



A9000P

Communication Protocol

Nº Document: A9000P_105

Version	Date	Author	Changes
1.00	6/2018	Victor Barbero	creation
1.01	01/2019	Victor Barbero	Mistake fixed on the order record definition and examples. There was a wrong “^” before the sample id in all order records.
1.02	01/2019	Victor Barbero	Size of data segment changed from 200 to 240 characters. In section 4.3.2, we have changed the action code field in the Order record. Before it was a ‘Q’ but it must be empty for patient samples. In section 4.4.1, we have changed the report type field in the Order record. Before it was a ‘Q’ but it must be an ‘F’ when we send final results
1.03	01/2019	Victor Barbero	In section 4.1, we have updated the record examples so they fit the description. Before they had 200 characters and now they have 240. In section 4.3.1 – Query Record, we have added the max size for the tube_id field(64 characters). In section 4.3.2 – Order Record, we have deleted the report type case ‘I’(instrument pending) because we don’t have any situation in which we need to use this value. In section 4.4.1 – Patient Record, we have added the max size for the patient_id field(32 characters). In section 4.4.1 – Order Record, we have deleted report type case ‘Q’ because it doesn’t apply to a result message. In section 4.4.1 – Result Record, we have deleted result status cases ‘P’, ‘C’ and ‘R’ because because they are not supported. In section 4.4.2, we have changed separator between comment code and comment text from ‘ ’ to ‘^’. In section 4.4.2, we have located the comments in the example after the correct result record. In section 5.5.1 – Order Record, we have deleted report type case ‘Q’, because it doesn’t apply to that situation.
1.04	02/2019	Victor Barbero	In section 4.1, we have updated the example and deleted a repeated comment record. We changed the order of comment records so they are now related with Result HG.
1.05	06/2019	Victor Barbero	Added example for the case when there are no pending tests

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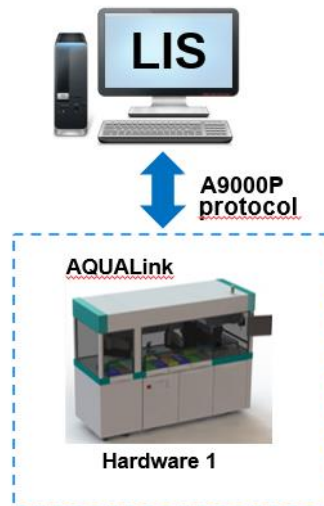
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1. AQUA System installations

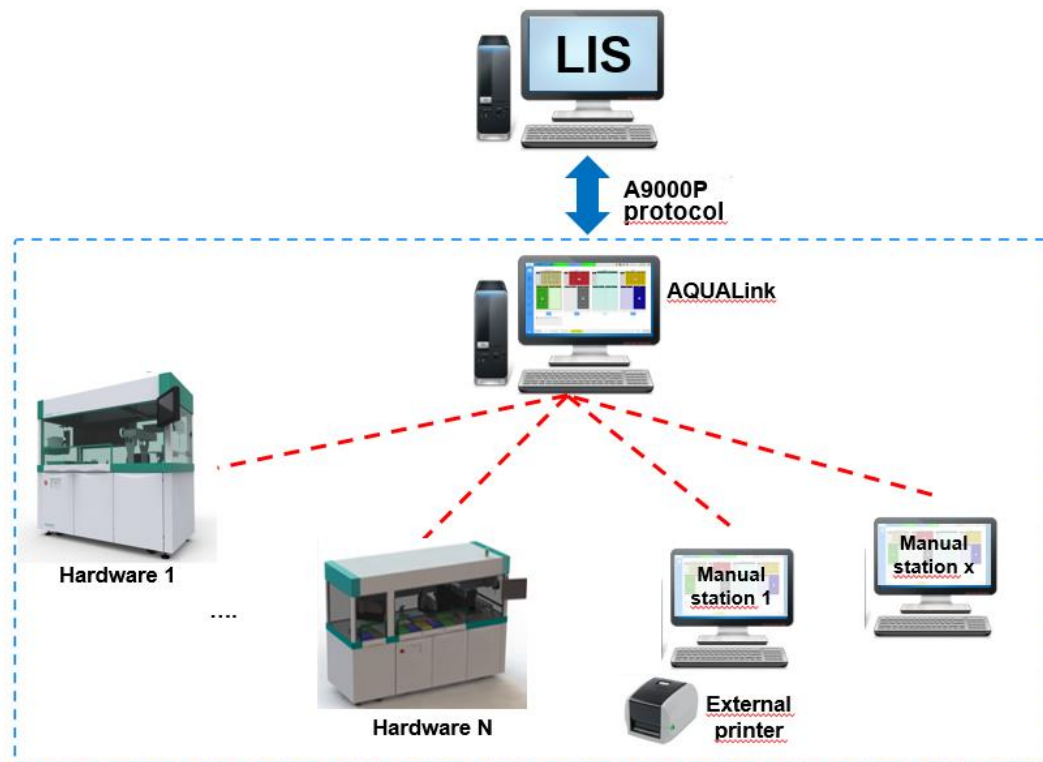
AQUA Systems can be installed and configured depending the needs of every laboratory. It can vary from a single AQUA installation, where only one AQUA Hardware machine deals with the samples arriving at the lab, up to a Multiple AQUA Systems installation, where there is an internal network managed by AQUALink.

In all scenarios, the interface with the LIS is centralized in one single AQUALink computer.

1.1. Single AQUA system installations



1.2. Multiple AQUA system installations



2. Communication configuration

AQUALink is the software that manages the information and communications between AQUA systems (1 or more) and the Laboratory Information System (LIS).

This document describes the communication protocol between AQUALink and the LIS.

- **AQUALink is the server and is listening for TCP connections at a given port.**
- **The LIS is the TCP client.**

The communications protocol used by the system is an open, non-proprietary communication standard developed by the American Society for Testing Materials (**ASTM**).

The system and the LIS are connected via Ethernet TCP/IP.

In the ASTM communication protocol, an application message consists of an ASTM header record, followed by any number of other ASTM records, such as patient and order records, and ends with an ASTM termination record.

2.1. IP Addresses and Port

In a specific AQUA System installation, AQUALink computer has to be given an IP reachable from the LIS computer.

AQUALink will be listening for requests at a specific communications port.

2.2. AQUALink Mode

AQUALink communication can be configured as:

- Bulk Order Upload only (**Mode = 1 (Upload)**)
 - LIS is in charge of sending requests with all sample ID
 - AQUALink checks the information previously received from the LIS every time it picks a tube from the input racks
- Bulk Order Upload with Query (**Mode = 2 (Upload-Query)**)
 - LIS is in charge of sending requests with all sample ID
 - AQUALink checks the information previously received from the LIS every time it picks a tube from the input racks.
 - If no information is found, AQUALink sends a query message for every sample ID picked at input racks to the LIS or if an operator manually requires it.
- Query (**Mode = 3 (Query)**)
 - AQUALink sends a query message for every sample ID picked at input racks to the LIS or if an operator manually requires it.

