CORNUCORNIA Containment Data Report

B. Hudson
T. Stubbs
R. Heinle

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CORNUCOPIA Instrumentation Summary

Instrumentation	Fielded	Data Return	Present in this Report
<u>Plug Emplacement</u>	yes	yes	yes
<u>Radiation</u>	yes	yes	yes
<u>Pressure</u>			
Stemming	yes	yes	yes
Challenge	yes	yes	yes
Cavity	yes	yes	yes
Atmospheric	yes	yes	yes
<u>Motion</u>			
Free field	no	-	-
Surface	yes	yes	yes
Plug	yes	yes	yes
Stemming	yes	yes	yes
Surface casing	yes	yes	yes
Emplacement pipe	yes	yes	yes
Recording trailer	yes	yes	yes
<u>Hydroyield (a)</u>	yes	yes	no
<u>Collapse (b)</u>	yes	yes	yes
<u>Stress</u>	yes	yes	yes
<u>Strain (c)</u>	yes	yes	yes
<u>Other Measurements (d)</u>	yes	yes	yes

- (a) CORRTEX in emplacement hole.
(b) EXCOR in emplacement hole.
(c) On emplacement pipe during stemming
(d) Displacement array between casing and plug

Event PersonnelContainment Physics

B. Hudson	LLNL
E. Woodward	LLNL
J. Kalinowski	EG&G/AVO
T. Stubbs	EG&G/AVO

Instrumentation

T. Woehrle	LLNL
D. Reid	EG&G/AVO
R. Spilsbury	EG&G/NVO
P. Tanner	EG&G/NVO

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1. Event Description

1.1 Containment summary

The CORNUCOPIA event was detonated in hole U2gas of the Nevada Test Site (see figure 1.1) at 08:05 PDT on July 24, 1986. A collapse to the ground surface occurred at about 9 hours after detonation resulting in a crater with a mean diameter of 137.5 m and a maximum depth of 16.9 m.

No radiation arrivals were detected above the ground surface and containment of CORNUCOPIA was satisfactory.

1.2 Site

A geologic map showing some of the surface features near the U2gas site is shown in Figure 1.2. The device had a burial depth of 381 m in the mixed alluvium of Area 2, about 180 m above the static water level (SWL). The corresponding geologic cross sections are shown in figure 1.3⁽¹⁾.

Stemming of the 2.74 m diameter emplacement hole followed the plan shown in figure 1.4. A log of the stemming operations was maintained by Holmes & Narver, Inc.⁽²⁾.

1.3 Instrumentation

Figure 1.5 shows a schematic layout of the instrumentation designed to monitor stemming emplacement and performance. Plugs within the stemming column consisted of three sanded gypsum concrete (SGC) structures and two "sandwiches" of LLNL fines, gypsum mud concrete, and LLNL fines. Emplacement of each of the three SGC plugs was monitored with temperature and conductivity probes. Stemming performance was monitored by at least one pressure and radiation station in each of the four coarse stemming regions between the containment plugs: three stations were fielded in the coarse stemming layer between the deepest SGC plug and the deepest sandwich plug. Radiation was also monitored about 3 m below the top surface of the bottom plug, near the location of the cable fan-out.

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The pressure challenging the bottom plug was monitored through two hoses that extended from the coarse stemming above the plug through the fines layer below it. Pressure transducers were fielded on the tops of both hoses and on one of the hoses, in the plug and near its lower surface.

Pressure in the explosion-produced cavity was monitored through six pressurized, fluid-filled, stainless steel tubes extending from above the bottom plug to near the working point. Results of these measurements are reported in reference 3.

Hydrodynamic yield of the device, as well as chimney formation, were monitored by two CORTEX/EXCOR cables (figure 1.5). Results of the hydrodynamic yield measurements are reported elsewhere⁽⁴⁾.

