

Living Documentation

Version 1.0.0-RC1

Table of Contents

1. Introduction	1
2. Manage database with Database Rider Core	2
2.1. Scenario: Seed database using yml dataset	2
3. Manage database with Database Rider CDI	5
3.1. Scenario: Seed database using yml dataset	5
4. Manage database with Database Rider Cucumber	9
4.1. Scenario: Seed database using Database Rider in Cucumber tests	11
5. Manage database with Database Rider and JUnit 5	16
5.1. Scenario: Seed database using Database Rider in JUnit5 tests	16
6. Dynamic data using scritable datasets	18
6.1. Scenario: Seed database with groovy script in dataset	18
6.2. Scenario: Seed database with javascript in dataset	19
7. Database assertion using expected datasets	21
7.1. Scenario: Database assertion with yml dataset	21
7.2. Scenario: Database assertion with regular expression in expected dataset	22
7.3. Scenario: Database assertion with seeding before test execution	23
7.4. Scenario: Failling database assertion	25
7.5. Scenario: Database assertion using automatic transaction	26

Chapter 1. Introduction

Database Rider aims for bringing [DBUnit](#) closer to your JUnit tests so **database testing will feel like a breeze!**. Here are the main features:

- [JUnit rule](#) to integrate with DBUnit via annotations:

```
@Rule
public DBUnitRule dbUnitRule = DBUnitRule.instance(jdbcConnection);①

@Test
@DataSet(value = "datasets/yml/users.yml")
public void shouldSeedDataSet(){
    //database is seed with users.yml dataset
}
```

① The rule depends on a JDBC connection.

- [CDI integration](#) via interceptor to seed database without rule instantiation;
- JSON, YAML, XML, XLS, and CSV support;
- [Configuration](#) via annotations or yml files;
- [Cucumber](#) integration;
- Multiple database support;
- Date/time support in datasets;
- Scriptable datasets with groovy and javascript;
- Regular expressions in expected datasets;
- [JUnit 5](#) integration;
- [DataSet export](#);
- [Connection leak detection](#);
- Lot of [examples](#).

The project is composed by 5 modules:

- [Core](#): Contains the dataset executor and JUnit rule;
- [CDI](#): provides the DBUnit interceptor;
- [Cucumber](#): a CDI aware cucumber runner;
- [JUnit5](#): Comes with an [extension](#) for JUnit5.
- [Examples module](#).

Chapter 2. Manage database with Database Rider Core

In order to manage database state in JUnit tests
As a developer
I want to use DBUnit in my tests.

Database Rider Core module brings [DBUnit](#) to your unit tests via [JUnit rules](#).

Dependencies

To use it just add the following maven dependency:

```
<dependency>  
  <groupId>com.github.database-rider</groupId>  
  <artifactId>rider-core</artifactId>  
  <version>1.0.0-RC1</version>  
  <scope>test</scope>  
</dependency>
```

2.1. Scenario: Seed database using yml dataset

Given

The following junit rules 🍌 (000ms)

```
@RunWith(JUnit4.class)
public class DatabaseRiderIt {

    @Rule
    public EntityManagerProvider emProvider =
    EntityManagerProvider.instance("rules-it"); ①

    @Rule
    public DBUnitRule dbUnitRule =
    DBUnitRule.instance(emProvider.connection()); ②
}
```

- ① [EntityManagerProvider](#) is a simple Junit rule that creates a JPA entityManager for each test. DBUnit rule don't depend on EntityManagerProvider, it only needs a **JDBC connection**.
- ② DBUnit rule responsible for reading [@DataSet](#) annotation and prepare the database for each test.

And

The following dataset 🍌 (000ms)

src/test/resources/dataset/yml/users.yml

```
user:
  - id: 1
    name: "@realpestando"
  - id: 2
    name: "@dbunit"
tweet:
  - id: abcdef12345
    content: "dbunit rules!"
    date: "[DAY,NOW]"
    user_id: 1
follower:
  - id: 1
    user_id: 1
    follower_id: 2
```

When

The following test is executed: 📌 (000ms)

```
@Test
@DataSet(value = "datasets/yml/users.yml", useSequenceFiltering =
true)
public void shouldSeedUserDataSet() {
    User user = (User)
EntityManagerProvider.em().createQuery("select u from User u join fetch
u.tweets join fetch u.followers where u.id = 1").getSingleResult();
    assertNotNull(user);
    assertEquals(1, user.getId());
    assertNotNull(user.getTweets().hasSize(1));
    Tweet tweet = user.getTweets().get(0);
    assertNotNull(tweet);
    Calendar date = tweet.getDate();
    Calendar now = Calendar.getInstance();

    assertEquals(now.get(Calendar.DAY_OF_MONTH), date.get(Calendar.
DAY_OF_MONTH));
}
```



Source code of the above example can be [found here](#).

