TARKO Containment Data Report

T. Stubbs

R. Heinle

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TARKO 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^(b)</u>	yes	yes	no
<u>Collapse^(c)</u>	yes	yes	yes
<u>Stress</u>	no	-	-
<u>Strain^(d)</u>	yes	yes	no
<u>Other Measurements^(e)</u>	yes	yes	yes

(a) Description only.

(b) SLIFER or CORRTX data; see reference 3.

(c) EXCOR or CLIPER in emplacement hole.

(d) Strain load on emplacement pipe, recorded in the stemming log⁽²⁾.

(e) Internal emplacement pipe temperature and pressure.

Event Personnel

Containment Physics

B. Hudson	LLNL
C. Olsen	LLNL
J. Kalinowski	EG&G/AVO
T. Stubbs	EG&G/AVO

Instrumentation

L. Starrh	LLNL
D. Longinotti	EG&G/AVO
L. Davies	EG&G/NVO
A. Moeller	EG&G/NVO

Contents

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1. Event Description

1.1 Site

The TARKO event was detonated in hole U2fd of the Nevada Test Site as indicated in figure 1.1. The TARKO device had a depth-of-burial (DOB) of 369 m in the alluvium area 2, about 280 m above the Paleozoic formation and 200 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 07:00 PST on February 27, 1980, and collapse progressed to the surface at about 4 hours after the detonation resulting in a crater having a mean radius of 45.7 m and a maximum depth of 13.6 m.

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

1.2. Emplacement

There were three stemming plugs above the TARKO event, each composed of rigid two-part- epoxy (TPE). The first (bottom) was about 7.6 m thick and the second plug was 3.0 m thick. Thickness of the top plug TPE was 4.3 m, the bottom of which was 2.1 m above the bottom of the surface casing. This top plug was overlain with a 2.4 m thick layer of soft "coal-tar epoxy" to act as a gas seal. A drag ring system was mounted to the emplacement pipe at the position of the bottom rigid plug, coupling this plug to the geologic formation. The emplacement pipe in the regions of the top and intermediate plugs was coated with hydroseal to allow free motion of the pipe through these structures. The emplacement hole was enlarged in the region of the intermediate plug allowing it to be "keyed" into the geologic formation. Stemming between the plugs consisted of layers of fines and coarse gravel. The top of the hole (above the top plug) was filled with surface-derived backfill to about 3 m below the ground surface. See figure 1.4.

TARKO included a mechanical PINEX experiment as part of the device diagnostics and, for this, the emplacement pipe was left open above the detector plate which was extracted to a receptacle above the ball valve closure on the top of the pipe. This receptacle was detached from the pipe shortly after the detonation and pulled to a location beyond the expected extent of the resulting crater. Below the detector plate, the pipe was sealed with a series of four pressure domes.

1.3 Instrumentation

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

Nine stations were fielded in the stemming to monitor pressure and radiation. The stemming region about 5 m beneath each of the three plugs contained pressure and radiation stations as well as the region about 8 m above each of the plugs except the top. Three additional stations in the coarse stemming at the elevations of the deepest three pressure domes as well as an elevation midway between the intermediate and top plugs were also monitored for pressure and radiation.

The internal gas pressure and temperature of the lower four sealed sections of the emplacement pipe were monitored just below the corresponding pressure dome defining the section. Vertical motion (acceleration and velocity) of the emplacement pipe was monitored at each of the three deepest pressure and temperature stations, at the elevation of the deepest pressure dome, at a station about 2.5 m below the formation coupling plug, at the location of the neutron detector plate (defining the fifth sealed section), and near the top of the pipe below the ball valve. An additional station monitored pressure and radiation internal to the pipe near its top at a depth of about 15 m.

Standard LLNL vertical motion canisters, containing variable reluctance velocity and acceleration transducers, were emplaced in all three of the rigid stemming plugs, and in the ground surface, 15.24 m from SGZ. A pair of standard Validyne accelerometers were placed on diametrically opposed sides of the surface casing in an attempt to detect tilt of the casing. The recording trailer was also instrumented for vertical motion.

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 gas sample hose were fielded to monitor cavity collapse and chimney formation.

Two "D-cable" systems were fielded to monitor the stemming emplacement and were recorded post-shot to sense collapse.

