

JERGUSON Intelligent Displacer Level Transmitter

Installation, operation and
maintenance instructions



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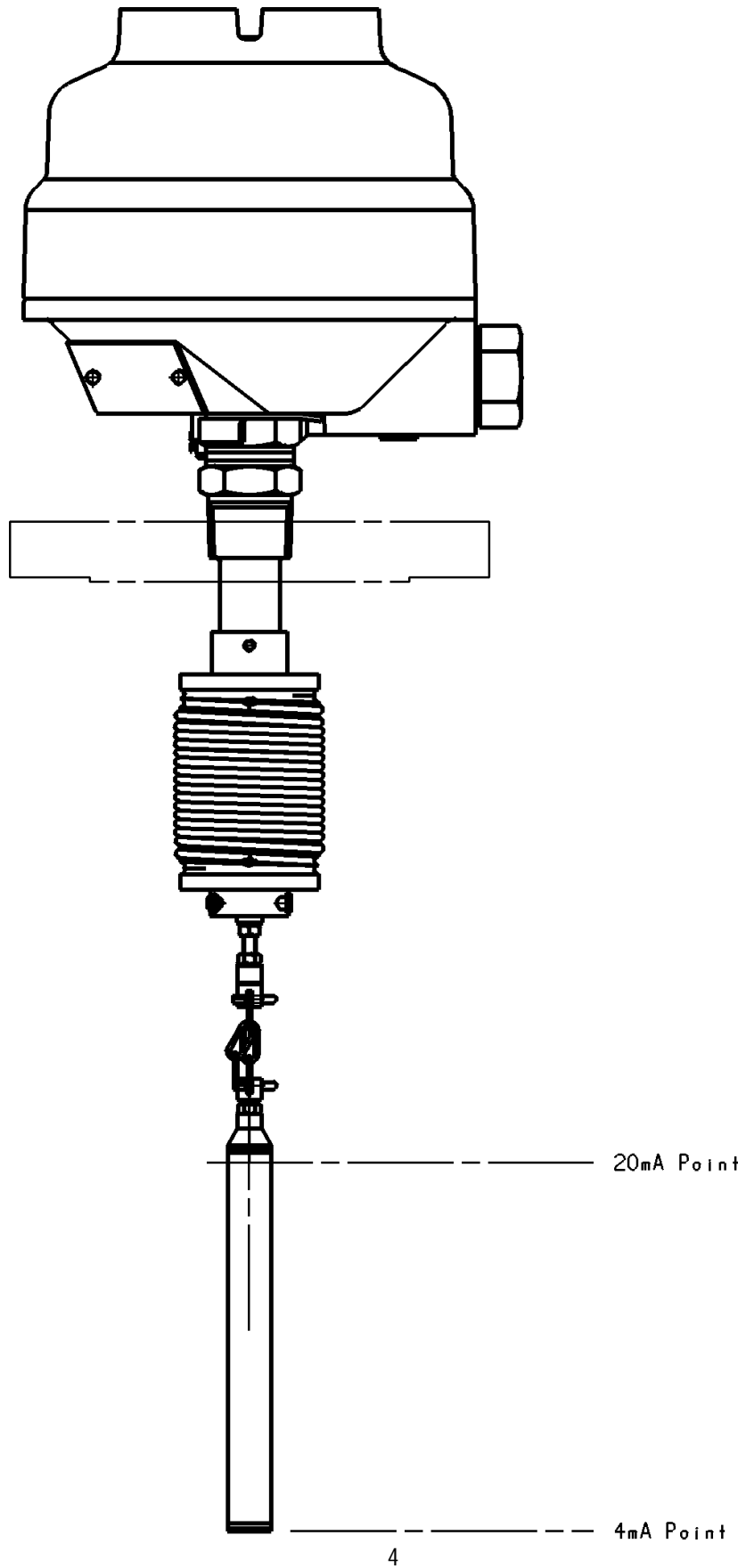
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The Displacement Level Transmitter



1.0. OVERVIEW

- 1.1 Use: The Displacer Level Transmitter type will transmit a 4 – 20mA signal proportional to liquid level or interface position over a simple 2 wire 24v dc power loop. The instrument is installed either directly on the top of the vessel or in an external chamber, valved to the main vessel, such that the displacer element is immersed in the liquid.

DT Series may be installed in a hazardous area. There are two designs of DT Series; one I.S. for use in a suitable I.S. circuit, and one Flameproof/Explosionproof, suitable for connection to suitable stopper glands and conduit. Always refer to the installation requirements stated on the enclosed certificates for specific installation instructions. DT Series may, of course, be used in a non-hazardous area, where any local wiring requirements apply.

- 1.2 Basic operation : The displacer, which is normally partially-immersed in the process fluid, is suspended from an extension spring. The effective weight on this spring changes as the level of the process liquid rises and falls on the displacer. This is predictable and depends upon the density of the liquid and the diameter of the displacer. In turn the extension of the suspension spring will change as the weight suspended from it changes. The core of an LVDT (Linear Variable Differential Transformer) is attached to the moving parts suspended from the spring, and moves up and down in the pressure tube of the transmitter enclosure. An LVDT is positioned on the pressure tube in the enclosure. The positional changes of the core in relation to the LVDT will cause electrical changes which are interpreted by the transmitter electronics as changes of liquid level.
- 1.3 Calibration : Each DT Series is factory calibrated to give optimum performance in the application conditions advised at the time of order. Provided these conditions have not changed, the instrument will give accurate readings of level at operating pressure, temperature and SG. Refer to sections 4 & 5 for details of re-calibration if this is necessary.
- 1.4 Take care ! : The DT Series is an instrument, and should be handled with due care and attention at all times. Mounting flanges can be heavy and difficult to handle. It is particularly important that the DT Series is not damaged when installing on the vessel or chamber, and that the Installation instructions in section 2 are carefully followed.

Thank you for choosing a Displacement level transmitter – correct installation and use will result in many years of trouble free operation.

PLEASE NOW READ THE RELEVANT SECTIONS OF THIS MANUAL.

Footnote :- In this manual the following terms are used which refer to trademarks from other manufacturers:

HART: is the protocol adopted for the DT Series SMART Communications.
HART is a registered trademark of the HART Communications Foundation and is a mnemonic For Highway Addressable Remote Transducer.

PSION: is the trade mark of PSION plc who manufacture the PSION ORGANISER Hand held computer. The SMART program is stored in a DATAPAK which is also a trademark of PSION plc, and is an accessory for the Model LZ Organiser

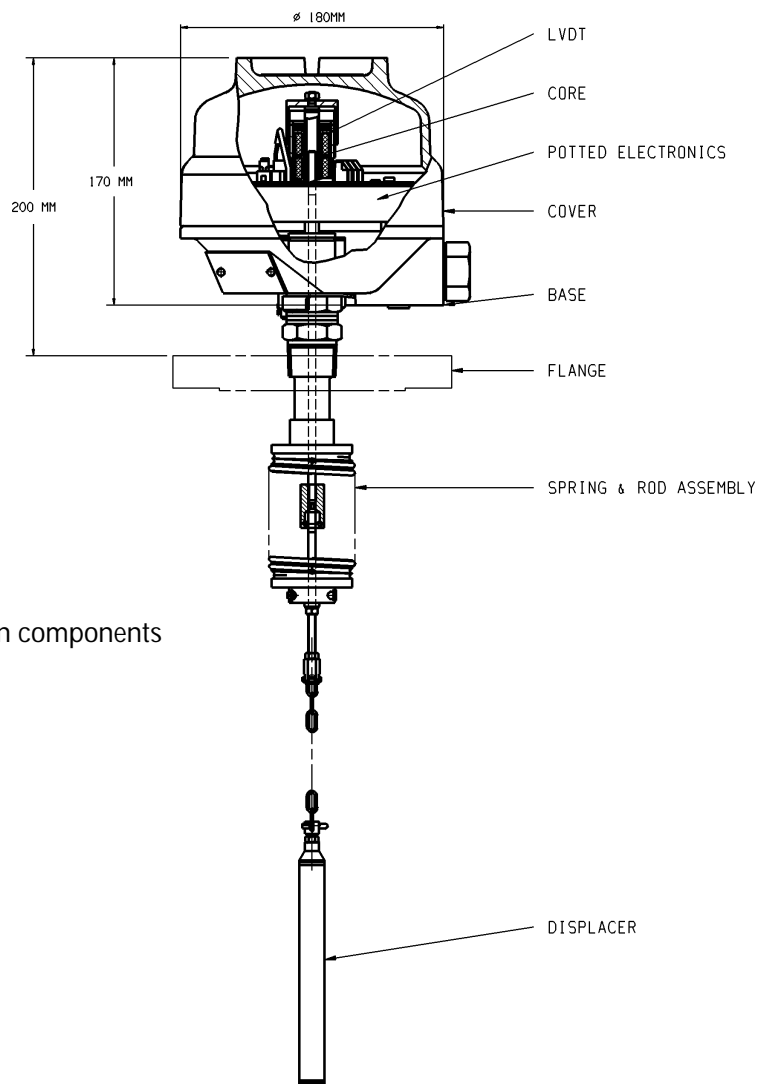


Fig I : DT Series - main components

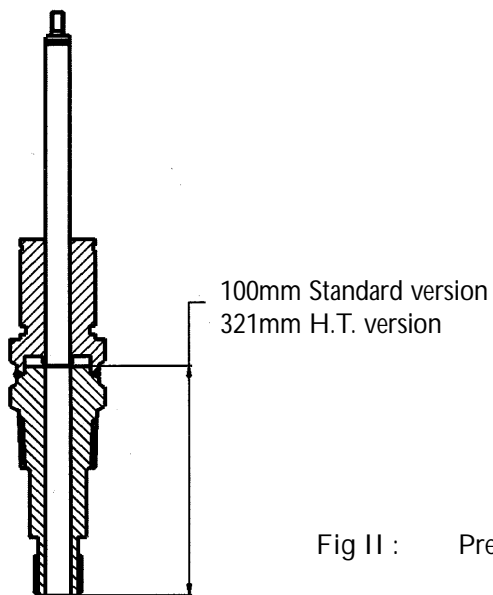


Fig II : Pressure tube assembly

2.0 UNPACKING & INSTALLATION

2.1 Unpacking

The unit is supplied in three parts, usually in two packages. The larger package contains the control head and spring/rod assembly. A second package contains the displacement element. Any mounting flange or chamber will be packaged separately. Refer to Fig I.

After unpacking the control head check that the model code / Tag Number is the one expected for this application (refer to Appendix A for model code explanation). Note that the head, the spring assembly and the displacer element are a matched set. Components must not be mixed and matched between transmitters. Each will be marked with the unique transmitter Final Assembly Number for identification.

If there are any queries, please refer to your local Agent , quoting the transmitter Final Assembly Number and our order reference.

2.2 Mounting arrangements

2.2.1 External Chamber Mounting Transmitters.

If a chamber has been supplied, unpack and remove any packing or tie strings. Ensure that the chamber is completely clean and fit to the mating vessel connections. The chamber should be mounted within 1.5 deg. to the vertical, and the top flange should be checked with a spirit level to see it is horizontal. Sometimes, when the DT Series is used on a chamber, there is not enough space above the upper liquid level for its moving parts. In these situations an extension in the form of a stand pipe will have been supplied, and this should now be fitted to the chamber using a suitable gasket or seal, ensuring once again that the top flange is horizontal.

2.2.2 Direct Mounting Transmitters.

2.2.2.1 Stilling tubes.

If there is a high degree of agitation in the vessel, such that the displacer element could be caused to swing or bounce, then a stilling tube should be installed in the vessel. Ensure that the stilling tube has an internal diameter large enough to allow free movement of the displacer element, and that a vent hole is drilled at the top to prevent air-locks. The tube must be installed vertically so that the displacer element does not touch the tube at any point.

2.2.2.2 Stand Off

Sometimes, when the DT Series is used on a vessel, there is not enough space above the upper liquid level for its moving parts. In these situations an extension in the form of a stand pipe will have been supplied, and this should now be fitted to the vessel using a suitable gasket or seal, ensuring that the top flange is horizontal.

2.3 Level transmitter assembly.

IMPORTANT NOTES.

It is strongly recommended that two people work together at this stage, particularly when installing the instrument on the vessel.

Take great care not to bend the rod at any stage of installation. A bent rod will prevent your DT Series from working.

Do not slacken any of the lock nuts on the rod assembly; these have all be present for your application.

When unpacked, the enclosure will be free to rotate on the pressure tube assembly. This is to allow correct orientation of the enclosure, conduit entry and display (if fitted) after installation. High pressure transmitters will have been supplied with the head factory fitted and secured in the mounting flange. If a flange is supplied separately, you should now screw the head into the mounting flange using a suitable thread sealant, using the hexagon to tighten and effect the pressure seal. The thread is 1" NPT taper.

Next, fit the spring and rod assembly to the head. Make sure that the core, rod, and anti-friction sleeve are free from any dirt or pieces of packing material. Remove any seal from the bottom of the pressure tube assembly and gently pass the core into the pressure tube assembly. Carefully feed the rod into the tube, avoiding the step reduction in diameter of the internal bore of the tube. (See Fig II).

Once inserted, check that the rod moves freely in the pressure tube, then screw the top of the upper spring carrier onto the thread at the foot of the pressure tube. Assemble finger tight, then lock in position by tightening the 3mm grub screw using a 1.5mm hexagonal key. (See Fig III)

The head assembly is now complete and no other adjustments need be made at this stage. Your transmitter has already been factory calibrated for use at the operating conditions stated at the time of order. Decide now if you wish to bench check the calibration of your transmitter at 20C, in which case refer to Appendix C or if you want to mount your transmitter on the vessel and check calibration at operating conditions, in which case please read on.

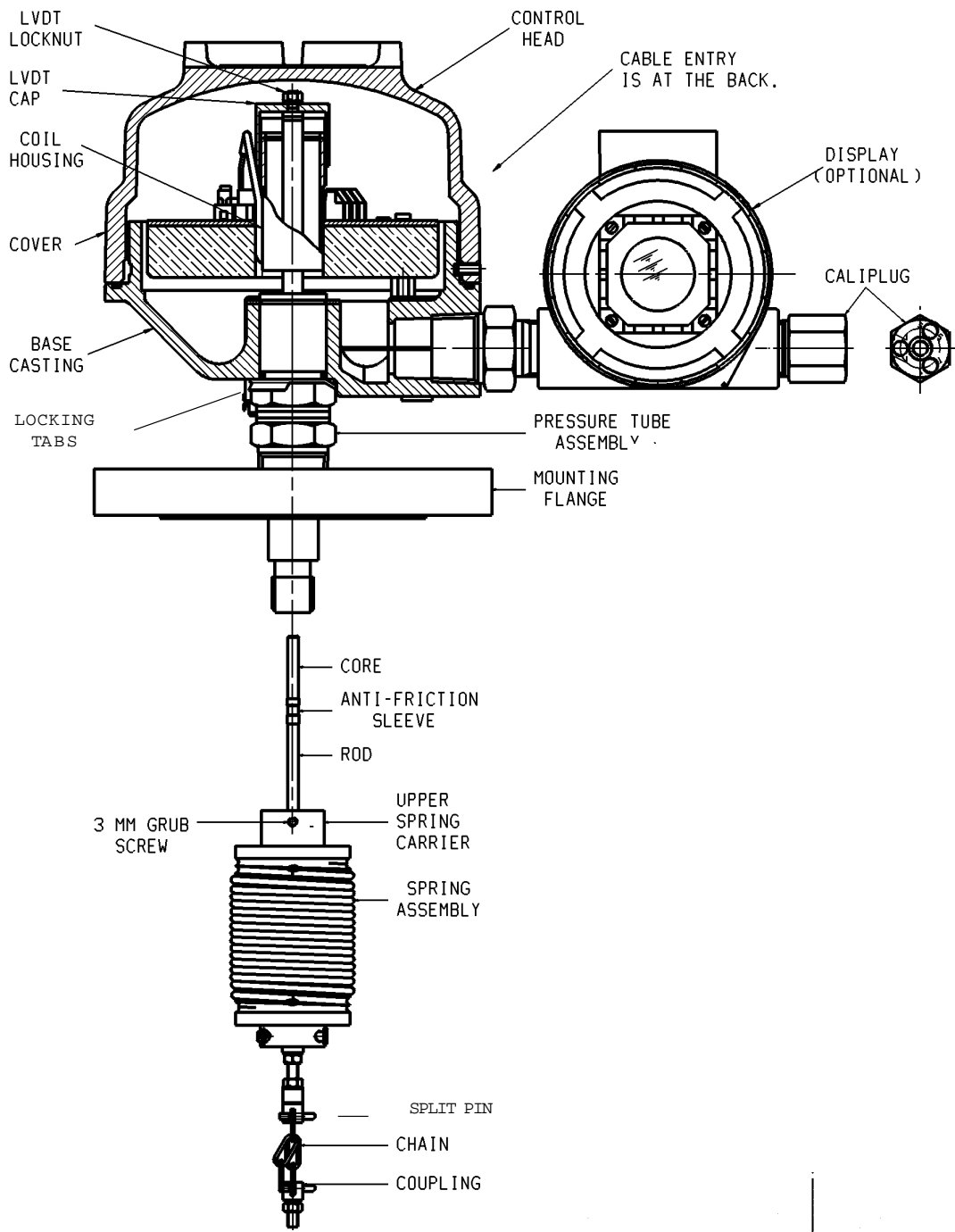


Fig III : Level transmitter components

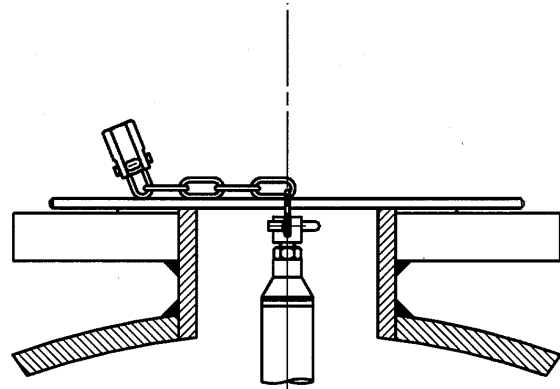


Fig IV : Supporting the displacer element before mounting the head assembly.

2.4 Checking the position of the transmitter range. (normal liquid application, not interface applications)

Before you mount the transmitter assembly into the vessel you may wish to check that the displacer element is hanging at the correct level below the transmitter head.

Attach the chain at the top of the displacer element (See Fig.III) to the end of the spring rod using the split pin provided. Locate the split pin in the third link down from the rod so that you have two unused links free at the top. (Do not remove these free links or fully bend the pin legs at this time as you may need to remove or re-position the displacer again later).

With the displacer element hanging in free air at 20C and the spring extended by the weight of the displacer, measure the distance from the sealing face of the mounting flange to the bottom of the displacer, which is called the "free hanging distance". Include the thickness of any seals or gaskets.

This is the approximate distance below the sealing face of the flange which is factory calibrated to give a 4mA output from the transmitter in a normal level application, unless you requested otherwise at the time of order. You can re-range later if you require – see Section 4.0. For interface applications it is not possible to check the 4mA point without the upper liquid present.

Check that this dimension is correct to your requirements, $\pm 5\text{mm}$, particularly if you are mounting the transmitter on a chamber. In this case, the dimension should be equal to the dimension from the chamber mounting flange sealing face to the centre line of the bottom process connection bore, or around 30mm from the bottom of the chamber for a side/bottom connection chamber.

There is some mechanical adjustment possible of the position of the displacer element below the top flange : $\pm 25\text{mm}$. If the error is within this band, locate the small length (typically 5 links) of chain on which the displacer element is suspended and adjust the number of links to correct the error. Do not cut any surplus links from the chain. If the error is greater than $\pm 25\text{mm}$, refer to Magne-Sonic for assistance.

2.5 Mounting the transmitter on the vessel or chamber.

If you attached the displacer to the head as above, it is best to now disconnect the displacer from the rod, leaving the chain attached to the displacer. Ensure that the chain is securely fixed to the displacer, checking that the locknut is tight.

Lower the displacer into the vessel and slip the 5mm diameter support rod through the lowest link of the chain so that the weight of the displacer is taken by the rod and the vessel mounting flange. See Fig.IV.

Remember that the enclosure is still free to rotate on the pressure tube at this stage.

