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# Initial Evaluation of WIPP Crushed Salt Model Applied to the Triaxial Compaction Test TK-031

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# Introduction

- This work represents our initial comparison of triaxial compaction test TK-031 data with results from a simulation of the test conditions using the WIPP Crushed Salt Model (WIPP CSM) described in Callahan (1999)

- Test data was provide by Svetlana Lerche of TUC (MS Excel file TK-031-030913-KOMPASS.xlsx)

- We have not adjusted the constitutive model parameters to improve the comparison with the TK-031 data

# WIPP Crushed Salt Model

- **The WIPP Crushed Salt Model includes:**
  - **density dependent nonlinear elastic shear and bulk modulii**

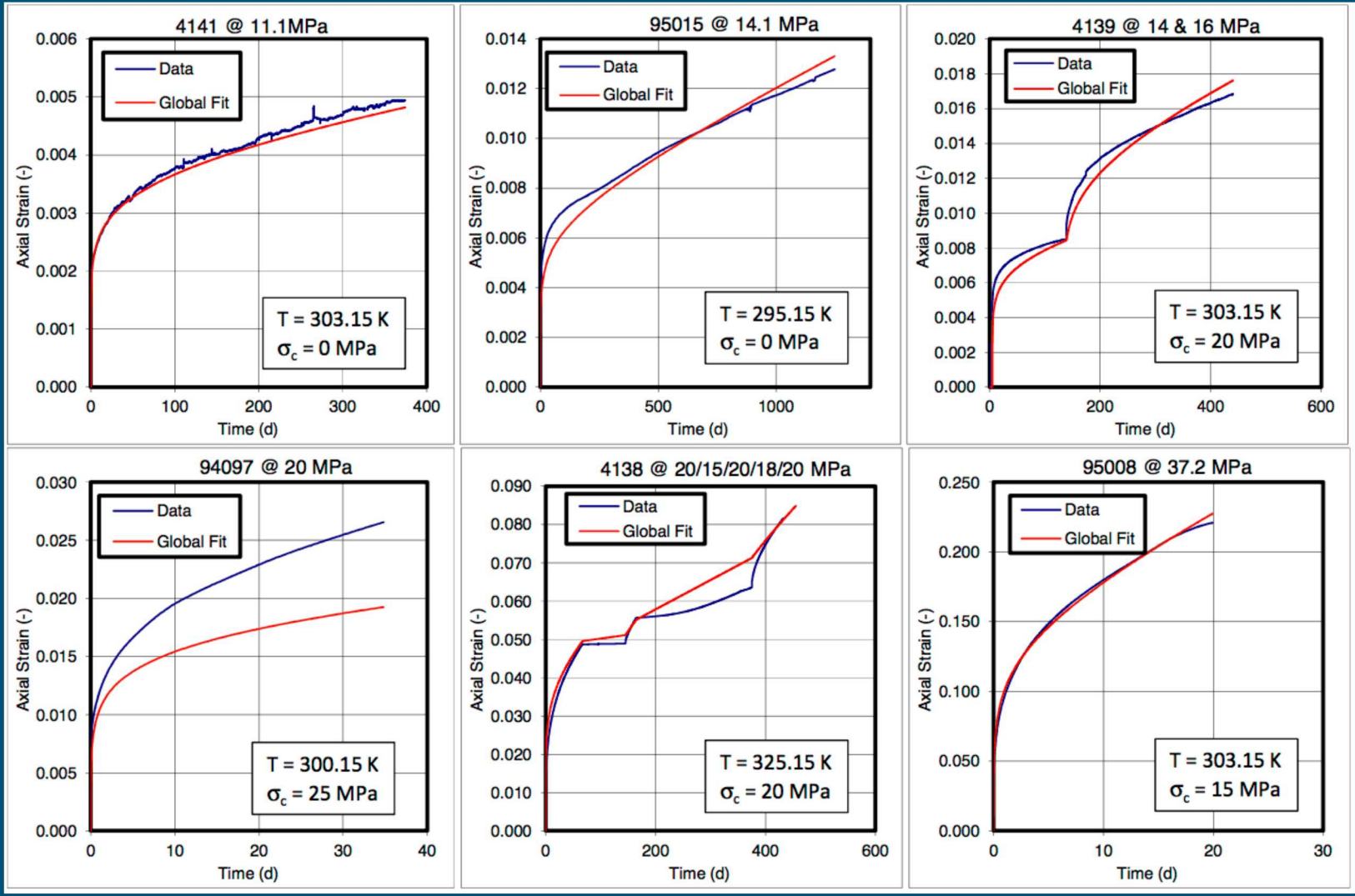
    The nonlinear elastic model parameters were adjusted to give a bulk and shear modulus for intact salt density of ~2170 Kg/m$^3$ consistent with the values given in (DeVries, 2011, Lux and Eberth, 2007 ) (intact salt Young's modulus = 2.5x10$^{10}$ Pa and Poisson's ratio = 0.25)
  - **3 mechanisms for dislocation creep (DC)**

