
Instruction manual 971 SmartRadar LT*i*

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Preface

This manual is intended for technicians involved in the commissioning and service of the Enraf series 971 SmartRadar LTi gauge.

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.

For installation of the 971 SmartRadar LTi, please refer to the Installation guides of the 971 SmartRadar LTi and SmartRadar Antennas. This manual describes the commissioning and service of the basic 971 SmartRadar LTi level measurement. Other features such as level alarm output contact, temperature measurement (spot or average), analog level output and pressure measurement are described in separate manuals. For an overview, refer to the list of related documents in appendix D.

Legal aspects

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

EC declaration of conformity

Refer to the EC declaration of conformity, shipped with the instrument.

Additional information

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

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1 Introduction

The Enraf 971 SmartRadar LTi is a radar based level gauge. It is designed to measure the product level in large storage tanks accurately and reliably.

The following options can be added to the basic SmartRadar:

- One hard alarm output contact, which can be linked to one of the four programmable alarms in the instrument;
- An Infra-Red connector for the configuration tool 847 Portable Enraf Terminal;
- An intrinsically safe output to connect the 977 Tank Side Indicator.

Additional sensors can be connected to the SmartRadar when the optional ICU_HPI board is installed. This provides the instrument inputs for:

- Spot temperature element (Pt100);
- HART channel for: 762 VITO Interface, which is a converter for average product (and vapour) temperature and/or water bottom measurement (via VITO temperature and/or water probes);
- HART channel for: pressure transmitters for HIMS configuration or vapour pressure measurement and for a side mounted water probe.

Standard, the SmartRadar is provided with Enraf field bus transmission for communication with remote tank gauging systems. Optionally, the following output signals are available:

- Analog 4-20 mA level output with HART communication for other measured quantities (Enraf field bus signal also available). This requires the optional ICU_HPO board;
- RS-232C or RS-485 serial communication (Enraf field bus signal not available). This requires the optional ICU_RS232/485 board.

Basic 971 SmartRadar LTi		
Optional Hard alarm output contact		
Optional IR connector for 847 PET (Portable Enraf Terminal)		
Optional I.S. output for 977 TSI (Tank Side Indicator)		
Optional input board	Optional output board	
ICU_HPI board: - spot temperature element - HART channel for 762 VITO - HART channel for P1, P3	ICU_RS232/485 board: - RS-232C or - RS-485	ICU_HPO board: - HART output and/or - analog 4-20 mA level output

1.1 Principle of measurement

The radar level gauge is a device that uses high-frequency (10 GHz) electromagnetic waves to determine the distance from the radar antenna to the product surface. The electro-magnetic wave is sent into the tank and reflected by the product. As an electro-magnetic wave travels with the speed of light, this measurement can not simply be done on the basis of time of flight. Instead, the phase difference between the transmitted and the received signal is measured. The corresponding travelled distance can then be calculated from this phase relation. This measurement principle is known as synthesized pulse radar (SPR).

In the 971 SmartRadar LTi the microwave signal is generated and led, via the tank separator, to the antenna (refer to figure 1.1). The radar antenna shapes the beam and sends the signal into the tank. The microwave signal reflected from the product is then received by the same radar antenna. The digital electronics in the SmartRadar LTi measure both the transmitted and the reflected signal.

After processing, the measured distance is converted into level data (innage or ullage) and made available for field communication.

1.2 Configurations

The 971 SmartRadar LTi is installed on the tank separator device.

The antenna is coupled to the 971 SmartRadar LTi via the tank separator device. The tank separator provides for adequate isolation between the tank contents and the electronics in the SmartRadar LTi. Refer to figure 1.1.

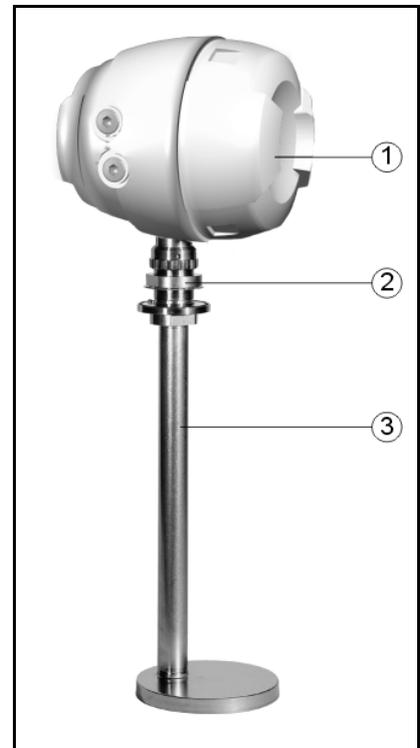
Depending on the application, different antennas are to be used. The tank separator adapts the different type of antennas.

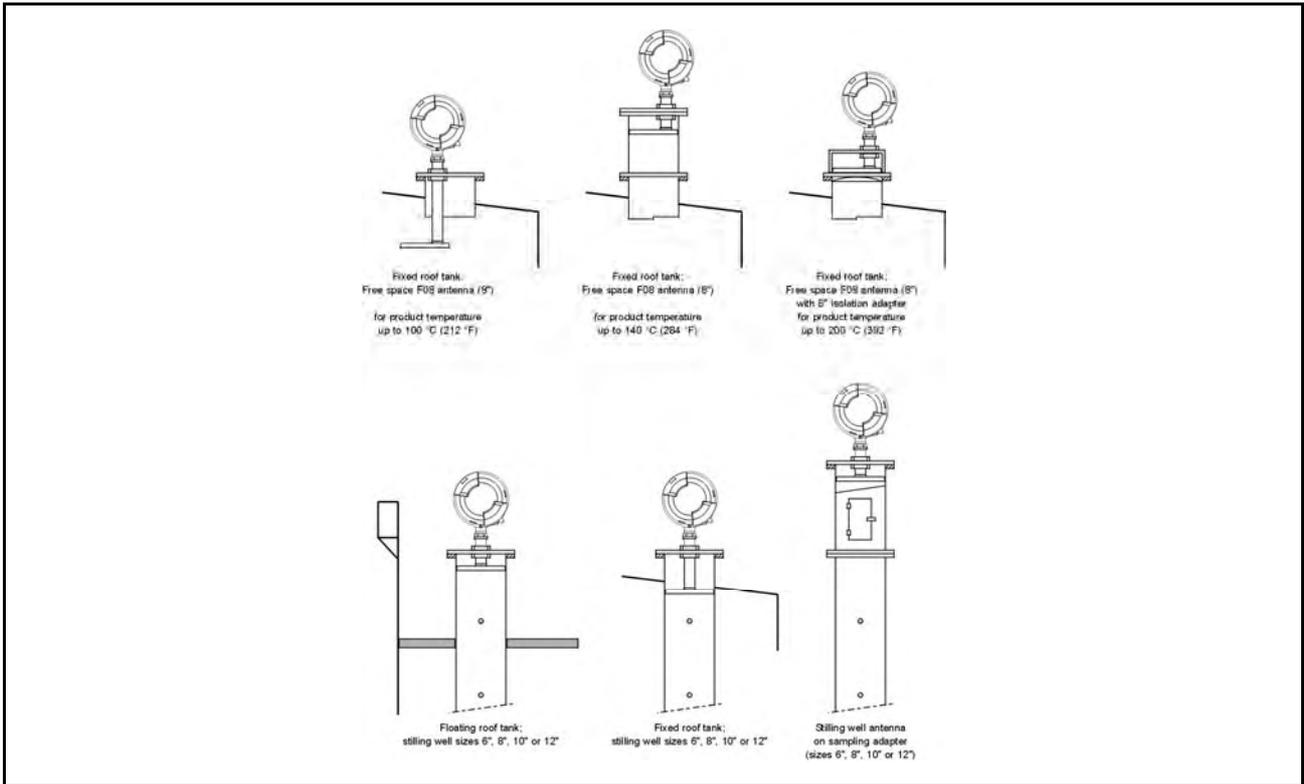
Item	Description
1	SmartRadar LTi
2	Tank separator
3	Antenna

For radar level measurement, tanks can be divided into 2 groups:

- Fixed-roof tanks; free space measurement (antenna type: F08);
- Tanks with a stilling well (fixed-roof and floating-roof tank); stilling well measurement (antenna types: S06, S08, S10 and S12).

Figure 1.2 gives an overview of the installation on the different tank types.





1.3 Optional functions

Optional functions can be added in the SmartRadar LTi.
The table below gives an overview of all options and related manuals.

Option	Board	Refer to
Level alarm output relay (or digital output)	ICU	Instruction manual ICU Hard alarm output contact (4416.633)
Analog level output (4 - 20 mA)	ICU_HPO	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
Spot temperature measurement	ICU_HPI	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
Average temperature measurement and water bottom measurement via 762 VITO	ICU_HPI	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
Pressure measurement for mass, density and/or vapour pressure via HART protocol	ICU_HPI	Instruction manual HIMS / HTG and vapour pressure (P3) measurement (4416.645)
Water bottom measurement via side mounted water probe	ICU_HPI	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
RS-232C/RS-485 communication	ICU_RS232/ 485	Instruction manual 973 SmartRadar LT RS-232/485 output communication (4416.647)
Modbus communication	ICU_RS232/ 485	Instruction manual Modbus™ protocol Enraf gauges (4416.513)
HART communication	ICU_HPO	Instruction manual 973 SmartRadar LT HART® output communication (4416.646)

1.4 Remote monitoring

Central monitoring of the SmartRadar is possible via tank inventory systems such as Entis Pro.
Remote display can be achieved using the 977 TSI Tank Side Indicator, the 877 FDI field indicator or the 878 CPI panel indicator.

1.5 Approvals (FM, ATEX)

The Enraf 971 SmartRadar LTi is an explosion proof instrument, which is designed to meet requirements of ATEX, Factory Mutual, and others. Measuring performance and data handling protocol meet API requirements.

2 Safety

2.1 Safety aspects of the 971 SmartRadar LTi

Warning

Do not use the instrument for anything else than its intended purpose.

The housing of the 971 SmartRadar LTi is explosion proof:

- II 1/2 G EEx de [ib/ia] IIB T4; KEMA 03ATEX1205 X certified by KEMA, Netherlands
- Class I, Division 1, Groups B, C, D T4, according to ANSI / NFPA 70 (Factory Mutual)

The covers of the SmartRadar LTi are provided with blocking facilities which prevent unauthorised opening.

Optionally, programming the 971 SmartRadar LTi can be done by the 847 PET (Portable Enraf Terminal), which is an intrinsically safe device and is connected to the SmartRadar LTi via an infra-red coupling.

Caution

The 971 SmartRadar LTi is an explosion proof instrument with intrinsically safe output/input circuits. Modification to the instrument may only be carried out by trained personnel that is authorised by Enraf. Failure to adhere to this will invalidate the approval certificate.

The emitted microwave energy is far below the accepted limits for exposure of the human body. Depending on the type of antenna, a maximum radiation of 0.1 mW/cm² is generated.

2.2 Personal safety

The technician must have basic technical skills to be able to safely commission the equipment. When the 971 SmartRadar LTi is installed in a hazardous area, the technician must work in accordance with (local) requirements for electrical equipment in hazardous areas.

Warning

In hazardous areas it is compulsory to use personal protection and safety gear such as: hard hat, fire-resistive overall, safety shoes, safety glasses and working gloves.

Avoid possible generation of static electricity. Use non-sparking tools and explosion-proof testers. Do not open any of the instrument covers while power is still connected.

Make sure no dangerous quantities of combustible gas mixtures are present in the working area.

Never start working before the work permit has been signed by all parties.

Pay attention to the kind of product in the tank. If any danger for health, wear a gas mask and take all necessary precautions.

2.3 Safety conventions

"**Warnings**", "**Cautions**", and "**Notes**" are 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 not requiring a "Warning" or "Caution"

3 Commissioning

3.1 Checks before starting the commissioning

Examine the mechanical and electrical installation after the 971 SmartRadar LTi is installed on the tank.

- Check the connections of all electrical cabling
- Check that all ground connections are made
- Check that non-used cable inlets are sealed with appropriate stopping plugs
- Close all covers carefully (mind O-rings) and apply power

3.2 Introduction in programming the 971 SmartRadar LTi

The item concept

The 971 SmartRadar LTi gauge is a field-configurable multi-processor instrument. This means that the instrument can be totally programmed out in the field, or remotely, without opening the gauge. All parameters, settings, etc. are accessible either via the optional PET (Portable Enraf Terminal) or remotely with the Enraf service tool via so-called items.

These items all have unique 2-letter indexes which allow easy access and programming. Many indexes associate with an abbreviation of the item description.

There are three different type of items:

Type of item	Description
Commands	These will force the gauge to execute a special task or function. Example: EX (exit). After the EX command, the instrument starts initialising and modified NOVRAM settings become active.
Data requests	Items for request of setup or measuring data from the gauge. Example: JS will return the jumper setting on the ICU board. Some of the data items are read-only.
NOVRAM Settings	All parameters which can be programmed and should not be lost after power break down, are stored in NOVRAM. The NOVRAM is a non-volatile RAM memory which does not require battery back up.

Data stored in NOVRAM can be protected by a password and/or by the NOVRAM protect jumper (refer to figure 3.1).

Protection levels are provided for all NOVRAM items, depending on the importance of an item. Protection level 2 is protected by password 2 (**W2**) and protection level 1 is protected by password 1 (**W1**). If the NOVRAM is protected by the NOVRAM jumper (jumper J4), level 2 data cannot be changed without opening the gauge. Most data requests and commands are not password protected.

Protection level 1

Access to items which are not directly measurement related data, such as high level alarm (**HA**), tank identifier (**TI**), etc. is protected by password 1 (**W1**). It is possible to modify these data only after entering the correct level 1 password W1=XXXXXX, where XXXXXX is the level 1 password. Password **W1** itself can be read protected by means of jumper J6 on the ICU board.

Protection level 2

All NOVRAM items which affect the (remote) level reading (such as reference level (**RL**) or transmission address (**TA**)) are protected by password 2 (**W2**). It is possible to modify these data only after entering the correct password W2=XXXXXX , where XXXXXX is the level 2 password. Additional measurement-related items, such as temperature items can also be protected by password 2. Password **W2** itself can be read protected by means of jumper J5 on the ICU board. In protection level 2, the items protected under protection level 1 can be also modified.