Vertical motion was monitored in the stemming at each of the pressure and radiation stations, in the top two SGC plugs, on the surface casing, on the top of the emplacement pipe, and 0.61 m in the ground surface at a range of 15.24 m from Surface Ground Zero (SGZ). The standard transducers in all of these stations were variable reluctance accelerometers and velocimeters. For evaluation, piezoresistive accelerometers were fielded in the stations mounted on the surface casing and in the ground surface. At the request of the nuclear chemistry group, six vertical motion stations were fielded on the gas sample hose at depths roughly corresponding to the locations of the stemming pressure and radiation stations. Triaxial motion of the recording trailer was also measured.

A proximity switch array was mounted in the top plug at the location of the bottom of the surface casing to detect relative motion between the plug and casing and relative displacement between an anchor in the ground surface and the gas sample hose was monitored by a transducer emplaced by the Nuclear Chemistry group.

A new version of a fluid-coupled stress gauge⁽⁵⁾ was tested at two locations in the bottom stemming plug.

Brief histories of the instrumentation set-up and fielding operations are given in references 6 and 7.

Figure 1.1 Map of the Nevada Test Site indicating the location of hole U2gas and the surrounding events.

Figure 1.3 Geologic cross sections through hole U2gaS. A site description is given in reference 1.

Figure 1.4 As-built stemming plan for hole U2gas, the CORNUCOPIA event emplacement hole.

Figure 1.5 As-built containment instrumentation plan for U2gas, the CORNUCOPIA event emplacement hole.

2. Emplacement

2.1 Pipe strain

Strain gauges were bonded to the emplacement pipe about 1 m above the diagnostics canister (station 81) and to the final pipe section below the load collar (station 87) with each station comprising two separate transducers. The final engineering report (reference 6) indicated that problems were encountered with these gauges: "The Pipe Strain Gages at the same elevations never agreed with each other. Neither of the gages at both elevations appeared to read accurately." Samples of the records returned are shown in Figure 2.1

2.2 Plug levels and temperature

As shown in figures 1.4 and 1.5, two "gas impedance plugs" were poured between the two deepest SGC plugs. Each of these elements was composed of gypsum cement slurry sandwiched between two layers of LLNL stemming fines. The emplacement of each of the five plugs was monitored with conductivity and temperature probes at locations tabulated in figure 1.5. Figures 2.2–2.6 show plots of the SGC and gypsum slurry emplacement and associated temperature histories. All plugs were satisfactorily emplaced.

Figure 2.1 Emplacement pipe strain histories at stations 81 and 87 during stemming as returned from the field. It was reported⁽⁶⁾ that all of the pipe strain transducer readings were questionable.

Figure 2.2 Sanded gypsum emplacement for the first plug. In the upper figure, the upper and lower plug boundaries were determined with a tag line (open circles); solid symbols indicate the probe elevations. Partially filled symbols represent probe elevations that were not reported in the stemming log. Probes labeled B, E, and H included temperature sensors.

Figure 2.3 Gypsum slurry emplacement for the second plug. In the upper figure, the upper and lower plug boundaries of the slurry plug were determined with a tag line (open circles); solid symbols indicate the probe elevations. Although the instrumentation plan (figure 1.5) calls out eight conductivity probes, the stemming log (reference 2) notes only four as being activated. Partially filled symbols represent probe elevations that were not reported in the stemming log.

Figure 2.4

Gypsum slurry emplacement for the third plug. In the upper figure, the upper and lower plug boundaries of the slurry plug were determined with a tag line (open circles); solid symbols indicate the probe elevations. Although the instrumentation plan (figure 1.5) calls out eight conductivity probes, the stemming log (reference 2) notes only four as being activated. Partially filled symbols represent probe elevations that were not reported in the stemming log.

Figure 2.5 Sanded gypsum emplacement for the fourth plug. In the upper figure, the upper and lower plug boundaries were determined with a tag line (open circles); solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors.

Figure 2.6 Sanded gypsum emplacement for the fifth (top) plug. In the upper figure, the upper and lower plug boundaries were determined with a tag line (open circles); solid symbols indicate the probe elevations. Probes labeled B, D, and F included temperature sensors.

