

LAMPS WG  
Internet-Draft  
Updates: [3370](#) (if approved)  
Intended status: Standards Track  
Expires: December 19, 2019

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June 17, 2019

**Use of the SHAKE One-way Hash Functions in the Cryptographic Message  
Syntax (CMS)  
draft-ietf-lamps-cms-shakes-11**

**Abstract**

This document describes the conventions for using the SHAKE family of hash functions with the Cryptographic Message Syntax (CMS) as one-way hash functions with the RSA Probabilistic signature and ECDSA signature algorithms, as message digests and message authentication codes. The conventions for the associated signer public keys in CMS are also described.

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## [1.](#) Change Log

[ EDNOTE: Remove this section before publication. ]

### [o \[draft-ietf-lamps-cms-shake-11\]\(#\):](#)

- \* Minor nits.
- \* Nits identified by Roman in AD Review.

### [o \[draft-ietf-lamps-cms-shake-10\]\(#\):](#)

- \* Updated IANA considerations section to request for OID assignments.

### [o \[draft-ietf-lamps-cms-shake-09\]\(#\):](#)

- \* Fixed minor text nit.
- \* Updates in Sec Considerations section.

### [o \[draft-ietf-lamps-cms-shake-08\]\(#\):](#)



- \* id-shake128-len and id-shake256-len were replaced with id-sha128 with 32 bytes output length and id-shake256 with 64 bytes output length.
- \* Fixed a discrepancy between [section 3](#) and 4.4 about the KMAC OIDs that have parameters as optional.
- o [draft-ietf-lamps-cms-shake-07](#):
  - \* Small nit from Russ while in WGLC.
- o [draft-ietf-lamps-cms-shake-06](#):
  - \* Incorporated Eric's suggestion from WGLC.
- o [draft-ietf-lamps-cms-shake-05](#):
  - \* Added informative references.
  - \* Updated ASN.1 so it compiles.
  - \* Updated IANA considerations.
- o [draft-ietf-lamps-cms-shake-04](#):
  - \* Added [RFC8174](#) reference and text.
  - \* Explicitly explained why RSASSA-PSS-params are omitted in [section 4.2.1](#).
  - \* Simplified Public Keys section by removing redundant info from RFCs.
- o [draft-ietf-lamps-cms-shake-03](#):
  - \* Removed paragraph suggesting KMAC to be used in generating k in Deterministic ECDSA. That should be [RFC6979](#)-bis.
  - \* Removed paragraph from Security Considerations that talks about randomness of k because we are using deterministic ECDSA.
  - \* Completed ASN.1 module and fixed KMAC ASN.1 based on Jim's feedback.
  - \* Text fixes.
- o [draft-ietf-lamps-cms-shake-02](#):



- \* Updates based on suggestions and clarifications by Jim.
- \* Started ASN.1 module.
- o [draft-ietf-lamps-cms-shake-01](#):
  - \* Significant reorganization of the sections to simplify the introduction, the new OIDs and their use in CMS.
  - \* Added new OIDs for RSASSA-PSS that hardcodes hash, salt and MGF, according the WG consensus.
  - \* Updated Public Key section to use the new RSASSA-PSS OIDs and clarify the algorithm identifier usage.
  - \* Removed the no longer used SHAKE OIDs from [section 3.1](#).
- o [draft-ietf-lamps-cms-shake-00](#):
  - \* Various updates to title and section names.
  - \* Content changes filling in text and references.
- o [draft-dang-lamps-cms-shakes-hash-00](#):
  - \* Initial version

## 2. Introduction

The Cryptographic Message Syntax (CMS) [[RFC5652](#)] is used to digitally sign, digest, authenticate, or encrypt arbitrary message contents. This specification describes the use of the SHAKE128 and SHAKE256 specified in [[SHA3](#)] as new hash functions in CMS. In addition, it describes the use of these functions with the RSASSA-PSS signature algorithm [[RFC8017](#)] and the Elliptic Curve Digital Signature Algorithm (ECDSA) [[X9.62](#)] with the CMS signed-data content type.