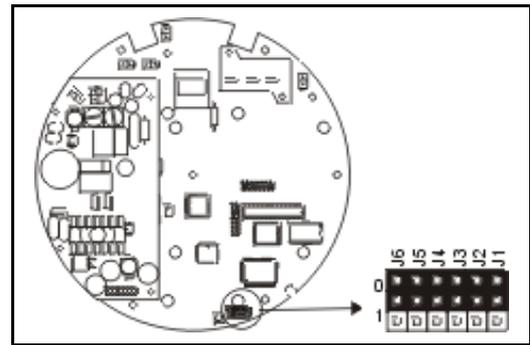


Figure 3.1 shows the jumper position on the ICU board. The table below gives an overview of the ICU jumper functions.

jumper	function	position "0"	position "1"
J6	read password 1	not protected	protected
J5	read password 2	not protected	protected
J4	NOVRAM protection	disabled	enabled
J3 ÷ J1	no function	x	x

Indexed items

In general, items have only one setting (i.e. HA+026.0000). Indexed items have more than one setting (elements). For instance: item **OS** (obstruction zone start position). Item **OS** has ten elements, corresponding with the ten programmable obstruction zones.

| OS |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| element 0 | element 1 | element 2 | element 3 | element 4 | element 5 | element 6 | element 7 | element 8 | element 9 |

Indexed items are requested by the two-character item name, followed by the element number and number of elements to be requested, separated by dots.

In general:

XX.n.i

- where: XX= two-character item name
- n = element number (starts with 0)
- i = number of elements (can be 1 or more, but maximum is 9)

For example:

- OS.0.1** <enter> requests the first obstruction zone start position;
- OS.1.1=+012.3400** <enter> programs the second obstruction zone start position.

Note:

Although it is possible to program more than one element at the time, it is **not** recommended. To avoid mistakes, program only one element at the time.

3.3 Connection of Enraf service tool

3.3.1 Communication via the Enraf field bus line

By default, the 971 SmartRadar LTI is set on transmission address 00. The 971 SmartRadar LTI, and also other types of Enraf gauges, can be connected in parallel to the Enraf field bus line. Each instrument must have its unique transmission address.

The items can be programmed using the Portable Enraf Terminal, which is connected via the optional Infra-red connector. If this option is not present, items can be programmed remotely.

SmartRadar LTI connected to an 858 CIU

Temporary disconnect the RS-232C connection from the Entis+ (or other host) and connect it to a service PC where the Enraf service tool is running (refer to figure 3.2a).

Mind the relation for the transmission addresses per transmission line of the 858 CIU:

TL1 (addresses: 00 - 29), TL2 (addresses: 30 - 59), TL3 (addresses: 60 - 99)

The SmartRadar LTI can be connected to the desired transmission line, although its address is still at default. Thus a SmartRadar LTI with default transmission address 00 can be connected to transmission line 2 (suitable for transmission addresses 30 - 59). Due to the mechanism that the request from the host (Enraf service tool) is transmitted over all three transmission lines, the SmartRadar LTI receives the commands. However, when the SmartRadar LTI is connected to transmission line 2 or 3, there is no response.

This concept only works if **one** new SmartRadar LTI is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.

SmartRadar LTI connected to an 880 CIU Prime

HostPort 2 from the CIU Prime must be available for the connection of a service PC where the Enraf service tool is running (refer to figure 3.2b).

To communicate via HostPort 2, the CIU Prime must be configured to CIU 858 emulation mode on HostPort 2. If HostPort 2 is in use, temporary disconnect it and temporary re-configure the CIU Prime for CIU 858 emulation via HostPort 2.

This concept only works if **one** new SmartRadar LTI is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.

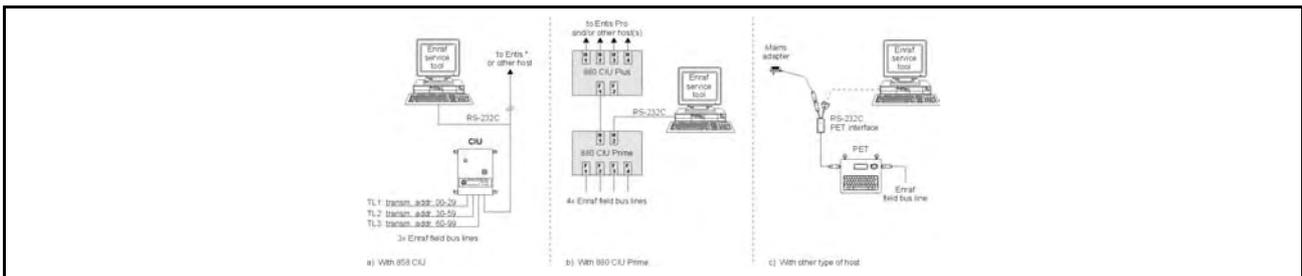
SmartRadar LTI connected to another type of host

Temporary disconnect the Enraf field bus line from the host.

Use a 847 PET (Portable Enraf Terminal) with optional RS-232C PET Interface as protocol converter between Enraf field bus signal and RS-232C to the service PC where the Enraf service tool is running (refer to figure 3.2c).

This concept only works if **one** new SmartRadar LTI is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00 connected to the Enraf field bus line. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.



3.3.2 Communication via RS-232C or RS-485

RS-232C

Connect the RS-232C transmission line from the SmartRadar LTI to a service PC where the Enraf service tool is running (refer to figure 3.3a). Default baud rate for RS-232C is 19200 baud.

Continue with section 3.3.4, programming communication parameters.

RS-485

Connect the RS-485 transmission line (eventually via an RS-485 / RS-232C converter) to a service PC where the Enraf service tool is running (refer to figure 3.3b).

Default baud rate for RS-485 is 19200 baud.

When more than one gauge is connected to the same transmission line (multi drop mode), make sure that only **one** new SmartRadar LTI is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.

3.3.3 Communication via HART[®] signal

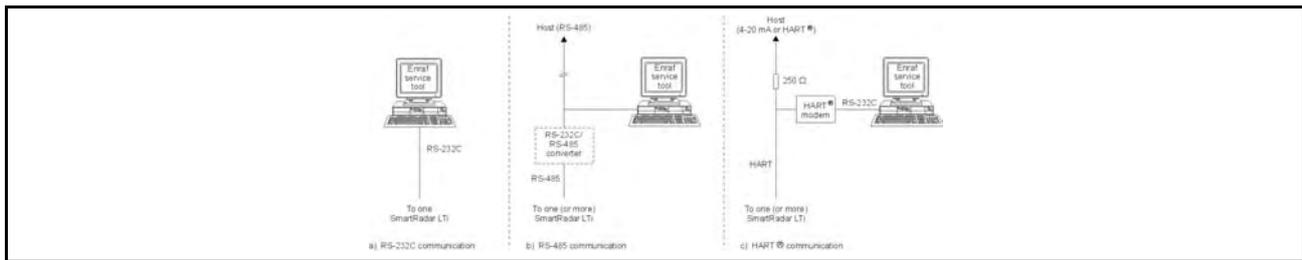
The SmartRadar LTI can be configured to give a 4 - 20 mA level output. In this mode it is possible to configure the SmartRadar LTI via the HART[®] communication protocol.

Connect the HART[®] transmission line via a HART[®] modem to a service PC where the Enraf service tool is running (refer to figure 3.3c).

A maximum of 15 SmartRadar LTI's with HART[®] output signal can be connected in parallel (multi drop mode); each gauge having a unique HART[®] communication address from 1 to 15.

When more than one gauge is connected to the same transmission line (multi drop mode), make sure that only **one** new SmartRadar LTI is powered with the default communication address 0.

Continue with section 3.3.4, programming communication parameters.



3.3.4 Programming communication parameters

Start up the Enraf service tool and make contact with the SmartRadar LTi to be configured.

Enraf service tool Logger:

Go to section: Send items (2). Set the transmission address to '00' <F2> and check the CIU address <F3>. If necessary, set record type to 'BZ' <F4> and set display <F5> to (01/02).

Enraf service tool Ensite:

It is not recommended to make a site scan, as the transmission address is still to be changed.

Therefore, to make contact with the gauge, set the address manually in the port settings.

Select this window by: Set up, Port settings (use the extended setup window).

Check the baud rate setting (1200 baud when communicating via Enraf field bus and HART® and 19200 baud when communicating via RS-232C or RS-485) and comport setting.

Go to the line Prefix: and set (check) the desired CIU address and set the transmission address to '00' <TA=00>.

Note:

When communicating via RS-232C / RS-485, default the CIU emulation address is disabled. Hence, delete the part with the CIU address (delete: <CIU=0>).

When communicating via HART®, delete the part with the CIU address (delete: <CIU=0>).

Enraf service tool Engauge:

Select the relevant CIU Prime folder and do: Add gauge (971).

Select: Properties and check / modify the Address (00). Then click tab Verify and continue to enter all settings.

For remote transmission, the items **TA** and **TI** must be programmed and items **GT** and **TS** should be checked. All these items reside under protection level 2. Proceed as follows:

Item	Name	Description								
W2=	Protection level 2	Enter password 2. Default level 2 password: ENRAF2								
TA=	Transmission address	Two digits. Enter the desired transmission address. If gauges are connected in parallel to the transmission line, each gauge must have its unique transmission address. Mind the address relation when connected to an 858 CIU: <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>CIU highway</th> <th>Transmission address (TA)</th> </tr> </thead> <tbody> <tr> <td>TL 1</td> <td>00 - 29</td> </tr> <tr> <td>TL 2</td> <td>30 - 59</td> </tr> <tr> <td>TL 3</td> <td>60 - 99</td> </tr> </tbody> </table>	CIU highway	Transmission address (TA)	TL 1	00 - 29	TL 2	30 - 59	TL 3	60 - 99
CIU highway	Transmission address (TA)									
TL 1	00 - 29									
TL 2	30 - 59									
TL 3	60 - 99									
TI=	Tank identifier	6 Characters; program the tank name into TI (spaces are not allowed). This name is used as subdirectory name in the Ensite service tool to store information (log file, reflection diagram, etc.) on the hard disk.								
GT=	Gauge type	1 Character. GT represents the type of instrument. For 971 SmartRadar LTi, GT is B.								
TS=	Transmission speed	4 Characters. For Enraf field bus line TS is 1200 (default) or TS is 2400 baud. For HART communication, TS remains on 1200 (default). For RS-232C or RS-485 communication, TS is default 19K2 and can be set lower to: 9600, 4800, 2400 or 1200 baud.								

EXExit Exit protection level. After the exit command, the 971 SmartRadar LTi will perform a controlled software reset and all changes made will be effective after start-up.

Example:

The SmartRadar LTi on tank 102 will get transmission address 42. The gauge should be programmed as follows:

Item (+setting)		Description
W2=ENRAF2	<enter>	Enter password 2 (ENRAF2 is default level 2 password)
TA=42	<enter>	Transmission address equals to 42
TI=TNK102	<enter>	Tank identifier.
GT	<enter>	Check whether the gauge type item is correct; if not, change it.
TS	<enter>	Check whether the transmission speed item is correct; if not, change it.
EX	<enter>	Exit protection level.

As the transmission address (and perhaps also the baud rate) is changed, the Enraf service tool must be adapted to the new conditions. That can be done as described earlier, or a 'site scan' can be made.

3.4 Programming the gauge

The 971 SmartRadar LTI is pre-programmed at the factory. Depending on the application, a number of additional parameters have to be set.

Note:

*The items described in this section are typical for the basic 971 SmartRadar LTI.
For the optional functions / boards such as: level alarm relay output, spot temperature measurement, average temperature measurement, analog level output and HIMS (Hybrid Inventory Management System) please refer to the applicable option manuals.*

- Step 1:** Collect the required data (such as radar position height, maximum safe fill height, alarm settings, etc.) on a piece of paper. Refer to 'Commissioning form 971 SmartRadar LTI' supplied with each gauge.
- Step 2:** Proceed with programming / checking of each item for the standard gauge without optional functions (level start-up, zones / thresholds and alarm setting).
- Step 3:** Check the identification code on the label of the 971 SmartRadar LTI to determine whether the gauge is equipped with one or more optional functions, and program the items for these options.

In the following sections, the items are listed that *as a minimum* should be programmed (checked) during commissioning of the level part of the SmartRadar. Commissioning is divided into the following steps:

- Step 1** Selecting dimension and decimal separator (section 3.4.1)
Step 2 Level start-up (section 3.4.2)
Step 3 Level check (section 3.4.3)
Step 4 Zones and threshold settings (section 3.4.4)
Step 5 Level alarm settings (section 3.4.5)
Step 6 Ullage readout (section 3.4.6)
Step 7 Password protection (section 3.4.7)
Step 8 Options (refer to the option manual(s) of the installed options)

3.4.1 Selecting dimension and decimal separator

When one or more dimension items are changed, all items with related formats will be automatically changed and the values will be automatically converted to the new dimension. The same applies for the decimal separator. The SmartRadar LTi can be completely programmed in another dimension than it is intended to operate in. Just change the item **LD** (and any other dimension items).