3. Stemming Performance

3.1 Pressure and radiation

As indicated in Figure 1.5, the region between each of the stemming plugs was monitored by pressure and radiation stations. The analog signals were transmitted up-hole and then recorded on magnetic tape in the recording trailer.

Gas pressure challenging the bottom plug was measured at station 35 (mounted between the first and second plugs and connected to the region below the first plug through a hose extending to below the first plug). A second pressure transducer (station 30), also connected to this hose, was mounted within and near the bottom of the bottom plug. The lower end of this hose remained open to the environment through a braided wire rope grid.

Both challenge pressure and radiation were monitored (station 33) through a second hose that was pressurized pre-event with dry nitrogen to about 70 psia. The lower end of this hose (beneath the fines underlayment of the bottom plug) was capped with a fiber glass bottle designed to be broken by the shock wave, allowing access to the pressure present in the coarse stemming.

All pressure and radiation transducers reported information until collapse at about 9 hours after detonation at which time signals from all stations below the top plug were lost. Figures 3.1–3.9 show the pressure and radiation histories from a few minutes before detonation to a short time after collapse. Radiation arrivals in the coarse stemming column are more clearly seen in figure 3.10 where the data are plotted to the first 1500 s after detonation. Solid diamonds indicate the suggested times of arrival at each station. The bottom panel shows the data collected in the coarse stemming immediately above the deepest SGC plug while the top panel shows data from each of the inter-plug coarse stemming layers.

Cavity pressure measurements taken at stations 51–53 (figure 3.11) are analyzed in reference 3 and will not be further discussed here except to note that cavity pressure closely matches challenge pressure at times near collapse. This is shown in the bottom plot of figure 3.11.

Barometric pressure was monitored at a station buried 0.61 m in the ground surface at the recording trailer park. Data obtained from this station are shown in figure 3.12.

Figure 3.1 Challenge pressure as measured below the first SGC plug (station 30) and radiation as measured in the first SGC plug near its top (station 31). Radiation appears to arrive at about 170 s at station 31.

Figure 3.2 Pressure and radiation histories measured in the coarse stemming above the first SGC plug (station 32 at 289.6 m depth). Radiation appears to arrive at about 60 s.

Figure 3.3 Radiation and challenge pressure histories measured in the pressurized hose through the first SGC plug (station 33 at 286.5 m depth). Radiation appears to arrive at about 340 s.

Figure 3.4 Pressure and radiation histories measured in the coarse stemming above the bottom SGC plug (station 34 at 280.4 m depth). Radiation appears to arrive at about 280 s.

Figure 3.5 Radiation and challenge pressure histories measured in the hose through the first SGC plug (station 35 at 274.3 m depth). Radiation appears to arrive at about 440 s.

Figure 3.6 Pressure and radiation histories measured in the coarse stemming below the second plug (station 36 at 268.2 m depth). This plug was composed of a "sandwich" of LLNL fines, gypsum mud concrete, and LLNL fines. Radiation appears to arrive at about 280 s.

Figure 3.7 Pressure and radiation histories measured in the coarse stemming below the third plug (station 37 at 231.6 m depth). This plug was composed of a "sandwich" of LLNL fines, gypsum mud concrete, and LLNL fines. Low level radioactive material arrivals were observed at this station at about 400 s.

Figure 3.8 Pressure and radiation histories measured in the coarse stemming below the fourth plug (station 38 at 176.8 m depth). This plug was composed of SGC. There is a possible low level radiation arrival at this station at about 750 s.

Figure 3.9 Pressure and radiation histories measured in the coarse stemming below the top SGC plug (station 39 at 50.3 m depth). No radiation arrival was seen at this station.

Figure 3.10 Composite of the radiation histories in the coarse stemming indicating the first arrival of radiation at each station. Arrivals are indicated by solid diamonds.

Figure 3.11 Cavity pressure measurements (stations 51, 52, and 53). The pressure challenging the bottom plug (station 33) is also shown along with that of station 53. See also figure 3.3.

