VILLE Containment Data Report

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March 1995

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Work performed under the auspices of the Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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VILLE Instrumentation Summary

Instrumentation	Fielded on this Event	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	no	-	-
Atmospheric	no	-	-
<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
<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	?
<u>Other Measurements (d)</u>	yes	yes	?

- (a) CORTEX or SLIFER in emplacement hole.
- (b) EXCOR or CLIPER in emplacement hole.
- (c) Emplacement pipe.
- (d) Gas temperature.

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1. Event Description

1.1 Site

The VILLE event was detonated in hole U4am of the Nevada Test Site as indicated in Fig. 1.1. A plan view map of the local region around hole U4am indicating the inferred faults and drill holes is shown in figure 1.2. The device had a depth-of-burial of 293 m in the alluvium of Area 4, about 240 m above the standing water level (SWL), as shown in Figure 1.3⁽¹⁾. Stemming of the 2.44 m diameter emplacement hole followed the plan shown in Fig. 1.4. A log of the stemming operations was maintained by Holmes & Narver⁽²⁾.

Detonation time was 08:15 PDT on June 13, 1985 and about 28 minutes later the chimney collapsed to the surface leaving a crater with a mean radius of 59.7 m and a maximum depth of 17.3 m.

No radiation arrivals were detected in the emplacement hole and the VILLE containment was considered successful.

1.2 Instrumentation

Figure 1.5 is a schematic layout of the instrumentation designed to monitor the emplacement procedures and stemming performance of the VILLE event.

Three of the five stemming plugs (the first, fourth and fifth) were composed of coarse gypsum aggregate in a gypsum cement slurry. Each of these three gypsum-filled-aggregate (GFA) plugs was monitored during emplacement with arrays of conductivity probes and thermistors. The remaining two plugs were soft, coal tar aggregate (CT/A) gas seal membranes having a thickness of about 1.5 m sandwiched between layers of fines material. A layer of CT/A was poured on the top of each of the top two GFA plugs.

The coarse stemming beneath every plug except the third was instrumented with pressure and radiation stations. Included in this were three stations designed to monitor the pressure and radiation challenging the bottom plug (plug 1). Station 32 was mounted about 25 m above the top of plug 1 and connected to the environment below the plug through a section of gas sample hose (about 45 m long). Station 31 was connected to the same hose,

but mounted in the plug near its bottom surface. A second section of gas sample hose extended below the plug from a location near the plug center where station 88 was located. This hose was pre-pressurized to about 60 psi before the event. The deepest soft CT/A plug was instrumented below, within and above for pressure, radiation and vertical motion. Similar stations containing pressure, radiation and vertical motion sensors were fielded below the top two GFA plugs and in the stemming between the bottom plug and the deepest CT/A plug.

Vertical motion was monitored in plugs 4, and 5, on the surface casing, on the top of the emplacement pipe, and at 0.61 m depth in the ground surface, 15.24 m from SGZ. Displacement between the surface casing and the top plug was monitored by an array of proximity switches located in the plug at the bottom of the surface casing.

Stress and strain of the bottom two plugs (both the GFA and CT/A elements) was monitored at four stations.

Data from each of the above transducers were transmitted to the recording trailer by an analog system and recorded on magnetic tape.

Two CLIPER/CORRTEX sensors were emplaced, as indicated in figure 1.5, to measure the hydrodynamic yield of the device and to monitor cavity collapse and chimney formation. Results of the yield measurements are reported elsewhere⁽³⁾.

A history of the fielding operations of the instrumentation, including the emplacement pipe strain measurements, is outlined in reference 4. Details of the instrumentation are given in reference 5.

Figure 1.1 Map of the Nevada Test Site indicating the location of hole U4am.

Figure 1.2 Plan view map of the U4am site.

LEGEND

- QTma - Mixed alluvium
- Tp - Paintbrush Tuff
- Tbg - Grouse Canyon Airfall
- Ttb - Tunnel Beds and older tuffs
- Pz - Paleozoic rocks
- SWL - Static water level
- ? - Gravity & seismic inferred faults

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Figure 1.3 Geologic cross sections through hole U4am.

Figure 1.4 As-built stemming plan for the event VILLE in Hole U4am.

2. Emplacement

2.1 Pipe strain

Figure 2.1 is the strain history measured on the emplacement pipe during stemming of the VILLE experiment. The emplacement pipe was instrumented with a strain gage station on the final pipe section just below the load collar (Station 87).