In the SHA-3 family, two extendable-output functions (SHAKEs), SHAKE128 and SHAKE256, are defined. Four other hash function instances, SHA3-224, SHA3-256, SHA3-384, and SHA3-512 are also defined but are out of scope for this document. A SHAKE is a variable length hash function defined as  $\text{SHAKE}(M, d)$  where the output is a  $d$ -bits long digest of message  $M$ . The corresponding collision and second preimage resistance strengths for SHAKE128 are  $\min(d/2, 128)$  and  $\min(d, 128)$  bits respectively (Appendix A.1 [[SHA3](#)]). And, the corresponding collision and second preimage resistance strengths for SHAKE256 are  $\min(d/2, 256)$  and  $\min(d, 256)$  bits respectively.



A SHAKE can be used in CMS as the message digest function (to hash the message to be signed) in RSASSA-PSS and ECDSA, message authentication code and as the mask generation function (MGF) in RSASSA-PSS. This specification describes the identifiers for SHAKEs to be used in CMS and their meaning.

### 2.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

### 3. Identifiers

This section defines four new object identifiers (OIDs) for using SHAKE128 and SHAKE256 in CMS.

Two object identifiers for SHAKE128 and SHAKE256 hash functions are defined in [[shake-nist-oids](#)] and we include them here for convenience.

```
id-shake128 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2)
    country(16) us(840) organization(1) gov(101) csor(3)
    nistAlgorithm(4) 2 11 }
```

```
id-shake256 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2)
    country(16) us(840) organization(1) gov(101) csor(3)
    nistAlgorithm(4) 2 12 }
```

In this specification, when using the id-shake128 or id-shake256 algorithm identifiers, the parameters MUST be absent. That is, the identifier SHALL be a SEQUENCE of one component, the OID.

[I-D.ietf-lamps-pkix-shake] [ EDNOTE: Update reference with the RFC when it is ready ] defines two identifiers for RSASSA-PSS signatures using SHAKEs which we include here for convenience.

```
id-RSASSA-PSS-SHAKE128 OBJECT IDENTIFIER ::= { iso(1)
    identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) algorithms(6)
    TBD1 }
```

```
id-RSASSA-PSS-SHAKE256 OBJECT IDENTIFIER ::= { iso(1)
    identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) algorithms(6)
    TBD2 }
```





The same RSASSA-PSS algorithm identifiers can be used for identifying public keys and signatures.

[I-D.ietf-lamps-pkix-shake] [ EDNOTE: Update reference with the RFC when it is ready ] also defines two algorithm identifiers of ECDSA signatures using SHAKEs which we include here for convenience.

```
id-ecdsa-with-shake128 OBJECT IDENTIFIER ::= { iso(1)
    identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) algorithms(6)
    TBD3 }
```

```
id-ecdsa-with-shake256 OBJECT IDENTIFIER ::= { iso(1)
    identified-organization(3) dod(6) internet(1)
    security(5) mechanisms(5) pkix(7) algorithms(6)
    TBD4 }
```

The parameters for the four RSASSA-PSS and ECDSA identifiers MUST be absent. That is, each identifier SHALL be a SEQUENCE of one component, the OID.

Two object identifiers for KMACs using SHAKE128 and SHAKE256 as defined in by the National Institute of Standards and Technology (NIST) in [[shake-nist-oids](#)] and we include them here for convenience.

```
id-KmacWithSHAKE128 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2)
    country(16) us(840) organization(1) gov(101) csor(3)
    nistAlgorithm(4) 2 19 }
```

```
id-KmacWithSHAKE256 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2)
    country(16) us(840) organization(1) gov(101) csor(3)
    nistAlgorithm(4) 2 20 }
```

The parameters for id-KmacWithSHAKE128 and id-KmacWithSHAKE256 are OPTIONAL.

[Section 4.1](#), [Section 4.2.1](#), [Section 4.2.2](#) and [Section 4.4](#) specify the required output length for each use of SHAKE128 or SHAKE256 in message digests, RSASSA-PSS, ECDSA and KMAC.

