SARSTEDT
Aktiengesellschaft & Co.

Interface to Laboratory Information Systems

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1 General

The connection between the laboratory information system (LIS) and the Sarstedt **L**ab **A**utomation **S**ystem (LAS, i.e. PVS, HSS, DC900 Flex, RC900 Flex) is realized via a serial interface (RS 232) or an Ethernet network interface.

For the serial connection a common null modem cable is used. The default communication parameters are:

Baud rate	19200 Bits/s
Parity	none
Data bits	8 Bits
Stop bits	1 Bit
Flow control	none

For the communication via Ethernet network a standard TCP socket connection is used. The communication port can be set to any value above 1024. The lab automation system (LAS) either can open a distinct port for incoming connections (server mode) or it can open a connection to a distinct port on a given server (client mode). By default the client mode is used.

The communication is bidirectional and asynchronous, lab automation system (LAS) and LIS can start sending a message independently from each other. Every incoming message must be confirmed by the receiver immediately with an ACK / NAK message. The next message should be sent only after the ACK / NAK message has been received or a timeout period has been elapsed. Meanwhile all communication partners can send and receive independent messages. That means a system can receive a message before the awaited ACK / NAK has arrived. The length of timeout period has to be agreed on both parties.
For the start-up of communication a synchronization process is mandatory. Both the communication partners hast to wait for an incoming SYN message that must be confirmed by an ACK message immediately.
To ensure data integrity all messages will contain a checksum. The communication will use the ISO8859 character set.

2 Data record structure

A data record (message) consists of a protocol frame and several message blocks:

Data record

<STX>{Sequence}|{Type}|{Information}|<CR><LF>{Checksum}<ETX>

<STX>	ASCII 0x02
<CR><LF>	ASCII 0x0D 0x0A
<ETX>	ASCII 0x03

The message blocks {Sequence}, {Type} and {Checksum} are mandatory for all messages. The {information} block is required for some message types only.

The message blocks “sequence”, “type” and “information” are separated / finalized by a pipe symbol (|).

Every message block consists of at least one data item:

Message block

{Tag$_1$}:{Value$_1$}|….|{Tag$_n$}:{Value$_n$}

Within a data item an identifier (tag) and the data value are separated by a colon (:). Several data items are separated by a pipe (|).

Pipe symbol	|	ASCII 0x7C
Colon symbol	:	ASCII 0x3A

The assembling of the message blocks are variable and will be described in the following chapters.

2.1 Sequence block

{Sequence} ➔ FN:XX where XX represents a number between 00 und 63.

The sequence number must have 2 digits.

The sequence number start with 0 after a synchronization process and it is increased by 1 for every message. After it has reached 63, the sequence number will start at 0 again with the next message. The sequence number of an outgoing message may not be related to the previous incoming message. That means the lab automation system and the LIS can use the sequence number independent from each other.
The sequence numbers serves as a means of verification for the last 64 data records and is intended for debug purposes. However, verification of the sequence numbers does not take place.

2.2 Type block

{Type} ➔ TYP:XXX where XXX represents the message type.

The following message types are defined:

Type	Sender	Description
SYN	LDV/LAS	Initiation of a dialogue / synchronization process (3.4)
ACK	LDV/LAS	Positive acknowledgement (3.1)
NAK	LDV/LAS	Negative acknowledgement (3.1)
LA	LAS	Request for order list for a specified tube (3.3)
RQ	LDV	Order list to be added to the tube order list (3.3.2)
RW	LDV	Order list to be repeated for this tube (3.3.3)
RS	LDV	Order list that will replace the tube’s order list (3.3.4)

WP	LAS	Workplace telegram (3.6)
MA	LAS	Material code telegram (**Fehler! Verweisquelle konnte nicht gefunden werden.**)
RACK_EX	LAS	Rack exchange notification (3.7)

2.3 Information block

{Information} ➔ {Tag$_1$}:{Value$_1$}|….|{Tag$_n$}:{Value$_n$}

The information block contains several information items separated by a pipe character. Every information item consists of an identifier (tag) / value pair that are separated by a colon. The sequence of the information items is arbitrary.

