Laboratory Testing of Waste Isolation Pilot Plant Surrogate Waste Materials

SAND2014-15465PE

Sandia National Laboratories

Geoscience Research and Applications Group

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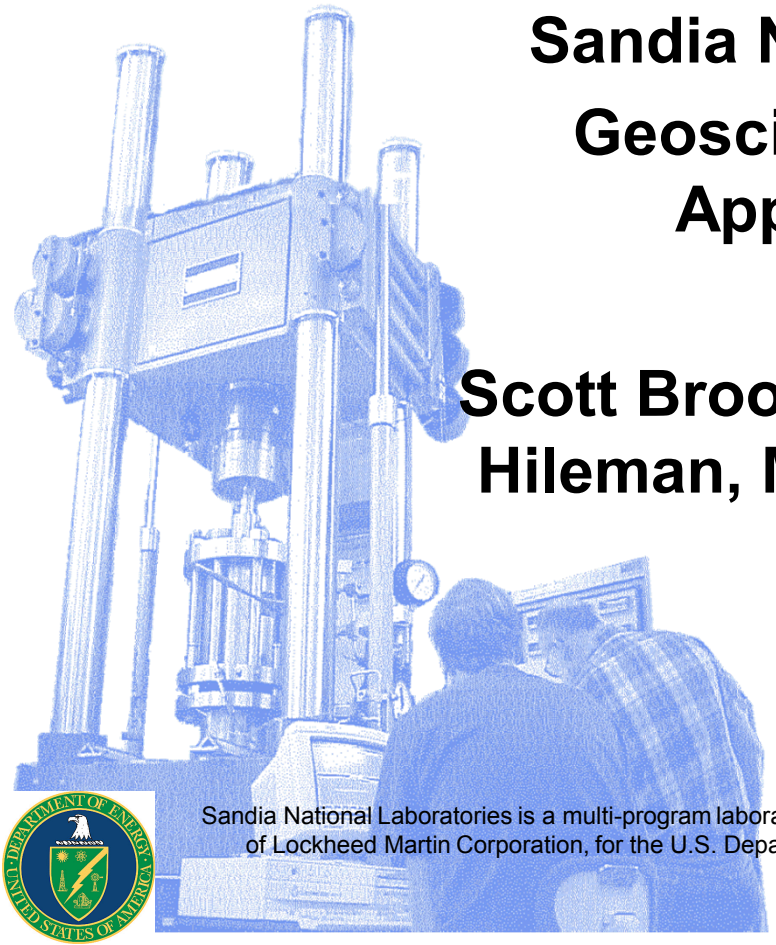

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Preliminary Results

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Disclaimer

- All test results are preliminary results from shakedown tests
- None of the tests have been performed under WIPP QA controls

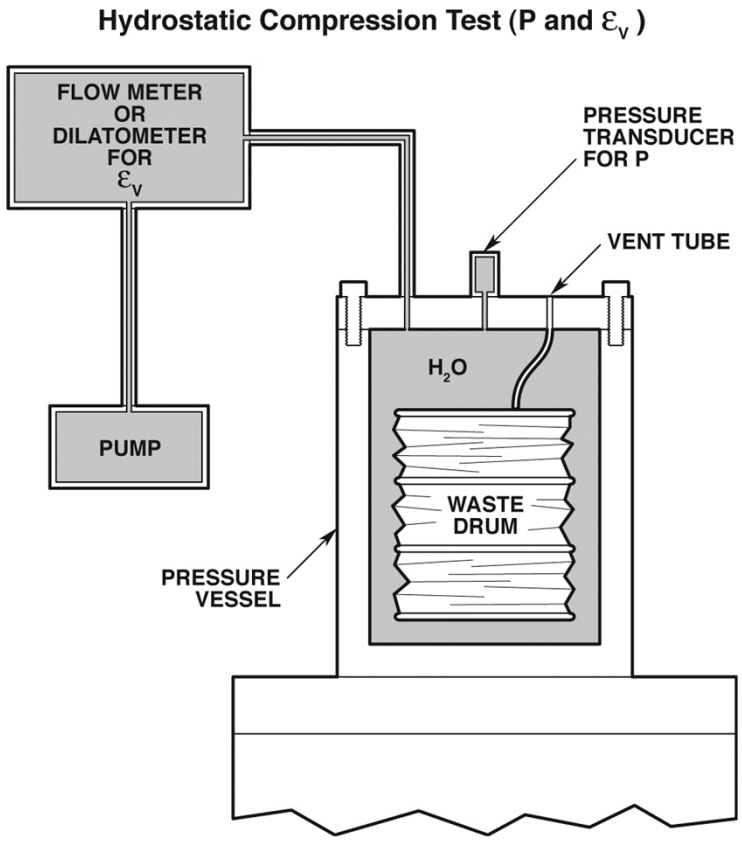
¼ scale waste package

Purpose and Scope

- Perform hydrostatic, uniaxial and triaxial loading tests on ¼ scale waste packages filled with representative waste to allow determination of a complete set of model parameters.
- Perform full-scale hydrostatic and uniaxial loading tests to validate scaling assumptions and provide a basis of evaluating the model in predicting the compressive behavior of waste package systems.
- Perform hydrostatic and triaxial loading tests on simulated degraded waste representing both 50% degraded and 100% degraded cases.
- Perform a limited number of ¼ scale and full-scale tests on alternative waste containers.

