

## 2.8 AES

For the Advanced Encryption Standard (AES) see [FIPS PUB 197].

Mechanism	Functions						
	Encrypt & Decrypt	Sign & Verify	SR & VR <sup>1</sup>	Digest	Gen. Key/Key Pair	Wrap & Unwrap	Derive
CKM_AES_KEY_GEN					✓		
CKM_AES_ECB	✓					✓	
CKM_AES_CBC	✓					✓	
CKM_AES_CBC_PAD	✓					✓	
CKM_AES_MAC_GENERAL		✓					
CKM_AES_MAC		✓					
CKM_AES_OFB	✓					✓	
CKM_AES_CFB64	✓					✓	
CKM_AES_CFB8	✓					✓	
CKM_AES_CFB128	✓					✓	
CKM_AES_XTS	✓					✓	
CKM_AES_XCBC_MAC		✓					
CKM_AES_XCBC_MAC_96		✓					

### 2.8.1 Definitions

This section defines the key type “CKK\_AES” for type CK\_KEY\_TYPE as used in the CKA\_KEY\_TYPE attribute of key objects.

Mechanisms:

- CKM\_AES\_KEY\_GEN
- CKM\_AES\_ECB
- CKM\_AES\_CBC
- CKM\_AES\_MAC
- CKM\_AES\_MAC\_GENERAL
- CKM\_AES\_CBC\_PAD
- CKM\_AES\_OFB
- CKM\_AES\_CFB64
- CKM\_AES\_CFB8
- CKM\_AES\_CFB128
- CKM\_AES\_XTS
- CKM\_AES\_XCBC\_MAC
- CKM\_AES\_XCBC\_MAC\_96

### 2.8.2 AES secret key objects

AES secret key objects (object class **CKO\_SECRET\_KEY**, key type **CKK\_AES**) hold AES keys. The following table defines the AES secret key object attributes, in addition to the common attributes defined for this object class:

Table 1, AES Secret Key Object Attributes

Attribute	Data type	Meaning
CKA_VALUE <sup>1,4,6,7</sup>	Byte array	Key value (16, 24, or 32 bytes)
CKA_VALUE_LEN <sup>2,3,6</sup>	CK_ULONG	Length in bytes of key value

<sup>1</sup> Refer to [PKCS #11-B] table 15 for footnotes

The following is a sample template for creating an AES secret key object:

```

CK_OBJECT_CLASS class = CKO_SECRET_KEY;
CK_KEY_TYPE keyType = CKK_AES;
CK_UTF8CHAR label[] = "An AES secret key object";
CK_BYTE value[] = {...};
CK_BBOOL true = CK_TRUE;
CK_ATTRIBUTE template[] = {
    {CKA_CLASS, &class, sizeof(class)},
    {CKA_KEY_TYPE, &keyType, sizeof(keyType)},
    {CKA_TOKEN, &>true, sizeof(true)},
    {CKA_LABEL, label, sizeof(label)-1},
    {CKA_ENCRYPT, &>true, sizeof(true)},
    {CKA_VALUE, value, sizeof(value)}
};

```

**CKA\_CHECK\_VALUE:** The value of this attribute is derived from the key object by taking the first three bytes of the ECB encryption of a single block of null (0x00) bytes, using the default cipher associated with the key type of the secret key object.

### 2.8.3 AES key generation

The AES key generation mechanism, denoted **CKM\_AES\_KEY\_GEN**, is a key generation mechanism for NIST's Advanced Encryption Standard.

It does not have a parameter.

The mechanism generates AES keys with a particular length in bytes, as specified in the **CKA\_VALUE\_LEN** attribute of the template for the key.

The mechanism contributes the **CKA\_CLASS**, **CKA\_KEY\_TYPE**, and **CKA\_VALUE** attributes to the new key. Other attributes supported by the AES key type (specifically, the flags indicating which functions the key supports) may be specified in the template for the key, or else are assigned default initial values.

