Honeywell Enraf

Instruction manual
VITO

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VITO

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Preface

This manual is intended for technicians involved with the commissioning and service of the Honeywell Enraf instruments.

A description preceding the technical procedures gives the technical information necessary to understand its functioning. It is recommended to read this description prior to performing any of the procedures.

Safety an prevention of damage

Refer to the chapter Safety in the instruction manual of the applicable instrument (servo/radar gauge or indicator) for detailed safety instructions.

"**Warnings**", "**Cautions**", and **Notes** have been used throughout this manual to bring special matters to the immediate attention of the reader.

- A **Warning** concerns danger to the safety of the technician or user;
- A **Caution** draws attention to an action which may damage the equipment;
- A **Note** points out a statement deserving more emphasis than the general text, but does not deserve a "Warning" or a "Caution".

The sequence of steps in a procedure may also be important from the point of view of personal safety and prevention of damage; it is therefore advised not to change the sequence of procedure steps or alter a procedure.

Legal aspects

The commissioning and trouble shooting to the instrument may only be conducted by qualified engineers, trained by Honeywell Enraf and with knowledge of safety regulations for working in hazardous areas.

Enraf B.V. disclaims any responsibility for personal injury or damage to equipment caused by :

- Deviation from any of the prescribed procedures;
- Execution of activities that are not prescribed;
- Neglect of the general safety precautions for handling tools and use of electricity.

EC declaration of conformity

The Honeywell Enraf instrument is in conformity with the protection requirements of EC Council Directive 89/336/EC. Refer to EC declaration of conformity delivered with the instrument or to the installation guide of the instrument.

Additional information

Please do not hesitate to contact Honeywell Enraf or its representative if you require any additional information.

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1 Average temperature measurement with Vito temperature probes

1.1 Introduction

Honeywell Enraf's portfolio for average temperature measurement consists from the following probes:

- 764 VITO temperature probe (MTT 16);
- 766 VITO water and temperature probe (MTT 16);
- 767 VITO temperature probe (MTT 9)
- 768 VITO water and temperature probe (MTT 9)

The measuring range (MK) of a probe is defined as the distance from the reference element / Pt100, which is always positioned at 1m from the bottom of the probe, to the position of the highest element.

Refer to figure 1.1 & 1.2.

1. The VITO MTT **764C** probe comprises 16 measuring elements and has its lowest element positioned at 1m from the bottom of the probe. Its 16 elements are subsequently equally divided from the reference resistor up to the highest element.

2. The VITO MTT **764D** probe comprises 16 measuring elements and has its lowest element positioned at the bottom of the probe. The remaining 15 elements are subsequently equally divided from the reference resistor up to the highest element.

3. The VITO MTT **766C** probe comprises a water probe & 16 measuring elements and has its lowest element positioned at 1m from the bottom of the probe. Its 16 elements are subsequently equally divided from the reference resistor up to the highest element.

4. The VITO MTT **766D** probe comprises a water probe & 16 measuring elements and has its lowest element positioned at the bottom of the probe. Its remaining 15 elements are subsequently equally divided from the reference resistor up to the highest element.

5. The VITO LT **767C** probe comprises 9 measuring elements and has its lowest element positioned at 1m from the bottom of the probe. Its 9 elements are subsequently equally divided over the from the reference resistor up to the highest element.

6. The VITO LT **767D** probe comprises 9 measuring elements and has its lowest element positioned at the bottom of the probe. The remaining 8 elements are subsequently equally divided over the from the reference resistor up to the highest element.

7. The VITO LT **768C** probe comprises a water probe & 9 measuring elements and has its lowest element positioned at the 1m from the bottom of the probe. Its 9 elements are subsequently equally divided from the reference resistor up to the highest element.

8. The VITO LT **768D** probe comprises a water probe & 9 measuring elements and has its lowest element positioned at the bottom of the probe. The remaining 8 elements are subsequently equally divided from the reference resistor up to the highest element.

1.2 Commissioning of average temperature measurement

The wiring sequence of all blue thermocouple wires is only measured once at start-up and the information is stored in the memory. The time required to complete all thermocouples measurements after powering up the instrument is approximately 2 minutes.

The commissioning of the optional average temperature part should be performed after the basic commissioning of the level gauge or indicator.

1.2.1 Average temperature settings

Before programming the temperature data, the sensitive length and the offset of the temperature probe must be known.

The sensitive probe-length is equal to the total probe length minus spacing for installation (700mm) and minus 1m in case of version C. Standard, the measuring ranges are:

- For C version probes (model code ……C
<he>): overall length – 1700mm.
- For D version probes (model code ……D
<he>): overall length – 700mm.

Other (smaller) measuring ranges (sensitive lengths) are possible: check on identification label of the VITO probe (or MTT) for the positioning of the highest element (last 4 digits; units: cm).

The offset is the distance from the lowest element to the tank's zero point (datum plate). The 764/767 VITO temperature sensor and 766/768 water and temperature sensor can have the lowest element on different places. This is identified on the instrument label:

- …..764 C <he> lowest element at 1 m from bottom of probe;
- …..764 D <he> lowest element at 0.065 m from lower end of probe;
- …..766 C <he> lowest element at 1 m from bottom of probe; depends on WaterProbe
- …..766 D <he> lowest element at 0.065 m from lower end of probe;
- …..767 C <he> lowest element at 1 m from bottom of probe;
- …..767 D <he> lowest element at 0.065 m from lower end of probe;
- …..768 C <he> lowest element at 1 m from bottom of probe; depends on WaterProbe
- …..768 D <he> lowest element at 0.065 m from lower end of probe;

Note:
In the model code given above a dot '.' Represents any character, the notation <ol> means: overall length (4 positions) and the notation <he> means: position of highest element (4 positions).

The position of the lowest element can also be verified by requesting the VITO device type & s/w version by means of items **VP** and **VV**, provided you know if a 764, 766, 767 or VITO 768 sensor is connected.

Refer to the table below how to obtain data with the temperature pointer items:

Item **VP**	Item **VV**	sensor model code
VP=03.10	VV: 764 C	…. 764 C <he>
	VV: 764 D	…. 764 D <he>
	VV: 767 C	…. 767 C <he>
	VV: 767 D	…. 767 D <he>
VP=03.10	VV: 766 C	.A..766 C <he>
	VV: 766 D	.A..766 D <he>
	VV: 768 C	.A..768 C <he>
	VV: 768 D	.A..768 D <he>

