**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION 8**
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# STEP-RATE TEST PROCEDURE

*Approved January 12, 1999*

**PURPOSE:**

The purpose of this document is to provide a guideline for the acquisition of a Step Rate Test (SRT). Test results may be used by the Region 8 Underground Injection Control (UIC) offices to determine a Maximum Allowable Injection Pressure (MAIP) to provide for the protection of the underground sources of drinking water at an injection well having mechanical integrity. These procedures are consistent with acceptable oilfield practices.

Step rate test results must be documented with service company or other appropriate (acceptable) records and/or charts, and the test should be witnessed by an EPA inspector. Attached is a form that you may copy and use to record data from your test. Arrangements for witnessing the test may be made by contacting the Region 8 UIC offices using the EPA toll-free number 1-800-227-8917.

**RECOMMENDED TEST PROCEDURES:**

1) **Shut in long the well long enough prior to testing** such that the bottom hole pressures approximate shut-in formation pressures. If the shut-in well flows to the surface, the wellhead injection string should be equipped with a gauge, and the static surface pressure read and recorded.

2) **Read and record the elapsed time and pressure values for each time and rate-step. Each rate-step should last exactly as long as the preceding rate-step**. If stabilized pressure values are not obtained within the rate-steps suggested below, the test results may be considered as inconclusive. A series of successively higher injection rates should be determined using guidelines below

| *Formation Permeability (md)* | *Total time per rate-step (min)* |
|---|---|
| # 5 md | 60 min |
| ∃ 10 md | 30 min |

3) Suggested injection rates:

5% B
10% E
20% E
40% X …of the anticipated maximum injection rate.
60% E
80% E
100% Δ

4) **Control injection rates** with a constant flow regulator that has been tested prior to use. A throttling device is not considered sufficient.



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5) **Measure flow rates** with a calibrated turbine flowmeter.

6) **Record injection rates** using a chart recorder or a strip chart.

7) **Measure pressures** with a down hole pressure bomb. If a surface gauge is used, the test pressures must be corrected for the estimated friction loss at each particular flow rate.

8) Measure <u>and record</u> injection pressures with a gauge or recorder (for immediate test results). **Record each time step and corresponding pressure.**

9) If the formation fracture pressure has definitively been exceeded, as evidenced by at least two injection rate-pressure combinations greater than the breakdown pressure, the injection pump can be stopped, and the line valve closed and pressure allowed to bleed-off into the injection zone.

10) **Record the ISIP.** There will occur a significant instantaneous pressure drop (Instantaneous Shut-in Pressure or ISIP), after which the pressure values will level out. This ISIP value must be read and recorded. The ISIP obtained in this manner may be considered to be the minimum pressure required to hold open a fracture in this formation at this well. In the event that the breakdown pressure was not obtained at the maximum test injection pressure utilized, the test results may indicate that the formation is accepting fluids without fracturing.

11) Once the ISIP is obtained, the SRT is concluded.

12) **Plot the injection rates and the corresponding stabilized pressure values.** These are graphically represented as a constant slope straight line to a point at which the formation fracture, or breakdown pressure is exceeded. The slope of this subsequent straight line should be less than that of the before-fracture straight line (see example).

## STEP RATE TEST DATA

***Well:*** _____ ***Date:*** _____ ***Operator:*** _____.

**STEP #1 Test Rate** ( ***5%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**STEP #2 Test Rate** ( ***10%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**STEP #3 Test Rate** ( ***20%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**STEP #4 Test Rate** ( ***40%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**STEP #5 Test Rate** ( ***60%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**STEP #6 Test Rate** ( ***80%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**STEP #7 Test Rate** ( ***100%*** *of maximum rate*) _____ (*bbl/min*)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time** (*min*) : | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| **Pressure** (psi): | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

**ISIP** : _____ (psi)

**Notes:**

***Test Run / Witnessed By:*** _____.

# ***EXAMPLE***

## ***STEP RATE TEST***

The following is an example of a Step-Rate Test with tabular and graphic results. The step-rate test data and graphic results of the test are on the following pages.

The operator of Anywell #1 set up a SRT for the following conditions:

A) Maximum anticipated injection rate was **4** bbl/min.

B) Following the recommended test procedures, the operator planned on using these rates for the test:

1) **5**% of 4 bbl/min = **0.2** bbl/min

2) **10**% of 4 bbl/min = **0.4** bbl/min

3) **20**% of 4 bbl/min = **0.8** bbl/min

4) **40**% of 4 bbl/min = **1.6** bbl/min

5) **60**% of 4 bbl/min = **2.4** bbl/min

6) **80**% of 4 bbl/min = **3.2** bbl/min

7) **100**% of 4 bbl/min = **4.0** bbl/min

C) The formation permeability is estimated as **100** md, therefore each step will last for 30 minutes.

For this test, the injection formation broke down at approximately 1200 psi, and the ISIP was listed as 1000 psi.

Because the injection formation will part at 1000 psi, the maximum injection pressure will be held to the ISIP. If the formation had not broken down at 1200 psi, the maximum allowable injection pressure would be the maximum pressure obtained during the test.

