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	:	

SAFETY ENFORCEMENT DIVISION
CALIFORNIA PUBLIC UTILITIES COMMISSION

CHAPTER TWO

PREPARED SUR-REPLY TESTIMONY

OF

MARGARET FELTS IN RESPONSE TO

REPLY TESTIMONY OF ROBERT A. CARNAHAN

San Francisco, California
June 30, 2020

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I. INTRODUCTION

The purpose of the following prepared Sur-Reply testimony, submitted on behalf of the California Public Utilities Commission's ("Commission") Safety Enforcement Division ("SED") is to reply to statements made by Robert A. Carnahan. In summary, Mr. Carnahan rephrases the violations of Section 451 of the California Public Utilities Code identified in my Opening Testimony:

- For failure to follow the company's internal 1988 plan to check casing of 12 wells for metal loss (violations 61-72),[1] and failure to follow the company's internal 1988 plan to check casing of well SS-25 for metal loss (violation 73).[2] These violations are incorrectly restated by Mr. Carnahan in his introduction as "SoCalGas should have used the Vertilog technology to check the casing on 13 wells. (Violations 61-73)."[3] However, after the introduction, Mr. Carnahan's testimony does not state which part addresses these violations.
- For failure to have a systematic practice to protect surface casing strings against external corrosion and failure to employ a proper understanding of the consequences of corroded surface casings and uncemented production casings (violation 86).[4] Mr. Carnahan restates this in the introduction of his testimony as "[SoCalGas] should have used cathodic protection to prevent the corrosion that led to the SS-25 leak (violation 86). . ."[5] However, after the introduction, Mr. Carnahan's testimony does not state which part addresses this violation.
- For failure to have a continuous pressure monitoring system for well surveillance because it prevented an immediate identification of the SS-25 leak and accurate estimation of the gas flow rate (violation 87).[6] In the introduction, Mr. Carnahan restates this violation as: "[SoCalGas] not having a continuous

[1] See my Opening Testimony, p. 3.

[2] See my Opening Testimony, p. 3.

[3] Carnahan Opening Testimony, p. 1, lines 8-9.

[4] See my Opening Testimony, p. 3.

[5] Carnahan Opening Testimony, p. 1, lines 9-10.

[6] See my Opening Testimony, p. 3.

pressure monitoring system for well surveillance prevented the immediate identification of the SS-25 leak and accurate estimation of gas flow rate (violation 87)."[7] Also, after the introduction, Mr. Carnahan's testimony does not state which part is addressing this violation.

Mr. Carnahan also alleges, without reference to my Opening Testimony, that I contended, without support, that "the" leak existed prior to October 23, 2015.[8]

My Opening Testimony states, "Also, well patches were documented for SS-25A and SS-25B, but there was no mention of such, or the potential for one, in the Well File record for SS-25, even though there was an ongoing leak in well SS-25 documented in Temperature Surveys from the late 1978 to the late 1990s.[9] There is no mention of repair in Well File SS-25, so presumably, this leak still existed at the time of the well failure in October 2015."[10] While the support for my statement is provided again in the footnote for this quote, this is not listed as a violation.

Although Mr. Carnahan links his testimony to specific violations identified by my Opening Testimony, Sections II-IV of his testimony responds to the Public Advocates Office (PAO) opening testimony, which is separate and unrelated to the violations in my Opening Testimony. I will leave it up to PAO to reply to Mr. Carnahan's testimony in Sections II-IV. Section V specifically addresses violation 87, and I will address those comments. Hower & Stinson also addressed all of the violations that Mr. Carnahan's testimony has, as well as my alleged contention that the leak existed prior to October 23, 2015.

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[7] Carnahan Opening Testimony, p. 1, lines 10-12.

[8] Carnahan Opening Testimony, p. 1, lines 19-20.

[9] Footnote 448, citing SS-25 Well File, Supporting Attachments SED, Examples: 01686-01702, 01711-01713, 01639-01645, 01544-01545, 01554-01556, 01592-01594, 01621-01622, 01627-01631, 01636-01638, 01717-01719.

[10] See my Opening Testimony, p. 71.

II. VERTILOG TECHNOLOGY

The first sentence in Section I of Mr. Carnahan's testimony, beginning on page 1, shows that Mr. Carnahan is replying to Public Advocates Office's (PAO) opening testimony, stating PAO alleges that "SoCalGas management failed to deal with integrity management issues by taking prudent action in response to 'Vertilog testing conducted at Aliso Canyon circa 1988.'"[11] Because Mr. Carnahan says in Section I of his testimony that he is replying to Public Advocates Office's Opening Testimony, I understand this section of his testimony does not address any of the violations in my Opening Testimony. However, Mr. Carnahan's introduction also links the PAO and SED allegations that SoCalGas should have used Vertilog technology to check the casing on 13 wells (SED violations 61 to 73).[12] If it is Mr. Carnahan's intent to address his discussion of Vertilog technology in this section to violations 61 to 73, then my reply to Hower & Stinson in section in Chapter 1, Section IV.A above also addresses Chapter I of Carnahan's testimony here. My Opening Testimony says that violations 61-72 are for failure to follow company's internal 1988 plan to check casing of 12 wells for metal loss, and violation 73 is for failure to follow the company's internal 1988 plan to check casing of well SS-25 for metal loss.[13]

III. VERTILOG TECHNOLOGY

In this section, Mr. Carnahan replies to PAO's Opening Testimony; not my Opening Testimony, which is not related to violations. I defer to PAO to reply to Mr. Carnahan's testimony.

