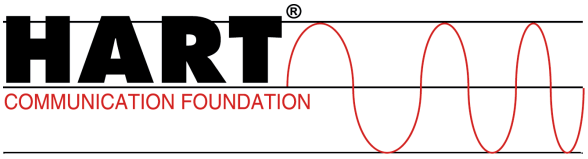
HART Protocol Specification

Field Communications



HART Field Communications Protocol Specification

HCF_SPEC-12, Revision 6.0

Release Date: 18 April, 2001

Release Date: 18 April, 2001

Document Distribution / Maintenance Control / Document Approval
To obtain information concerning document distribution control, maintenance control and document approval, please contact the HART Communication Foundation at the address shown below.

Trademark Information
HART® is a registered trademark of the HART Communication Foundation, Austin, Texas, USA. Any use of the term HART hereafter in this document, or in any document referenced by this document, implies the registered trademark. All other trademarks used in this or referenced documents are trademarks of their respective companies. For more information contact the HCF Staff at the address below.

Attention: Foundation Director
HART Communication Foundation
9390 Research Boulevard
Suite I-350
Austin, TX 78759, USA

Voice: (512) 794-0369
FAX: (512) 794-3904

http://www.hartcomm.org

Table of Contents

List of Tables

Preface

This preface is included for informational purposes only.

Revision 6.0 of the *HART Field Communications Protocol Specification* marks the transition from Revision 5 to Revision 6 of the HART Protocol. The HART Protocol Revision 6 supports the increasing functionality of HART communicating devices in the following ways:

Expansion of unit codes by classifying Device Variables according to function.

Modification of specification language for application to devices other than transmitters.

Addition of transducer trim commands to the *Common Practice Command Specification* in order to allow the linear trim of Device Variables.

Expansion of polling addresses for support of loop current at polling addresses other than 0.

Inclusion of delayed response mechanism to allow devices more time to perform calculations before responding to a request.

Responding to end-user request for longer tags by adding Universal Command support for 32-byte device tags.

Addition of Common Practice commands to write Device Variables, lock instrument panels, physically identify addressed devices, capture digital data from a device as input data for use in the calculations of another device, find devices and read Device Variable status.

Incorporation of Device Variable Classification codes for use in classifying devices according to related functions and assigning units codes to common Device Variables for each class.

Addition of Device Families to allow the commissioning and parameterization of Field Devices based on the process connection they support.

Completion of the block transfer mechanism introduced in HART Revision 5. This mechanism establishes the transfer of a data stream between a hosts and slave devices.

A detailed summary of the modifications made to Revision 5.9 of the *HART Field Communications Protocol Specification* in order to create Revision 6.0 are listed in Annex A.

Introduction

Designed to compliment traditional 4-20mA analog signaling, the HART Protocol supports two way digital communications for process measurement and control devices. Applications include remote process variable interrogation, cyclical access to process data, parameter setting and diagnostics. This document defines the specification documents that comprise the HART Field Communications Protocol. Specification of the HART protocol is based largely on the OSI 7-Layer Communication Model (see Figure 1).

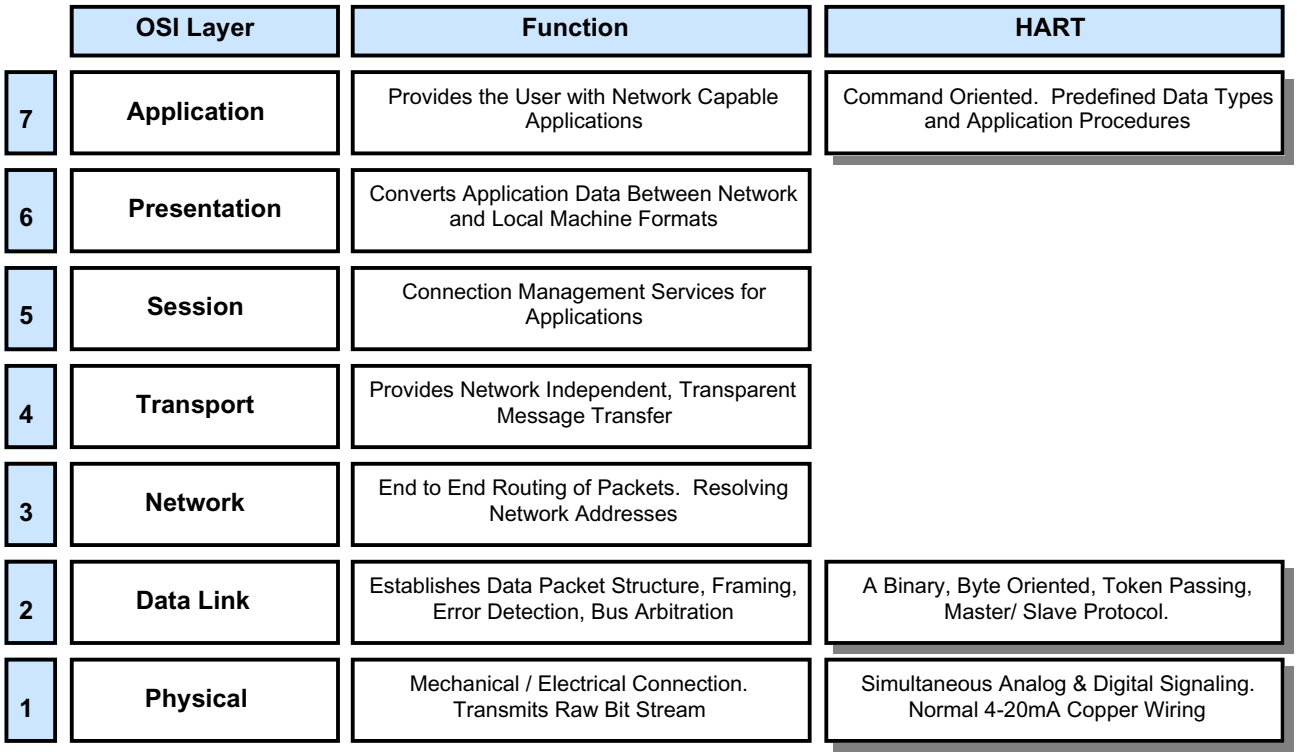


Figure 1. OSI 7-Layer Model

The HART protocol specifications directly address 3 layers in the OSI model: the Physical, Data Link and Application Layers. The Physical Layer connects devices together and communicates a bit-stream from one device to another. It is concerned with the mechanical and electrical properties of the connection and the medium (the copper wire cable) connecting the devices. Signal characteristics, like the FSK signal, are defined to achieve a raw uncorrected reliability (see the *FSK Physical Layer Specification*).