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
LD=	Level dimension	<p>Selects and converts the level dimension. This item contains one character, which can be:</p> <p>M : metres; format: sign X X X separator X X X X</p> <p>F : feet; format: sign X X X X separator X X X</p> <p>I : inches; format: sign X X X X X separator X X</p> <p>P : fractions; format: sign X X ' X X " X X</p>
DP=	Decimal separator	<p>The item DP (decimal separator) can be:</p> <p>. : point or</p> <p>, : comma.</p>
EX	Exit	Exit protection level

Standard formats

There are two standard formats; these formats are:

- Standard floating point format: sign point M M M M M M M M E sign P P
- Standard power format [dB]: sign X X X X point X

where: M = mantissa
P = exponent
X = value in decibel

3.4.2 Level start-up

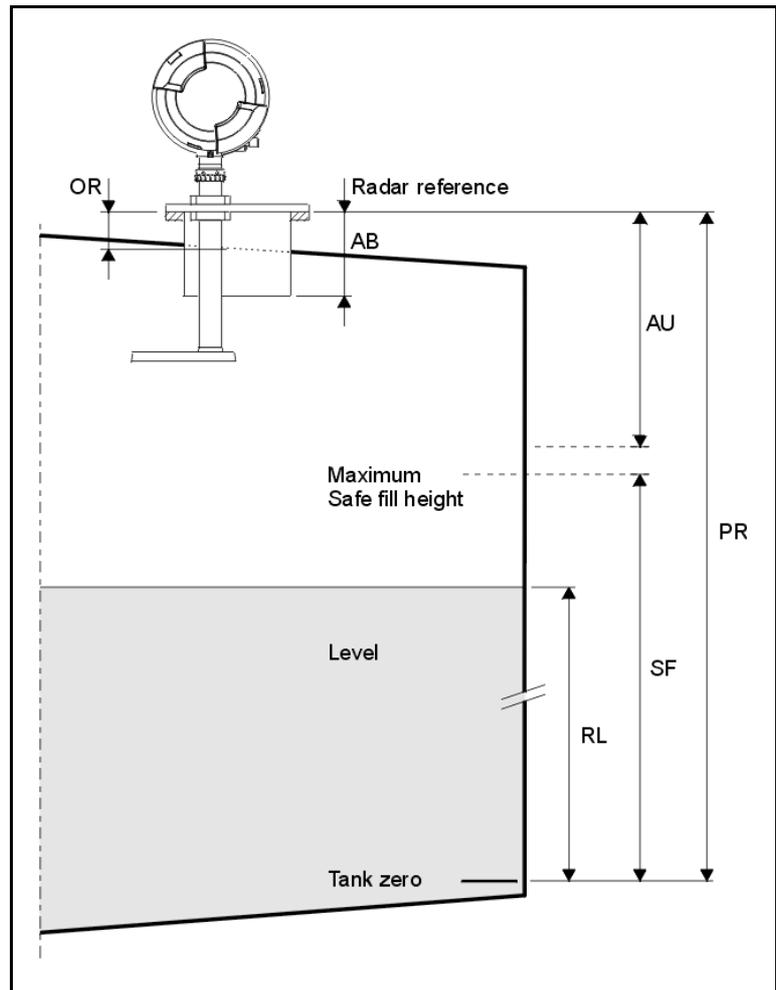
Refer to figure 3.4 for level start-up tank parameters.

To get the level from the gauge without any compensation enabled, only the following items should be programmed.

Radar reference:

The radar reference (zero point for the radar gauge measurement) is the roof nozzle position (refer to figure 3.4).

If the 971 SmartRadar LTi is equipped with a stilling well antenna model, item **BD** should be programmed. In all other cases skip this item and start from item **OM**.



Item	Name	Description
W2=	Protection level 2	Enter password 2 to alter the required settings.
BD=	Stilling well diameter	Floating point format; units: metres. This item contains the internal diameter of the stilling well (only if the SmartRadar LTI is installed on a stilling well).
OM=	Radar operational mode	This item contains one character, which determines the operational mode and depends on the antenna. F for free space measurement; S for stilling well measurement;
PR=	Position radar	Format according to item LD . Default: +027.0000 (m). This item represents the vertical distance from the Radar reference point to the tank zero (mostly the datum plate). When not exactly known, estimate the distance within ± 1 metre (3 ft). When setting the SmartRadar LTI reference level (see section 3.4.3), the value in item PR is overwritten.
SF=	Maximum safe fill height	Format according to item LD . With this item the gauge checks if the programmed upper measuring range is valid. The following relation is valid: SF < (PR - AU). If a conflict is detected, a warning is given (EE : 07901).
AB=	Nozzle length	Format according to item LD . Default: +000.0000 (m). Set this item only when the F08 antenna is installed inside the nozzle. Give in this item the nozzle length. When the antenna is installed inside the nozzle, a correction is automatically applied.
OR=	Offset to roof	Format according to item LD . This items represents the average distance from the radar nozzle to the roof. The SmartRadar LTI uses this information to determine the position of double reflections (product surface - roof - product surface - antenna).
4V=	Level calc. decision switch	This item contains 10 positions. The 7 th position enables or disables the AdvancedDSP routines: F enables AdvancedDSP level calculation - disables AdvancedDSP level calculation Refer to section 'AdvancedDSP level calculation routine' for information when to enable it, and to section 3.4.8 for other settings of item 4V .
AC=	Averaging constant	Two digits, default value: 90. Averaging constant for output filter of radar innage (item RI) and radar ullage (item RU) value. The higher the value for item AC , the more damping on the radar innage and radar ullage values.
EX	Exit	After the exit command, the 971 SmartRadar LTI will perform a controlled software reset, and start up with disabled access to protected levels.

AdvancedDSP level calculation routine

Under certain installation conditions, the product level calculation can be done more accurately when the AdvancedDSP level calculation routine is enabled. In that case the calculated level is less sensitive for obstructions in the microwave path, like equalisation holes in stilling well, welding seams and multipath effect from tank shell.

Note:

AdvancedDSP level calculation can only work correctly, when the level in the tank is not moving fast (less than 1 mm/sec).

It is advised to enable AdvancedDSP level calculation with the following antenna installation conditions:

- F08 antenna : for tanks with **H** (tank height) between 8 and 12 metres where **d** (distance to tank shell) is less than $0.2 \times H$. **d** becomes: $0.2 \times (H - 5)$ or larger;
- S06 .. S12 antennas : always, when in compliance with the stilling well conditions mentioned in the installation guide SmartRadar Antennas. Thus **not** when stilling well has slotted holes, or is much contaminated.

3.4.3 Level check

Refer to figure 3.4. Check if there is a valid level reading. It is no problem if the value is incorrect, as long as there are no error status messages. Two common error status messages are discussed below.

1) Level reading 999999999 with level status FL. Check error code item **EE** (this is an indexed item!).

If **EE** reads 07901, the maximum safe fill height (item **SF**) is set too high. Request for the “Antenna minimum ullage” (item **AU**). The following relation is valid: $SF + AU < PR$.

Either distance **PR** is not correct or the maximum safe fill height (**SF**) is too large for this installation.

2) If there is a “Warning code” present, check warning code item **WC** (this is an indexed item!).

If **WC** reads 07000, the reflected signal is not so strong that its peak rises above a threshold setting.

Lower the product zone threshold (or another zone threshold where the peak is found). Refer to section 3.4.4 for more information on zones and thresholds.

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
RL=	Reference level	Format according to item LD . The reference level is the actual level in the tank (obtained from e.g. manual dip)
EX	Exit	With the exit command, the actual level value in item RL is written in NOVRAM. Only then the value of item RL will be used with the next AR command
W2=	Protection level 2	Enter protection level 2 (default password: ENRAF2)
CM	Commissioning mode	Enter the commissioning mode to accept the reference level
AR	Accept reference	With this command, the 971 SmartRadar LT <i>i</i> accepts the value of the reference level and internally re-calculates the distance: radar position (item PR). After the controlled reset, by the EX command, the level reading is available.
EX	Exit	Exit protection level

With this procedure, the 971 SmartRadar LT*i* now measures the level value, given in item **RL**, and all relative level changes will be followed by the instrument.

3.4.4 Zones and threshold settings

The tank height is divided into 3 measuring zones: Antenna zone, Product zone and Bottom zone. In addition, ten obstruction zones can be programmed. Refer to figure 3.5.

Please note that the X-axis from figure 3.5 indicates **ullage**. The zero point on the X-axis represents the "Radar reference". This is the nozzle height, with respect to the tank zero, on which the antenna is mounted (item **PR**; position radar). Refer also to figure 3.4.

Warning

*The product reflection in the area "Antenna minimum ullage" will be indicated as product level with **reduced accuracy** and with warning code 07013: 'level above measuring range'. Do not use this area as normal operational area because of the chance for a **tank overflow**.*

The antenna is located inside the antenna minimum ullage area. In this area, reflections from the antenna will decrease to almost zero at 0.5 to 2 metres distance from the antenna surface (depending on the antenna).

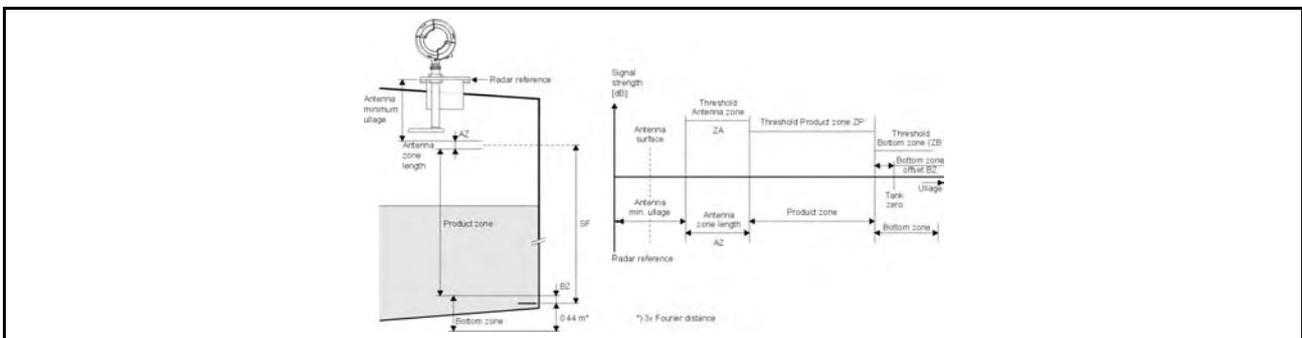
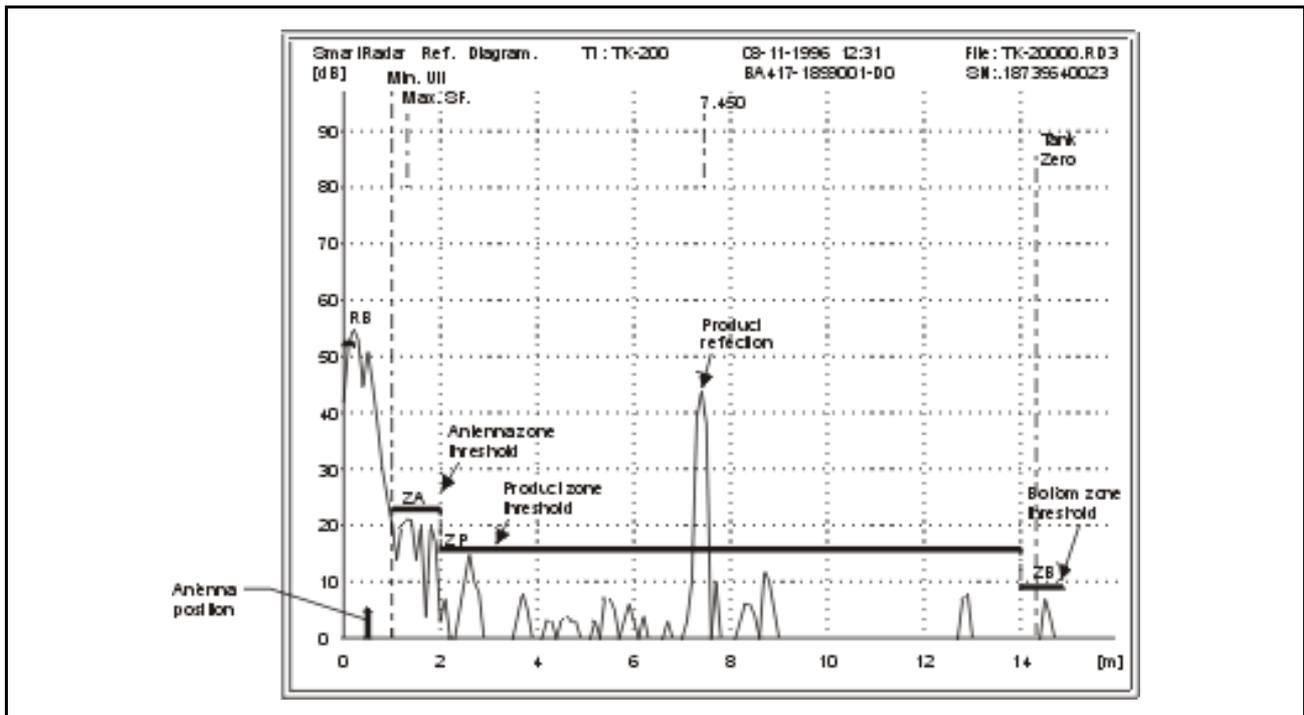


Figure 3.6 shows a so-called reflection diagram. The reflection diagram can be made with the Enraf service tool.

Not all reflections in the reflection diagram are selected as possible peak for the product level. A first selection can be made by the threshold in each of the three zones. The thresholds should be set such that noise is filtered out. Only the peaks above a threshold setting are selected as possible product peak.

The antenna zone length (item **AZ**) covers the area where antenna reflections are low but still present. The antenna zone threshold should cover the most of the antenna reflections. The antenna zone length does not need to extend till the antenna reflections are completely zero; only until the higher reflections are covered, such as those which might be expected in the product zone. Refer to example of reflection diagram in figure 3.6.



The area between antenna zone length and the bottom zone is called "product zone". The product zone threshold can be set with item **ZP**.

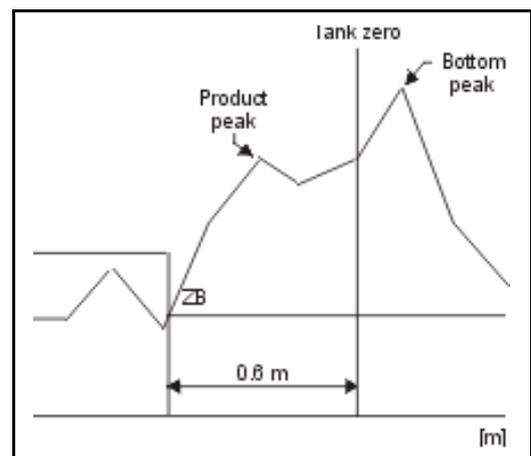
The bottom zone is defined around tank zero. With bottom zone offset (item **BZ**) the position above tank zero is defined where the product zone ends and the bottom zone begins. The bottom zone extends three Fourier distances under tank zero (approximately 0.44 m).

