [[ ]] meters for PANDA M-series tests, [[ ]] meters for PANDA P-series tests, and [[ ]] meters for GIRAFFE/Helium tests and System Interaction tests.

(1) Please explain the basis for selecting this range of PCCS vent submergence ([[ ]]) in these tests.

(2) Was there any difference in the PCCS vent submergence before and after a test? If so, what was the difference?

336. (1) Please provide a comparison of the important parameters including reactor pressure vessel (RPV), drywell (DW), and wetwell (WW) pressures, suppression pool (SP) level, and PCCS heat removal between PANDA M-series tests and PANDA P-series counterpart tests such as Test M7 vs. Test P3, and Tests M6/8 vs. Test P6.

(2) Provide a comparison of the important vessel and containment parameters (such as RPV water level, pressures of RPV and DW and WW, SP level, and GDCS pool level) of the three integral counterpart tests (GIRAFFE/Helium H1, PANDA M3, and either PANDA P1 or P4 (for t < 4 hours, without air injection to DW)). This question replaces a previous question (RAI 180). The counterpart tests were not specified in the previous RAI.

337. Data from the passive containment cooling (PCC) vent phase detectors in the PANDA tests do not seem to be fully consistent with the DW and WW pressure data. For example, based on the pressure difference between the DW and WW for PANDA Test M3 shown on ALPHA-613-0/Page15 (M3 Data Transmittal Report), there was continuous PCC venting into WW. In contrast, data from PCC vent phase detectors (on ALPHA-613-0/Page 20) showed continuous PCC venting only at t < [[ ]] seconds and sporadic PCC venting afterwards. Please provide an explanation.

338. [[

]] Are there any PANDA data regarding the two-phase flow characteristics (e.g., void fraction, pressure drop) in the RPV chimney? Note that this question is in response to the Advisory Committee on Reactor Safeguards (ACRS) interest on the two-phase flow in the ESBWR partitioned chimney, which was reflected in the questions raised in the two recent ACRS meetings.

339. Please provide Paul Sherrer Institute (PSI) document ALPHA-703-0, "PANDA P-Series Test Specification," Dec. 5, 1997. Is there a PSI/TEPSS document comparing pretest predictions with PANDA P-series tests? If so, please provide the document. (Note that on ALPHA-716-0/Page13 for Test P1, it is stated that the global DW/WW pressure response of test data was as expected from pretest calculations.)

340. [[

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341. What is the technical basis for setting the vacuum breaker (VB) opening pressure at 0.5 psi (i.e., the valve opens when the WW pressure exceeds the DW pressure by this amount)? We understand that the DW and WW can stand a maximum pressure differential of 3 psid. Has GE performed any TRACG sensitivity calculations or integral systems tests to determine the sensitivity of the peak containment pressure in a loss of coolant accident (LOCA) with respect to the VB opening pressure?

342. [[ ]] Has GE performed any TRACG analysis to determine how much safety margin that the PCCS has? In other words, what is the minimum PCCS heat removal capacity required to prevent the peak containment pressure from exceeding its design value for the main steam line break (MSLB)?

343. [[ ]]

344. [[ ]]

345. The DW water levels were measured in the PANDA tests but were not reported. Please provide this data?

RAIs for NEDC-33081P, "ESBWR Test Report"

346. Page 2-3, 3rd paragraph.

(1) It seems incorrect to say that the ESBWR LOCA analysis shows that essentially all of the initial inventory of the DW inerting gas is forced into the WW "within a matter of seconds," because the time required depends on the break size and location. Even for the MSLB, it will take more than a matter of seconds to move nitrogen gas to the WW. Please revise this statement.

(2) Please provide the TRACG-calculated time (in seconds) to move a major portion (e.g., 90% or higher) of the nitrogen gas from DW to the WW for the MSLB, GDLB, and BDLB (base cases only, no parametric studies).

(3) Please modify the following statement: "Thus, when the ESBWR PCCS is called upon to assume the decay heat load, it is expected that it will face a minimal challenge from residual noncondensable gas in the inlet mixture," to reflect the issue discussed in question 346.1 above.

347. Page 2-3, 4th paragraph. [[

]] Please provide the basis for the decay heat load estimate at one hour after the scram.

348. Page 2-4, last paragraph.

(1) What is the technical basis to selecting a leakage path between the DW and WW of $A/\sqrt{K}$ (where A is defined as the leakage area and K is defined as the loss coefficient) of 1 cm^2 for design basis accident evaluations.