While the Physical Layer transmits the bit stream, the Data Link Layer is responsible for reliably transferring that data across the channel. It organizes the raw bit stream into packets (framing), adds error detection codes to the data stream and performs Media Access Control (MAC) to insure orderly access to the communication channel by both master and slave devices.

In HART, the bit stream is organized into 8-bit bytes which are further grouped into messages. A HART transaction consists of a master command and a slave response. Media access consists of token passing between the devices connected to the channel. The passing of the token is implied by the actual message transmitted. Timers are used to bound the period between transactions. Once the timer expires, control of the channel is relinquished by the owner of the token. For more information see the *Data Link Layer Specification*.

The Application Layer defines the commands, responses, data types and status reporting supported by the Protocol. In addition, there are certain conventions in HART (for example how to trim the loop current) that are also considered part of the Application Layer. While the Command Summary, Common Tables and Command Response Code Specifications all establish mandatory Application Layer practices (e.g. data types, common definitions of data items, and procedures), the Universal Commands specify the minimum Application Layer content of all HART compatible devices.

A number of the HART Specification Documents are used to define the Application Layer. The Command Summary Specification provides the foundation for the Application Layer. Other Application Layer Specifications are:

- Universal Command Specification *defining the minimum command set for all HART compatible devices;*
- Common Practice Command Specification *define a variety of commands useful to a broad range of devices;*
- Device Families Command Specification *standardizing configuration commands for different types of process connections (both measurements and control outputs);*
- Common Tables Specification *providing standard enumerations and looked up tables for commands; and*
- Command Response Code Specification *specifying error and warning codes used by a field device when replying to commands from masters.*

1. SCOPE

This document identifies the revision level of the HART Field Communications Protocol, phrases commonly used throughout the Protocol, and the documents that comprise the HART Protocol Specification. Any product claiming compliance with the HART Protocol must meet all specifications defined by this document and the indicated revision level of the specification documents included by reference. Referenced documents define the different elements of the protocol (i.e., Data Link Layer, Physical Layer, and Application Layer).

In addition, this document defines the mechanisms for identifying the HART Field Communications Protocol Specification, the revision level of the specification, and approval of changes to the specification.

1.1 Conformance Requirements

Any product claiming compliance with the HART Protocol must adhere to all specifications in a specific HART Protocol revision. New HART field device implementations should use the latest HART Protocol revision.

Devices claiming HART Protocol compliance must adhere to all HART Protocol specifications including the device type and device revision numbering. Device types and device revision numbers must be assigned as specified in the *Command Summary Specification* and *Data Link Layer Specification.*

Manufacturers' Device-Specific Documents (see Section 2.2) are not formally part of the HART Protocol Specifications. While these documents are developed and controlled by the respective device manufacturer, they must comply with the Device-Specific Command revision criteria found in the *Command Summary Specification*.

1.2 Terms and Conditions

Subject to the Terms and Conditions of this Agreement, the HART Communication Foundation (the "HCF") grants You (the "User") a non-exclusive, limited license to use the HART Field Communications Protocol specifications and related materials (collectively, the "HART Materials") furnished hereunder to make, use, sell or distribute products complying with the standards included in the HART Materials. The HCF holds and retains all worldwide rights, title and interests, including without limitation, copyright in and to all HART Materials.

1.2.1 Warranty and Liability Disclaimers

User expressly acknowledges and agrees that HCF is providing the HART Materials "AS IS" AND WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, WARRANTIES OF PERFORMANCE, MECHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.

User also expressly acknowledges and agrees that USER BEARS ALL RISKS FOR USE OF HART MATERIALS AND UNDER NO CIRCUMSTANCES, INCLUDING NEGLIGENCE, SHALL

HCF BE LIABLE FOR ANY COSTS, EXPENSES, LOSSES, OR DAMAGES, INCLUDING BUT NOT LIMITED TO, DIRECT, INDIRECT, CONSEQUENTIAL, INCIDENTAL, SPECIAL OR OTHER DAMAGES IN TORT, CONTRACT, PRODUCT LIABILITY OR UNDER ANY OTHER THEORY OF LAW RESULTING FROM ANY USE OF THE HART MATERIALS.

1.2.2 General Provisions

This Agreement is effective until terminated by either party and will terminate independently without notice if User fails to comply with any provision of the Agreement or any instructions provided by HCF regarding HART Materials. Upon termination for any reason, User must cease all use of HART Materials and return all HART Materials provided to User by HCF with all copies thereof.

This Agreement shall be governed and construed in accordance with the laws of United States and the State of Texas. If for any reason a court of competent jurisdiction finds any provision of this Agreement, or a portion thereof, to be unenforceable, that provision shall be enforced to the maximum extent permissible to effect the intent of the parties and all other provisions shall remain in full force and effect.

This Agreement constitutes the entire agreement between User and HCF with respect to all HART Materials provided to User by HCF and supersedes any prior understanding or agreement (oral or written) regarding HART Materials. HCF may modify this agreement at any time for any reason.

2. REFERENCES

2.1 The HART Field Communications Protocol Specifications

The HART Field Communications Protocol Specification is a set of documents that define the HART Field Communications Protocol. This version of the specification is defined by the documents identified in Table 1.

Table 1. HART Protocol Specification Revision 6.0 Documents

Document Title	Doc. Rev.	Doc. Number
HART Field Communications Protocol Specification	6.0	HCF_SPEC-12
FSK Physical Layer Specification	8.1	HCF_SPEC-54
C8PSK Physical Layer Specification	1.0	HCF_SPEC-60
Data Link Layer Specification	8.0	HCF_SPEC-81
Command Summary Specification	8.0	HCF_SPEC-99
Universal Command Specification	6.0	HCF_SPEC-127
Common Practice Command Specification	8.0	HCF_SPEC-151
Device Families Command Specification	1.0	HCF_SPEC-160
Common Tables Specification	13.0	HCF_SPEC-183
Block Data Transfer Specification	1.0	HCF_SPEC-190
Command Response Code Specification	5.0	HCF_SPEC-307

2.2 Related HART Documents

The Protocol Specifications frequently reference the manufacturers' device-specific document. Device-specific documents are developed and controlled by the respective manufacturer and should follow the requirements of the following HART Communication Foundation document:

Field Device Specification Guide. HCF_LIT-18

2.3 Related Communication Documents

ANSI X3.4-1983. *Code for Information Interchange (ASCII).*

ISO 7498-1984. *Open Systems Interconnection — Basic Reference Model*.