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[11] Carnahan Opening Testimony, p. 1, line 23 to page 2, line 1.

[12] Carnahan Opening Testimony, p. 1, lines 7 to 9. "Specifically, SED alleges violations of Section 451 of the California Public Utilities Code because SoCalGas should have used the Vertilog technology to check the casing on 13 wells (Violations 61-73). . ."

[13] See my Opening Testimony, p. 3.

IV. PRESSURE TESTING IN 1988

In this section, Mr. Carnahan replies to PAO's opening testimony, not my Opening Testimony. This testimony is not related to the violations in my Opening Testimony and does not appear to have any relationship to those violations identified in Carnahan's introduction. I defer to PAO to reply to this section of Mr. Carnahan's testimony.

V. CATHODIC PROTECTION WOULD HAVE PROTECTED THE 11 ¾-inch SURFACE CASING

Mr. Carnahan states in Section IV of his testimony that "PAO further states '[i]f cathodic protection were applied to SS-25 prior to the invasion of groundwater, the resulting corrosion would not have occurred.' [Footnote omitted] SED makes a similar contention."[14] [15] Similar to the incorrect restatement of SED violation 86 in his introduction, the title of Section IV of Mr. Carnahan's testimony states, "PAO and SED both incorrectly assume that cathodic protection (CP) would have prevented the leak."[16] I defer to PAO to reply to the parts of Mr. Carnahan's testimony that are directed to PAO.

Mr. Carnahan's restatement of violation 86 is incorrect or unsupported for several reasons. First, violation 86 is for failure to have a systematic practice to protect surface casing strings against external corrosion and failure to employ a proper understanding of the consequences of corroded surface casings and uncemented production casings.[17] Mr. Carnahan incorrectly suggests that violation 86 is specific to SS-25. Violation 86 includes SS-25 but is not limited to it.

Second, in alleged support of his restatement of violation 86, Mr. Carnahan said that "SED makes a similar contention" and he then notes footnote 56, which refers to my

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[14] Carnahan Opening Testimony, p. 21, lines 23 to 25.

[15] As noted earlier, Mr. Carnahan incorrectly restates Violation 86 in his introduction as "[SoCalGas] should have used cathodic protection to prevent the corrosion that led to the SS-25 leak." Carnahan Opening Testimony, p. 1, lines 9-10.

[16] Carnahan Opening Testimony, p. 21, line 18.

[17] See my Opening Testimony, p. 4.

Opening Testimony at 45, and states "A cathodic protection system would have provided corrosion protection to the 11 ¾-inch casing."[18] Mr. Carnahan states in the next sentence on the next page that "This is not so. Cathodic protection (CP) does not protect production casing where it is contained within surface casing." The disconnect between the statement he quotes from my testimony and his statement is obvious. My comment was that CP would have protected the 11 ¾-inch casing, because the 11 ¾-inch casing touches soil, and could lose metal without CP. In contrast, Mr. Carnahan says CP would not protect the production casing within the surface casing.[19] These are two different issues. Mr. Carnahan's testimony claims to refute my statement but does not. He merely builds on his statement, which I have never disputed.

Third, Mr. Carnahan says that "[t]here is no conclusive evidence that there were holes in the 11 ¾-inch surface casing prior to rupture of the production casing."[20] Whether he is correct that there were no holes in the surface casing of SS-25 has nothing to do with violation 86, because that violation focuses on corrosion (not holes) related to surface casings, such as SS-25. There is overwhelming evidence of corrosion on the surface casing, which failed under the pressure from the production casing failure event.[21] Mr. Carnahan quotes Blade on this point: "[t]he gas flowing through the axial rupture on the 7-inch production casing caused an increase in pressure on the 11¾-inch surface casing. This caused several of the surface casing corroded regions to fail, creating holes and thus providing a pathway for gas to escape. Over 50 such holes provided a pathway for the gas to surface."[22] (Emphasis added) Had the 11 ¾-inch surface casing been protected by CP, it would not have been corroded, and therefore the pressure would not have caused it to fail, resulting in over 50 holes.

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[18] Carnahan testimony, p. 21, lines 24-25, and fn 56.

[19] Carnahan testimony, p.22 lines 1-2.

[20] Carnahan testimony, p.22 lines 10-11.

[21] Blade Report at 3, 119, 120 and 121.

[22] P.22 Lines 18-20.

Mr. Carnahan's testimony fails to provide sufficient arguments to prove that SoCalGas could not have protected the surface casing with CP. Therefore violation 86 should stand.