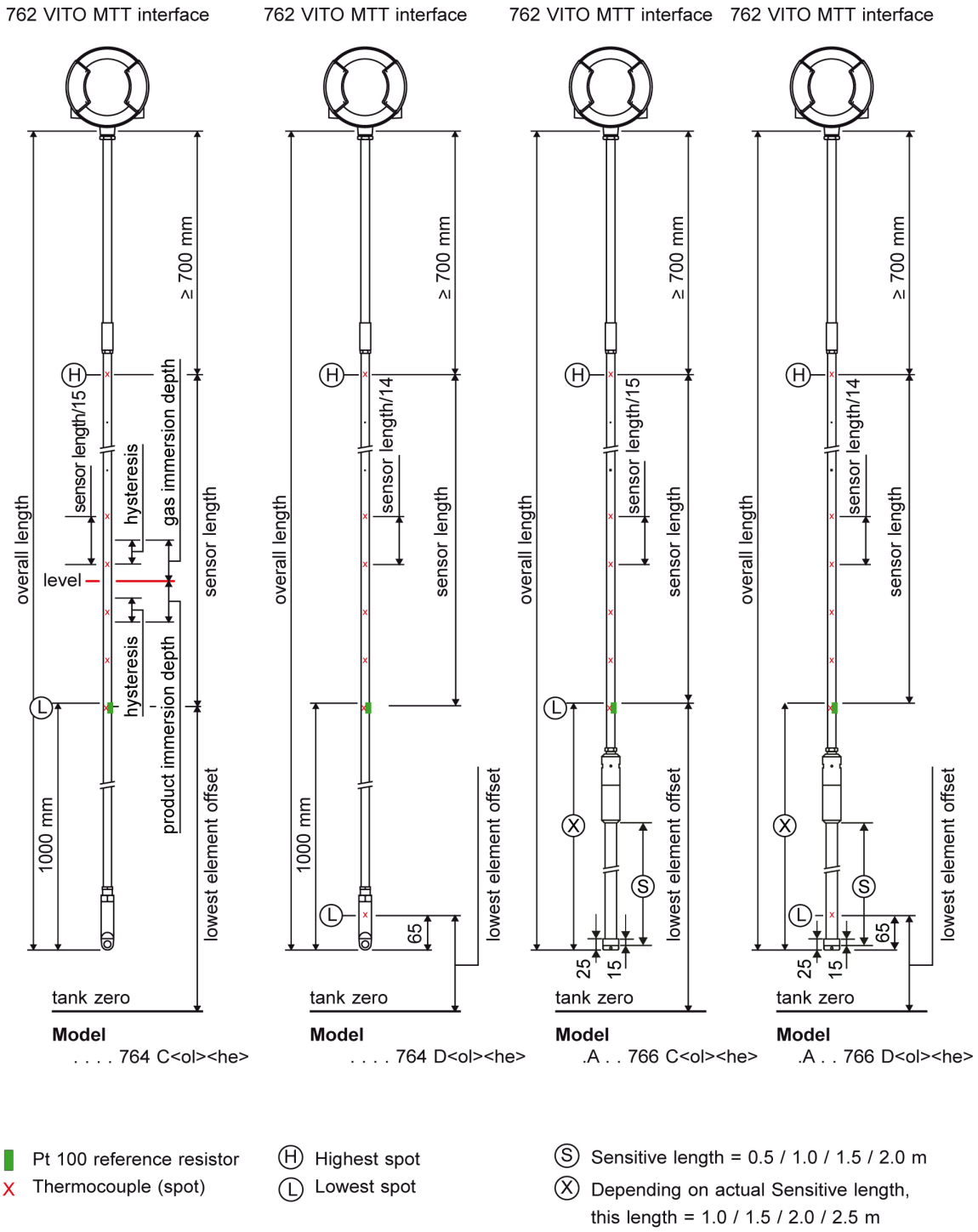


Figure 1.1 Tank and temperature probe data

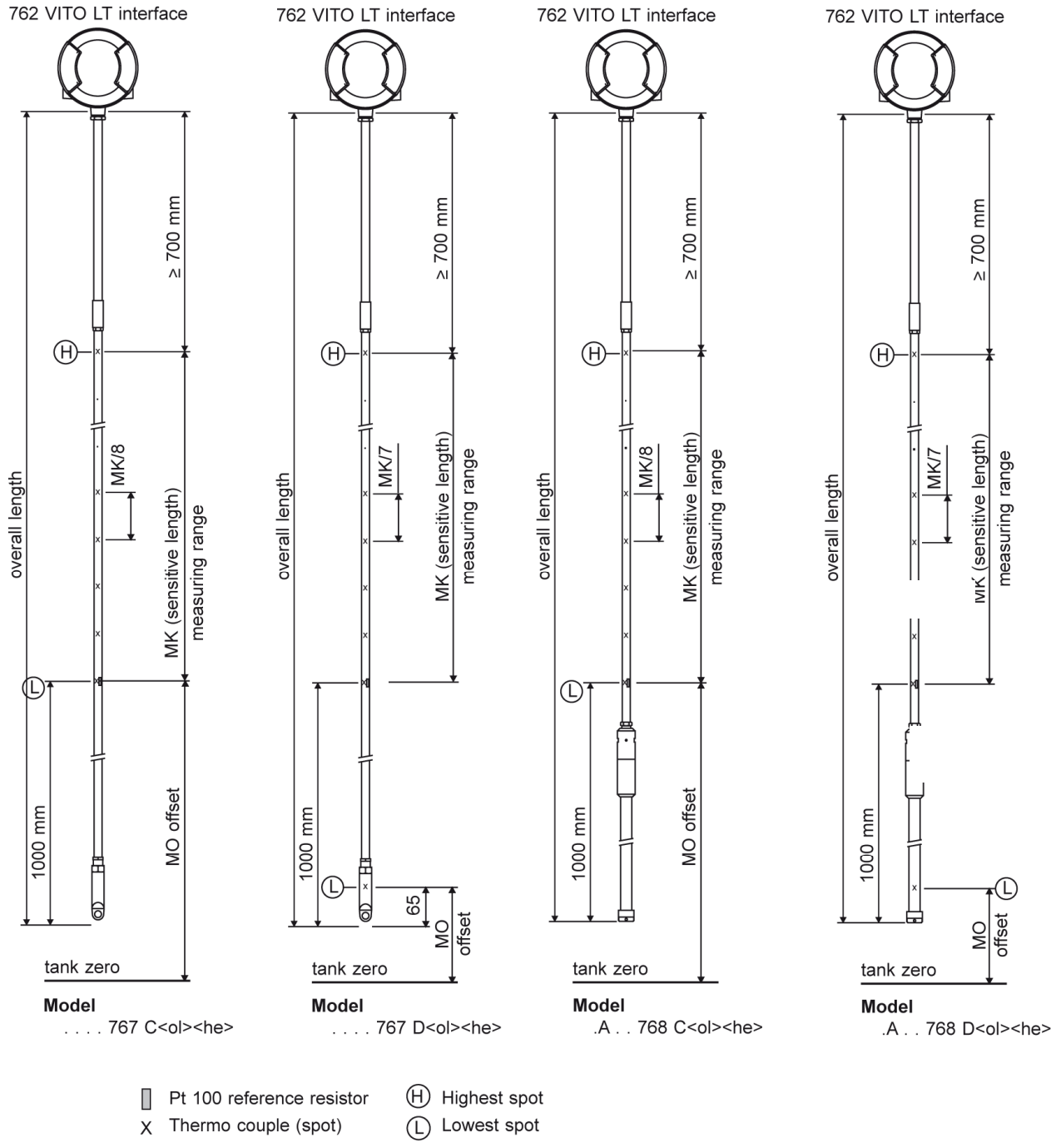


Figure 1.2 Tank and temperature probe data

Refer to figure 1.1 & 1.2

Item	Name	Description
W2=	Protection level 2	Enter protection level 2
TD=	Temperature dimension	One character; either 'C' or 'F'. Default set to C. C: degrees Celsius F: degrees Fahrenheit Both dimensions have the same format.
MK=	Sensitive length temperature Probe	Format according to item **LD** (default: +030.000) Refer to the description in section 1.2.1 about the Sensitive length (measuring length) of the temperature Probe. Enter that value in item **MK**.
MO=	Temperature element offset	Format according to item **LD** (default:+000.0000). Item **MO** represents the distance from tank zero (datum plate) to the lowest element (spot) in the sensor. The lowest element in the sensor depends on the type of temperature sensor. Refer to the instrument label and figure 1.2 The location of the lowest element can also be found by requesting item **VV** (with **VP**=03.10).
MI=	Switch hysteresis	Format according to item **LD** (default: +000.1000 m) The distance **MI** is a hysteresis around the switching point of the temperature elements.
MP=	Product immersion depth	Format according to item **LD** (default: +000.5000 m) The distance **MP** specifies the minimum required liquid level above a thermocouple before it is taken in the average product temperature calculation.
MG=	Gas immersion depth	Format according to item LD (default: +000.5000 m for 854/970/971/973 and +000.1000 m for 877). The distance **MG** specifies the minimum required distance below a thermocouple before it is taken in the average gas temperature calculation.
WP=	Water probe length	Format according to item **LD** (default: + 001.0000 m) The water probe length is required to calculate the sensitive length temperature probe (Item MK)
TU=	Temperature status conversion	One character (default: 'T') This item is used to indicate the temperature status character in case of a reduced or not guaranteed temperature accuracy. This is the case when the temperature status is: • out of specified temperature range • exceeding differential temperature range • last valid level used • manual level used • level below lowest temperature element If required, this item can be set to another character.
EX	Exit	Exit protection level 2.

With all "**D**" version temperature probes it is thereby possible to exclude the lowest spot element from the average temperature calculation. This can be done by setting the first position in item **MW** to 'F'. In fact, with item **MW** any spot temperature element (or more spots) can be disabled from average temperature calculation.