ISO 646. *Information Processing — ISO 7-bit coded character set for information interchange*.

ISO 8859-1-1987. *Information Processing —8-bit single-byte coded graphic character sets. Part 1 Latin alphabet No. 1*.

IEEE 754. *Standard for Binary Floating-Point Arithmetic*.

3. DEFINITIONS

Definitions of standard terms used throughout the Protocol Specifications are included here as a reference. All specification documents use these terms as defined below. However, individual Specification documents may define terms that are unique to that document as long as they do not conflict with the following definitions:

ACK — Message type 0x06. A Slave acknowledge to the Master's STX. See the *Data Link Layer Specification* for more information.

Actuator — A field device whose primary purpose is to vary its output thus affecting the connected process. An actuator typically uses the analog 4-20mA Loop Current as a setpoint.

Analog Channel — A continuously varying electrical signal connecting a field device to the remainder of the data acquisition or control system. Some field devices support multiple analog channels (input or output). Each Analog Channel transmits a single Dynamic Variable to or from the field device.

Application Layer — Topmost layer in the Open System Interconnect (OSI) model. In the HART Protocol, this layer includes: the definitions of data types; revision rules; application procedures; and the HART Commands.

ASCII	ASCII (American Standard Code for Information Interchange) is a character code defined by ANSI (the American National Standards Institute). It represents the U.S. alphabet (upper and lower case), numbers 0 to 9, and many punctuation characters as 7-bit binary codes. A number of codes are allocated for control functions such as start of text, end of text, carriage return, tab, and backspace. Many HART commands use a 6-bit subset of ASCII (see **Packed ASCII**). In most cases HART uses ASCII interchangeably with ISO Latin-1.
BACK	Message type 0x01. A Slave Burst message. See the *Data Link Layer Specification* for more information.
Bridge Device	A device that acts as a bridge between the HART network and another network. The other network could be another HART network.
Broadcast Address	A broadcast address is used by a master to send a command to all devices on the loop. However, only a single slave responds to the command. The slave must use other means (e.g. parameters in the data field) to determine if it responds to the command. The Broadcast Address is 38 bits of zeros in place of the Unique Identifier in the long frame address.
Burst Mode	A special mode of a slave device which repeatedly sends the response to a selected HART command without the need for a request from a master.
Burst Mode Device	A slave device that repeatedly issues the reply to a selected command. Once a slave is in this (optional) mode, the reply is sent without any further action by any master. A bursting slave is like a tertiary master because it also initiates channel activity.
Busy	The device is busy and cannot execute this command at this time. A device indicates Busy by returning Response Code 32 when allowed by the command specification. The requested command is not executed if a Busy response is returned.
Data Field	The sixth field in a HART message. The length of the Data field is indicated by the Byte Count field. The Data field contains the Application Layer content and is divided into sub-fields (See the *Command Summary Specification*).
Data Link Layer	Layer 2 in the OSI model. This layer is responsible for error-free communication of data. The Data Link Layer defines the message structure, error detection strategy, and bus arbitration rules.

Delayed Response	Allows the slave device to release the communication link (pass the token) while continuing to execute a command. If a slave is unable to respond to a command within the Slave Time-Out period, a Delayed Response (DR) sequence should be initiated. The DR begins with the slave notifying the master during Slave Time-Out that it is unable to complete the command but will continue the command's execution. Later, the master reissues exactly the same command request to complete the DR. This is quite different from returning a **Busy** response. See the *Command Summary Specification* for more information. Command specifications indicate if a delayed response is allowed for a particular command.
Delayed Response Mechanism	See **Delayed Response**. This mechanism allows a slave to defer the completion of a command, thus allowing more processing time than the Data Link Layer grants a slave. See the *Command Summary Specification* for more information. The command specifications will indicate if a delayed response is allowed for a particular command.
Device	A HART compatible Slave or Master.
Device ID	The integer returned in bytes 9-11 of Identity Commands (see the *Command Summary Specification*). This number is different for every device manufactured with a given Manufacturer ID and Device Type.
Device Reset	A hard reset of the device. This is equivalent to a cycling the power off and then back on to the device.
Device Revision	The integer returned in byte 5 of Identity Commands (see the *Command Summary Specification*). This defines the revision level of the command set supported by the field device including the device-specific commands. The *Command Summary Specification* defines when a new Device Type number must be allocated (as opposed to the Device Revision being incremented).

Device Type

The integer returned in byte 2 of Identity Commands (see the *Command Summary Specification*). This defines the command set supported by a device.

The *Command Summary Specification* defines when a new Device Type number must be allocated (as opposed to the Device Revision being incremented).

The *Data Link Layer Specification* defines the range of device type numbers that must be used for specific Manufacture IDs. In addition, manufacturers may document their Device Types in the *Common Tables Specification*.

Device Variable

A uniquely defined data item within a Field Device that is always associated with cyclical process information. A Device Variable's value varies in response to changes and variations in the process. All HART compatible field devices contain Device Variables. However, simple field devices may use only Dynamic Variables and not expose the underlying Device Variables at the Protocol Application Layer interface.

DR_CONFLICT

Delayed Response — Conflict

The requested command would cause a conflict with a currently executing delayed response command. See the *Command Summary Specification* for more information.

DR_DEAD

Delayed Response — Dead

This is only valid for intelligent I/O devices. The host is informed that the slave did not reply to the request. See the *Command Summary Specification* for more information.

DR_INITIATE

Delayed Response — Initiate.

The command could not be serviced in the time given by the Data Link Layer. A Delayed Response was initiated. See the *Command Summary Specification* for more information.

DR_RUNNING

Delayed Response — Running

The execution of the Delayed Response is not yet finished. The process is still running. See the *Command Summary Specification* for more information.

