

# **Richards Examples**

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# 1 Introduction

The Richards' equation describes slow fluid flow through a porous medium. This document outlines input-file examples for the Richards MOOSE code, drawing mainly upon the test suite. There are two other accompanying documents: (1) The theoretical and numerical foundations of the code, which also describes the notation used throughout this document; (2) The test suite, which describes the benchmark tests used to validate the code.

## 2 The examples

Each example is located in the *test* directory, which has path

```
<install_dir>/trunk/elk/tests/richards
```

or the *user* directory, which has path

```
<install_dir>/trunk/elk/doc/richards/user
```

### 2.1 Convergence criteria

### 2.2 Two-phase, almost saturated

If a two-phase model has regions that are fully saturated with the “1” phase (typically this is water), then the residual for the “2” phase is zero. This means the “2”-phase pressure will not change in those regions, potentially violating  $P_1 \leq P_2$ . If the “2” phase subsequently infiltrates to these regions, an initially crazy  $P_2$  might affect the results. This also holds for almost-saturated situations.

In these cases it is useful to add a penalty term to the residual to ensure that  $P_1 \leq P_2$ . An example can be found in the tests directory `pressure_pulse/pp22.i`. The choice of the  $a$  parameter is sometimes difficult: too big and the penalty term dominates the Darcy flow; too small and the penalty term does nothing. In both cases, convergence is poor as the penalty term switches on and off during the Newton-Raphson procedure. The documentation for `RichardsPPenalty` describes how to set  $a$  (run MOOSE with a `--dump` flag).

### 2.3 An excavation

In the user directory `excav/ex01.i` contains a single excavation, and the associated mass flux and mass balance.