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

### 2.8.4 AES-ECB

AES-ECB, denoted **CKM\_AES\_ECB**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on NIST Advanced Encryption Standard and electronic codebook mode.

It does not have a parameter.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism

encrypts the value of the **CKA\_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA\_KEY\_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA\_VALUE\_LEN** attribute of the template. The mechanism contributes the result as the **CKA\_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

*Table 2, AES-ECB: Key And Data Length*

Function	Key type	Input length	Output length	Comments
C_Encrypt	AES	multiple of block size	same as input length	no final part
C_Decrypt	AES	multiple of block size	same as input length	no final part
C_WrapKey	AES	any	input length rounded up to multiple of block size	
C_UnwrapKey	AES	multiple of block size	determined by type of key being unwrapped or <b>CKA_VALUE_LEN</b>	

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

## 2.8.5 AES-CBC

AES-CBC, denoted **CKM\_AES\_CBC**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on NIST's Advanced Encryption Standard and cipher-block chaining mode.

It has a parameter, a 16-byte initialization vector.

This mechanism can wrap and unwrap any secret key. Of course, a particular token may not be able to wrap/unwrap every secret key that it supports. For wrapping, the mechanism encrypts the value of the **CKA\_VALUE** attribute of the key that is wrapped, padded on the trailing end with up to block size minus one null bytes so that the resulting length is a multiple of the block size. The output data is the same length as the padded input data. It does not wrap the key type, key length, or any other information about the key; the application must convey these separately.

For unwrapping, the mechanism decrypts the wrapped key, and truncates the result according to the **CKA\_KEY\_TYPE** attribute of the template and, if it has one, and the key type supports it, the **CKA\_VALUE\_LEN** attribute of the template. The mechanism contributes the result as the **CKA\_VALUE** attribute of the new key; other attributes required by the key type must be specified in the template.

Constraints on key types and the length of data are summarized in the following table:

Table 3, AES-CBC: Key And Data Length

Function	Key type	Input length	Output length	Comments
C_Encrypt	AES	multiple of block size	same as input length	no final part
C_Decrypt	AES	multiple of block size	same as input length	no final part
C_WrapKey	AES	any	input length rounded up to multiple of the block size	
C_UnwrapKey	AES	multiple of block size	determined by type of key being unwrapped or CKA_VALUE_LEN	

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

### 2.8.6 AES-CBC with PKCS padding

AES-CBC with PKCS padding, denoted **CKM\_AES\_CBC\_PAD**, is a mechanism for single- and multiple-part encryption and decryption; key wrapping; and key unwrapping, based on NIST's Advanced Encryption Standard; cipher-block chaining mode; and the block cipher padding method detailed in PKCS #7.

It has a parameter, a 16-byte initialization vector.

The PKCS padding in this mechanism allows the length of the plaintext value to be recovered from the ciphertext value. Therefore, when unwrapping keys with this mechanism, no value should be specified for the **CKA\_VALUE\_LEN** attribute.

In addition to being able to wrap and unwrap secret keys, this mechanism can wrap and unwrap RSA, Diffie-Hellman, X9.42 Diffie-Hellman, EC (also related to ECDSA) and DSA private keys (see Section Error: Reference source not found for details). The entries in the table below for data length constraints when wrapping and unwrapping keys do not apply to wrapping and unwrapping private keys.

Constraints on key types and the length of data are summarized in the following table:

Table 4, AES-CBC with PKCS Padding: Key And Data Length

Function	Key type	Input length	Output length
C_Encrypt	AES	any	input length rounded up to multiple of the block size
C_Decrypt	AES	multiple of block size	between 1 and block size bytes shorter than input length
C_WrapKey	AES	any	input length rounded up to multiple of the block size
C_UnwrapKey	AES	multiple of block size	between 1 and block length bytes shorter than

Function	Key type	Input length	Output length
			input length

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

### 2.8.7 AES-OFB

AES-OFB, denoted CKM\_AES\_OFB. It is a mechanism for single and multiple-part encryption and decryption with AES. AES-OFB mode is described in [NIST sp800-38a].

