

Internet Engineering Task Force  
Internet-Draft  
Intended status: Standards Track  
Expires: July 20, 2018

J. Fenton  
Altmode Networks  
January 16, 2018

**SMTP Require TLS Option**  
**draft-ietf-uta-smtp-require-tls-01**

**Abstract**

The SMTP STARTTLS option, used in negotiating transport-level encryption of SMTP connections, is not as useful from a security standpoint as it might be because of its opportunistic nature; message delivery is, by default, prioritized over security. This document describes an SMTP service extension, REQUIRETLS, and message header field, Require-TLS. If the REQUIRETLS option or Require-TLS message header field is used when sending a message, it asserts a request on the part of the message sender to override the default negotiation of TLS, either by requiring that TLS be negotiated when the message is relayed, or by requesting that recipient-side policy mechanisms such as MTA-STS and DANE be ignored when relaying a message for which security is unimportant.

**Status of This Memo**

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on July 20, 2018.

**Copyright Notice**

Copyright (c) 2018 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents

(<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

## Table of Contents

<a href="#">1.</a>	<a href="#">Introduction . . . . .</a>	<a href="#">2</a>
<a href="#">1.1.</a>	<a href="#">Requirements Language . . . . .</a>	<a href="#">3</a>
<a href="#">2.</a>	<a href="#">The REQUIRETLS Service Extension . . . . .</a>	<a href="#">3</a>
<a href="#">3.</a>	<a href="#">The Require-TLS Header Field . . . . .</a>	<a href="#">5</a>
<a href="#">4.</a>	<a href="#">REQUIRETLS Semantics . . . . .</a>	<a href="#">5</a>
<a href="#">4.1.</a>	<a href="#">REQUIRETLS Receipt Requirements . . . . .</a>	<a href="#">5</a>
<a href="#">4.2.</a>	<a href="#">REQUIRETLS Sender Requirements . . . . .</a>	<a href="#">6</a>
<a href="#">4.2.1.</a>	<a href="#">Sending with TLS Required . . . . .</a>	<a href="#">6</a>
<a href="#">4.2.2.</a>	<a href="#">Sending with TLS Optional . . . . .</a>	<a href="#">7</a>
<a href="#">4.3.</a>	<a href="#">REQUIRETLS Submission . . . . .</a>	<a href="#">7</a>
<a href="#">4.4.</a>	<a href="#">Delivery of REQUIRETLS messages . . . . .</a>	<a href="#">8</a>
<a href="#">5.</a>	<a href="#">Non-delivery message handling . . . . .</a>	<a href="#">8</a>
<a href="#">6.</a>	<a href="#">Mailing list considerations . . . . .</a>	<a href="#">8</a>
<a href="#">7.</a>	<a href="#">IANA Considerations . . . . .</a>	<a href="#">9</a>
<a href="#">8.</a>	<a href="#">Security Considerations . . . . .</a>	<a href="#">9</a>
<a href="#">8.1.</a>	<a href="#">Passive attacks . . . . .</a>	<a href="#">10</a>
<a href="#">8.2.</a>	<a href="#">Active attacks . . . . .</a>	<a href="#">10</a>
<a href="#">8.3.</a>	<a href="#">Bad Actor MTAs . . . . .</a>	<a href="#">10</a>
<a href="#">9.</a>	<a href="#">Acknowledgements . . . . .</a>	<a href="#">11</a>
<a href="#">10.</a>	<a href="#">Revision History . . . . .</a>	<a href="#">11</a>
<a href="#">10.1.</a>	<a href="#">Changes since -00 Draft . . . . .</a>	<a href="#">11</a>
<a href="#">10.2.</a>	<a href="#">Changes since fenton-03 Draft . . . . .</a>	<a href="#">11</a>
<a href="#">10.3.</a>	<a href="#">Changes Since -02 Draft . . . . .</a>	<a href="#">11</a>
<a href="#">10.4.</a>	<a href="#">Changes Since -01 Draft . . . . .</a>	<a href="#">12</a>
<a href="#">10.5.</a>	<a href="#">Changes Since -00 Draft . . . . .</a>	<a href="#">12</a>
<a href="#">11.</a>	<a href="#">References . . . . .</a>	<a href="#">12</a>
<a href="#">11.1.</a>	<a href="#">Normative References . . . . .</a>	<a href="#">12</a>
<a href="#">11.2.</a>	<a href="#">Informative References . . . . .</a>	<a href="#">14</a>
	<a href="#">Author's Address . . . . .</a>	<a href="#">14</a>

## [1.](#) Introduction

The SMTP [[RFC5321](#)] STARTTLS service extension [[RFC3207](#)] provides a means by which an SMTP server and client can establish a Transport Layer Security (TLS) protected session for the transmission of email messages. By default, TLS is used only upon mutual agreement (successful negotiation) of STARTTLS between the client and server; if this is not possible, the message is sent without transport

Fenton

Expires July 20, 2018

[Page 2]

encryption. Furthermore, it is common practice for the client to negotiate TLS even if the SMTP server's certificate is invalid.