2.2 Plug levels and temperature

The emplacement of each of the three gypsum concrete plugs was monitored with an array of dielectric and conductivity probes and thermistors. The locations of the probes are tabulated in figure 1.5. The upper and lower boundary positions of the plugs were determined by tag lines. Figures 2.2 through 2.4 contain plots of the arrival times of the GFA slurry as a function of depth (as determined from the conductivity probes and tag lines) and GFA temperature histories. A temperature sensor was located at the approximate mean depth of each concrete plug. These data indicate that all plugs were emplaced as planned.

Figure 2.1 Strain measurements during the stemming at stations 87 (near the top of the pipe).

Figure 2.2. Emplacement diagnostics data at GFA plug 1. The upper and lower boundaries of the plug were determined with a tag line. Solid symbols indicate the elevation of the probes, shaded symbols indicate only the elevations of probes that were not contacted (the contact times are fictional), and the open symbols are at the tag depths. A temperature sensor was located at probe "C".

Figure 2.3. Emplacement diagnostics data at GFA plug 4. The upper and lower boundaries of the plug were determined with a tag line. Solid symbols indicate the elevation of the probes, shaded symbols indicate only the elevations of probes that were not contacted (the contact times are fictional), and the open symbols are at the tag depths. A temperature sensor was located at probe "B".

Figure 2.4. Emplacement diagnostics data at GFA plug 5. The upper and lower boundaries of the plug were determined with a tag line. Solid symbols indicate the elevation of the probes, shaded symbols indicate only the elevations of probes that were not contacted (the contact times are fictional), and the open symbols are at the tag depths. A temperature sensor was located at probe "B".

3. Stemming Performance

3.1 Radiation and Pressure

As seen in figure 1.5, the region near each GFA plug (except the deepest) was monitored by pressure and radiation stations. The signals were transmitted to the recording trailer in analog form and recorded on magnetic tape for later processing.

Pressure and radiation histories from a few seconds before detonation until loss of signal at cavity collapse (about 28 minutes later) are shown in figures 3.1–3.9.

Challenge pressure was monitored at three stations (88, 31 and 32; figures 3.1, 3.3 and 3.4, respectively). A direct comparison of the wave forms from stations 88 and 32 is shown in figure 3.10 wherein it is indicated that the two sensors register a difference of about 3 psi over the entire time span (after the initial pressurization of station 88 is eliminated). This pressure difference may be due the different mounting conditions of the stations: both were at the end of sections of gas sample hoses with the hose of station 32 being 32.6 m longer than that of station 88, including 24 m in the coarse stemming. No explanation is made for the wave form seen at station 31 (monitoring the same gas sample hose as station 32), which was expected to resemble those of stations 88 and 32.

Pressure measured in the coarse stemming on either side of the deepest CT/A gas seal plug (stations 33 and 35; figures 3.5 and 3.7, respectively) indicate that a pressure differential of about 3 psi was maintained across the plug. The pressure within the soft CT/A plug 2 was monitored by station 34 (figure 3.6). Essentially no pressure was registered at this station.

No radiation above ambient was observed at any station in the emplacement hole.

All pressure and radiation data are consistent with satisfactory containment.

Figure 3.1 Pressure challenging the deepest plug (station 88) at a depth of 246.9 m. Gas pressure was sensed through a section of wire rope (gas sample hose) that was pre-pressurized to about 57 psi. Sensor was emplaced within the GFA plug at a depth of 239.3 m. Signals were lost at collapse time (1675 s).

Figure 3.2 Pressure and radiation measured in the coarse stemming between the deepest GFA plug 1 and the gas seal plug 2 (Station 30 at 210.3 m depth). Signals were lost at collapse time (1675 s).

Figure 3.3 Pressure challenging the deepest plug (station 31) at a depth of 246.9 m. Gas pressure was sensed through a section of wire rope (gas sample hose). Sensor was emplaced within the GFA plug at a depth of 244.8 m and on the same hose that accommodated station 32. Signals were lost at collapse time (1675 s).

Figure 3.4 Pressure and radiation challenging the deepest plug (station 32) at a depth of 246.9 m. Gas pressure was sensed through a section of wire rope (gas sample hose). Sensor was emplaced within the coarse stemming above the deepest GFA plug at a depth of 206.7 m and on the same hose that accommodated station 31. Signals were lost at collapse time (1675 s).