The bottom zone definition is important in applications where the bottom can be seen through the product in the reflection diagram. At a low product level both the product reflection and the bottom reflection will then be present and the bottom reflection can be the strongest. In that case the bottom zone offset must be set large enough to make sure that when the tank is emptying the product peak enters the bottom zone first, before the bottom reflection enters the bottom zone. The bottom reflection peak enters the bottom zone in the opposite direction and the peaks merge when the tank gets empty.

The low speed of the radar signal through the liquid column gives the impression that the bottom looks further away than it really is. When the tank is emptying the bottom appears to rise. Figure 3.7 gives an example of such a situation. Item **BZ** should be set to a value of 0.6 to 1.0 metres (2' to 3' 4").

When measuring the roof of a (internal) floating roof tank, the mechanism of searching for a smaller peak in front of a larger peak in the bottom zone is disabled. By setting the third element in item **4S** (2nd level calculation decision switch) to 'R' you can declare the floating roof application.

Reflections beyond the bottom zone are ignored for level detection. The bottom zone threshold can be set with item **ZB**.



Changing the settings for the zones and thresholds should be done, on the basis of information from a reflection diagram.

It should be common practice at installation of the 971 SmartRadar LTI gauge to make a reflection diagram and, if necessary, adjust the zones and threshold settings.

Item	Name	Description
W2=	Protection level 2	Enter password 2
AZ=	Antenna zone length	Format according to item LD . If necessary, the antenna zone length can be altered.
BZ=	Bottom zone offset	Format according to item LD . As a default, the bottom zone starts 0.3 m above tank zero. Item BZ specifies this start position. If the bottom position is not exactly known, do not alter item BZ . However, set the bottom zone offset to a larger value when there is a strong bottom reflection.
ZA=	Antenna zone threshold	Format according to standard power format (dB). If required, the threshold of the Antenna zone can be altered with this item. Be sure to set the threshold above the antenna reflections.
ZP=	Product zone threshold	Format according to standard power format (dB). The product zone threshold should be set such that: <ul style="list-style-type: none"> • product reflections are passed, and • small meaningless peaks (noise) are suppressed. It is not meant to block obstructions; these are eliminated (not selected as product peak) by the peak detection software.
ZB=	Bottom zone threshold	Format according to standard power format (dB). The bottom zone threshold should be set such that: <ul style="list-style-type: none"> • product reflections are passed, and • small meaningless peaks (noise) are suppressed. It is not meant to block a bottom reflection; the bottom reflection will be identified by the peak detection software.
EX	Exit	Exit protection level

The peak detection software keeps a list of maximum 15 detected peaks above the threshold zones, from which one of them is the product peak. The number of detected peaks and their position and strength can be requested by the data items: **5C**, **5D** and **5E**.

Item	Name	Description
FC	Freeze RSP data	The freeze Radar Signal Processing data is a command that stores all relevant radar processing data in RAM memory. Wait approximately 5 seconds before requesting the next data.
5C	Number of peaks above threshold	This item contains the number of peaks above the threshold settings. The maximum number is 15; when more peaks are detected, only the 15 strongest peaks are listed.
5D.0.1	Position of detected peaks	Format according to item LD (indexed item; 15 elements). Each element contains the distance from the radar reference position to the detected peak.
5E.0.1	Amplitude of detected peaks	Format according to standard power format (dB) (indexed item; 15 elements). Each element contains the amplitude of the corresponding peak in item 5D .

When obstructions are expected and there cannot be made a reflection diagram, these items are very helpful to select the obstruction zones. However, the best results can be obtained from the information of a reflection diagram.

Obstruction reflections

Objects that are in the microwave path will cause reflections. All reflections from objects other than the product surface are called: 'obstruction reflections'.

Note:

In the reflection diagram you will probably also see second order reflection peaks, found at double distance.

Obstruction reflections can be caused by heating coils, welding seams from tank shell or stilling well, etc. Special examples of obstruction reflections are the antenna reflection and the bottom reflection.

Obstruction reflections can influence the level measurement:

- When an obstruction reflection is detected above the zone threshold, it becomes a candidate for the selection of the level peak. This is not a problem, as the peak detection software can handle this.
- When the product peak approaches an obstruction peak, the two peaks will influence the calculation of their positions. The influence starts when the peaks are 0.4 m (16") apart. The obstruction reduces the accuracy of the calculated level position. In many cases this is a one-side phenomenon, where the obstruction reflection disappears as the product submerges the reflecting object.
- The AdvancedDSP level calculation is less sensitive for the presence of an obstruction reflection. But the inaccuracy of the normally calculated level position may cause a jump of the AdvancedDSP level of 15 mm ($\frac{19}{32}$ "). These jumps can be prevented by declaring an obstruction zone around the position of the obstruction peak.

The SmartRadar LTi software provides for setting of obstruction zones and obstruction threshold for each zone. This can be used to prevent obstruction reflections from appearing in the list of detected peaks. From the list of detected peaks the product level peak is selected. As explained above, the peak detection software can cope with the presence of obstruction reflections without the obstruction zone settings.

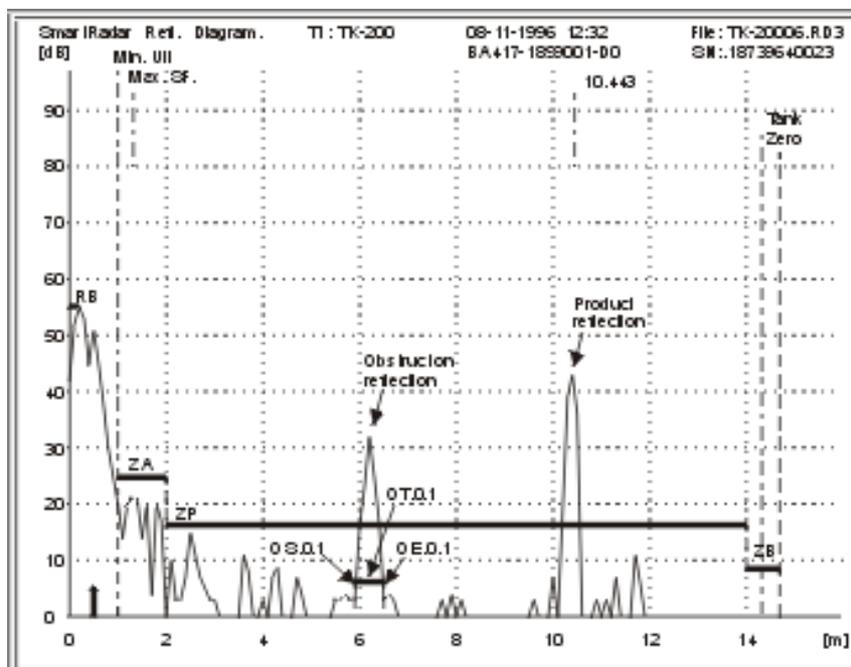
However, it is advised to define obstruction area's around obstruction peaks when the AdvancedDSP level calculation is used. It is then not required to set obstruction thresholds; only the zone definition is required.

Figure 3.8 shows a Reflection Diagram in which an obstruction is found at approximately 8 m level (6.25 m ullage). The product reflection is found at approximately 3.8 m level (10.44 m ullage).

In this example, the following settings should be selected:

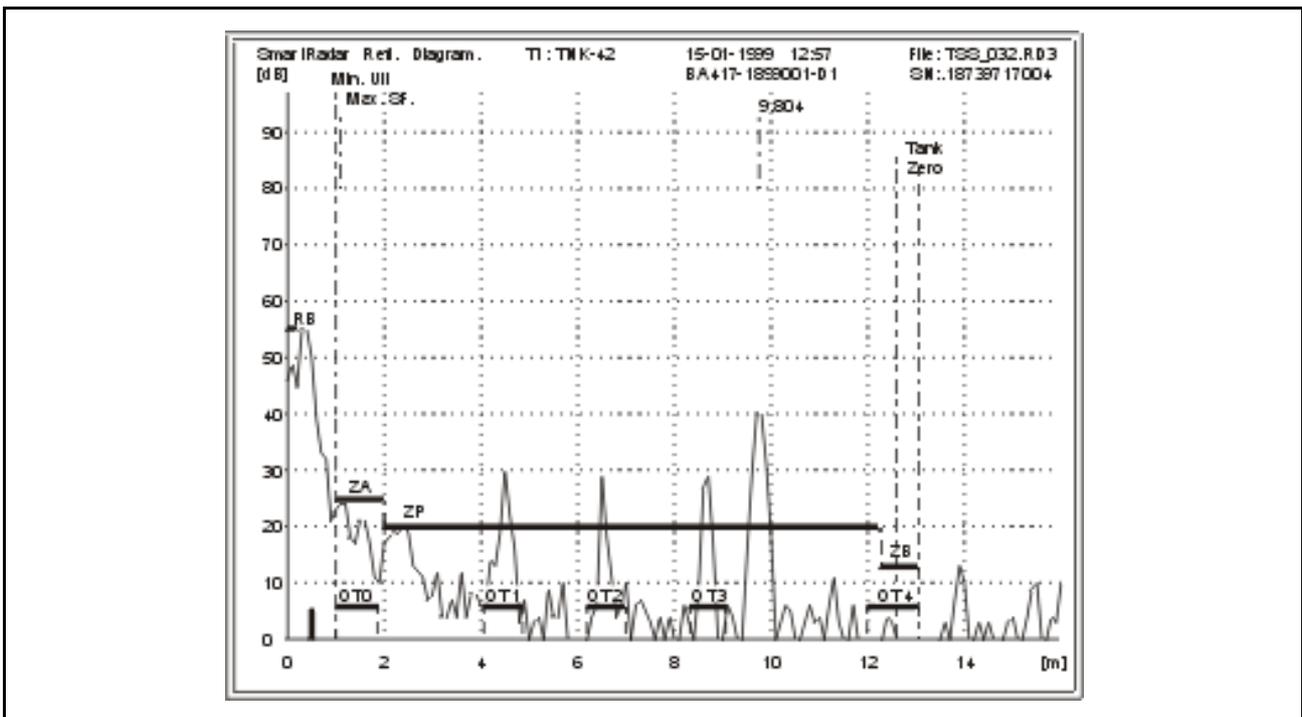
- Obstruction zone start at 5.85 m **ullage** (at least 0.4 m before the obstruction reflection).
- Obstruction zone end at 6.65 m **ullage** (at least 0.4 m after the obstruction reflection).
- Obstruction zone threshold at 5 dB.

Item	Name	Description
W2=	Protection level 2	Enter protection level 2
OS.0.1=	Obstruction zone 1 start	Format according to item LD . In the above example, obstruction zone 1 start should be programmed as 5.85 m (OS.0.1=+005.8500)
OE.0.1=	Obstruction zone 1 end	Format according to item LD . In the above example, obstruction zone 1 end should be programmed as 6.65 m (OE.0.1=+006.6500)
OT.0.1=	Obstruction zone 1 threshold	Format according to standard power format (dB). In the above example, the threshold of obstruction zone 1 is set at 5 dB (OT.0.1=+0005.0)
OZ=	Enable / disable obstr. zones	Ten ASCII characters; either E (enable) or D (disable) the obstruction zone. For example: OZ=EDDDDDDDDD enables the first obstruction zone
EX	Exit	Exit protection level



It is advised to use obstruction area's for recognizable obstruction peaks that stay below the zone threshold (for instance: welding seams from the tank shell or stilling well, or roof truss). Obstructions from welding seams can be recognized as they appear at regular intervals. Refer to figure 3.9.

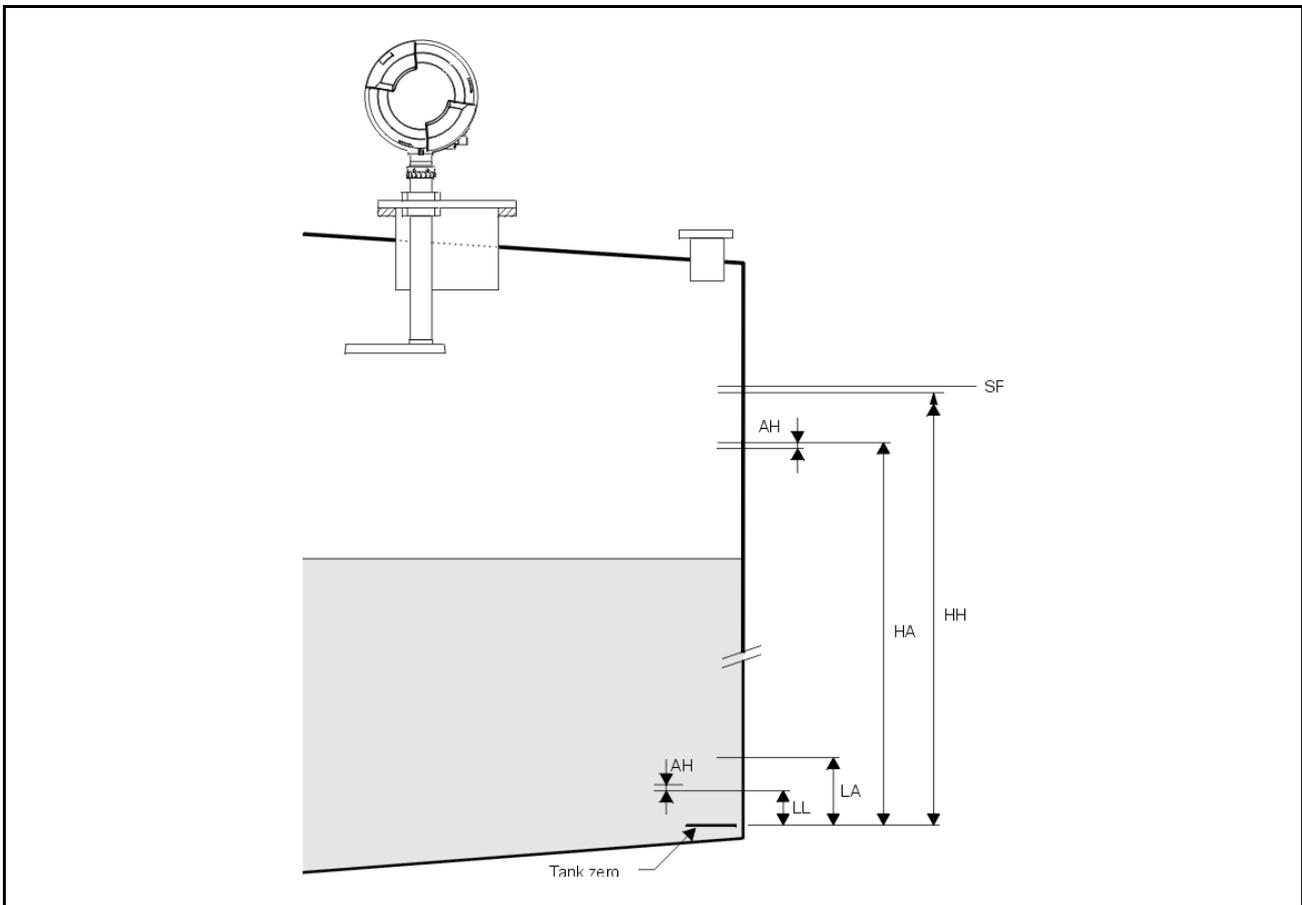
Select the peaks in the reflection diagram, which are known to be caused by an obstruction. Mark the obstructions with an obstruction zone. The length of the obstruction zone should be at least 0.8 m. As the bottom reflection and the antenna reflection belong to the obstructions, it is advised to define obstruction zones in front of the antenna position and the bottom position. For the AdvancedDSP level calculation, the obstruction threshold should be set below the product threshold (e.g. at 5 dB).