Experimental Process Description ¼ scale waste package tests

- Hydrostatic Compression Tests
- Test measurements:
  - Pressure on can
  - Fluid volume necessary to crush can
  - Ventend air volume
- Determination of:
  - Pressure on waste package
  - ε_V of waste package
- Either air volume or fluid volume will determine ε_V



Test setup

Preliminary Results

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Experimental Process Description ¼ scale waste package tests

- ¼ scale test matrix
- Combustible waste recipe from Wawersik, 2001
- Wawersik, 2001 scaled down the recipe of Butcher et al, 1991

Uniaxial	Hydrostatic	Triaxial	
Samples	**Samples**	**Confining stresses**	**Samples per σ_3**
3 to 4	**3 to 4**	**3**	**3 to 4**
		Total	**15 to 20**

Preliminary Results

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Experimental Process Description
¼ scale waste package tests

- ¼ scale ingredients

METALS: Steel Conduit, Copper Tubing, Can & Lid PAPER, CLOTH, WOOD: Wood, Rags PLASTICS: Polyethylene Pipe, Polyethylene Bottle, Polyvinylchloride Pipe, Gloves SORBENTS: Portland Cement, Oilsorb

Preliminary Results

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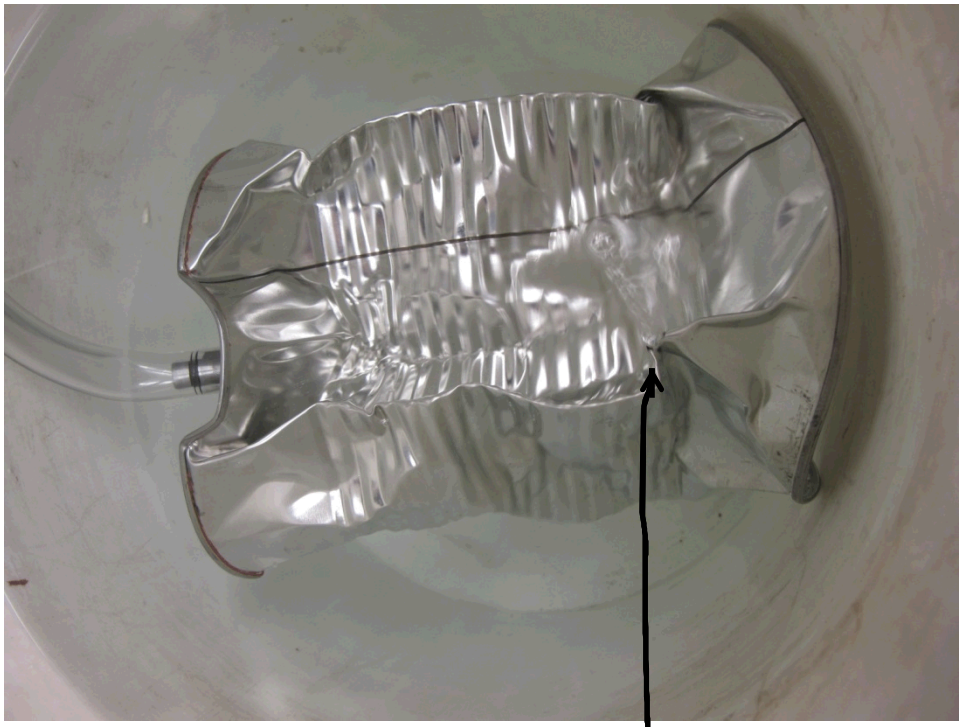
Experimental Process Description
¼ scale waste package tests



- First trial to ~1.5 MPa
- Leak at metal fold
- “Hand” readings taken from spirometer for ε_V determination

Preliminary Results

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Experimental Process Description
¼ scale waste package tests

- Second trial to ~2.76 MPa
- 3 coats of blue rubber jacket
- Leak due to puncture at steel pipe interface
- “Hand” readings taken from spirometer for ε_V determination

Preliminary Results

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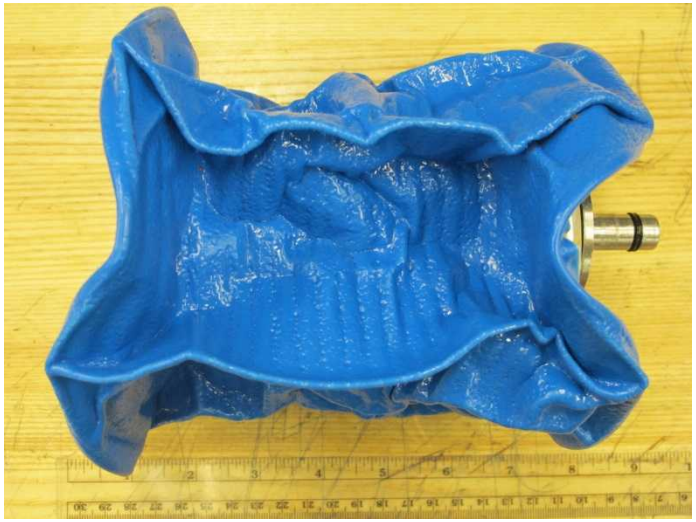
Experimental Process Description
¼ scale waste package tests



