CABOC

Containment Data Report

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CABOC Instrumentation Summary

Instrumentation	Fielded on this Event	Data Return	Present in this Report
<u>Plug Emplacement</u>	yes	yes	yes(a)
<u>Radiation</u>	yes	yes	yes
<u>Pressure</u>			
Stemming	yes	yes	yes
Challenge	no	-	-
Cavity	no	-	-
Atmospheric	no	-	-
<u>Motion</u>			
Free Field	no	-	-
Surface	yes	yes	yes
Plug	yes	yes	yes
Stemming	no	-	-
Surface Casing	no	-	-
Emplacement Pipe	no	-	-
<u>Hydroyield (b)</u>	no	-	-
<u>Collapse (c)</u>	yes	yes	yes
<u>Stress</u>	no	-	-
<u>Strain(d)</u>	yes	yes	no
<u>Other Measurements</u>	no	-	-

- (a) Description only.
(b) CORTEX and/or SLIFER in emplacement hole.
(c) EXCOR or CLIPER in emplacement hole.
(d) Strain load on emplacement pipe.

Event Personnel

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1. Event Description

1.1 Site

The CABOC event was detonated in hole U2cp of the Nevada Test Site as indicated in figure 1.1. The CABOC device had a depth-of-burial (DOB) of 335 m in the Paintbrush Tuffs of area 2, about 200 m above the Paleozoic formation and 260 m above the standing water level, as shown in the geologic cross-sections of figures 1.2 and 1.3⁽¹⁾. Stemming of the 2.44 m diameter emplacement hole followed the plan shown in figure 1.4. A log of the stemming operations was maintained by Holmes & Narver⁽²⁾.

Detonation time was 13:05 PST on December ,1981, and subsurface collapse progressed to a depth of between 37 and 77 m at about 57 minutes after the detonation.

No radiation arrivals were detected above ground and the CABOC containment was considered successful.

1.2. Emplacement

There were four stemming plugs above the CABOC event, each composed of rigid two-part- epoxy (TPE). The original design of the plugs was to be a layer of TPE about 3.6 m thick, overlain with a 2 m thick layer of soft coal tar, aggregate (CTA) to act as a sealing membrane. The bottom plug TPE plug was about 4.5 m thick and did not properly cure, requiring an additional 3 m thick layer to be poured on top of the CTA. Thickness of the top plug TPE was 7.62 m, about 1.6 m of which extended below the surface casing. A drag ring was mounted to the emplacement pipe at the position of the bottom rigid plug and the emplacement pipe in the regions of the remaining three plugs was coated with hydroseal to allow free motion of the pipe through these plugs. Stemming between the plugs consisted of layers of fines and coarse gravel. The top of the hole (above the top plug) was filled with ground surface derived backfill and the emplacement pipe was grouted to the surface. See figure 1.4.

1.3 Instrumentation

Figure 1.5 is a schematic layout of the instrumentation designed to monitor the containment performance of the CABOC event.

Eleven stations were fielded in the stemming to monitor pressure and radiation. The stemming region about 3 m beneath each of the four plugs contained pressure and radiation stations as well as the region about 2 m above each of the plugs except the top. Additionally, elevations in the coarse stemming below fines layers between the lower three plugs and on either side of a fines layer about 25 m above the diagnostics canister were also monitored for pressure and radiation.

Standard LLNL vertical motion canisters, containing variable reluctance velocity and acceleration transducers, were emplaced in all four of the rigid stemming plugs, the ground surface, 15.24 m from SGZ, and in the recording trailer.

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

Two CLIPER sensors, one attached to the emplacement pipe and one to the instrumentation pendant were fielded to monitor cavity collapse and chimney formation. Three "D-cable" systems were fielded, one on the instrumentation pendant and two on the emplacement pipe to monitor the stemming emplacement and were recorded post-shot to sense collapse.

Yield measurements were not attempted as part of the containment measurements.

A history of the fielding operations of the instrumentation is outlined in reference 3. Further details of the instrumentation are given in reference 4.

Figure 1.1 Map of the Nevada Test Site indicating the location of hole U2cp.

Figure 1.2 Northeast-Southwest geologic cross section through hole U2cp.

Figure 1.3 Northwest-Southeast geologic cross section through hole U2cp.

Figure 1.4 As-built stemming plan for the event CABOC in Hole U2cp.

Figure 1.5 As-built containment instrumentation plan for the emplacement hole (U2cp) on the CABOC event.