The following information items are defined:

Message type	Tag	Description	Mandatory
ACK	CHK	Checksum in acknowledge message	Yes
NAK	ERR	Error in acknowledge message Only ERR:CS for checksum error is allowed	Yes
	CHK	Found (wrong) checksum	No
LA	SID	Barcode (ID) for which the order list is requested	Yes
	SYS	Unique name of the automation system	No
	MAT	Unique Identifier for material or container type	No
RQ RW RS	SID	Barcode (ID) for which the order data are valid	Yes
	TST	Requested order list. Several orders (test names) are separated by comma (,). Test volumes may be submitted in parenthesis after a test name.	Yes
	NAM	Supplemental patient related data	No
	NEWID	New tube barcode for secondary tubes. This barcode will be used for daughter tubes.	No
WP	SID	Barcode (ID) of the distributed tube	Yes
	WRK	Logical distribution target name (workplace)	Yes
	TRG	Carrier ID (bar code) or carrier name at which the tube was placed	Yes
	POS	Position number at which the tube was placed	Yes
	NEWID	The barcode of the secondary tube if it is different from the primary tube.	No
	TST	Distributed tests Several orders (test names) are separated by comma (,).	No
	RVOL	Serum volume in the tube	No
	TVOL	Total available volume (all tubes)	No
	MAT	Material code	No

	ALQ	Number of Aliquot tube 0 – Primary tube, 1 – n Aliquot n	No
	SYS	Unique name of the automation system	No
MA	MAT	Unique Identifier for material or container type	Yes
	SYS	Unique name of the automation system	No
RACK_EX	TRG	Carrier ID (bar code) that has been removed	Yes
	SYS	Unique name of the automation system	No

Most of the information items that are not mandatory can be switched on and off in the Sarstedt LAS configuration.

2.4 Checksum block

The checksum is calculated by the following procedure:

1. Binary OR (XOR) of all characters after <STX> character but including the characters <CR><LF>at the end
2. Binary OR of the remaining value and 0xFF
3. OR of the remaining value increased by 1 and 0xFF
4. The remaining checksum is represented as two-digit hexadecimal number

Example:
<STX>FN:00|TYP:SYN|<CR><LF>EA<ETX>
CS1 = 0x46 XOR 0x4E XOR ……. XOR 0x0A
CS2 = CS1 XOR 0xFF
CS3 = CS2 + 1
CS = CS3 AND 0xFF

Remaining checksum: EA.

Telegram	**Hex**	**CS1**
<STX>		
F	0x46	0x46
N	0x4E	0x08
:	0x3A	0x32
0	0x30	0x02
0	0x30	0x32
|	0x7C	0x4E
T	0x54	0x1A
Y	0x59	0x43
P	0x50	0x13
:	0x3A	0x29
S	0x53	0x7A
Y	0x59	0x23
N	0x4E	0x6D
|	0x7C	0x11
<CR>	0x0D	0x1C
<LF>	0x0A	0x16
Result CS1		0x16
Result CS2	XOR 0xFF	0xE9
Result CS3	+ 1	0xEA
Result CS	AND 0xFF	0xEA

3 Message types

3.1 Acknowledge message

Every message has to be acknowledged positively or negatively by the communication counterpart. For a positive acknowledgement the receiver replies with an ACK message. This message contains the checksum of the message received previously together with the CHK information tag. Example for an ACK message:

<STX>FN:00|TYP:ACK|CHK:EA|<CR><LF>E7<ETX>

The receiver replies with a NAK message if the calculated checksum does not correspond to the checksum in the received message or if the message could not be processed successfully. The NAK message may contain the original checksum and an ERR information tag. Example for a NAK message:

<STX>FN:05|TYP:NAK|ERR:CS|CHK:B9|<CR><LF>83<ETX>

3.2 Synchronization message

A synchronization process can be initiated from both communication participants, i.e. when the communication has been broken (see 3.7). It is always started by each of the participants after a system start occurred and before the first message is send to the other system. The receiver must respond with an acknowledge telegram.
If a synchronization message is not acknowledged within a adjustable time span, the SYN message is re-send several times (default: 3). If a positive acknowledgement is not received after these steps, the communication should pause for a while until the next synchronization loop is initiated.

Example where synchronization from LAS to LIS is successful at the third try:

LAS: **<STX>FN:00|TYP:SYN|<CR><LF>EA<ETX>**
LIS:
LAS: **<STX>FN:01|TYP:SYN|<CR><LF>E9<ETX>**
LIS: **<STX>FN:05|TYP:NAK|ERR:CS|CHK:EA|<CR><LF>FF<ETX>:**
LAS: **<STX>FN:02|TYP:SYN|<CR><LF>EC<ETX>**
LIS: **<STX>FN:06|TYP:ACK|CHK:EC|<CR><LF>E3<ETX>**

3.3 Messages for query mode

3.3.1 Request for order list

In query mode, after a new tube has been identified by the Sarstedt LAS it sends an order request message (TYP:LA) to the LIS. This message contains the barcode of the tube.

