NIZA Containment Data Report

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NIZA 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	yes	yes	yes
<u>Hydroyield</u>	no	-	-
<u>Collapse</u> ^(b)	yes	yes	yes
<u>Stress</u>	no	-	-
<u>Strain</u> ^(c)	yes	yes	yes
<u>Other Measurements</u>	no	-	-

- (a) Description only.
(b) EXCOR or CLIPER in emplacement hole.
(c) Strain load on emplacement pipe.

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Contents

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1. Event Description

1.1 Site

The NIZA event was detonated in hole U9cr of the Nevada Test Site as indicated in figure 1.1. The NIZA device had a depth-of-burial (DOB) of 340 m in the Tunnel Beds Tufts of area 9, about 200 m above both the Paleozoic formation and 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 07:00 PDT on July 8, 1981, and collapse progressed to the surface at about 85 minutes after the detonation resulting in a crater having a mean radius of 55.6 m and a maximum depth of 6.3 m.

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

1.2. Emplacement

There were three stemming plugs above the NIZA event, each composed of rigid two-part- epoxy (TPE). The bottom plug was 7.3 m thick and the intermediate plug was 6.7 m thick. Thickness of the top plug TPE was 5.3 m, about 1.6 m of which extended below the surface casing. Each of these was overlain with a 1.8 m thick layer of soft "coal-tar epoxy" to act as a gas seal. 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 NIZA event.

Ten stations were fielded in the stemming to monitor pressure and radiation. The stemming region about 6 m beneath each of the three plugs contained pressure and radiation stations as well as the region about 5 m above each of the plugs except the top. Additionally, four elevations in the coarse stemming above and below the two fines layers between the diagnostics canister and the bottom plug were monitored for pressure and radiation as was the elevation above the fines layer between the bottom and second plugs.

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 in the recording trailer. Additionally, motion of the emplacement pipe was monitored at two locations about 1 m below the bottom rigid plug and the strain (load) was monitored at a station on the emplacement pipe near its top.

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 instrumentation pendant and the other attached to a gas sampling hose were fielded to monitor cavity collapse and chimney formation. One "D-cable" system was fielded to monitor the stemming emplacement and was 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 U9cr.

Figure 1.2 Northeast-Southwest geologic cross section through hole U9cr.

Figure 1.3 Northeast-South geologic cross section through hole U9cr.

Figure 1.4 As-built stemming plan for the event NIZA in Hole U9cr.

Figure 1.5 As-built containment instrumentation plan for the emplacement hole (U9cr) on the NIZA event.

2. Stemming Performance

2.1 Radiation and Pressure

Pressure and radiation stations were fielded on the NIZA at ten locations as indicated in figure 1.5. The pressure and radiation wave forms from about 50 s before detonation until 6000 s after, recorded at all stations, are shown in figures 2.1-2.10.

The pressure signal from station 31, below the deepest fines layer, (figure 2.1) was interrupted at or shortly after detonation and resumed transmitting upon collapse at about 5104 s. The radiation monitor of station 31 indicated a first arrival at about 3700 s. Pressure histories across the coarse stemming between the two bottom fines layers (stations 32 and 33, figures 2.2 and 2.3) were nearly identical in magnitude and wave form indicating a shock-induced jump in pressure which rapidly decayed to about 1 psi above ambient. Radiation was seen to arrive at station 32 at about 4000 s and no radiation directly associated with the cavity gas was detected at any elevation above that station. All pressure histories prior to collapse at elevations higher than station 33 can be explained as the result of ground motion.

Survival through collapse of stations below the top plug is usually questionable: the electrical cables are usually broken and the resulting signal, if any, is meaningless. In particular, pressure and radiation readings beyond collapse at 5112 s from station 33 (figure 2.3) and pressure histories from stations 34 and 36 (figures 2.4 and 2.6) are to be held suspect. On the other hand, the cables of station 40, just below the top plug may survive, being protected by the surface casing. This protection may be extended to the next station below, depending upon the collapse behavior. Figure 2.11 shows the history of the records from station 40 for the full recording time of about 7 hours. Only a very brief, low-level spike of radiation was detected at this station at collapse and the radiation offset seen between 15,000 and 23,000 s is unexplained. The pressure history is characteristic of a stemming fall in a competent, porous medium.

A stress gauge, bonded to the emplacement pipe near its top, (station 84) monitored the load on the pipe during emplacement and was recorded through the event and post-shot. Results of this measurement are shown in figure 2.12.

The pressure and radiation data are consistent with satisfactory containment.