Dynamic Variable	The connection between the process and an analog channel. All HART field devices may contain Primary, Secondary, Tertiary, and Quaternary Variables that are mapped to the first 4 analog channels in a field device. These are collectively called the Dynamic Variables. The Primary Variable is always supported and is connected to the first 4-20mA channel, the same channel that always supports HART communication. The SV, TV, and QV may or may not be supported and, furthermore, may not have an associated Analog Channel.
Enumeration	A numerical list where each number corresponds to a specific function or text string. Basically, an enumeration is a look-up table (e.g., of engineering unit codes) with each row containing the number and corresponding function or text string.
Extended Command Number	A 16 bit command number transmitted in the HART Data field. Messages containing an Extended Command Number contain the number 31 in the normal HART Command field.
Field Device	Field Devices are connected to the Process and their Device Variables vary as process conditions change. From a Data Link Layer perspective, HART compatible Field Devices are either a **Slave** or **Burst Mode Device**.
Fixed Current Mode	In this mode the field device's Loop Current value is fixed to the value issued by the master. For transmitters, this causes the first analog output to be forced to a fixed value. For actuators, the input loop current value measured by the actuator is set to a fixed value.
Floating Point	Floating point represents a real number consisting of an exponent, and a mantissa. HART requires floating point numbers and calculations to conform to the IEEE 754 standard. The HART Protocol uses this representation for many data items including all Dynamic and Device Variables.
Generic Host **Generic Master**	A host meeting the requirements of, at least, Host Conformance Class 3 (see the *Command Summary Specification*)
HART Message	The fundamental content transmitted across a HART Physical Layer. The HART Message consists of the following fields: Delimiter, Address, Expansion, Command, Byte Count, Data, and Check Byte. The Expansion and Data fields are not found in all HART Messages. The *Data Link Layer Specification* explains the construction and framing of HART Messages.
Host	One of (possibly) several applications that can be executed sequentially or simultaneously on a **Master.**

IEEE 754	A standard established by the Institute of Electrical and Electronic Engineers governing floating point number formats and calculations. See **Floating Point.**
ISO Latin-1	A character code set defined by the International Standards Organization. It represents the U.S. and Western European alphabet (upper and lower case), numbers 0 to 9, and many punctuation characters as an 8-bit binary codes. A number of codes are allocated for control functions such as start of text, end of text, carriage return, tab, and backspace. ISO Latin-1 is an extension of ACSII using the eighth bit to add 127 special Western European characters.
Long Frame	A HART message with a 5 byte address field. All HART commands must support Long Frame messages. See **Short Frame**.
Long Tag	A 32 character ISO Latin-1 string used to identify the field device. See **Tag**.
Loop Current	The value measured by a milli-ammeter in series with the field device. The Loop Current is a near DC analog 4-20mA signal used to communicate a single value between the control system and the field device. (Note: Voltage Mode Field Devices use "Volts DC" as their engineering units where "Loop Current" values are used)
Major Revision	A major revision indicates a set of functional capabilities. If a functional change is made, then the major revision number must be incremented.
Manufacturer ID	The integer returned in byte 1 of Identity Commands. See the *Command Summary Specification* for details on Identity Commands. This integer is used to construct the Unique Identifier used in long frame addresses and, together with the Device Type and Device Revision, indicates a unique field device command set. New Manufacturer IDs are controlled and must be allocated by the HART Communication Foundation.
Master	A device that initiates communication activity on a HART network by issuing commands to a **Field Device**. HART supports a primary and a secondary master.
Minor Revision	A minor revision indicates changes made that have no impact on functionality (e.g., clarifications, spelling corrections, etc.).
Multi-drop	A digital communications mode where multiple devices may share the same pair of wires for power and communications.

Not-A-Number	A floating point number that cannot be interpreted. A single, specific non-signaling NaN (0x7F, 0xA0, 0x00, 0x00) is allowed in some Command Specifications to indicate that the field device does not support certain data values. See the *Command Summary Specification* for more information
Packed ASCII	A 6-bit alphanumeric character using a HART-specific subset of the ASCII character set. This allows four characters to be packed into three bytes. This subset includes the digits 0 to 9, uppercase letters A to Z, and common punctuation characters. Lowercase and accented letters are not included.
Parity	A mechanism used to detect data transmission errors. When a bit is added that will cause the number of ones in a bit-stream to be either odd or even. The HART Protocol requires odd parity on individual bytes transmitted.
Physical Layer	Layer 1 in the OSI model. The Physical Layer is responsible for transmission of the raw bit stream and defines the mechanical and electrical connections and signaling parameters for devices.
Polling Address	An integer used to identify the field device. The Polling Address is used to construct the Short Frame address. The Polling Address is set to 0 in point to point installations. All field devices in multi-drop installations are generally configured to a different Polling Address to allow automatic identification by a master.
Preamble	A synchronization pattern generated at the beginning of a HART message to allow the proper start-up of the receiver. For asynchronous Physical Layers like the FSK Physical Layer, the preamble consists of five or more 0xFF bytes.
Re-Range	Actions performed to change the relationship between the physical signal associated with an Analog Channel and the digital value it is communicating. For example, re-ranging affects the relationship between the Loop Current (or Percent Range) and the Primary Variable. See **Trim.**
Request Data Bytes	The sub-field returned in the Data field that contains the Application Layer message data being transmitted from the Master to the Slave.
Request Message	An **STX**. A message sent from a Master to a Slave

Response Data Bytes — The sub-field returned in the Data field that contains the Application Layer message data being transmitted from the Slave to the Master. The first byte in the HART Data Field that is not a Response Code, Communication Status, Device Status or Extended Command Number.

Response Message — An **ACK** or **BACK**. The message returned by a Slave after receiving a message from a Master.

Shed Time — The maximum amount of time after successfully receiving a good message after which communications is assumed lost. Some Field Devices use a Shed Time-Out (e.g. on Command 113) to detect loss of communication with a master and take appropriate actions.

Short Frame — A HART message with a 1 byte address field. Only Command 0 Short Frame messages maybe answered by a field device. See **Long Frame**.

Slave — A passive device that communicates only in response to a message from a master.

Slave Time-Out — This time out is the maximum amount of time within which a slave must begin a response. If a response cannot be generated within this time period, the transaction is considered to have failed by the master. See the *Data Link Layer Specification* for more information.

STX — Message type 0x02. The start of a transaction. See the *Data Link Layer Specification* for more information.

Sub-Device — A HART compatible device communicated to via a **Bridge Device**. See the *Command Summary Specification* for more information.

Tag — The Tag is a 8 character (6 byte) Packed ASCII string used to identify the field device. In most plants the Tag indicates the mounted location and function of the field device. The term originated when physical tags were attached to instruments for this purpose. See **Long Tag.**

Time Constant — A measure of the responsiveness to an input step change. The time constant difference between the start of the step change to when the response has reached 63% of the final steady-state value.

Transmitter — A field device whose primary purpose is to perform process measurements. Typically the transmitter communicates its Primary Variable via the analog 4-20mA Loop Current to the control system.