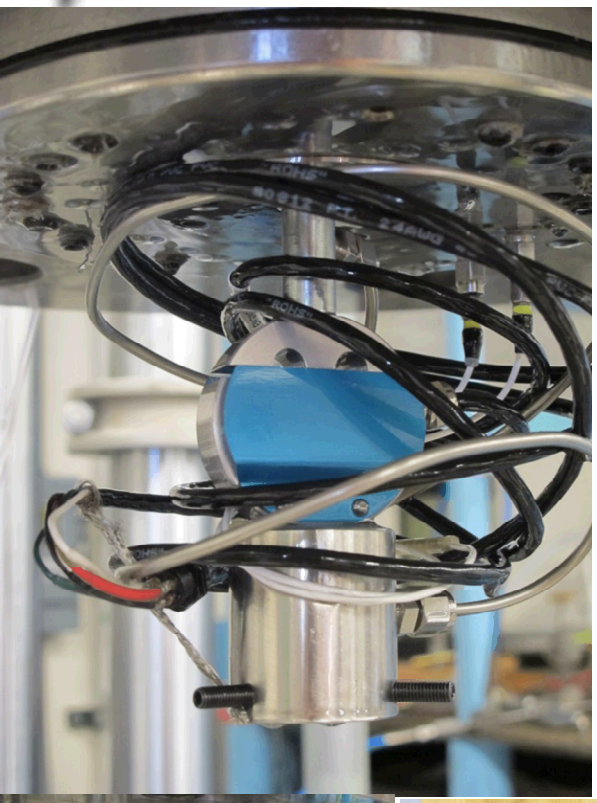
- Third trial to target pressure (15 MPa)
- 4 coats of blue rubber jacket
- LVDT mounted on spirometer for transducer based ε_V determination

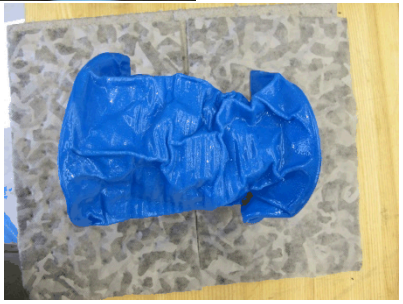
Experimental Process Description
¼ scale waste package tests

- Fourth trial to target pressure (15 MPa)
- 4 coats of blue rubber jacket
- 2 LVDT's mounted on spirometer for transducer based ε_V determination and added resolution for unload/reload loops
- Sample hung on internal load cell for buoyancy measurement

Preliminary Results

Experimental Process Description
¼ scale waste package tests





- Fifth trial to target pressure (15 MPa)
- 4 coats of blue rubber jacket
- 2 LVDT's mounted on spirometer for transducer based ε_V determination and added resolution for unload/reload loops
- Sample hung on internal load cell for buoyancy measurement
- 20.7 MPa pressure transducer used

Preliminary Results

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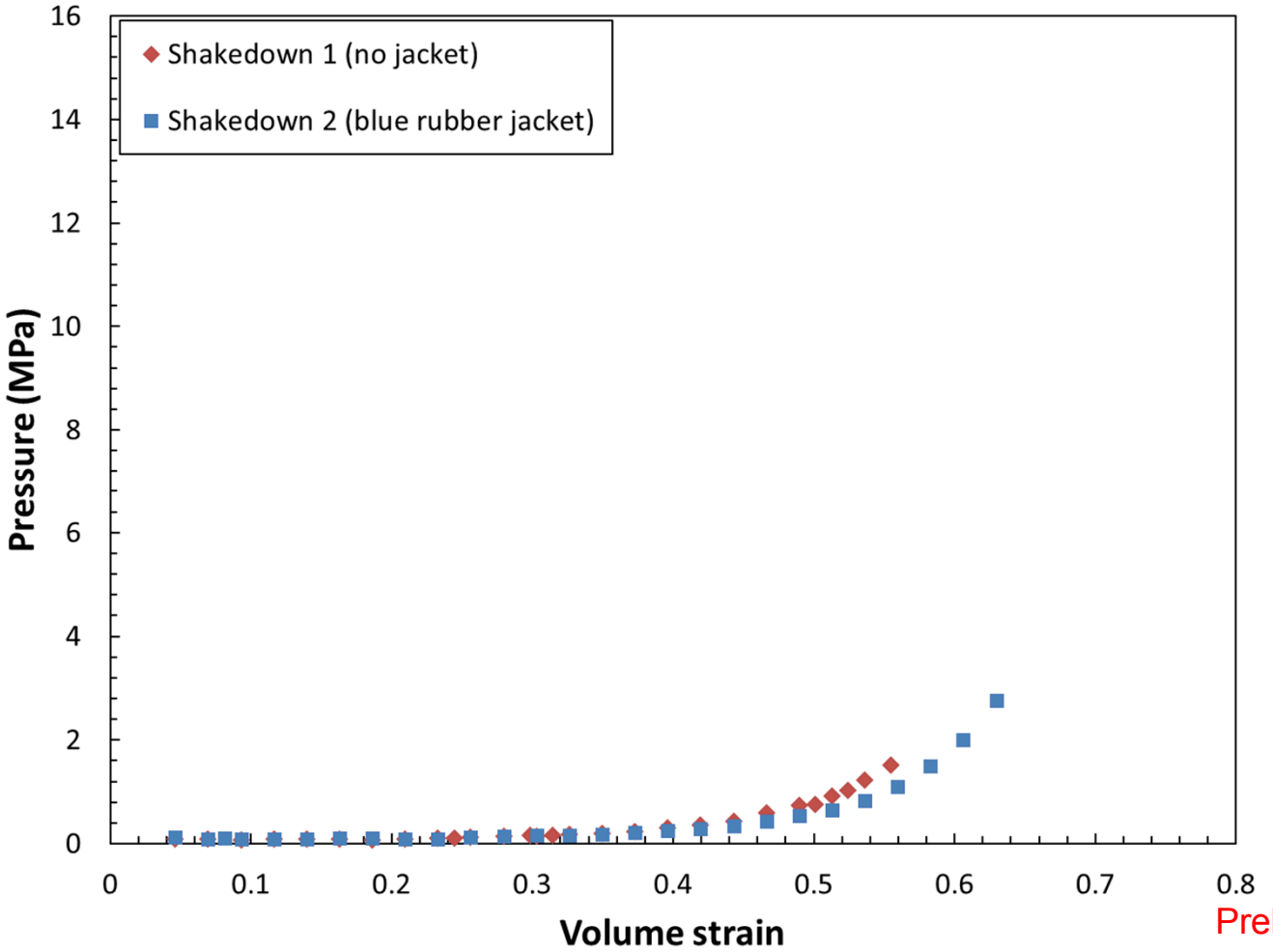
Experimental Process Description
¼ scale waste package tests