Strain (load) was monitored at a station on the emplacement pipe near its top. These data are available in the stemming log⁽²⁾.

Results of the hydrodynamic yield measurements are reported elsewhere⁽³⁾

A history of the fielding operations of the instrumentation is outlined in reference 4. Further details of the instrumentation are given in reference 5.

Figure 1.1 Map of the Nevada Test Site indicating the location of hole U2fd.

Figure 1.2 East-West geologic cross section through hole U2fd.

Figure 1.3 North-South geologic cross section through hole U2fd.

Figure 1.4 As-built stemming plan for the event TARKO in Hole U2fd.

Figure 1.5 As-built containment instrumentation plan for the emplacement hole (U2fd) on the TARKO event.

2. Stemming Performance

2.1 Radiation and Pressure

Stemming pressure and radiation stations were fielded on the TARKO event at nine locations as indicated in figure 1.5. The pressure and radiation wave forms from about 50 s before detonation until 15,000 s after, recorded at all stemming stations, are shown in figures 2.1-2.9. The first 200 s of pressure and radiation are also shown, for greater definition, in figures 2.10 - 2.18.

Figure 2.1 shows a prompt arrival of both pressure and radiation at the region elevation of the deepest pressure dome (station 32). The early radiation is likely the "shine" from the (open) emplacement pipe while the pressure history may be due to compaction. A later radiation arrival at about 80 s (see figure 2.10) may be due to migration of the cavity gasses in the stemming. The loss of pressure between 3000 and 4400 s is unexplained and is accompanied by a slight, abrupt drop in radiation at about 4200 s. At the second pressure dome the radiation and pressure histories initially show a pressure jump which then decays and a prompt, decaying arrival of radiation (figures 2.2 and 2.11). However, about 10 s after detonation, there is a pressure arrival accompanied by a surge of radiation. When compared with the data from station 32, this is suggestive of a rupture in the emplacement pipe near that elevation. A later radiation arrival at around 400 s, not accompanied by an obvious pressure change, may be a continuation of the migration of cavity gasses up the stemming.

Again, at station 34 (the elevation of the third pressure dome, see figures 2.3 and 2.12) there is both a prompt radiation arrival and a pressure jump. The radiation is likely due to pipe "shine" while the pressure history can be accounted for by compression. A second radiation arrival occurs at about 5000 s and may be a further continuation of cavity gas migration up the stemming.

Pressure histories from all stations above station 34 can be explained as the result of stemming or ground motion and all stations with the exception of the top two show the effects of pipe radiation "shine" (figures 2.17 and 2.18). The radiation transducers in the top two stations were temporarily discharged by the EMP and did not record possible early time "shine" effects.

2.2 Motion

Explosion-induced histories of the motion measured in the stemming and on the ground surface during the TARKO event are shown in figures 2.19–2.25. Characteristics of the associated motion and transducers are given in tables 2.1–2.3.

The drag ring system on the emplacement pipe may have induced motion that interfered with the ground motion signal at station 21 at early times (figure 2.19).

Significant early time acceleration induced from the emplacement pipe was also observed at station 22 (figure 2.20). Since the pipe was "greased" in the region of this plug the magnitude of the acceleration induced from the pipe motion is larger than expected. Its integral is almost negligible, however. Signals from this station were lost at about 0.8 s, likely due to cable breakage. The emplacement pipe was also coated with hydroseal in the region of the top TPE plug and the pipe-induced motion at this station was strongly mitigated (figure 2.21). The explosion-induced motion was otherwise unremarkable.

Figure 2.1 Pressure and radiation as monitored in the coarse stemming at the elevation of the deepest pressure dome (station 32 at 292.6 m depth).

Figure 2.2 Pressure and radiation measured in the fines stemming at the elevation of the second pressure dome (station 33 at 256 m depth).

Figure 2.3 Pressure and radiation measured in the coarse stemming at the elevation of the third pressure dome (station 34 at 219.5 m depth).

Figure 2.4 Pressure and radiation measured in the fines stemming beneath the formation coupling plug (station 35 at 192 m depth).

Figure 2.5 Pressure and radiation measured in the fines stemming above the formation coupling plug (station 36 at 173.7 m depth).