VI. CONTINUOUS PRESSURE MONITORING

Violation 87 is for failure to have a continuous pressure monitoring system for well surveillance because it prevented an immediate identification of the SS-25 leak and accurate estimation of the gas flow rate. Carnahan claims in his Section V heading that, "SED is Incorrect that Continuous Pressure Monitoring and Temperature/Noise Surveys Should Have Alerted SoCalGas to the SS-25 Leak Prior to October 23, 2015." Hower & Stinson also make assertions about violation 87, which I address in Chapter 1.[23] I also address Carnahan's assertions regarding violation 87 here.

A. Analysis of the Failure Event

Mr. Carnahan contends that "The Blade main report and various supplementary reports assert that the SS-25 7-in. casing's vertical rupture and circumferential parting were two separate events, with the circumferential parting occurring some period of time after the initial vertical rupture, but while the well was still on injection. To the contrary, it is evident the SS-25 7-in. casing vertical rupture and circumferential parting occurred as a single event, as illustrated in Figure 12 and Figure 13, and for the reasons described below:"[24]

When SED asked whether Blade agreed or disagreed with this statement, Blade stated that it disagreed.[25] Blade explained, "Mr. Carnahan's statement does not take into consideration all of the facts provided in Blades' Main and Supplementary reports. Central to the argument are two facts. First, there are arrest turning points on both ends of the axial rupture. Second, there is no continuity of chevron marks from the axial rupture

[23] Section VIII of Chapter 1 above

[24] Carnahan testimony, pp. 24-25.

[25] Blade Response to SED Data Request 58, Response 2.7.1, May 15, 2020, pp. 15-16.

to the circumferential parting."[26] Blade added detail to this explanation. In conclusion of their statement, Blade stated that "Blade does not accept any part of Mr. Carnahan's statement as true. If Blade were to accept Mr. Carnahan's primary assertion that the vertical rupture and the circumferential part were one event, it would only change Blade's interpretation of the failure sequence. However, it would not change the failure analysis conclusions."

Statements in my Opening Testimony on this issue rely on Blade's RCA, which I support. Mr. Carnahan's testimony fails to provide sufficient arguments to prove that a continuous pressure monitoring system for well surveillance would not have provided SoCalGas immediate identification of the SS-25 leak and accurate estimation of the gas flow rate. Therefore violation 87 should stand.

B. Prior Leaks in SS-25 Casing Existed

Mr. Carnahan challenges statements I made in my Opening Testimony regarding indications of prior leaks in SS-25 that went unaddressed by SoCalGas.[27] My Opening Testimony did not identify any violations having to do with failure to respond to prior indications of leaks. I testified in my Reply Testimony to the OSC that SS-25 temperature and noise surveys indicated leaks in the well casing from 1978 to 2012.[28] Exhibits were provided. The primary leak was just above the shoe and was noted many times in the records, and exhibits were provided to show that as well.[29] Blade acknowledged the cooling indication deep in well SS-25 but discounted it as not relevant to their RCA, and I agree with their assessment.[30] My point in showing these exhibits is not that it was a cause of the SS-25 failure, but that these indications on temperature and noise surveys

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[26] Blade Response to SED Data Request 58, Response 2.7.1 May 15, 2020, p. 16.

[27] Carnahan testimony, p. 28, lines 8-11.

[28] Reply Testimony to the OSC, p. 13-14

[29] Reply Testimony to the OSC, p. 13-14

[30] Blade Report, pp30. "A cooling feature was found below approximately 8,200 ft related to gas injection and withdrawal, but it was not related to a casing integrity issue."

went unaddressed by SoCalGas and that there were no interoffice memos in the file that discussed these survey results as I found in other well files, which is a recordkeeping issue.

Mr. Carnahan is incorrect in stating that SS-25 surveys did not identify any leaks prior to October 23, 2015.[31] For example, the SS-25 temperature survey from November 7, 1991, which Carnahan identifies in the second bullet on page 29 of his testimony,[32] shows a noise (gas leaking) was heard above 500 ft.[33] Specifically, it says under Results and Remarks "Heard distant noise above 1200'. At 500', bled casing kill line on well 25 A and heard even higher activity."[34] If SoCalGas really believes temperature and noise surveys are the tools to rely on to discover casing leaks, it should have investigated the indications on this survey, especially since this apparent leak appears on subsequent surveys through 2012.[35] As it turns out, 500 ft is the same well depth that SoCalGas personnel estimated to be the depth of the leak on SS-25 before they knew the casing had split and before they had any specific down-hole information about the October 23, 2015 leak.[36] For surveys in later years 2000-2014, Blade suggests "likely interpretations" of cooling shown on SS-25 temperature surveys is that they show ingress of groundwater into the surface casing annulus," concluding that "[t]he surface casing fluid level is consistent with the presence of OD corrosion."[37]

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[31] Carnahan testimony, p. 28 line 7.

[32] Carnahan testimony p.29 lines 6-17.

[33] Page 1171 from DR30_0000001- 1177 All.1992.

[34] Page 1171 from DR30_0000001- 1177 All.1992.

[35] 1995.1030.SS25.Temp.Survey.Leak.AC_CPUC_0000294.1995 TempSurvey, 2000.1017.AC_CPUC_0206642.2000.Ss-25.shallow.anomolies, 2001.0807.AC_CPUC_0206641.SS-25.shallow.anomolies, 2012.0601.SS25.Noise.Survey.AC_CPUC_0000186.2012.

