
**Information technology —
Telecommunications and information
exchange between systems — NFC
Security —**

Part 2:

**NFC-SEC cryptography standard using
ECDH and AES**

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Technologies de l'information — Téléinformatique — Sécurité NFC —

Partie 2 Norme de cryptographie NFC-SEC utilisant ECDH et AES

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 13157-2 was prepared by Ecma International (as ECMA-386) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

ISO/IEC 13157 consists of the following parts, under the general title *Information technology — Telecommunications and information exchange between systems — NFC Security*:

- *Part 1: NFC-SEC NFCIP-1 security services and protocol*
- *Part 2: NFC-SEC cryptography standard using ECDH and AES*

Introduction

The NFC Security series of standards comprise a common services and protocol standard and NFC-SEC cryptography standards.

This NFC-SEC cryptography standard specifies cryptographic mechanisms that use the Elliptic Curves Diffie-Hellman (ECDH) protocol for key agreement and the AES algorithm for data encryption and integrity.

This International Standard addresses secure communication of two NFC devices that do not share any common secret data ("keys") before they start communicating with each other.

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Information technology — Telecommunications and information exchange between systems — NFC Security —

Part 2: NFC-SEC cryptography standard using ECDH and AES

1 Scope

This International Standard specifies the message contents and the cryptographic methods for PID 01.

This International Standard specifies cryptographic mechanisms that use the Elliptic Curves Diffie-Hellman (ECDH) protocol for key agreement and the AES algorithm for data encryption and integrity.

2 Conformance

Conformant implementations employ the security mechanisms specified in this NFC-SEC cryptography standard (identified by PID 01) and conform to ISO/IEC 13157-1.

The NFC-SEC security services shall be established through the protocol specified in ISO/IEC 13157-1 and the mechanisms specified in this International Standard.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 10116:2006, *Information technology — Security techniques — Modes of operation for an n-bit block cipher*

ISO/IEC 11770-3:2008, *Information technology — Security techniques — Key management — Part 3: Mechanisms using asymmetric techniques*

ISO/IEC 13157-1:2010, *Information technology — Telecommunications and information exchange between systems — NFC Security — Part 1: NFC-SEC NFCIP-1 security services and protocol (also published by Ecma as Standard ECMA-385)*

ISO/IEC 15946-1:2008, *Information technology — Security techniques — Cryptographic techniques based on elliptic curves — Part 1: General*

ISO/IEC 18031:2005, *Information technology — Security techniques — Random bit generation*

ISO/IEC 18033-3:2005, *Information technology — Security techniques — Encryption algorithms — Part 3: Block ciphers*

ISO/IEC 13157-2:2010(E)

ISO/IEC 18092:2004, *Information technology — Telecommunications and information exchange between systems — Near Field Communication — Interface and Protocol (NFCIP-1) (also published by Ecma as Standard ECMA-340)*

IEEE 1363, *IEEE Standard Specifications for Public-Key Cryptography*

FIPS 186-2, *Digital Signature Standard (DSS)*

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 13157-1 apply.

5 Conventions and notations

The conventions and notations of ISO/IEC 13157-1 as well as the following apply in this document unless otherwise stated.

5.1 Concatenation

A || B represents the concatenation of the fields A and B: content of A followed by content of B.

5.2 Hexadecimal numbers

(XY) denotes a hexadecimal number XY (i.e. with the Radix of 16) and each pair of characters is encoded in one octet.

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6 Acronyms

For the purposes of this document, the acronyms given in ISO/IEC 13157-1 and the following apply.

A	Sender, as specified in ISO/IEC 13157-1
AES	Advanced Encryption Standard
B	Receiver, as specified in ISO/IEC 13157-1
d _A	Sender's private EC key
d _B	Recipient's private EC key
DataLen	Length of the UserData
EC	Elliptic Curve
ECDH	Elliptic Curve Diffie-Hellman
EncData	Encrypted data
G	The base point on EC
ID _A	Sender nfcid3
ID _B	Recipient nfcid3
ID _R	Any Recipient identification number (e.g. ID _B)
ID _S	Any Sender identification number (e.g. ID _A)
IV	Initial Value
K	Key

KDF	Key Derivation Function
KE	Encryption Key
KI	Integrity Key
MAC	Message Authentication Code
Mac _A / Mac _B	Integrity protection value of Sender/ Recipient
MacTag _A	Key confirmation tag from Sender
MacTag _B	Key confirmation tag from Recipient
MK	Master Key
NA / NB	Nonce generated by Sender/Recipient
NAA / NBB	Nonce generated by the pair of NFC-SEC entities
Nonce _S	Sender's nonce
Nonce _R	Recipient's nonce
PK	Public Key
PK _R	Recipient's Public Key
PK _S	Sender's Public Key
PRNG	Pseudo Random Number Generator
QA / QB	Compressed EC public key of Sender / Recipient
Q _A / Q _B	Decompressed EC public key of Sender / Recipient
RNG	Random Number Generator
SharedSecret	Shared secret
UserData	NFC-SEC User data
z	Unsigned integer representation of the Shared Secret
Z	Octet string representation of z

The acronyms used in Clauses 9 and 10 not listed above are formal parameters.

7 General

This International Standard specifies mechanisms for the Shared Secret Service (SSE) and the Secure Channel Service (SCH) in ISO/IEC 13157-1.