Figure 3.5 Pressure and radiation in the coarse stemming below gas seal plug 2 at a depth of 204.8 m (station 33). Signals were lost at collapse time (1675 s).

Figure 3.6 Pressure and radiation measured in gas seal plug 2 at a depth of 199.6 m (station 34). Signals were lost at collapse time (1675 s). The low level of pressure obtained from within the soft plug is questionable.

Figure 3.7 Pressure and radiation measured in the coarse stemming above gas seal plug 2 at a depth of 194.5 m (station 35). Signals were lost at collapse time (1675 s).

Figure 3.8 Radiation measured in the coarse stemming below GFA plug 4 at a depth of 108.2 m (station 36). The pressure transducer was off-line pre-shot. Signal was lost at collapse time (1679 s).

Figure 3.9 Pressure and radiation measured in the coarse stemming below the top GFA plug at a depth of 45.0 m (station 38). Signals were lost at collapse time (1681 s).

Figure 3.10 Comparison of challenge pressure wave forms sensed at stations 88 and 32.

3.2 Explosion-Induced Motion

Explosion-induced motion histories obtained from the VILLE experiment are shown in figures 3.11-3.24. Characteristics of the motion and of the motion transducers are given in tables 3.1-3.3.

The signal at station 4 near the bottom of the bottom GFA plug at a depth of 244.7 m (figure 3.11) exceeded the system dynamic range of 2500 g's at about 66 ms. Values quoted for this station in table 3.1 represent the motion occurring before this time.

Motion from all stemming stations below GFA plug 4 (30, 32, 33, 35, and 36) showed a large component of noise leading to uncertainty in the final derived displacement and, in some instances, the peak of the acceleration. A circuit breaker associated with the signal conditioning system for the accelerometers of stations 21, 22, 23, 5, 61 and 71 failed at about 0.75 s invalidating the data at later times for these channels.

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	195.2	49, 107	2.1	0.33	7	(a)
21uv		-	-	0.4(b)	6.5	-5
22av	257.0	150	1.2	0.48	6.9	(a)
22uv		-	-	0.48	6.7	-3
23av	292.4	114, 178	1.7(b)	0.5	7.4	(a)
23uv		-	-	0.5	7.0	-1
30av	82.1	50	33	8.1(c)	93	20(d)
32av	85.7	53	21	6.2(c)	72	80(d)
33av	87.6	123	19	5.8(c)	67	(e)
34av	92.8	50(d)	25	7.5(c)	94	73(d)
35av	97.9	50(d)	7	3.7(c)	42	50(d)
36av	184.2	46(f)	0.2	0.13	1.9	-5
38av	247.4	68, 150	0.2, 0.4	0.14, 0.19	2.8	-0.5
4av	47.6	22, 47	100, 2600	7, 133, (g)	(g)	(g)
5av	293	143	135	10	15, 63	(a)
5uv		-	-	9.6	74	62
61av	292.8	185	2.6	0.5	73	(a)
61uv		-	-	0.5	6.3	1
71av	326.9(h)	218	1.4	0.52	6.7	(a)
71uv		-	-	0.52	6.2	-5

(a) Signal terminated at about 0.75 s.

(b) Noisy signal: peak may be in error.

(c) Maximum value.

(d) Approximate.

(e) Could not estimate.

(f) Early arrival.

(g) Signal out of band: integral in error.

(h) Station in recording trailer; range approximate.

Table 3.2 Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
21av	174	0.85	8
22av	270	0.63	25
23av	310	0.7	25
30ac	(a)	(b)	500
32av	(a)	(b)	500
33av	(a)	(b)	500
34av	(a)	(b)	200
35av	(a)	(b)	150
36av	(a)	(b)	10
38av	(a)	(b)	50
4av	(c)		2500
5av	940	0.75	150
61av	428	0.75	30
71av	250	0.7	8

(a) Piezoresistive element: mounted resonance ≥ 2000 Hz.

(b) Manufacturer's specification: damping ratio = 0.7.

(c) Unknown characteristics: transducer supplied by Sandia.

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)
5uv	3.737	28.26	25.96	39.34	30
21uv	3.597	8.27	26.23	37.77	6
22uv	3.407	9.90	26.48	40.26	10
23uv	3.584	9.24	25.93	36.26	10
61uv	3.434	10.38	26.18	22.93	10
71uv	3.253	11.75	25.25	22.56	4

Figure 3.11 Vertical motion of the deepest GFA plug at a depth of 244.75 m (station 4). The peak of the signal at about 0.15 s exceeds the dynamic range of the system and the integral at times greater than this cannot be believed. This sensor was supplied by Sandia.