Item	Name	Description
W2=	Protection level 2	Enter protection level 2
MW=	MTT wiring connection	Sixteen hexa-decimal characters; default: 0000000000000000 When one (or more) of the elements must be disabled from average temperature calculation, set the desired position to 'F' For instance, to disable lowest spot element: MW=F000000000000000 ***Note:*** *When entering item MW with the Portable Enraf Terminal, the display will be cleared after entering the 15th character. Continue with entering the last character and press return. All 16 entered characters will be repeated at the top line of the PET.*
EX	Exit	Exit protection level 2

1.2.2 Additional temperature settings for 877 FDI

Item	**Name**	**Description**
W2=	Protection level 2	Enter protection level 2
TF=	Temperature source Selection	One ASCII character; either 'I' or 'E'. this item selects if there is a temperature measurement inside the indicator (internal) or to be fetched from the Enraf field bus (external). I: Internal E: External
EX	Exit	Exit protection level 2

1.3 Operation

1.3.1 Display

For operation of the display and the information on it (if applicable), refer tot the instruction manual of the related level gauge or indicator. Below, only an overview is given which display formats gives information about the average temperature measurement.

Display format	Displayed information
A	Product level and average product temperature
C	Average gas temperature and status
D	Average product temperature and status

1.3.2 Data items

The table below lists a number of data items. They contain measured data, verification data and error data. The verification data can be used to check the results of certain steps in the measuring sequence. The temperature status indicates the validity of the measured data. The error data provides low level error information about the temperature measurement (refer to section 1.4).

Item	Description	
AG	Measured/	Average gas temperature
AP	Calculated data	Average product temperature
MQ		Temperature status request (refer to section 2.4.2)
MU		Measured test resistance (floating point format); Must be: 166.5 Ω ± 0.03%
U0 – UF		Calculated spot positions (see below)
V0 - VF		Spot temperatures (see below)
RW	Thermocouple wiring connection sequence	
EM	Diagnostic data	Error request (refer to section 2.4.1).
FH		Fatal errors
F0		Last fatal error

Item **V0** is the temperature of the lowest spot element.
The calculated spot position item **U0** corresponds with item V0.
Refer to figure 2.2 to locate the lowest spot (L) with each particular temperature probe model.

1.4 Troubleshooting

1.4.1 Temperature error request (item EM)

This item helps you configuring correctly by the most recent temperature error encountered by the option board.

xxoo	no error, value at initialisation	
xx11	no reply on initial HART commands	communication error. Check connection level gauge – 762 VITO interface, or change 762 VITO interface or option board.
xx50	Pt100 (or spot 0) error	Brown wire connected to CN1 A-1 (or orange wire connected to CN2B-1) not connected .
xx51	spot 1 (or Pt100) error	Blue wire to CN2B-1 (or brown wire to CN1A-1) not connected
xx52	Spot 2 error	Blue wire to CN2A-2 not connected
xx64	Spot 14 error	Blue wire to CN5A-2 not connected
xx65	Spot 15 error	Yellow wire to CN5A-1 not connected
xx70	Sub-system error	Data from 762 VITO not valid. Reset instrument; if error persist, replace 762 VITO interface
xx71	Wrong probe connection	Thermocouple wires of VITO sensor connected wrongly (blue and yellow wires)
xx77	Wrong Pt100 connection	Brown and red wires of VITO sensor connected wrongly
xx80	R_{test} error	Measurement on test resistor failed. Reset instrument; if error persist replace 762 VITO
xx84	Standard deviation too large	EMC influence (check cable shields) or defective 762 VITO interface
xx92	No data available	Communication error between 762 VITO interface and level gauge. Check wiring; replace 762 VITO interface or option board.
xx98	No temperature sources found	No VITO temperature probe (and no RTD) connected
xx:	22 for MPU emulation	With error codes xx50 to xx65, connector numbers are mentioned
	24 for HPU emulation	Refer to installation guide 762 VITO interface 764,765,766, 767 or 768 VITO
	30 for HCU emulation	Temperature and/or water bottom probe for location of these connectors.

1.4.2 Temperature status request (Item MQ)

Temperature status request item contains four status bytes (Byte 0, Byte 1, Byte 2, Byte 3) of the option board. For decoding, refer to the ASCII table in appendix A.

Status byte 0:
Contains the characters '0' ÷ 'F', indicating the highest immersed spot element of the temperature probe.
At start up: 'I'.

Status byte 1:
Bit 0: General temperature fail
- 1: Fail in average product temperature
- 2: Fail in average gas temperature
- 3: Level exceeds lowest spot element
- 4: Level exceeds highest spot element
- 5: Spot element fail (one or more spots defect)
- 6: 1
- 7: 0

Status byte 2:
Bit 0: Last valid level used
- 1: Manual level used
- 2: Level time out
- 3: Device not calibrated
- 4: Exceeding differential temp, range
- 5: Out of specified temperature range
- 6: 1
- 7: 0

Status byte 3:
Bit 0: No previous store command
- 1-5: 0
- 6: 1
- 7: 0

Note:
Only the bits which are set to '1' have an active status.

2 Average temperature measurement with MRT

2.1 General

The 762 VITO MRT temperature selector is used for interfacing an Multiple Resistance Thermometer (MRT). This unit is basically a solid state electronic element selector, containing all hardware necessary for selecting and measuring an MRT with up to 13 temperature elements with one spot element.

2.2 Operating principle

Since most liquids, stored in storage tanks, are not homogeneous in temperature, an average temperature measurement over the entire liquid column is required. A Multiple Resistance Thermometer can provide this true average temperature measurement.

An MRT comprises a number of resistance elements of different lengths, all starting near the tank bottom. To measure the average product temperature, the longest fully immersed element is automatically selected and its temperature measured.

The average gas temperature is calculated by measuring the temperature of the longest resistance thermometer element and subtracting the contribution of the average product temperature.

The operational board located in the 854 level gauge, 877 FDI or 97x radar, selects the longest immersed element for the average product temperature calculation.

2.3 Commissioning

The commissioning of the optional board should be performed after the basic commissioning of the level gauge, radar gauge or indicator. The items mentioned in this section resides under protection level 2.

2.3.1 Format critical items

When the temperature dimension and/or the decimal separator has to be changed, it should be done at the start of the commissioning.

Item	Name	Description
TD	Temperature dimension	One ASCII character, either “C” or “F” • C: degrees Centigrade • F: degrees Fahrenheit Both dimensions have the same format: sign XXX sep XX Where: Sign: + or – X : digit Sep: decimal separator (“.” Or “,”)
DP	Decimal separator	One ASCII character; either “.” (point) or “,” (comma). If the instrument is equipped with an XPU 2 board, all related items are automatically converted. With an XPU board, all items depending on the temperature, level, density and pressure format have to be re-programmed with the correct decimal separator.

2.3.2 Temperature related settings

Item	Name	Description
J0 - JD	MRT element position.	J0 through JD represent the distance from the end of the probe (nearest to tank zero level) to the MRT element if selected by item [MJ].
MJ	Multi temperature distribution	This item determines whether fixed element positions are taken (=F=default) or configurable element positions (=T) via ithe items J0 .. JD. The fixed element positions are described at item U0 .. UD.
MT	Element type	Three ASCII characters (C3 C2 C1). Selects the element type connected to the 762 VITO MRT, with its characteristics. C3 R refers to an MRT without spot element Q refers to an MRT with spot element C2 C1 CB Rth = 90.2935 + T x 0.38826 (-100 ÷ +280 °C) CN Rth = 90.4778 + T x 0.38090 (-100 ÷ +280 °C) CS Rth = 90.5000 + T x 0.38730 (-100 ÷ +280 °C)
MN	Number of elements	Two ASCII digits. This item specifies the number of elements from the MRT, inclusive the spot element. The maximum number of elements is 13.