Figure 3.12 Barometric pressure measured at the ground surface in the trailer park. Zero time is relative to the detonation of CORNUCOPIA.

3.2 Motion

3.2.1 Shock-Induced

Figures 3.13–3.31 show the first five seconds of explosion-induced vertical motion as measured in the emplacement hole. Ordering of the figures is according to station distance from the working point (inversely to depth). Only station 21 is expected to represent accurately the motion of the surrounding medium, stations 31–39 should approximate it, and stations 41–46 (mounted to the gas sample hose which is expected to survive collapse) measure only the motion of that structure. Station 61 monitored the vertical motion of the ground surface at a depth of 0.91 m and a horizontal range of 15.24 m from SGZ. Explosion-induced data derived from this station are shown in figure 3.32. The triaxial motion of the recording trailer is shown in figures 3.33–3.35.

Characteristics of the motion are given in table 3.1 and characteristics of the motion transducers are given in tables 3.2 and 3.3.

Table 3.1 Summary of Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (cm)	Displacement Residual (cm)
21av	237.7	58(a), 117	1.2	0.56	9.7	-18
21uv		119	-	0.56	10.0	-15
22av	345.3	85(a), 184	0.47, 6.4(b)	0.52	7.7	-35
22uv		185	-	0.70	11.0	-22
23av		100(a), 212	1, 8.5(b)	0.65	10.3	-22
23ac	381.0	100(a), 210	1, 10.3(b)	0.68	11.2	-17
23uv		100(a), 210	-	0.66	10.5	-15
24av	382.8	95	130	17.6	154	80
24uv		95, 120	-	(c)	(c)	(c)
31av	68.6	28(d)	780	48	300(e)	(e)
32av	91.4	42	212	24.5	380	320
33av	94.5	45(d)	182	24.7	450	430
34av	100.6	48(d)	9(f), 90	18.5	275	220(d)
35av	106.7	50(d)	8(f), 59	20	360	350(d)
36av	112.8	55(d)	5(f), 31	12.0	180	150
37av	149.4	40(g), 74(d)	3.1(f), 2.6	3.3	57	25
38av	204.2	53(g), 100(d)	1.9	0.74	14	-90
39av	330.7	85, 175	1, 5.9(b)	0.64	10	-12

(a) Emplacement pipe or strongback–stemming interaction.

(b) Slap-down peak.

(c) Out of band.

(d) Approximate.

(e) Probable uncorrectable offset

(f) Precursor.

(g) Unknown arrival source

Table 3.1 Summary of Motion (continued)

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (cm)	Displacement Residual (cm)
41av	73.2	40	575	58	(c)	(c)
42av	93.0	40	10 ^(f) , 225	22.7	272	(e)
43av	112.8	45	3.7 ^(f) , 33	12	185	170 ^(d)
44av	149.4	45	2.5 ^(f) , 15.8	2.7	420	(e)
45av	205.7	58	2.0 ^(f) , 10	0.7	13.0	-25
46av	326.1	90	3	0.5	8.0	-25
61av		223	1.0, 24.5 ^(b)	0.45, 1.0	6.7	-32
61ac	380.7	225	1.5, 30.5 ^(b)	0.77, 0.90	13.0	-40
61uv		230	-	0.61, 1.15	12.0	-10
71av	†	255	5	1.3	9.5	-15
71uv	†	290	-	1.3	9.5	-19
71ar	†	250	3.6	0.35	12	8
71ur	†	250	-	0.35	12	5.5
71at	†	280	-1.25	-0.25	2.0	-2
71ut	†	?	-	-0.25	2.4	0.5

(a) Emplacement pipe or strongback–stemming interaction.

(b) Slap-down peak.

(c) Out of band.

(d) Approximate.

(e) Probable uncorrectable offset

(f) Precursor.

(g) Unknown arrival source

† In recording trailer, range approximately 426 m.

