CHEEDAM

Containment Data Report

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CHEEDAM 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	yes	yes	yes
Emplacement Pipe	yes	yes	yes
<u>Hydroyield</u> (b)	yes	yes	no
<u>Collapse</u> (c)	yes	yes	yes
<u>Stress</u>	no	-	-
<u>Strain</u> (d)	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.

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1. Event Description

1.1 Site

The CHEEDAM event was detonated in hole U2et of the Nevada Test Site as indicated in figure 1.1. The CHEEDAM device had a depth-of-burial (DOB) of 342 m in the Tunnel Beds Tuffs of area 2, about 85 m above the Paleozoic formation and 240 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 09:00 PST on February 17, 1983, and collapse progressed to the surface at about 1.1 hour after detonation. The resulting crater had a mean radius of 57.9 m and a maximum depth of 10.0 m

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

1.2. Emplacement

Part of the device diagnostics of the CHEEDAM experiment was a mechanical neutron Pinex within the emplacement pipe. This required that the emplacement pipe be left open except for a series of pressure barriers between the region of the bottom rigid plug and the pinhole. The emplacement pipe was suspended from a break-away beam (to assure alignment of the enclosed neutron Pinex experiment) and held in place by explosive bolts. These bolts were detonated shortly after the execution of the CHEEDAM event. A section of the top of the pipe was enlarged to accommodate the mechanism required to recover the Pinex detector and shortly after the experiment it was removed from the pipe to a position outside of the potential collapse crater. The pipe below this region was closed by a ball valve to preclude possible leakage up the pipe.

The top three stemming plugs above the CHEEDAM event were composed of rigid two-part- epoxy (TPE) The plugs were about 6.4 m thick except for the middle which was about 2.7 m thick. A soft (about 1.8 m thick) layer of coal-tar and aggregate (LAE 59MY, denoted CTA) was poured on the top and bottom rigid plugs to act as a gas seal. A drag ring was mounted to the emplacement pipe at the position of the bottom rigid plug (below the position of the Pinex detector) and the upper two rigid plugs were coated with hydroseal in the regions of the upper two plugs to allow free motion of the pipe. An additional 4 m thick CTA layer was sandwiched between fines material about 60 m below the deepest rigid plug. 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 except for the top 3 m which was left open. See figure 1.4.

1.3 Instrumentation

Figure 1.5 is a schematic layout of the instrumentation designed to monitor the stemming performance of the CHEEDAM event. The wire-line pendant supporting the containment-related instrumentation and cables was hung from a bracket on the top of the emplacement pipe and offset from the pipe by about 0.7 m.

Fourteen stations were fielded in the stemming to monitor pressure and radiation. Two groups of three stations were fielded to define the horizontal distribution of gas flow in the stemming column, one group above each of the two bottom plugs. One member of each trio was mounted on the emplacement pipe within the device diagnostics cable bundle while the remaining two were hung on the containment instrumentation pendant with one of the pair within the containment instrumentation cable bundle and the remaining member outside, in the stemming material. No attempt was made to orient the pendant: it is thus unknown which of the two stations was the closer to the emplacement pipe. The radiation monitor in each of these stations was fitted with lead shielding/collimation to reduce the radiation from sources other than the stemming. An experimental multiplexed pressure and radiation system comprised two stations, vertically separated by about 150 m. The deepest component of the multiplexed pair was at the elevation of the deepest pressure dome above the pinhole and had a comparison standard station at that elevation. The stemming region about 6 m beneath each of the four plugs contained pressure and radiation stations and an additional elevation in the stemming midway between the second and third plugs was also monitored for pressure and radiation as was the interior of the emplacement pipe near its top and below the ball valve.

Standard LLNL vertical motion canisters, containing variable reluctance velocity and acceleration transducers, were emplaced in all three of the rigid stemming plugs, the ground surface, 15.24 m from SGZ, and on the top of the emplacement pipe.

Displacement transducers (reel-type extensometers) were mounted between the surface casing and the top plug and between the emplacement pipe and the backfill above the top plug to obtain a direct measure of the relative motion between these elements.