The reflection diagram in figure 3.9 shows three obstructions at equal distances. It can therefore be assumed that there is a fourth obstruction (at approximately 11 metres ullage), though not visible in this diagram because it is submerged. For a clear overview of all obstructions, it is recommended to make a reflection diagram when the tank is empty.

3.4.5 Alarm settings

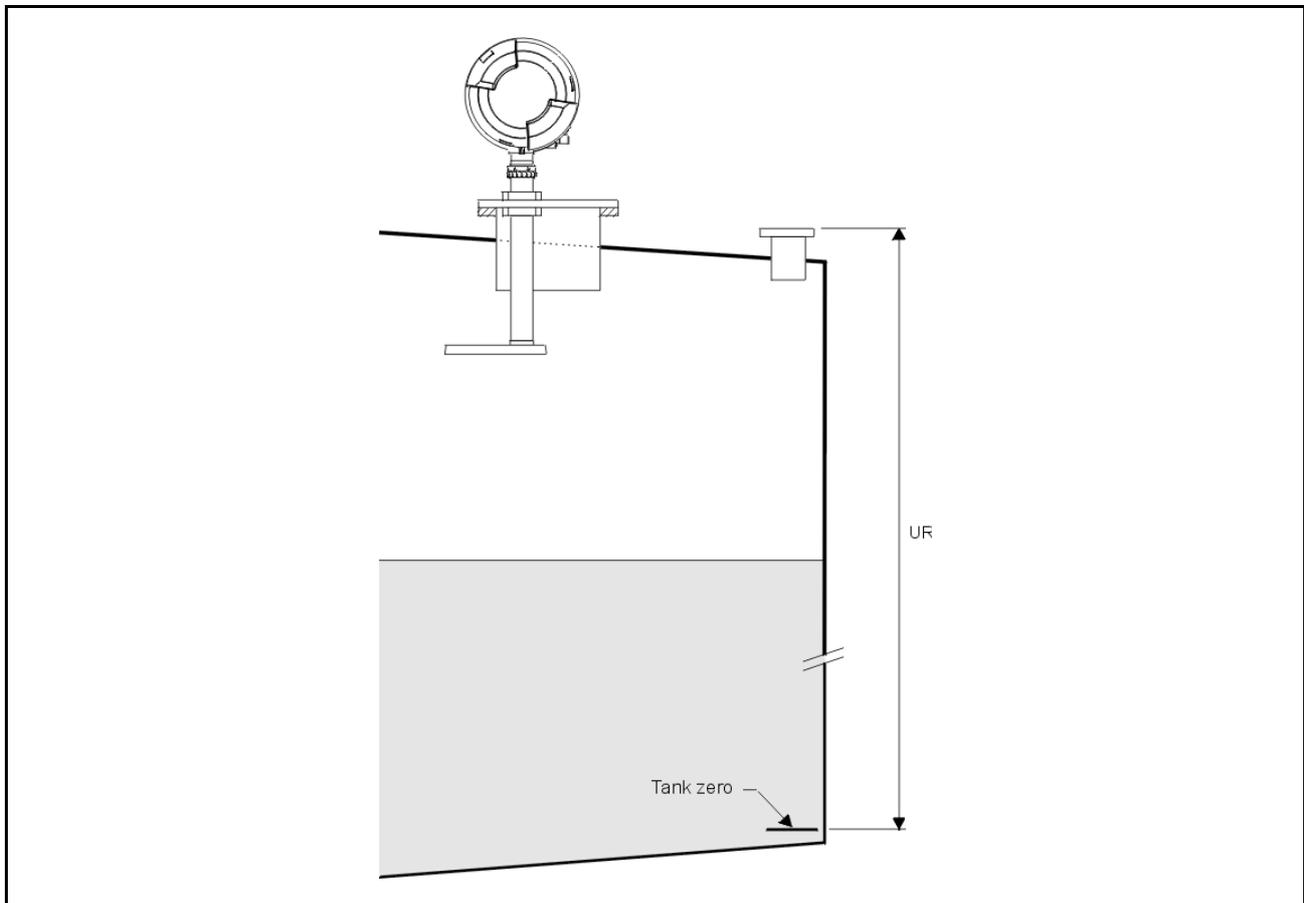
Refer to figure 3.10. High level alarm (**HA**) and low level alarm (**LA**) conditions are transmitted to the host via the communication lines.



Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
	AH= Level alarm hysteresis	Format according to item LD . Sets alarm hysteresis
	HA= High level alarm	Format according to item LD . High level alarm set point.
	HH= High high level alarm	Format according to item LD . High high level alarm set point.
	LA= Low level alarm	Format according to item LD . Low level alarm set point.
	LL= Low low level alarm	Format according to item LD . Low low level alarm set point.
EX	Exit	Exit protection level

3.4.6 Ullage readout

The two items described in this section need only be programmed, when ullage readout is required. Refer to figure 3.11.



Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
	UR= Upper reference	Format according to item LD . The upper reference value is only used when 'Ullage' is to be read from the 971 SmartRadar LTi gauge. The ullage is then calculated as: UR - 971 measured level
	DE= Level type	One ASCII character. DE = I for innage (default setting) DE = U for ullage
EX	Exit	Exit protection level

3.4.7 Password protection

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
W1=	Password 1	6 Characters, default value W1=ENRAF1. This password can be read protected by jumper J6 on the ICU board. If this jumper is set to position 1, the password can not be read
W2=	Password 2	6 Characters, default value W2=ENRAF2. This password can be read protected by jumper J5 on the ICU board. If this jumper is set to position 1, the password can not be read
DY=	Display selection	One ASCII character. For the 971 SmartRadar LT <i>i</i> (which has no local display) item DY must be set to N.
EX	Exit	Exit protection level.

3.4.8 Detection algorithm and special settings

Presentation of the measured level is the result of a two stage process:

- stage 1: detection
- stage 2: acceptance

Detection

The detection operates on the last radar signal captured. First peaks are detected that are above the thresholds (items **ZA**, **ZB** and **ZP**). When there are peaks found, the level peak is selected from the list of detected peaks (items **5D** and **5E**).

Special fuzzy logic is built in, to select the level peak from the set of detected peaks. It is important to know that the fuzzy logic makes use of pattern recognition. Especially at very high levels it looks for patterns with second or third order echo's. In free-space applications such echo's result from reflections against the roof of the tank. Knowledge about the position of the roof is therefore important. Therefore, the distance from the nozzle to the roof must be declared in item **OR**.

Acceptance

Acceptance operates around an authorised gauge level value and the 'low product delay counter' value.

The low product delay counter value can be set with item **FI** (default value: 99; maximum value: 99).

When an authorised gauge level is present, the value is used as the acceptance criterium for the level peaks presented by the detection stage.

Successful acceptance of the latest level peak is used to update the authorised gauge level value.

Consecutive rejection of level peaks and / or absence of level peaks over a number of measurements equal to the number in the low product delay counter, will result in discarding the authorised gauge level value.

When the value is discarded, the last valid value is available as level value over a period of 30 seconds.

When there is no authorised gauge level value, the level peaks presented by the detection stage are used to built up the evidence needed to arrive at a new authorised gauge level value. A level must be present, at least intermittent, over a number of measurements equal to the low product delay counter, before it can become authorised.

Item	Name	Description
W1=	Protection level 1	Enter password 1
FI=	Low product reflection warning delay counter	Two digits; default value: 99. The maximum value is 99 and then the delay is approximately 1 minute. During the delay, the last valid measured level is transmitted as the product level.
EX	Exit	Exit protection level

Reduced accuracy

Obstructions in the tank may produce reflections. When the level reflection is in the neighbourhood of an obstruction reflection the accuracy of the obtained level reading is reduced. The software provides for entering data to describe obstruction zones. See items **OS**, **OE**, **OT** and **OZ**. This can be used to detect that the level reflection is in an obstruction zone. When in addition level calculation decision switch item **4V** position 2 is set to 'O', a reduced accuracy warning will be set if the level reflection is in an obstruction zone.

When the level is in the bottom zone, a bottom reflection may reduce the accuracy of the level reading. When the level calculation decision switch item **4V** position 1 is set to 'B', a reduced accuracy warning will be produced if the level is in the bottom zone.

Peak selection with roof reflector

With light products it is possible to have a reflection from the tank bottom, specially at lower level through the product. Therefore, there is a routine that in the bottom zone is searched for a smaller peak in front of the highest peak, which is caused by the bottom.

However, when a roof reflector is used it is impossible to look through the product. That information is given in item **4S**, third position.

Item	Name	Description																											
W2=	Protection level 2	Enter password 2																											
4V=	Level calculation decision switch	Ten characters; default setting: - - - - - <table border="1"> <thead> <tr> <th>Pos.</th> <th>Char.</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>B</td> <td>Reduced accuracy if level peak in bottom zone - No reduced accuracy if level peak in bottom zone</td> </tr> <tr> <td>2</td> <td>O</td> <td>Reduced accuracy if level peak in obstruction zone - No reduced accuracy if level peak in obstruction zone</td> </tr> <tr> <td>3</td> <td>D</td> <td>Double reflection detection enabled (always)</td> </tr> <tr> <td>4</td> <td>S</td> <td>Reduced accuracy if level peak detected above the maximum safe fill height (item SF) - No reduced accuracy in the above situation</td> </tr> <tr> <td>5</td> <td>P</td> <td>Search for product peak before bottom reflection (always)</td> </tr> <tr> <td>6</td> <td>-</td> <td>Not used</td> </tr> <tr> <td>7</td> <td>F</td> <td>Enables AdvancedDSP level calculation - Normal level calculation</td> </tr> <tr> <td>8 - 10</td> <td>-</td> <td>Not used.</td> </tr> </tbody> </table>	Pos.	Char.	Function	1	B	Reduced accuracy if level peak in bottom zone - No reduced accuracy if level peak in bottom zone	2	O	Reduced accuracy if level peak in obstruction zone - No reduced accuracy if level peak in obstruction zone	3	D	Double reflection detection enabled (always)	4	S	Reduced accuracy if level peak detected above the maximum safe fill height (item SF) - No reduced accuracy in the above situation	5	P	Search for product peak before bottom reflection (always)	6	-	Not used	7	F	Enables AdvancedDSP level calculation - Normal level calculation	8 - 10	-	Not used.
Pos.	Char.	Function																											
1	B	Reduced accuracy if level peak in bottom zone - No reduced accuracy if level peak in bottom zone																											
2	O	Reduced accuracy if level peak in obstruction zone - No reduced accuracy if level peak in obstruction zone																											
3	D	Double reflection detection enabled (always)																											
4	S	Reduced accuracy if level peak detected above the maximum safe fill height (item SF) - No reduced accuracy in the above situation																											
5	P	Search for product peak before bottom reflection (always)																											
6	-	Not used																											
7	F	Enables AdvancedDSP level calculation - Normal level calculation																											
8 - 10	-	Not used.																											

4S= 2nd Level calc. decision switch

Ten characters; default setting: - - - - -

Pos. Char. Function

1	-	Normal communication mode (other settings are used for broadcast mode)
2	P	Plain selection of peaks (only for factory testing) - Intelligent peak selection
3	R	Measurement by means of roof reflector - Measurement direct on product
4 - 10	-	Not used

EX Exit

Exit protection level.

Possibility of peak selection dilemma after gauge startup

It is theoretically possible after a gauge startup, that two peaks are detected of which the second peak is at a double distance with respect to the first peak. The second peak might be a second order echo, in which case the first peak is the level peak. But it is also possible that the first peak is from an obstruction, whilst the second peak is the level peak.

In that case the first peak is used to present the level, with error code 07014 and level reading '99999999'.

In the course of the time it may become apparent which is the level peak when there is a level change. When this happens the error is removed and the correct level is presented.

When however the level in the tank does not change, it may take a long time for the situation with error 07014 to persist. That is why the operator can interfere.

With item **4W** the operator selects the first peak as level peak; with item **4X** the operator selects the second peak as level peak. In both cases the error 07014 is removed and turned into a warning 07014.

With these commands the operator can inspect the two level values involved in the dilemma and choose the level value that he judges is the product level.

In addition the operator can cancel the level selection with item **4Y**. This will restore the level failure situation with level reading '99999999' and error code 07014.

In the course of time, when there has been a sufficient level change, the start-up dilemma will be resolved. From that moment on error 07014 or warning 07014 will disappear, the level will be presented and the commands **4W**, **4X** and **4Y** will have no effect.

Item	Name	Description
4W	Select first peak	With this command, the first peak is used as level peak and error code 07014 is changed to warning code 07014. Warning code 07014 disappears when there is enough change in level to determine by the peak selection software that the selected peak indeed is the product peak.
4X	Select second peak	This command makes the second peak the level peak and error code 07014 is changed to warning code 07014. Warning code 07014 disappears when there is enough change in level to determine by the peak selection software that the selected peak indeed is the product peak.
4Y	Cancel select peak	This command cancels the 4W or 4X commands and the first peak is used as level peak with error code 07014. Only possible as long as there is the warning code 07014.