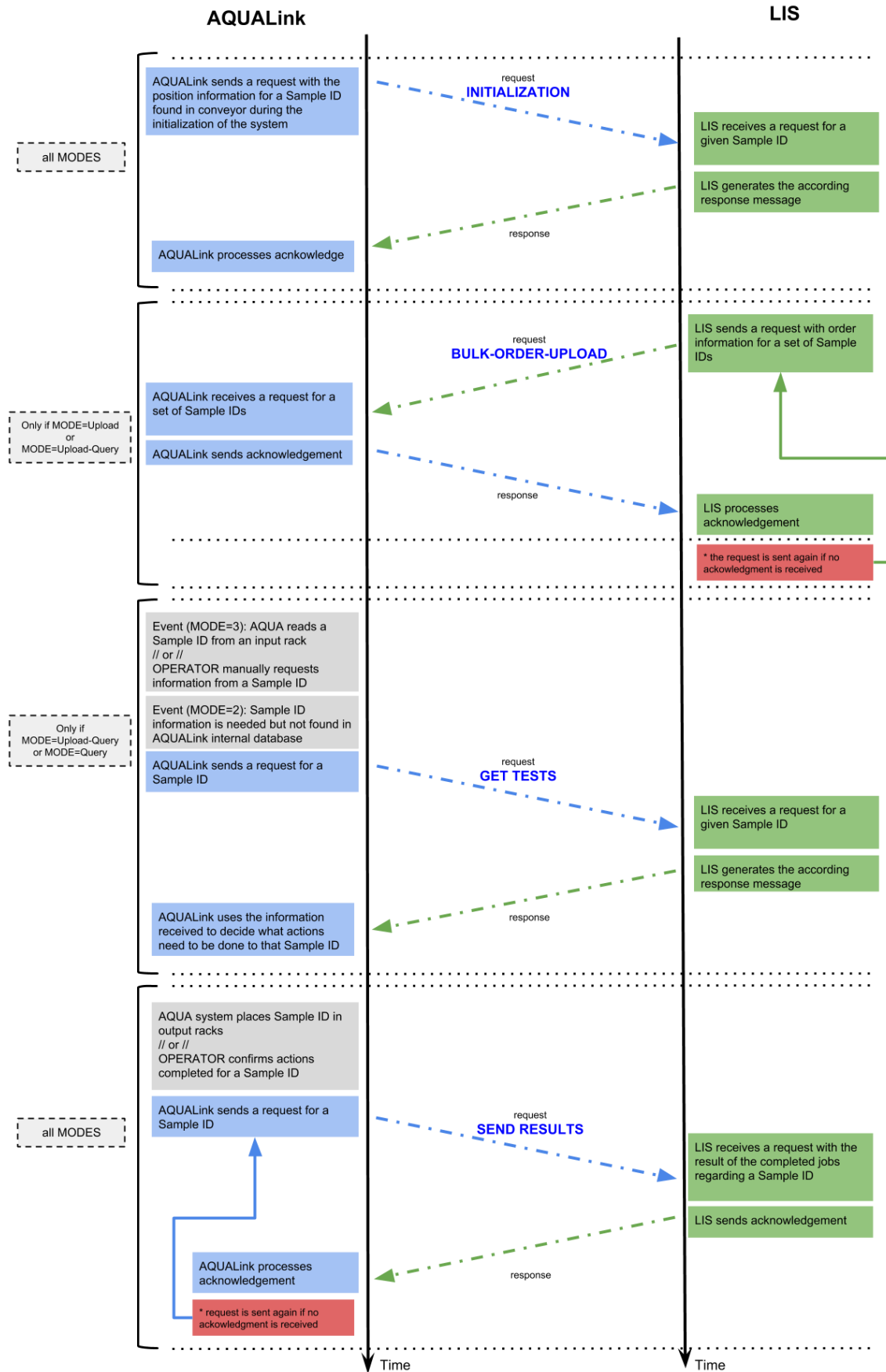
2.3. SEND RESULTS mode

This parameter configures the SEND RESULTS message so that:

- **Mode Tests:** the results of the actions performed by the AQUA System are sent as the result of new tests (not present in the Order record answered to the Query)
- **Mode Comments:** the results of the actions performed by the AQUA System are sent as a Comment Record of the Results record.

3. Communication flow

The communication flow between AQUALink and the LIS follows this diagram:



3.1. Retries to send information

When AQUALink fails to receive the confirmation of a message sent with information the message is stored as pending and retried every 5 minutes during the next 24h.

4. AQUALink requests to LIS

When AQUALink sends a request to the LIS, the timeout to receive a response is 30s. If the response time exceeds 3s, the communication will affect the system's performance.

There are three types of payloads:

- Initialization
- Get Tests
- Send Results

4.1. Record Structure

ASTM protocol uses 8-bit characters with values 7, 9, 11, 12, and 13 and values in the range of 32–126, which are defined by the ASCII standard (ANSI X3.4-1986). The system permits the transfer of values in the range of 129–254, but transfers them to their corresponding 7-bit values. The ASCII value 13 (carriage return) is reserved as a record terminator. The record structure does not allow unused values in ASTM records, but transmits the unused values through the use of escape sequences supported by ASTM.

ASTM records are composed of fields separated by field delimiters; the character | is the default field delimiter. Each field is identified by its position in the record, which is determined by the number of field delimiters that precede a field.

Fields are repeated if they are separated by repeat delimiters; the character \ is the default repeat delimiter. If there are no characters between two field delimiters, the field is empty (null). A null field is an indication that a corresponding field in the database of the system receiving the record should remain unchanged or that the field is unused.

A field that contains two double quotes (") indicates that the system receiving the record should delete the corresponding field in the database (database field is emptied). Any fields after the last field containing data can be left out of the record, that is, the system truncates unused fields from the record. The system assumes any field not present in the record to be null. An ASCII carriage return(<CR>) is used to indicate the end of the record.

Fields are separated into components, separated by component delimiters; the character ^ is the default component delimiter. Individual field components are not repeated. Only the entire field is repeated. Component delimiters are only required up to the last non-empty component.

The system truncates unused components from the field. Empty or absent components are null and indicate that a corresponding component or field in the database of the receiving system should not change or that the component is unused. A pair of double quotes in a component does not delete the component. Double quote pairs mean deletion only at the field level.

Based on the type of message being generated, the outgoing application layer software constructs a single ASTM application message and passes it to the ASTM data link layer software. These messages generally consist of multiple ASTM application records.

This message contains a sequence number and a checksum. It must contain message text.

ASTM protocol defines it as beginning with the character <STX>, followed by a one-character frame sequence number.

The data segment is next, with 1–240 ASCII characters, no restricted characters allowed.

After the data segment is the character <ETB>, if it's an intermediate message, or <ETX>, if it's the final message.

This is followed by a two-character frame checksum, and next is the carriage return character <CR>.

The frame ends with the line feed character <LF>.

Example:

```
<STX>1H|^&||A9000P||||LIS||P|1<CR>P|1|2233667744B||Smith^John^Levin||19721005|M||||Dr.Sanz|||||||
||||ER1<CR>O|1|^312011223344^OutputRack1^C6||^TGTG^HCG^MP1234|S|||||||||||||||||F<CR>R|1|^T
G^M^|OK||||F|||20180720120643<CR>R|2|^<ETB>CB<CR><LF>
```

If the data segment's size is bigger than 240 characters, it will be split, as it can be seen in the next example:

```
<STX>1H|^&||A9000P||||LIS||P|1<CR>P|1|2233667744B||Smith^John^Levin||19721005|M||||Dr.Sanz|||||||
||||ER1<CR>O|1|^312011223344^OutputRack1^C6||^TGTG^HCG^MP1234|S|||||||||||||||||F<CR>R|1|^T
G^M^|OK||||F|||20180720120643<CR>R|2|^<ETB>CB<CR><LF>
```

```
<STX>2^HCG^M^|ERROR||||F|||20181129043238<CR>R|3|^MP1234^M^|ERROR||||F|||201811290432
38<CR>C|1||SECONDARY_TUBE_1^SUCCESS_001888899990_2234_A10_not_capped|G<CR>C|2||PRI
MARY_WIDTH^15.3|G<CR>C|3||PRIMARY_HEIGHT^100|G<CR>C|4||VOLUME_ESTIMATI<ETB>91<CR>
<LF>
```

```
<STX>3ON^2.4|G<CR>C|5||CAP_TYPE^Yellow|G<CR>C|6||H_VALUE^True|G<CR>C|7||I_VALUE^False|
G<CR>C|8||L_VALUE^False|G<CR>C|9||PICTURE_URL^http://10.0.0.10/32131434.jpeg|G<CR>C|10||PRI
MARY_COMMENT^Label placed too low|G<CR>L|1|N<CR><ETX>92<CR><LF>
```

4.2. Initialization request

This message is sent from AQUALink to the LIS when an AQUA system is in initialization of the conveyor and an unknown sample tube is found in a transport puck. The sample is read by the output robot and the information regarding the position where it is placed is sent to the LIS for traceability.