## [4. Use in CMS](#)

### [4.1. Message Digests](#)

The id-shake128 and id-shake256 OIDs ([Section 3](#)) can be used as the digest algorithm identifiers located in the SignedData, SignerInfo, DigestedData, and the AuthenticatedData digestAlgorithm fields in CMS [[RFC5652](#)]. The encoding MUST omit the parameters field and the



output size, *d*, for the SHAKE128 or SHAKE256 message digest MUST be 256 or 512 bits respectively.

The digest values are located in the `DigestedData` field and the Message Digest authenticated attribute included in the `signedAttributes` of the `SignedData` `signerInfo`. In addition, digest values are input to signature algorithms. The digest algorithm MUST be the same as the message hash algorithms used in signatures.

## **4.2. Signatures**

In CMS, signature algorithm identifiers are located in the `SignerInfo` `signatureAlgorithm` field of `SignedData` content type and countersignature attribute. Signature values are located in the `SignerInfo` signature field of `SignedData` content type and countersignature attribute.

Conforming implementations that process RSASSA-PSS and ECDSA with SHAKE signatures when processing CMS data MUST recognize the corresponding OIDs specified in [Section 3](#).

When using RSASSA-PSS or ECDSA with SHAKEs, the RSA modulus and ECDSA curve order SHOULD be chosen in line with the SHAKE output length. In the context of this document SHAKE128 OIDs are RECOMMENDED for 2048 or 3072-bit RSA modulus or curves with group order of 256-bits. SHAKE256 OIDs are RECOMMENDED for 4096-bit RSA modulus and higher or curves with group order of 384-bits and higher.

### **4.2.1. RSASSA-PSS Signatures**

The RSASSA-PSS algorithm is defined in [\[RFC8017\]](#). When `id-RSASSA-PSS-SHAKE128` or `id-RSASSA-PSS-SHAKE256` specified in [Section 3](#) is used, the encoding MUST omit the parameters field. That is, the `AlgorithmIdentifier` SHALL be a SEQUENCE of one component, `id-RSASSA-PSS-SHAKE128` or `id-RSASSA-PSS-SHAKE256`. [\[RFC4055\]](#) defines RSASSA-PSS-params that are used to define the algorithms and inputs to the algorithm. This specification does not use parameters because the hash, mask generation algorithm, trailer and salt are embedded in the OID definition.

The hash algorithm to hash a message being signed and the hash algorithm as the mask generation function used in RSASSA-PSS MUST be the same, SHAKE128 or SHAKE256 respectively. The output-length of the hash algorithm which hashes the message SHALL be 32 or 64 bytes respectively.

The mask generation function takes an octet string of variable length and a desired output length as input, and outputs an octet string of



the desired length. In RSASSA-PSS with SHAKEs, the SHAKEs MUST be used natively as the MGF function, instead of the MGF1 algorithm that uses the hash function in multiple iterations as specified in Section B.2.1 of [\[RFC8017\]](#). In other words, the MGF is defined as the SHAKE128 or SHAKE256 output of the mgfSeed for id-RSASSA-PSS-SHAKE128 and id-RSASSA-PSS-SHAKE256 respectively. The mgfSeed is the seed from which mask is generated, an octet string [\[RFC8017\]](#). As explained in Step 9 of [section 9.1.1 of \[RFC8017\]](#), the output length of the MGF is  $\text{emLen} - \text{hLen} - 1$  bytes. emLen is the maximum message length  $\text{ceil}((n-1)/8)$ , where  $n$  is the RSA modulus in bits. hLen is 32 and 64-bytes for id-RSASSA-PSS-SHAKE128 and id-RSASSA-PSS-SHAKE256 respectively. Thus when SHAKE is used as the MGF, the SHAKE output length maskLen is  $(n - 264)$  or  $(n - 520)$  bits respectively. For example, when RSA modulus  $n$  is 2048, the output length of SHAKE128 or SHAKE256 as the MGF will be 1784 or 1528-bits when id-RSASSA-PSS-SHAKE128 or id-RSASSA-PSS-SHAKE256 is used respectively.