Refer to figure 2.1

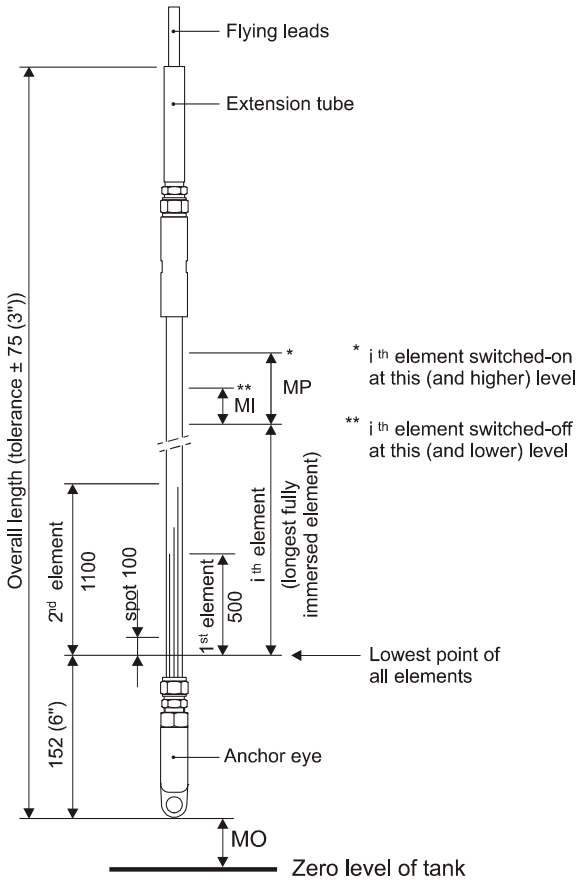


Figure 2.1 MRT definition

Item	Name	Description
MO	Temperature element offset	Format according to item LD. The offset represents the distance form the tank zero level to the lowest position of the MRT. ***Note:*** *Incase of ullage measurement, distance MO is taken from The upper reference point.*
MI	Switch hysteresis	Format according to item **LD**.The distance **MI** is a hysteresis around the switching point of the temperature elements.
MP	Product immersion depth	Format according to item **LD**.The distance **MP** specifies the minimum required liquid level above a element before it is selected for the average product temperature calculation
MG	Gas immersion depth	Format according to item L**D**.The distance **MG** specifies the minimum required distance before the resistance value of the longest element is taken in the average gas temperature calculation
TU	Temperature status conversion	One character (default: 'T') This item is used to indicate the temperature status character incase of a reduced or not guaranteed temperature accuracy. This is the case when the temperature status is: • out of specified temperature range • exceeding differential temperature range • last valid level used • manual level used • level below lowest temperature element

2.3.3 Additional settings for and 877 FDI

Item	Name	Description
TF=	Temperature source Selection	One ASCII character; either 'I' or 'E'. this item selects if there is a temperature measurement inside the indicator (internal) or to be fetched from the Enraf field bus (external). I: Internal E: External

2.3.4 Data items

There are of number of data items for the measured temperature, checks and status information. These data items are:

Item	Name	Description
AP	Average product temperature	This item contains the average product temperature, calculated from the longest immersed element. It is preceded by four status bytes from item **MQ**.
AG	Average gas temperature	This item contains the average gas temperature, calculated from the longest element reduced with the average product temperature influence. It is preceded by four status bytes from Item **MQ**.
MQ	Temperature status request	This item contains four bytes with temperature status information. For description of the status, refer to chapter 2.2
MU	Test resistance	The measured test resistance in floating point format The value should be 166,5 ohm ± 0.03%
U0 ÷ UD	Calculated element	Format according to item LD. These items gives the position of each element with respect to the lowest part of the MRT. **U0** : position of 1st element (0.25 m or 0.65 m or [J0]) **U1** : position of 2nd element (0.65 m or 1.25 m or [J1]) **U2** : position of 3th element (1.25 m or 1.95 m or [J2]) **U3** : position of 4th element (1.95 m or 2.85 m or [J3]) **U4** : position of 5th element (2.85 m or 4.15 m or [J4]) **U5** : position of 6th element (4.15 m or 5.65 m or [J5]) **U6** : position of 7th element (5.65 m or 7.35 m or [J6]) **U7** : position of 8th element (7.35 m or 9.25 m or [J7]) **U8** : position of 9th element (9.25 m or 11.65 m or [J8]) **U9** : position of 10th element (11.65 m or 14.65 m or [J9]) **UA** : position of 11th element (14.65 m or 18.45 m or [JA]) **UB** : position of 12th element (18.55 m or 22.95 m or [JB]) **UC** : position of 13th element (22.95 m or 29.65 m or [JC]) **UD** : position of 14th element (29.65 m or [JD])
V0 ÷ VD	Element temperatures	Format according to item **TD**. These 14 items contains the temperature of each element. **V0** : temperature of 1st element **V1** : temperature of 2nd element | | **VD** : temperature of 14th element
YP	Stored average prod. Temp.	Format according to item **TD**. Stored product temperature, copied from item **AP**, after an **ST** command was given.

2.4 Error codes

2.4.1 Temperature error HCU/HPI (item EM)

This item helps you configuring correctly by showing the most recent temperature error encountered by the option board.

xx00	no error
xx50	Element 1 detected absent
xx51	Element 2 detected absent
xx52	Element 3 detected absent
xx53	Element 4 detected absent
xx54	Element 5 detected absent
xx55	Element 6 detected absent
xx56	Element 7 detected absent
xx57	Element 8 detected absent
xx58	Element 9 detected absent
xx59	Element 10 detected absent
xx60	Element 11 detected absent
xx61	Element 12 detected absent
xx62	Element 13 detected absent
xx63	Element 14 detected absent

xx70	sub-system error. Check or replace VITO
xx72	not supported element type. Check item MT
xx73	wrong element configuration. Check item MN
xx80	R test error (out of limits)
xx81	R cable error (out of limits)
xx84	standard deviation too high
xx91	Wrong J0 .. JD setting. Check these items.
xx92	no data available. Check wiring or connection with VITO

xx22	for MPU emulation
xx24	for HPU emulation
xx30	for HCU emulation

2.4.2 Temperature status request (item MQ)

Four bytes status information (B0 B1B2 B3) with the following meaning:

Status byte 0:
Contains the characters ‘0’ ÷ 'D', indicating the highest immersed element of the MRT. At start up this is: ‘I’.

Status byte 1:
Bit 0: general temperature fail
1: fail in average product temperature
2: fail in average gas temperature
3: level exceeds lowest element
4: level exceeds highest element
5: element fail (one or more elements defect)
6: 1
7: 0

Status byte 2:
bit 0: last valid level used
1: manual level used
2: 0
3: 0
4: 0
5: 0
6: 1
7: 0

Status byte 3:
Bit 0: no previous store command
1: alternative (lower) element selected
2÷5: 0
6: 1
7: 0

for decoding of the status bytes, refer to the ASCII table in appendix A

Note:
Only the bits which are set to ‘1’ have an active status.

3 Average temperature measurement with RTD

4.1 General

The 762 VITO MRT can be used for interfacing with 1 through 3 RTD spots which are in a 3 wire connection or 1 through 14 RTD's as a probe with each RTD in a 2 common wire (ground and cable) connection.

3.2 Operating principle

The RTD elements below the product level will determine the average product temperature, in respect to product immersion depth and hysteresis mechanisms and to actual valid level, last valid level or manual level.

The RTD elements above the product level will determine the average gas temperature, in respect to gas immersion depth and hysteresis mechanisms and to actual valid level, last valid level or manual level.

3.3 Commissioning

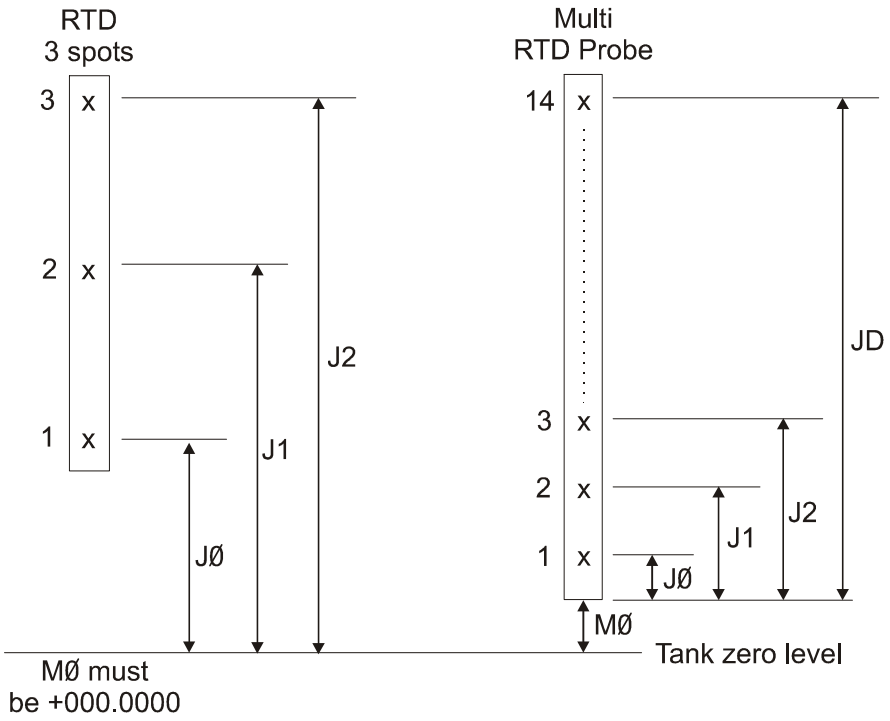
The commissioning of the optional board should be performed after the basic commissioning of the level gauge, radar gauge or indicator. The items mentioned in this section resides under protection level 2.