# EXAMPLE

## STEP RATE TEST DATA

**Well:** Anywell #1 **Date:** April 15, 2000 **Operator:** Lotsa Oil.

**STEP #1 Test Rate** ( *5% of maximum rate*) .2 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 0 | 90 | 95 | 98 | 99 | 100 | 100 |

**STEP #2 Test Rate** ( *10% of maximum rate*) .4 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 80 | 170 | 185 | 195 | 199 | 201 | 202 |

**STEP #3 Test Rate** ( *20% of maximum rate*) .8 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 190 | 320 | 385 | 392 | 398 | 403 | 404 |

**STEP #4 Test Rate** ( *40% of maximum rate*) 1.6 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 380 | 700 | 790 | 792 | 798 | 803 | 805 |

**STEP #5 Test Rate** ( *60% of maximum rate*) 2.4 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 751 | 990 | 1032 | 1093 | 1155 | 1188 | 1202 |

**STEP #6 Test Rate** ( *80% of maximum rate*) 3.2 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 1133 | 1250 | 1326 | 1370 | 1397 | 1399 | 1403 |

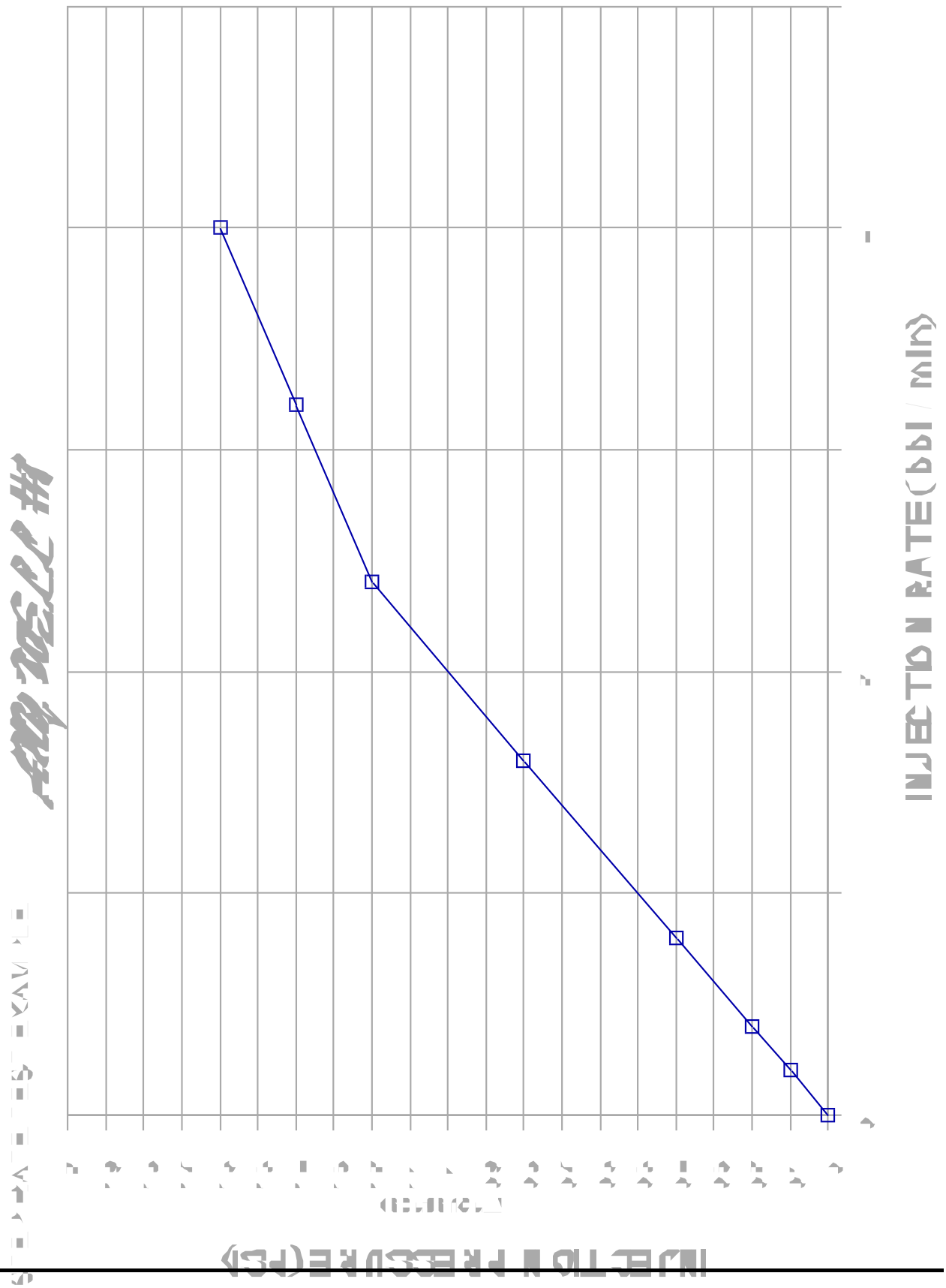
**STEP #7 Test Rate** ( *100% of maximum rate*) 4.0 (*bbl/min*)

| Time (*min*) : | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Pressure (psi): | 1350 | 1448 | 1503 | 1530 | 1571 | 1590 | 1600 |

**ISIP** : 1000 (psi)

**Notes:**

***Test Run / Witnessed By:*** Alan Testor.


INJECTION PRESSURE(PSI)
INJECTION RATE(bbl / min)