The RSASSA-PSS saltLength MUST be 32 or 64 bytes respectively. Finally, the trailerField MUST be 1, which represents the trailer field with hexadecimal value 0xBC [\[RFC8017\]](#).

#### **4.2.2. ECDSA Signatures**

The Elliptic Curve Digital Signature Algorithm (ECDSA) is defined in [\[X9.62\]](#). When the id-ecdsa-with-shake128 or id-ecdsa-with-shake256 (specified in [Section 3](#)) algorithm identifier appears, the respective SHAKE function is used as the hash. The encoding MUST omit the parameters field. That is, the AlgorithmIdentifier SHALL be a SEQUENCE of one component, the OID id-ecdsa-with-shake128 or id-ecdsa-with-shake256.

For simplicity and compliance with the ECDSA standard specification, the output size of the hash function must be explicitly determined. The output size,  $d$ , for SHAKE128 or SHAKE256 used in ECDSA MUST be 256 or 512 bits respectively.

It is RECOMMENDED that conforming implementations that generate ECDSA with SHAKE signatures in CMS generate such signatures with a deterministically generated, non-random  $k$  in accordance with all the requirements specified in [\[RFC6979\]](#). They MAY also generate such signatures in accordance with all other recommendations in [\[X9.62\]](#) or [\[SEC1\]](#) if they have a stated policy that requires conformance to these standards. These standards have not specified SHAKE128 and SHAKE256 as hash algorithm options. However, SHAKE128 and SHAKE256 with output length being 32 and 64 octets respectively can be used instead of 256 and 512-bit output hash algorithms such as SHA256 and SHA512 used in the standards.



### **4.3. Public Keys**

In CMS, the signer's public key algorithm identifiers are located in the `OriginatorPublicKey`'s `algorithm` attribute. The conventions and encoding for RSASSA-PSS and ECDSA public keys algorithm identifiers are as specified in [Section 2.3 of \[RFC3279\]](#), [Section 3.1 of \[RFC4055\]](#) and [Section 2.1 of \[RFC5480\]](#).

Traditionally, the `rsaEncryption` object identifier is used to identify RSA public keys. The `rsaEncryption` object identifier continues to identify the public key when the RSA private key owner does not wish to limit the use of the public key exclusively to RSASSA-PSS with SHAKEs. When the RSA private key owner wishes to limit the use of the public key exclusively to RSASSA-PSS, the `AlgorithmIdentifier` for RSASSA-PSS defined in [Section 3](#) SHOULD be used as the `algorithm` attribute in the `OriginatorPublicKey` sequence. Conforming client implementations that process RSASSA-PSS with SHAKE public keys in CMS message MUST recognize the corresponding OIDs in [Section 3](#).

Conforming implementations MUST specify and process the algorithms explicitly by using the OIDs specified in [Section 3](#) when encoding ECDSA with SHAKE public keys in CMS messages.

The identifier parameters, as explained in [Section 3](#), MUST be absent.

### **4.4. Message Authentication Codes**

KMAC message authentication code (KMAC) is specified in [\[SP800-185\]](#). In CMS, KMAC algorithm identifiers are located in the `AuthenticatedData` `macAlgorithm` field. The KMAC values are located in the `AuthenticatedData` `mac` field.

When the `id-KmacWithSHAKE128` or `id-KmacWithSHAKE256` OID is used as the MAC algorithm identifier, the `parameters` field is optional (absent or present). If absent, the SHAKE256 output length used in KMAC is 256 or 512 bits respectively and the customization string is an empty string by default.

Conforming implementations that process KMACs with the SHAKEs when processing CMS data MUST recognize these identifiers.

When calculating the KMAC output, the variable `N` is `0xD2B282C2`, `S` is an empty string, and `L`, the integer representing the requested output length in bits, is 256 or 512 for `KmacWithSHAKE128` or `KmacWithSHAKE256` respectively in this specification.