To enable secure communication between NFC devices that do not share any common secret data ("keys") before they start communicating with each other, public key cryptography is used to establish a shared secret between these devices, and more specifically the Elliptic Curve Diffie-Hellman key exchange scheme. This shared secret is used to establish the SSE and the SCH.

8 Protocol Identifier (PID)

This International Standard shall use the one octet protocol identifier PID with value 1.

9 Primitives

This Clause specifies cryptographic primitives. Clauses 11 and 12 specify the actual use of these primitives.

Table 1 summarizes the features.

Table 1 – Summary of features

Supported services	SSE (see ISO/IEC 13157-1) SCH (see ISO/IEC 13157-1)
Key agreement	ECDH P-192
KDF	AES-XCBC-PRF-128
Key confirmation	AES-XCBC-MAC-96
Data encryption	AES128-CTR IV Init: AES-XCBC-PRF-128
Data integrity	AES-XCBC-MAC-96
Sequence integrity	SN (see ISO/IEC 13157-1)
Encryption order	Encryption (9.5) before MAC calculation (9.6)

9.1 Key agreement

Peer NFC-SEC entities shall agree on a shared secret using Key agreement mechanism 4 from ISO/IEC 11770-3 and the Elliptic Curves Diffie-Hellman primitives from IEEE 1363 as further specified below.

9.1.1 Curve P-192

Curve P-192 as specified in FIPS 186-2 shall be used.

9.1.2 EC Key Pair Generation Primitive

The private key d shall be obtained from a random or pseudo-random process conforming to ISO/IEC 18031.

- a) Obtain the private key, d , from a random or pseudo-random process conforming to ISO/IEC 18031.
- b) Compute the public key, PK , as a point on EC, $PK = dG$.

9.1.3 EC Public key validation

The EC public key shall be validated as specified in *Public Key Validation* of ISO/IEC 15946-1.

9.1.4 ECDH secret value derivation Primitive

The ECDH primitive as specified in 7.2.1 *ECSVDP-DH* of IEEE 1363 shall output the ‘valid’ shared secret z and ‘invalid’ otherwise.

9.1.5 Random nonces

Each peer NFC-SEC entity should send fresh random nonces with the EC public key of the entity.

The nonces are used to provide more entropy to the keys derived from the shared secret (z), and to facilitate the EC key pair management.

The correct generation of these nonces is under the responsibility of the entity.

The entity should guarantee that the nonces it generates have 96 bits of entropy valid for the duration of the protocol. The nonces used in an NFC-SEC transaction shall be cryptographically uncorrelated with the nonces from a previous transaction.

See ISO/IEC 18031 for further recommendations on random number generation.

9.2 Key Derivation Functions

Two Key Derivation Functions (KDF) are specified; one for the SSE and one for the SCH.

The KDFs shall use AES in XCBC-PRF-128 mode as specified in A.1.

For the following sections KDF is:

$$\text{KDF}(K, S) = \text{AES-XCBC-PRF-128}_K(S)$$

The random source (nonces + shared secret z obtained from 9.1.4) used for the SCH shall be different from the random source used for the SSE.

9.2.1 KDF for the SSE

The KDF for the SSE is:

$$\text{MK}_{\text{SSE}} = \text{KDF-SSE}(\text{Nonce}_S, \text{Nonce}_R, \text{SharedSecret}, \text{ID}_S, \text{ID}_R)$$

Detail of the KDF-SSE function:

$$S = (\text{Nonce}_S [0..63] \parallel \text{Nonce}_R [0..63])$$

$$\text{KEYSEED} = \text{KDF}(S, \text{SharedSecret})$$

$$\text{MK}_{\text{SSE}} = \text{KDF}(\text{KEYSEED}, S \parallel \text{ID}_S \parallel \text{ID}_R \parallel (01))$$

9.2.2 KDF for the SCH

The KDF for the SCH is:

$$\{\text{MK}_{\text{SCH}}, \text{KE}_{\text{SCH}}, \text{KI}_{\text{SCH}}\} = \text{KDF-SCH}(\text{Nonce}_S, \text{Nonce}_R, \text{SharedSecret}, \text{ID}_S, \text{ID}_R)$$

Detail of the KDF-SCH function:

$$S = (\text{Nonce}_S [0..63] \parallel \text{Nonce}_R [0..63])$$

$$\text{KEYSEED} = \text{KDF}(S, \text{SharedSecret})$$

$$\text{MK}_{\text{SCH}} = \text{KDF}(\text{KEYSEED}, S \parallel \text{ID}_S \parallel \text{ID}_R \parallel (01))$$

$$\text{KE}_{\text{SCH}} = \text{KDF}(\text{KEYSEED}, \text{MK}_{\text{SCH}} \parallel S \parallel \text{ID}_S \parallel \text{ID}_R \parallel (02))$$

$$\text{KI}_{\text{SCH}} = \text{KDF}(\text{KEYSEED}, \text{KE}_{\text{SCH}} \parallel S \parallel \text{ID}_S \parallel \text{ID}_R \parallel (03))$$

9.3 Key Usage

Each derived key MK_{SCH} , KE_{SCH} , KI_{SCH} and MK_{SSE} should be used only for the purpose specified in Table 2.

The Keys MK_{SCH} , KE_{SCH} , KI_{SCH} and MK_{SSE} shall be different for each NFC-SEC transaction.