Then

The database should be seeded with the dataset content before test execution 📌 (000ms)

Chapter 3. Manage database with Database Rider CDI

In order to manage database state in **CDI** based tests
As a developer
I want to use DBUnit in a CDI test environment.

DBUnit CDI integration is done through a **CDI interceptor** which reads `@DataSet` to prepare database for CDI based tests.

CDI must be enabled in your test, see the following example:



```
@RunWith(CdiTestRunner.class) ①  
@DBUnitInterceptor ②  
public class DBUnitCDITest {  
  
}
```

- ① `CdiTestRunner` is provided by [Apache Deltaspike](#) but you should be able to use other CDI test runners.
- ② Needed to activate DBUnit interceptor

Dependencies

To use this module just add the following maven dependency:

```
<dependency>  
  <groupId>com.github.database-rider</groupId>  
  <artifactId>rider-cdi</artifactId>  
  <version>1.0.0-RC1</version>  
  <scope>test</scope>  
</dependency>
```

3.1. Scenario: Seed database using yml dataset

Given

DBUnit interceptor is enabled in your test beans.xml: 👍 (817ms)

src/test/resources/META-INF/beans.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://java.sun.com/xml/ns/javaee"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
http://java.sun.com/xml/ns/javaee/beans_1_0.xsd">
  <interceptors>

<class>com.github.database.rider.cdi.DBUnitInterceptorImpl</class>
  </interceptors>
</beans>
```



Your test itself must be a CDI bean to be intercepted. if you're using [Deltaspike test control](#) just enable the following property in `test/resources/META-INF/apache-deltaspike.properties`:

```
deltaspike.testcontrol.use_test_class_as_cdi_bean=true
```

And

The following dataset 🇺🇸 (000ms)

src/test/resources/dataset/yml/users.yml

```
user:
  - id: 1
    name: "@realpeano"
  - id: 2
    name: "@dbunit"
tweet:
  - id: abcdef12345
    content: "dbunit rules!"
    user_id: 1
  - id: abcdef12233
    content: "dbunit rules!"
    user_id: 2
  - id: abcdef1343
    content: "CDI for the win!"
    user_id: 2
follower:
  - id: 1
    user_id: 1
    follower_id: 2
```

When

The following test is executed: 📌 (000ms)

```
@Test
@DataSet("yml/users.yml")
public void shouldSeedUserDataSetUsingCdiInterceptor() {
    List<User> users = em.createQuery("select u from User u order
by u.id asc").getResultList();
    User user1 = new User(1);
    User user2 = new User(2);
    Tweet tweetUser1 = new Tweet();
    tweetUser1.setId("abcdef12345");
    assertThat(users).isNotNull().hasSize(2).contains(user1,
user2);
    List<Tweet> tweetsUser1 = users.get(0).getTweets();

    assertThat(tweetsUser1).isNotNull().hasSize(1).contains(tweetUser1);
}
```



Source code of the above example can be [found here](#).

Then

The database should be seeded with the dataset content before test execution 📌 (000ms)

Chapter 4. Manage database with Database Rider Cucumber

In order to manage database state in **BDD** tests
As a BDD developer
I want to use DBUnit along side my BDD tests.

DBUnit enters the BDD world through a dedicated JUnit runner which is based on [Cucumber](#) and [Apache DeltaSpike](#).

This runner just starts CDI within your BDD tests so you just have to use [Database Rider CDI interceptor](#) on Cucumber steps, here is the so called Cucumber CDI runner declaration:

```
package com.github.database.rider.core.bdd;

import cucumber.api.CucumberOptions;
import cucumber.api.junit.Cucumber;
import org.junit.runner.RunWith;