Policy mechanisms such as DANE [[RFC7672](#)] and MTA-STS [[I-D.ietf-uta-mta-sts](#)] may impose requirements for the use of TLS for email destined for some domains. However, such policies do not allow the sender to specify which messages are more sensitive and require transport-level encryption, and which ones are less sensitive and ought to be relayed even if TLS cannot be negotiated successfully.

The default opportunistic nature of SMTP TLS enables several "on the wire" attacks on SMTP security between MTAs. These include passive eavesdropping on connections for which TLS is not used, interference in the SMTP protocol to prevent TLS from being negotiated (presumably accompanied by eavesdropping), and insertion of a man-in-the-middle attacker exploiting the lack of server authentication by the client. Attacks are described in more detail in the Security Considerations section of this document.

REQUIRETLS consists of two mechanisms: an SMTP service extension and a message header field. The service extension is used to specify that a given message sent during a particular session **MUST** be sent over a TLS-protected session with specified security characteristics. It also requires that the SMTP server advertise that it supports REQUIRETLS, in effect promising that it will honor the requirement to enforce TLS transmission and REQUIRETLS support for onward transmission of those messages.

The Require-TLS message header field is used to convey a request to ignore recipient-side policy mechanisms such as MTA-STS and DANE, thereby prioritizing delivery over ability to negotiate TLS. Unlike the service extension, the Require-TLS header field allows the message to transit through one or more MTAs that do not support REQUIRETLS.

### **[1.1.](#) Requirements Language**

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.

## **[2.](#) The REQUIRETLS Service Extension**

1. The textual name of the extension is "Require TLS".

Fenton

Expires July 20, 2018

[Page 3]

2. The EHLO keyword value associated with this extension is "REQUIRETLS".
3. One MAIL FROM option is defined by this extension.
4. Two new SMTP status codes are defined by this extension to convey error conditions resulting from failure of the client to negotiate a TLS connection with the required security and as a result of an attempt to send to a server not also supporting the REQUIRETLS extension.

In order to specify REQUIRETLS treatment for a given message, the REQUIRETLS option is specified on the MAIL FROM command when that message is transmitted. This option MUST only be specified in the context of an SMTP session meeting the security requirements that have been specified:

- o The session itself MUST employ TLS transmission.
- o Any server authentication requirements included as an option to the REQUIRETLS option (see below) MUST have been satisfied in establishing the current session.
- o Following the negotiation of STARTTLS, the SMTP server MUST advertise in the subsequent EHLO response that it supports REQUIRETLS.

An optional parameter to the REQUIRETLS MAIL FROM option specifies the requirements for server authentication that MUST be used for any onward transmission of the following message. The parameter takes the form of either a single value or comma-separated list, separated from the REQUIRETLS option by a single "=" (equals-sign) character. If present, the parameter MUST take one or more of the following values:

- o CHAIN - The certificate presented by the SMTP server MUST verify successfully in a trust chain leading to a certificate trusted by the SMTP client. The choice of trusted (root) certificates by the client is at their own discretion.
- o DANE - The certificate presented by the SMTP server MUST verify successfully using DANE as specified in [RFC 7672](#) [[RFC7672](#)].
- o DNSSEC - The server MUST confirm that any MX record or CNAME lookup used to locate the SMTP server must be DNSSEC [[RFC4035](#)] signed and valid.

Fenton

Expires July 20, 2018

[Page 4]

The CHAIN and DANE parameters are additive; if both are specified, either method of certificate validation is acceptable. If neither CHAIN nor DANE is specified, the certificate presented by the SMTP server is not required to be verified.

### **3. The Require-TLS Header Field**

One new message header field, Require-TLS, is defined by this specification. It is used for messages requesting that recipient TLS policy (MTA-STS [[I-D.ietf-uta-mta-sts](#)] or DANE [[RFC7672](#)]) be ignored.