[36] 2015.1110.AC_CPUC_SED_DR_17_0046340.Suspected.hole.2015Nov10.

[37] Blade Main Report p. 100.

Mr. Carnahan argues that the cooling at the bottom of the well was not an indication of a leak, but gas movement into or out of the storage zone.[38] I agree with Mr. Carnahan that shoe leaks seem to be fairly common in wells at Aliso. However, if his explanation is correct, SoCalGas wasted a lot of ratepayer money over the years repairing shoe leaks in wells where they saw similar results on temperature surveys. Although these surveys are interesting and subject to interpretation, as well as highly susceptible to error, my Opening Testimony did not identify any violations having to do with failure to respond to prior indications of leaks, so the discussion here is academic.

VII. BLADE DISAGREED WITH MANY OF MR. CARNAHAN'S STATEMENTS –SUCH STATEMENTS, IF TRUE, WOULD NOT CHANGE BLADE'S RCA CONCLUSIONS

SED requested that Blade provide its expert opinion as to whether it agreed or disagreed with a number of Mr. Carnahan's statements. Mr. Carnahan's statements with Blade's comments are listed below.

- Carnahan Statement 1: "[Public Advocates Office's] allegations presuppose that the Vertilog technology at that time [1988] was reliable and accurate. That is not the case."[39]

In response to an SED Data Request, Blade disagreed with this statement,[40] with a detailed explanation, including:

> Although Mr. Carnahan describes the working principles of the Vertilog, he fails to provide the context that MFL and eddy current technology for the use of corrosion inspection were well established in oil and gas pipeline operations.
>
> Blade continues,
>
> Mr. Carnahan's assertion is that Vertilog was unreliable and inaccurate and combined with other factors, would not have prevented the SS-25 incident. His basis for finding the Vertilog unreliable and inaccurate is derived from

[38] Carnahan testimony, p. 28, line 23 to p. 29, line 2.

[39] Carnahan testimony, pp. 1-2.

[40] Blade Response to SED Data Request 58, Response 2.1.1, May 15, 2020 p. 6

his numerical comparison of five (5) Vertilogs from 1988-1990 to various HRVRT and USIT logs run in 2013 and 2016-2018. This is an approach that would not have been available to SoCalGas in the late 1980s or early 1990s. Certainly, logging technology of 2010s would be expected to be more accurate than that of late 1980s and early 1990s. However, this does not mean that the older logging tools did not provide useful or actionable information.[41]

Blade also noted that "Even if Blade accepted Mr. Carnahan's statement as true, it would not change any of the conclusions Blade reached in its Root Cause Analysis (RCA)."[42]

- Carnahan Statement 2: "While useful to a certain extent, the Vertilog technology circa 1988 suffered from certain substantial deficiencies."[43]

In response to an SED Data Request, Blade stated it disagreed with this statement,[44] explaining that, "The Vertilog circa 1988 was useful because it could be used to assess casing integrity in terms of the location and severity of metal loss."[45] Blade also stated that Mr. Carnahan's statement does not change the conclusions of the RCA, even if accepted as true.[46]

- Carnahan Statement 3: "For example, the Vertilog technology did not provide a method for differentiating isolated pitting from general corrosion."[47]

When SED asked Blade a data request about this statement, Blade stated that it disagreed with it.[48] When asked to explain, Blade stated, "The Vertilog was capable of differentiating general corrosion from isolated pitting." Blade provided

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[41] Blade Response to SED Data Request 58, Response 2.1.1 May 15, 2020 pp. 6-8.

[42] Blade Response to SED Data Request 58, Response 2.1.1, May 15, 2020 p. 10.

[43] Carnahan testimony, pp. 3 to 4.

[44] Blade Response to SED Data Request 58, Response 2.2.1, May 15, 2020, p. 11.

[45] Blade Response to SED Data Request 58, Response 2.2.1, May 15, 2020, p. 11.

[46] Blade Response to SED Data Request 58, Response 2.2.1, May 15, 2020, p. 11.

[47] Carnahan testimony, p. 4.

[48] Blade Response to SED Data Request 58, Response 2.3.1, May 15, 2020, p. 11.

further support for this statement.[49] Blade added that even if accepted as true, Mr. Carnahan's statement does not change Blade's RCA conclusions.[50]

- Carnahan Statement 4: "Another problem with Vertilog is that there are multiple permutations associated with the analysis of metal loss at any given depth, resulting in inherent uncertainty when interpreting the results."[51]

When SED asked Blade a data request about this statement, Blade stated that it disagreed with it.[52] Blade explained in part that,

> Casing inspection logs of all types can be processed and analysed using different criteria and assumptions. There is inherent uncertainty in interpreting all casing inspection logs. The process is not automated with only one set of answers. Log analysts use their best judgement to provide most probable interpretations.[53]
>
> Blade added that even if it accepted any part of the statement as true, it would not have changed any of Blade's RCA conclusions.[54]

Carnahan Statement 5: "Additional flaws of Vertilog were its inability to distinguish between defects and hardware (such as centralizers and scratchers) and its difficulty interpreting corrosion located near the surface casing shoe."[55]

When SED asked Blade a data request about this statement, Blade stated that it disagreed with it. When asked to explain, Blade stated as follows:

> Blade would agree that the tool will have difficulty interpreting corrosion above, but not below, the shoe. Blade agrees with ". . .flaws of Vertilog were its inability to distinguish between defects and hardware (such as centralizers and scratchers)…". However, there is a key omission in Mr. Carnahan's testimony regarding the method in which the tool designers had

[49] Blade Response to SED Data Request 58, Response 2.3.1, May 15, 2020, p. 11.