- First and second tests "hand" readings from spirometer
- Cans leaked at ~1.5 and 2.76 MPa

Preliminary Results

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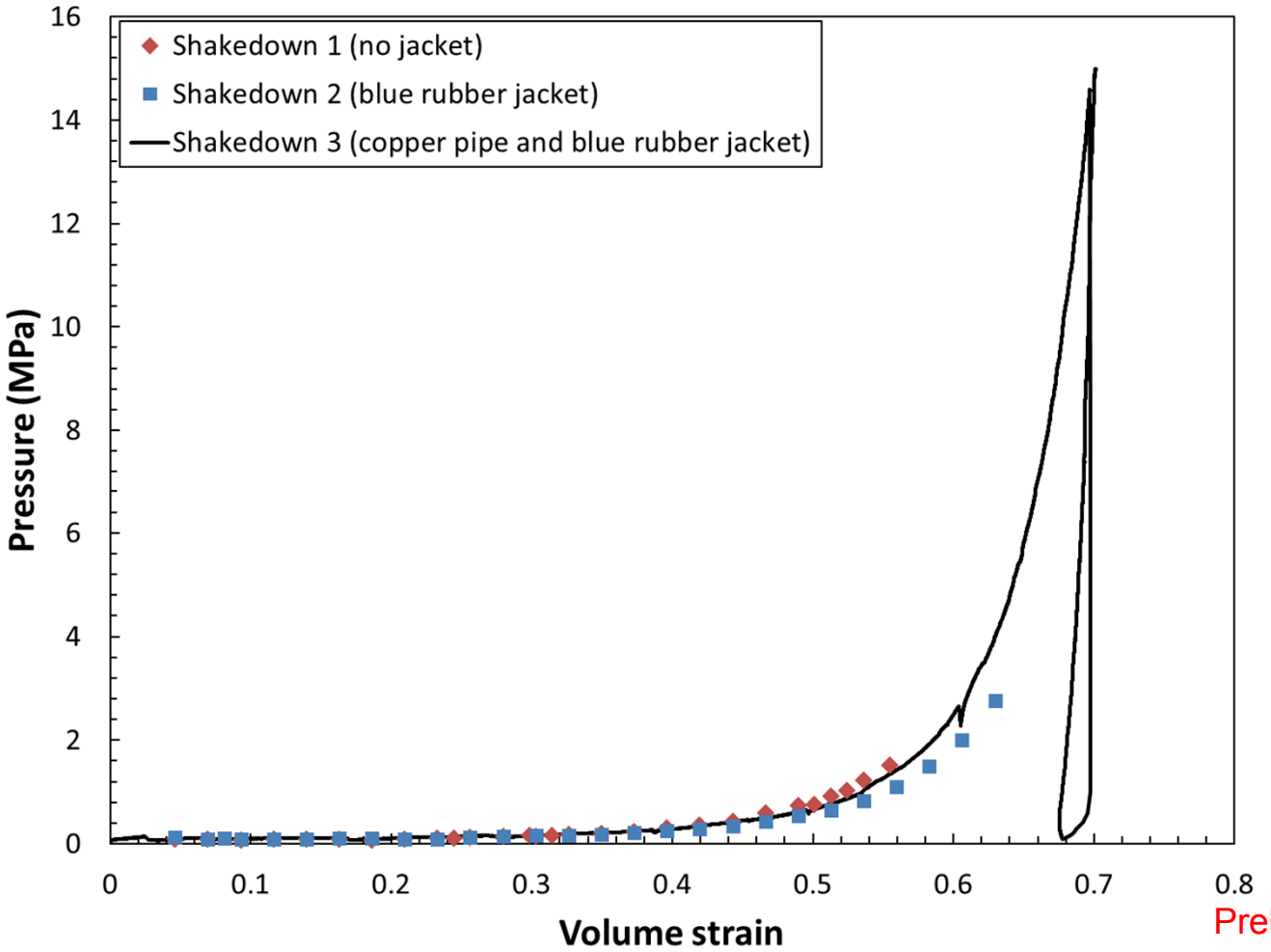
Experimental Process Description
¼ scale waste package tests



- Third test one LVDT mounted on spirometer
- Target pressure achieved (15 MPa)