4.2.1 Initialization request message

The request message is composed by the following records:

HeaderRecord + OrderRecord + TerminationRecord

Header Record:

The header record is always the first record in an application message. It contains general sender and receiver information.

The Header Record structure is as follows:

H|\^&|||SENDER_ID|||RECEIVER_ID||PROCESSING_ID|VERSION_NUMBER|

Variable	Description	Example Value	Comments
SENDER_ID	Identifier of the sender.	A9000P	
RECEIVER_ID	Identifier of the receiver.	LIS	
PROCESSING_ID	Processing id. Always 1 character	P	P(Production)
VERSION_NUMBER	Always 1.	1	

Example: H|\^&|||A9000P|||LIS||P|1

Order record:

The order record is used to supply information on a specific sample's test requests. This information is necessary either for ordering tests on a specific sample or for reporting results for tests on a specific sample.

The Order Record structure is as follows:

O|SEQUENCE_NUMBER|TUBE_ID^RACK_ID^HOLE_ID|

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
TUBE_ID	Identifier of the primary tube as read on the barcode.	312011223344	The max length is 64 characters.
RACK_ID	Identifier of the rack where the tube has been placed.	OutputRack1	
HOLE_ID	Coordinates in the rack where the tube has been placed.	C6	

Example: O|1|312011223344^OutputRack1^C6|

Termination record:

The termination record is the last record of a message and closes the message. It provides an explanation for ending the message.

The Termination Record structure is as follows:

L| SEQUENCE_NUMBER |TERMINATION_CODE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Always 1.	1	
TERMINATION_CODE	If the ending of the message is normal, this field is absent or N (Normal). A Termination Code of E is used if normal completion of the message is prevented by system errors, such as timeouts at the data link layer and memory allocation errors.	N	

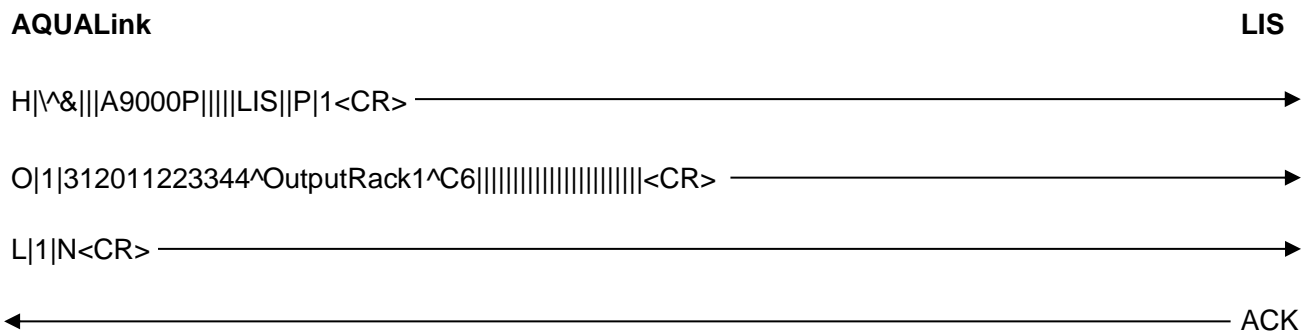
Example: *L|1|N*

4.2.2 Initialization response message

The LIS sends an acknowledge message confirming the reception of the request message.

4.2.3 Initialization message example

Here we can see an example of the whole process of request and response:



4.3. GET TESTS request

This message is sent from AQUALink to the LIS for three possible reasons:

1. An AQUA System hardware has picked a sample from an Input rack and has read the sample ID barcode
2. An Operator has manually asked the information and actions related to a sample ID code from an AQUALink software interface.
3. There is no information concerning a Sample ID in AQUALink internal database in mode Upload-Query

4.3.1 GET TESTS request message

The request message is composed by the following records:

HeaderRecord + QueryRecord + TerminationRecord

Header Record:

The header record is always the first record in an application message. It contains general sender and receiver information.

The Header Record structure is as follows:

H|\^&|||SENDER_ID|||RECEIVER_ID||PROCESSING_ID|VERSION_NUMBER|

Variable	Description	Example Value	Comments
SENDER_ID	Identifier of the sender.	A9000P	
RECEIVER_ID	Identifier of the receiver.	LIS	
PROCESSING_ID	Processing id. Always 1 character	P	P(Production)
VERSION_NUMBER	Always 1.	1	

Example: H|\^&|||A9000P|||LIS||P|1

Query Record:

The query record is used to request data from remote systems.

The Query Record structure is as follows:

Q|SEQUENCE_NUMBER|^TUBE_ID^RACK_ID^HOLE_ID|O

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Always 1. The system always ends an application message before transmitting another query record. Used to verify the integrity of an application message by ensuring that the message contains all records.	1	
TUBE_ID	Identifier of the primary tube as read on the barcode.	312011223344	The max length is 64 characters.
RACK_ID	Identifier of the rack from where the tube has been picked.	InputRack1	Can be left empty
HOLE_ID	Coordinates in the rack from where the tube has been picked.	C6	Can be left empty

When manually operated requests are sent, the RACK_ID and HOLE_ID can be left blank.

Example: Q|1|^312011223344^InputRack1^C6|O

Terminator Record:

The termination record is the last record of a message and closes the message. It provides an explanation for ending the message.

The Termination Record structure is as follows:

L| SEQUENCE_NUMBER |TERMINATION_CODE

Variable	Description	Example Value	Usage
SEQUENCE_NUMBER	Always 1.	1	
TERMINATION_CODE	If the ending of the message is normal, this field is absent or N (Normal). A Termination Code of E is used if normal completion of the message is prevented by system errors, such as timeouts at the data link layer and memory allocation errors.	N	

Example: *L/1/N*

4.3.2 GET TESTS response message

By **default**, the response from the LIS should **only include the list of Pending tests (or virtual tests***)**.

**** NOTE: the AQUALink software calculates what actions to do (sorting primary destination, decapping, aliquots, volumes of aliquots...) with the list of tests received. The tests can be real analytic determinations that are pending in the LIS database, or can be virtual tests that are agreed with the LIS and are configured during installation and startup. For example one virtual test per each possible aliquot type can be used. The volume and properties of the aliquot are configured in AQUALink database.*

The response message is composed by:

HeaderRecord + PatientRecord + OrderRecord + TerminationRecord

Header Record:

The header record is always the first record in an application message. It contains general sender and receiver information.

The Header Record structure is as it follows:

H|\&|||SENDER_ID|||RECEIVER_ID||PROCESSING_ID|VERSION_NUMBER|

Variable	Description	Example Value	Comments
SENDER_ID	Identifier of the sender.	LIS	This field can be empty on order download.
RECEIVER_ID	Identifier of the receiver.	A9000P	This field can be empty on order download.
PROCESSING_ID	Processing id. Always 1 character	P	P(Production)
VERSION_NUMBER	Always 1.	1	

Example: H|\&|||LIS|||A9000P||P|1

Patient Record:

The patient record is used to supply patient demographic information for order and result records that follow it. The following table describes the values each field can contain.

The Patient Record structure is as follows:

P|SEQUENCE_NUMBER|PATIENT_ID||FAMILY_NAME^FIRST_NAME^MIDDLE_NAME||BIRTH_DATE|
PATIENT_SEX|||PHYSICIAN|||LOCATION

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
PATIENT_ID	ID of the patient	2233667744B	The max length is 32 characters.