/**
 * Created by rmpestano on 4/17/16.
 */
@RunWith(Cucumber.class)
@CucumberOptions(features = {
    "src/test/resources/features/core/core-seed-database.feature",
    "src/test/resources/features/cdi/cdi-seed-database.feature",
    "src/test/resources/features/cucumber/cucumber-seed-database.feature",
    "src/test/resources/features/junit5/junit5-seed-database.feature",
    "src/test/resources/features/general/dataset-replacements.feature",
    "src/test/resources/features/general/expected-dataset.feature"
},
    plugin = "json:target/dbunit-rules.json")
public class DatabaseRiderBdd {
}
```



As cucumber doesn't work with JUnit Rules, see [this issue](#), you won't be able to use Cucumber runner with *Database Rider Core* because its based on JUnit rules, but you can use DataSetExecutor in [@Before](#), see [example here](#).

Dependencies

Here is a set of maven dependencies needed by Database Rider Cucumber:



Most of the dependencies, except CDI container implementation, are brought by Database Rider Cucumber module transitively.

```
<dependency>
  <groupId>com.github.database-rider</groupId>
  <artifactId>rider-cucumber</artifactId>
  <version>1.0.0-RC1</version>
  <scope>test</scope>
</dependency>
```

Cucumber dependencies

```
<dependency> ①
  <groupId>info.cukes</groupId>
  <artifactId>cucumber-junit</artifactId>
  <version>1.2.4</version>
  <scope>test</scope>
</dependency>
<dependency> ①
  <groupId>info.cukes</groupId>
  <artifactId>cucumber-java</artifactId>
  <version>1.2.4</version>
  <scope>test</scope>
</dependency>
```

① You don't need to declare because it comes with Database Rider Cucumber module dependency.

```
<dependency> ①  
  <groupId>org.apache.deltaspike.modules</groupId>  
  <artifactId>deltaspike-test-control-module-api</artifactId>  
  <version>${ds.version}</version>  
  <scope>test</scope>  
</dependency>  
  
<dependency> ①  
  <groupId>org.apache.deltaspike.core</groupId>  
  <artifactId>deltaspike-core-impl</artifactId>  
  <version>${ds.version}</version>  
  <scope>test</scope>  
</dependency>  
  
<dependency> ①  
  <groupId>org.apache.deltaspike.modules</groupId>  
  <artifactId>deltaspike-test-control-module-impl</artifactId>  
  <version>${ds.version}</version>  
  <scope>test</scope>  
</dependency>  
  
<dependency> ②  
  <groupId>org.apache.deltaspike.cdictrl</groupId>  
  <artifactId>deltaspike-cdictrl-owb</artifactId>  
  <version>${ds.version}</version>  
  <scope>test</scope>  
</dependency>  
  
<dependency> ②  
  <groupId>org.apache.openwebbeans</groupId>  
  <artifactId>openwebbeans-impl</artifactId>  
  <version>1.6.2</version>  
  <scope>test</scope>  
</dependency>
```

① Also comes with DBUnit Rules Cucumber.

② You can use CDI implementation of your choice.

4.1. Scenario: Seed database using Database Rider in Cucumber tests

Given

The following feature 👍 (000ms)

Feature: Contacts test

As a user of contacts repository

I want to crud contacts

So that I can expose contacts service

Scenario Outline: search contacts

Given we have a list of contacts

When we search contacts by name "<name>"

Then we should find <result> contacts

Examples: examples1

name	result
delta	1
sp	2
querydsl	1
abcd	0

Scenario: delete a contact

Given we have a list of contacts

When we delete contact by id 1

Then we should not find contact 1

And

The following dataset 🍌 (000ms)

```
contact:
- id: 1
  name: "deltaspike"
  email: "users@deltaspike.apache.org"
  company_id: 1
- id: 2
  name: "querydsl"
  email: "info@mysema.com"
  company_id: 2
- id: 3
  name: "Spring"
  email: "spring@pivotal.io"
  company_id: 3

company:
- id: 1
  name: "Apache"
- id: 2
  name: "Mysema"
- id: 3
  name: "Pivotal"
- id: 4
  name: "Google"
```

And

The following Cucumber test 🍌 (000ms)