Table 3.2 Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
21av	225	0.65	8
22av	260	0.67	8
23av	225	0.8	15
23ac	2265-25(a)		15
24av	900	0.65	120
31ac	2264-5000(a)		1875
32av	2260-M12(a)		675
33av	2260-M12(a)		625
34av	2262a-200(a)		250
35av	2260-M12(a)		625
36av	2262a-200(a)		250
37av	2262-25(a)		63.5
38av	2262-25(a)		25
39av	2262-25(a)		25
41av	1550	0.75	1600
42av	1400	0.75	400
42av	950	0.65	160
44av	620	0.75	30
45av	240	0.65	8
46av	230	0.65	8
47av	620	0.65	30
61av	620	0.65	30
61ac	2262-25(a)		30
71av	350	.65	15
71ar	410	0.85	15
71at	300	0.55	15

(a) Piezo-resistive elements; manufacturers model number

Table 3.3 Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (°C)	Operate Temperature (°C)	System Range (m/s)
21uv	3.561	9.59	25.65	53.53	6
22uv	3.410	10.54	25.24	57.66	6
23uv	3.677	8.77	25.51	16.95	8
24uv	3.617	10.33	25.16	19.66	12
61uv	3.478	10.44	25.47	22.97	8
71uv	3.515	9.28	25.75	17.75	7
71ur	3.334	9.40	24.95	17.75	5
71ut	3.315	9.29	25.01	17.75	5

Figure 3.13 Explosion-induced vertical motion of the bottom SGC plug at a depth of 312.4 m (station 31).

Figure 3.14 Explosion-induced vertical motion in the coarse stemming of the gas sample hose at a depth of 307.9 m (station 41).

Figure 3.15 Explosion-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 289.6 m (station 32).

Figure 3.16 Explosion-induced vertical motion in the coarse stemming of the gas sample hose at a depth of 288.0 m (station 42).

Figure 3.17 Explosion-induced vertical motion at the top of a challenge pressure hose at a depth of 286.5 m (station 33).

Figure 3.18 Explosion-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 280.4 m (station 34).

Figure 3.19 Explosion-induced vertical motion at the top of a challenge pressure hose at a depth of 274.3 m (station 35).

Figure 3.20 Explosion-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 268.2 m (station 36).

Figure 3.21 Explosion-induced vertical motion in the coarse stemming of the gas sample hose at a depth of 268.2 m (station 43).

Figure 3.22 Explosion-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 231.7 m (Station 37).

Figure 3.23 Explosion-induced vertical motion in the coarse stemming of the gas sample hose at a depth of 231.7 m (station 44).

Figure 3.24 Explosion-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 176.8 m (station 38).

Figure 3.25 Explosion-induced vertical motion in the coarse stemming of the gas sample hose at a depth of 175.3 m (station 45).

Figure 3.26 Explosion-induced vertical motion in the coarse stemming of the SGC plug at a depth of 146.3 m (station 21). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.27 Explosion-induced vertical motion in the coarse stemming of the gas sample hose at a depth of 54.9 m (station 46).

Figure 3.28 Explosion-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 50.3 m (station 39).

Figure 3.29 Explosion-induced vertical motion in the coarse stemming of the SGC plug at a depth of 35.7 m (station 22). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.30 Explosion-induced vertical motion of the surface casing (station 23). Records annotated with an 'a' are derived from the primary accelerometer; 'c', the secondary accelerometer; and 'v', the velocimeter.

Figure 3.31 Explosion-induced vertical motion of the top of the emplacement pipe (station 24). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.32 Explosion-induced vertical motion in the ground surface at a depth of 0.91 m and a horizontal distance of 15.24 m from Surface Ground Zero (station 61). Records annotated with an 'a' are derived from the primary accelerometer; 'c', the secondary accelerometer; and 'v', the velocimeter.

Figure 3.33 Explosion-induced vertical motion of the recording trailer (station 71). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.34 Explosion-induced horizontal-radial motion of the recording trailer (station 71). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.35 Explosion-induced horizontal-transverse motion of the recording trailer (station 71). Records annotated with an 'a' are derived from the accelerometer.