FAMILY_NAME	Family name of patient	Smith	
FIRST_NAME	First name of patient	John	
MIDDLE_NAME	Middle name of patient	Levin	
BIRTHDATE	Birthdate of the patient (format yyyyymmdd)	18/03/1975	
PATIENT_SEX	Sex of patient	Male	
PHYSICIAN	Name of the doctor	Conrad	
LOCATION	Set to the Location field of worklist entry or result.	ER1	

Example: P|1|2233667744B||Smith^John^Levin||19721005|M|||||Dr.Sanz|||||||ER1

Order Record:

The order record is used to supply information on a specific sample's test requests. This information is necessary either for ordering tests on a specific sample or for reporting results for tests on a specific sample. The Order Record structure is as follows:

O|SEQUENCE_NUMBER|TUBE_ID^RACK_ID^HOLE_ID||UNIVERSAL_TEST_ID|PRIORITY|||||ACTION_CODE|||||||REPORT_TYPE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
TUBE_ID	Identifier of the primary tube as read on the barcode.	312011223344	The max length is 64 characters.
RACK_ID	Identifier of the rack from where the tube has been picked.	InputRack1	This field can be empty on order download.
HOLE_ID	Coordinates in the rack from where the tube has been picked.	C6	
UNIVERSAL_TEST_ID	List of tests	^^T4\^^HCG\^^P1234	
PRIORITY	Value determined by the stat flag in the worklist entry. If the stat flag is Yes, the Priority field is set to S (Stat). If the stat flag is No, the Priority field is set to R (Routine).	S	S(Stat) or R(Routine)
ACTION_CODE	If the worklist entry or the result entry is for a control sample, the Action Code field is set to Q (QC Test Specimen). If the worklist entry or the result entry is for a patient sample, the Action Code field is empty. All values other than Q will be ignored for order download from the LIS.	Empty	Q or empty. In this case, as it is a patient sample, it would be empty.
REPORT_TYPE	If the outgoing message contains rejected incoming worklist or result data, or the test is not resultated, the Report Type field contains X (Work Cannot Be Done). If the outgoing message contains worklist data, the Report Type field contains O (Order). If the outgoing message contains result data, the Report Type field contains F (Final Results). If the outgoing message contains data in response to a query, the Report Type field contains Q (Response to a Query).	Q	

When manually operated requests are sent, the RACK_ID and HOLE_ID can be left blank.

Example: *O|1|312011223344^InputRack1^C6|^T4^HCG^P1234|S|Q*

Termination Record:

The termination record is the last record of a message and closes the message. It provides an explanation for ending the message.

The Termination Record structure is as follows:

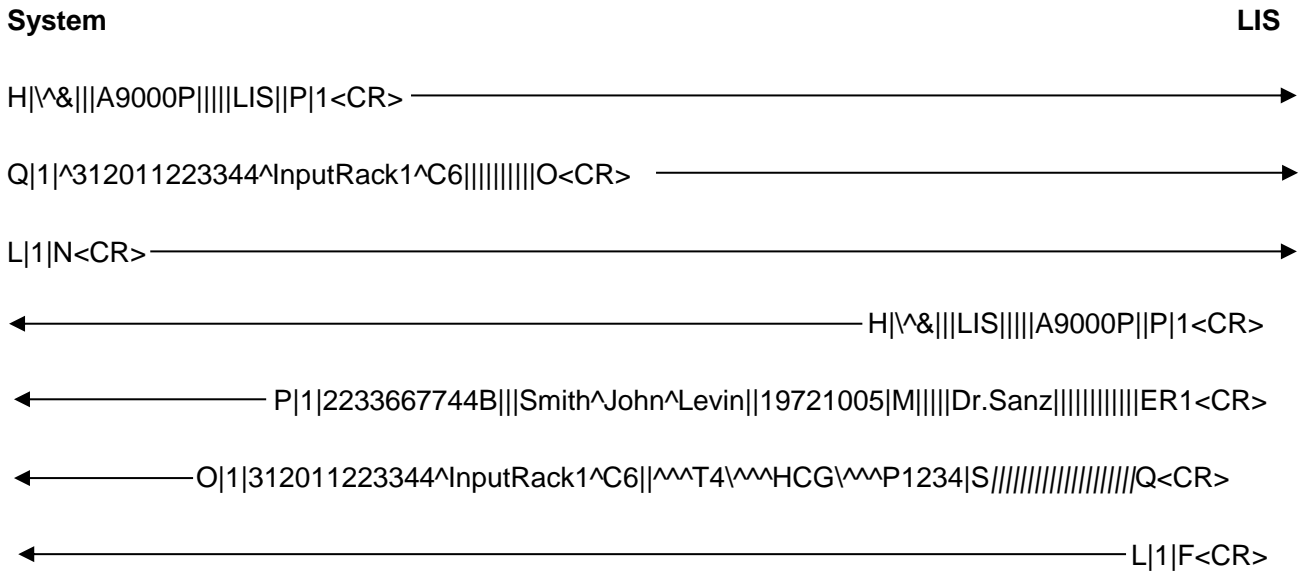
L| SEQUENCE_NUMBER |TERMINATION_CODE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Always 1.	1	
TERMINATION_CODE	A Termination Code of F (Final) is used in reply to a query to indicate that all available information is sent in response.	F	

Example: *L|1|F*

4.3.3 GET TESTS message example

Here we can see an example of the whole process of request and response:



In this example, an AQUA System has picked a sample tube from its input tray zone (InputRack1 at location C6), has read its barcode (312011223344) and sends a Query to the LIS to know what actions must be done. The LIS answers giving some demographic information (P record) and the pending tests assigned to that sample ID (T4, HCG, P1234).

If there are no pending tests for the sample tube, the LIS will send the following message:

```
H|\^&|||||P|1
L|1|
```

The AQUA System will interpret this message as “no pending tests”.

4.4. SEND RESULTS request

This message is sent from AQUALink to the LIS for three possible reasons:

1. An AQUA system hardware has placed a sample at an Output rack (actions finished) and sends the results for every requested test.
2. An Operator has manually performed some actions related to a sample ID code and confirms the result of them from an AQUALink software interface.

Depending on the SEND RESULTS mode selected, the message is described below.

4.4.1. SEND RESULTS request message (mode Tests)

The response message is composed by the following records:

HeaderRecord + PatientRecord + OrderRecord + ResultRecord + TerminationRecord

Header Record:

The header record is always the first record in an application message. It contains general sender and receiver information.

The Header Record structure is as follows:

H|\&|||SENDER_ID|||RECEIVER_ID||PROCESSING_ID|VERSION_NUMBER|

Variable	Description	Example Value	Comments
SENDER_ID	Identifier of the sender.	A9000P	
RECEIVER_ID	Identifier of the receiver.	LIS	
PROCESSING_ID	Processing id. Always 1 character.	P	P(Production)
VERSION_NUMBER	Always 1.	1	

Example: H|\&|||A9000P|||LIS||P|1

Patient Record:

The patient record is used to supply patient demographic information for order and result records that follow it. The following table describes the values each field can contain.