2.2 Motion

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

Stations 1 and 2 were mounted to the emplacement pipe about 5 m below the drag rings in the bottom rigid plug (the formation coupling plug). Coupling of the emplacement pipe to the formation by drag rings was expected to cause failure of the pipe at one or more locations below the rings, thus the inclusion of stations 1 and 2 to detect this failure. The motion recorded at these two stations (figures 2.14 and 2.15) is quite similar for the first 0.5 s and suggests a rotation of the stations and thus probable pipe failure.

Early arrivals (prior to the ground motion) produced by motion of the emplacement pipe were seen in the acceleration records at all down-hole stations. Station 21 was fielded in the deepest plug containing a drag ring on the emplacement pipe and the drag ring may have induced motion that interfered with the ground motion signal from this station at early times. Station 22, (in the middle rigid plug) had only an accelerometer functioning at event time. 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. The explosion-induced motion recorded in each of the rigid plugs and the ground surface was unremarkable except for the multiple ground surface spall seen at station 61 (figure 2.18) suggesting a medium of greater competency than that seen at many other areas in Yucca valley.

Figure 2.19 shows the explosion-induced wave form of the stress (load) monitored on the emplacement pipe over the same time span as the motion data.

Figure 2.1 Pressure and radiation as monitored in the coarse stemming below the deep fines layer at a depth of 278.5 m (station 31).

Figure 2.2 Pressure and radiation measured in the coarse stemming above the deep fines layer at a depth of 262.7 m (station 32).

Figure 2.3 Pressure and radiation measured in the coarse stemming below the second fines layer at a depth of 245.4 m (station 33).

Figure 2.4 Pressure and radiation measured in the coarse stemming above the second fines layer at a depth of 230.1 m (station 34).

Figure 2.5 Pressure and radiation measured in the coarse stemming beneath the formation coupling plug at a depth of 211.1 m (station 35).

Figure 2.6 Pressure and radiation measured in the coarse stemming above the formation coupling plug at a depth of 193.2 m (station 36).

Figure 2.7 Pressure and radiation measured in the coarse stemming above the fines layer at a depth of 142.3 m (station 37).

Figure 2.8 Pressure and radiation measured in the coarse stemming below the second rigid plug at a depth of 106.1 m (station 38).

Figure 2.9 Pressure and radiation measured in the coarse stemming above the second rigid plug at a depth of 90.8 m (station 39).

Figure 2.10 Pressure and radiation measured in the coarse stemming beneath the top plug at a depth of 44.5 m (station 40).

Figure 2.11 Pressure and radiation measured in the coarse stemming beneath the top plug at a depth of 44.5 m (station 40). Time span is the full recording time, about 7 hours.

Figure 2.12 Strain (load) measured on the emplacement pipe near its top.

Figure 2.13 Explosion-induced vertical motion of the emplacement pipe below the formation coupling plug (station 1, at a depth of 208.4 m).

Figure 2.14 Explosion-induced vertical motion of the emplacement pipe below the formation coupling plug (station 2, at a depth of 208.4 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 bottom rigid plug (station 21, at a depth of 203.6 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 2.16 Explosion-induced vertical motion of the second rigid plug (station 22, at a depth of 98.5 m). There was no velocimeter recorded at this location.

Figure 2.17 Explosion-induced vertical motion of the top plug (station 23, at a depth of 36.0m). 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 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 2.19 Strain (load) measured on the emplacement pipe near its top. The early time wave form is shown corresponding to the explosion-induced motion histories.

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)
1av	132.04	33	112(a)	5.9(a), 11.6	(b)	(b)
2av	132.04	32.5	117(a)	6(a), 10	(b)	(b)
2uv	-	-	-	5.8(a), 10.5	(b)	(b)
21av	136.86	35	7.2(a)	0.64(a), 0.76	22.2	9.8
21uv	-	-	-	0.78	21.0	6.8
22av	242.01	66(a), 133	4.3	0.34	6.3	-2
22uv	-	-	-	-	-	-
23av	304.39	84(a), 169	2.6	0.33, 0.51	6.9	-5.2
23uv	-	-	-	0.33, 0.51	6.9	-5.6
61av	339.6	198	3.9, 8.8(c)	0.66	7.5	-4.6
61uv	-	-	-	0.65	7.1	-4

(a) Pipe-induced motion.

(b) Could not estimate this value.

(c) Slap down.

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>
1av	31,000(a)	(a)	2500
2av	1830	0.55	500
22av	320	0.65	20
22av	314	0.65	20
23av	330	0.65	20
61av	595	0.65	50

(a) Gauge type: Endevco 2261A, quoted is the mounted resonance frequency with less than 1% critical damping.