(2) Since this leakage path is set at 1 cm^2 in the TRACG LOCA analyses, does it imply that K = 1?

349. Pages 3-1 (last paragraph) and 3-3 (Fig. 3-1). It is stated that [[

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(1) [[

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(2) [[

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(3) How many VB openings occurred in Test P2?

(4) [[

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(5) Why was the peak DW pressure in Test P2 about 0.1 bar lower than in Tests P4 and P1/8?

(6) Why did the DW pressure decrease much faster at around 8000 seconds in Test P2 than in Tests P4 and P1/8?

350. Page 3-4, Fig. 3-2.

(1) Does each data point shown in Fig. 3-2 represent the WW pressure increase between the end of the test and the beginning of the test? In other words, ΔP_{nc} (of x-axis) = P_{nc} (at the end of the test in the WW) – P_{nc} (at t = 0 in the WW), and ΔP (of y-axis) = WW pressure (at the end of the test) – WW pressure (at t = 0).

(2) Why did H1 and M3 fall below the 45-degree line? What is the physical implication?

(3) An improvement could be made to Fig. 3-2 by making the y-axis at the same length as the x-axis so that the 45-degree line would be truly the 45-degree line.

351. ALPHA-716-0/Page 18 (Fig. 3 for Test P1/8).

(1) Explain why the main steam line flow rate rose continuously between 0 and 900 seconds, as shown in Fig. 3. In other words, why didn't the peak flow rate occur at t = 0 seconds?

(2) [[

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352. ALPHA-716-0/Page 19 (Fig. 4). What was the reason for a drastic drop in the PCC1 feed flow rate at around 12,600 seconds (immediately after VB opening) as shown in Fig. 4?

353. ALPHA-716-0/Page 20 (Fig. 5). [[

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354. ALPHA-716-0/Page 24 (Fig. 9). As shown in Fig. 9 and stated on ALPHA-716-0/Page 14 (1st paragraph), the continuous temperature rise in the WW1 gas temperatures (MTG.S1.1 and MTG.S1.3) was due to DW steam condensation inside the main vent pipes (located inside the WW gas space) during the first 11 hours (39,600 seconds).

(1) In contrast, what caused the gas temperature of MTG.S1.6 to decrease between 21,000 and 40,000 seconds?

(2) What was the reason for the suppression pool surface temperature (MTS.S1.1) exceeding the gas temperatures (MTG.S1.6 and MTG.S1.3) for a large portion of the test duration?

(3) Explain why the VB opening at around 3.5 hours (12,600 seconds) was not reflected in the WW gas temperatures.

355. ALPHA-716-0/Pages 26, 28, and 30. Comparing the PCC upper tube temperatures in PCC1 (Figs. 11a), PCC2 (Fig. 12a), and PCC3 (Fig. 13a), only the PCC1 tube gas temperature experienced a large decrease immediately after VB opening (at around 3.5 hours or 12,600 seconds). Does this decrease imply that at around 3.5 hours, the opening of VB1 occurred before the opening of VB2 so that DW1 received a larger portion of the noncondensible gas vented from the WW?

356. ALPHA-716-0/Page 32. Why was the air partial pressure at mid-height of DW2 (MPG.D2.2) greater than that near the DW2 bottom (MPG.D2.3) as shown in Fig. 14?

357. ALPHA-716-0/Page 33.

(1) Why there was more air in WW2 (MPG.S2) than in WW1 (MPG.S1) by about 0.08 bar (1 psi)? Was this caused by the venting of two PCC units to WW2 (vs. the venting of only one PCC unit to WW1)?

(2) Why was the VB opening at around 3.5 hours (12,600 seconds) not reflected in the air partial pressure in the WW?

358. ALPHA-716-0/Pages 36 to 38. As shown in Fig. 18, all three PCC vent lines were not cleared between 20,000 and 40,000 seconds, while Fig. 5 (ALPHA-716-0/Page 20) shows continuous steam condensation in the PCC units. Does this imply that the PCC units are capable of condensing steam even when their vent lines are not cleared and are blocked with water?

359. ALPHA-716-0/Pages 41 to 42.

(1) Please provide an instrumentation diagram to show where these main vent thermocouples were located.

(2) Explain why there was a rapid decrease in the temperatures of MTG.MV1.2 and MTG.MV1.3 at around 40,000 seconds.

(3) Explain why there was a temperature drop and recovery of MTG.MV1.3 at around 10,000 seconds.