The Require-TLS header field has a single required parameter:

- o NO - The SMTP client SHOULD attempt to send the message regardless of its ability to negotiate STARTTLS with the SMTP server, ignoring policy-based mechanisms, if any, asserted by the recipient domain. Nevertheless, the client MAY negotiate STARTTLS with the server if available.

More than one instance of the Require-TLS header field MUST NOT appear in a given message.

## **4. REQUIRETLS Semantics**

### **4.1. REQUIRETLS Receipt Requirements**

Upon receipt of the REQUIRETLS option on a MAIL FROM command during the receipt of a message, an SMTP server MUST tag that message as needing REQUIRETLS handling with the option(s) specified in the REQUIRETLS parameter.

Upon receipt of a message not specifying the REQUIRETLS option on its MAIL FROM command but containing the Require-TLS header field in its message header, an SMTP server implementing this specification MUST tag that message with the option specified in the Require-TLS header field. If the REQUIRETLS MAIL FROM parameter is specified, the Require-TLS header field MUST be ignored but MAY be included in onward relay of the message.

The manner in which the above tagging takes place is implementation-dependent. If the message is being locally aliased and redistributed to multiple addresses, all instances of the message MUST be tagged in the same manner.





## **4.2. REQUIRETLS Sender Requirements**

### **4.2.1. Sending with TLS Required**

When sending a message tagged as requiring TLS, the sending (client) MTA MUST:

1. Look up the SMTP server to which the message is to be sent as described in [\[RFC5321\] Section 5.1](#). If the DNSSEC option is included in the message tag, the MX record lookups in this process MUST use DNSSEC verification and the response(s) MUST be DNSSEC-signed in order to ensure the integrity of the resource identifier [\[RFC6125\]](#) used to authenticate the SMTP server.
2. Open an SMTP session with the peer SMTP server using the EHLO verb. The server MUST advertise the REQUIRETLS capability.
3. Establish a TLS-protected SMTP session with its peer SMTP server and authenticate the server's certificate with the specified authentication method as specified in [\[RFC6125\]](#) or [\[RFC6698\]](#) as applicable.
4. The SMTP client SHOULD also require that meaningfully secure cipher algorithms and key lengths be negotiated with the server. The choices of key lengths and algorithms change over time, so a specific requirement is not presented here.

If any of the above steps fail, the client MUST issue a QUIT to the server and repeat steps 2-4 with each host on the recipient domain's list of MX hosts in an attempt to find a mail path that meets the sender's requirements. The client MAY send other, unprotected, messages to that server if it has any prior to issuing the QUIT. If there are no more MX hosts or if the MX record lookup is not DNSSEC-protected and DNSSEC verification is required, the client MUST NOT transmit the message to the domain.

Following such a failure, the SMTP client MUST send a non-delivery notification to the reverse-path of the failed message as described in [section 3.6 of \[RFC5321\]](#). The following status codes [\[RFC5248\]](#) SHOULD be used:

- o DNSSEC lookup failure: 5.x.x DNSSEC lookup required
- o REQUIRETLS not supported by server: 5.7.x REQUIRETLS needed
- o Unable to establish TLS-protected SMTP session: 5.7.10 Encryption needed

Fenton

Expires July 20, 2018

[Page 6]

Refer to [Section 5](#) for further requirements regarding non-delivery messages.

If all REQUIRETLS requirements have been met, transmit the message, issuing the REQUIRETLS option on the MAIL FROM command with the required option(s), if any.

#### **[4.2.2.](#) Sending with TLS Optional**

Messages tagged RequireTLS: NO are handled as follows. When sending such a message, the sending (client) MTA MUST:

- o Look up the SMTP server to which the message is to be sent as described in [\[RFC5321\] Section 5.1](#).
- o Open an SMTP session with the peer SMTP server using the EHLO verb. Attempt to negotiate STARTTLS if possible, and follow any policy published by the recipient domain, but do not fail if this is unsuccessful.

Some SMTP servers may be configured to require STARTTLS connections as a matter of policy and not accept messages in the absence of STARTTLS. This MUST be expected, and a non-delivery notification returned to the sender.

Since messages tagged with RequireTLS: NO will sometimes be sent to SMTP servers not supporting REQUIRETLS, that option will not be uniformly observed by all SMTP relay hops.

#### **[4.3.](#) REQUIRETLS Submission**

An MUA or other agent making the initial introduction of a message has authority to decide whether to require TLS, and if so, using what authentication method(s). When TLS is to be required, it MUST do so by negotiating STARTTLS and REQUIRETLS and include the REQUIRETLS option on the MAIL FROM command, as is done for message relay.