The Patient Record structure is as follows:

P|SEQUENCE_NUMBER|PATIENT_ID|||FAMILY_NAME^FIRST_NAME^MIDDLE_NAME||BIRTH_DATE|
PATIENT_SEX|||PHYSICIAN|||LOCATION

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
PATIENT_ID	ID of the patient	2233667744B	Max length is 32 characters.
FAMILY_NAME	Family name of patient	Smith	
FIRST_NAME	First name of patient	John	
MIDDLE_NAME	Middle name of patient	Levin	
BIRTHDATE	Birthdate of the patient (format yyymmdd)	18/03/1975	
PATIENT_SEX	Sex of patient	Male	

PHYSICIAN	Name of the doctor	Conrad	
LOCATION	Set to the Location field of worklist entry or result.	ER1	

Example: *P|1|2233667744B||Smith^John^Levin||19721005|M|||||Dr.Sanz|||||||ER1*

Order Record:

The order record is used to supply information on a specific sample’s test requests. This information is necessary either for ordering tests on a specific sample or for reporting results for tests on a specific sample. The Order Record structure is as follows:

O|SEQUENCE_NUMBER|TUBE_ID^RACK_ID^HOLE_ID||UNIVERSAL_TEST_ID|PRIORITY|||||ACTION_CODE|||||||REPORT_TYPE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
TUBE_ID	Identifier of the primary tube as read on the barcode.	312011223344	The max length is 64 characters.
RACK_ID	Identifier of the rack from where the tube has been placed.	OutputRack1	
HOLE_ID	Coordinates in the rack from where the tube has been placed.	C6	The max length is 10 characters.
UNIVERSAL_TEST_ID	List of tests	^^T4\^^HCG\^^P1234	
PRIORITY	Value determined by the stat flag in the worklist entry. If the stat flag is Yes, the Priority field is set to S (Stat). If the stat flag is No, the Priority field is set to R (Routine).	S	S(Stat) or R(Routine)
ACTION_CODE	If the worklist entry or the result entry is for a control sample, the Action Code field is set to Q (QC Test Specimen). If the worklist entry or the result entry is for a patient sample, the Action Code field is empty.	Empty	Q or empty
REPORT_TYPE	If the outgoing message contains rejected incoming worklist or result data, or the test is not resulted, the Report Type field contains X (Work Cannot Be Done). If the outgoing message contains worklist data, the Report Type field contains O (Order). If the outgoing message contains result data, the Report Type field contains F (Final Results).	F	F for Final Results

Example: *O|1|312011223344^OutputRack1^C6||^^T4\^^HCG\^^P1234|S|||||||F*

Result Record:

The result record supplies the final test result information for a single test of a specific sample. Results of multiple tests are specified in separate result records.

The structure of Result Record is as follows:

R|SEQUENCE_NUMBER|^^UNIVERSAL_TEST_ID^^|DATA_VALUE|||FLAGS||RESULT_STATUS|||DATE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a result record since the last order record. Used to verify the integrity of an application message by ensuring that the message contains all records.	1	
UNIVERSAL_TEST_ID	Id of the test.	HCG	
DATA_VALUE	The data generated by the test	OK	
FLAGS	It represents the system result flags.	H	If the result is flagged as low, this field contains L (Below Reference Range). If the result is flagged as high, this field contains H (Above Reference Range). If the result is flagged as under range, this field contains < (Below Concentration Range). If the result is flagged as over range, this field contains > (Above Concentration Range).
RESULT_STATUS	The result of the test.	F	The Result Status field has a value of F (Final).
DATE	The date the test was performed(the format is yyyyymmddhhmmss)	20181129043238	

Added Tests in Result Record:

A result record is generated for each test we received from the LIS. But we can also generate some additional results, which are described in the next table:

Test id	Description	Data Value Example	Usage
SECONDARY_TUBE_N	Secondary Tube generated during the test. We can get from 1 to 9 different secondary tubes. The structure of the data value would be: SECONDARYTUBESTATUS_SAMPLEID_RACKID_HOLEID_COMMENT	SUCCESS_1178888999 90_4311_A5_not capped	Mandatory if an aliquote has been made.
PRIMARY_WIDTH	Mesured width of the sample ID in mm	15.3	Optional
PRIMARY_HEIGHT	Mesured height of the sample ID in mm	100	Optional
VOLUME_ESTIMATION	Estimated available volume of the sample ID in mL	2.4	Optional
CAP_TYPE	Cap type of the sample ID	Yellow	Optional
H_VALUE	Estimation of Hemolyzed Sample ID (True/False).	True	Optional
I_VALUE	Estimation of Hemolyzed Sample ID (True/False).	False	Optional
L_VALUE	Estimation of Lipemic Sample ID (True/False).	False	Optional
PICTURE_URL	HTTP to download the captured image of the primary tube in JPEG format address where	http://10.0.0.10/32131434 .jpeg	Optional
PRIMARY_COMMENT	Comment related to the integrity of the primary tube	Label placed too low	Optional

Table 1: Added Tests

Examples:

R|1|^HCG^|^OK^|^|^F^|^|^20180720120643

R|2|^SECONDARY_TUBE_1^|^SUCCESS_001888899990_2234_A10^|^|^F^|^|^20180720120643

R|3|^PRIMARY_WIDTH^|^15.3^|^|^F^|^|^20180720120643

Termination Record:

The termination record is the last record of a message and closes the message. It provides an explanation for ending the message.

The Termination Record structure is as follows:

L| SEQUENCE_NUMBER |TERMINATION_CODE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Always 1.	1	
TERMINATION_CODE	If the ending of the message is normal, this field is absent or N (Normal). A Termination Code of E is used if normal completion of the message is prevented by system errors, such as timeouts at the data link layer and memory allocation errors.	N	

Example: L|1|N

Here we can see an example of the full message:

```
H|\&|||A9000P||||LIS|P|1<CR>
P|1|2233667744B|||Smith^John^Levin||19721005|M||||Dr.Sanz|||||||ER1<CR>
O|1|312011223344^OutputRack1^C6||^MT4^HCG^MP1234|S|||||||F<CR>
R|1|^MT4^^^|OK||||F|||20180720120643<CR>
R|2|^HCG^^^|ERROR||||F|||20181129043238<CR>
R|3|^MP1234^^^|ERROR||||F|||20181129043238<CR>
R|4|^SECONDARY_TUBE_1^^^|SUCCESS_001888899990_2234_A10_not
capped||||F|||20180720120643<CR>
R|5|^PRIMARY_WIDTH^^^|15.3||||F|||20180720120643
R|6|^PRIMARY_HEIGHT^^^|100||||F|||20180720120643
R|7|^VOLUME_ESTIMATION^^^|2.4||||F|||20180720120643
R|8|^CAP_TYPE^^^|Yellow||||F|||20180720120643
R|9|^H_VALUE^^^|True||||F|||20180720120643
R|10|^I_VALUE^^^|False||||F|||20180720120643
R|11|^L_VALUE^^^|False||||F|||20180720120643
R|12|^PICTURE_URL^^^|http://10.0.0.10/32131434.jpeg||||F|||20180720120643
R|13|^PRIMARY_COMMENT^^^|Label placed too low||||F|||20180720120643

L|1|N<CR>
```

Examples of situations:

- a Sample ID has multiple sorting destinations related to different tests and the tube is sorted to the one with higher priority
 - o The answer will include “OK” in the result only for the tests leading to that destination, and “ERROR” for the tests that had different sorting destination.
- a Sample ID has multiple secondary tubes to generate and it fails because there is not enough sample
 - o The answer will include “OK” in the result only for the tests that were included in the secondary tubes completely filled, and “ERROR” for the tests included in the secondary tubes not filled completely.

4.4.2. SEND RESULTS request message (mode Comments)

The response message is composed by the following records:

HeaderRecord + PatientRecord + OrderRecord + ResultRecord + ResultCommentRecord + TerminationRecord

In this mode, we will use comment records in order to send the information about the additional results we generate.

Result Comment Record:

The result comment record is used to communicate additional information related with a result record. This record is optional, and it always follows a result record.