3.4.9 Additional adjustment with measurement on stilling well

The propagation speed of the microwave, and hence the level measurement, depends on the inner diameter of the stilling well. The smaller the diameter, the lower the propagation speed, resulting in a larger measured radar ullage.

Item **BD** holds the inner diameter of the stilling well. When the real value of the inner diameter differs from the setting in item **BD**, the SmartRadar has a 'gain' error in the level measurement.

It is therefore recommended to check the level reading of the SmartRadar LTi with some manual dips at different static levels over the full operating range.

Note:

After commissioning, the AdvancedDSP routines require one complete passage through the full operating level range, before the optimum accurate level reading is obtained.

A level gain error, when present, can be corrected in two ways:

- ullage correction table
- adjustment of item **BD**

For the correction via the ullage correction table, refer to the description of items **CW**, **CL** and **CS**.

$$BD_{new} = \frac{0.036568}{\sqrt{1 - \varepsilon_{scale}^2 \times \left(1 - \frac{0.0013372}{BD_{orig}^2}\right)}}$$

The correct value for the stilling well diameter can be calculated with the following equation:
where:

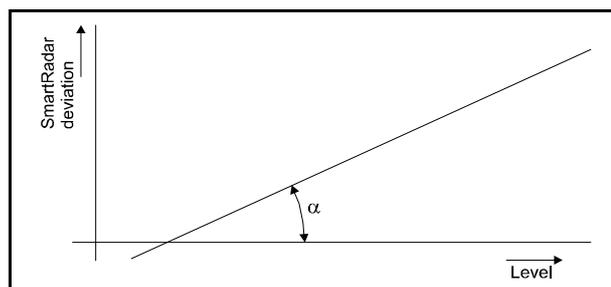
BD_{new} : recalculated stilling well diameter [m]

BD_{orig} : original stilling well diameter [m]

ε_{scale} : scale error (relative gain error)

example: 10 mm gain error on 20 m range: $\varepsilon_{scale} = 20 / (20 + 0.010) = 0.9995$.

for the sign of the scale error, refer to figure 3.12. If α is positive, the scale error sign is positive; if α is negative, the scale error sign is negative.



An example with an S10 antenna:

Item **BD** is programmed as 254 mm.

At 19 m level, the deviation of the SmartRadar LTi level is: -2 mm;

At 2 m level, the deviation of the SmartRadar LTi level is: +3 mm.

$$BD_{new} = \frac{0.036568}{\sqrt{1 - \left(\frac{17}{17 - 0.005}\right)^2 \times \left(1 - \frac{0.0013372}{0.254^2}\right)}} = 0.2576 \text{ [m]}$$

Note:

After the new stilling well diameter is programmed, the SmartRadar LTi must be set to level with the **RL** and **AR** sequence.

Hence, the procedure to follow is:

Item	Name	Description
W2=	Protection level 2	Enter password 2.
BD=	Stilling well diameter	Recalculated stilling well diameter.
RL=	Reference level	Reference level from manual measurement.
EX	Exit	Exit protection level.
W2=	Protection level 2	Enter password 2.
CM	Commissioning mode	Enter commissioning mode to accept the reference level.
AR	Accept reference	The reference level, given by item RL , will now be accepted as the radar level.
EX	Exit	Exit protection level.

3.5 Data items

The table below lists a number of data items. They contain measured data, verification data and diagnostic data.

The verification data can be used to check the peak selection result. The radar status indicates the validity of the measured data.

The diagnostic data provide low level error information about the instrument (refer to section 4.5).

Item	Description	
RD RI RU	Measured data	Product reflection signal strength (dB) Innage (format according to item LD); the value is preceded by two characters from radar status item QR Ullage (format according to item LD); the value is preceded by two characters from radar status item QR
5C 5D 5E RT QR	Verification data	Number of detected peaks Position of detected peaks (format according to item LD ; indexed item, 15 elements) Amplitude of detected peaks (standard power format; indexed item, 15 elements) Internal temperature of 971 SmartRadar LTi (format according to item TD) Radar status; refer to section 4.5.2
EB EE EP WC	Diagnostic data	Error DAB request Error ICU (APU part) request (indexed item, 10 elements) Error ICU (XPU-2 part) request Warning code ICU (APU part) (indexed item, 10 elements)

4 Service and troubleshooting

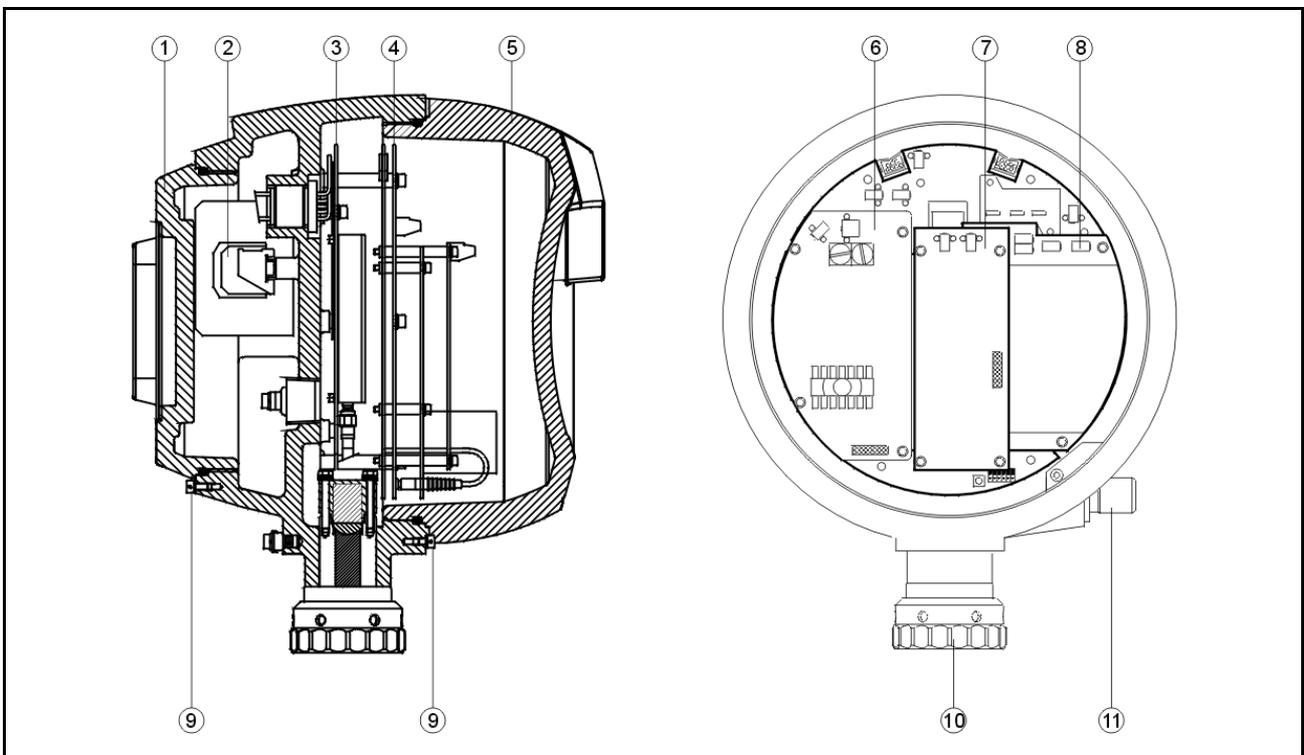
The 971 SmartRadar LTi does not require preventive maintenance.

For mechanical and electrical installation details, refer to the installation guides of the Antennas and the SmartRadar LTi

Depending on the application, the Antenna may over time become too contaminated for accurate level measurement. This condition is then signalled by the built-in diagnostics of the 971 SmartRadar LTi. Then a warning code (WC: 07001) is generated. In that case, the Antenna should be cleaned.

4.1 SmartRadar LTi layout

The SmartRadar LTi housing consists of two sections: the electronic compartment and the terminal compartment (refer to figure 4.1).



Item	Description	Item	Description	Item	Description
1	Rear cover	5	Front cover	9	Cover blocking devices
2	Terminals	6	ICU_GPS board (supply board)	10	Tank separator coupling
3	RFB-2 / DAB board	7	ICU_RS232/RS485 board or ICU_HPO board (optional)	11	Infra-red connector (optional)
4	ICU board	8	ICU_HPI board (optional)		

The electronic compartment can be accessed by removing (unscrewing) the front cover (5).
The terminal compartment can be accessed by opening the rear cover (1).

4.2 The instrument covers

The SmartRadar LT*i* enclosure is water proof IP67. For this purpose, the covers are fitted with O-rings. Check the O-rings before closing the instrument.

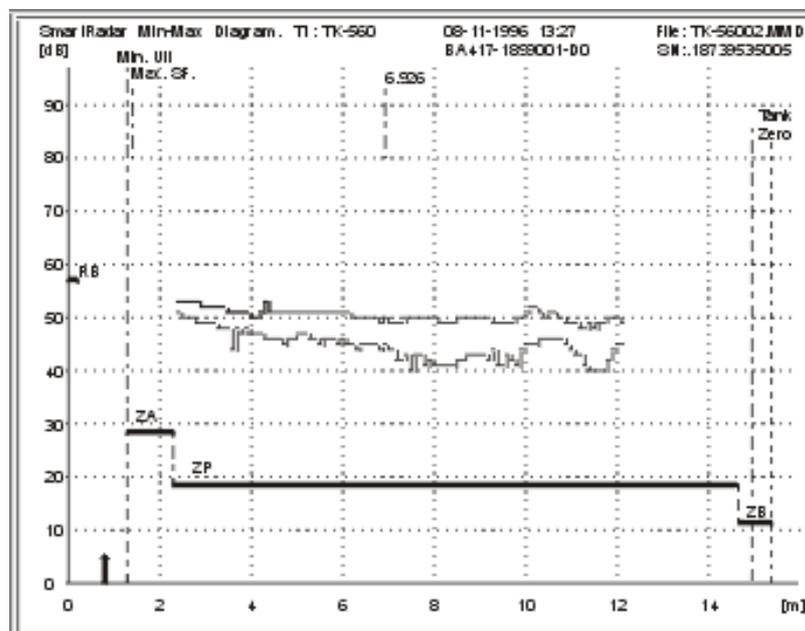
Caution

*Do not damage the thread of the covers and 971 housing and keep the thread free of dirt.
After opening, grease it lightly with anti seize grease.
When closing, never tighten the covers before the threads are properly engaged.
The covers should be turned counter-clockwise until the thread "clicks" in place,
then turn clockwise until the covers are fully closed.*

4.3 Min max diagram

One of the features of the 971 SmartRadar LT*i* is that the instrument keeps track of the measured reflections. The minimum and maximum product reflection strength, measured at each Fourier interval, is stored. Whenever a larger reflection strength is measured at a specific Fourier interval, the previous value is overwritten. The same is done for the minimum reflection strength value. In this way, a reflection history is present in the instrument.

The minimum and maximum reflection strength values can be retrieved by the Enraf service tool producing a so-called "min max diagram". Figure 4.2 gives an example of a min max diagram.



In the example above, all measured product reflections are well above the product zone threshold. However, if some of the minimum reflections were found just above or at the product zone threshold, this is a signal that the product zone threshold should be lowered (or the gain, item **50**, should be increased).

The memory of the min max diagram can be cleared with command **CZ**.

Item	Name	Description
W2=	Protection level 2	Enter password 2.
CZ	Clear min max diagram	Clears all elements of item 4T by writing 30 _H in them (sets 4T to default).
EX	Exit	Exit protection level.

4.4 Alarm loop checking

Normally, level alarms can be verified when the level reaches the low level or high level alarm set point. The level alarms and, if applicable, the hard alarm contact coupled to one of the level alarms, can be checked by a “loop check” command. This is independent of the actual level value.

The level alarm signalling can be checked in several ways:

- via the communication line to the host
- via the hard alarm output contact

When enabled, the alarm test (item **AT**) can be given. The specified alarm is then toggled for one minute. Item **AT** has 8 positions; four character pairs are used to specify the desired alarm for testing: HH, HA, LA and LL. Each alarm can be tested individually, or the alarms can be tested simultaneously.

Item	Name	Description
LE	Loop check enable	<p>The loop check enable item enables or disables the alarm test with item AT.</p> <ul style="list-style-type: none"> • E : enables alarm test with item AT • D : disables alarm test with item AT <p>If the alarm test is required, check if item LE is set to “E”. If item LE is set to “D”, change the setting to “E”.</p>
AT=	Alarm test	<p>The alarm test item toggles the specified level alarm for one minute. The settings for the alarms to be tested are as follows: aabbccdd (8 ASCII characters)</p> <p>where:</p> <ul style="list-style-type: none"> aa : HH high high level alarm test - - no high high level alarm test bb : HA high level alarm test - - no high level alarm test cc : LA low level alarm test - - no low level alarm test dd : LL low low level alarm test - - no low low level alarm test <p>For example: AT= - - HALA - - toggles the high and low level alarm for one minute.</p>

Note:

When, as in the above example, a high and low alarm are toggled at the same time, the high alarm prevails over the low alarm on the communication line. It is therefore recommended to check only one alarm at the time.

4.5 Error codes and status information

The 971 SmartRadar LTI is an instrument with error reporting. Detected errors can be requested by the 847 PET (optional) or by the Enraf service tool.

The following items provide the error data of the processor boards:

- EB** Error request RFB-2 / DAB board
- EE** Error request ICU board (APU part)
- EP** Error request ICU board (XPU-2 part)
- WC** Warning code ICU board (APU part) (not a real error, but a warning that the level may not be accurate)

These items contain an error (warning) code of the last occurred error condition. The error data can be read as long as the gauge is not reset.

Besides the error data, data items from level, and optional functions such as temperature and analog level output, contain one or more status characters which also give valuable information. Most status characters are bit coded. Appendix B contains an ASCII table for conversion of a status character into bits. Bits are numbered from 0 to 7 from right to left.