Figure 2.6 Pressure and radiation measured in the fines stemming beneath the intermediate plug (station 37 at 120.4 m depth).

Figure 2.7 Pressure and radiation measured in the fines stemming above the intermediate plug (station 38 at 106.7 m depth).

Figure 2.8 Pressure and radiation measured in the coarse stemming between the intermediate and top plugs (station 39 at 79.3 m depth).

Figure 2.9 Pressure and radiation measured in the fines stemming beneath the top plug (station 40 at 35.4 m depth).

Figure 2.10 Early-time pressure and radiation as monitored in the coarse stemming at the elevation of the deepest pressure dome (station 32 at 292.6 m depth). Note the radiation arrival at about 80 s accompanied with a slight pressure increase.

Figure 2.11 Early-time pressure and radiation measured in the fines stemming at the elevation of the second pressure dome (station 33 at 256 m depth).

Figure 2.12 Early-time pressure and radiation measured in the coarse stemming at the elevation of the third pressure dome (station 34 at 219.5 m depth).

Figure 2.13 Early-time pressure and radiation measured in the fines stemming beneath the formation coupling plug (station 35 at 192 m depth).

Figure 2.14 Early-time pressure and radiation measured in the fines stemming above the formation coupling plug (station 36 at 173.7 m depth).

Figure 2.14 Early-time pressure and radiation measured in the fines stemming beneath the intermediate plug (station 37 at 140.4 m depth).

Figure 2.16 Early-time pressure and radiation measured in the fines stemming above the intermediate plug (station 38 at 106.7 m depth).

Figure 2.17 Early-time pressure and radiation measured in the coarse stemming between the intermediate and top plugs (station 39 at 79.3 m depth).

Figure 2.18 Early-time pressure and radiation measured in the fines stemming beneath the top plug (station 40 at 35.4 m depth).

Figure 2.19 Explosion-induced vertical motion of the bottom rigid plug (station 21, at a depth of 184.3 m). The acceleration at early time shows strong motion induced by the emplacement pipe and the drag ring.

Figure 2.20 Explosion-induced vertical motion of the intermediate rigid plug (station 22, at a depth of 114.3 m). The acceleration at early time shows strong motion induced by the emplacement pipe and the drag ring.

Figure 2.21 Explosion-induced vertical motion of the top rigid plug (station 23, at a depth of 31.6 m).

Figure 2.22 Explosion-induced vertical motion of the surface casing (station 24A, at the ground surface).

Figure 2.23 Explosion-induced vertical motion of the surface casing (station 24B, at the ground surface). This station was mounted diametrically opposite station 24A.

Figure 2.24 Explosion-induced vertical motion of the ground surface at a depth of 0.9 m and horizontal range of 15.24 m (station 61).

Figure 2.25 Explosion-induced vertical motion of the recording trailer (station 71).

Table 2.1 Summary of Containment-Related Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (m)	Displacement Residual (m)
2av	75	12,7(a), 57	1100(a), 1120	18(a)	(c)	(c)
2uv(b)		-	-	-	-	-
3av	76	13,5(a), 75?	700(a), 1420	18(a)	(c)	(c)
3uv		13.0(a)	-	14(a)	(c)	(c)
4av	110	19.5(a)	530(a), 380	17.0(a), 28.5	4.10	3.1
4uv		20.0(a)	-	14.5(a), 25.	3.25	3.0
6av	147	26(a)	340(a)	14(a), 7.5	1.14	0.80
6uv		26(a)	-	12.5(a), 7.2	1.07	0.85
8av	179	34(a)	147(a)	5.0(a), 1.2	0.15	-0.35
8uv		34(a)	-	5.8(a), 1.5(d)	0.31	0.07
10av	191	37(a)	75(a)	2.6(a), 1.2	0.23	-0.08
10uv		38(a)	-	2.6(a), 1.3	0.25	0.04
13av	371	140(d)	7.2	0.84	0.035	-0.08
13uv		66(g)	-	0.83	0.046	0
21av	186	39(a)	4.2(a)	0.16(a), 1.7	0.32	-0.05
21uv		38(a)	-	0.12(a), 1.27	0.21	-0.05
22av	255	54(a), 120	0.85(a), 1.0	0.02(a), 0.44	0.104	(c)
22uv		50(a), 120	-	0.02(a), 0.45	0.105	(c)
23av	337	176	0.60	0.57	0.100	-0.13
23uv		180	-	0.61	0.106	-0.04
24Aav	369	196	0.85	0.61	0.100	-0.16
24Bav		195	0.90	0.61	0.108	-0.20
6 1av	368.5	210	1.4, 16.3(e)	0.65	0.097	-0.17
61uv		220(d)	-	0.62	0.091	-0.13
71av	413(f)	248	1.23, 1.8(g)	0.63, 0.85(g)	0.056	-0.19
71av		252	-	0.60, 0.85(g)	0.052	-0.17

(a) First motion (precursor or from pipe).

(b) This channel lost at ZIP.

(c) Gauge lost before this value attained.

(d) Indistinct.

(e) Slap-down.

(f) Approximate; station mounted in recording trailer.

(g) Maximum value in wave form.

Table 2.2 Containment-Related Accelerometer Characteristics

Gauge	Natural Frequency (Hz)	Damping Ratio	System Range (g's)
2av	1800	0.65	1000
3av	1700	0.65	1000
4av	1500	0.55	1000
6av	1400	0.65	500
8av	720	0.65	100
10av	820	0.65	100
13av	800	0.65	100
21av	820	0.75	100
22av	570	0.65	50
23av	360	0.75	20
24Aav	280	0.65	20
24Bav	340	0.65	20
61av	340	0.75	20
71av	185	0.75	10

Table 2.3 Containment-Related Velocimeter Characteristics

Gauge	Natural Frequency (Hz)	Time to 0.5 Amplitude (s)	Calibration Temperature (°F)	Operate Temperature (°F)	System Range (m/s)
2uv	3.8	75.0	75.8	63.10	500
3uv	4.0	69.1	74.3	62.90	300
4uv	4.0	28.8	73.8	62.09	25
6uv	4.1	19.1	74.2	59.40	10
8uv	3.5	13.5	73.3	62.90	3
10uv	3.7	8.5	73.2	70.94	3
13uv	3.5	12.9	73.2	50.18	4
21uv	3.5	13.1	73.3	86.72	3
22uv	3.5	7.6	73.6	90.92	2
23uv	3.6	8.2	73.8	104.32	1
61uv	3.6	13.7	73.7	49.48	3
71uv	3.8	11.1	74.2	71.89	

3 Collapse phenomena

3.1 Motion

Collapse-induced histories of the stemming and ground surface motion measured on the TARKO event are shown in figures 3.1-3.5. Station 22 was lost at early time and is not represented in this suite of data. All stations in and above the top plug survived collapse which reached the ground surface about 14380 s after detonation (figure 3.6). The high speed (60 ips) analog tapes were not reloaded after running to their respective ends so only the low-speed (3.75 ips) tapes captured the collapse data. Recorded at one channel per track, only the data from the velocity transducers were recorded on these tapes and the accelerations shown in figures 3.1-3.5 were derived as derivatives of the measured velocity. Noise content of the acceleration histories is unrealistically large due to numerical differentiation. It was felt that application of a digital filter to these records would degrade the peaks below their true values and thus was not done.

The plug and ground surface collapse motion data (Figures 3.1, 3.2, and 3.4) show a smooth upward progression occurring from about 14372 to 14380 s. Motion of the emplacement pipe (figure 3.5) during collapse begins with a signal at the time of the drop of the top plug (stations 23 and 24), an intermediate drop about 4 seconds later with a third drop at about 3 s after that. Comparing the data from the emplacement pipe (figure 3.5) with that of the top plug (figure 3.2), it would appear that the pipe followed the plug for a short time and then was held in position until it fell through the plug at the two later episodes. These later episodes were not sensed at any other stemming station than 13 suggesting that there was continued activity down-hole that did not reach the surface. As noted earlier, the pipe in the region of the top plug was coated with hydroseal to allow nearly free motion of the pipe through the plug. All other stations down-hole (with the exception of the pressure and radiation station immediately below the top plug) were lost prior to 14380 s.

3.2 Radiation and Pressure

Pressure and radiation histories recorded during the collapse activity are shown in figures 3.6 - 3.14. All stations except 32 (which was lost before collapse) show a slow drop in pressure indicating a stemming fall preceding the loss of signal with the exception of the station just below the top plug which survived collapse (station 40, figure 3.14).

A change in radiation corresponding in time to the decrease in pressure is seen at stations 32, 33, 34, 39, and 40 (figures 3.5, 3.6, 3.7, 3.13 and 3.14). The reduction in the dose rate at stations 33 and 34 may be explainable as due to an increase in the shielding afforded by the falling stemming. A scenario explaining the behavior seen in the two stations just below the top plug assumes that the stemming temporarily fell away from the top plug. "Shine" from the emplacement pipe could have been detected at the two stations just below the top plug due to lowered shielding from the stemming. Signals from station 39 (figure 3.13) were subsequently lost and the fall of material above station 40 (figure 3.14) increased the pressure and stemming density, tending to mitigate the radiation signal. It was also noted⁽⁶⁾ that radiation was detected in the stemming above the intermediate plug by probes lowered into the emplacement pipe on October 7 (about 9 months after the event). Radiation was also detected in the top plug and in the sand above it. The gas sampling hose which was pulled into the crater by more than 8 m and broken may have been a radiation source.

Progression of the collapse is shown in figure 3.15 by the position of the broken ends of the CLIPER cable (station 91) and selected pressure histories. Pressure records show the position of the onset of collapse to move uniformly up the hole to the elevation of the top plug and agree with the CLIPER data except for about a 3-5 second lead. CLIPER clock has occasionally been seen to be in error enough to account for such a discrepancy. No information is available on the timing accuracy of the CLIPER clock at this time.

CLIPER station 92, mounted on the gas sampling hose gave no usable information.

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 bottom rigid plug (station 21, at a depth of 183.4 m). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 3.2 Collapse-induced vertical motion of the top rigid plug (station 23, at a depth of 31.6 m). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 3.3 Collapse-induced vertical motion of the surface casing (station 24A, at the ground surface). Only an accelerometer was fielded at this location.

Figure 3.4 Collapse-induced vertical motion of the emplacement pipe (station 13, on the pipe 1.9 m above ground level but below the ball valve). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

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). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 3.6 Collapse epoch pressure and radiation as monitored in the coarse stemming at the elevation of the deepest pressure dome (station 32 at 292.6 m depth).

Figure 3.7 Collapse epoch pressure and radiation measured in the fines stemming at the elevation of the second pressure dome (station 33 at 256 m depth).

Figure 3.8 Collapse epoch pressure and radiation measured in the coarse stemming at the elevation of the third pressure dome (station 34 at 219.5 m depth).

Figure 3.9 Collapse epoch pressure and radiation measured in the fines stemming beneath the formation coupling plug (station 35 at 192 m depth).

Figure 3.10 Collapse epoch pressure and radiation measured in the fines stemming above the formation coupling plug (station 36 at 173.7 m depth).

Figure 3.11 Collapse epoch pressure and radiation measured in the fines stemming beneath the intermediate plug (station 37 at 120.4 m depth).

Figure 3.12 Collapse epoch pressure and radiation measured in the fines stemming above the intermediate plug (station 38 at 106.7 m depth).

Figure 3.13 Collapse epoch pressure and radiation measured in the coarse stemming between the intermediate and top plugs (station 39 at 79.3 m depth).

Figure 3.14 Collapse epoch pressure and radiation measured in the fines stemming beneath the top plug (station 40 at 35.4 m depth).

Figure 3.15 Progression of collapse as shown by the position of the break in the CLIPER cable on the instrumentation pendant (station 91). Also shown are representative pressure wave forms. For magnitudes of the pressure drops see figures 3.6-3.14.

4 Measurements on the Emplacement Pipe

4.1 Explosion-Induced Motion

Vertical motion of the emplacement pipe was monitored at seven elevations on the emplacement pipe. Stations were fielded on the either side of the deepest pressure dome, the location of the pinhole. Pipe motion at elevations just below the next two pressure domes and a location below the formation coupling plug were monitored. Further, the detector plate just above the formation coupling plug and the top section of the pipe near the ball valve were also instrumented for vertical motion. The histories obtained at these locations are shown in figures 4.1- 4.7. Peak motion values and transducer characteristics are given in tables 3.1-3.3.

Just below the deepest pressure dome (station 2, figure 4.1) the velocity gauge was lost at the arrival of the shock. The resulting signal is shown and integrated for completeness. The accelerometer at this station was lost at about 70 ms. At station 3 (figure 4.2) both the velocity and acceleration channels survived for more that 60 ms. All motion transducer channels fielded at elevations above this survived until collapse, yielding good correlation between the data derived from both the accelerometers and velocimeters.

Motion of station 10, on the pipe at the elevation of the detector plate (figure 4.6), closely matches the motion of station 21 in the plug (figure 2.19) except for the initial pulse of motion seen on the pipe (acceleration, velocity, and displacement). This indicates that the drag rings force the motion of the pipe to be nearly the same as that of the formation coupling plug. Motion of station 10 also matches that of the pipe at station 8 (figure 4.5). This further suggests that the pipe remained intact between stations 8 and 10, at least over the time period displayed.

To insure that the line-of-sight for the neutron PINEX experiment remained open during emplacement, the pipe was supported from the top by break-away beams. The motion of the top of the pipe (station 13, figure 4.7) included noise contributions from the break-away beams and a slight downward motion from the release of tension at about 20 ms.

4.2 Collapse-Induced Motion

Collapse-induced motion of the emplacement pipe seen is shown in figures 4.8 - 4.12. For completeness, the motion at station 13 is shown in figure 4.12 as well as figure 3.4. The high speed (60 ips) analog tapes were not reloaded after running to their respective ends so only the low-speed (3.75 ips) tapes captured the collapse data. Only the velocity transducers were recorded on these tapes, at one channel per track, and the accelerations shown in figures 4.8 - 4.12 were obtained as derivatives of the measured velocity. Noise content of the acceleration histories is unrealistically large due to numerical differentiation. It was felt that application of a digital filter to these records would degrade the peaks below their true values and thus was not done. Motion at the lowest pressure dome (stations 2 and 3) was lost before 100 ms after detonation and is not represented here. All motion stations at elevations above this survived until collapse.

Collapse is seen at the second pressure dome (station 4, figure 4.8) beginning at about 14,366.5 s and the channel was lost at about 14368 s after falling almost 3 m. About 3.5 s later, the collapse front reached station 6 (figure 4.9) but no indication of the earlier motion of station 4 is evident on the motion record of station 6. Since both stations were attached to the emplacement pipe it appears that the integrity of the pipe had been compromised by collapse time. Signals of the motion at station 6 can be seen at station 8 below the formation coupling plug (figure 4.10) as an upward pulse at station 6 "slapdown" time. Motion at the detector plate above the formation coupling plug (figure 4.11) is essentially the same as that at station 8, differences being the lack of the upward station 6 slapdown signal and the early loss of station 8. These data support the suggestion of a rupture of the emplacement pipe in the region of station 33 (near station 4) suggested in section 2.1.

4.3 Pressure, Temperature, and Radiation

Four sections of the emplacement pipe were sealed by pressure domes intended to retard and retain the gas pressure generated by the device. Just above the top pressure dome was a recoverable neutron detector which was drawn up through the pipe beyond the ball valve which was then closed shortly after the shot. Each of the four deepest sealed sections was internally monitored for pressure and temperature and the resulting data are shown in figures 4.13-4.16.

Stations 2 and 4 just below the first and second pressure domes, respectively, (figure 4.13 and 4.14) were both instrumented with high and low sensitivity pressure gauges. Data from station 4 were degraded by the EMP and should be disregarded.

It appears that station 2 may have detected gas flow in the pipe: the temperature change observed in figure 4.13 may have been due gas stagnation at the first pressure dome.

A slight pressure jump of about 1 bar (15 psi) beginning at about 3 ms and lasting for about 1.2 ms was seen at station 6, monitoring the third pressure dome (figure 4.15). There was no accompanying temperature change until the station was lost at around 24 ms.

The pipe section terminated by the fourth pressure dome was monitored by station 9 (figure 4.16). Digitization of the pressure and temperature records in the pipe section for the periods between -0.2 and 2 seconds and between 10,500 and 15,000 s were obtained; however, digitization of the continuous time period between -200 and 10,500 s was inadvertently omitted. Thus the data displayed in figure 4.16 is the best information available. No temperature change was observed, but there may have been a pressure change between a recorded initial value of 8 psi and a final value of 18 psi.

The emplacement pipe was also instrumented for internal pressure and radiation at station 12 in the top section at a depth of about 15 m. Histories of these measurements are shown in figure 4.17. No change from ambient background values are seen. The same digitizing oversight made for station 9 was made for the pressure channel of station 12.

Figure 4.1 Explosion-induced vertical motion recorded on the emplacement pipe 1.1 m below the first pressure dome above the diagnostics canister (station 2 at a depth of 293.7 m). This pressure dome was also the location of the pinhole of the pinex experiment. Heavy traces are the histories derived from the velocity gauge. The history derived from the velocimeter channel is shown for completeness only.

Figure 4.2 Explosion-induced vertical motion recorded on the emplacement pipe 0.8 m above the first pressure dome above the diagnostics canister (station 3 at a depth of 291.8 m). This pressure dome was also the location of the pinhole of the pinex experiment. Heavy traces are the histories derived from the velocity gauge.

Figure 4.3 Explosion-induced vertical motion recorded on the emplacement pipe 2.6 m below the second pressure dome above the diagnostics canister (station 4 at a depth of 258.7 m). Heavy traces are the histories derived from the velocity gauge.

Figure 4.4 Explosion-induced vertical motion recorded on the emplacement pipe 1.0 m below the third pressure dome above the diagnostics canister (station 6 at a depth of 220.4 m).

Figure 4.5 Explosion-induced vertical motion recorded on the emplacement pipe 6.4 m below the fourth pressure dome above the diagnostics canister and 2.4 m beneath the formation coupling plug (station 8 at a depth of 189.9 m). Heavy traces are the histories derived from the velocity gauge.

Figure 4.6 Explosion-induced vertical motion recorded on the emplacement pipe at the detector plate above the formation coupling plug (station 10 at a depth of 178.0 m). Heavy traces are the histories derived from the velocity gauge.

Figure 4.7 Explosion-induced vertical motion recorded on the emplacement pipe 1.9 m above ground and below the ball valve (station 13). Heavy traces are the histories derived from the velocity gauge.

Figure 4.8 Collapse-induced vertical motion recorded on the emplacement pipe 1.6 m below the second pressure dome above the diagnostics canister (station 6 at a depth of 207.0 m). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 4.9 Collapse-induced vertical motion recorded on the emplacement pipe 1.0 m below the third pressure dome above the diagnostics canister (station 6 at a depth of 220.4 m). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 4.10 Collapse-induced vertical motion recorded on the emplacement pipe 6.4 m below the fourth pressure dome above the diagnostics canister and 2.4 m beneath the formation coupling plug (station 8 at a depth of 189.9 m). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 4.11 Collapse-induced vertical motion recorded on the emplacement pipe at the detector plate above the formation coupling plug (station 10 at a depth of 178.0 m). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 4.12 Collapse-induced vertical motion of the emplacement pipe (station 13, on the pipe 1.9 m above ground level but below the ball valve). Acceleration at collapse was not recorded; the acceleration trace was derived from the velocity.

Figure 4.13 Pressure and temperature recorded in the emplacement pipe 1.1 m below the first pressure dome above the diagnostics canister (station 2 at a depth of 293.7 m). This pressure dome was also the location of the pinhole of the pinex experiment.

Figure 4.14 Pressure and temperature recorded in the emplacement pipe 2.6 m below the second pressure dome above the diagnostics canister (station 4 at a depth of 258.7 m).

Figure 4.15 Pressure and temperature recorded in the emplacement pipe 1.0 m below the third pressure dome above the diagnostics canister (station 6 at a depth of 220.4 m).

Figure 4.16 Pressure and temperature recorded in the emplacement pipe 0.6 m below the fourth pressure dome above the diagnostics canister (station 9 at a depth of 184.1 m).

Figure 4.17 Pressure and radiation recorded in the emplacement pipe near its top (station 12 at a depth of 14.9 m).

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