Preliminary Results

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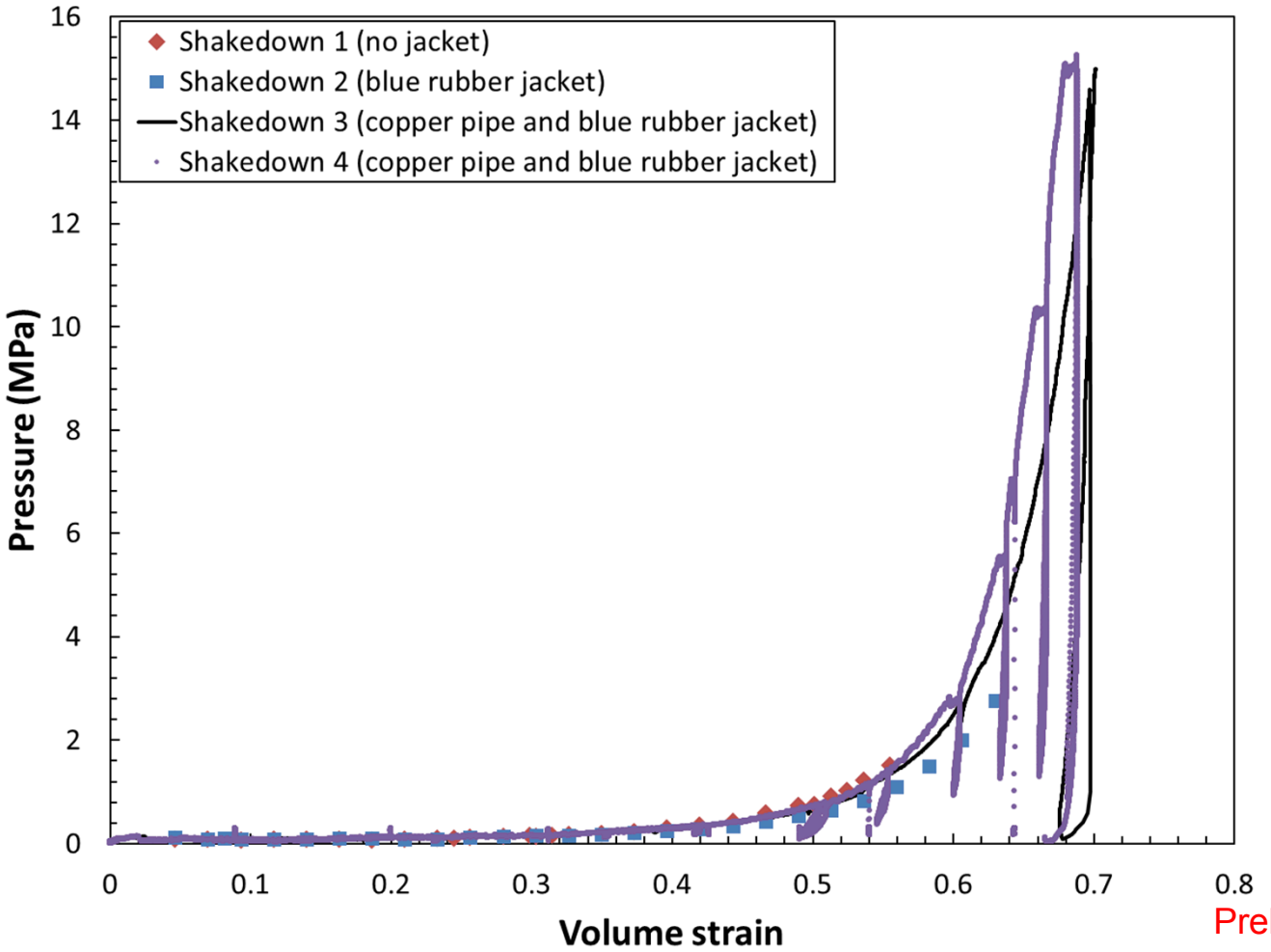
Experimental Process Description
¼ scale waste package tests



- Fourth test 2 LVDT's mounted on spirometer for unload/reload loop slope
- Target pressure achieved (15 MPa)