Ensure a suitable gasket or seal is fitted to the mating flange and, holding the head vertical, attach the bottom of the rod to the chain coupling. Bend the split pin legs to effect a permanent fixing. Taking the weight of the displacer by hand, carefully withdraw the support rod and allow the displacer element to extend the spring, lowering the element into the vessel. Do not allow the displacer weight to fall freely and damage the spring.

Check that the displacer element does not foul on any part of the chamber or vessel. Locate the transmitter flange on the mating flange so that the cable entry and display (if fitted) are facing the way you require.

Fit the flange bolts and tighten to the recommended torque (see Appendix B) to achieve a pressure seal. Check that the pressure tube is sufficiently tightened into the top flange, using the hexagons on the pressure tube.

Rotate the enclosure to the exact position required and strike the tabs of the locking tab washer (see Fig.III) under the enclosure base onto the hexagon flats of the pressure tube to prevent further rotation of the enclosure on the pressure tube.

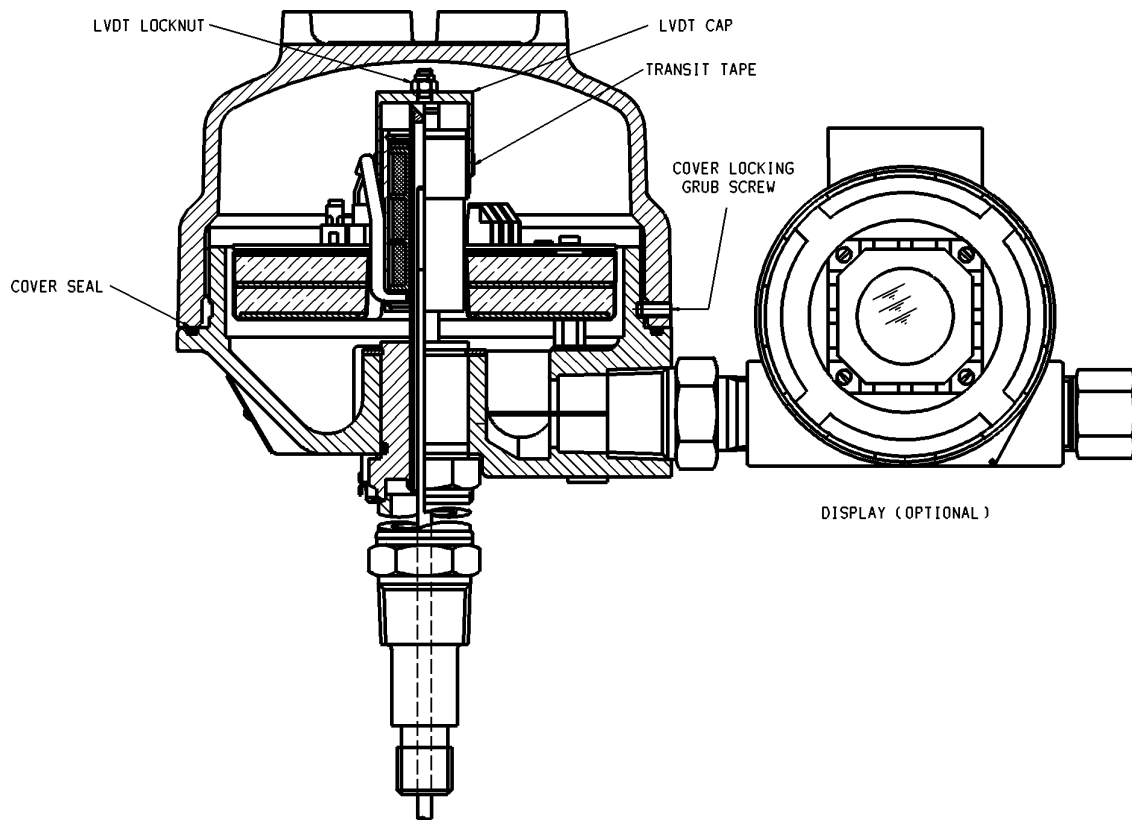


Fig V : Securing the LVDT cap

2.6 Securing the LVDT cap

The LVDT cap inside the enclosure leaves the factory free to rotate on the LVDT so that movement in transit and during installation is not transmitted to the LVDT. The LVDT cap must now be secured in position. (See Fig. V).

If the cover is in place, locate and unscrew the cover locking grub screw and unscrew the cover from the base.

Locate and tighten the LVDT locknut at the top of the pressure tube against the top of the LVDT cap so that it can no longer rotate on the LVDT. Remove the transit tape from the LVDT.

Refer now to wiring section or, if the transmitter is to be left in this condition for a period, check that the cover seal is in good condition and re-fit the cover, then secure cover locking screw. Check any conduits are suitably sealed against ingress of moisture.

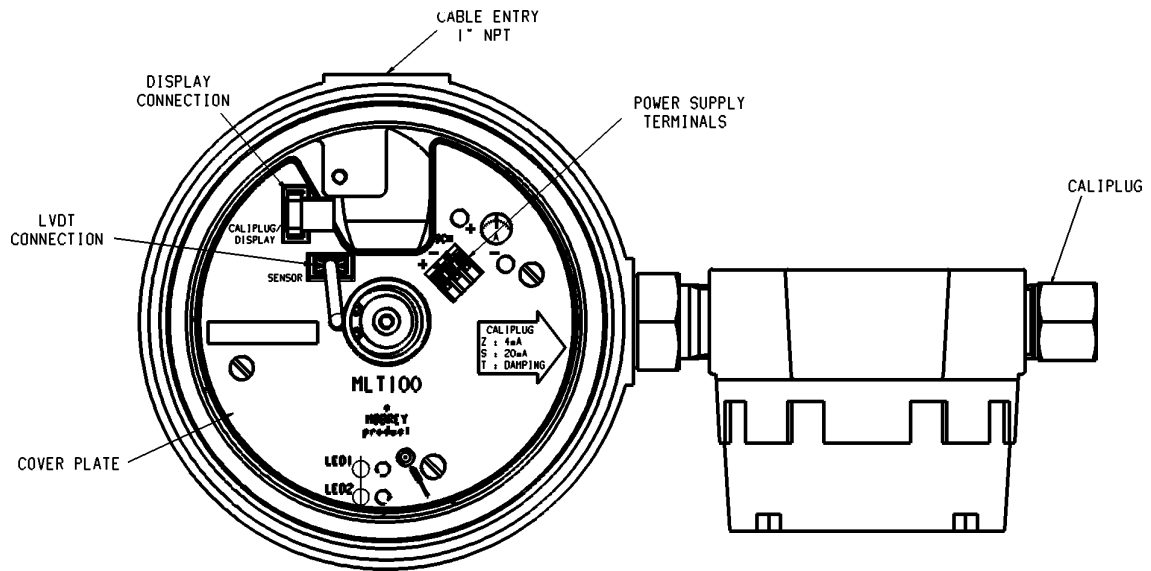


Fig VI : Transmitter head with cover removed.

3.0 ELECTRICAL CONNECTION

The DT Series is a 2-wire dc loop-powered transmitter and requires a 24v dc nominal power supply. Note that it is the responsibility of the installer to observe all local regulations and approval requirements, and to use materials to suit the environmental conditions of the particular application. Check and obtain any hazardous area work permits before applying power to the DT Series.

If you DT Series has been supplied with a Display module, note that you do not need to remove the cover of the display for wiring. All field wiring is connected in the main head enclosure.

If the head cover is in place, locate and unscrew the cover locking grub screw and unscrew the cover from the base.

Fig VI shows the layout inside the transmitter with the cover removed.

A terminal block is provided for power supply and screen connection, together with a pair of 2mm sockets for connection of an ammeter to monitor the loop current.

There are 2 small sockets integrated into the terminal block for convenient connection of a Handheld Communicator if required. (Use only an I.S. approved communicator if in a Hazardous area).

The small target and LED's are used for bench calibration of the transmitter if required – refer to Section 4.0

Whilst the cover is removed, ensure that the 2 multi-way plugs are not disturbed in their sockets. (The plugs will have been secured in their sockets at the factory with a sealing compound).

3.1 Power Supply

3.1.1. Operating voltage

The DT Series will work satisfactorily provided the voltage at the transmitter terminals remains between 12 and 40V dc.

In considering the voltage of the power supply, allowance must be made for the voltage drop across any load in series with the transmitter such as an indicator or the cable itself. The largest voltage drop will occur at the maximum current which is 21mA under alarm conditions. See Fig.VII for a Load v Voltage graph which defines the acceptable range of power supply voltages for any given installation.

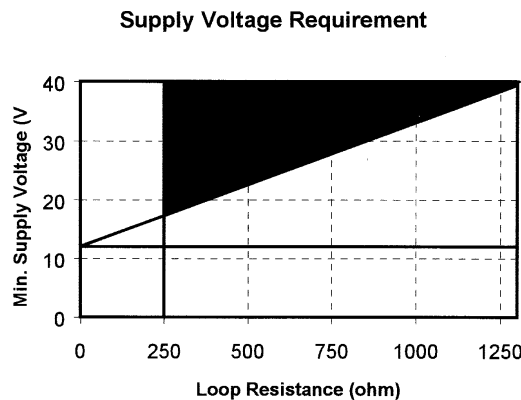


Fig.VII : Load .v. Voltage

3.1.2. Special Considerations for HART

If the HART communications facility built into the transmitter will be used at the time of installation or during its future working life, then it is essential that a resistive load of at least 250 Ohms is connected in the supply cable. This may be provided by other devices in the loop (Chart recorder, meter, etc.) or more usually by installing a standard 270 Ohm 0.25W resistor in series with transmitter at the power supply. In this way the master device will be able to signal to the transmitter without the power supply short-circuiting the data.

3.2 Cable type and length.

The cable should be single twisted pair shielded or multiple twisted pair with each pair shielded and an overall shield to BS5308 or equivalent.

The terminal block will accept wire size up to 2.5mm² (xxzSWG, 14AWG). It is recommended that the minimum conductor size should be 1.0mm² up to 5000ft total length and 20 AWG above 5000 ft., but the user should always ensure that the voltage at the terminals is a minimum of 12v dc.

3.2.1 Cable Capacitance

When used in Hazardous areas in an Intrinsically Safe circuit, refer to the Approval Pack supplied with this transmitter for details of the maximum cable capacitance allowed.

3.2.2 Special considerations for HART

In addition, excessive cable capacitance will attenuate the HART signalling and so the capacitance must anyway be limited if HART communications is to be used. The RC time constant for the network must not exceed 650µs, e.g. if the network resistance is, say, 650Ω then the maximum network capacitance is 0.1µF. HART transmitters are often given a Cn number where n is the multiple of 5000pF which the device presents to the network. In the case of DT Series the value of n is 1 since its capacitance is well below 5000pF.

3.2.3. Total loop resistance and capacitance

Additional equipment such as indicators or recorders may be inserted in the loop subject to the resistance and capacitance limits discussed above.

3.2.4. Multi-core cables

In multi-pair installations it is important that the other pairs do not interfere with the HART signalling – they should only be used for other HART loops or for purely analogue signals.

3.2.5. Cable trays

It is recommended that HART signal cables are not run alongside power cables.

3.3 Cable Gland

The cable gland entry thread is 1" NPT female – the enclosure is rated IP66 and so a suitable combination of gland and cable should be selected. When used in a hazardous area, glands must comply with the relevant Intrinsically Safe or Flameproof/Explosionproof requirements.

3.4 Connection

Connection of the supply cable is to the + and – terminals with the cable screen being connected to the 'scn' terminal. The cable screen should normally be earthed at the power supply end.

An external earth point is also provided.

3.5 Safety Barriers

In the case of passive barriers, allowance must be made for the additional voltage drop across the barrier itself.

Care should be exercised in selecting a barrier or isolator especially if it will be necessary to pass HART communications through the device.

Typical barriers are manufactured by :-

MTL
Stahl
Pepperl & Fuchs
Elcon
ABB

3.6 Lightning Protection

If local conditions dictate, it is recommended that a lightning suppresser is fitted. A typical manufacturer is Telematic who can supply products suitable for IS as well as non-IS installations.

3.7 Multi-drop installations (DT Series in HART digital mode)

Up to 15 transmitters (unless in an I.S. loop – see below) may be connected in parallel with each other, and each must be set to a different HART address between 1 and 15 (see Section vv). When HART transmitters are connected in multi-drop mode, each transmitter draws a fixed current of 4mA, and allowance must be made for the total maximum current that could be drawn ($15 \times 4\text{mA} = 60\text{mA}$)

3.7.1. Compatibility with other HART instruments.

Any 2-wire HART transmitter, regardless of the manufacturer, may be simply connected in parallel with another to create a multi-drop network. They may also be combined with separately powered, current sourcing or sinking devices but care must be taken to ensure that the HART signal current passes through the 250Ω minimum impedance to establish communications. For full details of HART instrument availability, refer to the HART Foundation publications or individual manufacturers literature.

3.7.2. Intrinsically safe installations.

In multi-drop IS installations, typically a maximum of 5 transmitters may be connected to the loop in parallel, thus limiting the current in the loop.

3.7.3. Handheld Communicators

A handheld communicator (HHC) may be connected across the network (downstream of the minimum 250 Ω loop resistance) to programme or interrogate a HART transmitter. Some HHC's support only a subset of a transmitter's functions, and will thus only access the transmitters Universal and Common Practice commands. However, the DT Series is fully supported by the Magne-Sonic CK1 HHC and by the UNIVERSAL 275 HHC (provided the 275 is loaded with the transmitter's Device Description – contact Magne-Sonic or the HART Communications Foundation for details).

3.8 Final checks.

When all wiring is complete, check that the two multi-way plugs remain securely in their respective sockets.

Check that the cable gland is tightened into the conduit and a good seal is formed. If the transmitter is to be commissioned at this point, refer now to Section 4.0. If not, check that the cover seal is in good condition, then replace the cover and screw down fully to ensure the weatherproof rating of the enclosure is maintained. (Do not attempt to overtighten as the torque you apply to the cover will be transmitted to the pressure tube union and locking tab washer; these must not be loosened by overtightening of the cover). Tighten the cover locking grub screw.

4.0 COMMISSIONING

Your DT Series transmitter has been supplied calibrated to the requirements of the specific application advised at the time of ordering. You should now refer to the Set-up Certificate supplied with the transmitter to check this data is still valid.

If you wish to carry out some bench calibration or testing, refer now to Appendix C

4.1 In-Situ Commissioning

Important note : Some of the adjustments described below require the DT Series cover to be removed with power on. Check and obtain any hazardous area work permits required before removing the cover.

4.1.2. Initial power up

Turn on the power and check that the "Heartbeat" LED in the Caliplug beats at about once every 3 seconds. If your transmitter is fitted with a display module, the display will show the software revision number (in the format *.*), then change to show the measured value.

With the displacer element hanging on the spring and rod assembly, the displacer spring will be extended due to the weight of the element hanging on it.

Your transmitter has been calibrated to give an accurate 4 – 20mA output proportional to level at a specific set of operating conditions : SG, pressure and temperature. When experiencing these operating conditions, the spring will behave differently to its normal performance in air at 20C, so the transmitter output at 20C may not be as you expect.

The current output can be displayed on a milliammeter connected at the two sockets provided or on the HHC. However, if your transmitter has been calibrated for operation at temperatures above ambient, you are likely to see higher values than this as the spring will be stiffer at 20C than at the operating temperature, and hence the core is sitting higher in the LVDT coil. Once operating conditions are reached, the spring will relax and the core will drop, giving an output of 4mA with the vessel empty.

4.2 Local calibration adjustments at operating conditions.

Once the vessel has reached process operating conditions, the following can be checked and adjusted if required :-

If you wish to fine tune the 4 and 20mA points or to re-range the transmitter to give the 4-20mA output over a different span, this can now be done. Note, the 4mA point can be positioned above the 20mA point to reverse the operation of the transmitter, thus giving a falling current output with rising liquid level.

To maintain accuracy, it is recommended that the maximum turndown used is 3:1.

Zero level – 4mA point. With no liquid in the vessel, the output should be 4mA.

If the output is within 3.9 and 4.1mA, refer to 4.2.1 below to fine tune to exactly 4mA. If the output with the vessel empty and at operating conditions is outside of these limits, it is likely that the position of the LVDT in the transmitter head needs to be adjusted. Refer to Appendix C "LVDT Setting" before making any further adjustments.

High level – 20mA point. This occurs with the displacer element almost fully covered with liquid (to within 10-15mm of the top of the parallel portion of the element), and the output should be 20mA.

These adjustments may be made locally with the Magnetic Scroller (MMS) and the Caliplug on the transmitter (See Section 4.2.1. overleaf) , or may be made either locally or remotely using a SMART Communicator (HHC) connected across the two wire loop. (For details of adjustments using the HHC, refer now to Section 7.0).

4.2.1. Local calibration using the Magnetic Scroller (MMS) and the Caliplug with the transmitter at operating pressure, temperature and SG.

4mA point : With the vessel empty or the liquid at the level required for 4mA output, insert the magnetic tip of the MMS into the Caliplug port marked "Z". Hold in until acceptance of the new setting is given by the Caliplug LDD flashing at an increased rate of twice per second.

20mA point : With the liquid at the level required for 20mA output, insert the magnetic tip of the MMS into the Caliplug port marked "S". Hold in until acceptance of the new setting is given by the Caliplug LED flashing at an increased rate of twice per second.

Ranging with a partially full vessel : If it is not possible to fill the vessel to the required 20mA level, the transmitter can be ranged in a partially full vessel.

With liquid in the vessel at a level above the 4mA level, the current output can be incremented to a value that represents this level. For example, with the vessel $\frac{3}{4}$ full, the current would be set at a value of 16mA.

Connect a milliammeter at the two sockets inside the enclosure.

To enter the ranging mode, hold the MMS on the small target icon on the internal nameplate for about 3 seconds. One (or both) of the 2 LED's adjacent to the target icon will start to flash. Insert the magnetic tip of the MMS into the "S" port of the Caliplug to increase the current out as shown on the milliammeter, or the "Z" port to decrease the current at this level. Withdraw the MMS once the current level has been set to the required level.

Hold the MMS on the target again to deactivate the LED's and exit the ranging mode. Note, the instrument will automatically exit the ranging mode if left for longer than 5 minutes.

Damping : The damping of the transmitter may be adjusted using the MMS and the Caliplug. The damping value entered is actually a time constant in seconds which is applied as smoothing to the level reading and the output current. A new value may be entered up to a value of 100 seconds. A large value will have the effect of smoothing out rapid changes of level and will also smooth out the effects of turbulence. (It would be highly unusual to select a value greater than 30 seconds.)

Insert the magnetic tip of the MMS into the "T" port of the Caliplug and hold in place for a number of seconds equivalent to the damping that you require, noting that the LED flash rate increases to once per second during setting of damping. Once the MMS is removed, the new damping value is set.

Your DT Series is now ready to operate.

Finally check all seals and conduits are in good condition and replace the transmitter head cover and secure with the locking grub screw.

If you experience any unusual output or apparently faulty operation of your DT Series, refer to Section 4.3 "Adjustments to accommodate changes in process operating conditions and Section 5.0 "Fault finding".

4.3 Adjustments to accommodate changes in process operating conditions

It may be that actual process conditions are a little different to those envisaged at time of order and used to set-up your DT Series.

Your DT Series has been factory set to give you the correct output under the operating conditions which you quoted in your enquiry/order. If you intend to operate outside the parameters for which the DT Series has been factory set, please read the notes below. These describe a variety of deviations and their implications. Typical deviations are:

- a. More dense process liquid.
- b. Less dense process liquid.
- c. More dense upper liquid/gas.
- d. Less dense upper liquid/gas.
- e. Higher process temperature.
- f. Lower process temperature.
- g. The range is in the wrong place.

If you have a SMART HHC, the electronics can be reconfigured to accommodate different operating conditions, but your working range may be affected. The transmitter output can be re-ranged, giving the 4-20mA output over the correct liquid level excursion, but this is achieved electronically by changing the values of pre-programmed parameters. The base process value (PV) will still show as the true measured value of the liquid level. Transmitter accuracy is little affected provided the process condition changes are within the limits stated in each case. Refer now to Section 7.0 for details of how to make changes using the HHC.

4.3.1 Adjustments using the MMS to locally re-range the transmitter

Sometimes the effects of changed process operating conditions, provided that they are within the limits stated in each case below, are minimal and simple re-ranging using the MMS tool to set new Zero and Span levels is adequate.