```
package com.github.database.rider.examples.cucumber;

import com.github.database.rider.cucumber.CdiCucumberTestRunner;
import cucumber.api.CucumberOptions;
import org.junit.runner.RunWith;

@RunWith(CdiCucumberTestRunner.class)
@CucumberOptions(
    features = {"src/test/resources/features/contacts.feature"},
    plugin = {"json:target/cucumber.json"}
    //glue = "com.github.dbunit.rules.examples.glues"
)
public class ContactFeature {
}
```

When

The following cucumber steps are executed 🍌 (000ms)

```
package com.github.database.rider.examples.cucumber; ①

import com.github.database.rider.core.api.dataset.DataSet;
import com.github.database.rider.cdi.api.DBUnitInterceptor;
import cucumber.api.java.en.Given;
import cucumber.api.java.en.Then;
import cucumber.api.java.en.When;
import org.example.jpdomain.Contact;
import org.example.jpdomain.Contact_;
import org.example.service.deltaspike.ContactRepository;

import javax.inject.Inject;

import static org.junit.Assert.assertEquals;
import static org.junit.Assert.assertNull;

@DBUnitInterceptor
public class ContactSteps {

    @Inject
    ContactRepository contactRepository; ①

    Long count;
```



```

    @When("^we search contacts by name \"([^\"]*)\"$")
    public void we_search_contacts_by_name_(String name) throws
    Throwable {
        Contact contact = new Contact();
        contact.setName(name);
        count = contactRepository.countLike(contact, Contact_.name);
    }

    @Then("^we should find (\\d+) contacts$")
    public void we_should_find_result_contacts(Long result) throws
    Throwable {
        assertEquals(result, count);
    }

    @Given("^we have a list of contacts$")
    @DataSet("datasets/contacts.yml") ②
    public void given() {
        assertEquals(contactRepository.count(), new Long(3));
    }

    @When("^we delete contact by id (\\d+)$")
    public void we_delete_contact_by_id(long id) throws Throwable {
        contactRepository.remove(contactRepository.findById());
    }

    @Then("^we should not find contact (\\d+)$")
    public void we_should_not_find_contacts_in_database(long id) throws
    Throwable {
        assertNull(contactRepository.findById());
    }
}

```

① As the Cucumber cdi runner enables CDI, you can use injection into your Cucumber steps.

② Dataset is prepared before step execution by `@DBUnitInterceptor`.



Source code for the example above can be [found here](#).

Then

The database should be seeded with the dataset content before step execution 🍌 (000ms)

Chapter 5. Manage database with Database Rider and JUnit 5

In order to manage database state in [JUnit 5](#) integration tests
As a developer
I want to use DBUnit along side my JUnit 5 tests.

DBUnit is enabled in JUnit 5 tests through an [extension](#) named **DBUnitExtension**.

Dependencies

To use the extension just add the following maven dependency:

```
<dependency>
  <groupId>com.github.dbunit-rules</groupId>
  <artifactId>junit5</artifactId>
  <version>1.0.0-RC1</version>
  <scope>test</scope>
</dependency>
```

5.1. Scenario: Seed database using Database Rider in JUnit5 tests

Given

The following dataset 🍌 (000ms)

src/test/resources/dataset/users.yml

```
user:
  - id: 1
    name: "@realpestando"
  - id: 2
    name: "@dbunit"
```

When

The following junit5 test is executed 🍌 (000ms)

```
@ExtendWith(DBUnitExtension.class) ①
@RunWith(JUnitPlatform.class) ②
@DataSet(cleanBefore = true)
public class DBUnitJUnit5It {

    private ConnectionHolder connectionHolder = () -> ③
        EntityManagerProvider.instance("junit5-
        pu").clear().connection();④

    @Test
    @DataSet(value = "usersWithTweet.yml")
    public void shouldListUsers() {
        List<User> users =
        EntityManagerProvider.em().createQuery("select u from User
        u").getResultList();
        assertThat(users).isNotNull().isNotEmpty().hasSize(2);
    }
}
```

① Enables DBUnit;

② JUnit 5 runner;

③ As JUnit5 requires **Java8** you can use lambdas in your tests;

④ DBUnitExtension will get connection by reflection so just declare a field or a method with **ConnectionHolder** as return type.



Source code of the above example can be [found here](#).

Then

The database should be seeded with the dataset content before test execution 🍌 (000ms)

Chapter 6. Dynamic data using scritable datasets

In order to have dynamic data in datasets
As a developer
I want to use scripts in DBUnit datasets.

Scritable datasets are backed by JSR 223. [2: Scripting for the Java Platform, for more information access the official [docs here](#)].

Complete source code of examples below can be [found here](#).

6.1. Scenario: Seed database with groovy script in dataset

Given

Groovy script engine is on test classpath 🍷 (000ms)