Preliminary Results

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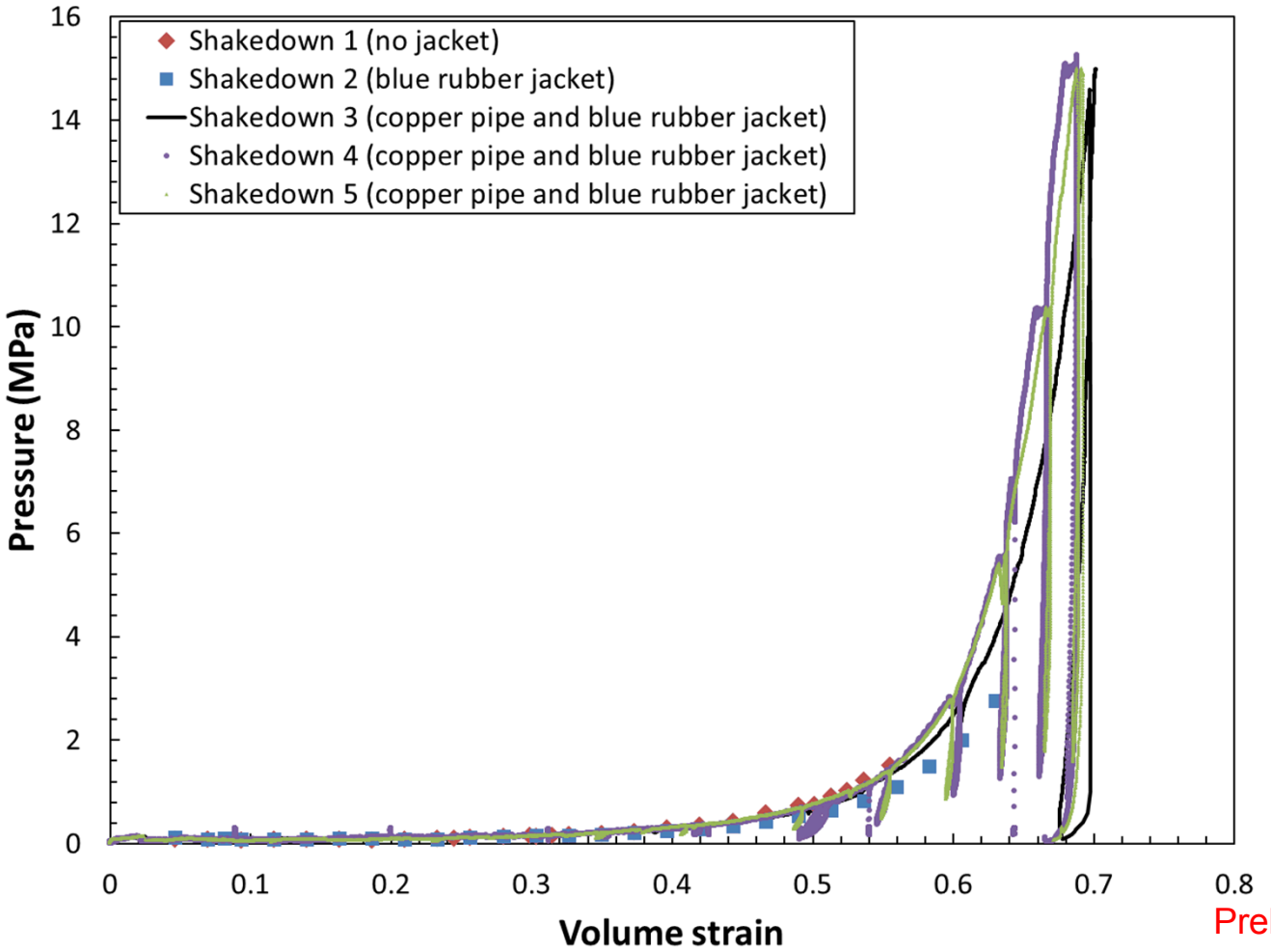
Experimental Process Description
¼ scale waste package tests



- Fifth test 2 LVDT's mounted on spirometer for unload/reload loop slope
- Target pressure achieved (15 MPa) for three tests in a row

Preliminary Results

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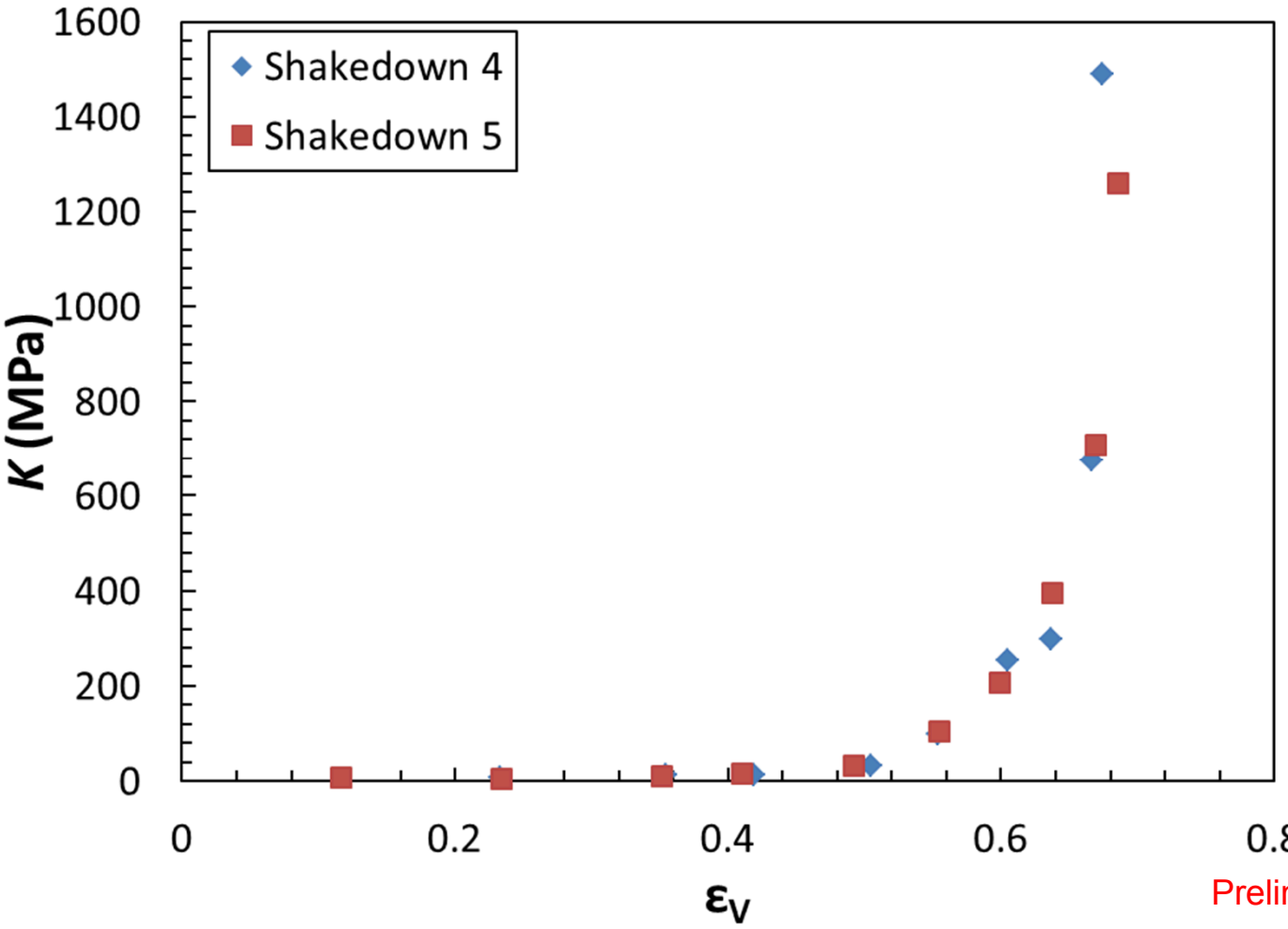
Experimental Process Description
¼ scale waste package tests