[50] Blade Response to SED Data Request 58, Response 2.3.1, May 15, 2020, p. 12.

[51] Carnahan testimony, p. 5.

[52] Blade Response to SED Data Request 58, Response 2.4.1, May 15, 2020, p. 12.

[53] Blade Response to SED Data Request 58, Response 2.4.1, May 15, 2020, p. 13.

[54] Blade Response to SED Data Request 58, Response 2.4.1, May 15, 2020, p. 13.

[55] Carnahan testimony, p. 7.

envisioned solving this issue. References [5, 6] describe the use of accurate casing records to address the interpretation of centralizers and scratchers.[56]

Blade added more detail and documentation to this explanation. Blade added that even if it accepted Mr. Carnahan's statement as true, it would not have changed any of Blade's conclusions in the RCA.[57]

- Carnahan Statement 6: "The SS-25 fracture surface exhibits clear chevron marks at a number of locations. Chevron marks denote the direction of propagation of cracks in steels – the apex of the chevron points toward the fracture origin (Figure 14). Chevron marks on the SS-25 fracture surface show clearly that the circumferential fracture is an extension of the axial fracture (Figure 15). This interpretation is consistent with remarkably similar chevron marks shown in a textbook on failure analysis (Figure 16).71."[58]

SED asked Blade if Blade agreed with this statement or not, and Blade stated that it disagreed, explaining,

Blade disagrees with Mr. Carnahan's testimony because he does not show with metallurgical evidence, the extension of the axial fracture to the circumferential parting. Therefore, there is no metallurgical evidence to support the interpretation that axial rupture and circumferential parting are one event."[59]

At SED's questioning, Blade said it does not accept any part of Mr. Carnahan's statement as true. Blade added that if it accepted the statement as true, then it would only change Blade's interpretation on the failure sequence, but not the failure analysis conclusions.[60]

- Carnahan Statement 7: "Blade's contention that a separate fracture origin exists on the circumferential portion of the fracture is incorrect (Figure 17). Rather than a fracture origin, this area is merely a continuation of the circumferential portion of the fracture. Fracture surface markings within the

[56] Blade Response to SED Data Request 58, Response 2.5.1, May 15, 2020, p. 13.

[57] Blade Response to SED Data Request 58, Response 2.5.1, May 15, 2020, p. 13.

[58] Carnahan testimony, p. 24, lines 7-11.

[59] Blade Response to SED Data Request 58, Response 2.8.1, May 15, 2020, p. 20.

[60] Blade Response to SED Data Request 58, Response 2.8.1, May 15, 2020, p. 23.

hypothesized origin are the same as or similar to those outside of the origin."[61]

SED asked Blade if it agreed or not with this statement, and Blade stated it disagreed, explaining as follows:

> An examination of the chevron marks in Figure 17 (i.e., Figure 68 in Blade's Main Report, page 72), showed that the features inside the origin were different from chevron marks outside the origin. The examination identified an area (the origin) that was absent of chevron marks but had chevron marks on either side pointing towards it. For clarity, white dashed lines have been added to outline the chevron marks that point back towards to the origin from either side of the origin. This observation is consistent with the illustration, Figure 14, provided by Mr. Carnahan.[62]

Blade also said it does not accept any part of Mr. Carnahan's statement as true. If Blade were to accept Mr. Carnahan's primary assertion that the vertical rupture and the circumferential part were one event, then it would only change Blade's interpretation on the failure sequence. However, it would not change the failure analysis conclusions.[63]

- Carnahan Statement 8: "The Blade report says nothing about how this alleged fracture origin came into existence. If the origin was created during the casing manufacturing process or by a sub-critical crack growth mechanism such as fatigue or stress-corrosion, the surface of the origin would appear distinctly different."[64]

SED asked Blade if it agreed or disagreed with this statement, and Blade said it disagreed, explaining that:

> Blade disagrees with Mr. Carnahan's testimony because there is a SEM micrograph in the Blade supplementary report that clearly identifies the

[61] Carnahan testimony, p. 24, lines 11-14.

[62] Blade Response to SED Data Request 58, Response 2.9.1, May 15, 2020, pp. 23-24.

[63] Blade Response to SED Data Request 58, Response 2.9.1, May 15, 2020, pp. 24.