```
<dependency>
  <groupId>org.codehaus.groovy</groupId>
  <artifactId>groovy-all</artifactId>
  <version>2.4.6</version>
  <scope>test</scope>
</dependency>
```

And

The following dataset 🍌 (000ms)

```
tweet:
- id: "1"
  content: "dbunit rules!"
  date: "groovy:new Date()" ①
  user_id: 1
```

① Groovy scripting is enabled by `groovy: string`.

When

The following test is executed: 🍌 (000ms)

```
@Test
@DataSet(value = "datasets/yml/groovy-with-date-
replacements.yml",cleanBefore = true, disableConstraints = true,
executorId = "rules-it")
public void shouldReplaceDateUsingGroovyInDataset() {
    Tweet tweet = (Tweet) emProvider.em().createQuery("select t from
Tweet t where t.id = '1'").getSingleResult();
    assertThat(tweet).isNotNull();

    assertThat(tweet.getDate().get(Calendar.DAY_OF_MONTH)).isEqualTo(now.ge
t(Calendar.DAY_OF_MONTH));

    assertThat(tweet.getDate().get(Calendar.HOUR_OF_DAY)).isEqualTo(now.get
(Calendar.HOUR_OF_DAY));
}
```



Source code of the above example can be [found here](#).

Then

Dataset script should be interpreted while seeding the database 🍌 (000ms)

6.2. Scenario: Seed database with javascript in dataset



Javascript engine comes within JDK so no additional classpath dependency is necessary.

Given

The following dataset 🍌 (000ms)

```
tweet:
  - id: "1"
    content: "dbunit rules!"
    likes: "js:(5+5)*10/2" ①
    user_id: 1
```

① Javascript scripting is enabled by `js:` string.

When

The following test is executed: 🍌 (000ms)

```
@Test
@DataSet(value = "datasets/yml/js-with-calc-
replacements.yml",cleanBefore = true ,disableConstraints = true,
executorId = "rules-it")
public void shouldReplaceLikesUsingJavaScriptInDataset() {
    Tweet tweet = (Tweet) emProvider.em().createQuery("select t from
Tweet t where t.id = '1'").getSingleResult();
    assertThat(tweet).isNotNull();
    assertThat(tweet.getLikes()).isEqualTo(50);
}
```



Source code of the above example can be [found here](#).

Then

Dataset script should be interpreted while seeding the database 🍌 (000ms)

Chapter 7. Database assertion using expected datasets

In order to verify database state after test execution
As a developer
I want to assert database state with datasets.

Complete source code of examples below can be [found here](#).

7.1. Scenario: Database assertion with yml dataset

Given

The following dataset 👍 (000ms)

expectedUsers.yml

```
user:  
  - id: 1  
    name: "expected user1"  
  - id: 2  
    name: "expected user2"
```

When

The following test is executed: 🍌 (000ms)

```
@RunWith(JUnit4.class)
@DBUnit(cacheConnection = true)
public class ExpectedDataSetIt {

    @Rule
    public EntityManagerProvider emProvider =
    EntityManagerProvider.instance("rules-it");

    @Rule
    public DBUnitRule dbUnitRule =
    DBUnitRule.instance(emProvider.connection());

    @Test
    @DataSet(cleanBefore = true)①
    @ExpectedDataSet(value = "yml/expectedUsers.yml", ignoreCols = "id")
    public void shouldMatchExpectedDataSet() {
        EntityManagerProvider instance =
    EntityManagerProvider.newInstance("rules-it");
        User u = new User();
        u.setName("expected user1");
        User u2 = new User();
        u2.setName("expected user2");
        instance.tx().begin();
        instance.em().persist(u);
        instance.em().persist(u2);
        instance.tx().commit();
    }
}
```

① Clear database before to avoid conflict with other tests.

Then

Test must pass because database state is as in expected dataset. 🍌 (000ms)

7.2. Scenario: Database assertion with regular expression in expected dataset

Given

The following dataset 🍌 (000ms)

expectedUsersRegex.yml