An example for a bit coded status character:

- a status character reads: **F**;
- written out in bits (refer to Appendix B): **0100 0110**;
- (b7=0, b6=1, b5=0, b4=0, b3=0, b2=1, b1=1, b0=0).

Bit 7 is always a '0' and bit 6 is always a '1', to avoid 'control' characters.

Look up the description of the particular error (e.g. **QR** in section 4.5.2) to find the description of the meanings allocated to each bit of the character. Only the bits set to '1' represent an actual status.

4.5.1 XPU-2 error code (item EP) of ICU board

The XPU-2 error code is a three-digit number. When the XPU-2 detected an error about a certain item, that item follows the error code, separated by a space.

For instance: 067 LL : invalid level format in item **LL**.

Some ICU (XPU-2 part) error codes of item **EP** are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Enraf service tool.

000	No error	
014	NOVRAM operation error	Set item 03 to '@'; Check all settings, there may be an error
051	Unknown item	Item not known to SmartRadar LTI, check for correct item
056	Wrong protection level	First enter protection level 1 or 2
067	Invalid level format	Check item LD , then give the setting in the correct level format
075	Invalid density format	Check item DI , then give the setting in the correct density format
076	Invalid floating point format	Give setting in correct floating point format (refer section to 3.3.1)
082	Invalid password	Give the correct password for W1 and W2
089	Invalid pressure format	Check item PI , then give setting in the correct pressure format
101	Watchdog reset error	The watchdog reset is a sign that there is a serious fault, caused by interference, or a faulty ICU board
137	No optional board	Missing optional board; either not well connected to the ICU board, or optional board is defective
200	Invalid indexed item format	Wrong indexed item format; use points between indexes
201	Invalid indexed item start index	Wrong indexed item element number; too large or invalid
202	Invalid indexed item index length	Wrong indexed item length; can be between "1" and "9"
999	Fatal ICU error	Serious internal ICU software error; check contents of item 00 and report to Enraf Delft

4.5.2 APU warning code (item WC), error code (item EE) and status request (item QR) of ICU board

Some ICU (APU part) warning codes of item **WC** (indexed item of 10 elements) are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Enraf service tool.

00000	No warning	
07001	Sensor contaminated	Clean the antenna
07005	Top / bottom clipping in raw samples A-channel	Lower A-channel gain in item 50 , or enable automatic amplification control item 4M
07006	Top clipping raw samples A-channel	
07007	Bottom clipping raw samples A-channel	Level measured with reduced accuracy and close to antenna! Select first peak or select second peak command has been issued. Warning code disappears after peak detection routine has detected a certain (valid) level change.
07013	Level above measuring range	
07014	Ambiguous init situation	
07200	Reduced accuracy	
07201	A-channel measurement error after start-up	This will be solved when the level in the tank reaches the reference level, or when a new RL level is entered, followed by the AR command
21005	Maximum safe fill (item SF) exceeded	Item SF must not be zero and not exceed the range (PR - AU)

Some ICU (APU part) error codes of item **EE** (indexed item of 10 elements) are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Enraf service tool.

00000	No errors encountered	
07000	Low product reflection	No product reflection above threshold; check with a reflection diagram and lower threshold value in item ZP if possible
07005	Top / bottom clipping in raw samples A-channel	Lower A-channel gain in item 50 , or enable automatic amplification control item 4M
07006	Top clipping raw samples A-channel	
07007	Bottom clipping raw samples A-channel	Make a reflection diagram to find the peak (or use items 5C , 5D and 5E) Set reference level (item RL) in accordance to the product peak and proceed with accept reference procedure Select first peak (item 4W) or select second peak (item 4X), after verification of level by means of manual measurement The antenna and bottom zone may not overlap; check items AZ and BZ Check sign of item AZ (should not be negative) Item ZA must be between 0 and 90 dB Item ZP must be between 0 and 90 dB Bottom zone (item BZ) must be within measuring range (40 metres). Check also item PR Item ZB must be between 0 and 90 dB Obstruction zone start and end must be within measuring range (40 metres). Check also item PR Define obstruction zones in consecutive order Item OT.n.i must be between 0 and 90 dB Antenna zone (item AZ) and bottom zone (item BZ) may not overlap Item BD must be between +0.0440 and +0.3353 metres range Item OM must be either 'F' or 'S' Wrong type of antenna used (i.e. stilling well antenna on a free space SmartRadar LTi) Item SF must not be zero and not exceed the range (PR - AU) Check item AX , or replace ICU board Check item CL ; each level may only be entered once
07009	No peak detected	
07014	Ambiguous init situation	
07101	Antenna zone out of range	
07102	Antenna zone end before begin	
07103	Antenna zone threshold out of range	
07104	Product zone threshold out of range	
07106	Start bottom zone after bottom end	
07107	Bottom zone threshold out of range	
07108	Obstruction zone start out of range	
07109	Obstruction zone end out of range	
07110	Obstruction zone position switch	
07112	Obstruction zone threshold out of range	
07113	Short measuring range	
07170	Stilling well diameter out of range	
07172	Operation mode unknown	
07173	Antenna mode / Operation mode conflict	
07901	Maximum safe fill (item SF) exceeded	Item SF must not be zero and not exceed the range (PR - AU)
18001	Relay error	Check item AX , or replace ICU board
21003	Ullage correction table error	Check item CL ; each level may only be entered once
99999	Value at initialization	

Item **QR** consists of 2 bytes (Byte 0, Byte 1) with status information of the ICU board (APU part).

Status byte 0:

bit0 : Low level alarm
 1 : Low low level alarm
 2 : High level alarm
 3 : High high level alarm
 4 : General ICU fail
 5 : Init / No previous store command
 6 : 1
 7 : 0

Status byte 1:

bit 0 : Level fail
 1 : Warning (for example: sensor contaminated)
 2 : Last valid level used
 3 : Reduced accuracy
 4 : Out of measuring range (close to antenna)
 5 : Blocked
 6 : 1
 7 : 0

4.5.3 DAB error code (item EB) and status request (item QH) of RFB-2/DAB board

Some RFB-2/DAB error codes of item **EB** are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Enraf service tool.

0000	No errors encountered	
0051	Antenna parameter can not be stored	SEEPRM for the antenna or the SmartRadar LTi is defective, or write protect strap is in protect position
0053	SmartRadar LTi parameters can not be stored	
0054	SmartRadar LTi calibration parameters can not be stored	Write protect strap is in protect position
0055	Antenna SEEPRM is write protected	
0056	SmartRadar LTi SEEPRM is write protected	
0057	SmartRadar LTi calibration SEEPRM is write protected	

Item **QH** consists of 2 bytes (Byte 0, Byte 1) with status information of the RFB-2 / DAB board.

Status byte 0:

bit 0 : SEEPRM write allowed
 1 : SEEPRM write busy
 2-5 : 0
 6 : 1
 7 : 0

Status byte 1:

bit 0 : Reduced accuracy
 1 : Non fatal RFB-2/DAB error
 2 : Fatal RFB-2/DAB error
 3 : EXT line level
 4 : Sweep ready (if externally triggered)
 5 : Number of ADCs (0: 1 ADC; 1: 2 ADCs)
 6 : 1
 7 : 0

4.6 Updating software

The 971 SmartRadar LTI is a multiple microprocessor gauge. If a new software version is installed, or an option board is added, it may be necessary to replace one or more of the program memories (EPROM) on the processor boards of the 971 SmartRadar LTI.

The actual version of the installed software can be checked with item **SV**. In case of a software update, check whether the contents of item **SV** correspond with the documentation accompanying the new software.

Because of the strict relationship between the various processor boards, it may become necessary to replace the memory of more than one processor board. Such a change may require an initialization of the NOVRAM, followed by re-programming the user parameters.

The table below gives the software versions for the different processor boards which can operate together.

Processor	ICU board (XPU-2 part)	ICU board (APU part)	RFB-2 / DAB board	Optional board
Software version	XPU K1.1	APU D1.0	DAB B1.0	HPI A1.1 HPO A1.0 HPO A1.1

Note:

Because software updates of different processor boards may be required in the future, this table may not be up to date. For further information, contact Enraf or the local representative.

Before changing the software (EPROM's), make a log file with the Enraf service tool. In this way, the settings already given to the instrument, are saved on disk and can be re-loaded into the instrument after the software update.

Warning

Switch off supply before opening any of the covers.

Proceed as follows:

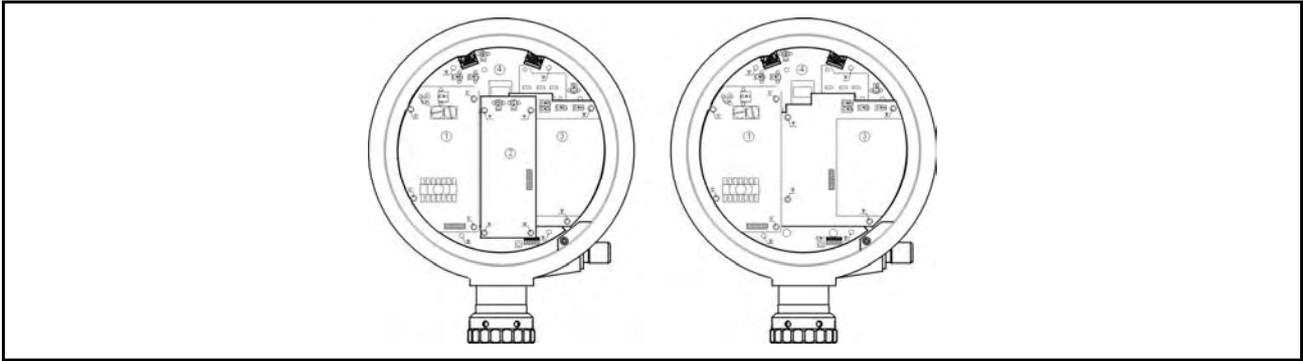
Switch off mains supply and open cover of electronic compartment.

4.6.1 Replacing software (EPROM) on ICU_HPO board

Refer to figure 4.3 and to Appendix C.

Locate ICU_HPO board (2).
Remove EPROM and insert new EPROM (mind notch!).

If software on other boards needs to be changed, refer to the relevant sections in subchapter 4.6. Otherwise, refer to sections 4.6.5 and 4.6.6.



Item	Description
1	Supply board (ICU_GPS)
2	Optional communication board (ICU_RS232/485 or ICU_HPO)
3	Optional interface board (ICU_HPI)
4	ICU board

4.6.2 Replacing software (EPROM) on ICU_HPI board

Refer to figure 4.3 and to Appendix C.

When no optional communication board (ICU_RS232/485 or ICU_HPO) is installed;

Locate ICU_HPI board (3).

Remove EPROM and insert new EPROM (mind notch!).

When an optional communication board (ICU_RS232/485 or ICU_HPO) is installed;

Loosen the 4 Allen head screws, marked "A" in figure 4.3 (use Allen head key 2.5 mm).

Pull optional communication board away from ICU_HPI board so that it is released from its interconnector and move it aside.

Locate ICU_HPI board (3).

Remove EPROM and insert new EPROM (mind notch!).

Put optional communication board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

If software on other boards needs to be changed, refer to the relevant sections in subchapter 4.6.

Otherwise, refer to sections 4.6.5 and 4.6.6.

4.6.3 Replacing software (EPROM's) on ICU board

Refer to figure 4.3 and to Appendix C.

a) XPU-2 EPROM / NOVRAM:

When no optional interface board (ICU_HPI) is installed;
Locate ICU board (4).
Remove EPROM and insert new EPROM (mind notch!).
Remove NOVRAM and insert new NOVRAM (mind notch!).

When optional interface board (ICU_HPI) is installed;

When optional communication board (ICU_RS232/485 or ICU_HPO) is installed;

Loosen the 4 Allen head screws, marked "A" in figure 4.3 (use Allen head key 2.5 mm).
Pull optional communication board away from ICU_HPI board so that it is released from its interconnector and move it aside.

Loosen the 4 Allen head screws, marked "B" in figure 4.3 (use Allen head key 2.5 mm).

Pull optional interface board away from ICU board so that it is released from its interconnector and move it to above. Locate ICU board (4).

Remove XPU-2 EPROM and insert new EPROM (mind notch!).

Remove NOVRAM and insert new NOVRAM (mind notch!).

Put ICU_HPI board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

Put optional communication board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

When no optional communication board (ICU_RS232/485 or ICU_HPO) is installed;

Loosen the 4 Allen head screws, marked "B" in figure 4.3 (use Allen head key 2.5 mm).

Pull optional interface board away from ICU board so that it is released from its interconnector and move it to above.

Locate ICU board (4).

Remove XPU-2 EPROM and insert new EPROM (mind notch!).

Remove NOVRAM and insert new NOVRAM (mind notch!).

Put ICU_HPI board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

b) APU EPROM's:

Loosen the 4 Allen head screws, marked "C" in figure 4.3 (use Allen head key 2.5 mm).

Pull supply board away from ICU board so that it is released from its interconnector and move it to the right.

Locate ICU board (4).

Remove APU EPROM's and insert new APU EPROM's (APU-L and APU-H) (mind notch!).

Put ICU_GPS board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

If software on the RFB-2 / DAB boards needs to be changed, refer to the next section.

Otherwise, refer to sections 4.6.5 and 4.6.6.

4.6.4 Replacing software (EPROM) on RFB-2 / DAB board

The ICU_GPS board and eventually installed optional boards can remain on the ICU board. However, all wiring connected to them must be, temporary, disconnected.

- connectors CN2 and CN4 on ICU_GPS board
- connectors CN1 and CN2/3 on optional communication board
- connectors CN2, CN3, CN4 or CN5 on optional interface board
- connector CN5 on ICU board (blue wires, marked 7 and 8)
- connector CN6 on ICU board (white wires, marked T , T)
- connector CN7 or CN8 on ICU board (black wires, marked 5 and 6)

When the optional Infra-Red connector is installed, also disconnect temporary the cable to CN1 on ICU board (black cable next to XPU-2 jumpers).

Loosen the 4 Allen head screws, marked "D" in figure 4.3 (use Allen head key 3 mm).
Pull ICU board with mounting plate away from RFB-2 / DAB board so that it is released from its interconnector
The RFB-2 / DAB board is now visible (refer to Appendix C).
Remove DAB EPROM and insert new DAB EPROM (mind notch!).
Put ICU board with mounting plate in place (mind the interconnector!) and secure it with the 4 Allen head screws. Insert all connectors which were disconnected.