Refer now to the various conditions below:-

- a. More dense process liquid.
Because the lift from the process liquid is increased, the output will show 100% (top level) when the level in the vessel is below what you expect. We recommend that you accept this; re-ranging the DT Series to give 20mA at full vessel conditions is not recommended as this may cause the LVDT to operate outside of its calibrated range. At low level (0%) the output will correctly correspond with the level in the vessel.
- b. Less dense process liquid.
The lift from the process liquid is reduced and the output will never reach 100% (top level). The process liquid will reach the top of the Displacer without providing the upthrust expected. The range will thus be reduced at its top end. It is possible to re-range the DT SeriesL to output 20mA with the displacer element fully covered in this less dense liquid refer to Section 4.2 on re-ranging. At low level (0%) the DT Series output will correctly correspond with the level in the vessel.
- c. More dense upper liquid/gas.
The effect can be significant with an interface liquid, or where the gas above the process liquid is at a very high pressure. The displacer will be covered by the process liquid at high level (100%) and at this point the DT Series output will correspond with the level in the vessel. At the other extreme when the displacer is entirely in the upper liquid/gas, the extra lift will cause the DT Series output to have a value higher than the 0% that you would expect from the level in the vessel. For example, when the interface reaches the bottom of the displacer, the DT Series output might be 2%. If the interface falls further, no change in DT Series output can occur. It is possible to re-range the DT Series to output 4mA (0%) when the displacer element is covered with the more dense upper liquid or gas – refer to Section 4.2 on re-ranging.

- d. Less dense upper liquid/gas
 The displacer will be covered by the process liquid at high level (100%) and at this point the DT Series output will correspond with the level in the vessel. At the other extreme, when the displacer is entirely in the upper liquid/gas, the reduced lift will cause the DT Series output to give a value of 0% whilst the element is still partially immersed in the lower liquid. We recommend that you accept this; re-ranging the DT Series to give 4mA (0%) when the displacer element is covered by the less dense upper liquid or gas is not recommended as this may cause the LVDT to operate outside of its calibrated range.
- e. Higher process temperature.
 The spring rate will be lower so the displacer will hang lower than it was designed to. The DT Series output will indicate a lower level in the vessel than that which actually exists. This deviation will be greater at low level than at high level. You should check from the graphs below, in Fig. VIII, that the new process temperature does not require a longer Pressure Tube Assembly. If it does, talk to about what is best to be done, otherwise the electronics will be damaged by excessive temperature.

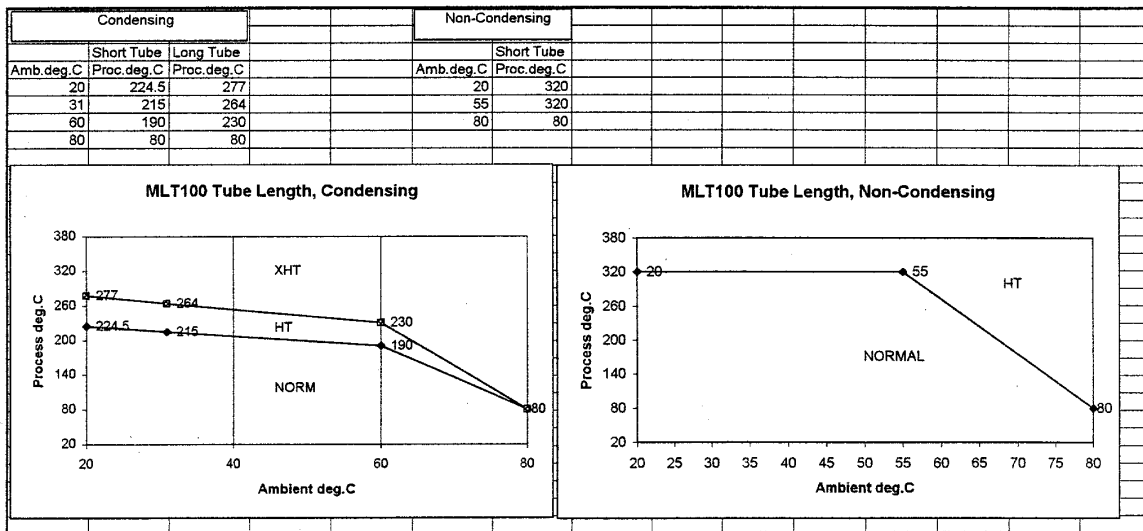


Fig VIII : Temperature graphs

- f. Lower process temperature.
 The spring rate will be higher so the displacer will hang higher than it was designed to. The DT Series output will indicate a higher level in the vessel than that which actually exists. This deviation will be greater at low level than at high level. Use the MMS to set zero at this point --see Section NN. However, if the change in process temperature from that quoted at time of order is greater than +/- 50C, the LVDT may operate outside of its calibrated range at higher liquid levels.
- g. The range is in the wrong place.
 Lengthening or shortening the suspension chain will put this right. Where the chain would need to be shorter than one link, the only possibility is to fit a stand-off to the vessel/chamber.

5.0 FAULT-FINDING & ERROR MESSAGES

5.1 No output

Check that the voltage at the transmitter terminals is greater than 12v dc.

Check that the polarity of the power applied is correct. (The DT Series is reverse polarity protected).

If the above is correct, check that the Caliplug LED is flashing at a frequency of about once every 3 seconds.

Check that the Caliplug connection lead is secure in its socket.

If a display is fitted, check that the display lead is secure in its socket and that the display is showing a reading.

If there is no Display or Caliplug LED activity, the DT Series should be returned to your local agent for repair or replacement.

5.2 Incorrect Output

If your DT Series does not have a display module fitted, but you are seeing an incorrect current output for a known level in the tank, check the following:

Check that the correct displacer and spring/rod assembly have been fitted to the transmitter head. Each item will be marked with the same Final Assembly Number (FAN). The FAN of the instrument can be found from the Set-up Certificate supplied with each DT Series.

Check that the displacer element is hanging at the correct level below the transmitter mounting flange. Refer to Section 2.4.

Check that the rod and core move freely in the pressure tube. A bent or damaged rod could result in sluggish or incorrect output.

Check that the spring is not damaged. Any permanent deformation by over-extension will cause incorrect readings.

Check that the liquid SG, operating pressure and temperature are all as given on the Set-up certificate. Some site adjustments are possible. Refer to Section 4.3.

If the DT Series is assembled correctly and all components move freely, you should carry out a bench check as detailed in Appendix C to ensure that the LVDT is positioned correctly.

5.3 Display Module – Error Messages

The transmitter monitors its performance and reacts to any problems. If a display is fitted then a description of the condition will be displayed. Additionally, for certain conditions, after a delay specified by parameter P21, the current output will take the value as specified by parameter P22.

Only one alarm condition is displayed at any one time and so each has been allocated a priority. The table below details the condition, its priority, its displayed code and whether it affects the current output.

Priority	Description	Message	Current
1	ROM Checksum Error	ROM	Y
2	RAM Error	RAM	Y
3	EEPROM Checksum Error	E ² PROM	Y
4	ADC reference too high	ADC H	Y
5	ADC reference too low	ADC L	Y
6	Sensor output too high	SO H	N
7	Sensor output too low	SO L	N
8	PV out of limits	PV OL	N
9	Temperature out of limits	°C OL	N
10	Current Saturated	SAT	N

Message and action

5.3.1. ROM, RAM, E²PROM, ADCH, ADCL

These are all error messages generated when internal self-checking reveals a fault. The DT Series should be returned to your local agent for repair or replacement.

5.3.2. SOH

This means that the core has travelled too high in the pressure tube and that the LVDT output is therefore too high. Check that the displacer element is the correct element for this Transmitter. Carry out a bench calibration to check that the LVDT is in the correct position. If the message only appears when there is liquid in the vessel, check that the liquid SG is as expected and not too high.

5.3.3. SOL

This means that the core is too low in the pressure tube and that the LVDT output is therefore too low. Check that the displacer element is the correct element for this Transmitter. Carry out a bench calibration to check that the LVDT is in the correct position. If the message only appears when there is liquid in the vessel, check that the liquid SG is as expected and not too low.

5.3.4. PVOL

Check as in SOH and SOL above.

5.3.5. °COL

This indicates that the process temperature or a combination of the process and ambient temperatures have resulted in the electronics becoming too hot or too cold. Using the HHC, check P46 and P47 to see the maximum and minimum temperatures recorded. If the electronics has recorded a temperature above 85°C then the electronics may have been permanently damaged. The DT Series should be returned to your local agent for repair or replacement.

5.3.6. SAT

This means the current output is saturated (outside the limits 3.8 to 20.5mA). Reset the 4 and 20mA points using the MMS or a SMART HHC.

6.0 MAINTENANCE

6.1 Routine Maintenance

There is very little maintenance required on the DT Series.

Take great care when removing the instrument from any vessel. This is a 2 man operation. The assembly must be kept vertical when removing from the vessel to prevent damage to the spring and rod assembly. Refer to Section 2.5.

All that need be checked during routine strip down is that the spring rod remains free to move in the pressure tube and that any chamber or stilling tube is free of debris or build-up.

Refer to Section 2.5 when replacing the DT Series into the vessel.

6.2 Spares

The DT Series is a factory built instrument and there are no spare parts that can be fitted in the field. Should the DT Series require any repair or replacement parts, it must be returned

7.0 SMART COMMUNICATION

With a SMART HHC, you can make adjustments and calibrate at any point on the two wire connection to the transmitter. You can also make many other adjustments and obtain operational and diagnostic information using the HHC.

Alternatively, have a PC based software package called H-View which allows you to make adjustments and obtain readings through a standard PC. Contact your local agent for details.

If you have a CK HHC (Psion Organiser based) and the appropriate datapak, refer now to Appendix D for details of assembly, connection and menu structure before reading on to the specific adjustments listed below.

If you have another type of SMART communicator or computer based software tool, you must ensure that the Device Description (DD) is correctly loaded or compiled to gain access to all of the MLT parameters. If you do not have the DD loaded, you will only be able to access the Universal and Common Practice commands.

Contact any HART Host Subscriber to update your communication device with the latest DD.

The transmitter is a SMART instrument using the HART protocol to communicate with external devices.

The HHC is a hand-held organiser based communication device fitted with a HART interface to allow communication with HART instruments.

By connecting the HHC across the two wire loop at any point downstream of the minimum 250 Ohm loop resistance, communication can be established. The terminal block of the DT Series has integral 2mm sockets provided for this purpose.

Refer to Appendix D3.0 for details of HHC connection and operation.

The following paragraph details how to re-range and change damping using the HHC once communication with the DT Series has been established.

7.1 Calibration adjustments at operating conditions.

Important note : Making changes to the position or span of the 4-20mA range with a communicator can cause the transmitter to make step changes in the output. You should arrange to set your plant control loop to "Manual" before making changes if this could be a problem.

7.1.1. 4mA point – from the "Program" menu / "Calibrate" sub-menu, access Parameter P16. The factory default value is "0".

Enter the desired new value of the PV (Process Value), normally the level in metres, required to give a 4mA output, and confirm when prompted by pressing the "exe" key that this is correct. The new value is now entered and saved.

Note, the 4mA point can be positioned above the 20mA point to reverse the operation of the transmitter, thus giving a falling current output with rising liquid level.

7.1.2. 20mA point – from the "Program" menu / "Calibrate" sub-menu, access Parameter P15. The factory default value is "A". This represents "Automatic" and in this case means that the 20mA point is automatically set to the maximum range of the transmitter. For example, a transmitter with a range of 600mm leaves the factory with the 20mA point set at 0.6m.

Enter the desired new value of the PV (Process Value), normally the level in metres, required to give a 20mA output, and confirm when prompted by pressing the "exe" key that this is correct. The new value is now entered and saved.

7.1.3. Damping – from the "Program" menu / "Engineer" sub-menu, access parameter P20. The factory default value is 5s.

Enter the desired new value in seconds and press "exe" to confirm and save the new value.

7.2 Further customisation using the SMART HHC

There are some other features of the transmitter that can be changed at this stage:

7.2.1. Identity

The following parameters can be recalled from the "Program" menu / "Identity" sub-menu, and those shown * below can be site configured :-

P00 MESSAGE	*general purpose 32 character message
P01 TAG	*transmitter identifier (8 characters)
P02 DESCRIPTION	*E.G. transmitter application or location (16 char)
P03 DATE	Automatically updated on exit if changes made
P04 FINAL ASSY No.	Factory set – hardware assembly number
P05 SENSOR SERIAL No	Factory set – LVDT serial number
P06 PASSWORD	* 3 level password system.

Simply enter any message or tag number as appropriate and the transmitter will retain this information in memory for future identification. This is particularly useful if you are likely to interrogate the transmitter using the HHC from a remote location.

Refer to Appendix D for more detailed information.

7.2.2. Display

The display, if fitted, can be programmed to show specific information. The digital display is capable of displaying two values; it will alternate between the value for "display 1" set on P23 and "display 2" set on P24, accessible through the "Program" menu / "Engineering" sub-menu. The options available are fully listed in Appendix D.

A typical configuration might be to alternate the measured level with the mA current output, useful during commissioning. Once set up, the display may be changed back to show the measured level or, if more useful, the percentage level.

7.2.3 Alarm delay time and action

The time elapsed before an alarm is signalled can be set in seconds on P21, accessible through the "Program" menu / "Engineering" sub-menu.

The default time is 5s, but you may change this within the limits 1s to 1000s. It is unlikely you will need to set a time greater than 30s.

The action taken after the delay time has elapsed can be selected using P22, accessible through the "Program" menu / "Engineering" sub-menu. The default action on the current output is to hold the last reading, but you may change this to drive to either 3.6mA or 21mA so that a control device can detect the alarm incident. Refer to Appendix D for more detailed information.

7.2.4. Units of Operation and Display

The units displayed on the display (if fitted) or the HHC when used can be changed from the default "metres" using P12 accessible through the "Program" menu / "Calibrate" sub-menu.

Note that the numerical value of PV – the actual measurement of liquid level – will not change when the display units are changed. To change from the default PV measurement in metres, use P13 Scaling Factor. Refer to Appendix D for more detailed information.

7.2.5. Standing Value

If there will still be liquid in the vessel when the displacer element is fully uncovered, the reading can be adjusted to show this by adding the amount of the liquid remaining to the measured value. The PV of the liquid, entered in the PV units defined on P12 and P13, is entered on P14, accessible through the "Program" menu / "Calibrate" sub-menu.

7.2.6. Non-linear Profiling

For applications where the relationship between height and contents is not linear, such as in a cylindrical tank on its side, the DT Series can be programmed with a look-up table so that the microprocessor can convert height to contents. The DT Series is factory programmed with a suite of standard tank shapes which may be called up on P11, or the data for a custom look-up table is entered by the user on P30-P39, accessible through the "Program" menu / "Special-P" sub-menu.

Refer to Appendix D12.0 for more detailed information.

- 7.3 Adjustments to accommodate changes in process operating conditions using a SMART HHC.
- 7.3.1 Temperature change
Changes in operating temperature cause the wet side assembly to hang at a different level than that planned. The effect of the new temperature on the spring rate can be corrected by programming in the new operating temperature on P25, accessible through the "Program" menu / "Engineering" sub-menu. This new value is then used by the microprocessor to accurately calculate the level.
- 7.3.2 SG difference
The effects of SG change can be corrected by programming in the new operating SG on P26 (Lower fluid SG) and P27 (Upper fluid SG), accessible through the "Program" menu / "Engineering" sub-menu. An SG change of the lower liquid to an SG greater than originally programmed in will cause a 20mA output to occur before the displacer element is fully covered. Programming in the new SG will correct this so that the correct current output is given, but note that if the change in the lower SG from that used to factory calibrate the instrument is greater than 10%, the output may become non-linear if the core operates outside of the calibrated range of the LVDT.
Conversely, if the operating SG of the lower liquid is lower than the SG originally programmed in, the core will not travel high enough to give a full 20mA output. Programming in the new operating SG will correct this, effectively re-scaling the output to be correct. There is no danger in this instance of a non-linear output.
Changes in the upper SG will have the opposite effect to those described above.

ORDERING INFORMATION

JDT	DISPLACER TRANSMITTER		
CODE	MATERIAL		
C	Carbon Steel	S	316 SST
CODE	ANSI RATING		
0	150# R.F. ANSI	3	900# R.F. ANSI
1	300# R.F. ANSI	4	1500# RTJ ANSI
2	600# R.F. ANSI	5	2500# RTJ ANSI
CODE	ENCLOSURES		
F	Explosion proof Cl. I, Div. 1 Grps. B, C & D	S	EEx ia (CENELEC) I.S.
CODE	TEMPERATURE RANGE – Select from Chart on page 3		
A	Standard temperature	B	High temperature
CODE	DISPLAY		
N	Without display	D	With display
CODE	CHAMBER – Type & Orientation		
A	Not required – Top Mount Flanged		
B	Side/bottom with no vent		
C	Side/bottom with 1/2" NPT vent		
D	Side/bottom with 3/4" NPT vent		
F	Side/bottom with 3/4" flanged vent		
G	Side/side with 1/2" NPT drain & no vent		
H	Side/side with 3/4" NPT drain & no vent		
J	Side/side with 1" NPT drain & no vent (std.)		
K	Side/side with 1/2" NPT drain & vent		
L	Side/side with 3/4" NPT drain & vent		
M	Side/side with 1" NPT drain & vent		
N	Side/side with 3/4" drain & no vent		
P	Side/side with 3/4" flanged drain & 3/4" NPT vent		
Q	Side/side with 3/4" flanged drain & 3/4" flanged vent		
PROCESS CONNECTIONS			
CODE	CHAMBERED	CODE	TOP MOUNTED
01	Screwed 1" NPT	60	3" 150# R.F. ANSI
02	1" Socket Weld	61	3" 300# R.F. ANSI
11	1" ANSI #150 RF	62	3" 600# R.F. ANSI
12	1" ANSI #300 RF	65	4" 150# R.F. ANSI
13	1" ANSI #600 RF	66	4" 300# R.F. ANSI
14	1" ANSI #900 RF	67	4" 600# R.F. ANSI
18	1" ANSI #1500 RTJ	69	6" 150# R.F. ANSI
21	1 1/2" ANSI #150 RF	80	2 1/2" NPT
22	1 1/2" ANSI #300 RF	90	3" NPT
23	1 1/2" ANSI #600 RF		
24	1 1/2" ANSI #900 RF		
28	1 1/2" ANSI #1500 RTJ		
31	2" ANSI #150 RF		
32	2" ANSI #300 RF		
33	2" ANSI #600 RF		
34	2" ANSI #900 RF		
38	2" ANSI #1500 RTJ		

JDT C O F A N B 01 TYPICAL MODEL NUMBER



Bolting torque details : Carbon steel bolts only

Min torques in Nm (lbf.ft) Max torque = min + 10%

IMPORTANT :-

For use with carbon steel bolts only

If ordinary carbon steel or similar lower quality bolts are used the torques recommended are as shown below.

The gasket sealing force created by the application of these torques is not sufficient to withstand full flange pressure rating. To achieve full rating, use high tensile steel bolts as below.

If in doubt about your bolt/sealing application consult your engineering department or gasket manufacturer.

Flange	#150	#300
3"	54 (40)	95 (70)
4"	54 (40)	95 (70)
6"	95 (70)	

Flange	PN16	PN40
DN65	58 (43)	58 (43)
DN80	58 (43)	58 (43)
DN100	58 (43)	113 (83)
DN125	58 (43)	194 (143)
DN150	113 (83)	194 (143)

A	20 (15)
G	20 (15)

Bolt torques for SPIRAL WOUND gaskets with a compression stop: high tensile steel bolts only.

Bolt size	Nm	lbf.ft
5/8"	122	90
3/4"	203	150
7/8"	325	240
1"	499	368
1 - 1/8"	722	533
1 - 1/4"	101	750

Gasket compression for joints without compression stops: high tensile steel bolts only.

Initial gasket thickness	Compressed thickness	Compression
1.6mm	1.3/1.4mm	0.2/0.3mm
2.5mm	1.9/2.0mm	0.5/0.6mm
3.2mm	2.3/2.5mm	0.7/0.9mm
4.4mm	3.2/3.4mm	1.0/1.2mm
6.4mm	4.6/5.1mm	1.3/1.8mm

C. Bench checking - LVDT setting (20C)

C.1.0 Using the Set-Up Certificate

Refer to the Set-up Certificate and read the value of the weight that must be hung on the spring to simulate a mid point or Null position of the core in the LVDT.