Figure 3.12 Vertical motion of the stemming between the deepest GFA plug 1 and the deepest gas seal plug 2 (station 30 at a depth of 210.3 m).

Figure 3.13 Vertical motion of the stemming below the deepest gas seal plug 2 (station 32 at a depth of 206.7 m). This station was attached to a section of gas sample hose.

Figure 3.14 Vertical motion of the stemming below the deepest gas seal plug 2 (station 33 at a depth of 204.8 m).

Figure 3.15 Vertical motion of the deepest gas seal plug 2 (station 34 at a depth of 199.6 m).

Figure 3.16 Vertical motion of the stemming above the deepest gas seal plug 2 (station 35 at a depth of 194.5m).

Figure 3.17 Vertical motion of the stemming below GFA plug 4 (station 36 at a depth of 108.2 m).

Figure 3.18

Vertical motion of GFA plug 4 (station 21 at a depth of 97.2 m). Traces annotated with "a" are derived from the accelerometer.

Figure 3.19 Vertical motion of the stemming below the top GFA plug 5 (station 38 at a depth of 45.0 m).

Figure 3.20 Vertical motion of the top GFA plug 5 (station 22 at a depth of 35.4 m). Traces annotated with "a" are derived from the accelerometer.

Figure 3.21 Vertical motion of the surface conductor (station 23). Traces annotated with "a" are derived from the accelerometer.

Figure 3.22 Vertical motion of the top of the emplacement pipe (station 5). Traces annotated with "a" are derived from the accelerometer.

Figure 3.23

Vertical motion of the ground surface (station 61 at a horizontal range of 15.24 m and a depth of 0.9 m). Traces annotated with "a" are derived from the accelerometer.

Figure 3.24 Vertical motion of the recording trailer (station 71 at a horizontal range of about 327 m). Traces annotated with "a" are derived from the accelerometer.

3.3 Collapse phenomena

Collapse motion histories are shown in figures 3.25-3.37. All stations below the top plug were lost at collapse between 1675 and 1681 s. All stations in and above the top plug survived collapse. Station 22 (figure 3.33) was mounted in the concrete of the GFA plug, 0.3 m above the bottom of the surface casing.

Both CLIPER cables (station 91 and 92) performed as expected, giving the lower position of each cable end as a function of time during the cavity collapse. These data are shown in figure 3.38 along with selected displacement wave forms (not to vertical scale). The CLIPER history suggest that there was a final failure in the top plug near the bottom of the surface casing. The displacement histories from stations 22 and 61 shown in figure 3.38 suggest that all material fell as a unit after the collapse front reached the surface casing. Figure 3.39 displays the displacement histories of the top plug (station 22), the surface casing (station 23), and the emplacement pipe (station 5). There does not seem to be any separation between the surface casing and the plug, at least until the sensor at station 23 exceeds its dynamic range and the histories of station 22 and 23 cease to track. The emplacement pipe begins its motion at about 1679 s, the time the collapse reaches GFA plug 4 as shown in figure 3.38.

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 "on" imply the nearby presence of ferrous metal (surface casing) and "off"; its absence. No change of switch state was noted until the time of surface collapse and then switches "a", "b", "c" and "d" registered a change of state (switch "c" was lost at collapse time). Figure 3.40 shows the switch closure history around collapse time. Correlation of the proximity switch data and the collapse slap-down peak suggests that the collapse drove the switch array 15 ± 5 cm into the casing. (The switches had a vertical separation of 5.08 cm.)

Figure 3.25 Collapse motion of the stemming between the deepest GFA plug 1 and the deepest gas seal plug 2 (station 30 at a depth of 210.3 m). Signal was lost at about 1676 s.

Figure 3.26

Collapse motion of the stemming below the deepest gas seal plug 2 (station 32 at a depth of 206.7 m). This station was attached to a section of gas sample hose. Signal was lost at about 1675.5 s.

Figure 3.27 Collapse motion of the stemming below the deepest gas seal plug 2 (station 33 at a depth of 204.8 m). Signal was lost at about 1675.5 s.