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

Two CLIPER/CORTEX sensors, one attached to the emplacement pipe and one to the instrumentation pendant were fielded to estimate device yield and to monitor cavity collapse and chimney formation. Results of the yield measurement are reported elsewhere⁽³⁾. A "D-cable" was fielded on the instrumentation pendant to monitor the stemming emplacement and was recorded post-shot to sense collapse.

After emplacement, but before stemming, it was found that station 21 (in the deepest rigid plug) was compromising the trailer electronics and it was decided to disconnect this station.

A history of the fielding operations of the instrumentation is outlined in reference 4. Details of the instrumentation are given in reference 5 and a detailed description of the purposes of the containment instrumentation is given in reference 6.

Figure 1.1 Map of the Nevada Test Site indicating the location of hole U2et.

Figure 1.2 East-West geologic cross section through hole U2et.

Figure 1.3 North-South geologic cross section through hole U2et.

Figure 1.4 As-built stemming plan for the event CHEEDAM in Hole U2et.

Figure 1.5 As-built containment instrumentation plan for the emplacement hole (U2et) on the CHEEDAM event.

2. Stemming Performance

2.1 Radiation and Pressure

Pressure and radiation stations were fielded on the CHEEDAM at fourteen locations as indicated in figure 1.5. The first 60 s of pressure and radiation wave forms for the stations on either side of the deep soft plug are shown in figures 2.1-2.4. The pressure and radiation wave forms from about 50 s before detonation until 4500 s after, recorded at all stations, are shown in figures 2.5-2.19.

The early-time wave forms of the pressure and radiation at the deepest station (station 32, just below the bottom soft plug) are quite similar (figure 2.1): an initial spike, quickly followed by a lower plateau lasting for about 8 s and then a slow decay toward ambient. This is suggestive of communication with the cavity gasses. At later times, a second radiation arrival is seen in the data of station 32 at about 1500 s (figure 2.5), but without an associated pressure change. At still later times (around 3700 s) there is a slight change in both pressure and dose rate. This may be due to movement in the formation and/or the stemming column prior to final collapse at about 4060 s.

The region just above the bottom soft plug was monitored with three stations at almost the same elevation: one strapped to the emplacement pipe (station 33), one on the pendant within the containment cable bundle (station 34), and one on the pendant in the stemming outside the containment cable bundle (station 35). Wave forms measured at both stations on the pendant were identical: a very brief pulse of radiation at detonation disappearing within 2 s and a ground motion-induced pressure increase which relaxes to about 1.5 psi over ambient at collapse (See figures 2.3-2.4 and 2.7-2.8.) Station 33, on the emplacement pipe, shows a much slower radiation decay to near ambient at collapse and a pressure wave form that remains about 6 psi above ambient for nearly 120 s before decaying to about 2 psi above ambient at collapse (See figures 2.2 and 2.6). This suggests some communication with the cavity gasses at station 33 with shine from the same source accounting for the radiation readings at stations 34 and 35. A component of the early-time radiation could have been shine from the emplacement pipe Pinex experiment.

Comparison of the wave forms recorded at station 36 (figure 2.9), a standard station, with those from station 37 (figure 2.10), one of the two multiplexed stations, indicates that the experimental multiplex system worked properly.

Pressure wave forms from all stations above a depth of 160 m can be explained as resulting from ground motion (figures 2.15-2.18). However, the long time that the pressure takes to decay for stations below at 175 m depth suggests that the pressure may be influenced by the cavity gasses and/or the Pinex experiment. The only station above a depth of 240 m reporting radiation was station 39 (figure 2.12), mounted on the emplacement pipe at an elevation about 5 m above the top pressure plate in the emplacement pipe (the upper most element of the Pinex experiment). This was also about 3.5 m above the deepest rigid plug. Station 39 was one member of a trio of stations the other two members of which (stations 40 and 41) were hung on the instrumentation pendant. The pressure wave forms of all three are similar.

No other radiation arrival was detected above the bottom rigid plug before collapse, when all radiation signals were lost (at about 4068 s). This includes station 15, mounted to sense radiation and pressure within the top of the emplacement pipe (figure 2.19) The radiation data are consistent with satisfactory containment.

2.2 Motion

Explosion-induced histories of the motion measured on the CHEEDAM event are shown in figures 2.20–2.22. Characteristics of the associated motion and transducers are given in tables 2.1–2.3.

Station 21 was disconnected pre-shot as it was causing considerable electrical system interference.