When TLS is not to be required, the sender MUST include the Require-TLS header field in the message. SMTP servers implementing this specification will interpret this header field as described in [Section 4.1](#).

In either case, the decision whether to specify REQUIRETLS, and with what option(s), MAY be done based on a user interface selection or based on a ruleset or other policy. The manner in which the decision to require TLS is made is implementation-dependent and is beyond the scope of this specification.

Fenton

Expires July 20, 2018

[Page 7]

#### **4.4. Delivery of REQUIRETLS messages**

Messages are usually retrieved by end users using protocols other than SMTP such as IMAP [[RFC3501](#)], POP [[RFC1939](#)], or web mail systems. Mail delivery agents supporting REQUIRETLS SHOULD observe the guidelines in [[I-D.ietf-uta-email-deep](#)].

#### **5. Non-delivery message handling**

Non-delivery ("bounce") messages usually contain important metadata about the message to which they refer, including the original message header. They therefore MUST be protected in the same manner as the original message. All non-delivery messages, whether resulting from a REQUIRETLS error or some other, MUST employ REQUIRETLS using the same authentication method(s) as the message that caused the error to occur.

The path from the origination of an error bounce message back to the MAIL FROM address may not share the same REQUIRETLS support as the forward path. Therefore, users requiring TLS are advised to make sure that they are capable of receiving mail using REQUIRETLS at the same authentication method(s) as messages they send. Otherwise, such non-delivery messages will be lost.

If unable to send a bounce message due to a REQUIRETLS failure (the return path not supporting the TLS requirements in the original message), the MTA sending the bounce message MAY send a redacted non-delivery message to the postmaster of the domain identified in the envelope-From address identifying the message only by Message-ID and indicating the type of failure. The original From, Return-path, To, Sender, Cc, and related header fields MUST NOT be included in this message.

Senders of messages requiring TLS are advised to consider the increased likelihood that bounce messages will be lost as a result of REQUIRETLS return path failure.

#### **6. Mailing list considerations**

Mailing lists, upon receipt of a message, originate new messages to list addresses, as distinct from an aliasing operation that redirects the original message, in some cases to multiple recipients. The requirement to preserve the REQUIRETLS tag and options therefore does not necessarily extend to mailing lists, although the inclusion of the Require-TLS header field MAY cause messages sent to mailing lists to inherit this characteristic. REQUIRETLS users SHOULD be made aware of this limitation so that they use caution when sending to



mailing lists and do not assume that REQUIRETLS applies to messages from the list operator to list members.

Mailing list operators MAY apply REQUIRETLS requirements in incoming messages to the resulting messages they originate. If this is done, they SHOULD also apply these requirements to administrative traffic, such as messages to moderators requesting approval of messages.

## **7. IANA Considerations**

If published as an RFC, this draft requests the addition of the keyword REQUIRETLS to the SMTP Service Extensions Registry [[MailParams](#)].

If published as an RFC, this draft also requests the creation of a registry, REQUIRETLS Security Requirements, to be initially populated with the CHAIN, DANE, DNSSEC, and NO keywords.

If published as an RFC, this draft requests the addition of an entry to the Simple Mail Transfer Protocol (SMTP) Enhanced Status Codes Registry [[SMTPStatusCodes](#)] in the 5.7.YYY range to indicate lack of REQUIRETLS support by an SMTP server to which a message is being routed.

If published as an RFC, this draft requests the addition of the header field name Require-TLS to the Permanent Message Header Field Names Registry [[PermMessageHeaderFields](#)].

This section is to be removed during conversion into an RFC by the RFC Editor.

## **8. Security Considerations**

The purpose of REQUIRETLS is to improve communications security for email by giving the originator of a message an expectation that it will be transmitted in an encrypted form "over the wire". When used, REQUIRETLS changes the traditional behavior of email transmission, which favors delivery over the ability to send email messages using transport-layer security, to one in which requested security takes precedence over delivery and domain-level policy.

The following considerations apply to the REQUIRETLS service extension but not the RequireTLS header field, since messages specifying the header field are less concerned with transport security.



Fenton

Expires July 20, 2018

[Page 9]

### **8.1. Passive attacks**

REQUIRETLS is generally effective against passive attackers who are merely trying to eavesdrop on an SMTP exchange between an SMTP client and server. This assumes, of course, the cryptographic integrity of the TLS connection being used.