3.3.1 Format critical items

When the temperature dimension and/or the decimal separator has to be changed, it should be done at the start of the commissioning.

Item	Name	Description
W2=	Protection level 2	Enter protection level 2
TD	Temperature dimension	One ASCII character, either “C” or “F” • C: degrees Centigrade • F: degrees Fahrenheit Both dimensions have the same format: sign XXX sep XX Where: Sign: + or – X : digit Sep: decimal separator (“.” Or “,”)
EX	Exit	Exit protection level 2

3.3.2 Temperature related settings



Item	Name	Description
W2=	Protection level 2	Enter protection level 2
MT	Element type	Three ASCII characters (C3 C2 C1). Selects the element type Connected to the 762 VITO MRT C3 S refers to a RTD spot element C2 C1 PL Pt100 large (-200 ÷ +250 °C)
MN	Number of elements	Two ASCII digits. This item specifies the number of elements of the RTD, 1 through 3 means RTD spot in a 3 wire connection. 4 through 14 means a multi RTD probe.
MO	Temperature element offset probe.	Format according to item **LD**. The offset represents the distance from the tank zero level to the lowest position of the multi RTD In case of the RTD spots this item should be left at 0. ***Note:*** *Incase of ullage measurement, distance MO is taken from The upper reference point.*
J0 - JD	RTD element position.	In case of the RTD spots J0 through J2 represent the distance from tank zero level to the RTD spot. In case of a multi RTD probe J0 through JD represent the distance from the end of the probe (nearest to tank zero level) to the RTD element.

Item	Name	Description
MI	Switch hysteresis	Format according to item LD.The distance MI is a hysteresis around the switching point of the temperature elements.
MP	Product immersion depth	Format according to item LD.The distance MP specifies the minimum required liquid level above a element before it is selected for the average product temperature calculation
MG	Gas immersion depth	Format according to item LD.The distance MG specifies the minimum required distance before the resistance value of the longest element is taken in the average gas temperature calculation
TU	Temperature status conversion	One character (default: 'T') This item is used to indicate the temperature status character incase of a reduced or not guaranteed temperature accuracy. This is the case when the temperature status is: • out of specified temperature range • last valid level used • manual level used • level below lowest temperature element • If required, this item can be set to another character.
EX	Exit	Exit protection level 2

3.3.3 Additional settings for and 877 FDI

Item	Name	Description
W2=	Protection level 2	Enter protection level 2
TF=	Temperature source Selection	One ASCII character; either 'I' or 'E'. this item selects if there is a temperature measurement inside the indicator (internal) or to be fetched from the Enraf field bus (external). I: Internal E: External
EX	Exit	Exit protection level 2

3.3.4 Data items

There are of number of data items for the measured temperature, checks and status information. These data items are:

Item	Name	Description
AP	Average product temperature	This item contains the average product temperature, calculated by averaging the immersed elements. It is preceded by four status bytes from item MQ.
AG	Average gas temperature	This item contains the average gas temperature, calculated by averaging the not immersed elements. It is preceded by four status bytes from Item MQ.
MQ	Temperature status request	This item contains four bytes with temperature status information. For description of the status, refer to chapter 4.4.2
MU	Test resistance	The measured test resistance in floating point format The value should be 166,5 ohm ± 0.03%
U0 ÷ UD	Calculated element position	Format according to item LD. These items gives the position of each element. U0 = lowest element position.
V0 ÷ VD	Element temperatures	Format according to item TD. These 14 items contains the temperature of each element. V0 = lowest element temperature.
YP	Stored average prod. Temp.	Format according to item TD. Stored product temperature, copied from item AP, after an ST command was given.

3.4 Error codes

3.4.1 Temperature error (item EM)

This item helps you configuring correctly by showing the most recent temperature error encountered by the option board.

xx00	no error
xx50	Element 1 detected absent
xx51	Element 2 detected absent
xx52	Element 3 detected absent
xx53	Element 4 detected absent
xx54	Element 5 detected absent
xx55	Element 6 detected absent
xx56	Element 7 detected absent
xx57	Element 8 detected absent
xx58	Element 9 detected absent
xx59	Element 10 detected absent
xx60	Element 11 detected absent
xx61	Element 12 detected absent
xx62	Element 13 detected absent
xx63	Element 14 detected absent

xx = 22 for MPU emulation
xx = 24 for HPU emulation
xx = 30 for HCU emulation

xx70	sub-system error. Check or replace VITO
xx72	not supported element type. Check item MT
xx73	wrong element configuration. Check item MN
xx80	R test error (out of limits)
xx81	R cable error (out of limits)
xx84	standard deviation too high
xx91	Wrong J0 .. JD setting. Check these items.
xx92	no data available. Check wiring or connection with VITO

3.4.2 Temperature status request (item MQ)

Four bytes status information (B0 B1B2 B3) with the following meaning:

Status byte 0:
Contains the characters '0' ÷ 'D', indicating the highest immersed element of the RTD. At start up this is: 'I'.

Status byte 1:
Bit 0: general temperature fail
1: fail in average product temperature
2: fail in average gas temperature
3: level exceeds lowest element
4: level exceeds highest element
5: element fail (one or more elements defect)
6: 1
7: 0

Status byte 2:
bit 0: last valid level used
1: manual level used
2: 0
3: 0
4: 0
5: 0
6: 1
7: 0

Status byte 3:
Bit 0: no previous store command
1: alternative (lower) element selected
2÷5: 0
6: 1
7: 0

for decoding of the status bytes, refer to the ASCII table in appendix A

Note:
Only the bits which are set to '1' have an active status.

4 Water bottom measurement

4.1 Introduction

The water bottom probe is based on a capacitive measurement principle. The probe is one plate of the capacitor and earthed, electrically conducting parts as water and the tank shell, is the other plate. A change in water level is detected by the water bottom probe as a change in capacitance.

4.1.1 Water probe versions

There are four different water probe versions which can be interfaced:

- The 765 VITO water probe;
- The 766 VITO water and temperature probe;
- The external HART® water bottom probe
- The 768 VITO water and temperature probe

The 765 VITO water probe, the 766 VITO water and temperature probe and the 768 VITO water and temperature probe are connected to the 762 VITO interface, which is connected to the HCU board or ICU-HPI board. The external water bottom probe is connected to HART input 2 (same input where pressure transmitters are connected).