## 5. IANA Considerations

One object identifier for the ASN.1 module in [Appendix A](#) was requested for the SMI Security for S/MIME Module Identifiers (1.2.840.113549.1.9.16.0) registry:

Decimal	Description	References
TBD	CMSAlgsForSHAKE-2019	[EDNOTE: THIS RFC]

## 6. Security Considerations

This document updates [\[RFC3370\]](#). The security considerations section of that document applies to this specification as well.

NIST has defined appropriate use of the hash functions in terms of the algorithm strengths and expected time frames for secure use in Special Publications (SPs) [\[SP800-78-4\]](#) and [\[SP800-107\]](#). These documents can be used as guides to choose appropriate key sizes for various security scenarios.

When more than two parties share the same message-authentication key, data origin authentication is not provided. Any party that knows the message-authentication key can compute a valid MAC, therefore the content could originate from any one of the parties.

## 7. Acknowledgements

This document is based on Russ Housley's draft [\[I-D.housley-lamps-cms-sha3-hash\]](#). It replaces SHA3 hash functions by SHAKE128 and SHAKE256 as the LAMPS WG agreed.

The authors would like to thank Russ Housley for his guidance and very valuable contributions with the ASN.1 module. Valuable feedback was also provided by Eric Rescorla.

## 8. References

### 8.1. Normative References

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- [RFC3370] Housley, R., "Cryptographic Message Syntax (CMS) Algorithms", [RFC 3370](#), DOI 10.17487/RFC3370, August 2002, <<https://www.rfc-editor.org/info/rfc3370>>.
- [RFC4055] Schaad, J., Kaliski, B., and R. Housley, "Additional Algorithms and Identifiers for RSA Cryptography for use in the Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", [RFC 4055](#), DOI 10.17487/RFC4055, June 2005, <<https://www.rfc-editor.org/info/rfc4055>>.
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- [RFC5652] Housley, R., "Cryptographic Message Syntax (CMS)", STD 70, [RFC 5652](#), DOI 10.17487/RFC5652, September 2009, <<https://www.rfc-editor.org/info/rfc5652>>.
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- [SHA3] National Institute of Standards and Technology, U.S. Department of Commerce, "SHA-3 Standard - Permutation-Based Hash and Extendable-Output Functions", FIPS PUB 202, August 2015.
- [SP800-185] National Institute of Standards and Technology, "SHA-3 Derived Functions: cSHAKE, KMAC, TupleHash and ParallelHash. NIST SP 800-185", December 2016, <<http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-185.pdf>>.

## **8.2. Informative References**

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[RFC3279] Bassham, L., Polk, W., and R. Housley, "Algorithms and Identifiers for the Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", [RFC 3279](#), DOI 10.17487/RFC3279, April 2002, <<https://www.rfc-editor.org/info/rfc3279>>.

[RFC5753] Turner, S. and D. Brown, "Use of Elliptic Curve Cryptography (ECC) Algorithms in Cryptographic Message Syntax (CMS)", [RFC 5753](#), DOI 10.17487/RFC5753, January 2010, <<https://www.rfc-editor.org/info/rfc5753>>.

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National Institute of Standards and Technology (NIST),  
"SP800-107: Recommendation for Applications Using Approved  
Hash Algorithms", May 2014,  
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[SP800-78-4]

National Institute of Standards and Technology (NIST),  
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Personal Identity Verification", May 2014,  
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78/4/final/documents/sp800\\_78-4\\_revised\\_draft.pdf](https://csrc.nist.gov/csrc/media/publications/sp/800-78/4/final/documents/sp800_78-4_revised_draft.pdf)>.

[X9.62] American National Standard for Financial Services (ANSI),  
"X9.62-2005 Public Key Cryptography for the Financial  
Services Industry: The Elliptic Curve Digital Signature  
Standard (ECDSA)", November 2005.