RAIs for NEDC-32606P, "SBWR Testing Summary Report"

360. Page 2-6, 1st paragraph. It is stated that "For design basis accidents, the peak long-term drywell pressure occurs when all the noncondensible gases are present in the wetwell and, consequently, the drywell is nearly pure saturated steam."

(1) Is this statement based on TRACG analysis or test data? Let us compare this statement with the PANDA M3 test data: when the peak DW pressure occurred at around 10,000 seconds (ALPHA-613-0/Page 15), the partial air pressure in the DW was in a range of [[ ]] (ALPHA-613-0/Page 22).

(2) Is this range of the noncondensible gas concentration deemed to be negligible (with respect to its adverse impact on the PCC heat removal) so that it would be correct to say that the DW is filled with nearly pure saturated steam?

It should be pointed out that a similar comparison to the GIRAFFE/Helium test data cannot be made for the lack of noncondensible gas concentration data, and an RAI on this issue has been included among those regarding the GIRAFFE tests.

361. Pages 2-9 (last paragraph) and 2-25 (Fig. 2.1-2).

(1) When the PCC vent tank was closed, was the vent valve shown in Fig. 2.1-2 (on top of the vent tank on the right-hand-side) shut off? If so, the pressure in the vent tank would rise if the pure steam flow into the PCC was not completely condensed.

(2) For the PANTHERS/PCC steady-state pure steam tests, did the vent tank pressure ever rise?

(3) What action was taken if the vent tank pressure began to rise? (There seem to be two options: either reducing the pure steam flow rate to the PCC until the vent tank pressure stops rising and eventually reaches an equilibrium pressure, or maintaining the pure steam flow rate to the PCC until the vent tank pressure rises to a higher equilibrium pressure.)

362. Page 2-10, 1st paragraph. Explain how the vent tank pressure was controlled in the steam-air steady-state tests.

363. Page 2-10, 3rd paragraph.

(1) Please provide a basis for the statement that main vent clearing occurs within a few seconds of the LOCA (e.g., BDLB or GDLB).

(2) What is the duration of main vent clearing for the MSLB?

364. Page 2-13, 2nd paragraph. Please provide a drawing of a spectacle flange.

365. Page 2-14, last paragraph. Please explain the statement that "the pressure corresponds to that required to condense all of the given steam at zero air fraction."

366. Page 2-24, Fig. 2.1-1.

(1) What is the large vertical pipe connected to the lower header of the PANTHERS PCC shown in the left hand sketch of Fig. 2.1-1?

(2) Why is this pipe not shown on the right hand sketch of Fig. 2.1-1?

367. Page 2-27, Fig. 2.1-4.

(1) As shown in Fig. 2.1-4, the pressure drop between the PCC top header and the bottom header is negligible. Are there any data to support this statement? Is this statement inapplicable to the steady-state and transient PANTHERS/PCC tests?

(2) [[

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(3) The VB setpoint of 2.1 kPa (0.30 psi) seems to be too low. Should the ESBWR/SBWR VB setpoint equal 3.45 kPa (0.50 psi)?

368. Page 2-30, Fig. 2.1-7. What is the PANTHERS/PCC heat rejection rate with inlet steam flow at 5 kg/s and zero air mass fraction?

369. Page 2-46, Fig. 2.2-1. The left hand sketch of Fig. 2.2-1 shows a large vertical pipe which is bigger in diameter than the vertical pipe housing of the isolation condenser (IC) vertical inlet line as shown in the middle sketch. Please explain this discrepancy.

370. Page 2-54, 1st paragraph. To avoid confusion, it seems appropriate to replace the statement, "The PCC/IC pools were isolated for this and all subsequent tests, " with the following statement: "The PCC/ICs pools were not interconnected for this and all subsequent tests."

371. Page 2-54, 2nd paragraph. It appears incorrect to say that Test M2 is a repeat of Test M3, because all the break flow was directed into DW2 in Test M2.

372. Page 2-54, last paragraph. Please quantify the bypass area that is ten times the scaled SBWR design value (in cm^2).

373. Page 2-61, last paragraph. Please explain the statement: "A design limitation of the test facility which does not permit two-phase flow from the RPV to the DW through the steam lines." Is this a concern to PANDA tests?

374. Page 2-67, 4th paragraph. Please add a figure to show the RPV, DW, and WW pressures and the PCC inlet mass flow rates (or add two separate figures if it is preferred). [[

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375. Page 2-68, 2nd paragraph. Please provide a comparison of air concentration (or partial air pressure) in the DW between Tests M3 and M9 to support the statement that more air remained in the DW in Test M9 than in Test M3.