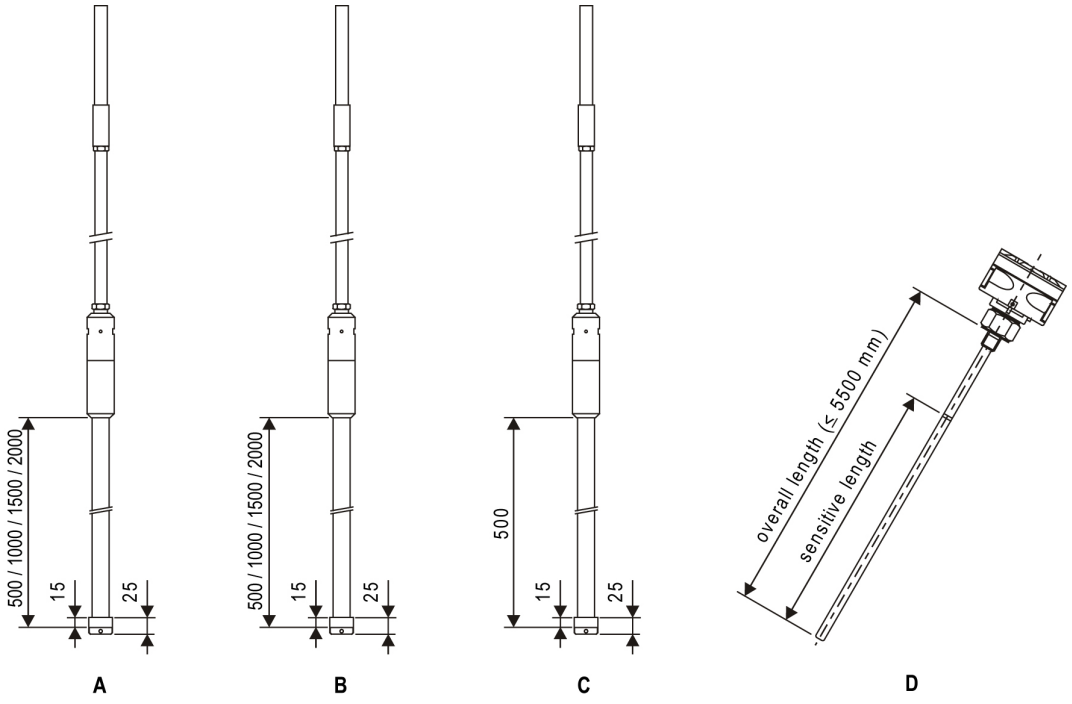


Figure 4.1 VITO water probes, Side mounted water probe

Refer to figure 4.1

A) 765 VITO water probe
   Can be delivered in three sensitive lengths for the water measurement: 0.5m, 1.0m, 1.5m and 2.0m.
B) 766 VITO MTT water and temperature probe
   There is one sensitive length for the water measurement: 0.5m, 1.0m, 1.5m and 2.0m.
C) 768 VITO LT water and temperature probe
   There is one sensitive length for the water measurement: 0.5m.
D) Side mounted water probe

4.1.2 Principle of measurement

When correctly calibrated, the capacitance value given in PV LRV (primary Variable Lower Range Value) is the capacitance measured by the probe when no water is present (sensitive part of probe completely immersed in product). The capacitance value given in PV URV (Primary Variable Upper Range Value) is the capacitance measured by the probe when the sensitive part of probe completely immersed in water.

Note:
The 765, 766 and 768 VITO water probes uses items VR an VT to store the minimum and maximum capacitance values.

The measured capacitance by the water probe has a linear function with the water level. Hence, the water level is calculated as:

$$\text{Water level} = \frac{PV - PV\ LRV}{PV\ URV - PV\ LRV} \times \text{sensitive length probe} + \text{water probe bottom position}$$

Where: PV = the measured capacitance by the water probe; with VITO water sensor, item MX is used
PV LRV = the minimum capacitance (0% water); with VITO water probe, item VR is used
PV URV = the maximum capacitance (100% water); with VITO water probe, item VT is used

Or,

$$LW = \frac{MX - VR}{VT - VR} \times WP + WB$$

If LW > WS otherwise LW = 0

Where: LW = water level
WP = water probe length
WB = water probe bottom position
WS = alarm hysteresis

4.2 Commissioning measurements

The purpose of these calibration measurements is to determine the water probe offset and a control measurement for the water level.

With these measurements the product level is used as a horizontal line between the point where the tank zero point is located and the point where the water probe is installed.

4.2.1 Commissioning measurements with roof suspended probes

If the commissioning takes place directly after installation, the measurements at the probe position in figure 4.2 have already been made if the instructions are followed from the installation guide. Otherwise, that measurement should be made now, by partly removing the probe to enable a measuring tape to be lowered from the nozzle. The following values are obtained:

- Nozzle height
- Product level at water probe location
- Water level at water probe location

From these measurements, calculate the ‘ullage’ value ‘A’:

A= nozzle height – product level at water probe location

The next step is to fetch the product level with respect to the tank zero point. This can be done in several ways:

- Read the level from the level gauge if that has recently been checked (calibrated);

- Take a manual ‘innage’ measurement to the datum plate of the tank;
- Take a manual ‘ullage’ measurement from the Upper Reference Point and calculate the level by; level = URP – ‘ullage’.

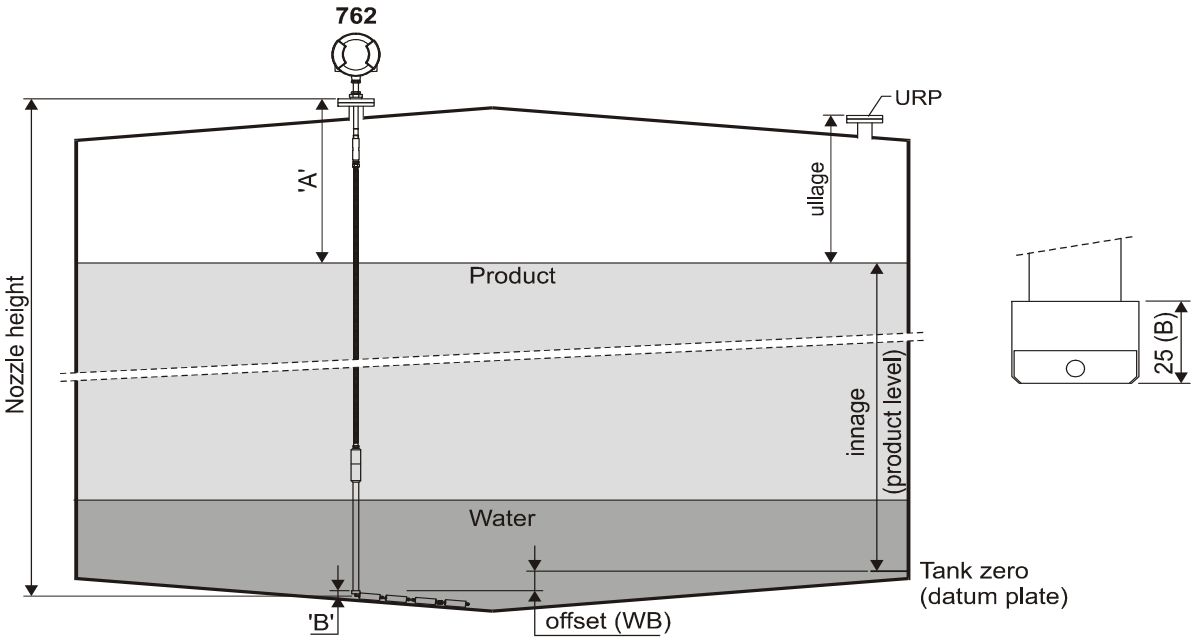


Figure 4.2 Calibration measurements for water probe

If the commissioning takes place directly after installation, the measurements at the probe position in figure 4.2 have already been made if the instructions are followed from the installation guide. Otherwise, that measurement should be made now, by partly removing the probe to enable a measuring tape to be lowered from the nozzle. The following values are obtained:

- Nozzle height
- Product level at water probe location
- Water level at water probe location

From these measurements, calculate the ‘ullage’ value ‘A’:

A= nozzle height – product level at water probe location

The next step is to fetch the product level with respect to the tank zero point. This can be done in several ways:

- Read the level from the level gauge if that has recently been checked (calibrated);
- Take a manual ‘innage’ measurement to the datum plate of the tank;
- Take a manual ‘ullage’ measurement from the Upper Reference Point and calculate the level by; level = URP – ‘ullage’.

Refer to figure 4.2 At the bottom part of the probe there is an inactive metal part with a height of 25mm (1”). That is represented as distance **‘B’**.
The offset, which had to be programmed in item **WB**, can be found from:

WB = (**A** + product level at reference point) – (Nozzle height – **B**)

Note:
*If **WB** is a negative figure then it is possible to have a negative water level reading.*

Calibrating the water probe
Refer to Appendix B for information about calibrating the water probe. Where the water dip is mentioned, please refer to the measured water level at the probe position as described before.