    The DC model of Munson and Dawson (1979, 1982, 1989) was parameterized by RESPEC based on data for Asse salt (DeVries, 2011)
  - **Pressure solutioning (PS) term when moisture is present in the crushed salt**

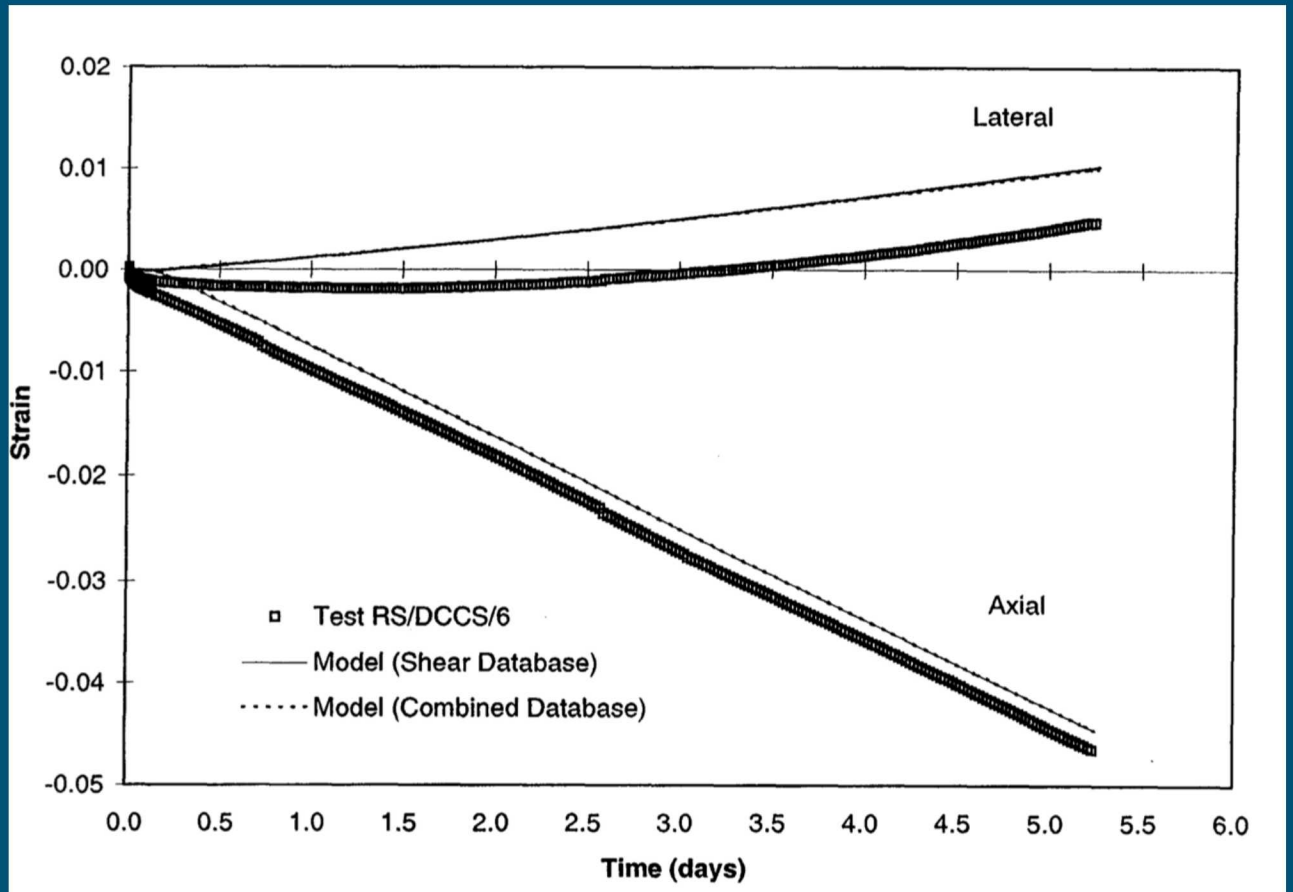
    The PS model parameters are the same as developed for WIPP crushed salt described in Callahan (1999). The mean value of moisture content w = 0.05 wt-% and grain size parameter d = 8mm (Stuhrenberg, 2013) were used in the PS model