Figure 3.28 Collapse motion of the deepest gas seal plug 2 (station 34 at a depth of 199.6 m). Signal was lost at about 1675.5 s.

Figure 3.29

Collapse motion of the stemming above the deepest gas seal plug 2 (station 35 at a depth of 195.5 m). Signal was lost at about 1677.5 s.

Figure 3.30 Collapse motion of the stemming below GFA plug 4 (station 36 at a depth of 108.2 m). Signal was lost at about 1679 s.

Figure 3.31 Collapse motion of GFA plug 4 (station 21 at a depth of 97.2 m). Signal was lost at about 1679 s.

Figure 3.32 Collapse motion of the stemming below the top GFA plug 5 (station 38 at a depth of 45.0 m). Signal was lost at about 1671 s.

Figure 3.33 Collapse motion of the top GFA plug 5 (station 22 at a depth of 35.4 m).

Figure 3.34

Collapse motion of the surface conductor (station 23). The velocity signal exceeded the dynamic range of the system so the final displacement is greater than that shown.

accelerometer signal lost at about + 0.75 s

Figure 3.35 Collapse motion of the top of the emplacement pipe (station 5).

Figure 3.36 Collapse motion of the ground surface (station 61 at a horizontal range of 15.24 m and a depth of 0.9 m). Velocity amplitude was greater than system range so final displacement is greater than that shown.

accelerometer signal lost at about + 0.75 s

Figure 3.37 Collapse motion of the recording trailer (station 71 at a horizontal range of about 327 m).

Figure 3.38

Progression of collapse in stemming column as indicated by CLIPER data (stations 91 and 92). Also shown are selected displacement wave forms (not to vertical scale) from five stations in the emplacement hole and one station on the ground surface.

Figure 3.39 Comparison of the displacement histories of the top GFA plug, surface casing and emplacement pipe.

Figure 3.40 Proximity switch array behavior during collapse. No switch state change was observed prior to this time.

4. Other Measurements

4.1 Gas temperature in the challenge pressure hose

Temperature of the gas within the section of gas sample hose connecting station 32 with the coarse stemming below the first GFA plug was monitored at station 32. The temperature history thus obtained is shown in figure 4.1. The data at times later than 100 s are suspect.

4.2 Stress and strain in the deepest plugs

Stress measurements were made in the bottom GFA plug and in the bottom CT/A gas seal plug. The resulting wave forms are shown in figures 4.2 - 4.8. Amplitudes of these records are given in percent change of initial gauge resistance.

The sensor of station 4 (at 244.7 m depth in the GFA plug, figure 4.2) was a fluid-coupled disk supplied by Sandia Corporation.

Bi-axial stress and strain transducers⁽⁶⁾ were mounted at two elevations in the bottom GFA plug and at one location in the bottom CT/A. The active elements for stress were Ytterbium while the strain elements were composed of Constantan. Figures 4.3, 4.5, and 4.7 show the raw transducer outputs while figures 4.4, 4.6, and 4.8 show the "corrected" stress derived from these records. The polarity of the sensors is such that the strain component of the Ytterbium is removed by a simple addition of the Constantan output multiplied by the ratio of the strain gage factors (1.57 in this case).

The stress wave should arrive at these stations no earlier than 40 ms suggesting that the wave form seen on stations 1, 2, and 3 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 Temperature as monitored in the challenge pressure hose (station 32).

Figure 4.2 Stress in the deepest GFA plug as monitored by a Sandia fluid-coupled disk transducer at a depth of 244.7 m (station 4).

Figure 4.3 Bi-axial stress and strain in the deepest GFA plug at a depth of 242.3 m (station 1). Ytterbium data are NOT corrected for strain.

Figure 4.4 Bi-axial stress and strain in the deepest GFA plug at a depth of 242.3 m (station 1). Stress data are corrected for strain.

Figure 4.5 Bi-axial stress and strain in the deepest GFA plug at a depth of 236.2 m (station 2). Ytterbium data are NOT corrected for strain

Figure 4.6 Bi-axial stress and strain in the deepest GFA plug at a depth of 236.2 m (station 2). Stress data are corrected for strain.

Figure 4.7 Bi-axial stress and strain in the deepest gas seal (soft) plug at a depth of 199.6 m (station 3). Ytterbium data are NOT corrected for strain

Figure 4.8 Bi-axial stress and strain in the deepest gas seal (soft) plug at a depth of 199.6 m (station 3). Stress data are corrected for strain.

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