4.2.2 Commissioning measurements for side mounted probes

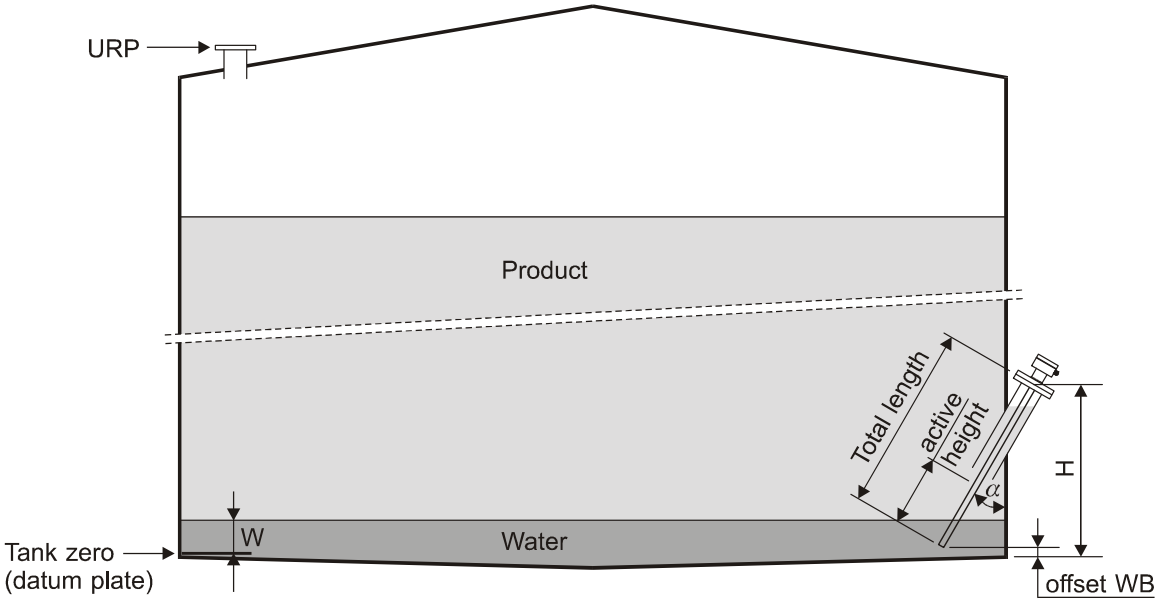


Figure 4.3 Calibration measurements for side mounted probe

From the probe installation must be known:

- Active length of probe
- Total length of probe
- Angle of installation (α)
- Height '**H**' of nozzle

The water probe length (**WP**) can be calculated as:

WP = active length of probe x cos (α)

Offset (WB) can be calculated as:

WB = **H** – (total length x cos (α))

When the water bottom measurement has no relation to the tank zero, the offset **WB** can be used as water probe bottom position.

If the water bottom measurement is related to the tank zero, then the water probe bottom position (**WB**) can be determined when the probe is immersed in some water.

The reading of the probe is taken; item **LW**.
A manual water dip is taken from the tank zero point (datum plate); note this value as '**W**'.
Calculate the water probe bottom position **WB** as:

WB = W – LW

Calibrating the water probe
Refer to appendix B for information about calibrating the water probe.
Where is mentioned the water dip, refer to the measured water level at the probe position as described above.

4.2.3 Water probe settings

Item	Name	Description
W2=	Protection level 2	Enter protection level 2
WB=	Water probe bottom position	Format according to item **LD** (default: + 000.0000 m) This item gives the offset to the water probe zero point in Relation. With the tank zero point. Refer to sections 4.2.1 and 4.2.2 how to obtain this offset value.
WP=	Water probe length	Format according to item **LD** (default: + 001.0000 m) The water probe length (together with the water probe Bottom position) is required to calculate the water level.
WF=	Water level field communication	One character: 's' or 'D'. Only valid with 854 level gauges. This item selects from which source the water level is measured and transmitted in the level record (B-record) to the system. S: from the water probe (VITO water sensor or side mounted water probe) D: from water dip (displacer) Select 'S; for 854 the gauges (default: D).
WH=	Water high alarm	Format according to item **LD** (default: +000.0000 m) With this item a water high alarm set point can be given. When active, the water high alarm condition is signalled on the Instrument display in display format K (if display is available). The water alarm information is also transmitted in the water level record (M-record).
WS=	Water alarm hysteresis	Format according to item **LD** (default: + 000.0100 m). The water alarm hysteresis prevents the water alarm to be Switched on and off when the water level is around the water High or water low alarm set point.
EX	Exit	Exit protection level

Water probe length :

The 766 VITO water and temperature probe has one length for the water measurement; the other water probes can have different lengths. The actual water probe length can be found from the identification code of the probe. The table below gives an overview:

765 VITO water probe	766 VITO MTT water and temperature probe	768 VITO LT water and temperature probe	Side mounted water probe
0.485 m 0.985 m 1.985 m	0.485 m 0.985 m 1.985 m	0.485 m Not required to Specify in item **WP**	Active length x cos (α) (refer to section 4.2.2)

4.3 Operation

4.3.1 Display

For operation of the display and the information on it, refer to the instruction manual of the applicable level gauge or 877 FDI. Below, only an overview is given which display format gives information about the water bottom measurement.

Display format	Displayed information
K	Water level and status

4.3.2 Water above / below probe warning

Automatically a warning is given when the water level is too low or too high for the probe to measure correctly.

- The water above probe status (AP) is displayed and signalled in the water level record when the water level is within 1% of the probe length (item WP) from the top of the water probe.
- The water below probe status (BP) is displayed and signalled in the water level record when the water level is within 1% of the probe length (item WP) from the bottom of the water probe.

Around these warnings there is a hysteresis of ½% of the probe length (item WP).

4.3.3 Data items

Below, a summary is given of the available data items and error codes. There is one operational command with the water bottom measurement.

Item	Description	
LW	Measured /	Water level, preceded by two status bytes (refer to section 4.4.3)
LH	Calculated data	Water ullage, preceded by two status bytes (refer to section 4.4.3)
N4		Serial number external water probe
PV		Measured capacitance from side mounted water probe
MX		Measured capacitance from 765/766/768 VITO water probe
VV	Verification data	Refer to description at section 4.4.4
EW	Diagnostic data	Error water request (refer to section 4.4.1)
HE		HART communication errors (refer to section 4.4.3)
FH		Fatal HCU/ICU_HPI errors
H0		Last fatal HCU/ICU_HPI error

Operational command:

SR Stop HART request (used with HART communicator).

4.4 Troubleshooting

4.4.1 Water error request (item EW)

Data item **EW** contains the most recent error code concerning the water probe measurement, encountered by the optional HCU/ICU_HPI board.

Item **EW** with external water bottom probe (Side mounted water probe):

xx00	No error, value at initialisation	
xx11	No reply on initial HART commands	Check connection level gauge – water probe; check if HART device address of water probe is 4; change water probe electronics, or HCU/ICU_HPI board
xx35	Wrong dimension	Dimension of PV should be: m (metres) or mm (millimetres)
xx40	Device malfunction	Defective water probe (electronics)
xx98	No water sources found	No water probe connected

Item **EW** with 765, 766 and 768 VITO water probe:

xx00	No error, value at initialisation	
xx01	C_{test} error	Either defective 762 VITO interface or defective (leaking) water probe
xx02	Linearity error	Should be within 1% of the test capacitance, if too large, change 762 VITO interface
xx03	No water probe available	Measured capacitance is >4000 pF; check water probe wiring (green wire and coax Cable) to 762 VITO interface terminals
xx04	Sub system error	Defective 762 VITO interface
xx05	Capacitance too low	Measured capacitance <50pF; check water probe wiring or change 765/766/768 VITO probe
xx06	Capacitance too high	Measured capacitance >3000pF;check water probe wiring or change 765/766/768 VITO probe
xx07	Capacitance shortcut	Either water probe error or internal 762 VITO interface error
xx11	No reply on initial HART commands	Communication error. Check connection level gauge – 762 VITO interface, or change 762 VITO interface or HCU/ICU_HPI board
xx79	Not calibrated	check items VR and VT (set to zero or are equal to each other)
xx98	No water sources found	No water probe connected

xx: 24 for HPU emulation; 28 for HSU emulation; 30 for HCU emulation

4.4.2 HART communication errors

Item **HE** contains four counters. The first three counters are used by pressure transmitters (if present). The last counter contains the number of times the external water probe is detected absent. The external water probe is considered to be absent after three consecutive requests, or after receiving three incorrect/invalid answer records. Default value item **HE** 000:000:000:000

4.4.3 Water level (ullage) status bytes

The water level and ullage, items **LW** and **LH**, are constructed as follows: $s_0 s_1$IIIIIIIII

IIIIIIIII : water level (or ullage) value; format according the level dimension **LD**.
$s_0 s_1$: two status bytes, bit coded; containing the following information:

<u>status byte s0</u>
bit 0: general probe fail
1: low water alarm
2: high water alarm
3: water below probe warning
4: water above probe warning
5: 0
6: 1
7: 0

<u>status byte s1</u>
bit 0: water probe (0=present; 1= absent)
1: 0 (not used)
2: 0 (not used)
3: 0 (not used)
4: 0 (not used)
5: 0
6: 1
7: 0

Note:
Only the bits which are to set to '1' have an active status.