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>
2uv	4.04	23.2	74.0	98.93	25
21uv	3.17	22.15	74.0	105.5	10
22uv	3.54	12.0	73.0	108.3	10
23uv	3.71	10.5	74.0	126.6	10
61uv	3.41	8.40	74.0	80.16	10

3 Collapse phenomena

3.1 Motion

Collapse-induced histories of the motion measured on the NIZA event are shown in figures 3.1-3.5. Collapse reached the ground surface 5111.8 s after detonation with slap-down occurring about 1 s later.

3.2 Radiation and Pressure

Pressure and radiation histories recorded during the 20 s of the collapse activity are shown in figures 3.6 - 3.15. A slight rise in radiation is observed in station 33 (figure 3.8) just prior to loss of signal at 5106 s. The continuation of signal after collapse, both from the pressure and radiation channels, should be discounted. Although not shown, the radiation signal from station 34 (figure 3.9) after collapse is quite erratic and should also be neglected. At station 37 (figure 3.12) there is an abrupt radiation arrival occurring about 2 s before the pressure record indicates stemming fall. Both channels were lost at the same time (5111.2 s). Both channels of station 40 survived collapse and the radiation wave form detected was of the same character as that of station 37, suggesting the same source.

Progression of the collapse is shown in figure 3.16 by the position of the broken ends of the CLIPER cables and representative histories of pressure and emplacement pipe strain (load). CLIPER station 91 was mounted on the containment instrumentation pendant and the CLIPER station denoted "GSH" was emplaced with the gas sample hose.

The strain history of the emplacement pipe during collapse is shown in figure 3.17 along with the radiation history of station 37 and the collapse acceleration of station 21. As seen in figure 3.16, the collapse progresses to the formation coupling plug at about 5108 s, the approximate time that the emplacement pipe starts to move and the abrupt radiation arrival occurs at station 37. One scenario for this is that the emplacement pipe drops, opening a pathway for radiation shine from the gas sampling hose to the radiation detector. A similar explanation may suffice for the radiation signature seen at station 40.

D-cable information is not in a form that is usable to investigate the progression of the cavity collapse.

Figure 3.1 Collapse-induced vertical motion of the emplacement pipe below the formation coupling plug (station 2, at a depth of 208.4 m). These records are shown for timing and completeness only.

Figure 3.2 Collapse-induced vertical motion of the bottom rigid plug (station 21, at a depth of 203.6 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 3.3 Collapse-induced vertical motion of the second rigid plug (station 22, at a depth of 98.5 m). There was no velocimeter recorded at this location.

Figure 3.4 Collapse-induced vertical motion of the third rigid plug (station 23, at a depth of 36.0 m). The traces annotated with "a" are derived from the acceleration while the velocimeter-derived signals are shown as heavy traces.

Figure 3.5 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 3.6 Collapse epoch pressure and radiation as monitored in the coarse stemming below the deep fines layer at a depth of 278.5 m (station 31).

Figure 3.7 Collapse epoch pressure and radiation measured in the coarse stemming above the deep fines layer at a depth of 262.7 m (station 32).

Figure 3.8 Collapse epoch pressure and radiation measured in the coarse stemming below the second fines layer at a depth of 245.4 m (station 33).

Figure 3.9 Collapse epoch pressure and radiation measured in the coarse stemming above the second fines layer at a depth of 230.1 m (station 34).

Figure 3.10 Collapse epoch pressure and radiation measured in the coarse stemming beneath the formation coupling plug at a depth of 211.1 m (station 35).

Figure 3.11 Collapse epoch pressure and radiation measured in the coarse stemming above the formation coupling plug at a depth of 193.2 m (station 35).

Figure 3.12 Collapse epoch pressure and radiation measured in the coarse stemming above the fines layer at a depth of 142.3 m (station 37).

Figure 3.13 Collapse epoch pressure and radiation measured in the coarse stemming below the second rigid plug at a depth of 106.1 m (station 38).

Figure 3.14 Collapse epoch pressure and radiation measured in the coarse stemming above the second rigid plug at a depth of 90.8 m (station 39).

Figure 3.15 Collapse epoch pressure and radiation measured in the coarse stemming beneath the top plug at a depth of 44.5 m (station 40).

Figure 3.16 Progression of collapse as shown by the position of the break in the CLIPER cables on the instrumentation pendant (station 91) and on the gas sample hose (GSH). Also shown are representative pressure wave forms and the emplacement pipe load.

Figure 3.17 Strain on the emplacement pipe, radiation measured at station 37 (at a depth of 142.3 m, above the fines layer between the first and second rigid plugs) and the collapse acceleration of the formation coupling plug during the collapse epoch.

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