376. Page 2-75, Fig. 2.3-5.

(1) In Fig. 2.3-5, how many times did VB open in PANDA Test M3A? It appears that there were only three VB openings based on the DW pressure drops shown in Fig. 2.3-5 (excluding the small pressure drop at 13,000 seconds), but the figure legend stated four VB openings in Test M3A.

(2) As stated on p. 2-63 (2nd paragraph), M3B showed decreases in the DW pressure when the PCC pools were refilled (Fig. 2.3-8). This statement appears to be true with one exception; Fig. 2.3-5 shows no DW pressure decrease for M3B at around 11,000 seconds when the PCC pools were refilled. What is the rationale for this exception?

377. Page 2-77, Fig. 2.3-7. Was the tube wall temperature shown in Fig. 2.3-7 measured at the inside surface of the condenser tube?

378. Page 2-79, Fig. 2.3-9. Why was the DW pressure of Test M2 (asymmetric steam flow to the DW) lower than that of Test M3 in Fig. 2.3-9?

379. Page 2-80, Fig. 2.3-10. Since the DW pressure of Test 10A (2 PCC units) was either lower or the same as that of Test M3 (3 PCC units) as shown in Fig. 2.3-10, does this imply that 2 PCC units were sufficient to remove the decay heat for these PANDA tests?

380. Page 2-101, next to the last paragraph. It is stated that "The core heater in the facility simulated the decay heat following a scram with 1:400 scale adjusted for stored energy effects."

(1) Please explain how the GIRAFFE core power was adjusted for the stored energy effects.

(2) Quantify this core power adjustment in a table by dividing the initial core power in the GIRAFFE tests (listed in Table 2.5-2 on p. 2-105, Table 2.5-3 on p. 2-106,

and Table 2.6-2 on p.2-119) into two parts – the equivalent decay heat power for GIRAFFE (scaled from the SBWR after the scram) and the adjustment to the core power (in kW).

381. Pages 2-103 (1st paragraph) and 2-111 (Fig. 2.5-5). [[

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382. Pages 2-103 (3rd paragraph) and 2-109 (Fig. 2.5-3). [[

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(1) Does GE agree or disagree with this comment? Give us a reason for disagreement.

(2) [[

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383. Page 2-103 (last paragraph). There are no figures in this report to compare the important parameters of the two GIRAFFE tie-back tests (T1 and T2) and the previous GIRAFFE test for which Test T1 was a tie-back test. Please provide figures to compare the important parameters (e.g., DW/WW/RPV pressures, PCC condensate flow rate, etc.)

384. Page 2-105, last line. Was the GDCS injection completed before the test initiation for all the GIRAFFE/Helium tests?

385. Pages 2-112 (4th and 5th paragraphs) and 2-114 (3rd paragraph).

(1) Is a GIRAFFE 3-tube IC unit with two tubes plugged and only one tube operational equivalent to one IC condenser in the SBWR (which has three IC condensers)?

(2) [[

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386. Pages 2-112 (last paragraph) and 2-118 (Table 2.6-1). As stated, a single GDCS pool in GIRAFFE is equivalent to all three GDCS pools in the SBWR, and only one of the three GDCS pool would have pool-to-RPV flow under a GDLB with a single failure of a GDCS injection valve (Table 2.6-1) connected to one of the two remaining intact pools. We have two questions regarding this statement.

(1) Is it correct to say that for a GDLB in the SBWR concurrent with an injection line valve failure on another GDCS pool, two out of the three GDCS pools can still provide water injection to the RPV? Each of the three GDCS pools in the SBWR has two injection lines connected to the RPV; if an injection line fails to open because of a valve failure, the other line can still provide water from this pool to the RPV.

(2) Similarly for a GDLB in the ESBWR with an injection line valve failure, how many GDCS pools (a total of four in the ESBWR) are available to provide water injection to the RPV?

387. Pages 2-113 (1st paragraph) and 2-119 (Table 2.6-2). As stated, the initial test conditions for the GIRAFFE/SIT tests approximate the SBWR conditions when the RPV pressure reaches 150 psia.

(1) What was the basis for the initial test conditions in Table 2.6-2?

(2) Compared to three other GDLB tests, Test GS3 (BDLB) had the highest initial DW and WW pressures, but it had the lowest initial SP water temperature. Why didn’t Test GS3 have the highest initial SP temperature?

388. Page 2-113, last paragraph. As stated, data from Test GS3 were examined to identify any potential systems interactions associated with the IC and PCC operation for a BDLB. How was this done? Was there a similar BDLB test but without the isolation of the ICs and PCCS operation for comparison?