Trim	A two-point calibration of a Device Variable used to set zero and span. See **Re-Range.**
Unique Identifier	The concatenation of the Manufacturer ID, Device Type and Device ID used in constructing the long frame address (see the *Data Link Layer Specification*). These three data, when combined, uniquely identify a specific field device. No two devices ever manufactured may have the same combination of these three data.
Units Code	An integer that indicates the engineering units (e.g. millibars, meters per second, or degrees Celsius) for the associated data item. In HART, all floating point numbers have a specified or implied Units Code. See *Common Tables Specification* for the required Units Code Tables.
Valve	See **Actuator**

4. PROTOCOL REVISION RULES

This section defines the rules and procedures for revising the HART Protocol. Unless otherwise stated in an individual specification document, all revisions to protocol specification documents follow the rules stated in this section.

4.1 Specification Identification

Document and revision numbers combine to uniquely identify HART Protocol Specification documents.

4.1.1 Document Number

All specification documents are numbered. The format of specification document numbers is HCF_SPEC-x, where 'x' is a number that is unique to a specific document title. The document number remains the same throughout the life of a document, with one exception. The document number of the document titled '*HART Field Communications Protocol Specification'* will increment when any major revision indicator of the Protocol is incremented.

4.1.2 Revision Number

All specification documents have a major and minor revision number. The revision number has a format of 'y.z'. Where 'y' indicates a major revision number and 'z' a minor revision. The initial value for any major revision (i.e., new specification document) is 1. When any major revision occurs, the minor revision number is reset to 0.

As a specification is changed, the major and minor revision numbers are incremented as follows:

- The major revision number increments for functional changes that add or modify the capabilities included in a HART Protocol Specification document.
- The minor revision number increments for non-functional changes to a HART Protocol Specification document (e.g., clarification, spelling correction, etc.).

4.2 HART Field Communications Protocol Revision Level

The revision level of the *HART Field Communications Protocol Specification* indicates the revision level of the HART Field Communications Protocol.

4.2.1 Major Revisions

Incrementing the major revision number of this document indicates a substantive, functional change to the HART Protocol. The following rules identify major revisions to the HART Protocol:

- A major revision to the document titled *Universal Command Specification* always changes the major revision level of the HART Protocol and the *HART Field Communications Protocol Specification*.
- A major revision of any of the following specification documents may require a major revision of the HART Protocol and this document:

  Data Link Layer Specification

  FSK Physical Layer Specification

  C8PSK Physical Layer Specification

  Command Summary Specification

  Common Practice Command Specification

  Command Response Code Specification

  Common Tables Specification

  The HCF Board of Directors will review changes to any of the above documents and determine whether a major revision of the HART Protocol has occurred. If a change to the above documents is not considered a major protocol revision, the change will be determined a minor revision and the Protocol revision level will be changed accordingly.

- The addition of a new specification sub-document will be a major revision to the HART Protocol and the *HART Field Communications Protocol Specification*.

The major revision number of the documents titled *'HART Field Communications Protocol Specification'* and the *'Universal Command Specification'* must be identical.

4.2.2 Minor Revisions

Unless otherwise determined by the HCF Board of Directors, the following will be considered a minor revision of the HART Protocol:

- Any minor revision to any specification documents, or
- Any revision (major or minor) of the following documents

  Common Tables Specification

  Device Families Command Specification

  Block Transfer Specification

4.3 Modifications to Protocol Specifications

Proposals for modifications to any HART Specification may be submitted by any HCF member company, the HCF staff, or as the result of a defect report forwarded to the HCF. All proposals are forwarded to the HCF Executive Committee. The Executive Committee may reject the proposal, accept the proposal or forward the proposal to an HCF Technical Working Group. The Working Group may reject a proposal, modify the proposal or accept the proposal. A complete and accepted proposal is forwarded to the Executive Committee.

Once a proposal is accepted by the Executive Committee, it is balloted to the HCF voting members. Once balloting is complete the proposal is once again reviewed by the appropriate Working Group. All comments are reviewed and, if possible, incorporated into the proposal. Serious flaws indicated in the comments may result in the rejection of the proposal by the Working Group, even if a majority of member companies favor the proposal. The Working Group must make every effort to incorporate comments to maximize consensus for the proposal.

Once these steps are complete, the proposal is authorized for incorporation into the Protocol Specification documents as outlined in the proposal. The Working Group shall determine whether the changes to the Specification documents constitute a major or minor revision. The modified Specification documents shall be marked "Preliminary" until balloted and approved by the HCF voting members.

4.4 Approval

Any change to the HART Protocol Specification requires the approval of HCF voting members. All proposed changes will be balloted and approved in accordance with HCF by—laws. In addition, the HCF Board of Directors must ratify any changes to the HART Protocol Specification. Once ratified, "Preliminary" shall be removed from the specification documents and the resulting Protocol Revision released.

All approved Specification documents shall be signed by the Working Group Chairman, the Chairman of the Executive Committee, and the HCF Director. The signature sheets shall be kept on file at the HCF offices.

5. HART FIELD COMMUNICATIONS PROTOCOL REVISION MATRIX

Table 2 shows the documents, along with their revision level, that comprise each HART Field Communications Protocol revision. The HART Implementation Matrix provides the history of the HART Field Communications Protocol Specifications. This matrix allows any HART Field Communications Protocol Specification revision to be reconstructed.

Note: Prior to the release of HART Protocol Revision 5.5, new document numbers were incremented with each document revision. With the release of Revision 5.5, this practice is no longer used.

In an earlier revision system, some document revisions did not have a 'z' component of the 'y.z' revision number. If the 'z' component is not applicable to a particular document,the '-' characteris used in its place.