It has a parameter, an initialization vector for this mode. The initialization vector has the same length as the blocksize.

Constraints on key types and the length of data are summarized in the following table:

*Table 5, AES-OFB: Key And Data Length*

Function	Key type	Input length	Output length	Comments
C_Encrypt	AES	any	same as input length	no final part
C_Decrypt	AES	any	same as input length	no final part

For this mechanism the CK\_MECHANISM\_INFO structure is as specified for CBC mode.

### 2.8.8 AES-CFB

Cipher AES has a cipher feedback mode, AES-CFB, denoted CKM\_AES\_CFB8, CKM\_AES\_CFB64, and CKM\_AES\_CFB128. It is a mechanism for single and multiple-part encryption and decryption with AES. AES-OFB mode is described [NIST sp800-38a].

It has a parameter, an initialization vector for this mode. The initialization vector has the same length as the blocksize.

Constraints on key types and the length of data are summarized in the following table:

*Table 6, AES-CFB: Key And Data Length*

Function	Key type	Input length	Output length	Comments
C_Encrypt	AES	any	same as input length	no final part
C_Decrypt	AES	any	same as input length	no final part

For this mechanism the CK\_MECHANISM\_INFO structure is as specified for CBC mode.

## 2.8.9 General-length AES-MAC

General-length AES-MAC, denoted **CKM\_AES\_MAC\_GENERAL**, is a mechanism for single- and multiple-part signatures and verification, based on NIST Advanced Encryption Standard as defined in FIPS PUB 197 and data authentication as defined in FIPS PUB 113.

It has a parameter, a **CK\_MAC\_GENERAL\_PARAMS** structure, which specifies the output length desired from the mechanism.

The output bytes from this mechanism are taken from the start of the final AES cipher block produced in the MACing process.

Constraints on key types and the length of data are summarized in the following table:

*Table 7, General-length AES-MAC: Key And Data Length*

Function	Key type	Data length	Signature length
C_Sign	AES	any	0-block size, as specified in parameters
C_Verify	AES	any	0-block size, as specified in parameters

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

## 2.8.10 AES-MAC

AES-MAC, denoted by **CKM\_AES\_MAC**, is a special case of the general-length AES-MAC mechanism. AES-MAC always produces and verifies MACs that are half the block size in length.

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

*Table 8, AES-MAC: Key And Data Length*

Function	Key type	Data length	Signature length
C_Sign	AES	any	½ block size (8 bytes)
C_Verify	AES	any	½ block size (8 bytes)

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

## 2.8.11 AES-XTS

### 2.8.12 AES-XCBC-MAC

AES-XCBC-MAC, denoted **CKM\_AES\_XCBC\_MAC**, is a mechanism for single- and multiple-part signatures and verification; based on NIST's Advanced Encryption Standard and [RFC 3566].

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

*Table 9, AES-XCBC-MAC: Key And Data Length*

Function	Key type	Data length	Signature length
C_Sign	AES	any	16 bytes
C_Verify	AES	any	16 bytes

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.

### 2.8.13 AES-XCBC-MAC-96

AES-XCBC-MAC-96, denoted **CKM\_AES\_XCBC\_MAC\_96**, is a mechanism for single- and multiple-part signatures and verification; based on NIST's Advanced Encryption Standard and [RFC 3566].

It does not have a parameter.

Constraints on key types and the length of data are summarized in the following table:

*Table 10, AES-XCBC-MAC-96: Key And Data Length*

Function	Key type	Data length	Signature length
C_Sign	AES	any	12 bytes
C_Verify	AES	any	12 bytes

For this mechanism, the *ulMinKeySize* and *ulMaxKeySize* fields of the **CK\_MECHANISM\_INFO** structure specify the supported range of AES key sizes, in bytes.