The Result Comment Record structure is as follows:

```
C|SEQUENCE_NUMBER|COMMENT_SOURCE|COMMENT_CODE^COMMENT_TEXT|COMMENT_TYP
E
```

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a result comment record within the current outgoing application message. Used to verify the integrity of an application message by ensuring that the message contains all records.	1	
COMMENT_SOURCE	If the comment is a result flag, the Comment Source field is set to I. If the comment is a operator-entered comment, this component is blank.	Empty.	Always empty.
COMMENT_CODE	The added test id(see Table 1: Added Tests).	PRIMARY_HEIGHT	
COMMENT_TEXT	The value for the test.	100	
COMMENT_TYPE	If there is a result flag, this component is I. If there is a operator-entered comment, this component is G.	G	Always G.

Example: C|1||PRIMARY_HEIGHT|100|G

Here we can see an example of the full message:

```
H|\&||A9000P||||LIS|P|1<CR>
P|1|2233667744B||Smith^John^Levin||19721005|M|||||Dr.Sanz|||||||ER1<CR>
O|1|312011223344^OutputRack1^C6||^T4^HCG^P1234|S|||||||F<CR>
R|1|^T4^^^|OK||||F||||20180720120643<CR>
C|1||SECONDARY_TUBE_1^SUCCESS_001888899990_2234_A10_not capped|G<CR>
C|2||PRIMARY_WIDTH^15.3|G<CR>
C|3||PRIMARY_HEIGHT|100^G<CR>
C|4||VOLUME_ESTIMATION^2.4|G<CR>
C|5||CAP_TYPE^Yellow|G<CR>
C|6||H_VALUE^True|G<CR>
C|7||I_VALUE^False|G<CR>
C|8||L_VALUE^False|G<CR>
C|9||PICTURE_URL^http://10.0.0.10/32131434.jpeg|G<CR>
C|10||PRIMARY_COMMENT^Label placed too low|G<CR>
R|2|^HCG^^^|ERROR||||F||||20181129043238<CR>
R|3|^ P1234^^^|ERROR||||F||||20181129043238<CR>
L|1|N<CR>
```

4.4.2 SEND RESULTS response message

The LIS sends an acknowledge message confirming the reception of the request message.

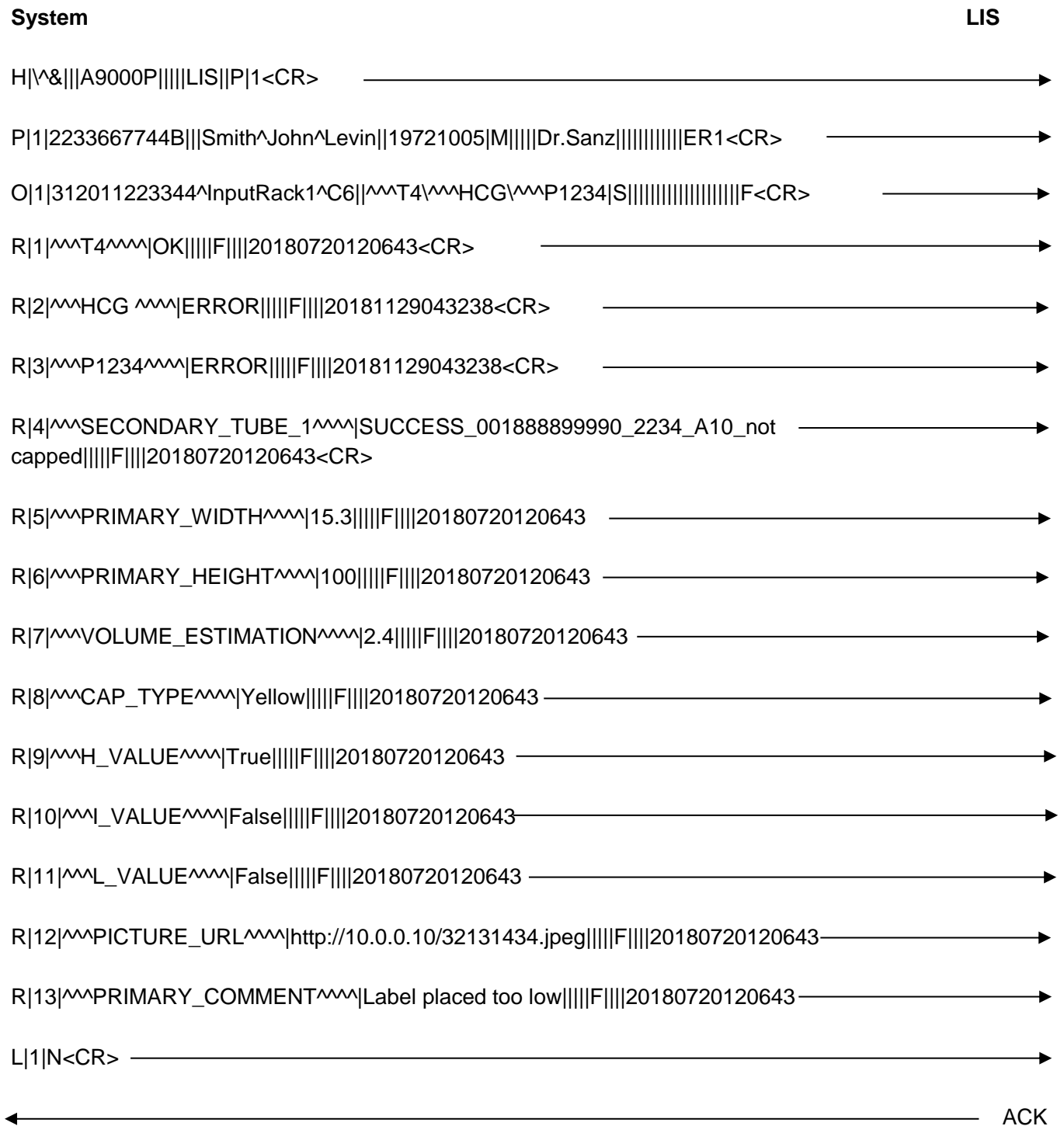
4.4.3 SEND RESULTS message example (mode Comment)

Here we can see an example of the whole process of request and response:



4.4.4 SEND RESULTS message example (mode Tests)

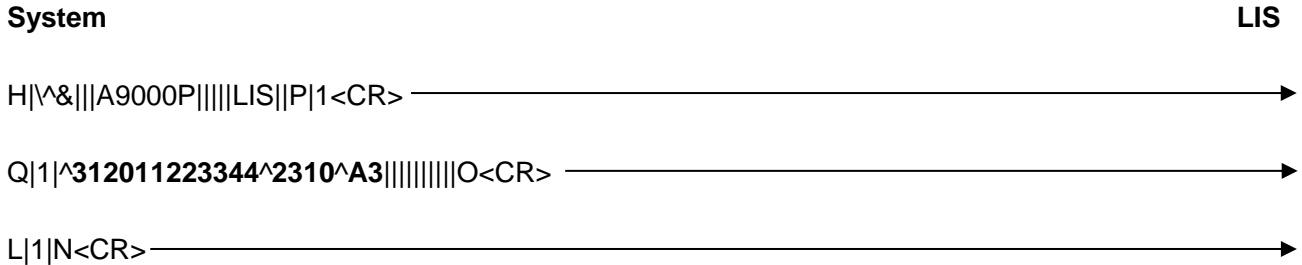
Here we can see an example of the whole process of request and response:



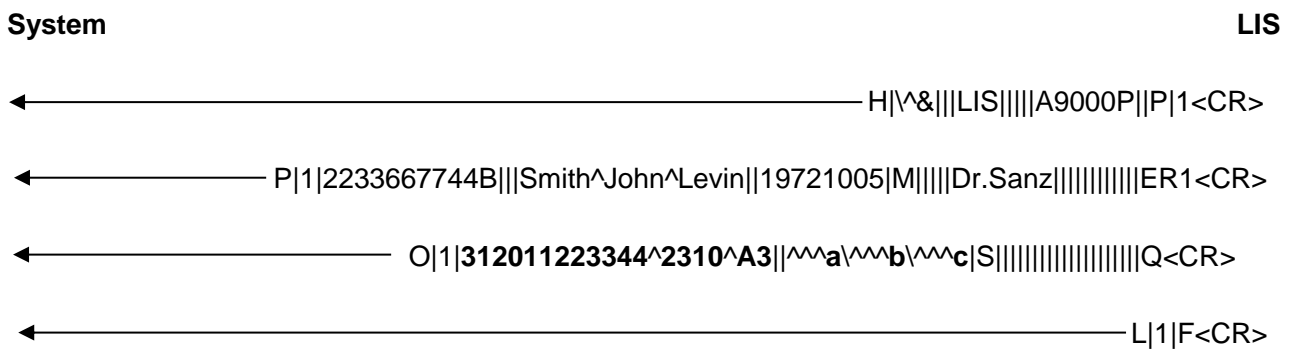
4.5. Communication examples

4.5.1. Example 1

The AQUA sends a query to the LIS, regarding primary tube with code **312011223344**, picked from input rack **2310** and hole **A3**:



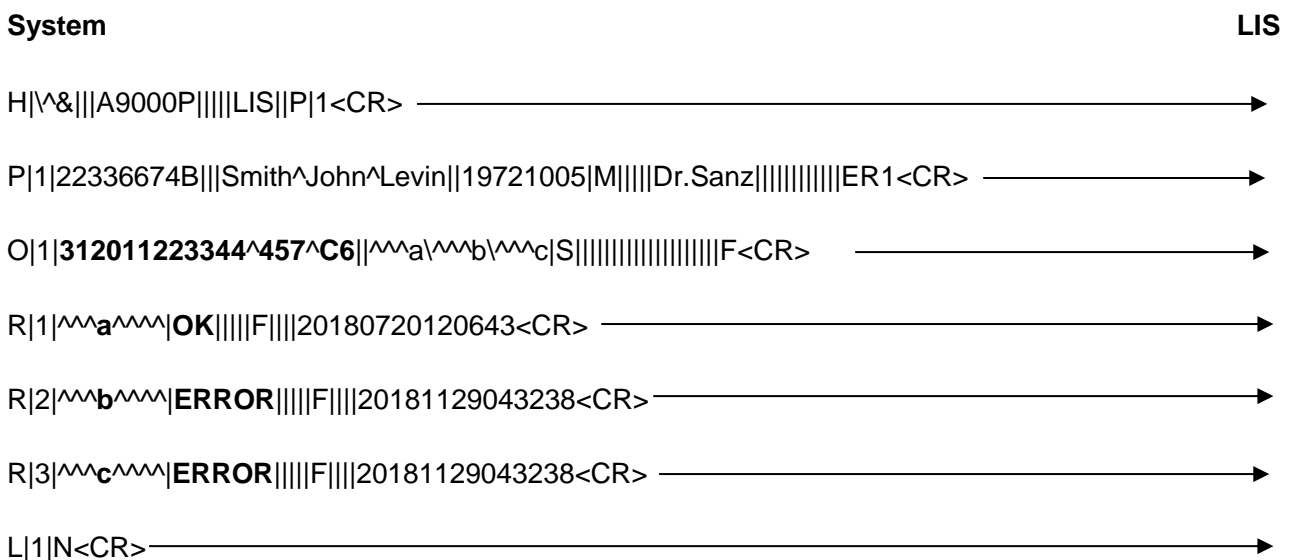
The LIS responds with tests **a**, **b** and **c**:



The AQUA is configured as a sorter. Tests **a**, **b** and **c** correspond to classification destinies, and test 'a' has the highest priority.

The AQUA places the tube **312011223344** in output rack **457** and hole **C6**, and classifies the tube in 'a', sending the following message to the LIS:

MODE TESTS



MODE COMMENT

System **LIS**

H|\&|||A9000P|||||LIS||P|1<CR> →

P|1|22336674B|||Smith^John^Levin||19721005|M|||||Dr.Sanz|||||||ER1<CR> →

O|1|312011223344^457^C6||^a\^b\^c|S|||||||F<CR> →

R|1|^a^|OK|||||F|||||20180720120643<CR> →

R|2|^b^|ERROR|||||F|||||20181129043238<CR> →

R|3|^c^|ERROR|||||F|||||20181129043238<CR> →

L|1|N<CR> →

The LIS sends an acknowledge message confirming the reception of the request message:

System **LIS**

← ACK

4.5.2. Example 2

*The AQUA sends a query to the LIS, regarding primary tube with code **312011223344**, picked from input rack **2310** and hole **A3**:*

System **LIS**

H|\&|||A9000P|||||LIS||P|1<CR> →

Q|1|^312011223344^2310^A3|||||||O<CR> →

L|1|N<CR> →

*The LIS responds with tests **a**, **b** and **c**:*

System **LIS**

← H|\&|||LIS|||||A9000P||P|1<CR>

← P|1|2233667744B|||Smith^John^Levin||19721005|M|||||Dr.Sanz|||||||ER1<CR>

← O|1|312011223344^2310^A3||^a\^b\^c|S|||||||Q<CR>

← L|1|F<CR>

The AQUA is configured to make an aliquote of each type.

For test a aliquots, it's configured to substitute the first three digits of the code with '314'.

For test b aliquots, it's configured to substitute the first three digits of the code with '335'.

For test c aliquots, the code will remain the same as in the primary tube.

The AQUA places the tube **312011223344** in output rack **457** and hole **C6**.

In this example, the AQUA makes the three aliquots successfully:

Test a -> It generates a secondary tube with code **314011223344** and it places it in rack **2234**, hole **A10**, not capped.

Test b -> It generates a secondary tube with code **335011223344** and it places it in rack **874**, hole **D4**, capped.

Test c -> It generates a secondary tube with code **312011223344** and it places it in rack **1166**, hole **C2**, not capped.

The AQUA sends the following message to the LIS:

MODE TESTS

System	LIS
H \& A9000P LIS P 1<CR>	→
P 1 22336674B Smith^John^Levin 19721005 M Dr.Sanz ER1<CR>	→
O 1 312011223344^457^C6 ^a\^b\^c S F<CR>	→
R 1 ^a OK F 20180720120643<CR>	→
R 2 ^b OK F 20181129043238<CR>	→
R 3 ^c OK F 20181129043238<CR>	→
R 4 ^SECONDARY_TUBE_1 SUCCESS_314011223344_2234_A10_not capped F 20180720120643<CR>	→
R 5 ^SECONDARY_TUBE_2 SUCCESS_335011223344_874_D4_capped F 20180720120643<CR>	→
R 6 ^SECONDARY_TUBE_3 SUCCESS_312011223344_1166_C2_not capped F 20180720120643<CR>	→
L 1 N<CR>	

MODE COMMENT

System	LIS
H \& A9000P LIS P 1<CR>	→
P 1 22336674B Smith^John^Levin 19721005 M Dr.Sanz ER1<CR>	→
O 1 312011223344^457^C6 ^a\^b\^c S F<CR>	→
R 1 ^a OK F 20180720120643<CR>	→

```

C|1||SECONDARY_TUBE_1^SUCCESS_314011223344_2234_A10_not capped|G<CR> —————>
R|2|^b^|OK||||F||||20181129043238<CR> —————>
C|2||SECONDARY_TUBE_2^SUCCESS_335011223344_874_D4_capped|G<CR> —————>
R|3|^c^|OK||||F||||20181129043238<CR> —————>
C|3||SECONDARY_TUBE_3^SUCCESS_312011223344_1166_C2_not capped|G<CR> —————>
L|1|N<CR> —————>

```

The LIS sends an acknowledge message confirming the reception of the request message:

```

System LIS
<----- ACK

```

4.5.3. Example 3

The AQUA sends a query to the LIS, regarding primary tube with code **312011223344**, picked from input rack **2310** and hole **A3**:

```

System LIS
H|^&|||A9000P||||LIS||P|1<CR> —————>
Q|1|^312011223344^2310^A3|||||||O<CR> —————>
L|1|N<CR> —————>

```

The LIS responds with tests **a**, **b** and **c**:

```

System LIS
<----- H|^&|||LIS||||A9000P||P|1<CR>
<----- P|1|2233667744B||Smith^John^Levin||19721005|M||||Dr.Sanz|||||||ER1<CR>
<----- O|1|312011223344^2310^A3|^a^b^c|S|||||||Q<CR>
<----- L|1|F<CR>

```

The AQUA is configured to make an aliquote of each type.
 For test a aliquots, it's configured to substitute the first three digits of the code with '314'.
 For test b aliquots, it's configured to substitute the first three digits of the code with '335'.
 For test c aliquots, the code will remain the same as in the primary tube.
 The AQUA places the tube **312011223344** in output rack **457** and hole **C6**.
 In this example, the AQUA makes the first aliquote successfully and fails the other two:
Test a -> It generates a secondary tube with id **314011223344** and it places it in rack **2234**, hole **A10**, not

capped.