- Bulk modulus (K) determined as a function of volumetric strain for trial tests 4 and 5 from unload/reload loops

Preliminary Results

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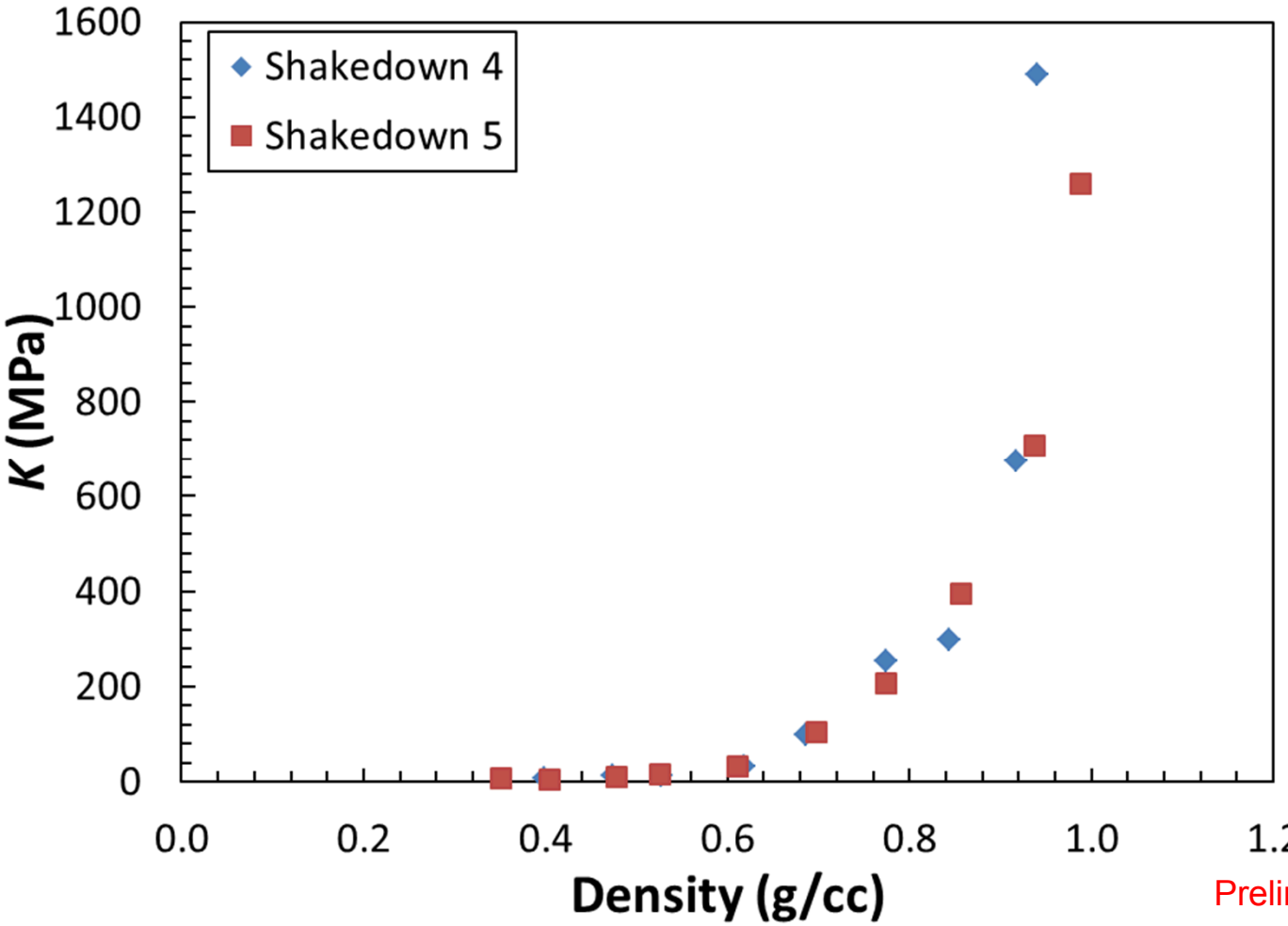
Experimental Process Description
¼ scale waste package tests



