ORKNEY Containment Data Report

R. Heinle

B. Hudson

T. Stubbs

March 1995

This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.

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

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

6H

MASTER

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This report has been reproduced
directly from the best available copy.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ORKNEY Instrumentation Summary

Instrumentation	Fielded	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
Recording trailer	no	-	-
<u>Hydroyield (a)</u>	yes	yes	no
<u>Collapse (b)</u>	yes	yes	yes
<u>Stress</u>	yes	yes	yes
<u>Strain</u>	yes	yes	yes
<u>Other Measurements (c)</u>	yes	yes	yes

- (a) EXCOR/CORRTEX in emplacement hole.
(b) EXCOR measurement in emplacement hole.
(c) Metritape slurry level, internal plug strain, slurry pressure

Event Personnel

Containment Physics

B. Hudson	LLNL
V. Wheeler	LLNL
J. Kalinowski	EG&G/AVO
T. Stubbs	EG&G/AVO

Instrumentation

C. Cordill	LLNL
R. McNairy	LLNL
D. Longinotti	EG&G/AVO
W. Webb	EG&G/NVO
A. Moeller	EG&G/NVO

Contents

[illegible]

1. Event Description

1.1 Containment summary

The ORKNEY event was detonated in hole U10be of the Nevada Test Site (figure 1.1). Detonation time was 6:50 AM PST on May 2, 1984. No subsidence was observed but possible radiation arrivals were detected below the deepest liquid filled aggregate, gas seal plug; none were detected higher in the emplacement hole. The ORKNEY event containment was satisfactory.

1.2 Site.

A geologic map showing some of the surface features near the U10be site is shown in figure 1.2. The device had a burial depth of 210 m in Area 10 alluvium about 370 m above the static water level (SWL), as shown in the geologic cross sections of figure 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⁾.

1.3 Instrumentation

Figure 1.5 is a schematic layout of the instrumentation in hole U10be, designed to monitor the stemming emplacement procedures and performance on the ORKNEY event.

For quality assurance during emplacement, each of the four gypsum filled aggregate (GFA) plugs was monitored with an array of conductivity probes, a metritape, a liquid pressure transducer, and a thermistor.

The coarse stemming beneath every plug except the top (plug 7) was instrumented with pressure and radiation stations. Included in this was a system (station 31) designed to monitor the pressure and radiation challenging the bottom plug (plug 1). Station 31 was mounted about 15 m above the top of plug 1 and connected to the environment below the plug through a 33 m section of gas sample hose.

As part of an effort to develop a multiplex system to reduce the number of down-hole cables and emplacement costs, two pressure and radiation systems were also mounted on either side of the deepest coal tar aggregate (CTA) soft plug (plug 2) and transmitted information up-hole through a single cable. A second multiplex system was used to monitor two stress and strain stations mounted in the bottom plug.

Vertical motion was monitored in plugs 4, 5, and 7, 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. The full strain tensor was monitored in the same three GFA plugs in which were placed motion stations. Displacement between the surface casing and the top plug was monitored by a Bourns® linear potentiometer having a 24 inch full scale range.

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

Hydrodynamic yield of the device and cavity subsidence was monitored by an EXCOR/CORRTEX cable (labeled "CLIPER/CORRTEX" in figure 1.5) fielded in the emplacement hole. Results of the hydrodynamic yield measurements are reported elsewhere⁽³⁾.

A brief history of the fielding operations of the instrumentation (including the emplacement pipe strain measurements) is given in reference 4. Further details of the instrumentation are given in reference 5.

Figure 1.1 Map of the Nevada Test Site indicating the approximate location of hole 10be.

Figure 1.2 Geologic Map of the region near hole U10be.

5

Figure 1.4 As-built stemming plan for hole U10be.

Figure 1.5 As-built containment instrumentation plan for the ORKNEY event emplacement hole U10be.

2. Emplacement

2.1 Load on the emplacement pipe

Figure 2.1 shows the load experienced by the emplacement pipe during the stemming operations. There was some initial concern over the loading of the pendant on which the containment diagnostics instrumentation was emplaced so the load on this element was also monitored during stemming. The load history thus obtained is shown in figure 2.2.