4.6.5 NOVRAM init

Check whether jumper J4 on the ICU board is set to position "0" (refer to section 3.2). If the jumper is placed in position "1", change it temporary to position "0".
Close covers and apply power.

If NOVRAM needs to be formatted, proceed as follows:

a) If Infra-Red connector is present:

Issue the command **IN** on the PET three times in sequence. After the third time the NOVRAM will be formatted and the message: "NV-data initializing" appears.

Note:

Any other command in between the three IN commands, either from the PET or the Enraf field bus, will abort the init procedure. To avoid requests from the Enraf field bus, they can be disconnected temporarily.

When the NOVRAM formatting is ready, the message: "NV-data init completed" will be shown.

Re-enter the items: **TA** (transmission address)

TI (tank identifier)

TS (transmission speed)

GT (gauge type)

Refer to section 4.6.6 Re-load user parameters.

b) Without Infra-Red connector, hook-up Enraf service tool as described in section 3.3.

Select on the Enraf service tool the feature: send items.

Select transmission address 00, and give the command **IN** three times in sequence.

When the NOVRAM formatting is ready, the message: "NV-data init completed" will be shown in the communication window.

Program the required transmission address (item **TA**) and the required tank identifier (item **TI**).

Refer to the next section Re-load user parameters.

4.6.6 Re-load user parameters

If not yet done, check whether jumper J4 on the ICU board is set to position "0" (refer to section 3.2). If the jumper is placed in position "1", change it temporary to position "0". Close covers and apply power.

Proceed as follows:

Re-transmit the log file from the Enraf service tool.

Program all new settings which are required with the updated software.

Set the SmartRadar LTi to the correct level (check by means of a manual measurement) by using the **RL**, **AR** procedure (refer to chapter 3.4.3).

Make a new log file and a reflection diagram with Enraf service tool for future reference.

If jumper J4 on the ICU board was temporary set from position "1" to position "0", proceed as follows:

Switch off supply, open electronic compartment cover.

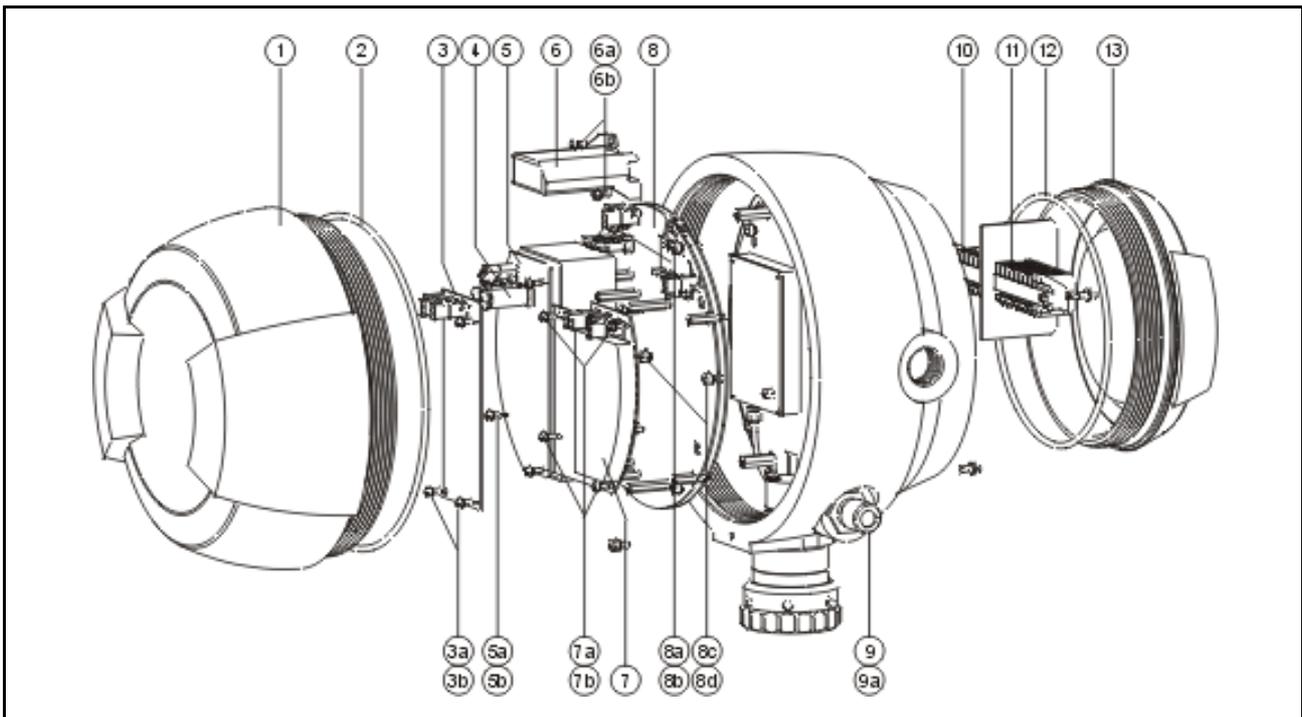
Change jumper J4 to position "1".

Close cover and apply power.

Appendix A Article and part numbers

It is recommended to keep one set printed circuit boards on stock for spare.
Refer to the figure on the next page.

No.	Description	Part. no.
1	Front cover	0186.853
2	O - ring (215 x 4 NBR70)	2132.990
3	Communication board (option)	
	ICU_RS232/485 board (RS-232C or RS-485)	0973.911
	ICU_HPO board (analog 4-20 mA + HART®)	0973.912
3 ^{a,b}	Spare set screws, option (screws, spacers, connector)	0973.991
4	Fuses (2 x)	
	(ac supply: 1.6 A, 250 V)	2655.177
	(dc supply: 2.0 A, 250 V)	2655.178
5	ICU_GPS board	
	(supply: 110 - 240 Vac)	0973.930
	(supply: 24 - 64 Vdc)	0973.931
5 ^{a,b}	Spare set screws, standard (screws, washers)	0973.990
6	ICU_IS board	
	(option)	0973.550
6 ^{a,b}	Spare set screws, option (screws, spacers, connector)	0973.991
7	ICU_HPI board	
	(option)	
	for VITO temperature and/or water probe	0973.920
	for VITO temperature and/or water probe and ART® devices	0973.921
	Hfor spot temperature Pt100	0973.922
	for spot temperature Pt100 and HART® devices	0973.923
	for spot temp., VITO temp. and/or water probe and HART® devices	0973.924
7 ^{a,b}	Spare set screws, option (screws, spacers, connector)	0973.991
8	ICU board	
	(basic version)	0973.601
	(with alarm relay)	0973.603
8 ^{a-d}	Spare set screws, standard (screws, washers)	0973.990
9	Infra-Red connector	
	(option)	
	(part of IR connector assembly)	0854.380
9 ^a	O - ring	2132.210
10	Terminals (grey)	
	(8 x)	2635.308
11	Terminals (blue)	
	(9 x)	2635.309
12	O - ring	
	(160 x 4 NBR70)	2132.989
13	Rear cover	0186.854
	Grease, anti seize	4000.015



The part numbers of the EPROM's (and NOVRAM) are shown in table below. For software compatibility, refer to table in section 4.6 (page 43).

EPROM	Part no.	EPROM	Part no.
ICU - APU L&H (set)	0181.302	ICU_HPI	0181.311
ICU - XPU-2	0181.301	ICU_HPO	0181.320
RFB-2 / DAB	0181.309	NOVRAM (ICU - XPU-2)	2518.929

Parts in the 971 SmartRadar LTi can be easily exchanged, with the exception of the RFB-2 / DAB board. That is because of the calibration of the VCO part and the quartz microwave feed through in the SmartRadar LTi housing.

Antennas can be changed regardless the type or stem length. When the antenna is changed for another type, or for the same type but with a different stem length, the antenna calibration parameters in the DAB SEEPROM must be altered (refer to nearest Enraf office for information about these parameters). Refer to table on next page for the part numbers. Also the tank separator can be changed.

Tank separator	Part no.
for all antenna models	0873.880
O - ring for enclosure against flange / adapter plate	2132.817
O - ring for enclosure of antenna stem	2132.334

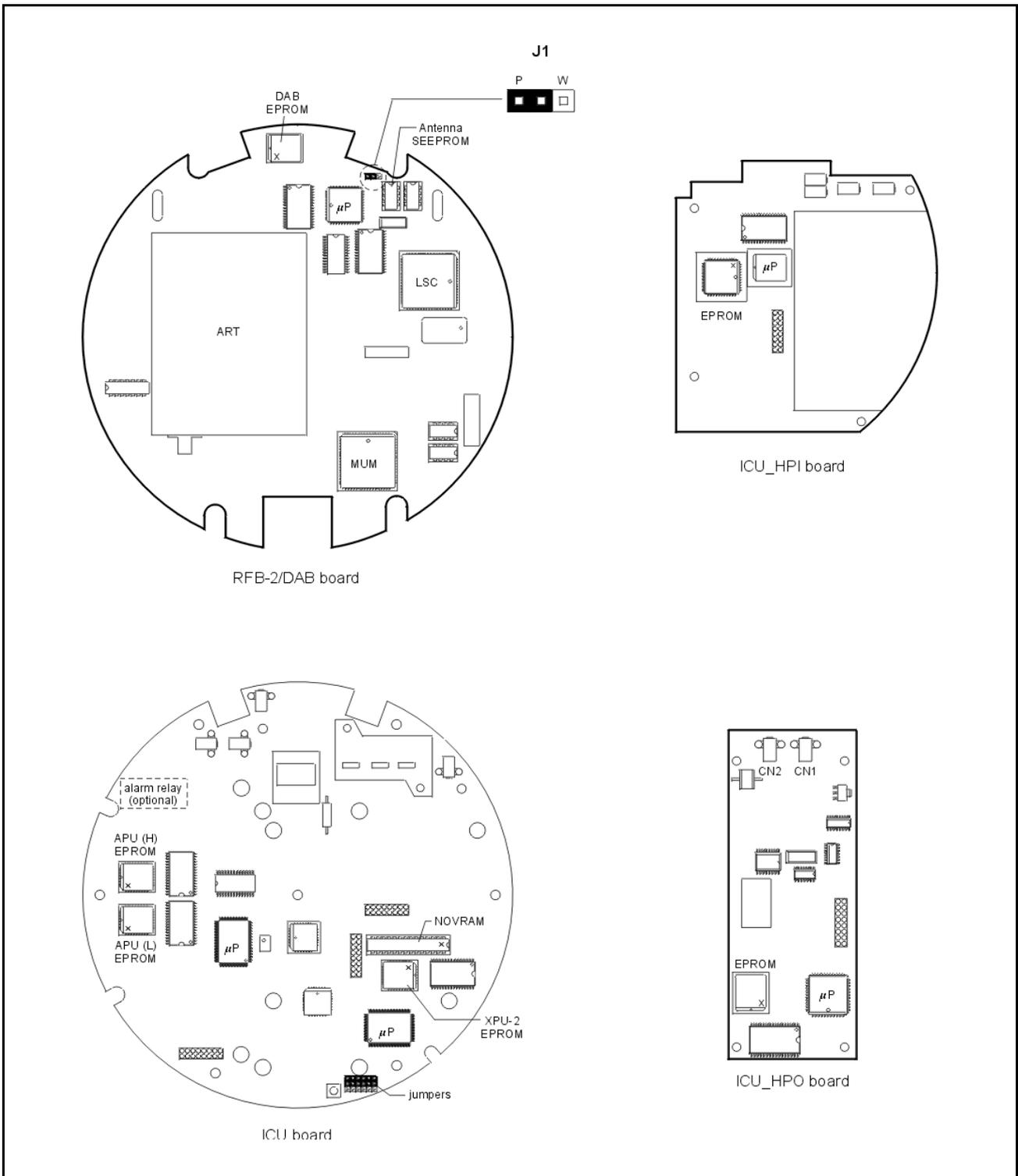
Antenna type part numbers

Antenna type	Stem length [mm]	Part number
S06 6" stilling well	0050	0873.911
	0300	0873.913
	0500	0873.915
	0800	0873.918
S08 8" stilling well	0050	0873.921
	0300	0873.923
	0500	0873.925
	0800	0873.928
S10 10" stilling well	0050	0873.931
	0300	0873.933
	0500	0873.935
	0800	0873.938
S12 12" stilling well	0050	0873.941
	0300	0873.943
	0500	0873.945
	0800	0873.948
F08 8" free space	0050	0873.971
	0300	0873.973
	0500	0873.975
	0800	0873.978

Appendix B ASCII table

HEX	MSB				0	1	2	3	4	5	6	7
	3	2	1	0	654	654	654	654	654	654	654	654
	3	2	1	0	000	001	010	011	100	101	110	111
0	0	0	0	0	NUL	SOH	SP	0	Q	P	.	!
1	0	0	0	1	STX	DC1	!	1	A	Q	*	1
2	0	0	1	0	ETX	DC2	'	2	B	R	b	r
3	0	0	1	1	END	DC3	#	3	C	S	c	#
4	0	1	0	0	ACK	DC4	%	4	D	T	d	l
5	0	1	0	1	NAK	NAK	%	5	E	U	e	u
6	0	1	1	0	SYN	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	
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 C PCB layout



The **x** inside the EPROM in the figure above notes the notch on the EPROM. The notch of the EPROM **must** fit with the notch of the EPROM socket on the processor board.

Appendix D Related documents

Installation guide 971 SmartRadar LTi

Installation guide SmartRadar Antennas

Model 971 SmartRadar LTi Safety instructions for installation, commissioning, operation and maintenance

Instruction manual 973 SmartRadar LT Hard alarm output contact

Instruction manual ENSITE service tool

Instruction manual 847 PET

Instruction manual Temperature, Water bottom and Analog output options

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

Instruction manual 973 SmartRadar LT HART[®] output communication

Instruction manual 973 SmartRadar LT RS-232/485 output communication

Instruction manual Modbus[™] protocol Enraf gauges

Protocol manual SmartRadar

Item documentation Enraf series 854, 873, 877 & 973 gauges

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