3.2.2 Collapse

The motion data during collapse are shown in figures 3.36–3.51, again ordered by distance from the working point. Collapse was not meaningfully recorded by stations 31, 41, 42, and 43. Signals from the variable reluctance transducers mounted in station 23 survived for only about 1.5 s after collapse slap–down while all other channels in and above the top plug survived until recording was halted. A total displacement of about 15 m derived from stations 22, 23, and 61 correlates well with the surveyed value of 16.9 m.

Collapse slap–down was observed at 32,356.3 s (8 hr, 59 min., 16.3 s) after detonation at station 22 (figure 3.48). A vertical, linear array of seven proximity switches was mounted in the top SGC plug next to the bottom of the surface casing. Switch states labeled "closed" imply the nearby presence of ferrous metal (surface casing) and "open"; its absence. No change of switch state was noted until the time of surface collapse and then only switches "b" and "c" registered a change of state. Figure 3.52 shows the switch closure history around collapse time. Because of their inactivity, switch channels a, d, e, f, and g were digitized at very slow rate (about 7 samples per second) while switches b and c were sampled at a rate of 1 KHz around the time of transition to obtain a greater time resolution of the closures. The constant outputs from channels e, f, and g are approximately the same as that of channel d and are, for clarity, omitted from figure 3.52. Correlation of the proximity switch data and the collapse slap–down peak strongly suggests that the collapse moved the plug material 10 ± 5 cm farther into the casing. (The switches had a vertical separation of 5.08 cm.)

Collapse progression was monitored by two EXCOR cables, one mounted on the emplacement pipe (91) and the other (92) in the stemming column. Figure 3.53 shows the position of the lower end of the cables as a function of time. Also shown are the times of occurrence of first indication of collapse from the motion stations (the "butterflies") and the time of proximity switch closure (station 85). For clarity, only the stations near the top of the hole and stations that were "free–floating" in the coarse stemming are represented.

3.2.3 Relative Motion of Gas Sample Hose

Relative motion between the gas sample hose and an anchor in the ground surface was monitored by a Genisco reel type transducer. This had a full range of about 18 m and was initially set at an extension 3.59 m. The time scale of figure 3.54 scale precludes the visibility of the jump increase at zero time of about 0.1 m.

Figure 3.36 Collapse-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 289.6 m (station 32).

Figure 3.37 Collapse-induced vertical motion in the coarse stemming at the top of a challenge pressure hose at a depth of 286.5 m (station 33). These data are likely influenced by the section of gas sample hose attached to the sensor station.

Figure 3.38 Collapse-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 280.4 m (station 34).

Figure 3.39 Collapse-induced vertical motion in the coarse stemming at the top of a challenge pressure hose at a depth of 274.3 m (station 35). These data are likely influenced by the section of gas sample hose attached to the sensor station.

Figure 3.40 Collapse-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 271.3 m (station 36).

Figure 3.41 Collapse-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 231.6 m (station 37).

Figure 3.42 Collapse-induced vertical motion on the gas sample hose at a depth of 231.6 m (station 44).

Figure 3.43 Collapse-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 176.8 m (station 38).

Figure 3.44 Collapse-induced vertical motion on the gas sample hose at a depth of 175.3 m (station 45).

Figure 3.45 Collapse-induced vertical motion of the SGC plug at a depth of 146.3 m (station 21). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.46 Collapse-induced vertical motion on the gas sample hose at a depth of 45.9 m (station 46).

Figure 3.47 Collapse-induced vertical motion in the coarse stemming of the emplacement hole at a depth of 50.3 m (station 39).

Figure 3.48 Collapse-induced vertical motion of the top SGC plug at a depth of 35.7 m (station 22). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.49 Collapse-induced vertical motion of the surface casing (station 23). Records annotated with an 'a' are derived from the primary accelerometer; 'c', the secondary accelerometer; and 'v', the velocimeter.