Test b -> The generation of the secondary tube fails.

Test c -> The generation of the secondary tube fails.

MODE TESTS

System	LIS
H \& A9000P LIS P 1<CR>	→
P 1 22336674B Smith^John^Levin 19721005 M Dr.Sanz ER1<CR>	→
O 1 312011223344^457^C6 ^a^b^c S F<CR>	→
R 1 ^a^ OK F 20180720120643<CR>	→
R 2 ^b^ ERROR F 20181129043238<CR>	→
R 3 ^c^ ERROR F 20181129043238<CR>	→
R 4 ^SECONDARY_TUBE_1^ SUCCESS_314011223344_2234_A10_not capped F 20180720120643<CR>	→
R 5 ^SECONDARY_TUBE_2^ ERROR_335011223344_874_D4_capped F 20180720120643<CR>	→
R 6 ^SECONDARY_TUBE_3^ ERROR_312011223344_1166_C2_not capped F 20180720120643<CR>	→
L 1 N<CR>	

MODE COMMENT

System	LIS
H \& A9000P LIS P 1<CR>	→
P 1 22336674B Smith^John^Levin 19721005 M Dr.Sanz ER1<CR>	→
O 1 312011223344^457^C6 ^a^b^c S F<CR>	→
R 1 ^a^ OK F 20180720120643<CR>	→
C 1 ^SECONDARY_TUBE_1^ SUCCESS_314011223344_2234_A10_not capped G<CR>	→
R 2 ^b^ ERROR F 20181129043238<CR>	→
C 2 ^SECONDARY_TUBE_2^ ERROR_335011223344_874_D4_capped G<CR>	→
R 3 ^c^ ERROR F 20181129043238<CR>	→
C 3 ^SECONDARY_TUBE_3^ ERROR_312011223344_1166_C2_not capped G<CR>	→

L|1|N<CR>—————→

The LIS sends an acknowledge message confirming the reception of the request message:

System

LIS

←————— ACK

5. LIS requests to AQUALink

The LIS module **can** send requests at any time to the AQUALink module. There is only one type of payload which is used to upload bulk order requests.

5.1. Bulk Order Upload

This message is sent from LIS to AQUALink to update the information concerning the expected samples in the lab.

5.1.1. Bulk order upload request message

The request message is composed by:

HeaderRecord + PatientRecord + OrderRecord + TerminationRecord

Header Record:

The header record is always the first record in an application message. It contains general sender and receiver information.

The Header Record structure is as follows:

H|\&|||SENDER_ID|||RECEIVER_ID||PROCESSING_ID|VERSION_NUMBER|

Variable	Description	Example Value	Comments
SENDER_ID	Identifier of the sender.	A9000P	
RECEIVER_ID	Identifier of the receiver.	LIS	
PROCESSING_ID	Processing id. Always 1 character	P	P(Production)
VERSION_NUMBER	Always 1.	1	

Example: H|\&|||LIS|||A9000P||P|1

Patient Record:

The patient record is used to supply patient demographic information for order and result records that follow it. The following table describes the values each field can contain.

The Patient Record structure is as follows:

P|SEQUENCE_NUMBER|PATIENT_ID||FAMILY_NAME^FIRST_NAME^MIDDLE_NAME||BIRTH_DATE|
PATIENT_SEX|||PHYSICIAN|||LOCATION

Variable	Description	Example Value	Comments
----------	-------------	---------------	----------

SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
PATIENT_ID	ID of the patient	2233667744B	The max length is 32 characters.
FAMILY_NAME	Family name of patient	Smith	
FIRST_NAME	First name of patient	John	
MIDDLE_NAME	Middle name of patient	Levin	
BIRTHDATE	Birthdate of the patient (format yyyymmdd)	18/03/1975	
PATIENT_SEX	Sex of patient	Male	
PHYSICIAN	Name of the doctor	Conrad	
LOCATION	Set to the Location field of worklist entry or result.	ER1	

Example: *P|1|2233667744B||Smith^John^Levin||19721005|M||||Dr.Sanz|||||||ER1*

Order Record:

The order record is used to supply information on a specific sample's test requests. This information is necessary either for ordering tests on a specific sample or for reporting results for tests on a specific sample. The Order Record structure is as follows:

O|SEQUENCE_NUMBER|TUBE_ID^RACK_ID^HOLE_ID||UNIVERSAL_TEST_ID|PRIORITY|||||ACTION_CODE|||||||REPORT_TYPE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Equal to the nth occurrence of a patient record within the current outgoing application message. Used for validating the integrity of the application message by ensuring that the message contains all records.	1	
TUBE_ID	Identifier of the primary tube as read on the barcode.	312011223344	The max length is 64 characters.
RACK_ID	Identifier of the rack from where the tube has been picked.	InputRack1	
HOLE_ID	Coordinates in the rack from where the tube has been picked.	C6	
UNIVERSAL_TEST_ID	List of tests	^^T4\^^HCG\^^P1234	
PRIORITY	Value determined by the stat flag in the worklist entry. If the stat flag is Yes, the Priority field is set to S (Stat). If the stat flag is No, the Priority field is set to R (Routine).	S	S(Stat) or R(Routine)
ACTION_CODE	If the worklist entry or the result entry is for a control sample, the Action Code field is set to Q (QC Test Specimen). If the worklist entry or the result entry is for a patient sample, the Action Code field is empty.	Empty	Q or empty
REPORT_TYPE	If the outgoing message contains rejected incoming worklist or result data, or the test is not resulted, the Report Type field contains X (Work Cannot Be Done). If the outgoing message contains worklist data, the Report Type field contains O (Order). If the outgoing message contains result data, the Report Type field contains F (Final Results).	Empty	

	If the outgoing message contains data in response to a query, the Report Type field contains Q (Response to a Query). If the outgoing message is a response to a remote query for pending results, the Report Type field contains I (Instrument Pending).		
--	---	--	--

Example: O|1|312011223344^InputRack1^C6||^T4|^HCG|^P1234|S|

Termination Record:

The termination record is the last record of a message and closes the message. It provides an explanation for ending the message.

The Termination Record structure is as follows:

L| SEQUENCE_NUMBER |TERMINATION_CODE

Variable	Description	Example Value	Comments
SEQUENCE_NUMBER	Always 1.	1	
TERMINATION_CODE	A Termination Code of F (Final) is used in reply to a query to indicate that all available information is sent in response.	N	

Example: L|1|F

5.1.2. Bulk order upload response message

AQUALink sends an acknowledge message confirming the reception of the request message.

If there is an error while storing the information in AQUALink database, the LIS should be aware of it and resend the information accordingly.

5.1.3. Bulk order upload message example

Here we can see an example of the whole process of request and response:

