# SQL Injection

## What is SQL Injection (SQLi) and How to Prevent It

SQL Injection (SQLi) is a type of an injection attack that makes it possible to execute malicious SQL statements. These statements control a database server behind a web application. Attackers can use SQL Injection vulnerabilities to bypass application security measures. They can go around authentication and authorization of a web page or web application and retrieve the content of the entire SQL database. They can also use SQL Injection to add, modify, and delete records in the database.

An SQL Injection vulnerability may affect any website or web application that uses an SQL database such as MySQL, Oracle, SQL Server, or others. Criminals may use it to gain unauthorized access to your sensitive data: customer information, personal data, trade secrets, intellectual property, and more.

SQL Injection attacks are one of the oldest, most prevalent, and most dangerous web application vulnerabilities. The OWASP organization (Open Web Application Security Project) lists injections in their OWASP Top 10 2017 document as the number one threat to web application security.

## How and Why Is an SQL Injection Attack Performed

To make an SQL Injection attack, an attacker must first find vulnerable user inputs within the web page or web application. A web page or web application that has an SQL Injection vulnerability uses such user input directly in an SQL query. The attacker can create input content. Such content is often called a malicious payload and is the key part of the attack. After the attacker sends this content, malicious SQL commands are executed in the database.

SQL is a query language that was designed to manage data stored in relational databases. You can use it to access, modify, and delete data. Many web applications and websites store all the data in SQL databases. In some cases, you can also use SQL commands to run operating system commands. Therefore, a successful SQL Injection attack can have very serious consequences.

- Attackers can use SQL Injections to find the credentials of other users in the database. They can then impersonate these users. The impersonated user may be a database administrator with all database privileges.
- SQL lets you select and output data from the database. An SQL Injection vulnerability could allow the attacker to gain complete access to all data in a database server.
- SQL also lets you alter data in a database and add new data. For example, in a financial application, an attacker could use SQL Injection to alter balances, void transactions, or transfer money to their account.
- You can use SQL to delete records from a database, even drop tables. Even if the administrator makes database backups, deletion of data could affect

application availability until the database is restored. Also, backups may not cover the most recent data.

- In some database servers, you can access the operating system using the database server. This may be intentional or accidental. In such case, an attacker could use an SQL Injection as the initial vector and then attack the internal network behind a firewall.

## Simple SQL Injection Example

The first example is very simple. It shows, how an attacker can use an SQL Injection vulnerability to go around application security and authenticate as the administrator.

The following script is pseudocode executed on a web server. It is a simple example of authenticating with a username and a password. The example database has a table named `users` with the following columns: `username` and `password`.

```
# Define POST variables uname = request.POST['username'] passwd = request.POST['password']


# SQL query vulnerable to SQLi
sql = "SELECT id FROM users WHERE username='" + uname + "' AND password='" + passwd + "'"


# Execute the SQL statement database.execute(sql)
```

These input fields are vulnerable to SQL Injection. An attacker could use SQL commands in the input in a way that would alter the SQL statement executed by the database server. For example, they could use a trick involving a single quote and set the `passwd` field to:

```
password' OR 1=1
```

As a result, the database server runs the following SQL query:

```
SELECT id FROM users WHERE username='username' AND password='password' OR 1=1'
```

Because of the `OR 1=1` statement, the `WHERE` clause returns the first `id` from the `users` table no matter what the `username` and `password` are. The first user `id` in a database is very often the administrator. In this way, the attacker not only bypasses authentication but also gains administrator privileges. They can also comment out the rest of the SQL statement to control the execution of the SQL query further:

```
-- MySQL, MSSQL, Oracle, PostgreSQL, SQLite
' OR '1'='1' --
' OR '1'='1' /*
-- MySQL
' OR '1'='1' #
-- Access (using null characters)
' OR '1'='1' %00
' OR '1'='1' %16
```

## Example of a Union-Based SQL Injection

One of the most common types of SQL Injection uses the UNION operator. It allows the attacker to combine the results of two or more SELECT statements into a single result. The technique is called union-based SQL Injection.

The following is an example of this technique. It uses the web page **testphp.vulnweb.com**, an intentionally vulnerable website hosted by Acunetix.

The following HTTP request is a normal request that a legitimate user would send:

```
GET http://testphp.vulnweb.com/artists.php?artist=1 HTTP/1.1Host: testphp.vulnweb.com
```