    Question- Would the moisture present at the beginning of the test eventually evaporate so the PS effect would not be active later in the test? Since the moisture was still in the sample after drying at 105 deg C I assumed that it remains throughout the test duration.
- A constant temperature of 50 deg C was used in the evaluation

# Comparison of tests on Asse (Speisesalz) Salt and MD model fit for dislocation creep (DeVries, 2011)



# Example comparison of a WIPP Crushed Salt Model prediction with crushed salt experimental data (Callahan, 1999)




Test Details

- Constant axial strain rate test
- Axial compressive strain rate = $1 \times 10^{-7}$/s
- Axial compressive confining stress 1MPa
- Initial fractional density (initial density/intact salt density) = 0.921
- T= 20C

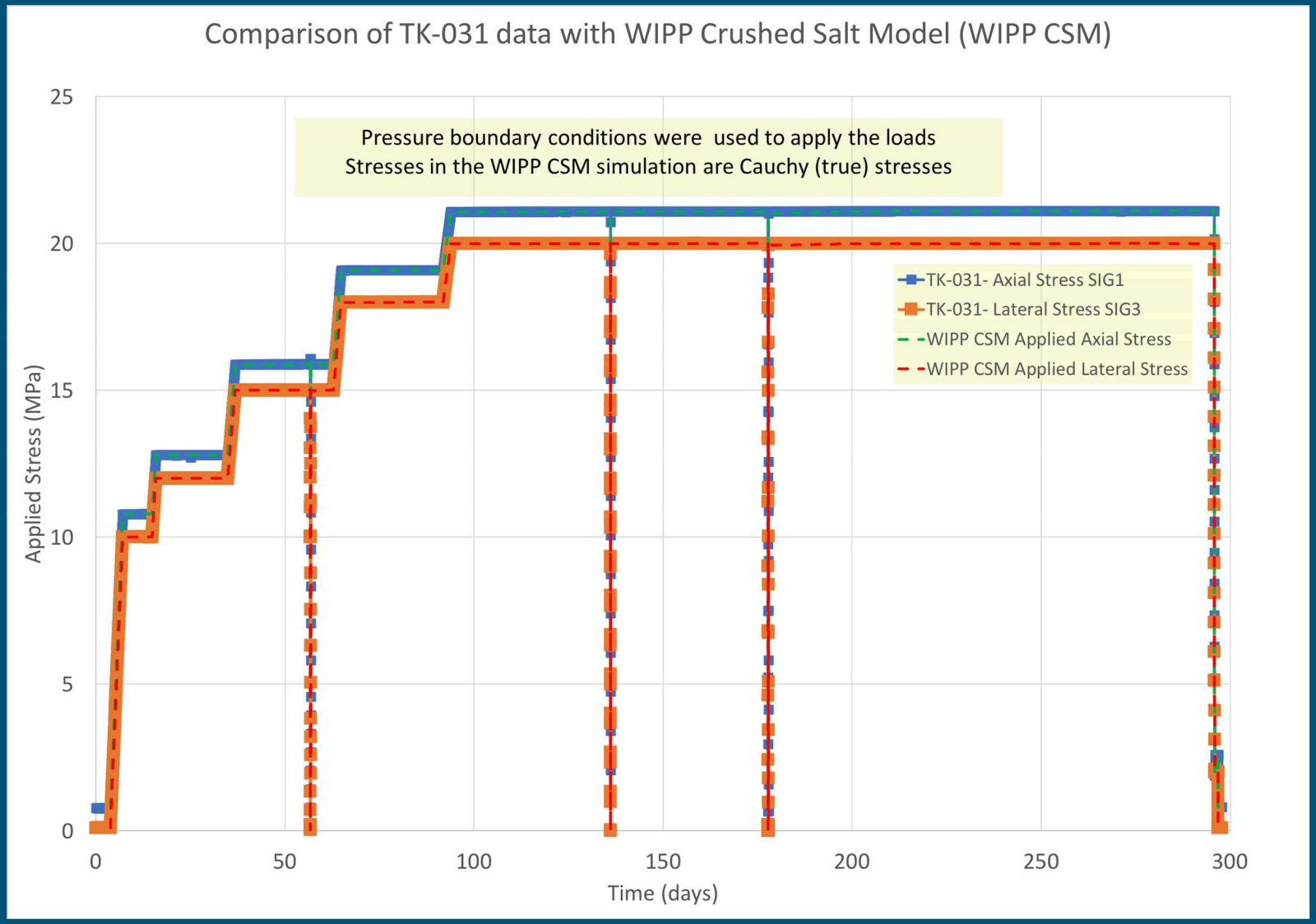
# Finite Element Model Simulation of TK-031