### **8.2. Active attacks**

Active attacks against TLS encrypted SMTP connections can take many forms. One such attack is to interfere in the negotiation by changing the STARTTLS command to something illegal such as XXXXXXXX. This causes TLS negotiation to fail and messages to be sent in the clear, where they can be intercepted. REQUIRETLS detects the failure of STARTTLS and declines to send the message rather than send it insecurely.

A second form of attack is a man-in-the-middle attack where the attacker terminates the TLS connection rather than the intended SMTP server. This is possible when, as is commonly the case, the SMTP client either does not verify the server's certificate or establishes the connection even when the verification fails. The REQUIRETLS CHAIN and DANE options allow the message sender to specify that successful certificate validation, using either or both of two different methods, is required before sending the message.

Another active attack involves the spoofing of DNS MX records of the recipient domain. An attacker having this capability could cause the message to be redirected to a mail server under the attacker's own control, which would presumably have a valid certificate. The REQUIRETLS DNSSEC option allows the message sender to require that valid DNSSEC [[RFC4033](#)] signatures be obtained when locating the recipient's mail server, in order to address that attack.

In addition to support of the DNSSEC option, domains receiving email SHOULD deploy DNSSEC and SMTP clients SHOULD deploy DNSSEC verification.

### **8.3. Bad Actor MTAs**

A bad-actor MTA along the message transmission path could misrepresent its support of REQUIRETLS and/or actively strip REQUIRETLS tags from messages it handles. However, since intermediate MTAs are already trusted with the cleartext of messages they handle, and are not part of the threat model for transport-layer security, they are also not part of the threat model for REQUIRETLS.

Fenton

Expires July 20, 2018

[Page 10]

It should be reemphasized that since SMTP TLS is a transport-layer security protocol, messages sent using REQUIRETLS are not encrypted end-to-end and are visible to MTAs that are part of the message delivery path. Messages containing sensitive information that MTAs should not have access to MUST be sent using end-to-end content encryption such as OpenPGP [[RFC4880](#)] or S/MIME [[RFC5751](#)].

## **9. Acknowledgements**

The author would like to acknowledge many helpful suggestions on the ietf-smtp and uta mailing lists, in particular those of Viktor Dukhovni, Tony Finch, Jeremy Harris, Arvel Hathcock, John Klensin, John Levine, Rolf Sonneveld, and Per Thorsheim.

## **10. Revision History**

To be removed by RFC Editor upon publication as an RFC.

### **10.1. Changes since -00 Draft**

- o Created new header field, Require-TLS, for use by "NO" option.
- o Removed "NO" option from SMTP service extension.
- o Recommend DEEP requirements for delivery of messages requiring TLS.
- o Assorted copy edits

### **10.2. Changes since fenton-03 Draft**

- o Wording improvements from Rolf Sonneveld review 22 July 2017
- o A few copy edits
- o Conversion from individual to UTA WG draft

### **10.3. Changes Since -02 Draft**

- o Incorporation of "MAY TLS" functionality as REQUIRETLS=NO per suggestion on UTA WG mailing list.
- o Additional guidance on bounce messages

Fenton

Expires July 20, 2018

[Page 11]

#### **10.4. Changes Since -01 Draft**

- o Specified retries when multiple MX hosts exist for a given domain.
- o Clarified generation of non-delivery messages
- o Specified requirements for application of REQUIRETLS to mail forwarders and mailing lists.
- o Clarified DNSSEC requirements to include MX lookup only.
- o Corrected terminology regarding message retrieval vs. delivery.
- o Changed category to standards track.

#### **10.5. Changes Since -00 Draft**

- o Conversion of REQUIRETLS from an SMTP verb to a MAIL FROM parameter to better associate REQUIRETLS requirements with transmission of individual messages.
- o Addition of an option to require DNSSEC lookup of the remote mail server, since this affects the common name of the certificate that is presented.
- o Clarified the wording to more clearly state that TLS sessions must be established and not simply that STARTTLS is negotiated.
- o Introduced need for minimum encryption standards (key lengths and algorithms)
- o Substantially rewritten Security Considerations section

### **11. References**

#### **11.1. Normative References**

[I-D.ietf-uta-email-deep]

Moore, K. and C. Newman, "Cleartext Considered Obsolete: Use of TLS for Email Submission and Access", [draft-ietf-uta-email-deep-12](#) (work in progress), December 2017.

[MailParams]

Internet Assigned Numbers Authority (IANA), "IANA Mail Parameters", 2007,  
<<http://www.iana.org/assignments/mail-parameters>>.