Example for order request telegram:

LAS: **<STX>FN:03|TYP:LA|SID:42837383|<CR><LF>BA<ETX>**
LIS: **<STX>FN:06|TYP:ACK|CHK:BA|<CR><LF>E8<ETX>**

The LIS must confirm this request immediately with an ACK telegram. As soon as the order data for the barcode requested are available, the LIS should send a list of all orders (using the TST information tag) that are scheduled for distribution for tubes with the same barcode. The LIS can transmit the order list using more than one telegram. By the TYP

information tag the LIS can define how the new order list is treated at the sample distributor. This is useful if the LAS already received an order list for the same barcode previously.

If more than one Sarstedt Automation system is installed or if the LAS may operate in different modes, the request for order message usually contains the SYS information tag. Using the information in this tag the LIS is able to identify the exact system and the operation mode used at time when the tube was identified.

3.3.2 TYP:RQ

Only new orders will be added to the tube's order list. Any submitted orders that has been finished already with an previous tube will be ignored.
Example:

1. Tube:	Order list:	TST:T1,T2,T3,T4
	Finished:	T1,T2
2. Tube:	Order list:	TST:T1,T2,T3,T4,T5
	New list:	T3,T4,T5

Using the TYP:RQ message the LIS can assign new orders i.e. for doing additional tests to tubes that are processed a second time on the LAS (re-runs).

3.3.3 TYP:RW

Every order that is submitted in the new order list is assigned to the tube regardless whether the order has been already finished with previous tubes.
Example:

1. Tube:	Order list:	TST:T1,T2,T3,T4
	Finished:	T1,T2
2. Tube:	Order list:	TST:T1,T2,T3,T4,T5
	New list:	T1,T2,T3,T4,T5

Using the TYP:RW message the LIS can order re-runs of tests to tubes that are processed a second time on the LAS (order repetition).

3.3.4 TYP:RS

The order list submitted in the message will replace any old order list. All old orders that are not finished yet will be deleted.
Example:

1. Tube:	Order list:	TST:T1,T2,T3,T4
	Finished:	T1,T2
2. Tube:	Order list:	TST:T5,T6
	New list:	T5,T6

Using the TYP:RS message the LIS can reset the order list on the LAS.

3.3.5 Common syntax

Beside the type identifier all order list messages have the same structure. The message must have the SID item (unique tube ID) and the TST item (list of orders). If the LIS has no orders, the order list has to be empty. Optional it is possible to send a patient identifier (NAM item) and the test volumes (in parenthesis after each test name). The LAS will use the volume values only, if the distribution function of the target workplace is selected accordingly. The unit of all volume values are µl.

Example: Order request with patient name, message type: RQ
LAS: <STX>FN:03|TYP:LA|SID:42837383|<CR><LF>BA<ETX>
LIS: <STX>FN:01|TYP:ACK|CHK:BA|<CR><LF>E1<ETX>
....
LIS: <STX>FN:02|TYP:RQ|SID:42837383|NAM:Robels|TST:FE,GE,CREA|<CR><LF>97<ETX>
LAS: <STX>FN:04|TYP:ACK|CHK:97|<CR><LF>E9<ETX>

Example: Order request with test volumes, message type: RS
LAS: <STX>FN:05|TYP:LA|SID:42836483|<CR><LF>BA<ETX>
LIS: <STX>FN:03|TYP:ACK|CHK:BA|<CR><LF>E3<ETX>
....
LIS: <STX>FN:04|TYP:RS|SID:42836483|TST:KC(600),BC(300)|<CR><LF>82<ETX>
LAS: <STX>FN:06|TYP:ACK|CHK:82|<CR><LF>EF<ETX>

Example: Order request with empty test list, message type: RW
LAS: <STX>FN:11|TYP:LA|SID:0473|<CR><LF>B9<ETX>
LIS: <STX>FN:09|TYP:ACK|CHK:B9|<CR><LF>91<ETX>
....
LIS: <STX>FN:10|TYP:RW|SID:0473|TST:|<CR><LF>A5<ETX>
LAS: <STX>FN:12|TYP:ACK|CHK:A5|<CR><LF>96<ETX>

3.3.6 Specification of barcodes for secondary tubes

Using the NEWID item the LIS can define a new barcode for secondary tubes that is different to the primary tube's barcode. This item is not mandatory. If it is missing, the secondary tube receives the barcode of the corresponding primary tube.
The NEWID item is valid for all orders that are submitted in the same message. In order to define different barcodes for various orders, the order list has to be divided on several messages.
Usually the Sarstedt lab automation system is able to distribute some orders as well with primary tubes as with secondary tubes. The individual method is selected by the system automatically without considering the NEWID tag. The lab automation system use the NEWID tag only, if the order is actual carried out using a secondary tube.