389. Page 2-129, Fig. 2.6-9.

(1) What was the IC condensate flow rate for Test GS2 in comparison to the PCCS condensate flow rate shown in Fig. 2.6-9?

(2) There is a typographical error in Fig. 2.6-9 for which the unit of pressure should be in “MPa” instead of “kPa.”

Request for Additional Information for GE's PANTHERS-IC Test Report
(SIET document # 00458 RP 95, Rev. 0)

The comments related to this test report are made in the context of the ESBWR Scaling Analysis. A general comment about the material presented in the report is that, even though it seems clear and easy to read and follow, there is almost no quantitative evaluation of scale or distortions. The statements "prototypical as practical" and "non-prototypical" are used often without explanation or reference of what they mean in terms of the extent of the prototypical quality or lack thereof. A number of the questions are derived from this observation.

390. Page 10, Section 2.2, item (c): What constitutes a "large fluctuation" of tube-side heat transfer and flowrates?

391. On page 11, item (h): An elbow flow meter is mentioned on this page. Also, on page 17 the "elbow flow meter" is mentioned twice, indicating that there are two of these devices. Why are the instruments not mentioned in the instrumentation description or data reduction? What happened to this data?

392. Page 11, item (k): The vibrations measured in this test are representative of one half of the actual structure and function of the IC. How is are the measured vibrations scaled to take this into account?

393. Page 12, Section 3.1, item (e): It is noted that there are several departures from prototypical dimensions of the main steam supply line. Please, explain the nature, extent and impact of these non-typical dimensions.

394. Page 12, item (g): What is meant by the phase "prototypical as is practical …" What is the condensate drain line prototypical of? Since the IC in the test a half-unit full-scale IC, is the area of the drain line one-half of the area of the actual drain line? The schematics suggest that the full IC will have a single drain line. The underlying assumption is that doubling the size of the tested IC would double the drain line flow. Please provide the basis for this assumption. In addition, the dynamic response of a half drain line, or even a full drain line with half-unit IC would be different from the prototype. How are these differences accounted for in the test and the analysis?

395. Page 13, Section 3.2: It is stated that since the facility includes a half-unit full-scale IC, scaling analysis is not necessary. Please explain how the dynamic response of the flow and the system vibration aspects were accounted for in the scaling analysis.

396. Page 16, Section 3.5.1: The last paragraph in this sections suggests that there may be a steam flow into the system that is not being measured. Is this statement correct? Please provide additional details regarding this steam flow and any impact it may have on the test results.

397. Bottom of page 16: There is a typographical error, it should read “steam” instead of “staam.”

398. On page 17, Section 3.6: It is stated that the IC returns to the vessel [[ ]] below the water level. Is this the collapsed water level or the two-phase water level? If it is the two-phase water level, how is this level detected or measured?

399. Section 3.6, bottom of page 17: [[ ]]

400. The top paragraph of page 18 discusses the characteristic time of valves, specifically to simulate the prototypic valve opening of the IC return. It is not clear in this report or in the NEDC-33082P, “ESBWR Scaling Report,” how the characteristic time of the IC system compares to the other dynamic (and simultaneous) aspects of the system response. It is also not clear whether the dynamic response characteristic of the IC return line was considered in the design of the test or in the analysis of the data. Please explain if and how these dynamic features of the test were analyzed in the context of scaling and data sufficiency.

401. Section 3.7 on page 18: The vent lines are described in detail. Are the vent lines prototypical?

402. Section 4.9 on page 23: The scribe marks used to measure permanent strains are described. It is stated in the report that the results are not yet available. Are these results now available? Were there any permanent deformations of the system? Please provide the detailed results from the measurement of the scribe marks.

403. Were the data acquisition systems discussed on page 24 synchronized?

404. Page 35, Section 7.1: It is suggested that tests to examine the effect of inlet pressure could be conducted consecutively. If a test has already been performed, the water in the IC return line would be warmer than it was during the initial test, thus varying the head available in the IC line. How was this effect addressed in the experiments?

405. The test matrix for the startup demonstration of the IC consisted of a single test. How is it demonstrated that this test encompasses the expected phenomena, given that the IC return line is not entirely prototypical, even assuming that the half-unit IC and the return pipe behave in a prototypical fashion? What basis, analytical or experimental, supports the sufficiency if the test data for this component? According to the conclusions in Section 9, this test was not conducted. Was the test conducted after the test report was written?