The displacement wave forms output by the extensometers at the top of the emplacement hole are shown in figure 2.24. Both stations 16 and 17 had an initial extension of about 20 cm and the detonation induced a further extension of about 20 cm on both transducers. A direct subtraction of the first 4 seconds of the wave form of station 17 from that of station 16 is shown in figure 2.25. Ideally, this should show the relative displacement between the emplacement pipe and the top plug. As a further determination of this quantity, the displacement wave form derived from the motion transducer in the top plug subtracted from that of the motion transducer on the top of the emplacement pipe is also shown. The agreement is good for the first second and the discrepancy at later time might be attributed to stemming compaction.

The emplacement pipe was held in place during and after stemming by a break-away beam. Tension on the pipe was released when explosive bolts holding the pipe to the beam were ignited at 143 ms after detonation of the CHEEDAM device. Station 15, mounted on a flange at the top of the emplacement pipe, shows an initial downward motion (figure 2.22) which was probably caused by this release of tension in the pipe.

2.3 Collapse phenomena

Collapse-induced histories of the motion measured on the CHEEDAM event are shown in figures 2.26–2.29. Collapse reached the ground surface 4068 s after detonation with slap-down occurring about 1.3 s later.

The collapse motion of the ground surface is shown in figure 2.29. The peak acceleration at collapse exceeded the system limits of 24 g's for a brief time and was extrapolated to about 55 g's by augmenting the truncated, as-recorded peak by a triangular pulse that brought the integral (velocity) to the zero base-line at late time. The slap-down signal at station 23 also exceeded the system limits (4 g's) and the same data manipulation was applied resulting in an extrapolated peak of about 11 g's.

The displacement wave forms output during collapse by the extensometers at the top of the emplacement hole are shown in figure 2.23. The signal from station 16 (between the top of the emplacement pipe and the stemming) returns to zero output at about collapse time, the condition that occurs when the messenger line breaks. Station 17 (between the surface casing and the top plug) indicates a separation of nearly 3.5 m at collapse. Full scale extension was greater than 6 m. At later time (4154 s, not shown) the signal from station 17 abruptly returns to zero output, suggesting a break in the messenger line of this station.

Progression of the collapse is shown in figure 2.30 by the position of the broken end of the CLIPER cables and representative histories of pressure and acceleration. CLIPER station 91 was mounted on the device canister and the emplacement pipe while station 92 was mounted with the containment instrumentation pendant. D-cable information is not in a form that is usable to investigate the progression of the cavity collapse.

Figure 2.1 The first 60 s of pressure and radiation measured in the coarse stemming below the soft plug and 1 m above the elevation of the pin hole (station 32 at a depth of 261.5 m).

Figure 2.2 The first 60 s of pressure and radiation measured in the coarse stemming above the soft plug (station 33 at a depth of 251.6 m). This shielded station was attached to the emplacement pipe.

Figure 2.3 The first 60 s of pressure and radiation measured in the coarse stemming above the soft plug (station 34 at a depth of 250.7m). This shielded station was hung on the pendant and mounted inside of the associated cable bundle.

Figure 2.4 The first 60 s of pressure and radiation measured in the coarse stemming above the soft plug (station 35 at a depth of 250.7m). This shielded station was hung on the pendant and mounted outside of the associated cable bundle.

Figure 2.5 Pressure and radiation measured in the coarse stemming below the soft plug and 1 m above the elevation of the pin hole (station 32 at a depth of 261.5 m).

Figure 2.6 Pressure and radiation measured in the coarse stemming above the soft plug (station 33 at a depth of 251.6 m). This shielded station was attached to the emplacement pipe.

Figure 2.7 Pressure and radiation measured in the coarse stemming above the soft plug (station 34 at a depth of 250.7m). This shielded station was hung on the pendant and mounted inside of the associated cable bundle.

Figure 2.8 Pressure and radiation measured in the coarse stemming above the soft plug (station 35 at a depth of 250.7m). This shielded station was hung on the pendant and mounted outside of the associated cable bundle.

Figure 2.9 Pressure and radiation measured in the coarse stemming at a depth of 235.2 m (station 36). This was standard instrumentation fielded to compare with an experimental multiplex station at the same elevation.