Example: Order request with a unique barcode for secondary tubes
LAS: <STX>FN:01|TYP:LA|SID:42837383|<CR><LF>BC<ETX>
LIS: <STX>FN:01|TYP:ACK|CHK:BC|<CR><LF>E3<ETX>
...
LIS: <STX>FN:02|TYP:RQ|SID:42837383|TST:FE,GE,CREA|NEWID:428373831|<CR><LF>94<ETX>
LAS: <STX>FN:02|TYP:ACK|CHK:94|<CR><LF>EE<ETX>

All secondary tubes will receive the same barcode: 428373831

Example: Order request with different barcodes for secondary tubes
LAS: <STX>FN:01|TYP:LA|SID:42837383|<CR><LF>BC<ETX>
LIS: <STX>FN:01|TYP:ACK|CHK:BC|<CR><LF>E3<ETX>
...
LIS: <STX>FN:02|TYP:RQ|SID:42837383|TST:FE|NEWID:428373831|<CR><LF>85<ETX>
LAS: <STX>FN:02|TYP:ACK|CHK:85|<CR><LF>EE<ETX>
LIS: <STX>FN:03|TYP:RQ|SID:42837383|TST:GE|NEWID:428373832|<CR><LF>88<ETX>
LAS: <STX>FN:03|TYP:ACK|CHK:88|<CR><LF>E2<ETX>
LIS: <STX>FN:04|TYP:RQ|SID:42837383|TST:CREA|NEWID:428373833|<CR><LF>97<ETX>
LAS: <STX>FN:04|TYP:ACK|CHK:97|<CR><LF>E9<ETX>

The secondary tubes will receive different barcodes with respect to their orders.

3.3.7 Supplemental patient related data

Using the NAM item LIS can define optional patient related data. This data is not used for distribution. However, this data is assigned to the corresponding barcode and it is used for creating the label of the aliquot tubes.

Within the NAM item up to 30 different data fields can be put in separated by a distinct delimiter character. The default delimiter character is the caret „^“:

….|NAM:field01^field02^field03^…….^field30|….

The meaning of the distinct fields 01..30 can be defined by the LIS vendor.

Examples for valid NAM items:
…|NAM:Jane Doe^01/01/2011^M^Routine^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^|…
…|NAM:John Doe^01/01/2011^M|…

3.4 Messages for batch mode

In batch mode the Sarstedt LAS does not send query messages. Using the RQ, RW and RS messages described above, the LIS can send order data as soon as they are available for a distinct barcode. By the TYP information tag the LIS defines how the new order list is treated in regards of data that were send before.
If the LAS accepts the order list, the telegram is confirmed by an ACK telegram. Otherwise the LAS responds with a NAK telegram.

3.5 Material code message

The Sarstedt lab automation system is able to sort tubes according to the material (i.e. derived from the exact tube type). In this case the system will not send a request for orders according to chapter 3.3 to the LIS. Using the MA message however, the system can inform the LIS about the barcode and the material code of each tube that is identified by the system. Sending the MA telegram is supplemental.

Example for MA message:
LAS: <STX>FN:03|TYP:MA|SID:42837383|MAT:09|<CR><LF>B6<ETX>
LDV: <STX>FN:50|TYP:ACK|CHK:B6|<CR><LF>94<ETX>
To the tube with barcode 42837383 the material code identifier 09 was assigned.

The material code identifier (i.e. 09) and their relation to a certain material or tube type are defined within the LAS configuration.

3.6 Workplace message

The LAS is able to send a workplace message whenever a tube (primary or secondary) is distributed. This message is optional and has to be switched on at the Sarstedt system if necessary.
Every workplace message contains the SID, WRK, TRG and POS information items. With the WRK tag the system submits the name of the logical distribution target that is called

workplace in the Sarstedt terminology. The TRG tag defines the target carrier (rack) and the POS tag defines the position number on this rack.
Optional the workplace message can contain the TST tag and the TVOL / RVOL tags. With the TST tag the order names assigned to the workplace is submitted and with the TVOL / RVOL tags the totally available volume and the serum volume information of the tube are submitted.