[64] Carnahan testimony, p. 24, lines 15-17.

circumferential fracture origin. This has not been referenced or discussed in Mr. Carnahan's testimony."[65]

In this data response, Blade added significant detail and documentation referencing its Root Cause Analysis in further support of its reasoning. While Blade stated it did not accept any part of Mr. Carnahan's statement to be true, Blade also noted that even if true, Mr. Carnahan's statement would not change any of the RCA conclusions.[66]

- Carnahan Statement 9: "Blade's inability to determine the size of alleged fracture original (they report it as 5.22 mm deep and either 14.54 mm long or 21.72 mm long [footnote omitted]) is inconsistent with the absence of features identifying it as an origin."[67]

When SED asked Blade if it agreed or disagreed with this statement, Blade stated that it disagreed, explaining that:

> Blade did identify two semi elliptical areas as possible critical crack sizes (origin) for the circumferential parting based on thorough examination with the stereo microscope and SED; it was 5.22 mm deep and either 14.54 mm long or 21.72 mm long. The exact length is later established in the Blade report as 21.72 mm long."[68]

Blade provides additional detail and documentation in further support. When SED asked, Blade also answered that it does not accept any part of Mr. Carnahan's statement as true, but even if Blade were to accept the statement as true, it would not change any of the RCA conclusions.[69]

- Carnahan Statement 10: "Blade's scanning electron microscope (SEM) photos of the hypothesized origin show predominantly cleavage features. [Footnote omitted.] Blade reported that no noticeable changes in fracture mode were observed outside of the origin [Footnote omitted.] and their SEM photographs corroborate this. As such, the hypothesized origin must

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[65] Blade Response to SED Data Request 58, Response 2.10.1, May 15, 2020, pp. 24-25.

[66] Blade Response to SED Data Request 58, Response 2.10.1, May 15, 2020, pp. 24-25.

[67] Carnahan testimony, p. 24, lines 18-19.

[68] Blade Response to SED Data Request 58, Response 2.11.1, May 15, 2020, pp. 27.

[69] Blade Response to SED Data Request 58, Response 2.11.1, May 15, 2020, pp. 27.

have been created by mechanical force in the same manner as the circumferential parting."[70]

SED asked Blade if Blade agreed or disagreed with this statement, and Blade said it disagreed, explaining that,

> Because the circumferential parting had initiated from a crack-like surface flaw at a temperature below the steel ductile to brittle transition temperature (DBTT), the micro fracture mode would be cleavage. . .As discussed previously, data from all aspects of the failure (metallurgical, loads, temperatures) should be integrated to deliver a precise interpretation. Just interpreting metallurgical data alone is inadequate. A comprehensive interpretation is crucial to identifying the fracture sequence.[71]

Blade added more detail to support this answer. Blade also was asked and responded that, "Blade does not accept any part of Mr. Carnahan's statement as true. . .However, it would not change the failure analysis conclusions. . .It would not change any of the RCA conclusions."[72]

- Carnahan Statement 11: "Blade's analysis of the circumferential parting is logically flawed. According to Blade's analysis and calculations, the origin was required for circumferential parting to occur as a separate event. But the fracture mode of the origin is the same as that of the circumferential parting, begging the question as to how the origin came into existence since mechanical loads were insufficient to cause a separate circumferential parting in the absence of the origin."[73]

When SED asked Blade whether it agreed or disagreed, SED stated it disagreed, explaining that

> Blade's analysis of the circumferential parting followed well-established guidelines for determination of the failure origin, and the evidence of discontinuity of chevron marks between circumferential parting and axial rupture provide a sound scientific basis to conclude that the circumferential parting occurred as a separate event. The circumferential fracture mode was

[70] Carnahan testimony, p. 24, lines 20-23.

[71] Blade Response to SED Data Request 58, Response 2.12.1, May 15, 2020, p. 29.

[72] Blade Response to SED Data Request 58, Response 2.12.1, May 15, 2020, p. 30.

[73] Carnahan testimony, pp. 24 line 24 to 25, line 2.

a temperature driven process, consequently, the origin has cleavage features that is consistent with fracture under low temperatures."[74]

Blade added detail to this answer, including reference to its main and supplementary reports.

Blade was asked by SED, and answered that it does not accept any part of Mr. Carnahan's statement as true. However, Blade said it would not change the failure analysis conclusions even if it was true.[75]

- Carnahan Statement 12: "For there to have been a circumferential fracture separated in time from the vertical fracture, the vertical fracture would have to arrest (stop). There is no fractographic evidence showing arrest of the vertical fracture extending upward from the area of the burst. The vertical fracture extending downward from the area of the burst arrested most likely because it was approaching thicker material at the casing threaded connection."[76]

When asked whether it agreed or disagreed with this statement, Blade said it disagreed, explaining that despite Mr. Carnahan raising that there is no fractographic evidence showing arrest of the vertical feature extending upward from the area of the burst, Blade did provide extensive macro and micro fractographic evidence showing arrest of the vertical feature extending upward from the area of the burst.[77] Blade noted that Mr. Carnahan raised an issue stating that, "the vertical fracture extending downward from the area of the burst arrested most likely because it was approaching thicker material at the casing threaded connection."[78] Blade stated and explained why it disagreed with this statement as well, citing extensively to its RCA documents.[79] When asked, Blade added that it does not accept any part of Mr. Carnahan's statement as true and added, "If Blade

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[74] Blade Response to SED Data Request 58, Response 2.13.1, May 15, 2020, pp. 30-31.