Figure 3.50 Collapse-induced vertical motion of the top of the emplacement pipe (station 24). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.51 Collapse-induced vertical motion of the ground surface at a depth of 0.61 m and horizontal range of 15.24 m from SGZ (station 22). Records annotated with an 'a' are derived from the primary accelerometer; 'c', the secondary accelerometer; and 'v', the velocimeter.

Figure 3.52 Proximity switch closure history. Switches a and d remained in their respective initial states and were sampled at about one sample per second. Switches e, f, and g remained in the same state as d and, for clarity, are omitted. The vertical separation between each switch was 5.08 cm.

Figure 3.53 Position of the bottom of the EXCOR cables. Station 91 was on the emplacement pipe while 92 was on the pendant; we have no explanation for the late signal from station 92. The first indications of collapse motion at the motion stations are indicated by the "butterflies" while the proximity switch closures is indicated by the filled circle.

Figure 3.54 Relative displacement of the gas sample hose and the surface casing. Initial gauge displacement reading is 3.59 m with a 10 cm jump to 3.69 m occurring near to zero time. The time scale precludes the visibility of the initial value.

4 Other Measurements

4.1 Geophone station in the trailer park

Figure 4.1 shows the data as recorded on a high sensitivity accelerometer and a geophone mounted in the ground surface of the trailer park (station 63). The accelerometer underwent unexplained, random baseline offsets thus voiding the readings from this instrument.

4.2 Stress in the bottom plug

Biaxial stress and strain transducers⁽⁴⁾ were mounted at two elevations in the bottom SGC plug. The active elements for stress were Ytterbium while the strain elements were composed of Constantan. Orientation of station 1 was as if strain were a vector quantity and the radial and transverse components were to be measured. The two orientations of the elements of station 2 were not relative to the working point, but were mutually orthogonal. Amplitudes of the records shown in figures 4.2 and 4.3 are given in percent change of gauge resistance since the gauge factor of Ytterbium is uncertain.

The stress wave should arrive at these stations no earlier than 40 ms suggesting that the waveform seen on all transducers starting at detonation time is probably due to coupling of the EMP into the transducer system. Due to its magnitude and duration, this common signal appears to interfere with the stress and strain data in an irremovable manner.

Figure 4.1 Data from the vertical geophone and sensitive accelerometer mounted in the ground surface at the recording trailer (station 63). The history of the accelerometer is in question.

Figure 4.2 Stress and strain as measured in the bottom SGC plug (station 1, depth = 419.1 m). Amplitudes are in percent change of transducer resistance. A common signal, beginning at zero time and continuing into the expected data region (after 40 ms), reduces the value of the data represented here.

Figure 4.3 Stress and strain as measured in the bottom SGC plug (station 2, depth = 416.1 m). Amplitudes are in percent change of transducer resistance. A common signal, beginning at zero time and continuing into the expected data region (after 40 ms), reduces the value of the data represented here.

References

1. Steven R. Clark and Nancy W. Howard, "U2gas Site Characteristics Report", CP 84-79, Lawrence Livermore National Laboratory, Livermore, CA, August 22, 1984.
2. Alfred E. Burer, "Containment Report for U2ga(s)", Holmes & Narver, NTS:A2:86-59, July 22, 1986.
3. B. C. Hudson, et. al., "CORNUCOPIA Cavity Pressure Measurement", Fourth Symposium on Containment of Underground Nuclear Explosions, Colorado Springs, Colorado, 9/21-24, 1987
4. LLNL contacts for additional information: R. Heinle (CORRTEX data).
5. J. Kalinowski, T. Stubbs, L. Davies, and B. Hudson, "Recent stress gage developments", Range Commanders Council, Telemetry Group, 4-6 July, 1985, Monterey, California.
6. Richard A. Spilsbury, "Special Measurements Final Engineering Report for CORNUCOPIA, U2gas", EG&G, Energy Measurements, Las Vegas, NV, SM:86E-135-39.
7. Richard A. Spilsbury, "Special Measurements Physics/Instrumentation package for CORNUCOPIA, which reflects the As-Built Final Revision" EG&G, Energy Measurements, Las Vegas, NV, SM:86E-135-38.

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