## **Appendix A. ASN.1 Module**

This appendix includes the ASN.1 modules for SHAKEs in CMS. This module includes some ASN.1 from other standards for reference.

```
CMSAlgsForSHAKE-2019 { iso(1) member-body(2) us(840)
    rsadsi(113549) pkcs(1) pkcs-9(9) smime(16) modules(0)
    id-mod-cms-shakes-2019(TBD) }
```

```
DEFINITIONS EXPLICIT TAGS ::=
```

```
BEGIN
```

```
-- EXPORTS ALL;
```

```
IMPORTS
```

```
DIGEST-ALGORITHM, MAC-ALGORITHM, SMIME-CAPS
FROM AlgorithmInformation-2009
{ iso(1) identified-organization(3) dod(6) internet(1) security(5)
    mechanisms(5) pkix(7) id-mod(0)
    id-mod-algorithmInformation-02(58) }
```

```
RSAPublicKey, rsaEncryption, id-ecPublicKey
FROM PKIXAlgs-2009 { iso(1) identified-organization(3) dod(6)
    internet(1) security(5) mechanisms(5) pkix(7) id-mod(0)
    id-mod-pkix1-algorithms2008-02(56) } ;
```

```
--
```





```
-- Message Digest Algorithms (mda-)
-- used in SignedData, SignerInfo, DigestedData,
-- and the AuthenticatedData digestAlgorithm
-- fields in CMS
--
MessageDigestAlgs DIGEST-ALGORITHM ::= {
  -- This expands MessageAuthAlgs from [RFC5652]
  -- and MessageDigestAlgs in [RFC5753]
  mda-shake128    |
  mda-shake256,
  ...
}

--
-- One-Way Hash Functions
-- SHAKE128
mda-shake128 DIGEST-ALGORITHM ::= {
  IDENTIFIER id-shake128  -- with output length 32 bytes.
}
id-shake128 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16)
                                     us(840) organization(1) gov(101)
                                     csor(3) nistAlgorithm(4)
                                     hashAlgs(2) 11 }

-- SHAKE256
mda-shake256 DIGEST-ALGORITHM ::= {
  IDENTIFIER id-shake256  -- with output length 64 bytes.
}
id-shake256 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2) country(16)
                                     us(840) organization(1) gov(101)
                                     csor(3) nistAlgorithm(4)
                                     hashAlgs(2) 12 }

--
-- Public key algorithm identifiers located in the
-- OriginatorPublicKey's algorithm attribute in CMS.
-- And Signature identifiers used in SignerInfo
-- signatureAlgorithm field of SignedData content
-- type and countersignature attribute in CMS.
--
-- From RFC5280, for reference.
-- rsaEncryption OBJECT IDENTIFIER ::= { pkcs-1 1 }
--   -- When the rsaEncryption algorithm identifier is used
--   -- for a public key, the AlgorithmIdentifier parameters
--   -- field MUST contain NULL.
--
id-RSASSA-PSS-SHAKE128 OBJECT IDENTIFIER ::= { iso(1)
        identified-organization(3) dod(6) internet(1)
```



```
        security(5) mechanisms(5) pkix(7) algorithms(6)
        TBD1 }
id-RSASSA-PSS-SHAKE256 OBJECT IDENTIFIER ::= { iso(1)
        identified-organization(3) dod(6) internet(1)
        security(5) mechanisms(5) pkix(7) algorithms(6)
        TBD2 }
-- When the id-RSASSA-PSS-* algorithm identifiers are used
-- for a public key or signature in CMS, the AlgorithmIdentifier
-- parameters field MUST be absent. The message digest algorithm
-- used in RSASSA-PSS MUST be SHAKE128 or SHAKE256 with a 32 or
-- 64 byte outout length respectively. The mask generation
-- function MUST be SHAKE128 or SHAKE256 with an output length
-- of (n - 264) or (n - 520) bits respectively, where n
-- is the RSA modulus in bits. The RSASSA-PSS saltLength MUST
-- be 32 or 64 bytes respectively. The trailerField MUST be 1,