```
user:
  - id: "regex:\\d+"
    name: regex:^expected user.* #expected user1
  - id: "regex:\\d+"
    name: regex:. *user2$ #expected user2
```

When

The following test is executed: 🍌 (000ms)

```
@Test
@DataSet(cleanBefore = true)
@ExpectedDataSet(value = "yml/expectedUsersRegex.yml")
public void shouldMatchExpectedDataSetUsingRegex() {
    User u = new User();
    u.setName("expected user1");
    User u2 = new User();
    u2.setName("expected user2");
    EntityManagerProvider.tx().begin();
    EntityManagerProvider.em().persist(u);
    EntityManagerProvider.em().persist(u2);
    EntityManagerProvider.tx().commit();
}
```

Then

Test must pass because database state is as in expected dataset. 🍌 (000ms)

7.3. Scenario: Database assertion with seeding before test execution

Given

The following dataset 🍌 (000ms)

user.yml

```
user:
  - id: 1
    name: "@realpestando"
  - id: 2
    name: "@dbunit"
```

And

The following dataset 🍌 (000ms)

expectedUser.yml

```
user:
  - id: 2
    name: "@dbunit"
```

When

The following test is executed: 🍌 (000ms)

```
@Test
@DataSet(value = "yml/user.yml", disableConstraints = true)
@ExpectedDataSet(value = "yml/expectedUser.yml", ignoreCols = "id")
public void shouldMatchExpectedDataSetAfterSeedingDataBase() {
    tx().begin();
    em().remove(EntityManagerProvider.em().find(User.class, 1L));
    tx().commit();
}
```

Then

Test must pass because database state is as in expected dataset. 🍌 (000ms)

7.4. Scenario: Failing database assertion

Given

The following dataset 📌 (000ms)

expectedUsers.yml

```
user:
  - id: 1
    name: "expected user1"
  - id: 2
    name: "expected user2"
```

When

The following test is executed: 📌 (000ms)

```
@Test
@ExpectedDataSet(value = "yml/expectedUsers.yml", ignoreCols = "id")
public void shouldNotMatchExpectedDataSet() {
    User u = new User();
    u.setName("non expected user1");
    User u2 = new User();
    u2.setName("non expected user2");
    EntityManagerProvider.tx().begin();
    EntityManagerProvider.em().persist(u);
    EntityManagerProvider.em().persist(u2);
    EntityManagerProvider.tx().commit();
}
```

Then

Test must fail with following error: 🍷 (000ms)



```
junit.framework.ComparisonFailure: value (table=USER, row=0,
col=name) expected:<[]expected user1> but was:<[non ]expected
user1>                                     at
org.dbunit.assertion.JUnitFailureFactory.createFailure(JUnitFailur
eFactory.java:39)                           at
org.dbunit.assertion.DefaultFailureHandler.createFailure(Default
FailureHandler.java:97)                     at
org.dbunit.assertion.DefaultFailureHandler.handle(DefaultFailure
Handler.java:223) at ...
```

7.5. Scenario: Database assertion using automatic transaction

Given

The following dataset 🍌 (000ms)

expectedUsersRegex.yml

```
user:
  - id: "regex:\\d+"
    name: regex:^expected user.* #expected user1
  - id: "regex:\\d+"
    name: regex:.*user2$ #expected user2
```

When

The following test is executed: 🍌 (000ms)

```
@Test
@DataSet(cleanBefore = true, transactional = true, executorId =
"TransactionIt")
@ExpectedDataSet(value = "yml/expectedUsersRegex.yml")
@DBUnit(cacheConnection = true)
public void shouldManageTransactionAutomatically() {
    User u = new User();
    u.setName("expected user1");
    User u2 = new User();
    u2.setName("expected user2");
    EntityManagerProvider.em().persist(u);
    EntityManagerProvider.em().persist(u2);
}
```



Transactional attribute will make Database Rider start a transaction before test and commit the transaction **after** test execution but **before** expected dataset comparison.

Then

Test must pass because inserted users are committed to database and database state matches expected dataset. 🍌 (000ms)