Table 2. HART Protocol Revision Number Cross Reference

HART Protocol Revision	FSK Physical Layer	C8PSK Physical Layer	Voltage Modulation Physical Layer	Physical and Data Link Layer	Data Link Layer	Command Summary	Universal Command	Common Practice Command	Device Families (See Note 2)	Common Tables	Block Transfer (See Note 2)	Command Response Code
2.1	NA	NA	NA	3.-	NA	3.1	3.-	3.1	NA	1.1	NA	(See Note 1)
2.2	NA	NA	NA	3.-	NA	3.1	3.1	3.2	NA	1.2	NA	(See Note 1)
3.1	NA	NA	NA	3.-	NA	4.1	3.-	4.1	NA	2.1	NA	1.-
3.2	NA	NA	NA	3.-	NA	4.1	3.1	4.1	NA	2.1	NA	1.1
4.1	NA	NA	NA	4.-	NA	5.1	4.1	5.1	NA	3.1	NA	2.1
4.2	NA	NA	NA	4.-	NA	.5.1	4.1	5.2	NA	3.1	NA	2.1
5.0	7.0	NA	NA	NA	7.0	6.0	5.0	6.0	NA	4.0	NA	3.0
5.1	7.1	NA	1.0	NA	7.0	7.0	5.1	7.0	NA	5.0	NA	4.0
5.2	7.2	NA	1.0	NA	7.0	7.0	5.1	7.0	NA	6.0	NA	4.0
5.3	7.2	NA	1.0	NA	7.0	7.0	5.1	7.0	NA	7.0	NA	4.0
5.4	7.2	NA	1.0	NA	7.0	7.0	5.1	7.0	NA	8.0	NA	4.0
5.5	7.2	NA	1.0	NA	7.1	7.0	5.1	7.0	NA	8.0	NA	4.0
5.6	8.0	NA	NA	NA	7.1	7.0	5.1	7.0	NA	9.0	NA	4.0
5.7	8.0	NA	NA	NA	7.1	7.1	5.2	7.1	NA	9.0	NA	4.1
5.8	8.0	NA	NA	NA	7.1	7.1	5.2	7.1	NA	10.0	NA	4.1
5.9	8.1	NA	NA	NA	7.1	7.1	5.2	7.1	NA	11.0	NA	4.1
5.10	8.1	NA	NA	NA	7.1	7.1	5.2	7.1	NA	12.0	NA	4.1
6.0	**8.1**	**1.0**	**NA**	**NA**	**8.0**	**8.0**	**6.0**	**8.0**	**1.0**	**13.0**	**1.0**	**5.0**

Notes:

1. Command Response Codes were included in the *Common Tables Specification* in HART Revision 2.1 and 2.2.
2. This Specification consists of a main specification and several of sub-specifications. For a complete listing of the sub-specifications and their revisions refer to the listed (i.e., Device Families or Block Transfer) specification.

NA Not Applicable..

6. HART FIELD COMMUNICATIONS PROTOCOL DOCUMENT LIST

In an earlier revision system, some document revisions did not have a 'z' component of the 'y.z' revision number. If the 'z' component is not applicable to a particular document, the '-' character is used in its place.

References with Rosemount Inc. Document Numbers (format DXXXXXXX) are included for historical purposes.

Table 3. HART Field Communications Protocol Specification

HART Field Communications Protocol Document Title	Doc Rev	Document Number	Rosemount Inc. Document Number
HART Field Communications Protocol Specification	6.0	HCF_SPEC-12	
HART-Smart Communications Protocol Specification	5.9	HCF_SPEC-11	
HART-Smart Communications Protocol Specification	5.8	HCF_SPEC-11	
HART-Smart Communications Protocol Specification	5.7	HCF_SPEC-11	
HART-Smart Communications Protocol Specification	5.6	HCF_SPEC-11	
HART-Smart Communications Protocol Specification	5.5	HCF_SPEC-11	
HART-Smart Communications Protocol Specification	5.4	HCF_SPEC-11	
HART-Smart Communications Protocol Specification	5.3	HCF_SPEC-10	
HART-Smart Communications Protocol Specification	5.2	HCF_SPEC-9	
HART-Smart Communications Protocol Specification	5.1	HCF_SPEC-8	
HART-Smart Communications Protocol Specification	5.0	HCF_SPEC-7	
HART-Smart Communications Protocol Specification	4.2	HCF_SPEC-6	D8900029 IR: 19 Jul 88, CR: 21 Oct 91, PD: 21 Oct 91, Rev B
HART-Smart Communications Protocol Specification	4.1	HCF_SPEC-5	D8900029 IR: 19 Jul 88, CR: 3 Nov 90, PD: 10 Apr 91, Rev A
HART-Smart Communications Protocol Specification	3.2	HCF_SPEC-4	D8900026 IR: 18 Jul 88, CR: 9 Jul 91, PD: 9 Jul 91, Rev B
HART-Smart Communications Protocol Specification	3.1	HCF_SPEC-3	D8900026 IR: 18 Jul 88, CR: 13 Mar 90, PD: 8 Apr 91, Rev A
HART-Smart Communications Protocol Specification	2.2	HCF_SPEC-2	D8700046 IR: 23 Dec 87, CR: 13 May 91, PD: 13 May 91, Rev B
HART-Smart Communications Protocol Specification	2.1	HCF_SPEC-1	D8700046 IR: 23 Dec 87, CR: 13 Mar 90, PD: 22 Mar 91, Rev A

Table 4. FSK Physical Layer Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
FSK Physical Layer Specification	8.1	HCF_SPEC-54	
FSK Physical Layer Specification	8.0	HCF_SPEC-54	
FSK Physical Layer Specification	7.2	HCF_SPEC-53	[1]
Physical[2] Layer Specification	7.1	HCF_SPEC-52	D8900097 IR: 29 Dec 89, CR: 20 Jun 90, PD: 25 Jun 90, Rev B
Physical[3] Layer Specification	7.0	HCF_SPEC-51	D8900097 IR: 29 Dec 89, CR: 29 Dec 89, PD: 29 Dec 89, Rev A

Table 5. Physical and Data Link Layer Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Physical[4] and Data Link Layer Specification	6.-	HCF_SPEC-44	D8900033 IR: 28 Jun 89, CR: 28 Jun 89, PD: 30 Jun 89, Rev A
Physical[5] and Data Link Layer Specification	5.-	HCF_SPEC-43	D8900032 IR: 30 Jun 88, CR: 30 Jun 88, PD: 30 Jun 88, Rev A
Physical[6] and Data Link Layer Specification	4.-	HCF_SPEC-42	D8900031 IR: 20 Mar 88, PD: 28 Mar 88, Rev A
Physical[7] and Data Link Layer Specification	3.-	HCF_SPEC-41	D8600076 IR: 14 Sep 87, CR: 23 Dec 87, PD: 23 Dec 87, Rev A

Table 6. Voltage Modulation Physical Layer Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Voltage[8] Modulation Physical Layer Specification	1.0	HCF_SPEC-71	D9000062, IR: 5 Nov 90, CR: 5 Nov 90, PD: 5 Nov 90, Rev A.

Table 7. C8PSK Physical Layer Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
C8PSK Physical Layer Specification	1.0	HCF_SPEC-60	

[1] Was HUG-3, Revision A

[2] FSK Physical Layer

[3] FSK Physical Layer

[4] FSK Physical Layer

[5] FSK Physical Layer

[6] FSK Physical Layer

[7] FSK Physical Layer

[8] Superseded by HCF_SPEC-54, Revision 8.0

Table 8. Data Link Layer Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Data Link Layer Specification	8.0	HCF_SPEC-81	
Data Link Layer Specification	7.1	HCF_SPEC-81	
Data Link Layer Specification	7.0	HCF_SPEC-81	

Table 9. Command Summary Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Command Summary Information	8.0	HCF_SPEC-99	
Command Summary Information	7.1	HCF_SPEC-99	
Command Summary Information	7.0	HCF_SPEC-99	
Command Summary Information	6.0	HCF_SPEC-98	
Command Summary Information	6.-	HCF_SPEC-97	D8900036, IR: 30 Jun 89, CR: 30 Jun 89, PD: 5 Jul 89, Rev NA
Command Summary Information	5.1	HCF_SPEC-96	D8900035, IR: 19 Jul 88, CR: 3 Nov 90, PD: 5 Mar 91, Rev B
Command Summary Information	5.-	HCF_SPEC-95	D8900035, IR: 19 Jul 88, CR: NA, PD: 28 Jun 88, Rev A
Command Summary Information	4.1	HCF_SPEC-94	D8900034, IR: 23 Mar 88, CR: 13 Mar 90, PD: 4 Mar 91, Rev B
Command Summary Information	4.-	HCF_SPEC-93	D8900034, IR: 23 Mar 88, CR: 23 Mar 88, PD: 14 Apr 88, Rev A
Command Summary Information	3.1	HCF_SPEC-92	D8700027, IR: 30 Apr 87, CR: 13 Mar 90, PD: 26 Feb 91, Rev B
Command Summary Information	3.-	HCF_SPEC-91	D8700027, IR: 30 Apr 87, CR: 9 Dec 87, PD: 22 Dec 90, Rev A

Table 10. Universal Command Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Universal Command Specification	6.0	HCF_SPEC-127	
Universal Command Specification	5.2	HCF_SPEC-127	
Universal Command Specification	5.1	HCF_SPEC-127	D8900038 IR: 8 Feb 90, CR: 18 Oct 90, PD: 19 Apr 91, Rev C
Universal Command Specification	5.0	HCF_SPEC-126	D8900038 IR: 8 Feb 90, CR: 8 Feb 90, PD: 12 Feb 90, Rev A
Universal Command Specification	5.-	HCF_SPEC-125	D8700028 IR: 30 Jun 89, CR: 30 Jun 89, PD: 5 Jul 89, Rev C
Universal Command Specification	4.1	HCF_SPEC-124	D8900037 IR: 10 Jun 90, CR: 3 Nov 90, PD: 3 Nov 90, Rev B
Universal Command Specification	4.-	HCF_SPEC-123	D8900037 IR: 10 Jun 88, CR: 10 Jun 88, PD: 10 Jun 88, Rev A
Universal Command Specification	3.1	HCF_SPEC-122	D8700028 IR: 9 Dec 87, CR: 13 May 87, PD: 13 May 91, Rev B
Universal Command Specification	3.-	HCF_SPEC-121	D8700028 IR: 30 Apr 87, CR: 9 Dec 87, PD: 9 Dec 87, Rev NA

Table 11. Common Practice Command Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Common Practice Command Specification	8.0	HCF_SPEC-151	
Common Practice Command Specification	7.1	HCF_SPEC-151	
Common Practice Command Specification	7.0	HCF_SPEC-151	D8900050 IR: 11 Oct 90, CR: 11 Oct 90, PD: 21 Nov 90, Rev A
Common Practice Command Specification	6.0	HCF_SPEC-150	D8900041 IR: 8 Feb 90, CR: 8 Feb 90, PD: 15 Feb 90, Rev A
Common Practice Command Specification	6.-	HCF_SPEC-149	D8900041 IR: 30 Jun 89, CR: 30 Jun 89, PD: 5 Jul 89, Rev NA
Common Practice Command Specification	5.2	HCF_SPEC-148	D8900040 IR: 19 Jul 88, CR: 21 Oct 91, PD: 21 Oct 91, Rev C
Common Practice Command Specification	5.1	HCF_SPEC-147	D8900040 IR: 19 Jul 88, CR: 3 Nov 90, PD: 23 Feb 91, Rev B
Common Practice Command Specification	5.-	HCF_SPEC-146	D8900040 IR: 10 Jun 88, CR: 10 Jun 88, PD: 28 Jun 88, Rev NA
Common Practice Command Specification	4.1	HCF_SPEC-145	D8900039 IR: 18 Jul 88, CR: 13 Mar 90, PD: 28 Mar 91, Rev B
Common Practice Command Specification	4.-	HCF_SPEC-144	D8900039 IR: 7 Jan 88, CR: 18 Jul 88, PD: 18 Jul 88, Rev A
Common Practice Command Specification	3.2	HCF_SPEC-143	D8700029 IR: 30 Apr 87, CR: 13 May 91, PD: 13 May 91, Rev B
Common Practice Command Specification	3.1	HCF_SPEC-142	D8700029 IR: 30 Apr 87, CR: 13 Mar 90, PD: 23 Feb 91, Rev A
Common Practice Command Specification	3.-	HCF_SPEC-141	D8700029 IR: 30 Apr 87, CR: 30 Apr 87, PD: 22 Dec 87, Rev A

Table 12. Device Families Command Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	
Device Families Command Specification	1.0	HCF_SPEC-160	

Table 13. Common Tables Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Common Tables	13.0	HCF_SPEC-183	
Common Tables	12.0	HCF_SPEC-183	
Common Tables	11.0	HCF_SPEC-183	
Common Tables	10.0	HCF_SPEC-183	
Common Tables	9.1	HCF_SPEC-183	
Common Tables	8.0	HCF_SPEC-183	
Common Tables	7.0	HCF_SPEC-182	
Common Tables	6.0	HCF_SPEC-181	1
Common Tables	5.0	HCF_SPEC-180	D9000051 IR: 18 Oct 90, CR: 18 Oct 90, PD: 21 Nov 90, Rev A
Common Tables	4.0	HCF_SPEC-179	D8900044 IR: 9 Feb 90, CR: 9 Feb 90, PD: 15 Feb 90, Rev A
Common Tables	4.-	HCF_SPEC-178	D8900044 IR: 30 Jun 89, CR: 30 Jun 88, PD: 5 Jul 89, Rev NA
Common Tables	3.1	HCF_SPEC-177	D8900043 IR: 10 Jun 88, CR: 3 Nov 90, PD: 28 Feb 91, Rev B
Common Tables	3.-	HCF_SPEC-176	D8900043 IR: 10 Jun 88, CR: 10 Jun 88, PD: 28 Jun 88, Rev A
Common Tables	2.1	HCF_SPEC-175	D8900042 IR: 23 Mar 88, CR: 13 Mar 90, PD: 27 Feb 91, Rev B
Common Tables	2.-	HCF_SPEC-174	D8900042 IR: 7 Jan 88, CR: 23 Mar 87, PD: 14 Apr 88, Rev A
Common Tables	1.2	HCF_SPEC-173	D8700051 IR: 30 Apr 87, CR: 13 May 91, PD: 27 Feb 91, Rev C
Common Tables	1.1	HCF_SPEC-172	D8700051 IR: 30 Apr 87, CR: 13 Mar 90, PD: 27 Feb 91, Rev B
Common Tables	1.-	HCF_SPEC-171	D8700051 IR: 3 Apr 87, CR: 9 Dec 87, PD: 22 Dec 87, Rev NA

Table 14. Block Transfer Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	
Block Transfer Specification	1.0	HCF_SPEC-190	

[1] Was HUG-2 Revision; A

Table 15. Command Response Code Specification

HART Field Communications Protocol Document Title	Doc Rev	Doc Number	Rosemount Inc. Doc Number
Command Response Code Specification	5.0	HCF_SPEC-307	
Appendix 1. Command Specific Response Code Definitions	4.1	HCF_SPEC-307	
Appendix 1. Command Specific Response Code Definitions	4.0	HCF_SPEC-307	D9000052, IR: 18 Oct 90, CR: 4 Jan 91, PD: 15 Jan 91
Appendix 1. Command Specific Response Code Definitions	3.0	HCF_SPEC-306	D8900046, IR: 11 Feb 90, CR: 11 Feb 90, PD: 15 Feb 90, Rev A
Appendix 1. Command Specific Response Code Definitions	3.-	HCF_SPEC-305	D8900046, IR: 30 Jun 89, CR: 30 Jun 90, PD: 5 Jul 89, Rev NA
Appendix 1. Command Specific Response Code Definitions	2.1	HCF_SPEC-304	D8900045 IR: 10 Jun 88, CR: 3 Nov 90, PD: 4 Apr 91, Rev B
Appendix 1. Command Specific Response Code Definitions	2.-	HCF_SPEC-303	D8900045 IR: 10 Jun 88, CR: 4 May 88, PD: 28 Jun 88, Rev A
Appendix 1. Command Specific Response Code Definitions	1.1	HCF_SPEC-302	D8900027 IR: 23 Mar 88, CR: 9 Jul 91, PD: 9 Jul 91, Rev B
Appendix 1. Command Specific Response Code Definitions	1.-	HCF_SPEC-301	D8900027 IR: 10 Mar 88, CR: 23 Mar 88, PD: 15 Apr 88, Rev A

ANNEX A. REVISION HISTORY

A1.Changes from Revision 5.10 to 6.0

he document titled: *HART Field Communications Protocol Specification*, HCF_SPEC-11, Document Revision: 5.9, was updated with the release of HCF_SPEC-12, Document Revision 6.0, to reflect the following changes:

These new sections were added as part of the format revisions for all HART Protocol Specification documents: Scope, References, Definitions, Symbols/Abbreviations.

The Scope section was added.

New specifications were incorporated including: the (optional) *C8PSK Physical Layer*, *Device Families*; and *Block Transfer*.

Section 1.2, Terms and Conditions, was updated and clarified

Common definitions used throughout the HART Protocol Specifications are now defined in Section 3, Definitions.

Section 4, Protocol Revision Rules, was revised to reflect actual HCF practices and harmonized with HCF by-law requirements.

A2. Changes from Version 5.9 to Version 5.10

The last revision to the document titled: HART-SMART Communications Protocol Specification HCF_SPEC-11, was Document Revision 5.9. This document has been updated with Revision 5.10 to reflect changes to the documents that define the protocol. These documents include:

The document titled Common Tables , HCF_SPEC-183, Document Revision: 11.0 was modified and a new revision, 12.0, created. Consequently, modifications were made to Table˚1, Table 2 and Table 11 to include document revision 12.0 of Common Tables .

A3.Changes from Revision 5.8 to 5.9

The last revision to the document titled *HART Field Communications Protocol Specification*, was HCF_SPEC-11, Document Revision: 5.8. This document was updated with Revision 5.9 to reflect the following changes:

The document titled Common Tables Specification has been updated from Revision 10.1 to Revision 11.1 to reflect the assignment of additional manufacturer codes and units codes. For details of specific changes refer to the change summary within the revised document.

The document titled FSK Physical Layer Specification has been updated from Revision 8.0 to Revision 8.1. For details of specific changes refer to the change summary within the revised document.

A4.Changes from Revision 5.7 to 5.8

The last revision to the document titled *HART Field Communications Protocol Specification*, was HCF_SPEC-11, Document Revision: 5.7. This document was updated with Revision 5.8 to reflect the following changes:

The document titled Common Tables Specification has been updated from Revision 9.0 to Revision 10.1 to reflect the assignment of additional manufacturer codes and units codes. For details of specific changes, refer to the change summary within the revised document.

Paragraph 2 was modified to include the HART Protocol and Specification revision criteria.

In paragraph 3 the document abbreviations for Rosemount documents were deleted as no longer necessary. The Rosemount document numbers are provided in the listing for historical cross-reference only.

Formatting changes were made to the Table 1 - HART Protocol Specifications to delete the column titled 'Document Version' which is not used in the current document numbering system. For reference, no document version other than A was ever published.

Formatting changes were made to the Table 2 - HART Revision Implementation Matrix to delete unused columns indicating Appendix 2 and Appendix 3 which are not used.

Formatting changes were made to the Tables 3 through 12 - to delete the column titled 'Document Version' which is not used in the current document numbering system. For reference, no document version other than A was ever published.

A5.Changes from Revision 5.6 to 5.7

This document was updated with Revision 5.7 to reflect changes to the documents which define the protocol.

Certain documents required reformatting as a result of translating them from ASCII text or Multimate file formats to Microsoft Word. The revisions have been made to mark this translation only and in no way did this process change document content. These documents include:

The document titled: 'Command Summary Specification', Document Revision: 7.0, HCF_SPEC-99, was modified and a new revision created. The file required translation from ASCII text file format to Microsoft Word.

The document titled: 'Universal Command Specification', Document Revision: 5.2, HCF_SPEC-127, was modified and a new revision created. The file required translation from Multimate file format to Microsoft Word.

The document titled: 'Common Practice Command Specification', Document Revision: 7.0, HCF_SPEC-151, was modified and a new revision created. The file required translation from ASCII text file format to Microsoft Word.

The document titled: 'Command Specific Response Code Definitions', Document Revision: 4.0, HCF_SPEC-307, was modified and a new revision created. The file required translation from ASCII text file format to Microsoft Word.