- The WIPP Crushed Salt model was run using a single 8-node hexahedral finite element with applied pressures on 3 faces and kinematic boundary conditions (no normal displacement) on the opposing 3 faces

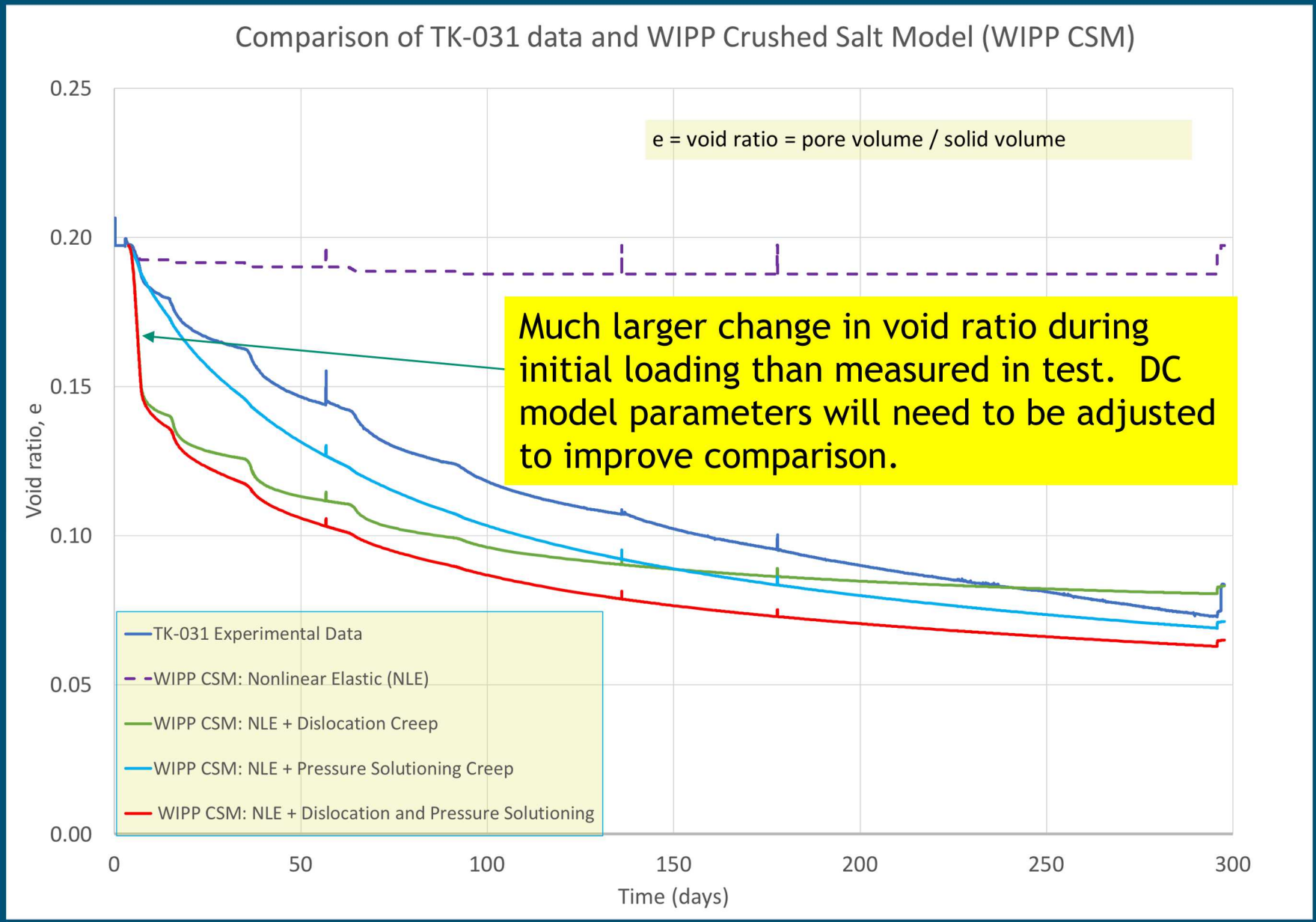
- The pressure-time histories that were applied in the simulation were taken from the data file TK-031-030913-KOMPASS.xlsx (SIG1, SIG3)