The SID tag always contains the primary tube's barcode. However, if the barcode of a secondary tube is different from the primary tube, the new barcode is submitted with the NEWID tag as well.

Example: Workplace message without additional data
LAS: <STX>FN:34|TYP:WP|SID:4200006|WRK:KC|TRG:HIT_KC|POS:010|<CR><LF>BC<ETX>
LIS: <STX>FN:30|TYP:ACK|CHK:BC|<CR><LF>E1<ETX>
A tube with ID 4200006 was placed on a rack named HIT_KC at position 10. The name of the logical distribution target is KC.

Example: Workplace message with order list
LAS:
<STX>FN:40|TYP:WP|SID:0100008|WRK:KC|TRG:HIT_KC|POS:011|TST:Bor|<CR><LF>FB<ETX>
LIS:
<STX>FN:36|TYP:ACK|CHK:FB|<CR><LF>E4<ETX>
A tube with ID 0100008 was placed on the rack HIT_KC at position 11. The name of the logical distribution target is KC. The corresponding order is Bor.

Example: Workplace message with volume data
LAS:
<STX>FN:54|TYP:WP|SID:1234|WRK:KC|TRG:HIT|POS:012|RVOL:600|TVOL:1068|<CR><LF>E4<ETX>
LIS:
<STX>FN:50|TYP:ACK|CHK:E4|<CR><LF>97<ETX>
An aliquot of 600µl was taken from the primary tube with ID 1234. The secondary tube was placed on rack HIT at position 12. The logical distribution target is KC. The totally available volume is 1068µl.

Example: Workplace message for secondary tube with new barcode ID
LAS:
<STX>FN:31|TYP:WP|SID:1230|NEWID:1234|WRK:KC|TRG:HIT_KC|POS:010|<CR><LF>9EC<ETX>
LIS:
<STX>FN:31|TYP:ACK|CHK:9E|<CR><LF>9D<ETX>
An aliquot was made from the primary tube with ID 1230. The secondary tube has the barcode ID 1234 and was placed on rack HIT_KC at position 10. The logical distribution target is KC.

Example: Workplace message with material code
LAS:
<STX>FN:32|TYP:WP|SID:0100008|WRK:SERUM|TRG:HIT|POS:011|MAT:09|<CR><LF>A2<ETX>
LDV:
<STX>FN:36|TYP:ACK|CHK:A2|<CR><LF>95<ETX>
The tube with ID 0100008 was placed on rack HIT at position 11. The logical distribution target is SERUM. The material identifier for this tube is 09.

3.7 Rack Exchange notification

If needed by the LIS the LAS can send a notification message at the time a carrier (rack) is removed from the system by the operator. However, this message is sent only if the operator did enter an ID (bar code) for this rack at the time it was placed on the LAS.

Example: Rack exchange notification
LAS:
<STX>FN:33|TYP:RACK_EX|TRG:123456|SYS:LAS1_MODE1|<CR><LF>EA<ETX>
LDV:
<STX>FN:37|TYP:ACK|CHK:EA|<CR><LF>E3<ETX>
A rack with bar code id 123456 was removed from LAS system identified by LAS1_MODE1.

4 Error treatment

Any message send by the LAS that is not acknowledged positively within a certain time span will be send again several times (default: 3 times). This is also true for messages that are followed by a NAK message.
If the retry counter reaches the max allowed value without success, the communication is treated as broken. In this case the LAS will initiate a synchronization process (3.4).
The LAS system will stop working only, when the communication with the LIS is broken and the synchronization was not successful. In this case the system will show an error message.
The communication will restart if a new synchronization process is started manually and finished successfully.

Minor communication errors are not notified (i.e. wrong protocol frame, wrong checksum within the re-try limits, unknown barcode ID). However, if a certain tube will not receive a valid order list due to these errors, it is distributed to a distinct error target. Therefore the operation of the LAS is not impacted by communication errors that occurs occasionally.

5 Document History

Version	Date	Author	Description
V2.01e	21.01.2008	UR	New document based on German version V2.01
	28.04.2008	UR	Spelling correction
V2.02	29.10.2008	UR	MA message and MAT identifier added
V2.03	30.09.2009	UR	Naming changed
V2.04	11.01.2012	UR	Detailed description of NAM item added
V2.05	05.12.2013	UR	Description of NAM item changed
V2.06	03.02.2015	UR	Clarification of communication protocol Clarification of query mode and batch mode New identifier SYS added
V2.07	28.09.2016	UR	Added new information tags New rack exchange notification added: RACK_EX
V2.08	17.06.2019	NW	Reformulated chapter 1. General