2.2 Plug levels and temperature

A total of seven plugs were fielded in the emplacement hole as shown in figured 1.5. Four of these (plugs 1, 4, 5, and 7) were composed of gypsum filled aggregate (GFA), the middle two of which were overlain with a thin (2 m thick) sealing layer of coal tar filled aggregate (CTA). Two gas seal membranes (plugs 2 and 3) each consisting of sandwiches of two layers of LLNL fines surrounding a 3.3 m thick layer of CTA were placed between GFA plugs 1 and 4. Plug 6 was composed of 6 m of two-part epoxy (TPE) and topped with 1.5 m thick sealing layer of CTA. This plug was placed to contain the bottom 3 m of the surface casing.

Emplacement of each of the four GFA plugs was monitored with an array of conductivity probes, thermistors, liquid pressure transducers, and metritape level sensors . The locations of the conductivity probes are tabulated in figure 1.5. Figures 2.3-2.6 show plots of the GFA emplacement and temperature histories. Open circles indicate the upper and lower boundary positions of the plugs as measured with tag lines while solid circles indicate the elevations of the probes and the times at which they were activated. Metritape readings are shown as open squares.

Two different types of pressure transducers were fielded near the bottom of each of the four GFA plugs in an attempt to determine the plug thickness by measuring the liquid slurry hydrostatic head. The pressure histories detected are shown for completeness in figures 2.3-2.6 and indicate limited success. Each trace is shown to such time as the pressure peak (due to 36 of the gypsum) is passed.

A thermistor was fielded in the TPE plug at the bottom of the surface casing as an indication of the polymerization process in that plug. The temperature history thus obtained is shown in figure 2.7.

All plugs were emplaced as planned.

Figure 2.1 Strain measurements made on the emplacement pipe during the stemming at station 89 (near the top of the pipe), at station 186 (2.9 m above the diagnostics canister) and at station 189 (1.5 m above plug 1).

Figure 2.2 History of the load on the containment diagnostics instrumentation pendant during stemming operations.

Figure 2.3 Sanded gypsum emplacement for the first plug. The upper and lower plug boundaries were calculated or determined with a tag line (open circle). Solid circles indicate the conductivity probe elevations shaded circles denote the probes that were not activated and Metritape readings are shown as open squares. Elevations of the pressure sensors accompany the traces. The temperature probe was at the elevation of probe C.

Figure 2.4 Sanded gypsum emplacement for the fourth plug. The upper and lower plug boundaries were calculated or determined with a tag line (open circle). Solid circles indicate the conductivity probe elevations shaded circles denote the probes that were not activated and Metritape readings are shown as open squares. Elevations of the pressure sensors accompany the traces. The temperature probe was at the elevation of probe D.

Figure 2.5 Sanded gypsum emplacement for the fifth (top) plug. The upper and lower plug boundaries were determined with a tag line (open circles). Solid circles indicate the conductivity probe elevations shaded circles denote the probes that were not activated and Metritape readings are shown as open squares. Elevations of the pressure sensors accompany the traces. The temperature probe was at the elevation of probe E.

Figure 2.6

Sanded gypsum emplacement for the seventh (top) plug. The upper and lower plug boundaries were determined with a tag line (open circles). Solid circles indicate the conductivity probe elevations shaded circles denote the probes that were not activated and Metritape readings are shown as open squares. Elevations of the pressure sensors accompany the traces. The temperature probe was 0.5 m below the elevation of probe D.

Figure 2.7 Temperature history of the TPE plug indicating that polymerization reached a maximum temperature increase of slightly in excess of 50 degrees Fahrenheit about 10 hours after pouring.

3. Stemming Performance

3.1 Radiation and Pressure

All pressure and radiation data are consistent with satisfactory containment.

As indicated in figure 1.5, the region below each of the plugs (except plugs 3 and 7) was monitored by pressure and radiation stations. Signals from these stations were transmitted to the recording trailer in analog form and recorded on magnetic tape.

Pressure and radiation histories, from a few seconds before detonation until almost 3.6 hours after detonation, are displayed in figures 3.1–3.8. Figure 3.9 shows all of the radiation histories extending to about 36 hours suggesting the possibility of radiation introduced to the stemming at depths greater than 140 m (below the deepest CTA sealing plug).

Comparison of the data from stations 32 and 33, the lower station of the multiplex pair, (figures 3.2 and 3.3) indicates a favorable long-time performance of the multiplex system. This conclusion is confirmed by comparison of figures 3.4 and 3.5 (the data from station 34 compared with those from station 35, the upper station of the multiplex pair).

No pressure wave forms suggesting pressure changes other than those that could be produced by ground motion or system drift were observed.

3.2 Motion

Figures 3.10 -3.15 show the first four seconds of explosion-induced vertical motion obtained from the top three GFA plugs, the emplacement pipe, the surface casing, and the ground surface.

Figure 3.16 shows the relative displacement of the top GFA plug and the surface casing as determined from the difference in the derived displacement histories of stations 23 and 24. Also shown is the displacement history measured by the Bourns[®] linear potentiometer. Due to the inherent experimental errors in taking the difference of two integrals, both records are consistent with no separation between the plug and the surface casing. The high noise level seen on the Bourns transducer makes it of little value as an independent device on this experiment.

Visual comparison of figure 3.10 with figure 3.14 indicates an upward permanent displacement of about 40 cm of the emplacement pipe relative to the surface casing (and the top plug).

3.3 Collapse

The only indication of collapse was seen on the CLIPER cables at about 106 minutes after detonation. CLIPER and CORRTX receivers share the same cables and to preclude interference with CORRTX, the CLIPER electronics were disabled until 1.0 second after detonation. When the system was reactivated, it was found that the cable mounted on the emplacement pipe (station 91) was broken at a depth of 180.65 m and did not change thereafter. The cable associated with station 92 (mounted on the instrument pendant) was broken at a depth of 176.6. Its broken end remained at a constant position until shifting to a depth of 175.3 m at a time of 6387 s after detonation. No further CLIPER changes were observed. This strongly suggests that plug 1 acted as a stemming platform (the bottom of the plug is at a depth of 177.4 m).

Table 3.1 Summary of Motion

Gauge	Slant Range (m)	Arrival Time (ms)	Acceleration Peak (g)	Velocity Peak (m/s)	Displacement Peak (cm)	Displacement Resid. (cm)
10av	211	63	76	11.6	51	48
10uv		-	-	10.9	45	38
21av	116.3	35 ^(a) , 60	1.95	0.49	4.8	1.0
21uv		-	-	0.44	4.2	0.3
22av	153.9	44 ^(a) , 77	1.27, 2.8 ^(b)	0.31	3.7	1.2
22uv		-	-	0.31	3.7	0.9
23av	204.7	58 ^(a) , 112	0.90, 2.7 ^(b)	0.39	4.3	1.2
23uv		-	-	0.40	4.5	0.4
24av	210	60 ^(a) , 116	0.90, 3.0 ^(b)	0.37	3.9	0 ^(c)
24uv		-	-	0.37	4.0	1.1
61av	210.6	127	1.63, 10.7 ^(b)	0.39	4.2	0 ^(c)
61uv		-	-	3.8	4.2	0.5

(a) Emplacement pipe-stemming interaction.

(b) Slap-down peak.

(c) Approximate.

Table 3.2 Accelerometer Characteristics

<u>Gauge</u>	<u>Natural Frequency (Hz)</u>	<u>Damping Ratio</u>	<u>System Range (g's)</u>
10av	740	0.67	80
21av	250	0.75	8.0
22av	255	0.75	6.0
23av	235	0.70	8.0
24av	230	0.75	3.0
61av	230	0.75	8.0

Table 3.3 Velocimeter Characteristics

<u>Gauge</u>	<u>Natural Frequency (Hz)</u>	<u>Time to 0.5 Amplitude (s)</u>	<u>Calibration Temperature (°C)</u>	<u>Operate Temperature (°C)</u>	<u>System Range (m/s)</u>
10uv	4.092	25.80	24.44	14.43	40.
21uv	3.601	8.78	24.42	10.71	6.0
22uv	3.508	9.39	24.22	37.91	4.0
23uv	3.279	11.66	24.11	35.08	6.0
24uv	3.741	8.55	26.07	51.41	6.0
61uv	3.360	9.05	24.55	10.92	6.0

Figure 3.1 Pressure and radiation challenging the deepest plug (station 31 at 146 m depth).

Figure 3.2 Pressure and radiation measured in the coarse stemming below plug 2, the first CTA soft plug (station 32 at 143 m depth).

Figure 3.3 Pressure and radiation as measured in the coarse stemming below plug 2, the first CTA soft plug (station 33 at 143 m depth). This is the deeper of two stations attached to a multiplex system and is at the same elevation as station 32.

Figure 3.4 Pressure and radiation measured in the coarse stemming above plug 2, the first CTA soft plug (station 34 at 134m depth).

Figure 3.5 Pressure and radiation as measured in the coarse stemming above plug 2, the first CTA soft plug (station 35 at 134 m depth). This is the shallower of two stations attached to a multiplex system and is at the same elevation as station 34.

Figure 3.6 Pressure and radiation measured in the coarse stemming below plug 4, the second GFA plug (station 36 at 96 m depth).

Figure 3.7 Pressure and radiation measured in the coarse stemming below plug 5, the third GFA plug (station 37 at 68 m depth).

Figure 3.8 Pressure and radiation measured in the coarse stemming below two-part-epoxy plug 6 (station 38 at 38 m depth).

Figure 3.9 All of the radiation histories displayed for about 32 hours (114,300 s) after detonation. The data from stations 31, 32, and 33 suggest the arrival, after 20,000 s, of low levels of radiation that was confined below the deepest gas seal layer (plug 2 at a depth of 140 m).

Figure 3.10 Explosion-induced vertical motion of the top of the emplacement pipe (station 10). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.11 Explosion-induced vertical motion of plug 4, the second GFA plug (station 21 at a depth of 85 m). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.12 Explosion-induced vertical motion of plug 5, the third GFA plug (station 22 at a depth of 56 m). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.13 Explosion-induced vertical motion of plug 7, the fourth GFA plug (station 23 at a depth of 5 m). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.14 Explosion-induced vertical motion of the surface casing (station 24). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.15 Explosion-induced vertical motion of the ground surface (at a depth of 0.91 m and 15.24 m from surface ground zero, station 61). Records annotated with an 'a' are derived from the accelerometer.

Figure 3.16 Vertical separation between the surface casing and the top plug as determined from the motion gages (stations 23 and 24) and the linear displacement transducer (station 88). Downward motion of the top plug relative to the surface casing is positive.

4. Other Measurements

4.1 GFA Plug strain

Each of the top three GFA plugs was instrumented for the strain tensor with Ailtech® strain transducers. The right-handed orthogonal coordinate system (vertical, radial, and transverse) is relative to the centerline of the emplacement hole with the "offset" direction being the composite of the other three. Results of these measurements are shown in figures 4.1 - 4.3.

4.2 Stress in bottom plug

Stress and the associated strain were monitored at two locations in the bottom GFA plug and the results are shown in figures 4.4 and 4.5. Sample rates for these records were 1 KHz and show a 60 Hz signal beginning at zero time and lasting for about 0.6 s on three of the four records. The first 8 seconds of data are shown.

Transducers were fluid-coupled flat-pack grids of interlaced Constantan and Ytterbium produced by Dynasen, Inc.⁽⁶⁾. Polarity of the resulting signals was such that positive indicates a compressive strain. Since the strain gage factor of Yb is a factor of -1.3 times that of Constantan, a simple addition of 1.3 times the fractional resistance change of Constantan to the Yb fractional resistance change signal removes the strain component from the Yb signal. Figure 4.6 shows 500 seconds of the corrected stress measured at the two (nearby) locations. Sample rates were low enough that both the peak magnitudes and the 60 Hz signals seen in figures 4.4 and 4.5 are missing from figure 4.6.

Figure 4.1 Explosion-induced strain measured in the GFA plug 4 (station 183 at a depth of 83.2 m). The right-handed orthogonal coordinate system (vertical, radial, and transverse) is relative to the centerline of the emplacement hole with the "offset" direction being the composite of the other three.

Figure 4.2 Explosion-induced strain measured in the GFA plug 5 (station 184 at a depth of 53.9 m). The right-handed orthogonal coordinate system (vertical, radial, and transverse) is relative to the centerline of the emplacement hole with the "offset" direction being the composite of the other three.

Figure 4.3 Explosion-induced strain measured in the top GFA plug 7 (station 185 at a depth of 4.9 m). The right-handed orthogonal coordinate system (vertical, radial, and transverse) is relative to the centerline of the emplacement hole with the "offset" direction being the composite of the other three.

Figure 4.4 Radial stress and strain measured in the bottom GFA plug at a depth of 172.2 m (station 131). The Yb signal includes contributions from strain.

Figure 4.5 Transverse (or hoop) stress and strain measured in the bottom GFA plug at a depth of 166.1 m (station 132). The Yb signal includes contributions from strain.

Figure 4.6 A composite plot of the strain-corrected radial and hoop stress measured in the bottom GFA plug (stations 131 and 132). A low sample rate precludes reproduction of the peak magnitudes seen in figures 4.4 and 4.5.

References

1. Nancy Howard, "U10be Preliminary Site Characteristics Summary", CP 83-107, Lawrence Livermore National Laboratory, Livermore, CA, November 3, 1983.
2. R. Hutchinson for Alfred E. Burer, "Emplacement and Containment Report for ORKNEY U10be", Holmes & Narver, NTS:A2:87-12, February 2, 1987.
3. LLNL contacts for additional information: R. Heinle (CORRTEX data).
4. William G. Webb, "Special Measurements Final Engineering Report, ORKNEY, U10be," EG&G, Energy Measurements, Las Vegas, NV, SM:84E-115-20, 30 July 1984.
5. William G. Webb, "Special Measurements Physics/Instrumentation Package for ORKNEY, U10be, Final 'as built'" EG&G, Energy Measurements, Las Vegas, NV, SM:84E-115-21, 30 July 1984.
6. J. A. Charest, "Field Stress Measurements", Dynasen, Inc., 20 Dean Arnold Place, Goleta, CA, 1984.

Distribution:

LLNL

TID (11)	L-053
Test Program Library	L-045
Containment Vault	L-221
Burkhard, N.	L-221
Cooper, W.	L-049
Denny, M.	L-205
Dong, R.	L-140
Goldwire, H.	L-221
Heinle, R. (5)	L-221
Mara, G.	L-049
Moran, M.T.	L-777
Moss, W.	L-200
Olsen, C.	L-221
Patton, H.	L-205
Pawloski, G.	L-221
Rambo, J.	L-200
Roland, K.	L-221
Roth, B.	L-049
Valk, T.	L-154
Yunker, L.	L-203

LANL

App, F.	F-659
Brunish, W.	F-659
Kunkle, T.	F-665
Trent, B.	F-664

Sandia

Chabai, A.	MS-1159
Smith, Carl W.	MS-1159

EG&G/AVO

Brown, T.	A-5
Gilmore, L.	A-1
Hatch, M.	A-5
Still, G.	A-5
Stubbs, T.	A-5

EG&G/NVO

Bellow, B.	N 13-20
Davies, L.	N 13-20
Moeller, A.	N 13-20
Robinson, R.	N 13-20
Webb, W.	N 13-20

DNA

Ristvet, B.

S-Cubed

Peterson, E.

Eastman Cherrington Environment
1640 Old Pecos Trail, Suite H
Santa Fe, NM 87504

Keller, C.