-- which represents the trailer field with hexadecimal value
-- 0xBC. Regardless of id-RSASSA-PSS-* or rsaEncryption being
-- used as the AlgorithmIdentifier of the OriginatorPublicKey,
-- the RSA public key MUST be encoded using the RSAPublicKey
-- type.

-- From RFC4055, for reference.
-- RSAPublicKey ::= SEQUENCE {
--   modulus INTEGER, -- -- n
--   publicExponent INTEGER } -- -- e

id-ecdsa-with-shake128 OBJECT IDENTIFIER ::= { iso(1)
        identified-organization(3) dod(6) internet(1)
        security(5) mechanisms(5) pkix(7) algorithms(6)
        TBD3 }
id-ecdsa-with-shake256 OBJECT IDENTIFIER ::= { iso(1)
        identified-organization(3) dod(6) internet(1)
        security(5) mechanisms(5) pkix(7) algorithms(6)
        TBD4 }
-- When the id-ecdsa-with-shake* algorithm identifiers are
-- used in CMS, the AlgorithmIdentifier parameters field
-- MUST be absent and the signature algorithm should be
-- deterministic ECDSA [RFC6979]. The message digest MUST
-- be SHAKE128 or SHAKE256 with a 32 or 64 byte outout
-- length respectively. In both cases, the ECDSA public key,
-- MUST be encoded using the id-ecPublicKey type.

-- From RFC5480, for reference.
-- id-ecPublicKey OBJECT IDENTIFIER ::= {
--   iso(1) member-body(2) us(840) ansi-X9-62(10045) keyType(2) 1 }
--   -- The id-ecPublicKey parameters must be absent or present
--   -- and are defined as
-- ECParameters ::= CHOICE {
```



```
--      namedCurve          OBJECT IDENTIFIER
--      -- -- implicitCurve  NULL
--      -- -- specifiedCurve SpecifiedECDomain
--  }

--
-- Message Authentication (maca-) Algorithms
-- used in AuthenticatedData macAlgorithm in CMS
--
MessageAuthAlgs MAC-ALGORITHM ::= {
  -- This expands MessageAuthAlgs from [RFC5652] and [RFC6268]
  maca-KMACwithSHAKE128  |
  maca-KMACwithSHAKE256,
  ...
}

SMimeCaps SMIME-CAPS ::= {
  -- The expands SMimeCaps from [RFC5911]
  maca-KMACwithSHAKE128.&smimeCaps  |
  maca-KMACwithSHAKE256.&smimeCaps,
  ...
}

--
-- KMAC with SHAKE128
maca-KMACwithSHAKE128 MAC-ALGORITHM ::= {
  IDENTIFIER id-KMACwithSHAKE128
  PARAMS TYPE KMACwithSHAKE128-params ARE optional
  -- If KMACwithSHAKE128-params parameters are absent
  -- the SHAKE128 output length used in KMAC is 256 bits
  -- and the customization string is an empty string.
  IS-KEYED-MAC TRUE
  SMIME-CAPS {IDENTIFIED BY id-KMACwithSHAKE128}
}

id-KMACwithSHAKE128 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2)
  country(16) us(840) organization(1)
  gov(101) csor(3) nistAlgorithm(4)
  hashAlgs(2) 19 }

KMACwithSHAKE128-params ::= SEQUENCE {
  kMACOutputLength  INTEGER DEFAULT 256, -- Output length in bits
  customizationString OCTET STRING DEFAULT ''H
}

-- KMAC with SHAKE256
maca-KMACwithSHAKE256 MAC-ALGORITHM ::= {
  IDENTIFIER id-KMACwithSHAKE256
  PARAMS TYPE KMACwithSHAKE256-params ARE optional
  -- If KMACwithSHAKE256-params parameters are absent
```



```
-- the SHAKE256 output length used in KMAC is 512 bits
-- and the customization string is an empty string.
IS-KEYED-MAC TRUE
SMIME-CAPS {IDENTIFIED BY id-KMACWithSHAKE256}
}
id-KMACWithSHAKE256 OBJECT IDENTIFIER ::= { joint-iso-itu-t(2)
    country(16) us(840) organization(1)
    gov(101) csor(3) nistAlgorithm(4)
    hashAlgs(2) 20 }
KMACwithSHAKE256-params ::= SEQUENCE {
    kMACOutputLength    INTEGER DEFAULT 512, -- Output length in bits
    customizationString OCTET STRING DEFAULT ''H
}

END
```

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