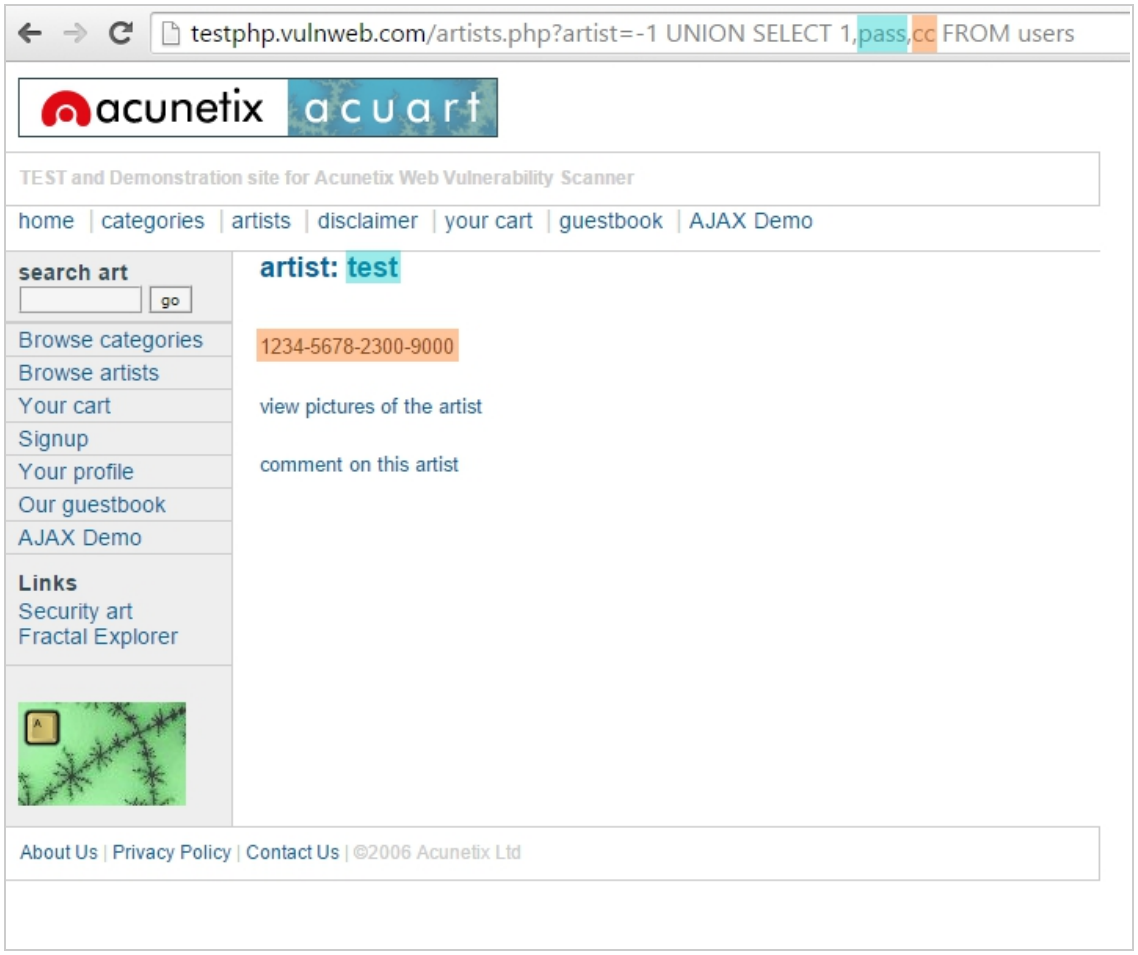

The `artist` parameter is vulnerable to SQL Injection. The following payload modifies the query to look for an inexistent record. It sets the value in the URL query string to `-1`. Of course, it could be any other value that does not exist in the database. However, a negative value is a good guess because an identifier in a database is rarely a negative number.

In SQL Injection, the `UNION` operator is commonly used to attach a malicious SQL query to the original query intended to be run by the web application. The result of the injected query will be joined with the result of the original query. This allows the attacker to obtain column values from other tables.

```
GET http://testphp.vulnweb.com/artists.php?artist=-1 UNION SELECT 1, 2, 3 HTTP/1.1
Host: testphp.vulnweb.com
```


The following example shows how an SQL Injection payload could be used to obtain more meaningful data from this intentionally vulnerable site:

```
GET http://testphp.vulnweb.com/artists.php?artist=-1 UNION SELECT 1,pass,cc FROM users WHERE uname='
test' HTTP/1.1
Host: testphp.vulnweb.com
```




## How to Prevent an SQL Injection

The only sure way to prevent SQL Injection attacks is input validation and parametrized queries including prepared statements. The application code should never use the input directly. The developer must sanitize all input, not only web form inputs such as login forms. They must remove potential malicious code elements such as single quotes. It is also a good idea to turn off the visibility of database errors on your production sites. Database errors can be used with SQL Injection to gain information about your database.

If you discover an SQL Injection vulnerability, for example using an Acunetix scan, you may be unable to fix it immediately. For example, the vulnerability may be in open source code. In such cases, you can use a web application firewall to sanitize your input temporarily.

## How to Prevent SQL Injections (SQLi) – Generic Tips

Preventing SQL Injection vulnerabilities is not easy. Specific prevention techniques depend on the subtype of SQLi vulnerability, on the SQL database engine, and on the programming language. However, there are certain general strategic principles that you should follow to keep your web application safe.


### Step 1: Train and maintain awareness

To keep your web application safe, everyone involved in building the web application must be aware of the risks associated with SQL Injections. You should provide suitable security training to all your developers, QA staff, DevOps, and SysAdmins. You can start by referring them to this page.


### Step 2: Don't trust any user input

Treat all user input as untrusted. Any user input that is used in an SQL query introduces a risk of an SQL Injection. Treat input from authenticated and/or internal users the same way that you treat public input.


### Step 3: Use whitelists, not blacklists

Don't filter user input based on blacklists. A clever attacker will almost always find a way to circumvent your blacklist. If possible, verify and filter user input using strict whitelists only.


### Step 4: Adopt the latest technologies

Older web development technologies don't have SQLi protection. Use the latest version of the development environment and language and the latest technologies associated with that environment/language. For example, in PHP use PDO instead of MySQLi.


### Step 5: Employ verified mechanisms

Don't try to build SQLi protection from scratch. Most modern development technologies can offer you mechanisms to protect against SQLi. Use such mechanisms instead of trying to reinvent the wheel. For example, use parameterized queries or stored procedures.