[75] Blade Response to SED Data Request 58, Response 2.13.1, May 15, 2020, p. 31.

[76] Carnahan testimony, p. 25, lines 2-6

[77] Blade Response to SED Data Request 58, Response 2.14.1, May 15, 2020, pp. 32-36.

[78] Blade Response to SED Data Request 58, Response 2.14.1, May 15, 2020, p. 36.

[79] Blade Response to SED Data Request 58, Response 2.14.1, May 15, 2020, p. 36.

were to accept Mr. Carnahan's assertion then it would only change Blade's interpretation on the failure sequence. However, it would not change the failure analysis conclusions."[80]

- Carnahan Statement 13: "The 7-in. casing did not have to become cold for the circumferential fracture to occur. The fracture that extended vertically upward from burst area did not require cooling of the material. Similarly, no further cooling would be required for this fracture to change direction and propagate circumferentially."[81]

When asked whether Blade agreed or disagreed with the statement, Blade disagreed, explaining that,

> Mr. Carnahan's testimony 'The 7-in. casing did not have to become cold for the circumferential fracture to occur' ignores the evidence provided in Blade's Main Report, is subjective, and without any basis. The fact is, as stated on page 55 in Blade's Main Report, that 'the circumferential parting was brittle, which was different from the axial rupture." Blade agrees with Mr. Carnahan's statement that "The fracture that extended vertically upward from burst area did not require cooling of the material." However, Blade stated that it, "disagrees with Mr. Carnahan's statement 'Similarly, no further cooling would be required for this fracture to change direction and propagate circumferentially'. This statement is not relevant to the failure at SS-25."[82] Blade stated that "Blade does not accept any part of Mr. Carnahan's conclusion in the above statement. . .Mr Carnahan's testimony, if accepted to be true in its totality, it would not change the failure analysis conclusions."[83]

- Carnahan Statement 14: "There is no mechanical reason for the upward extending vertical fracture to arrest. The stress intensity at the tip of the fracture, essentially the driving force for fracture, was increasing as the fracture became longer."[84]

SED asked Blade whether it agreed or disagreed with this statement, and Blade said it disagreed, providing a detailed explanation in support, complete with

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[80] Blade Response to SED Data Request 58, Response 2.14.1, May 15, 2020, pp. 36-37.

[81] Carnahan testimony, pp. 25, lines 6-9.

[82] Blade Response to SED Data Request 58, 2.15.1, May 15, 2020, pp. 37 to 38.

[83] Blade Response to SED Data Request 58, Response 2.15.1, May 15, 2020, p. 38.

[84] Carnahan testimony, p. 25, lines 9-11.

reference to the RCA Reports, and scholarly articles. Blade added that it does not accept any part of Mr. Carnahan's statement as true. Blade stated that even if it were to accept Mr. Carnahan's statement as true, then it would only change Blade's interpretation on the failure sequence, but it would not change the failure analysis conclusions.[85]

- Carnahan Statement 15: "Some temperature surveys over the years reported possible slight leakage in the vicinity of the production casing shoe and noise logs were run following a number of these temperature surveys. SoCalGas performed noise logs in SS-25 on the following ten dates: September 8, 1978, December 11, 1978, August 8, 1979, November 24, 1981, February 23, 1983, April 11, 1984, July 27, 1984, November 7, 1991, November 7, 2006, and June 1, 2012. None of these noise logs indicate a gas leak in the production casing. None of these noise logs indicate a gas leak in the production casing or at the production casing shoe."[86]

When SED asked Blade if it agreed or disagreed with this statement, Blade said that it agrees with the part of the statement that said, "None of these noise log indicate a gas leak in the production casing." However, Blade disagreed with the part of the statement that said, "None of these noise logs indicate a gas leak. . .at the production casing shoe."[87] At SED's prompting, Blade explained that "One of the noise logs, performed on April 11, 1984, identified a possible leak near the production casing shoe."[88] Blade added more detail to this response. When asked if any of the statements it accepted as true changed the conclusions Blade reached in its Root Cause Analysis, Blade said no.[89]

- Carnahan Statement 16: "The same six logs also measured noise across all four frequency ranges slightly above the packer and completion equipment at the base of the well, and across the storage formation. Such noise is expected and is associated with movement of gas in the storage formation

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[85] Blade Response to SED Data Request 58, Response 2.16.1, May 15, 2020, pp. 38-40.

[86] Carnahan Testimony, p. 29, lines 5-10.

[87] Blade Response to SED Data Request 58, Response 2.19.1, May 15, 2020, p. 43.

[88] Blade Response to SED Data Request 58, Response 2.19.1, May 15, 2020, p. 43.