[PermMessageHeaderFields]

Internet Assigned Numbers Authority (IANA), "Permanent Message Header Field Names Registry", 2004, <<https://www.iana.org/assignments/message-headers/message-headers.xhtml#perm-headers>>.

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC3207] Hoffman, P., "SMTP Service Extension for Secure SMTP over Transport Layer Security", [RFC 3207](#), DOI 10.17487/RFC3207, February 2002, <<https://www.rfc-editor.org/info/rfc3207>>.
- [RFC4035] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Protocol Modifications for the DNS Security Extensions", [RFC 4035](#), DOI 10.17487/RFC4035, March 2005, <<https://www.rfc-editor.org/info/rfc4035>>.
- [RFC5248] Hansen, T. and J. Klensin, "A Registry for SMTP Enhanced Mail System Status Codes", [BCP 138](#), [RFC 5248](#), DOI 10.17487/RFC5248, June 2008, <<https://www.rfc-editor.org/info/rfc5248>>.
- [RFC5321] Klensin, J., "Simple Mail Transfer Protocol", [RFC 5321](#), DOI 10.17487/RFC5321, October 2008, <<https://www.rfc-editor.org/info/rfc5321>>.
- [RFC6125] Saint-Andre, P. and J. Hodges, "Representation and Verification of Domain-Based Application Service Identity within Internet Public Key Infrastructure Using X.509 (PKIX) Certificates in the Context of Transport Layer Security (TLS)", [RFC 6125](#), DOI 10.17487/RFC6125, March 2011, <<https://www.rfc-editor.org/info/rfc6125>>.
- [RFC6698] Hoffman, P. and J. Schlyter, "The DNS-Based Authentication of Named Entities (DANE) Transport Layer Security (TLS) Protocol: TLSA", [RFC 6698](#), DOI 10.17487/RFC6698, August 2012, <<https://www.rfc-editor.org/info/rfc6698>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.



Fenton

Expires July 20, 2018

[Page 13]

**[SMTPStatusCodes]**

Internet Assigned Numbers Authority (IANA), "Simple Mail Transfer Protocol (SMTP) Enhanced Status Codes Registry", 2008, <<http://www.iana.org/assignments/smtp-enhanced-status-codes>>.

**11.2. Informative References****[I-D.ietf-uta-mta-sts]**

Margolis, D., Risher, M., Ramakrishnan, B., Brotman, A., and J. Jones, "SMTP MTA Strict Transport Security (MTA-STS)", [draft-ietf-uta-mta-sts-14](#) (work in progress), January 2018.

[RFC1939] Myers, J. and M. Rose, "Post Office Protocol - Version 3", STD 53, [RFC 1939](#), DOI 10.17487/RFC1939, May 1996, <<https://www.rfc-editor.org/info/rfc1939>>.

[RFC3501] Crispin, M., "INTERNET MESSAGE ACCESS PROTOCOL - VERSION 4rev1", [RFC 3501](#), DOI 10.17487/RFC3501, March 2003, <<https://www.rfc-editor.org/info/rfc3501>>.

[RFC4033] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "DNS Security Introduction and Requirements", [RFC 4033](#), DOI 10.17487/RFC4033, March 2005, <<https://www.rfc-editor.org/info/rfc4033>>.

[RFC4880] Callas, J., Donnerhacke, L., Finney, H., Shaw, D., and R. Thayer, "OpenPGP Message Format", [RFC 4880](#), DOI 10.17487/RFC4880, November 2007, <<https://www.rfc-editor.org/info/rfc4880>>.

[RFC5751] Ramsdell, B. and S. Turner, "Secure/Multipurpose Internet Mail Extensions (S/MIME) Version 3.2 Message Specification", [RFC 5751](#), DOI 10.17487/RFC5751, January 2010, <<https://www.rfc-editor.org/info/rfc5751>>.

[RFC7672] Dukhovni, V. and W. Hardaker, "SMTP Security via Opportunistic DNS-Based Authentication of Named Entities (DANE) Transport Layer Security (TLS)", [RFC 7672](#), DOI 10.17487/RFC7672, October 2015, <<https://www.rfc-editor.org/info/rfc7672>>.

Author's Address

Fenton

Expires July 20, 2018

[Page 14]

Jim Fenton  
Altmode Networks  
Los Altos, California 94024  
USA

Email: [fenton@bluepopcorn.net](mailto:fenton@bluepopcorn.net)