2. Stemming Performance

2.1 Radiation and Pressure

Pressure and radiation stations were fielded on the CABOC at eleven locations as indicated in figure 1.5. The pressure and radiation wave forms from about 50 s before detonation until 3600 s after, recorded at all stations, are shown in figures 2.1-2.11.

Both the pressure and radiation signals from stations 31 and 32 (spanning the deepest fines layer, above the device canister) were lost at or shortly after detonation. The maximum reading of the radiation monitors is 5 volts corresponding to an artificial level of 10^9 R/Hr (the maximum level to which these devices were calibrated was 3.5×10^4 R/Hr). Station 34 was buried in the second pour of the bottom rigid TPE plug and is expected to yield no valid data. Data from these three stations are shown for completeness.

Pressure behavior monitored by all other stations at or near detonation time can be explained by motion of the formation and stemming. Station 41, just below the top plug, (figure 2.11) shows the effects of subsurface collapse and/or stemming fall and survived until recording was terminated about 24 hours after detonation (figure 2.12). The offsets in the radiation record of figures 2.11 and 2.12 is likely due to motion of the included reference source with respect to the detector.

No radiation arrival was detected above the bottom rigid plug before subsurface collapse, when all radiation signals except those from station 41, below the top plug, were lost (at about 3420 s).

The pressure and radiation data are consistent with satisfactory containment.

Figure 2.1 Pressure and radiation measured in the coarse stemming at a depth of 280.1 m, below the deep fines layer (station 31).

Figure 2.2 Pressure and radiation measured in the coarse stemming at a depth of 264.9 m, above the deep fines layer (station 32).

Figure 2.3 Pressure and radiation measured in the coarse stemming at a depth of 206.0 m, below the bottom rigid plug (station 33).

Figure 2.4 Pressure and radiation measured in the coarse stemming above the deepest rigid plug (station 34 at a depth of 194.8 m). The initial pour of TPE did not cure properly and a second layer was poured on top of the soft sealing layer. This section of TPE covered station 34, probably invalidating the readings therefrom.

Figure 2.5 Pressure and radiation measured in the coarse stemming at a depth of 173.4 m, below a fines layer (station 35).

Figure 2.6 Pressure and radiation measured in the coarse stemming at a depth of 145.9 m, below the second rigid plug (station 36).

Figure 2.7 Pressure and radiation measured in the coarse stemming at a depth of 135.3 m, above the second rigid plug (station 37).

Figure 2.8 Pressure and radiation measured in the coarse stemming at a depth of 113.4 m, below a fines layer (station 38).

Figure 2.9 Pressure and radiation measured in the coarse stemming at a depth of 86.0 m, below the third rigid plug (station 39).

Figure 2.10 Pressure and radiation measured in the coarse stemming at a depth of 75.3 m, above the third rigid plug (station 40).

Figure 2.11 Pressure and radiation measured in the coarse stemming at a depth of 39.6 m, below the top plug (station 41).

Figure 2.12 Pressure and radiation measured in the coarse stemming at a depth of 39.6 m, below the top plug (station 41). The full recording time of about 24 hours is displayed.

2.2 Motion

Explosion-induced histories of the motion measured on the CABOC event are shown in figures 2.13–2.18. Characteristics of the associated motion and transducers are given in tables 2.1–2.3.

Early arrivals in the acceleration records are seen at all down-hole stations with the most pronounced at station 21, in the deepest plug containing a drag ring on the emplacement pipe. This drag ring may have induced motion that interfered with the ground motion signal at early times. Since the pipe was coated with hydroseal in the regions of the TPE plugs at elevations higher than the drag ring, the pipe-induced motion at these higher stations was mitigated.

2.3 Collapse phenomena

Collapse-induced histories of the motion measured on the CABOC event are shown in figures 2.19–2.23. Collapse reached the ground surface 4068 s after detonation with slap-down occurring about 1.3 s later.

Progression of the collapse is shown in figure 2.24 by the position of the broken end of the CLIPER cables and representative histories of pressure and displacement. CLIPER station 91 was mounted on the device canister and the emplacement pipe while station 93 was mounted with the containment instrumentation pendant. There appears to be an unexplained time discrepancy (of about 2 s) between the CLIPER and the pressure and displacement histories. Station 91 indicated a single break at a depth of about 76 m (near the top of the third stemming plug) at a time of 3418.6 s with no subsequent change in cable length and is thus not shown in figure 2.24. D-cable information is not in a form that is usable to investigate the progression of the cavity collapse.

The pressure history during collapse of the station just below the top plug (station 41) suggests a stemming fall into the top of the chimney with a competent emplacement hole and top plug. This is shown in figure 2.25. A vacuum was created as the stemming fell away from the station and the maintenance of a reduced pressure for an extended period indicates low communication with higher pressure gas (ambient) in the formation.