Figure 2.10 Pressure and radiation measured in the coarse stemming at a depth of 235.0 m (station 37). This station contained experimental multiplex electronics and was fielded to compare with a station at the same elevation containing standard instrumentation. A second multiplexed station was fielded at a depth of 86 m: see figure 2.17.

Figure 2.11 Pressure and radiation measured in the stemming below the deepest rigid plug (station 38, at a depth of 196.6 m).

Figure 2.12 Pressure and radiation measured in the coarse stemming above the deepest rigid plug (station 39 at a depth of 177.4 m). This shielded station was attached to the emplacement pipe.

Figure 2.13 Pressure and radiation measured in the coarse stemming above the deepest rigid plug (station 40 at a depth of 176.7 m). This shielded station was hung on the pendant and mounted inside of the associated cable bundle.

Figure 2.14 Pressure and radiation measured in the coarse stemming above the deepest rigid plug (station 41 at a depth of 176.7m). This shielded station was hung on the pendant and mounted outside of the associated cable bundle.

Figure 2.15 Pressure and radiation measured in the coarse stemming between plugs 2 and 3 (station 42 at a depth of 158.2 m).

Figure 2.16 Pressure and radiation measured in the coarse stemming below the middle rigid plug (station 43 at a depth of 104.2 m).

Figure 2.17 Pressure and radiation measured in the coarse stemming above plug 3 (station 44, at a depth of 86 m). This was the second of a pair of stations fielding experimental multiplex electronics. See station 37, figure 2.10.

Figure 2.18 Pressure and radiation measured in the coarse stemming below the top plug (station 45, at a depth of 43.3 m).

Figure 2.19 Pressure and radiation measured in the top of the emplacement pipe (station 14).

Figure 2.20 Explosion-induced vertical motion of the intermediate rigid plug (station 22 at a depth of 99.7 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.21 Explosion-induced vertical motion of the top plug (station 23 at a depth of 32.6 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.22 Explosion-induced vertical motion of the top of the emplacement pipe (station 15). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.23 Explosion-induced vertical motion of the ground surface at a depth of .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 Extensometer readings from stations 16 (mounted between the emplacement pipe and the top of the stemming) and station 17 (mounted between the surface casing and the top plug). The early-time plots were taken from data that were sampled at much higher rate than were the late-time data.

Figure 2.25 First four seconds of algebraic difference between the outputs of station 16 and station 17. This should be the history of the separation of the emplacement pipe and the top plug. Also shown is the same quantity as derived from the motion of the emplacement pipe and the top plug.

Figure 2.26 Collapse-induced vertical motion of the intermediate rigid plug (station 22 at a depth of 99.7 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.27 Collapse-induced vertical motion of the top plug (station 23 at a depth of 32.6 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.28 Collapse-induced vertical motion of the top of the emplacement pipe (station 15). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 2.29 Collapse-induced vertical motion of the ground surface at a depth of .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 2.30 Progression of collapse as shown by the position of the break in the CLIPER cables. Station 91 (heavy trace) was attached to the device canister and the emplacement pipe while station 92 was on the instrumentation pendant. Also shown are representative pressure and acceleration traces. Station 23 survived collapse, presumably because it was protected by the surface casing.

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)
15av		140(a,b)	10(b), 7.9	-0.74(b)	-4.3	-4
15uv		140(a,b)	-	-0.81(b)	1.6,-4.6	-4
22av		58(a), 131	3.10	0.40	6.7	4
22uv		133	-	0.40	6.4	0.2
23av		175	1.14, 2.97(c)	0.48	6.5	-2
23uv		178	-	0.44	6.0	-1.5
61av		210	2.40, 3.55(c),	0.66	7.1	7(d)
61uv		212	-	0.65	6.8	-4

(a) Pipe-induced motion.

(b) Interference in signal caused by explosive release of strong-backs.

(c) Slap down.

(d) Noise interference causes upward drift at late time- data questionable.

(e) Extremely noisy.

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	328	0.55	12
22av	268	0.75	6
23av	180	0.75	4
61av	299	0.75	24

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>
15uv	3.636	8.14	76.96	51.56	6
22uv	3.586	8.16	77.41	95.41	4
23uv	3.749	7.49	76.93	100.34	3
61uv	3.603	8.62	77.00	43.39	8

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