[89] Blade Response to SED Data Request 58, Response 2.19.1, May 15, 2020, p. 43.

and through the completion equipment. The 1991 log includes operator comments regarding noise interpreted as "bubbling" at a depth of about 7,500 ft., which is shown in the excerpt of the log in Figure 22. As can be seen in the figure, the noise log was repeated over the depth range of 7,200 ft. to 7,600 ft. and the indicated bubbling noise was not detected."[90]

When SED asked Blade if it agreed or disagreed with this statement, Blade stated that it disagreed with the first sentence in this quoted passage.[91] Blade explained that "Not all the logs were run across the packer, completion equipment and storage formation."[92] Blade added more detail to this explanation. Blade also responded to SED that the statement would not have changed any of the conclusions to Blades RCA Report.[93]

VIII. BLADE ACCEPTED CERTAIN OF CARNAHAN'S STATEMENTS AS TRUE, BUT SUCH STATEMENTS WOULD NOT CHANGE BLADE'S RCA CONCLUSIONS

While accepting certain of Mr. Carnahan's other statements as true, Blade said it would not change any conclusions reached in its Root Cause Analysis. Such statements are listed here.

- "Pressure testing is intended to detect existing casing leaks, not wall loss."[94]
- "The cooling shown on the SS-25 temperature logs at this depth was not indicative of a leak. The movement of gas into or out of the storage zone always causes localized cooling; indeed, cooling behavior where a storage well meets the reservoir has been well known for many years, as can be seen in Figure 19."[95]

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[90] Carnahan Testimony, p. 30 lines 6-11.

[91] Blade Response to SED Data Request 58, Response 2.25.1, May 15, 2020, p. 45.

[92] Blade Response to SED Data Request 58, Response 2.25.1, May 15, 2020, p. 49.

[93] Blade Response to SED Data Request 58, Response 2.25.1, May 15, 2020, p. 50.

[94] Carnahan Testimony, p. 20; Blade Response to SED Data Request 58, Response 2.6.1, May 15, 2020, p. 14-15.

[95] Carnahan Testimony, pp. 28-30; Blade Response to SED Data Request 58, Response 2.17.1, May 15, 2020, p. 41.

- "All storage wells at Aliso Canyon exhibit the same or similar cooling at that depth. For example, Figure 20 shows that Fernando Fee 32A and Porter 72A both exhibit cooling at the bottom of the wells, and the same is true for SS-25A and SS-25B (Figure 21)."[96]
- "A radioactive tracer survey performed on July 29, 1984 reported possible slight leakage behind pipe from top perf at 8510 ft up to around 8430 ft and 8190 ft. This survey indicates gas flowing up to the bottom of the cap rock at approximately 8182 ft and into the permeable S1 formation."[97]
- "The noise logs display four curves, representing sound at frequencies of 200 Hz, 600 Hz, 1,000 Hz, and 2,000 Hz, respectively. Low frequency noise (200 and 600 Hz) is usually indicative of surface noise or low rate flow of fluids behind casing. High frequency noise (1,000 and 2,000 Hz) is usually indicative of the flow of gas, bubbling of gas in liquids, or high-rate gas flow. The interpretation of noise logs is well-established: a sharply-defined, high-frequency noise over a short length of casing is an indication of a gas leak."[98]
- "There are no such sharply-defined, high-frequency noises over short lengths of casing in the SS-25 noise logs that would indicate the presence of a gas leak. In some of the logs, there is a noticeable sharp peak in noise, but these were caused by the operators testing the noise logging tool prior to entering the completion equipment at or below 8,000 ft., and these operator tests are clearly labelled on the logs (see, e.g., November 24, 1981 log)."[99]
- "SoCalGas performed the noise log of December 11, 1978 from 5,800 to 7,770 ft., and that log measured no anomalous noise. The logs of November 7, 2006 and June 1, 2012 were performed for the entire length of the well and measured no anomalous noise."[100]

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[96] Carnahan Testimony, p. 29 lines 3-5; Blade Response to SED Data Request 58, Response 2.18.1, May 15, 2020, pp. 42-43.

[97] Carnahan Testimony, p. 29 lines 10-13; Blade Response to SED Data Request 58, Response 2.20.1, May 15, 2020, pp. 45-46.

[98] Carnahan Testimony, p. 29 lines 13-17; Blade Response to SED Data Request 58, Response 2.21.1, May 15, 2020, pp. 46.

[99] Carnahan Testimony, p. 29, lines 18-21; Blade Response to SED Data Request 58, Response 2.22.1, May 15, 2020, pp. 46-47.

[100] Carnahan Testimony, p. 29, line 22 to 30 line 2; Blade Response to SED Data Request 58, Response 2.23.1, May 15, 2020, p. 47.

"SoCalGas performed the remaining noise logs performed in 1978, 1979, 1981, 1984 (2 runs), and 1991 to assess potential leaks. All logs measured generally shallow low frequency noise (200 to 600 Hz). These low-frequency measurements are interpreted to originate from surface noise at the Aliso Canyon site or operations in nearby wells, which is common and described by McKinley [1995].84 The 1978 log includes operator comments referencing surface noise."[101]

[101] Carnahan Testimony, p.30, lines 3-6 ; Blade Response to SED Data Request 58, Response 2.24.1, May 15, 2020, pp. 48.