Figure 2.13 Explosion-induced vertical motion of the bottom rigid plug (station 21, at a depth of 201.6 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces. The acceleration at early time shows strong motion induced by the emplacement pipe and the drag ring.

Figure 2.14 Explosion-induced vertical motion of the second rigid plug (station 22, at a depth of 141.2 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.15 Explosion-induced vertical motion of the third rigid plug (station 23, at a depth of 81.4 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.16 Explosion-induced vertical motion of the top plug (station 24, at a depth of 33.5 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.17 Explosion-induced vertical motion of the ground surface at a depth of 0.9 m and horizontal range of 15.24 m (station 61). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.18 Explosion-induced vertical motion of the recording trailer (station 71). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.19 Collapse-induced vertical motion of the bottom rigid plug (station 21, at a depth of 201.6 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces. This plug was firmly attached to the emplacement pipe by a drag ring.

Figure 2.20 Collapse-induced vertical motion of the second rigid plug (station 22, at a depth of 141.2 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.21 Collapse-induced vertical motion of the third rigid plug (station 23, at a depth of 81.4 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.22 Collapse-induced vertical motion of the top plug (station 24, at a depth of 33.5 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.23 Collapse-induced vertical motion of the ground surface at a depth of 0.9 m and horizontal range of 15.24 m (station 61). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.24 Progression of collapse as shown by the position of the break in the CLIPER cables. Station 93 was on the instrumentation pendant. Also shown are representative pressure and displacement wave forms (not to vertical scale).

Figure 2.25 Pressure history monitored during the subsurface collapse at station 41, below the top plug.

Table 2.1 Summary of Containment-Related Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (cm)	Displacement Residual (cm)
21av	133.4	30(a), 67(b)	6.3	4.1	46	40
21uv		33(a), 70	-	3.75	42	29
22av	193.9	47(a), 95	2.43	1.04	19.5	7.7
22uv		48(a), 100	-	1.15	20.4	8.5
23av	253.7	62(a), 131	1.54	0.70	16.4	6.3
23uv		65(a), 133	-	0.83	15.6	5.5
24av	301.5	76(a), 163	1.2, 3.3(c)	0.95	18.4	6.1
24uv		77(a), 164	-	0.87	16.5	1.6
61av	334.4	190	2.1, 6.3(c)	1.0	17.3	0.50
61uv		192	-	0.97	16.7	-1.8
71av	374(d)	227	3.8(e)	1.05	12.0	-12
71uv		228	-	0.94	11.9	-6.7

(a) Pipe-induced motion.

(b) Ground motion, may be influenced by pipe motion.

(c) Slap down.

(d) Station in recording trailer: range approximate.

(e) Peak due to noise in signal at 0.6 s.

Table 2.2 Containment-Related Accelerometer Characteristics

<u>Gauge</u>	<u>Natural Frequency (Hz)</u>	<u>Damping Ratio</u>	<u>System Range (g's)</u>
15av	520	0.65	50
22av	240	0.65	8
23av	151	0.75	4
24av	290	0.65	20
61av	550	0.65	30
71av	185	0.75	10

Table 2.3 Containment-Related Velocimeter Characteristics

<u>Gauge</u>	<u>Natural Frequency (Hz)</u>	<u>Time to 0.5 Amplitude (s)</u>	<u>Calibration Temperature (°F)</u>	<u>Operate Temperature (°F)</u>	<u>System Range (m/s)</u>
21uv	3.50	12.55	74.55	96.34	20
22uv	3.61	10.28	74.30	98.77	8
23uv	3.57	10.80	74.70	113.16	8
24uv	3.51	11.70	73.73	111.38	8
61uv	3.69	6.90	74.30	49.76	10
71uv	3.0	11.06	74.20	71.47	4

References

1. Gayle A. Pawloski, "U2cp Preliminary Site Characteristics Summary", DM 81-48, Lawrence Livermore National Laboratory, Livermore, CA, June 9, 1981.
2. George Kronsbein, "Containment Report for U2cp," Holmes & Narver, NTS:A2:81-118, December 14, 1981.
3. L. E. Davies, "Special Measurements Final Engineering Report CABOC, U2cp", EG&G, Energy Measurements, Las Vegas, NV, SM:81E-90-35, 18 February, 1982.
4. L. E. Davies, "Special Measurements Physics/Instrumentation Package for CABOC, U2cp, Revision 'A' (final)", EG&G, Energy Measurements, Las Vegas, NV, SM:81E-90-36, 18 February, 1982.