4.4.4 Water bottom pointer (items VP and VV)

By means of the value pointer (item **VP**) a vector can be loaded to the HCU or ICU_HPI option board. Next with item **VV**, the selected data is returned. Item **VP** consists of 4 positions, in the middle separated by a '.' Or ','; v w , x y (or v w, x y). the values for the value pointer are listed in the table together with the obtained data.

v w	,	x y	Selected data	Example/dimension
0 0	,	0 0	HCU/ICU_HPI emulation & Function Emulation: MPU, HSU, HPU, HCU Function: HC: HART channel installed AO: analog output ST: spot temperature MT: VITO average temperature WS: external water bottom probe WT: VITO water bottom probe PR: pressure transmitters MR: VITO average temperature MRT	VV=HCU HCAOMTWTPR
0 0	,	0 1	Configuration boot code Sales code option: C boot code: 0A J 2E W 1A X 12 Y 3F	VV=HCU CONF 1G: 3F
0 0	,	0 2	HCU/ICU_HPI hardware version	VV= HW VERSION: 00
0 0	,	0 3	Boot code software version	VV= BOOTSW VERS:01
0 3	,	0 1	Error counters HART addresses 3.4 and 5	VV= 0000:0000:0013
0 3	,	0 9	Detected HART device addresses external water probe has HART address 4 and 762 VITO-T and VITO-R has HART address 5) VITO-LT has HART address 6)	VV=----5----------
0 3	,	1 0	See 1.2.1 Average temperature settings	
0 3	,	1 1	Real active functions of VITO interface (refer to description of VP=03,10)	
0 3	,	1 2	Actual executed HART commands from 762 VITO interface	
0 3	,	2 0	Averaging constant 762 VITO interface (floating point format)	
0 4	,	0 0	C_{test} from 762 VITO interface (floating point format)	
0 4	,	0 1	$C_{linearity}$ form 762 VITO interface (floating point format)	

Item	Name	Description
VP=	Water bottom value pointer	Water bottom value pointer; format: 2 digits, separator, Digits (refer to table above). Example: VP=04.00: value pointer loaded to request the Measured test capacitor.
VV	Water bottom pointer value	Water bottom pointer value. This item holds the value requested by item **VP** (refer to table above)

Appendix A ASCII table

HEX MSB		0	1	2	3	4	5	6	7
	BIT	654	654	654	654	654	654	654	654
LSB	3 2 1 0	000	001	010	011	100	101	110	111
0	0 0 0 0	NUL	DLE	SP	0	@	P	‘	p
1	0 0 0 1	SOH	DC1	!	1	A	Q	a	q
2	0 0 1 0	STX	DC2	“	2	B	R	b	r
3	0 0 1 1	ETX	DC3	#	3	C	S	c	s
4	0 1 0 0	EOT	DC4	$	4	D	T	d	t
5	0 1 0 1	ENQ	NAK	%	5	E	U	e	u
6	0 1 1 0	ACK	SYN	&	6	F	V	f	v
7	0 1 1 1	BEL	ETB	‘	7	G	W	g	w
8	1 0 0 0	BS	CAN	(	8	H	X	h	x
9	1 0 0 1	HT	EM	)	9	I	Y	i	y
A	1 0 1 0	LF	SUB	*	:	J	Z	j	z
B	1 0 1 1	VT	ESC	+	;	K	[	k	{
C	1 1 0 0	FF	FS	‘	<	L	\	l	l
D	1 1 0 1	CR	GS	-	=	M	]	m	}
E	1 1 1 0	SO	RS	.	>	N	^	n	~
F	1 1 1 1	SI	US	/	?	O	-	o	DEL

Appendix B Configuration procedure for 765/766/768 VITO water probe

Make sure the VITO water (temperature) probe is installed properly (refer to installation guide VITO)

Check by means of a hand dip the water level.

If there is no water found, or the water level is below the sensitive part of the VITO water probe, the measured capacitance is used as the value for item VR.

If there is water found within the sensitive part of the VITO, an interpolation is applied on the measured capacitance to find the capacitance value at zero water level.

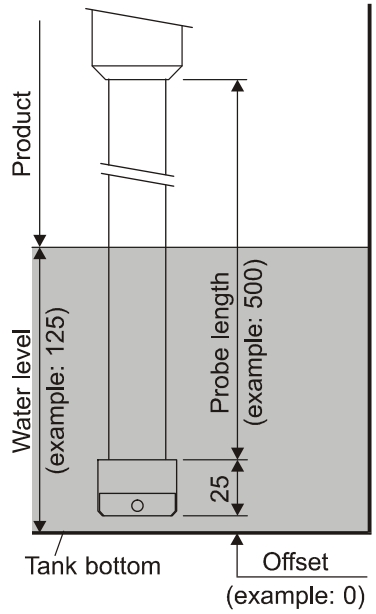
Refer to figure: manual measurement of water level.

The interpolation of the capacitance value is done as follows:

$$\%\ water = \frac{Water\ level - 25\ mm - offset}{sensitive\ length} \times 100\%$$

Example:

$$\%\ water = \frac{125 - 25 - 0}{500} \times 100 = 20\%$$



Manual measurement of water level

To calculate the value for item VR (minimum capacitance), the actual measured capacitance (item MX) and the maximum capacitance (item V) should be known These two values can be read by the PET or via the service program from the instrument.

The minimum capacitance value is then calculated as follows:

$$VR = VT - \frac{VT - MX}{100 - \%water} \times 100$$

Example:

$$VR = 1000 - \frac{1000 - 840}{100 - 20} \times 100 = 800\ pF$$

Proceed as follows:
Apply power to the instrument to which the 762 VITO interface is connected and wait for approximately 2 minutes.

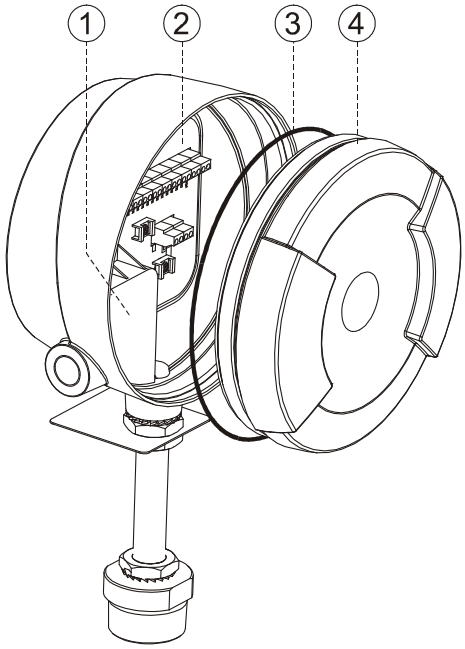
Item	Name	Description
MX	Actual measured capacitance	Read the actual measured capacitance (floating point format).
W1=	Protection level 2	Enter protection level 2
VT	Maximum capacitance	Read the maximum capacitance (floating point format).
VR	Minimum capacitance	Program the minimum capacitance; Either the value from item **MX** or the calculated minimum Capacitance value (floating point format).
EX	Exit	Exit protection level

Appendix C Part numbers

For VITO family:

Refer to figure: 762 VITO interface

Item	Description	Part no.
1	Protective cover over HART terminals	0186.901
2a	Printed circuit board 762 VITO MTT Interface	0762.950
2b	Printed circuit board 762 VITO MRT Interface	0762.960
2c	Printed circuit board 762 VITO LT Interface	0762.970
3	O-ring, 190.18 x 2.62, NBR70	2132.991
4	Cover 762 VITO interface	0186.798



762 VITO interface

Appendix D Related documents

Instruction manual series 854 ATG level gauge
Instruction manual series 854 XTG level gauge
Instruction manual 990 SmartRadar Flexline
Instruction manual 877 Field Display & Interface
Instruction manual 97x SmartRadar series

Instruction manual HIMS /HTG and vapour pressure (P3) measurement

Installation guide 762 VITO interface & 764, 765, 766, 767 or 768 VITO temperature and/or water bottom probes
Installation guide 864 MTT Multi Thermo sensor Thermometer

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