- Question. What is the best way to simulate the test? In the experiment, the sample is loaded axially by an applied force (F1) while the lateral loading is imposed by fluid pressure (SIG3). I assumed that the axial stress (SIG1) reported in the file is the Cauchy stress (F1/A) based on statements in the report by Stührenberg (2013) hence the use of pressure boundary conditions in the model.

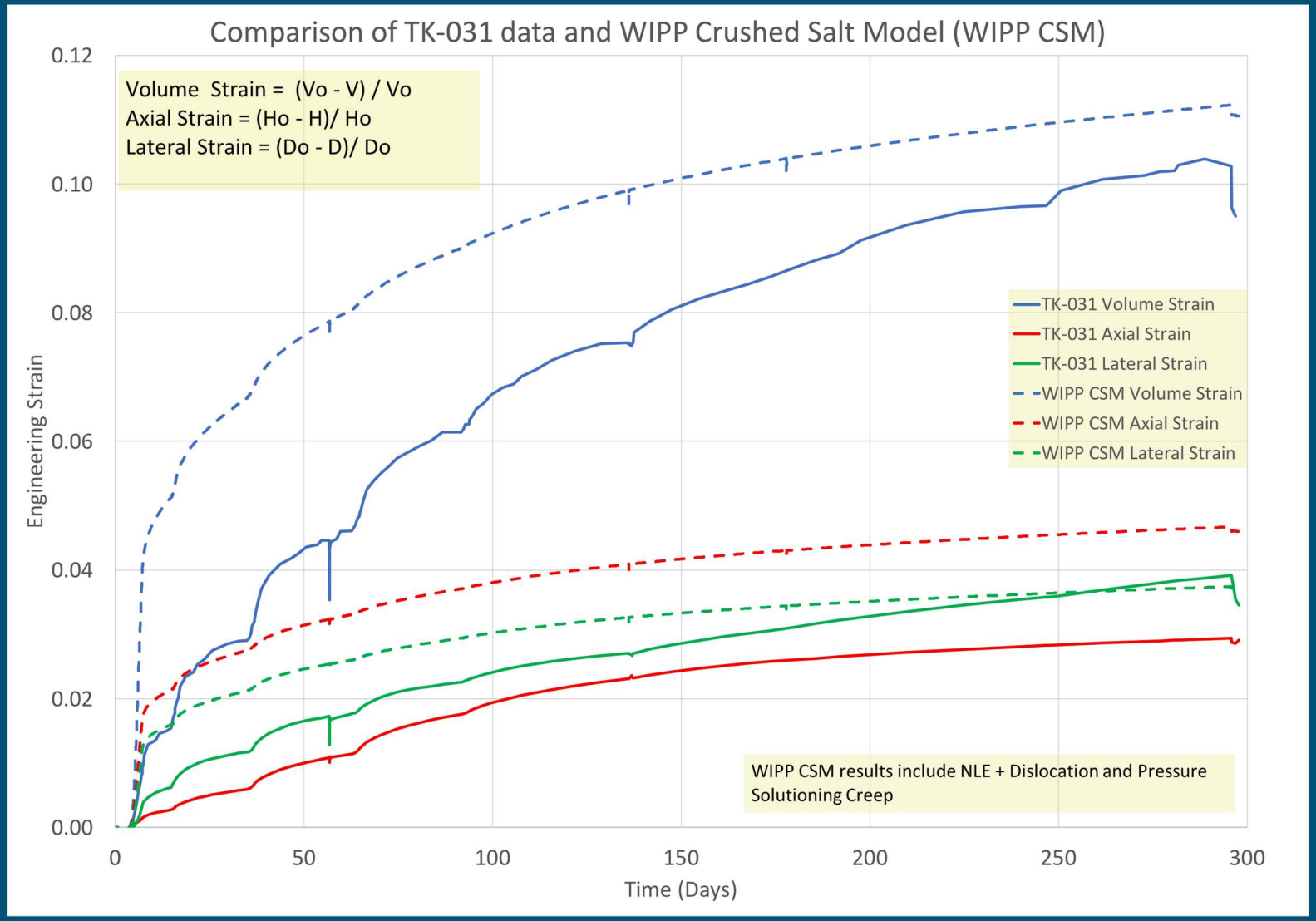
# Axial and Lateral Stress Loading conditions



# Void Ratio Evaluation



# Volumetric, Axial and Lateral Strains




WIPP CSM gives larger axial strains than lateral strains while TK-031 data shows larger lateral strains than axial strains.

# Summary

- The results presented reflect our initial comparison of TK-031 test data and WIPP Crushed Salt Model (WIPP CSM) results
- The model overestimates the early time compaction due to dislocation creep
- The WIPP CSM also predicts larger axial strain than lateral strain while the test data shows the lateral strain is larger than the axial strain. Is this expected? Anisotropic initial state? Do the other models show similar differences?
- We will need to determine what adjustments can be made to improve the comparison of model and experiment

Thank you for your attention

# References


1. Callahan, G.D., *Crushed Salt Constitutive Model*, SAND98-2680, prepared by RESPEC, Rapid City, SD, for Sandia National Laboratories, Albuquerque, NM., February 1999.
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3. Lux, K.-H. and Eberth, S. *Fundamental and First Application of a New Healing Model for Rock Salt*, Proceedings, 6th Conference on the Mechanical Behavior of Salt. Hannover, Germany, May 22-25, M. Wallner, K.H. Lux, W. Minkley, and H.R. Hardy, Jr. (eds.). Taylor & Francis Group, London, England, pp. 129-138.
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6. Munson, D. E., Fossum, A.F., and Senseny, P.E., *Advances in resolution of discrepancies between predicted and measured in situ WIPP room closures.* Technical Report SAND88-2948, Sandia National Laboratories, Albuquerque, NM, 1989.
7. Stührenberg, D., *Triaxial Compaction Test TK-031 Evaluation Report*, R+D Radioactive Waste Repository, THM Geotechnical Barriers,, Federal Institute for Geosciences and Natural Resources, Hannover, Germany, August 2013.