- Bulk modulus (K) determined as a function of density for trial tests 4 and 5 from unload/reload loops
- Initial density for both cans was 0.31 g/cc

Preliminary Results

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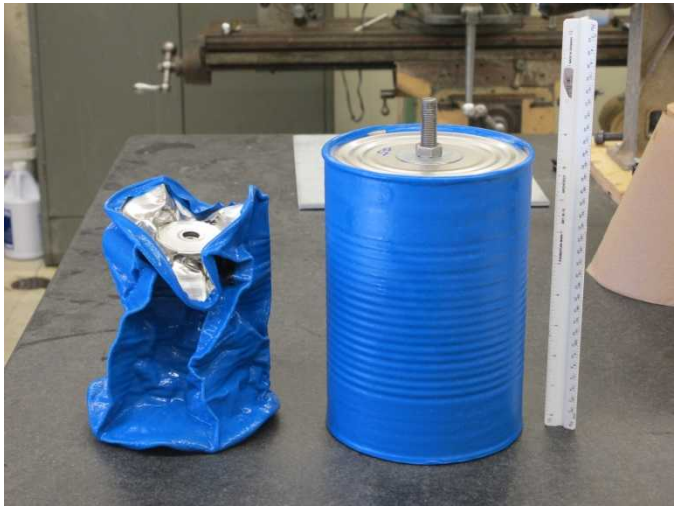
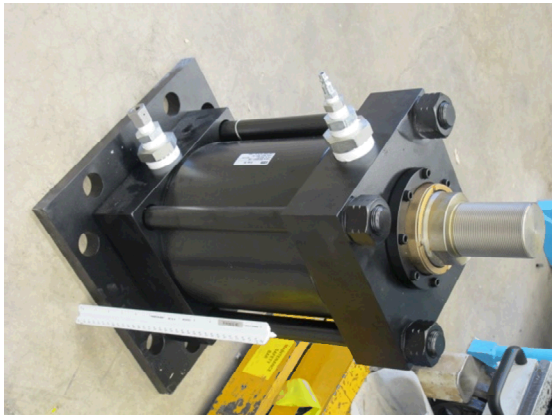
Experimental Process Description
¼ scale waste package tests





Preliminary Results

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Experimental Process Description
Full scale waste package tests

- Uniaxial Compression Tests
- Test measurements:
  - Axial force on can
  - Fluid/air volume change
  - Axial displacement
- Determination of:
  - σ_1 applied to waste package
  - ε_1 of waste package
  - ε_V of waste package
- Can be tested in house
- Used for model validation

Experimental Process Description
Full scale waste package tests

- Hydrostatic Compression Tests
- Possibly use SWRI facilities
- Test measurements:
  - Pressure on can
  - Fluid volume necessary to crush can
  - Vented air volume

- **Determination of:**
  - **Pressure on waste package**
  - **ε_V of waste package**
- **Either air volume, fluid volume, or buoyancy will determine ε_V**

Preliminary Results

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Experimental Process Description
Full scale waste package tests

- Full scale test matrix
- Combustible waste recipe from Butcher et al, 1991

Uniaxial	Hydrostatic
Samples	Samples
3 to 4	3 to 4
Total	6 to 8

Preliminary Results

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References

- Butcher, B.M., T.W. Thompson,, R.G. VanBuskirk, and N.C. Patti. 1991. *Mechanical Compaction of Waste Isolation Pilot Plant Simulated Waste*. SAND90-1206, Albuquerque, NM: Sandia National Laboratories.
- Fossum, A.F. and J.T. Fredrich. 1998. Estimation of Constitutive Parameters for Belridge Diatomite, South Belridge Diatomite Field, SAND98-1407. Albuquerque, NM: Sandia National Laboratories.
- Hansen, F.D., Knowles, M.K., Thompson, T.W., Gross, M., McLennan, J.D., Schatz, J.F., 1997, *Description and Evaluation of a Mechanistically Based Conceptual Model for Spall*, SAND97-1369, Sandia National Laboratories, Albuquerque, NM.
- Huerta, M., Lamoreaux, G. H., Romesberg, L. E., Yoshimura, H. R., Joseph, B. J., and May, R. A., 1983, *Analysis, Scale Modeling and Full-Scale Tests of Low-Level Nuclear Waste Drum Response to Accident Environments*, Sandia Report SAND80-2517, Sandia National Laboratories, Albuquerque, NM.
- Sandler, I.S. and D. Rubin. 1979. *An Algorithm and a Modular Subroutine for the CAP Model.* International Journal for Numerical and Analytical Methods in Geomechanics, John Wiley and Sons, Ltd. Vol. 3, 173-186.
- VandeKraats, J., 1987, *Quarter-Scale Modeling of Room Convergence Effects on CH TRU Drum Waste Emplacements Using WIPP Reference Design Geometries*, Report DOE/WIPP 87-012, Prepared for the Department of Energy under Contract DE-AC04-86AL31950, Westinghouse Experimental Engineering, Carlsbad, NM.
- Wawersik, W. R., 2001, *One-Quarter-Scale Laboratory Crush Tests on Unconfined Waste Cans and a Confined Waste Package in Support of the Waste Isolation Pilot Plant (WIPP)*, Sandia Report SAND98-2574, Sandia National Laboratories, Albuquerque, NM.