Remove the displacer element and chain (noting which chain link is used to hang the element) and hang the weight in place.

Hold the magnetic tip of the Magnetic Scroller (MMS) against the small target icon on the internal nameplate for about 3 seconds. If the LVDT cap is in the correct position, the two LED's adjacent to the target will flash alternately.

If adjustment is required, only 1 of the LEDs will flash. Slacken the locknut at the top of the LVDT cap. Note which LED is flashing and slowly turn the LVDT cap in the direction of the arrow against the flashing LED until both LEDs flash alternately.

The LVDT cap can now be re-secured in position. Tighten the LVDT locknut at the top of the pressure tube against the top of the LVDT casing so that the cap can no longer rotate on the LVDT.

To exit this mode, hold the MMS against the target for a few seconds and the LEDs will cease flashing. If left, the instrument will automatically exit this mode after a period of about 4 minutes.

Re-fit the Displacer element and chain assembly using the correct chain link, and ensure the locking nut on the chain adaptor is securely tightened.

C.2.0 Calibration check using water at 20°C

It is possible to check the transmitter output if the vessel or system is to be filled with water at any time.

Refer now to the Set-up Certificate where you will find a graph / chart showing the mA output for a given water level at 20°C. Simply immerse the displacer element in water to the given level and check that the output is as stated.

C.3.0 The Calibration Certificate

If requested at the time of order, a Calibration Certificate will have been supplied with your DT Series. This certificate is NAMAS traceable and shows the transmitter mA output for a given weight applied to the spring. (This weight is equivalent to the displacer downforce in grams applied). When calibrating your transmitter in accordance with this certificate, you must use suitably calibrated and certified weights and instruments at the ambient temperature shown on the certificate to replicate the transmitter outputs stated.

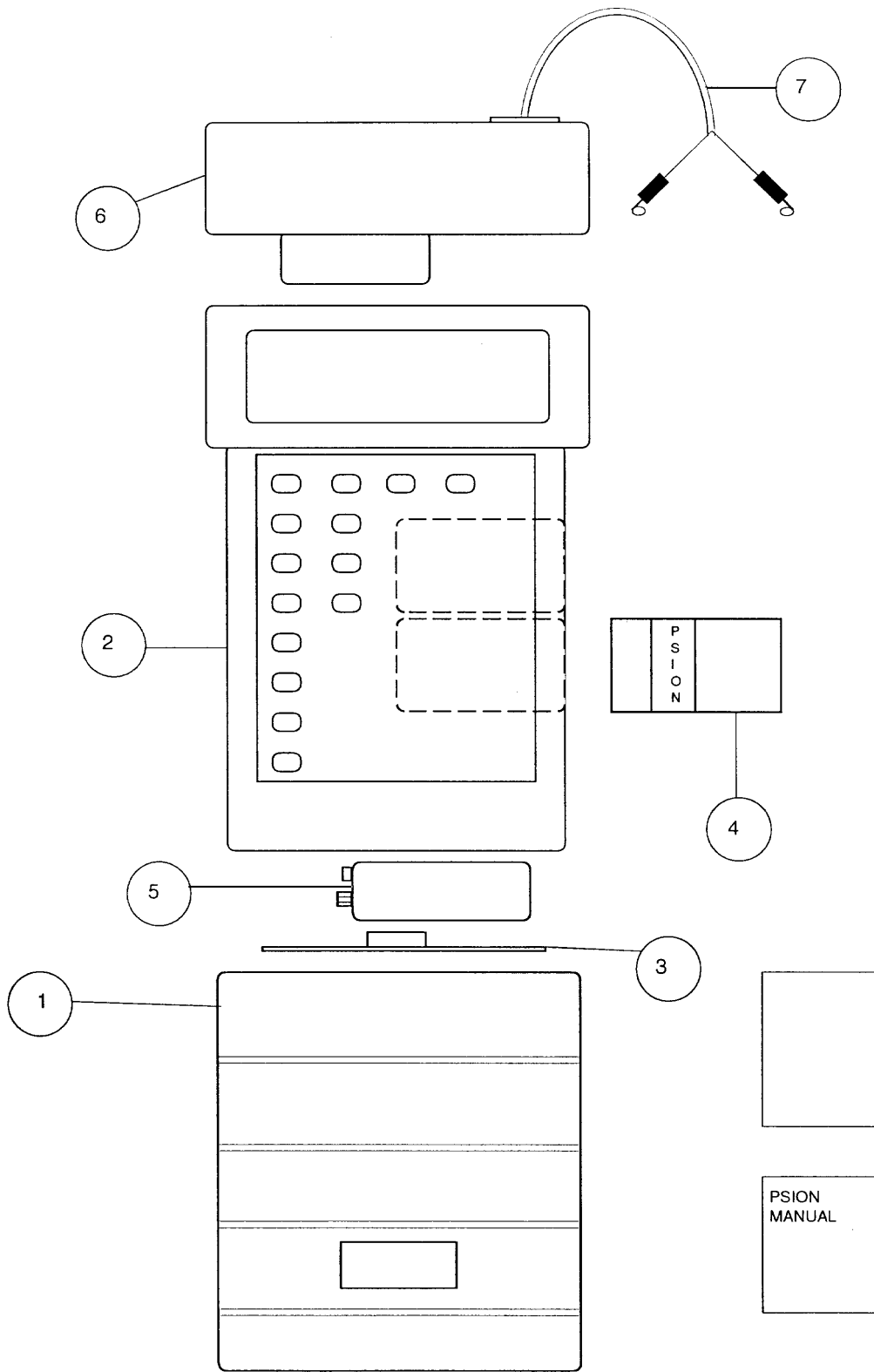


Fig D1 CK* HHC assembly

D. HANDHELD COMMUNICATOR – CK*

D.1.0. Hand Held Communicator – Assembly Instructions

The CK* SMART Hand Held Communicator is supplied as a kit of items (Figure DI) which are assembled as follows:

D.1.1 Remove the lower sliding cover (1) of the Psion organiser (2) completely to expose the battery compartment lid (3) at the base of the keypad, and the two slots for Datapaks behind the right hand side of the keypad.

D.1.2 Remove the lower of the two blank Datapak mouldings and insert the preprogrammed SMART Datapak (4), pressing the unit home. This lower slot is the "C" slot in Psion Organiser memory.

D.1.3 Remove the battery compartment lid (3) and insert the 9V battery (5), positive terminal first. Replace the battery compartment lid (3) and the lower sliding cover (1) over the base of the Psion Organiser. Leave the keyboard exposed.

D.1.4 At the top of the Psion Organiser above the LCD, slide the cover across to the right to expose the connector. Insert the SMART interface unit (6) in this slot.

D.1.5 The lead used to connect the cabling is plugged into the SMART interface unit. On the CK1 and CK3 this is via a 3.5mm jack plug. On the -CK2 a multi pin plug is used. The latter also has the hook-on connectors built into the leads instead of push on crocodile clips.

D.1.6 The SMART Interface Unit has another socket at the top left hand side for connection of a standard Psion external power unit as an alternative to battery operation.

D.2.0. Notes

D.2.1 Although it is possible to insert two Datapaks into the HHC, this is not recommended as a conflict between them can occur.

D.2.2 The CK* Datapaks enable communication with both MSP100 ultrasonic level transmitters and DT Series displacement level transmitters, and also gives generic support for all other HART transmitters.

D.2.3 When not in use, remove the SMART Interface unit from the HHC to prolong battery life.

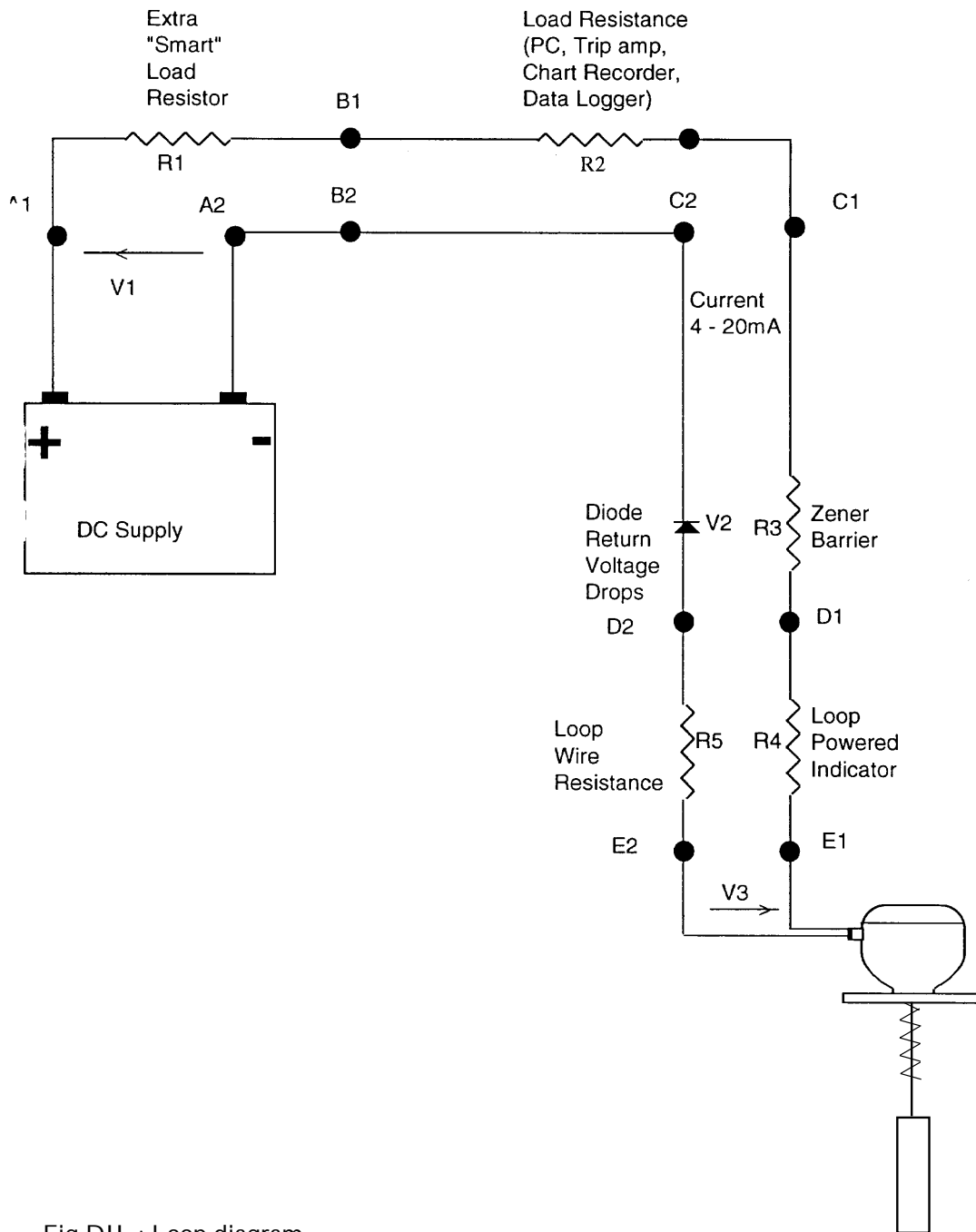


Fig D11. : Loop diagram

D.3.0. Requirements for SMART Operation (Refer to Fig. D11)

- D.3.1 The Displacer transmitter requires a DC supply voltage of 12 volts at its terminals for satisfactory operation (V3).
- D.3.2 Resistance between any two SMART Interface connection points must exceed 250 ohms. (R1).
- D.3.3 For the minimum DC supply voltage (V1) to be calculated, the voltage drops in the loop at 20mA must be assessed. The absolute minimum value of V1 will therefore be 17 volts, since 5 volts is required for the voltage drop across R1 at 20mA. (See Note 2 below).
- D.3.4 If R1 is 250 ohms or more the SMART communicator can be connected between B1-B2, or C1-C2, or D1-D2 or E1-E2. It is also allowable to connect across the SMART Load resistor R1, on B1-A1, or across any resistance in the circuit that exceeds 250 ohms.
- D.3.5 The standard CK1 SMART communicator cannot be taken into a hazardous area, so should not be used at points D1-D2 and E1-E2 unless no hazard exists. The CK2 or an MTL 611 fitted with a CK4 Datapak can be connected at these points in the hazardous area.
- D.3.6 The current loop load resistance R2 can be considered to be part of the 250 ohms needed as the SMART Load resistor. In this case R1 + R2 must exceed 250 ohms, and the communicator can be connected between C1-C2, D1-D2, E1-E2, or C1-A1.

Technical Notes:

1. At no time can the SMART communicator be attached across A1-A2, since the DC supply effectively short circuits the transmitted and returned digital communications signals.
2. The minimum DC Voltage V1 required for satisfactory 20mA loop operation can be calculated from the formula –

$$V1 > 12 + V2 + [20 \times 10^{-3} \times (R1 + R2 + R3 + R4 + R5)]$$

- D.3.6.3. An alternative way of looking at this voltage requirement is in terms of the maximum loop resistance that can be tolerated, which has to be less than $(V1 - V2 - 12) \times 50$ ohms.

The maximum allowable value for V1 is 40 Volts in terms of the transmitter : any zener barriers will define a lower maximum voltage level.

- D.3.6.4. The HART protocol itself sets the maximum values that can apply to the loop resistances, labelled R1 to R5.

The total load on the loop (R1 + R2 + R3 + R4) must not exceed 1100 ohms.

In addition the maximum length of cable in a loop working on the HART protocol is specified as 3000 metres on a single screened loop cable, or 1500 metres if multicore multi-loop cabling is used.

D.4.0. How to connect the SMART Communicator

Assemble the Psion based SMART Communicator unit as shown in Fig. D1 fitting the battery, 100 SMART Datapak, SMART Interface unit and lead. The push on crocodile clips are optional.

Power the Transmitter from a DC supply as shown in Figure D11. A 250 ohm (or higher value) load resistance must be incorporated in the loop.

The SMART Communicator is self powered and draws no current from the loop.

The two wires from the SMART Communicator are interchangeable – it does not matter which way round they are connected.

- a) These two wires can be plugged into the terminal block inside the lid of the transmitter, using the 2mm plug connectors provided on the CK1 or CK3. They are connected to terminals + and – i.e. in parallel with the DT Series.
- b) Alternatively connection can be made via the crocodile clips or hook on probes to each wire of the 2 wire current loop at a convenient terminal box or strip.
- c) At the control room the two wires can be connected either across the "SMART" Load resistor or between a terminal on the chart recorder/indicator and the other side of the loop.

D.5.0. Hand Held Communicator : Operation

Language

Initially the Psion Organiser will power up and display the Psion Copyright message, when the ON button is pressed. Then a choice of languages will be offered. This applies to the operation of the Psion Organiser functions only, DT Series programme, although Datapaks will be available in different languages.

DT Series Programme

The main menu selection of the Psion Organiser is automatically amended to include the option when the Datapak is fitted. This cannot be permanently repositioned nor deleted.

Time

The only data in the Psion Organiser used by the programme is the date held in the Organiser memory. On making changes to an DT Series the date will be stored in the transmitter microprocessor, as shown by the Psion Organiser. To set this clock, select TIME, press MODE, select SET, and use the arrows to select the correct date and time on the display. Then press EXE to start the clock, and ON/CLEAR to return to the main menu.

Disconnecting SMART Interface

To disconnect the interface unit it is necessary to press down the catch in the top centre face of the unit to release the lock, when the interface can be pulled vertically away. The Psion programme knows when the interface is not present and will no longer seek to find an instrument connected – it will only allow OFFLINE programming. Naturally, no diagnostic parameters are made available.

Note : Programme Lock-up

This will occur if the interface unit is disconnected from the Psion before it has finished all communications, or as a function of the Psion ON button features. The LCD is frozen:

- a) Reconnect the interface unit, to allow completion of the procedure.
- b) If the Lock-up has occurred after pressing the ON/CLEAR button, it probably results from the Psion Organiser "CLEAR" function which stops/freezes all programmes running at the time. The programme can be restarted by pressing any button again (except Q).
- c) If the Lock-up occurs as a result of an incomplete procedure, there is no easy release process. The LCD on the SMART Communicator is frozen. Once the buffer store for instructions has been filled with 16 command key instructions, a bell like sound is made when any further button is pressed. The best escape route is to remove the battery to totally clear the memory of the Psion. Beware that this will also clear the date, diary and alarm memories of the Psion Organiser itself. Clearing the memory occurs after approx. 30 seconds with no battery, or immediately on pressing ON/CLEAR after the battery has been removed.

D6.0 Intrinsically safe SMART Communicator

The CK2 SMART Communications kit is based on the intrinsically safe MTL 611 (a variant of the Psion LZ) with an intrinsically safe DT CNF41 SMART HART Protocol Interface and a specially programmed IS Datapak for the Transmitter.

This can be treated exactly the same as the standard Communications kit and the programme is as described in this manual. If fitted with the correct battery this unit is certified intrinsically safe, and can be used in a Zone 1 hazardous area. It can therefore be used to communicate with a transmitter using the D1-D2 or E1-E2 connection points quoted in Fig. D11 even when these are in Zone 1.

D.7.0 How to drive a Psion based SMART Communicator

Familiarity with the Psion

The Psion is supplied with several manuals to describe its function. The main keyboard functions that are important are the yellow keys. Press "ON" and see the functions of the arrows to move the cursor around the selections in the menu. Press "EXE" to see the Psion functions. Note that a short cut to selecting a menu item is to press the key with the initial letter of the required selection – for example "O" switches the unit "OFF".

Note that if the "CALC" option is selected, the keyboard changes from the "Alphabet" marked on the keys, to the "numbers" and symbols marked above the keys. The Psion selects the expected function required of the keyboard. This function can be changed back by depressing the "SHIFT" key.

Menu

If "Magne-Sonic" is selected from the start up menu on the Psion, by pressing "EXE" the space available in the A memory of the Psion is checked. If there is insufficient then a message is displayed and the program returns to the main menu. Data, Note Pad or Diary files in A must be removed to allow the program to run. The SMART Communicator then establishes whether the SMART interface unit is plugged in or not.

```

                                10:41
MOBREY  Find   Save
Diary   Calc   Time
Notes   World  Alarm
```

When the SMART interface is not connected, the Communicator does not look for an instrument – it offers OFF-LINE programming (Refer to.....NOTE RE SELECT INSTRUMENT).

When the SMART interface is connected to the Psion, on selecting the "Magne-Sonic" menu item the programme seeks an instrument that is expected to be functioning on a 4-20mA loop (the loop that is expected to be connected to the SMART interface cables).

```

MOBREY V3.1
SEEKING INSTRUMENT
PLEASE WAIT
```

If the loop is not powered, or the interface cables are not properly connected to the loop, or the loop impedance/resistance values are incorrect, the unit will fail to find the transmitter.

```

NO SINGLE LOOP
INSTRUMENT CONNECTED

RETRY (Y)es or (N)o
```

If the transmitter is programmed to respond as a numbered sensor on a multi sensor loop, it will also fail to communicate to the SMART communicator at this point. (See multidrop operation Section D16.0).

When an Transmitter is located on the loop, this is identified and further instructions awaited.

```

MLT100          FOUND
TAG            TANK 1
ACCESS (Y)es or (N)o
```

Alternatively an Unknown Instrument may have been found, i.e. a HART instrument that is not a DT Series or MSP100 (see section 3.6 for further details). This will cause a similar message and prompt to be displayed.

```
UNKNOWN INSTRUMENT
TAG FLOW1
ACCESS (Y)es or (N)o
```

In either case pressing "Y" will cause the following prompt to be displayed:

```
UPLOAD ALL
PARAMETERS
NOW?
(Y)es or (N)o
```

Pressing "Y" will result in all the parameters being read into the HHC. If "N" is pressed then the delay imposed by a full upload can be avoided. If parameters in the D0 to D8 and P0 to P69 are accessed later on all the parameters in that group will be uploaded. Thus only the parameters of interest need to be uploaded, with the minimum delay. A full upload must be done at some stage if the parameters in the instrument are saved, printed, or used to program another instrument.

The asterisks show each transfer of digital information. If one transfer is incorrect, or corrupted, the Communicator will advise and ask for an action decision – an example of one of these error messages is –

```
NO RESPONSE FROM
TRANSMITTER
RETRY (Y)es or (N)o
```

A retry will attempt to obtain the same data again, whereas the "No" decision will jump that data transfer and collect the next set of data, to try to gain whatever information is available. The data loaded in the Working register for the missing parameters will be the default values, instead of those present in the instrument. Typically, a full upload data collection time is between 30 and 45 seconds.

The main screen describing the equipment now gives transmitter identify information – i.e.

```
MLT100
TAG TANK ALL
MLT100 XDUCER
ACCEPT (Y)es or (N)o
```

Line 2 of the display is the Tag number loaded as Parameter 01, and Line 3 is the Description loaded into P02. If this is not acceptable the program suggests a return to the Psion menu functions. If it is acceptable, pressing the Y button will give access to the FUNCTION menu of the Program. The transmitter parameters are now loaded into the SMART Communicator (Psion Organiser) memory in the WORKING Register.

Future work on this data can be carried out whilst the SMART communicator is connected to the loop, in which case all changes will be immediately sent to the DT Series, or after disconnection of the Communicator, in which case the amended programme will have to be stored in the "OFFLINE" register of the communicator.

The Psion Organiser has four separate registers of data relating to the transmitter. These registers are named WORKING, SAFE, OFF-LINE and DEFAULT, and are explained in Section D13.0. All changes and operations occur in the Working Register, identified by W on the right hand end of line 2 on the display. The other registers are for storage and transfer of data between transmitters or for reference.

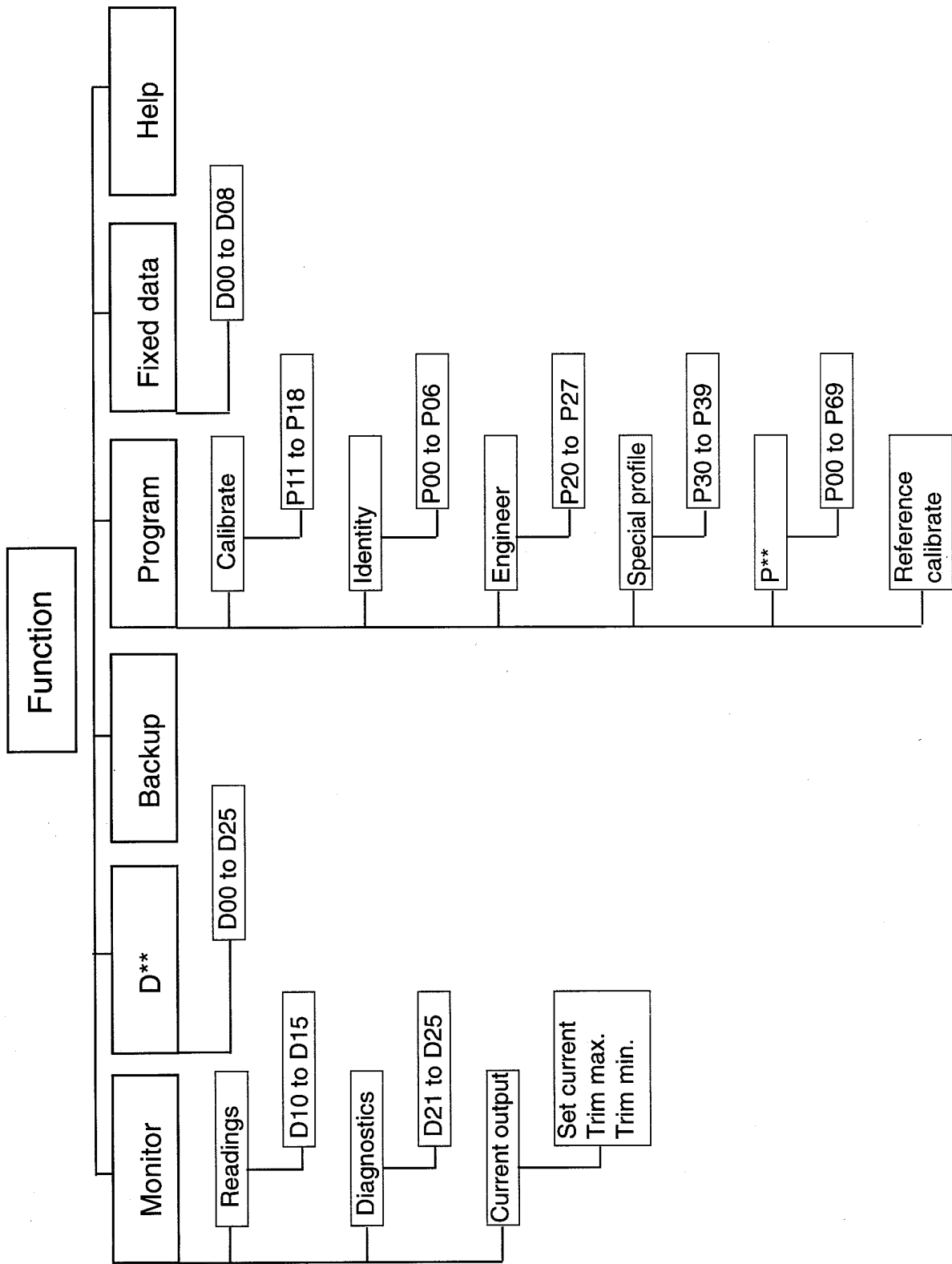


Chart DIII : PSION HHC menu structure

Microprocessor Parameters

D8.0 Introduction and FUNCTION menu

The microprocessor in the transmitter retains the calibration required for the particular application or tank involved, once this has been entered into the memory (EEPROM). On the initial interrogation of the transmitter, this information is transferred to the SMART Communicator using the HART protocol, which defines the command structure and message format.

When received by the SMART Communicator, these messages are loaded into the WORKING register (which resides in the Psion Organiser memory), which then adds the descriptions and other information shown on the 4 line liquid crystal display. The operator is presented with the information he requested, in a meaningful format in relation to the application.

The first selections of the transmitter programme use a menu structure, where the operator identifies the part of the programme required from a list of options available. The detailed information under each menu item can be inspected, after selection, by scrolling through the listing. Each item is given an identifier in the top right hand corner of the screen, identified by a parameter reference number, to allow accurate recording of the data interrogated and to simplify communications relating to this data.

The programme is divided into two main sets of data, selected from the FUNCTION menu. The FUNCTION menu is the first programme screen presented when the data from the transmitter is accepted and interrogation is to begin.

```
***** FUNCTION *****
Monitor   Program
Backup   Fixed data
D**      Help
```

The structure of the programme built around this display screen is shown in Chart DIII.

MONITOR – The data presented on selecting MONITOR is the live “read only” information from the transmitter, for example the liquid level in the tank, and the value of the current output. These parameters are labelled D, for Display information parameters, and are indexed between D10 and D25. The Display parameters are described and listed in Section D10.0

PROGRAM – The data presented on selecting PROGRAM is the operator adjustable data used to configure the transmitter for the particular application. These are “read/write” parameters, labelled P for Program parameter, and are indexed from P00 to P69. The Program parameters are described and listed in Section D10.0

FIXED DATA – These are the factory preset display parameters, identifying the equipment type, serial number, software information, etc.

BACK UP – This menu item controls the transfer of data between registers or a file available in the Psion Organiser memory: operation is described in Section D13.0.

D** - Allows direct access to a Display parameter by entering the relevant code number.

HELP – The HELP information display screens give some introductory advice on the use of the keys on the Psion Organiser and the Programme structure.

D8.1 Monitor/Display Parameters – D**

Access and programme structure

The Display Parameters (D**) are separated into three blocks giving three types of operator read only information. These are shown in Fig. DIII.

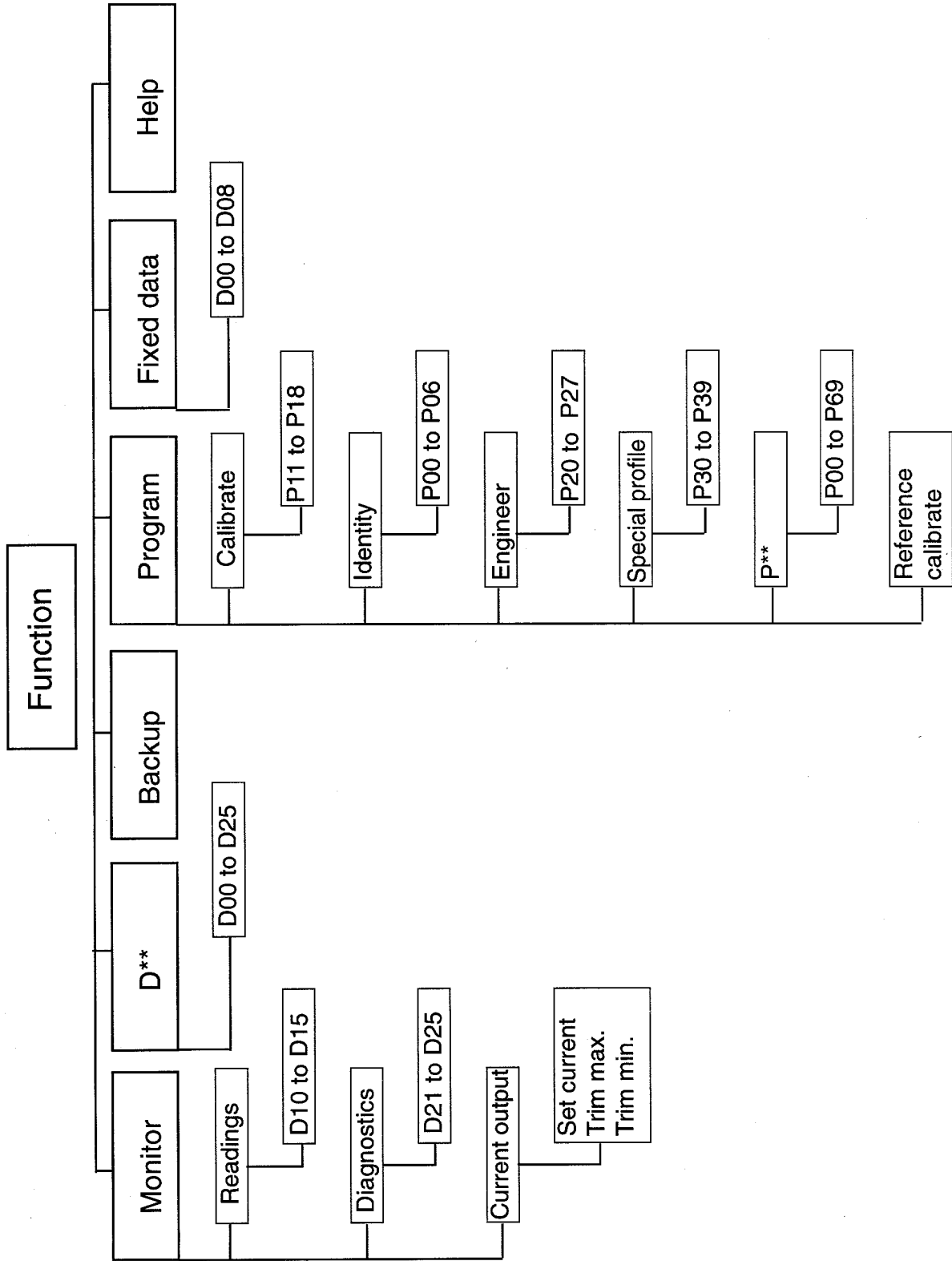


Chart DIII : PSION HHC menu structure

FIXED DATA – is accessed from the FUNCTION menu, and defines factory set identification codes. These are D00 to D08.

READINGS – are the actual level measurement values live from the transmitter, and are the process measurements of interest to the operator. These are D10-D15, and are accessed from the MONITOR menu.

DIAGNOSTICS – are the live values and data of interest to the transducer maintenance engineer, to assess the performance of the transmitter. These are D20-D25, accessed from the MONITOR menu.

All the Display parameters can be accessed directly from the FUNCTION menu by selecting the appropriate identification number, e.g. D20.

ENTER PARAMETER No D -

The live data recalled on the displays D10-D15 and D20-D25 are updated continuously by the SMART Communicator every 0.5 seconds, and so represents the latest available information from the transmitter. When monitoring these parameters the Psion Organiser is active and so will not switch itself off (the normal action after 5 minutes without any keyboard input).

Additional messages and codes are displayed in a priority order on the LCD when the Display parameters are in use, to indicate exceptional tank conditions or operational problems.

D8.2 PROGRAM Parameters – P**

Access and Programme Structure

The PROGRAM Parameters are separated into six blocks. Five of these blocks are available for operator access to configure the transmitter as required for the particular application, or adjust the normal mode of operation of the unit. The sixth block of parameters is for use by service engineers or under direct instructions from them. Access to all the PROGRAM parameters is made via the PROGRAM menu, as shown in Figure DIII.

The five blocks of PROGRAM parameters are as follows:

CALIBRATE – The normal operator adjustments equivalent to zero and span, units, tank shape and standing value. Parameters P11-P18.

ENGINEER – The more technical operator parameters, establishing response time, alarm delay time, sensitivity, temperature and specific gravity. Parameters P20-P27.

IDENTITY – These are the plant identifiers – for example tag numbers, function description, plus serial numbers and password entry. Parameters P00-P06.

P** - Allows direct access to a PROGRAM parameter by entry of the relevant code number. (This is the only access route for the service engineer parameters P44-P48 and P51-P69.

SPECIAL P(ROFILE) – When selected on P11, the special profile of 10 points on a non linear relationship between liquid height and process value are entered via Parameters 30-39.

REF-CAL – This allows 4 and 20mA points of the range of the displacer used to represent zero and max PV to set by reference to the current level of liquid.

These PROGRAM parameters are read/write parameters, so that when a particular parameter is recalled its value can be changed by one of three methods – either entering a new value on the blue numeral key pad, or on the alphabet keys for a text entry parameter, or by scrolling sideways. Each of the parameters uses only one of these methods : sideways scrolling is prompted by the appearance of horizontal arrows on line 3 of the LCD. When the new value is on the display correctly, this is entered using the "EXE" key. The SMART Communicator immediately then transmits the change to the transmitter. If the value is incorrect or the operator wants to revert to the original value, the CLEAR/ON key will reinstate the existing parameter value on the display, without affecting the transmitter.

Within the memory of the Psion Organiser there are four separate registers for each of the PROGRAM Parameters. These registers are known as WORKING, SAFE, OFFLINE and DEFAULT, and are further described in Section D13.0. All programme changes are made in the WORKING register, and these are the values sent to the Transmitter memory. The display can be cycled through the registers by using the MODE key, and the initial letter of the register currently displayed is shown at the right hand end of the second line – the same line as the parameter value. Individual parameters can be moved into the WORKING register from other registers, by pressing the EXE key whilst the required register value is displayed.

WORKING REGISTER

Holds the same value as is currently in the transmitter.

SAFE REGISTER

Use as a backup, can only be sent to the same transmitter as it was loaded from.

OFF-LINE REGISTER

General purpose register, use to program a transmitter offline or transfer data between transmitters of the same type.

DEFAULT REGISTER

The normal ex-factory values.

When a new value is programmed into certain parameters a warning message OUTPUT MAY BE CHANGED is displayed with the option to proceed with or abort this change. This may be of importance where the output, either digital or analogue, is controlling some process, such that a sudden change could cause problems.

D9.0 Keyboard Functions

ON/CLEAR KEY

Aborts data entry if this has been started, else returns to the previous menu.

EXE KEY

When display is read/write parameter, writes the value on line 2 or the list selection on line 3 to the transmitter.

– AND – ARROW KEYS

Used to step through a parameter block in numerical order.

MODE KEY

Used to access the WORKING, SAFE and OFF-LINE registers and the DEFAULT value while a read/write parameter is being displayed. The selected register is indicated by W, S, O or D on the right hand side of line 2.

↔ AND ® ARROW KEYS

Used to select an item from a list when <> is displayed on the right of line 3.

P** AND D** ENTRY

Allows direct access to a parameter via its number. Other parameters in the same group can then be accessed by the – and – arrow keys.

The performance of the DT Series is controlled by parameters stored in its non-volatile memory. Some of these parameters are set at the factory and some are set by the customer. Further parameters are produced by the DT Series to provide information about its performance. The parameters used to set up the transmitter are called Program or "P" parameters. The parameters produced by the transmitter to provide information to the user are called Diagnostic or "D" parameters. All parameters used in the DT Series are listed below. All of these parameters are accessible using a Handheld Communicator. Only parameters P15, P16 and P20 may be changed using the MSP-MMS magnetic scroller. Further details are provided in Section D11.0

PROGRAM PARAMETERS

IDENTITY GROUP

P00	MESSAGE	general purpose 32 character message
P01	TAG	transmitter identifier (8 characters)
P02	DESCRIPTION	of, say, transmitter application or location (16 char)
P03	DATE	when last change made to sensor
P04	FINAL ASSY No	hardware assembly number
P05	SENSOR SERIAL No	LVDT serial number
P06	PASSWORD	3 level password system

CALIBRATE GROUP

P11	CURVE PROFILE	curve shape option
P12	PV DISPLAY UNITS	select units associated with the PV
P13	PV SCALE FACTOR	PV max value
P14	STANDING VALUE	value of PV at zero level
P15	CALIBRATION MAX	PV for 20mA output
P16	CALIBRATION MIN	PV for 4mA output
P17	LEVEL FOR MAX PV	height up displacer at which PV is maximum
P18	LEVEL FOR MIN PV	height up displacer at which PV is minimum

ENGINEERING GROUP

P20	SMOOTHING TIME	time constant applied to output
P21	ALARM DELAY	time before alarm action P22 is taken
P22	ALARM ACTION	current out on alarm condition detection
P23	DISPLAY 1	parameter to be displayed on display module
P24	DISPLAY 2	optional second parameter to be displayed
P25	PROCESS TEMP	used to compensate system for process temp
P26	SG LOWER	specific gravity of the lower liquid
P27	SG UPPER	specific gravity of the upper liquid

CURVE PROFILE GROUP

P30	10% HT	%PV at 10% liquid height
P31	20% HT	%PV at 20% liquid height
P32	30% HT	%PV at 30% liquid height
P33	40% HT	%PV at 40% liquid height
P34	50% HT	%PV at 50% liquid height
P35	60% HT	%PV at 60% liquid height
P36	70% HT	%PV at 70% liquid height
P37	80% HT	%PV at 80% liquid height
P38	90% HT	%PV at 90% liquid height
P39	100% HT	%PV at 100% liquid height

PROTECTED GROUP

P44	ELEC TEMPERATURE	for sensor assembly correction
P45	TEMP COEFFICIENT	for temperature correction of sensor assembly
P46	TEMPERATURE MAX	the highest sensor temperature reading
P47	TEMPERATURE MIN	the lowest sensor temperature reading
P48	BYTE READ/WRITE	diagnostic tool for service engineer only
P51	DISPLACER LENGTH	length of displacer element
P52	DISPLACER CS AREA	cross-sectional area of displacer
P53	DISPLACER WEIGHT	weight of suspended parts

P54	SPRING MATERIAL	spring material selectable from menu
P55	SPRING RATE	linear extension rate of spring
P58	TEMP SETUP	process temperature assumed at factory setup
P59	SG SETUP	SG of upper fluid assumed at factory setup
P60	MIN SENSOR OUTPUT	base value of D21
P61	LVDT COEFF 1	first order coefficient for polynomial correction
P62	LVDT COEFF 2	second order coefficient for polynomial correction
P63	LVDT COEFF 3	third order coefficient for polynomial correction
P64	LVDT COEFF 4	fourth order coefficient for polynomial correction
P65	LVDT COEFF 5	fifth order coefficient for polynomial correction
P66	LVDT GAIN FACTOR	to normalise LVDT output
P67	LVDT RATE	rate of change of LVDT output
P68	UPPER SENSOR LIMIT	maximum usable value of sensor output D21
P69	LOWER SENSOR LIMIT	minimum usable value of sensor output D21

DIAGNOSTIC PARAMETERS

FIXED DATA GROUP

D00	MANUFACTURER ID	MOBREY
D01	TRANSMITTER TYPE	MLT100 order code
D02	PREAMBLE BYTES	no. of bytes to set up modulation
D03	UNIV COMMAND REV	protocol revision conformed to
D04	TS COMMAND REV	MOBREY command specification
D05	SOFTWARE REV	instrument software version number
D06	HARDWARE REV	instrument hardware version number
D07	FLAGS	see HART protocol specification
D08	DEVICE ID NUMBER	factory-set unique address of sensor

READINGS GROUP

D10	PROCESS VALUE	output calculated from the level
D11	LEVEL	immersed length of displacer
D12	CURRENT OUTPUT	proportional to PV - limits set on P15 and P16
D13	PERCENT OUTPUT	current output as % of full scale
D14	ULLAGE	space available (refill quantity)
D15	ALARM REPORT	active alarms/warnings - press @ for next alarm

DIAGNOSTICS GROUP

D21	NORMALISED	sensor output after linearisation & smoothing
D22	COMPENSATED	sensor output after temp compensation
D23	RAW LVDT OUTPUT	unprocessed sensor output
D24	PERCENT OF RANGE	% of range of level of interest between P17 & P18
D25	TEMPERATURE	sensor temperature monitored or preset using P44

D11.0 Parameter Descriptions

The DT Series stores a wide range of parameters, enabling it to perform more functions than a simple 4 to 20mA transmitter. Some of these parameters are required to comply with the HART protocol whilst others, for example, enable the transmitter to calculate and display the contents of a non-linear vessel in true volumetric units.

The DT Series "Program" parameters each have default values which are loaded into the transmitter's memory when first manufactured. Some of these values are adjusted at the factory to suit the customer's application. Several of the parameters have upper and lower limits outside of which they should not be set. These limits are defined within the transmitter itself and, in the case of Handheld Communicators supplied are also set in the Communicator.

Certain parameters, when changed, can cause a step change in the output. In these cases the HHC will prompt for confirmation before making the change. This gives the user the opportunity to, say, put the control loop into manual.

This section of the manual details the function of each parameter in numerical order, together with its default value and limits if applicable. A typical screen from the HHC is shown for each parameter.

P00 MESSAGE

The MESSAGE is a 32 character alphanumeric text string which may be stored in the transmitter so that the user may, for example, record details of the application.

The default value is: DISPLACER LEVEL TRANSMITTER

```
MESSAGE P00
*****
GENERAL PURPOSE 32
CHARACTER MESSAGE
```

P01 TAG

The TAG is an 8-character identifier. It is displayed whenever the HHC establishes communication with a HART transmitter.

The default value is: MLT

```
TAG P01
*****
TRANSMITTER
IDENTIFIER ( 8 CHAR )
```

P02 DESCRIPTION

The DESCRIPTION is a 16-character field which may, say, be used to provide further detail on the application.

The default value is: MLT TRANSMITTER

```
DESCRIPTION P02
*****
TRANSMITTER USE OR
LOCATION (16 CHAR)
```

P03 DATE

The DATE may be used to store the date when the last changes are made to the transmitter's configuration. The CK1 HHC automatically loads the correct date if it makes any such changes.

The default value is typically: 01/01/97

```
DATE WAS P03
** *** **
WHEN LAST CHANGE
MADE TO SENSOR
```

P04 FINAL ASSY No

The Final Assembly Number is a Unique Number allocated to the transmitter at the factory.

FINAL ASSY No P04

HARDWARE ASSEMBLY
NUMBER

P05 SENSOR SERIAL No

The Sensor Serial Number is the serial number of the LVDT which provides the level input signal to the electronics.

SENSOR SERIAL No P05

INSTRUMENT SERIAL
NUMBER

P06 PASSWORD

The Password controls changes to the parameters within the transmitter. It has 3 possible values:

CLOSED – this prevents any changes to parameter settings

OPEN – this allows configuration of the transmitter to suit the application

OPENx this additionally allows access to the “protected” parameters which relate to the calibration of the transmitter. These should not be adjusted without reference to the factory.

The default value is: OPEN

PASSWORD P06

P11 CURVE PROFILE

The DT Series can provide an output proportional to volume, flow or contents in a non-linear application. The DT system is pre-programmed with a selection of common non-linear profiles detailed in the Non-linear Profiling section of this manual. These profiles may be selected using the - and @ keys. Selecting “Special” allows the user to plot his own curve.

The default value is: Linear

CURVE PROFILE P11

***** ⓑ à
CURVE SHAPE OPTION

Refer to Appendix E for further details of this facility.

P12 PV DISPLAY UNITS

The Process Value (PV) may be configured to display a wide range of variables from Levels to Volumes. P12 enables the user to associate appropriate units to the calculated value, and these units will be displayed on the optional integral display and on the HHC.

The default value is: metres

PV DISPLAY UNITS P12

***** ⓑ à
RESET MATHS ON P13

P13 PV SCALE FACTOR

The PV Scale Factor enables the transmitter to provide an answer in the customer's preferred units. Typically it may be used to give an answer of volume in cubic metres. The value of P13 should be set to the maximum (100%) value of the PV. If the value is set to Automatic then the transmitter takes the displacer length (or the span defined by P17 and P18) as its full-scale range and adjusts the output accordingly. See also the appendix on the Block Diagram. The default value is: Automatic

```
PV SCALE FACTOR P13
*****
MAX VALUE
AUTOMATIC (A) = P51
```

P14 STANDING VALUE

A displacer level transmitter can only give a meaningful output over the length of its displacer. If, however, the vessel still has some contents when the level is at the bottom of the displacer then this value may be added to the PV by entering the difference value in P14. P14 may be positive or negative. The default value is: 0.0

```
STANDING VALUE P14
**** **
VALUE OF PV
AT ZERO LEVEL
```

P15 CALIBRATION MAX

After calculating the PV, the transmitter will normally output a 4-20mA signal proportional to the value. P15 may be used to set the value of PV which is used to represent 20mA. A value of Automatic will use the displacer length to specify the height at which to output 20mA. This parameter and P16 may also be adjusted via the Caliplug – see section on Commissioning.

The default value is: Automatic

Can also be set by using the ref cal option on the program menu.

```
CALIBRATION MAX P15
***** **
PV FOR 20mA OUTPUT
AUTOMATIC (A) = P51
```

P16 CALIBRATION MIN

After calculating the PV, the transmitter will normally output a 4-20mA signal proportional to the value. P16 may be used to set the value of PV which is used to represent 4mA. This parameter and P15 may also be adjusted via the Caliplug – see section on Commissioning.

The default value is: 0.0

Can also be set by using the ref cal option on the program menu.

```
CALIBRATION MIN P16
***** **
PV FOR 4mA OUTPUT
```

P17 LEVEL FOR MAX PV

The top end of the displacer is not necessarily the level which is required to represent the maximum PV. P17 can be used to specify another level for this purpose and subsequent calculations will be based upon this revised point. See also the appendix on the Block diagram.

The default value is: Automatic, meaning the max. PV is at the top of the displacer.

Can also be set by using the ref cal option on the program menu.

```
LEVEL FOR MAX PV P17
***** m
HEIGHT UP DISPLACER
AUTOMATIC (A) = P51
```

P18 LEVEL FOR MIN PV

The bottom end of the displacer is not necessarily the level which is required to represent zero PV. P18 can be used to specify another level for this purpose and subsequent calculations will be based upon this revised point.

The default value is: 0.0

Can also be set by using the ref cal option on the program menu.

```
LEVEL FOR MIN PV P18
***** m
HEIGHT UP DISPLACER
```

20 SMOOTHING TIME

In circumstances where the level is unstable it may be beneficial to adjust the amount of damping applied to the PV and current output. P20 may be set to any value between 0 and 100 seconds. This parameter may also be adjusted via the Caliplug – see section on Commissioning.

The default value is: 5 seconds

```
SMOOTHING TIME P20
** s
TIME CONSTANT USED
ON OUTPUT DATA
```

P21 ALARM DELAY

The transmitter continuously monitors its performance and will signal an alarm if certain parameters go outside of pre-determined limits. Under these circumstances it will signal that an alarm condition exists as described under P22 below. P21 may be used to set the delay between the alarm condition occurring and the transmitter signalling.

The default value is: 5 seconds

```
ALARM DELAY P21
** s
DELAY BEFORE ALARM
ACTION(P22) IS TAKEN
```

P22 ALARM ACTION

The transmitter continuously monitors its performance and will signal an alarm if certain parameters go outside of pre-determined limits. See appendix on Error Messages for possible alarm conditions. An alarm condition is signalled by:

Setting an Alarm bit in every HART message

Flashing an Alarm message on the display (if fitted)

Setting its current output to a user-defined state set by P22.

The options for P22 are to set the current to 3.6mA, 21mA or to Hold the last reading.

The default value is: Hold

```
ALARM ACTION P22
****
****      B à
CURRENT OUT ON FAULT
```


P23 DISPLAY 1

The display module, if fitted, can be programmed to display any 1 or 2 parameters from a selection of parameters. P23 is used to define Display 1. The → and Ⓢ à keys may be used to make the selection. The choice is from:

- PV
 - Level
 - Current (Output)
 - Percent (Current Output)
 - Ullage
 - Sensor Outputs D21à D23
 - Percent of PV Range D24
 - Temperature D25
- The default value is: PV

```

DISPLAY 1 SELECT P23
***
***          Ⓢ à
IF FITTED

```

P24 DISPLAY 2

In a similar way to P23, P24 can be used to define a second display which will flash alternately with Display 1 on the display module. It has the same choice as for P23 except for the addition of "none" if no second display is required. When flashing, the 2 displays are distinguished by the Display 1 and Display 2 being accompanied by arrows → and ← respectively.

The default value is: none

```

DISPLAY 2 SELECT P24
***
***          Ⓢ à
IF FITTED - OPTIONAL

```

P25 PROCESS TEMP

The process temperature has an effect on the performance of the transmitter. This effect will have been allowed for in the factory calibration. If, however, the temperature is significantly different from that originally specified, it may be compensated for by entering a revised value in P25. If set to Automatic then the value from the temperature sensor in the enclosure is used.

The default value is: Automatic

```

PROCESS TEMP P25
***** °C
USED TO COMPENSATE
FOR PROCESS TEMP

```

P26 SG LOWER

The performance of a Displacer Level Transmitter is dependent on the specific gravities of the Lower and Upper fluids. The transmitter will have been calibrated for certain SGs in the factory but, subject to certain limitations, revised values may be entered in P26 and P27 to match the true process conditions.

The default value is: 1.0

```

SG LOWER P26
****
SPECIFIC GRAVITY
OF LOWER LIQUID

```

P27 SG UPPER

See also P26 above. At the factory, the transmitter will have been calibrated for certain process conditions. The SG of the upper fluid is stored in P27 and P59. The value in P59 should not be changed but P27 may be adjusted to match revised process conditions.
The default value is: 0.0

```
SG UPPER P27
***
SPECIFIC GRAVITY
OF UPPER LIQUID
```

P30 to P39 NON-LINEAR PROFILE POINTS

When a non-linear profile has been selected by P11, the profile is plotted using parameters P30 to P39. Each plot point represents the percentage of maximum PV corresponding to 10% increments in level. The range of this level is defined by P17 and P18 relative to the bottom end of the displacer. For further details see Non-linear Profiling in D12.0

The default values provide a linear output.

```
PROFILE POINT 1 P30
%LEVEL FOR PV(%P13)
10% LEVEL @ 10.0%B
20% LEVEL @ 20.0%
```

IMPORTANT NOTE :

Parameters P44 to P69 are vital to the calibration of the transmitter and should not be adjusted without authority from qualified personnel, for which password access will be required.

P44 ELEC TEMPERATURE

The level sensor and its associated electronics have a small temperature co-efficient and so to optimise accuracy a temperature sensor provides automatic compensation. However, the measured value can be overridden using P44.
The default value is: Automatic

```
ELEC TEMPERATURE P44
** °C
FOR SENSOR ASSEMBLY
CORRECTION - A=AUTO
```

P45 TEMP COEFFICIENT

The temperature co-efficient of the level sensor and its associated electronics is stored in P45 and provides automatic temperature compensation.

The default value is optimised for the transmitter.

```
TEMP COEFFICIENT P45
***
FOR TEMP CORRECTION
OF SENSOR ASSEMBLY
```

P46 TEMPERATURE MAX

The transmitter monitors the temperature of the electronics and LVDT sensor and records the maximum measured value for later recall. Any value greater than 50°C is recorded automatically in P46.

```
TEMPERATURE MAX P46
  ** °C
THE HIGHEST SENSOR
TEMPERATURE READING
```

P47 TEMPERATURE MIN

The transmitter monitors the temperature of the electronics and LVDT sensor and records the minimum measured value for later recall. Any value less than -10°C is recorded automatically in P47.

```
TEMPERATURE MIN P47
  ** °C
THE LOWEST SENSOR
TEMPERATURE READING
```

P48 BYTE READ/WRITE

This parameter allows the Service Engineer access to useful data. This facility must not be used without direction from qualified personnel.

```
BYTE READ/WRITE P48
ADD DATA
ONLY ENTER DATA FOR
WRITE OPERATIONS
```

P51 DISPLACER LENGTH

The transmitter is normally calibrated over the full length of the displacer. P51 is factory configured with the displacer length in metres.

```
DISPLACER LENGTH P51
  *** m
```

P52 DISPLACER CS AREA

To perform its calculations, the transmitter needs to know the cross-sectional area of the displacer. P52 is factory configured with the area in square centimetres.

```
DISPLACR CS AREA P52
  *** cm2
CROSS-SECTIONAL
AREA OF DISPLACER
```

P53 DISPLACER WEIGHT

To perform its calculations, the transmitter needs to know the weight of the suspended components including the displacer. P53 is factory configured with this total weight in grams.

```
DISPLACER WEIGHT P53
  *** g
INCLUDING ATTACHED
ROD, ACTUATOR etc
```

P54 SPRING MATERIAL

To perform its calculations, the transmitter needs to know the characteristics of the spring material. P54 specifies the spring material from which the transmitter can calculate the relevant characteristics.

SPRING MATERIAL	P54

***	£ à

P55 SPRING RATE

To perform its calculations, the transmitter needs to know the rate of the spring. P55 is factory configured with the actual spring rate in gram per centimetre.

SPRING RATE	P55
*** g/cm	
LINEAR EXTENSION	
RATE OF SPRING	

P58 TEMP SETUP

To optimise the design of the transmitter, it is necessary to know the process temperature in which the transmitter will be operating. This is stored in P58. If the actual process temperature is significantly different from that advised at the time of order, then the revised value should be entered in P25 – no change should be made to P58.

TEMP SETUP	P58
*** °C	
PROCESS TEMPERATURE	
ASSUMED AT SETUP	

P59 SG SETUP

To optimise the design of the transmitter, it is necessary to know the specific gravity of the upper fluid in which the transmitter will be operating. This is stored in P59. If the actual upper SG is different from that advised at the time of order, then the revised value should be entered in P27 – no change should be made to P59.

SG SETUP	P59

SG OF UPPER FLUID	
ASSUMED AT SETUP	

P60 MINIMUM SENSOR OUTPUT

During factory calibration, the value of the LVDT level sensor output at zero level is recorded and stored as P60. This is the reference value upon which the transmitter bases its calculations.

MIN SNSR OUTPUT	P60
**** mV	
BASE VALUE OF D21	

P61 to 65 LVDT COEFFICIENTS 1 to 5

To provide a linear output over the operating range, the LVDT sensor output is linearised by a fifth order polynomial. These polynomial co-efficients are stored as P61 to P65.

LVDT COEFF 1	P61

VALUE FOR POLYNOMIAL	
CORRECTION	

P66 LVDT GAIN FACTOR

In order to allow interchangeability of the LVDT sensor, the output is normalised to achieve a common span. The gain factor is stored as P66

```
LVDT GAIN FACTOR P66
***
TO NORMALISE LVDT
OUTPUT
```

P67 LVDT RATE

After processing the LVDT output the overall sensor system produces an electronic output proportional to linear movement. P67 defines the sensitivity of the sensor in milli-volts per cm.

```
LVDT RATE P67
*** mV/cm
RATE OF CHANGE OF
LVDT OUTPUT
```

P68 UPPER SENSOR LIMIT

The LVDT sensor is calibrated over a range where linear operation is guaranteed. In exceptional circumstances its output may extend beyond the calibrated range and under these circumstances the transmitter will provide a warning. P68 stores the limit of the calibrated region at the upper end of the LVDT travel.

```
UPPER SNSR LIMIT P68
***
MAXIMUM USABLE VALUE
OF SENSOR OUTPUT D21
```

P69 LOWER SENSOR LIMIT

See also P68 above. P69 stores the limit of the calibrated region of LVDT movement at the lower end of the LVDT travel.

```
LOWER SNSR LIMIT P69
***
MINIMUM USABLE VALUE
OF SENSOR OUTPUT D21
```

The following "D" parameters are diagnostics read-only parameters which are either fixed in the transmitter at manufacture (D00 to D08) or produced within the transmitter as a result of measurements taken (D10 to D25).

D00 MANUFACTURER ID

For HART communications to operate correctly, the transmitter must identify its manufacturer. The manufacturer's code number automatically forms part of the communications address. The code is 59

```
MANUFACTURER ID D00
59
```

D01 TRANSMITTER TYPE

D01 stores the type code for the transmitter head.

```
TRANSMITTER TYPE D01  
  
DISPLACER LEVEL  
TRANSMITTER
```

D02 PREAMBLE BYTES

D02 tells a HART master device how many preamble bytes it should send in its messages to the transmitter in order to guarantee reliable communications. Sending too many bytes would simply slow down the communications update rate. In the DT Series the value is fixed at 5.

```
PREAMBLE BYTES D02  
5  
NO OF BYTES TO SET  
UP MODULATION
```

D03 UNIV COMMAND REV

D03 identifies the major revision of the HART protocol with which the transmitter complies. In the case of the DT Series it is revision 5.

```
UNIV COMMAND REV D03  
5  
PROTOCOL REVISION  
CONFORMED TO
```

D04 TS COMMAND REV

Over a lifetime of a product type, extra functionality may be introduced by adding extra variables or commands. To signal this to a HART master device, D04 contains details of the Transmitter Specific Command revision

```
TS COMMAND REV D04  
* *  
COMMAND  
SPECIFICATION
```

D05 SOFTWARE REV

Extra software functionality, which does not affect HART, may be identified to the user by D05, the Software Revision.

```
SOFTWARE REV D05  
* *  
INSTRUMENT SOFTWARE  
VERSION NUMBER
```

D06 HARDWARE REV

The presence of any hardware changes may be identified to the user by D06, the Hardware Revision.

```
HARDWARE REV D06  
* *  
INSTRUMENT HARDWARE  
VERSION NUMBER
```

D07 FLAGS

The Flags byte, D07, gives a HART master details of the transmitter's HART functionality.

FLAGS	D07
**	
SEE HART PROTOCOL SPECIFICATION	

D08 DEVICE ID NUMBER

The Device ID Number is a unique number which forms part of the transmitter's HART address and ensures that no two HART transmitters ever have the same address.

DEVICE ID NUMBER	D08
FACTORY-SET UNIQUE ADDRESS OF SENSOR	

D10 PROCESS VALUE

The DT Series is fundamentally a level measuring device and by default the Process Value or PV will be the level of the lower liquid. However, as described elsewhere in this manual, the level value can be processed to provide an answer in terms of volume, mass or even flow. This resultant PV is displayed with its units as parameter D10.

PROCESS VALUE	D10
***** **	
OUTPUT CALCULATED FROM THE LEVEL	

D11 LEVEL

The length of the displacer element that is immersed in the lower liquid is displayed as D11. The PV is calculated from this basic level measurement

LEVEL	D11
***** m	
IMMERSED LENGTH OF DISPLACER	

D12 CURRENT OUTPUT

The current output is related to the PV by parameters P15 and P16. Its value, in mA, is displayed as D12.

CURRENT OUTPUT	D12
***** mA	
PROPORTIONAL TO PV LIMITS SET P15+P16	

D13 PERCENT OUTPUT

A convenient alternative way of viewing the answer is as a percentage. D13 displays the PV as a percentage based on the limits set on P15 and P16. If the current output is active, that is not in multi-drop mode, then this also represents the percentage of current output – e.g. if the current is 12mA then D13 is 50%.

PERCENT OUTPUT	D13
***** %	
CURRENT OUTPUT AS % OF FULL SCALE	

D14 ULLAGE

The Ullage space is the difference in the present PV and the maximum value defined by P15. In other words it is the amount in PV units required to fill the vessel so as to give 20mA current output.

```
ULLAGE          D14
***** **
SPACE AVAILABLE
(REFILL QUANTITY)
```

D15 ALARM REPORT

The DT Series monitors its performance and detects if there is any malfunction or if any values go out of normal limits. The parameters it monitors are listed in Appendix D14.0. The HHC displays a full text message when the condition is first detected and then truncates it to a 2 character code at the right hand end of the display. Only one condition, the highest priority one, can be displayed at a time. However, D15 can be inspected to scroll through full descriptions of all active alarms.

```
ALARM REPORT    D15
*****
PRESS à FOR NEXT
ALARM
```

D21 NORMALISED LVDT OUTPUT

The Level Sensor in the DT Series is a Linear Variable Differential Transformer (LVDT). The LVDT output goes through several stages of processing as shown in the Block Diagram in Appendix E. D21 is the LVDT sensor output value after temperature compensation, linearisation, scaling, and smoothing.

```
NORMALISED      D21
**** mV
SENSOR OUTPUT AFTER
POLYNOMIAL+SMOOTHING
```

D22 COMPENSATED LVDT OUTPUT

D22 is the LVDT sensor output value after temperature compensation.

```
COMPENSATED     D22
****
SENSOR OUTPUT AFTER
TEMP COMPENSATION
```

D23 RAW LVDT OUTPUT

D23 is the LVDT sensor output value before any processing.

```
RAW LVDT OUTPUT D23
****
```


D24 PERCENT OF RANGE

The DT Series produces a value (D11) for the liquid level relative to the bottom of the displacer element. However, this may not be the range of interest and P17 and P18 re-define where the minimum and maximum levels should be. D24 represents the position of the liquid level between these 2 limits.

```
PERCENT OF RANGE D24
*** %
```

D25 TEMPERATURE

The DT Series measures the temperature in the enclosure so that it may make corrections for changes in temperature if necessary. D25 displays this measured value unless it is overridden by fixing the temperature with P44.

```
TEMPERATURE D25
*** °C
MONITORED OR PRESET
USING P44
```

REFERENCE CALIBRATE

The Ref_cal section allows the actual level of the liquid being measured to be used to set the current output and PV range parameters.

The sensor output option allows P17 and P18 to be set. The current output option allows P15 and P16 to be set.

In both cases the present value of the parameter to be changed is displayed, with a prompt to continue. If selected the potential new value for the selected parameter is displayed and continually updated, with an "INPUT STABLE" prompt, if "Y" is pressed then the displayed value is written to the selected parameter. If "N" is pressed the process returns to the previous screen.

At any stage, in either reference calibrate procedure, if the CLEAR/ON key is pressed then a return to the PROGRAM menu is immediately made.

D12.0. Using the Tank profile facility

P11 Curve Profile

```
CURVE PROFILE P11
LINEAR 1
NON-LINEAR < - - >
CURVE SHAPE OPTION
```

Default value LINEAR

This parameter establishes the relationship to be used between the liquid level (or height) and the process value derived from that level. The process value then drives the current loop.

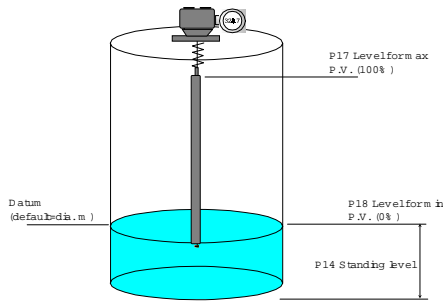
The allowed selections on Parameter 11 are scrolled using the left and right arrows. Allowed selections are LINEAR and then seven non-linear functions – SPECIAL, CYLINDER, SPHERICAL, CONICAL 1, CONICAL 2, FLUME and VNOTCH WEIR. These are as follows:

D12.1 LINEAR – The process value (transmitter 4-20mA output) is a linear multiplier of the liquid height above the zero reference, in metres.

For a tank with constant cross section, the volume of the contents can be shown as the process value by selecting LINEAR on P11, and entering the maximum volume on P13. The units of measurement – gallons, litres, etc. – are then set on P12. See Fig DIV

Tank Contents Curve Profiles for Standard Tank Shapes

Fig. D.IV - Linear vessel or sump



Unless factory calibrated to your specific instructions, the DT Series will give a 4-20mA output proportional to level over its full length, with 4mA representing a level of 0m at the end of the displacer element. You can re-range on site if necessary (See 4.2).

If the displacer element does not cover the full depth of the tank, there is provision to add a standing level to the calculations. Simply enter the level, in metres, on P14, and the DT Series will give a proportional output over the length of the displacer. Note that the output will now never reach 4mA, as the displacer length is now only a part of the full output range. You will need to re-set P17, the Process Value for a 20mA output, by increasing the value by the standing level.

Example :

Displacer length 1.50m. : P17 = 1.50 / P18 = 0m / P14 = 0m

To allow for a standing level of 0.5m : P17 = 2.0m / P18 = 0m / P14 = 0.5m

Resulting output signal : 8mA at 0.5m and below, 20mA at 2.0m.

To operate in units other than metres, the "PV Scale factor" P13 can be used. (See D11.0)

Example : To operate in feet, set P13 to the maximum value of the PV. For a displacer length of 1.5m, where PV max is 1.5m, set P13 to $(1.5 \times 1.094) = 1.641$.

If you wish to re-range the transmitter, you can reset P17 and/or P18 so that the transmitter output is proportional to level over this new range. Note, P17 and P18 are ALWAYS entered in metres.

To operate in litres, set P13 to the volume in litres equivalent to the length of the displacer element. For an element of length of 1.5m in a vessel of dia 2m, set P13 to $1.5 \times \frac{\pi \times 2.0^2}{4} \times 1000 = 4712$ litres

If there is a standing level (or volume) to be taken into account, this is entered on P14 as previously described, but note that the units MUST BE entered in the same units as the readout. i.e. feet or litres in the above examples. Whatever units are chosen for the readout, the display and / or HHC can be configured to suit using P12.

P12 Units

```
PV DISPLAY UNITS P12
Metres W
Metres < - - >
RESET MATHS ON P13
```

Default value metres

The units used to display the Process Value are set on Parameter 12. These units are also used to set the milliamp output span and zero points on P15 and P16. The allowed units are scrolled by using the horizontal arrows. If the units required are not present, then the displays can show no units by selecting "none" – possibly the actual units in use can be entered in P00 (Message).

The bottom line on the display of P12 reminds the operator that if units of measurement are changed, then the maths values on the scaling parameters (e.g. P13) should be recalculated and amended.

P13 Scale Factor

```
PV SCALE FACTOR P13
1.0000 W
MAX VALUE
AUTOMATIC (A) = P51
```

Default value 1.00

The PV Scale Factor provides the mathematics used to relate the Process Value to the liquid height, which is initially measured by the transmitter in metres above the reference level.

This function can also be used to display height of liquid in feet or millimetres or other linear units, by adjusting P12 and P13 appropriately.

D12.2 "NON-LINEAR" – All the non-linear functions selected have a curve or profile to relate the process value/output measurement to the liquid height. The functions therefore relate liquid volume contents to height in a non-linear tank, or liquid flow in an open channel to the height upstream of an obstruction such as a weir or flume.

For all selections other than LINEAR it is necessary to select the correct, site related values for Parameters 12 and 13 as shown on in the following diagrams. The various non-linear profiles available are as follows:

Technical Note : The transmitter accepts the non-linear profiles from the SMART Interface in the form of a 10 point plot of percentage of maximum process value against percentage of maximum level, and then uses interpolation to produce values for intermediate points. The Psion Organiser calculates the ten points to be loaded in the memory according to the curve profile selected on P11. The values of these ten points can be seen on Parameters 30-39 : direct access to change these parameters is only available when the SPECIAL profile is selected on P11.

CYLINDRICAL – When the PV output required is to represent the volume contents in a horizontally mounted cylindrical tank, this curve is selected. The dimension of the equivalent ideal tank are entered as shown in Fig. D.IV, assuming the tank is horizontal and has effectively flat ends.

SPHERICAL – To provide the PV output as volume contents in a spherical tank, this curve is selected. The equivalent ideal spherical tank dimensions are entered in the parameters 10-14 as shown in D.IV. If the actual tank measurement range is limited by transducer positioning or tank shape to part of a sphere, the ideal full sphere dimensions must be used. The 4-20mA output can then be restricted to operation over a smaller volume span if required.

CONICAL – For rectangular or cylindrical tanks with a conical bottom two patterns are provided to suit different tank aspect ratios. These are CONICAL 1 AND conical 2, shown in D.IV.

CONICAL 1 is for tanks where the major part of the tank height is taken up with the cone. The profile creates an imaginary tank where the linear section is the same height as the conical section, and P13 and P14 are entered for this imaginary tank. This profile is applicable on all tanks where the maximum height to be measured is less than twice the conical section height, H. Note that the zero reference distance and the conical height is measured from the apex of the cone – where it would be without considering discharge pipework, etc.

CONICAL 2 is used for tanks which have a much smaller proportion of the height as a cone. It is applicable for tanks where the maximum measurement is up to 5 times the conical section height above the apex of the cone. For higher tanks the non-linearity introduced by the conical section becomes insignificant, and a LINEAR profile should be used.

D12.3 SPECIAL – If the curve profile labelled SPECIAL is chosen, access is allowed to parameters P30-P39 to draw the unique profile for this site, tank or flume, according to data available. The microprocessor in the transmitter then interpolates between these ten points to give an accurate curve fit for the PV output.

The standard procedure for using the SPECIAL profile is shown in Fig D.V, with some examples. It is necessary to have either tabulated or graphical data to relate the required process value to the liquid height, to derive the required profile points.

Technical Notes: The origin (0,0) of the graph of PV versus height is used in the interpolation as the start point.

Profile Point 10 occurs at the height used as the maximum level, normally the top of the displacer unless re-positioned by P17. It is possible that the PV value corresponding to this height is less than 100% of Parameter 13. This means that for ease of calculations of percentages, P13 can be selected as any value above the maximum required to be monitored.

SPECIAL PROFILE Parameters P30-39

For a non-linear relationship between PV and Liquid Level, Parameters 30 to 39 set out the 10 point graph relating the two functions. When Parameter 11 is used to select a pre programmed function – e.g. contents of a cylindrical horizontally mounted tank – CYLINDRICAL) Parameters 30-39 are automatically allocated values recalled from the memory of the Psion Organiser SMART Datapak. These values cannot be changed by accessing Parameters 30-39 – they are effectively “Read Only” parameters. This is useful in that the curve used is defined and shown. (Beware that if LINEAR is selected on P11 the Parameters P30-39 retain their previous values – the LINEAR profile ignores P30-39). Any attempt to write new values to these parameters will receive the screen response.

```
PROFILE POINTS
PROTECTED BY P11
```

When Parameter 11 is set to the “SPECIAL” non-linear profile, access is allowed for the operator to write values into P30-P39, as described in Figure 9, to construct a special profile relating PV to height. Both of these are expressed as percentages of the maximum or “full” value in Parameters 30 to 39.

The profile points are scrolled on the same screen, to allow previous points to be monitored. For example, the display showing Point 4, Parameter 33, is as follows, where the arrow indicates the value which is to be adjusted:

```
PROFILE POINT 4 P33
30% LEVEL @ 25.2%
40% LEVEL @ 37.3% ↵
50% LEVEL @ 50.0%
```

The initial screen shown for Parameter 30 reminds the operator that the Liquid Level is expressed as a percentage of the P14 value, and the PV corresponding to this level is expressed as a percentage of P13.

```
PROFILE POINT 1 P30
↵ % LEVEL for PV(%P13)
10% LEVEL @ 10.0% ↵
20% LEVEL @ 20.0%
```

Default values	LINEAR Profile
Maximum values	100%
Minimum values	0%

Special profile relationship between process value and liquid height

Example :

P36 is a Profile Point 7. Find X co-ordinate that represents 70% of the max height (P17-P18). On graph obtain Y co-ordinate and express as percentage of max value (P13). Enter this percentage as P36.

Fig. D. V.

HAND HELD COMMUNICATOR REGISTERS

D13.0 SAFE, WORKING, OFFLINE, DEFAULT, Registers

Introduction to Registers

From the FUNCTION screen, whilst interrogating an transmitter, there is a selection titled "BACKUP". This allows the data now stored in the WORKING register (i.e. the transmitter data) to be transferred to a separate secure memory, to either retain it while making changes to the transmitter (i.e. as a "revert to the original program" insurance data store) or to save it in memory so that it can be copied or consulted back in the office. The registers available are shown in Fig DVI, and are listed as:

WORKING REGISTER

This is literally the work sheet where all work is done – all changes made to the parameters on the SMART Communicator keyboard are made to the data in the WORKING Register. While the Communicator is attached across the 4-20mA loop, the WORKING register is exactly the same as the transmitter memory, so all changes made to the WORKING register are also made to the transmitter itself. The transmitter memory and the WORKING register in the SMART Communicator are identical. If communication between the two units fails, then changes attempted in the WORKING register will be rejected.

Note : The SMART Communicator can be unaware of changes to the transmitter memory made by (a) a Primary Master (such as H-View) also attached to this transmitter loop, and (b) the local zero and span on the DT Series.

The data existing in the WORKING register is overwritten (and therefore lost) when new data is loaded from another register, or when the SMART communicator is reconnected to an DT Series loop, because the start up routine will load this new memory into the WORKING register. To save any data that has been entered in an "Off-loop" state (i.e. back in the office) the data must be held in the OFFLINE register (see below).

It is recommended that the data in the WORKING register is transferred OFFLINE before disconnection of the SMART communicator from the loop, if it is likely to be needed for reference back in the office. However, the data in the WORKING register is retained in the Psion memory after this disconnection, and can still be interrogated until overwritten by new data.

SAFE REGISTER

The SAFE Register is literally a register where the current calibration data can be stored and kept SAFE, while changes are made on the WORKING register and the SMART Communicator is attached to the loop. If these WORKING register changes then prove ineffective or not required, the SAFE register data can be recalled into the WORKING register (and therefore to the transmitter) to reset all the parameters to their original values – i.e. the values in the transmitter when the last "Backup" operation transferring the data to the SAFE register was carried out. The data in the SAFE register can only be loaded into the WORKING REGISTER when the communicator is attached to the same transmitter that was the source of the data – i.e. the transmitter with the same unique identifier (D08). It is not possible to transfer programmes between instruments using the SAFE register.

The SAFE register is retained even when the Communicator is disconnected from the loop, powered down, and then reconnected to another loop, collecting new data in the WORKING register. It is not accessible until the correct transmitter loop is interrogated, so that the check on the D08 Unique Identifier has been satisfied.

OFF-LINE REGISTER

This is the register used for transfer of programmes between one unit and the next, or from a programme developed on the SMART Communicator at the office desk, stored OFF-LINE and then down loaded into an transmitter on the plant later. Such data transfer is achieved by connecting the SMART Communicator across the relevant loop, loading the WORKING register with the current program (see below) then transferring the OFF-LINE stored data into the WORKING register – this overwrites the previous programme in (both the transmitter memory and the WORKING Register).

An obvious precaution in the above procedure after loading the WORKING register with the current transmitter data, is to transfer this data to the SAFE register in case the OFF-LINE sorted new programme does not give the expected result – if necessary the DT Series can be restored to its original programme status by transferring the SAFE register data to the WORKING register.

The OFF-LINE register is retained when the communicator is disconnected from the loop or powered down. It is only wiped when a new set of data is transferred to the OFF-LINE register from the WORKING register.

Only one set of parameters can be stored in the OFF-LINE register at once.

MEMORY LOCATIONS IN SMART COMMUNICATOR

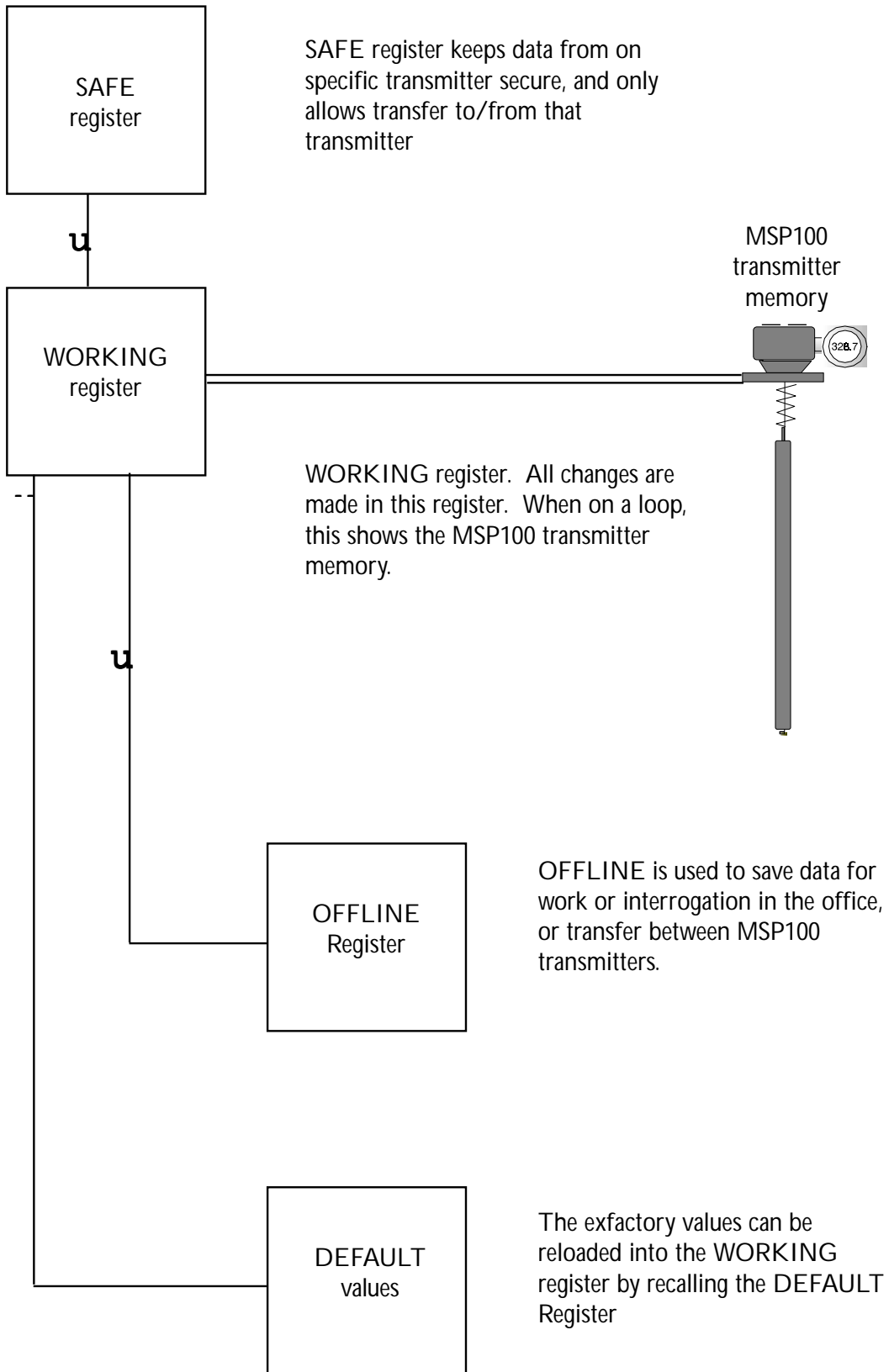


Fig. DVI :

DEFAULT REGISTER

This is the register of all the normal ex factory settings for the Transmitter. It is a useful start or reference point for programming any transmitter, since the values set in each parameter are known and only those that need reprogramming have to be amended. The DEFAULT values can also be used to reset any transmitter to ex factory status, therefore wiping any other programme amendments made previously.

D13.2 Manipulation and Transfers between registers

a) Offline operation

The screens showing the Transfer functions of data between registers provide step by step instruction for achieving such data transfer (See Figure D.VII). There are also facilities for allowing the normal interface between the Psion Organiser and a printer or personal computer to provide output of the programme data.

The options presented on the LCD are amended when the SMART Communicator senses that a loop is not present or the Interface unit is not plugged into the Psion. In such cases OFF-LINE operation is offered or selected automatically (See Figure D.VII). After changes to the PROGRAM screens which modify data in the WORKING Register, these changes must be saved in the OFF-LINE Register or to a Data File using the TRANSFER function.

b) Loop transfers

The BACK-UP selection on the main FUNCTION menu allows manipulation of the data held in the various registers shown in Figure D.VI. Since all transfers are to or from the WORKING Register, the initial screen

```
SELECT DATA SOURCE
Safe      Off Line
Working   Defaults
File
```

Immediately transfers data to the WORKING Register if SAFE or OFFLINE are selected. If the source is a Data File then a location and a File name are prompted for and the data is transferred to the OFFLINE Register followed by a transfer from OFFLINE to WORKING. This final transfer can be prevented by pressing "N" when asked to accept that the output may be changed. If the data source is the WORKING Register, the screen prompts for a full upload if any parameters have not yet been read then asks for a destination decision.

```
SELECT DATA
DESTINATION
Safe      Off-line
File
```

To know where to place the data. Transfer to a Data File will prompt for a location and a file name. The location is either the internal memory at A or a Data or Rampak in the upper side slot which is B. The filename can be up to 8 characters long. In this case the WORKING Register remains unchanged after the data transfer.

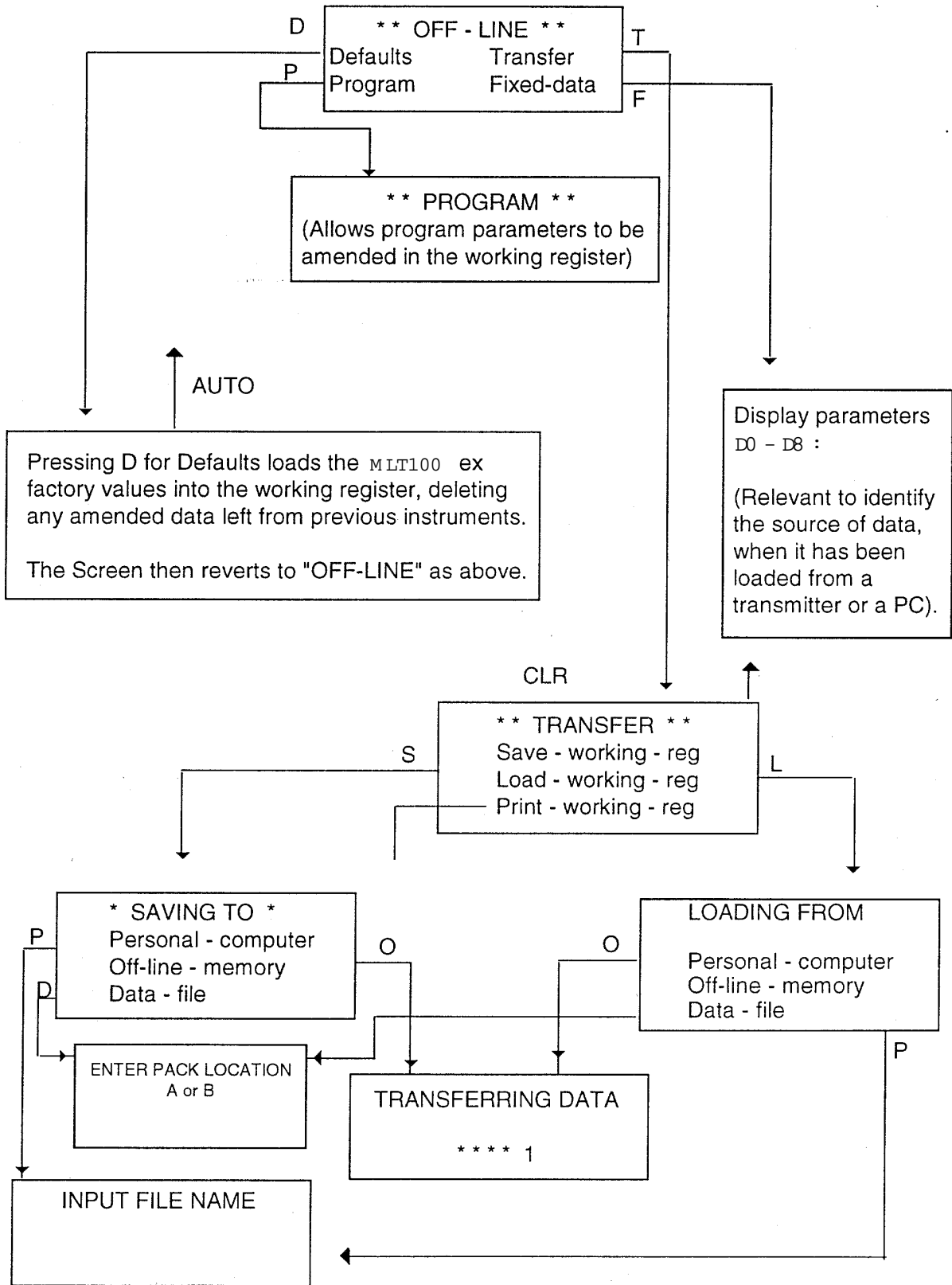
Please note that Parameters in the range P44 to P69 are not transferred to the WORKING Register in any BACK-UP data transfer. These parameters are left as set up by the Service Engineer for that particular transmitter.

D.13.3 Printout or PC transfer of programme data

When used "Off-Line" the Hand Held Communicator can be instructed to transfer the programme memory into a PC or print a list of the parameters and the values in the working register on a paper printer. This is achieved using the Standard Psion COMMS LINK routines and interfaces.

To send or receive data from a PC the COMMS LINK must be plugged in and connected to the PC port and the CL program must be running on the PC. See the COMMS LINK manual for further details.

OFF-LINE MEMORY TRANSFERS



The Psion will set itself up for transfer to or from a PC when this option is selected.

The file name is any valid MS DOS file name including path names and extensions. The PSION/HART program restricts the length of the input to 17 characters.

The actual transfer to a PC is a complete list of parameter numbers (P0-P69 and D0-D8), of the memory values in the WORKING register. Certain parameters have numeric codes to identify the option (normally chosen in text, such as LINEAR or HOLD). Do not modify this data while it is in the PC file.

To printout the parameter list the COMMS LINK must first be set up to match the requirements of the attached printer with regards to the Baud Rate, start bits, stop bits and protocol. To test the printer and get the desired settings, use the AUTO function in the SETUP menu, and experiment with the HAND settings, try XON + DTR first.

The printout includes the parameter number, title and value of all the valid parameters in the range P0 and P69 and D0 to D8. Where necessary the value will be related text instead of the value in the data file, e.g. "HOLD" instead of 2.

D.13.4 Display of Parameter Data

The four different registers relate only to the \Programmed Parameters in the memory. When interrogating an transmitter, a typical parameter display would show:

STANDING VALUE	P14
**** **	W
VALUE OF PV	
AT ZERO LEVEL	

The W shown on the second line right hand end indicates that this displayed value is the value present in the WORKING register. This can be compared with the SAFE, OFFLINE or DEFAULT equivalent values by pressing the "MODE" button, which cycles through these registers. The data displayed is labelled with the initial letter of the register selected. This is useful for comparing transmitters (between W and O) or noting changes on this transmitter (Between W and S). A transfer of this single parameter can be made into the WORKING register by pressing "EXE" when the desired alternative register value is shown on the LCD – the display will show the letter changing to W to acknowledge the transfer.

D.14.0 ERROR MESSAGES ON THE HHC

D.14.1 Alarm and Error Messages

Throughout the programming of the Transmitter using the SMART Communicator, any failure of a communication message or other problem in the SMART interface will be advised with a message on the Liquid Crystal Display. Certain error messages prompt for an operator input or decision, for example, whether the procedure should be repeated. These need simple "Yes" or "No" responses. Other errors, for example, "No response from transmitter" when programme parameters are being changed, will produce a reset of the parameter value back to the original value in the WORKING Register.

In the first interrogation of the transmitter, each asterisk shown on the LCD represents a message, which can contain up to 10 parameters. In the event of a failure of this communication, the option of a retry or move to the next set of parameters is offered. It is always preferred to use "Retry" to collect a full set of data. (See Section D7.0)..

Transmitter Status Messages

Further operational alarm/error messages are shown on the LCD when any display parameter is selected. When either Readings or Diagnostic parameters (D10-D36) are shown, the SMART Communicator is interrogating the transmitter every 0.5 seconds, and the information returned includes various message signals concerning the current status of the returned echo. These messages are displayed on the LCD line 2 for two seconds when the condition is first detected, instead of the Display parameter value. After this display period the condition message is abbreviated to a two letter code shown on the right hand side of the LCD, as long as the condition persists. These status messages are updated every 10 seconds. Only one status message is displayed at a time, in a priority order, as listed below, to see all the alarms present use D15.

CURRENT SATURATED (CS)

The echo currently monitored is from a process value outside the pre-programmed 4-20mA range, so the current is either at 4mA or 20mA and is possibly not valid.

TEMPERATURE LIMIT (TL)

This indicates that the process temperature or a combination of the process and ambient temperatures have resulted in the electronics becoming too hot or too cold. Using the HHC, check P46 and P47 to see the maximum and minimum temperatures recorded. If the electronics has recorded a temperature above 85°C then the electronics may have been permanently damaged. The DT Series should be returned to your local agent for repair or replacement.

SENSOR OUTPUT HIGH (SH)

This means that the core has travelled too high in the pressure tube and that the LVDT output is therefore too high. Check that the displacer element is the correct element for this Transmitter. Carry out a bench calibration to check that the LVDT is in the correct position. If the message only appears when there is liquid in the vessel, check that the liquid SG is as expected and not too high.

SENSOR OUTPUT LOW (SL)

This means that the core is too low in the pressure tube and that the LVDT output is therefore too low. Check that the displacer element is the correct element for this Transmitter. Carry out a bench calibration to check that the LVDT is in the correct position. If the message only appears when there is liquid in the vessel, check that the liquid SG is as expected and not too low.

There are also various microprocessor fault messages which should be shown on the LCD, indicating significant problems with the sensor microprocessor. For all these error conditions reference should be made to the factory, and it will probably be necessary to return the unit for repair. The messages and codes are:

ROM CHECKSUM	RC
EEPROM SIGNATURE	ES
EEPROM CHECKSUM	EC
RAM TEST	RT
ADC REFERENCE HIGH	AH
ADC REFERENCE LOW	AL

When an Unknown instrument is being interrogated, a universal set of error messages is used:

DEVICE MALFUNCTION	DV
PV OUT OF LIMITS	PL
NON PV OUT OF LIMITS	NL
CURRENT SATURATED	CS

14.2 Invalid Data Entry

When the Operator tries to enter a command or parameter value which is invalid, the message on the screen will indicate this. Typical messages occur as follows:

“INVALID INPUT” (Rejected by the Psion Organiser)
 “INVALID DATA” (Rejected by the transmitter)

- Parameter value entered is outside the limits allowed for that parameter, or resetting of this parameter is not allowed as per the data entered.

“IN WRITE PROTECT MODE”

- The Password is “Closed” or does not allow access to this parameter.

“INVALID PARAMETER NUMBER”

- Parameter number entered is not know by DT Series.

“PASSWORD NOT OPEN”

- If the Password in the transmitter memory *see in the WORKING Register of the SMART Communicator) is set “CLOSED”, then it will not be possible to load data from the SAFE or OFFLINE register. The Password protects the data in the DT Series.

“INVALID ACTION NOT THE SAME INSTRUMENT”

- If an attempt is made to transfer SAFE register data to the WORKING register of an transmitter which is not the origin of the SAFE register data, this will not be allowed. The message indicates that D08 on the currently connected loop is not the same as the D08 in the SAFE register.

“PROFILE POINTS PROTECTED BY P11”

- The Special Curve Profile Parameters P30-P39 can only be adjusted when the “Special” Curve is selected on P11. Any other curve selected on P11 will define P30-P39. If P11 has selected “LINEAR” then Parameters P30-P39 are ignored and their values are irrelevant.

“INSTRUMENT IN MULTIDROP MODE”

- The current output control circuitry in the transmitter is only active when the DT Series is operating on a 4-20mA loop. In a multidrop configuration the current is set to 4mA, and trimming and current set commands are inoperative.

14.3 Communication Errors

Communications between the transmitter and the SMART interface/Psion organiser are subject to error checking and acknowledgement signals according to the HART protocol. This means that only valid messages are accepted, and if the message is invalid then it will be rejected.

The screen of the LCD will indicate if a message has not been received correctly. This is perhaps most likely to be seen when the Display parameters are being used, since these are updated with a new value in a message every 0.5 seconds. If the message is received incorrectly, the second and third lines of the display will show one of the following messages:

```
VERTICAL PARITY ERROR IN REPLY
OVERRUN ERROR IN REPLY
FRAMING ERROR IN REPLY
LONGITUDINAL PARITY ERROR IN REPLY
BUFFER OVERFLOW IN REPLY
```

Which describe the cause of the fault.

There is an identical group of errors in the outgoing message:

```
VERT PARITY ERROR IN OUTGOING MESSAGE
OVERRUN ERROR IN OUTGOING MESSAGE
FRAMING ERROR IN OUTGOING MESSAGE
LONGDNL PARITY ERROR IN OUTGOING MESSAGE
BUFFER OVERFLOW IN OUTGOING MESSAGE
```

If this occurs frequently, it is appropriate to check the electrical connections to the instrument loop, the presence of the SMART load resistor and that the SMART Communicator is attached at the correct position in the loop.

The "IN OUTGOING MESSAGE" group of error messages if displayed while accessing the Programme Parameters implies that the message from the SMART Communicator was not received correctly by the DT Series. Therefore the instructions in the message would have been rejected, and the Parameters remain unchanged at their previous value. This previous value will be shown on the LCD screen on the SMART Communicator after the error message, to prompt the operator to repeat the last parameter value amendment. During a Register transfer this message will automatically cause the Communicator to hold transmission, and suggest a retry because of the error.

The "IN REPLY" group of error messages if displayed when programming the instrument, signals a more significant communications failure. This indicates that the acknowledgement of the change instruction sent to the DT Series was incorrect. It is not known whether the |Parameter value in the DT Series was changed or not. The SMART Communicator assumes that it was not changed, and reverts to the original (pre change) value : this prompts the operator to re-enter the required new value. It is important that the Parameter is re-entered, to ensure that the Working register memory in both the Psion and the DT Series contain the same data.

If either of the above two Outgoing or Reply Comms Error messages occurs in a Backup menu transfer between registers, it is advisable to repeat the Backup operation to complete the data transfer, or check that the memory has been transferred correctly.

The message "NO RESPONSE FROM TRANSMITTER! Indicates a failure of the power on the loop or a failure of the connection of the SMART interface across the loop or the address of the instrument has been changed. Connection should be re-established if possible.

The message "LOCKED OUT BY BUS ACTIVITY" indicates there are either two secondary masters on the bus or a primary master is continuously trying to access an instrument that does not exist.

The message "INCOMPLETE REPLY" indicates that a start of a message was detected but the message was not completed in the time allowed. This is most likely to be due to a power failure or a loss of connection.

D.15.0 Current Loop Checks and Trimming

Introduction

The 4-20mA transmitter has no customer or service engineering adjustable potentiometers on the printed circuit boards. All current trimming of the 4mA and 20mA set points is achieved via the SMART communicator. Because this is a "live" interaction, the access to this function is via the MONITOR functions and screen on the Communicator.

Select "Current – Output" and the screen displayed is

```
** CURRENT OUTPUT **  
Set current  
Trim-maximum  
Trim-maximum
```

These three functions are as follows:

D.15.1 Set current

This selection is used for transmitters attached to a single 4-20mA loop to check for correct functioning of all the equipment – the communications and the other loop indicators and outputs.

By selecting the "Set-current" option the screen prompts the operator to choose a current value for the loop, for example 12mA.

```
ENTER NEW VALUE  
12-
```

On pressing "EXE", the current in the loop is set to this value, and the loop indicators and trips can be checked for function and calibration. The LCD screen changes to suggest selection of a new value if necessary. To abort the procedure press ON/CLEAR

```
CURRENT OUTPUT =  
12 mA  
ENTER NEW VALUE  
-
```

Some specific error messages are used to prevent the loop current being set outside the valid 4-20mA limits.

D15.2 Trim Current

If the procedure shown above suggests that there is a calibration difference between the output and other current monitoring equipment on the loop, it will be necessary to use a calibrated meter to establish which unit is in error. Using the "Set current" routine of Section 3.4.2. the DT Series can be instructed to provide outputs between 4 and 20mA that the DT Series considers correct. If these are in error, the "Trim current" routine is used as follows:

The "Trim current" selection sets the current output of the DT Series either at maximum (supposed to be 20mA) or minimum (supposed to be 4mA) depending on the option selected. For maximum the display shows:

CURRENT OUTPUT IS
NOW 20mA. MEASURE
CURRENT AND USE - & -
TO TRIM THE OUTPUT

Follow the instructions and if the current output is in error, i.e. not 20mA, use the – and – arrows as trimming signals to adjust the value to be exactly 20mA. Each press of the arrow causes an audible signal and adjusts the output value by a discrete step. (approx 6mA)

This process should then be repeated for the 4mA setting. Once the current output is seen to be correct the ON/CLEAR key is used to escape.

Mode Cancelled Warning

If while trimming or fixing the current the analog output returns to its normal mode the message FIXED CURRENT MODE CANCELLED will be displayed. This could occur for three reasons, master has sent the appropriate command, the DT Series has been powered off then on again, or the output in fixed current mode has been at the same value for 20 minutes.

D16.0 Multidrop or Bus Operation

16.1 Introduction

The Level transmitter, when supplied from the factory with standard ex-factory programming, is suitable for operation on a single instrument loop – i.e. it is configured to set the current in such a 4-20mA loop to the value dictated by the liquid level measured.

Part of the HART capability and conformance is that the same sensor is able to be configured for operation on a multi-sensor loop – this is variously referred to as “Multi-drop” or “Bus” operation. To function in this manner the transmitter draws 4mA only, and is connected in parallel with various other similar sensors. Each transmitter on the Bus is given a unique address, between 1 and 15, and in its simplest form a digital communications system is used on the single loop to collect data from each address. The DT Series is able to be configured in this way, and so provides the capability of upgrading to digital signalling on one Multi-drop loop when this is eventually installed on the plant.

16.2 Simple Addresses

The simple addresses available for transmitters are 0-15. All standard ex-factory simple addresses are set to zero (unless special programming has been requested).

Address 0 – is used for any DT Series transmitter providing control of a 4-20mA loop proportional to PV

Addresses 1-15 – are used for DT Series or any other HART transmitter on a Multi-drop/multi-sensor loop. Each transmitter (or sensor) draws a fixed 4mA from the power supply on the loop, and responds to digital interrogations labelled for the specific address.

16.3 Extended Addressing

The Extended Addressing facility of the HART Revision 5.1 Protocol is available with the DT Series. This makes access to instruments on a Multi-drop loop slightly simpler, since the specific instrument can be identified by Tag Number or Unique Identifier codes.

The Tag Number is that coding entered on the programme parameter P1. This has the standard ex-factory value DT Series, unless the purchase order has specifically identified a different Tag.

The Unique Identifier is a set of three code numbers specified by the HART protocol, to identify the equipment manufacturer (by code), the instrument type (by code), and the serial number (as on the label on the transmitter).

The manufacturer's code number in the HART protocol is 59. DT Series Type No. is 41. (MSP100 is 21, Pressure Transmitter is 19). The sensor serial number is loaded into the memory as parameter D08, the device ID number. This is also written on the transmitter label.

16.4 Access to a Multi-drop/Bus Transmitter

The SMART communicator is attached across the two wires which provide the power for all the transmitters, in the same way as for a single transmitter loop. The load resistance between the communicator and the power supply is still essential. The current drawn by each sensor is 4mA, with all transmitters in parallel, so the total current can be calculated. Obviously with the 15 transmitters attached, the load resistor of 250 ohms will create a voltage drop of 15V, so the power supply would have to provide 27V minimum. With intrinsically safe barriers and Cenelec approved systems, a maximum of 4 transmitters are expected to be allowed on the hazardous side of any barrier. (See Approval Documentation).

When the DT Series selection is made from the Main Psion menu, the initial loop interrogation seeks a standard 4-20mA single loop transmitter. The screen shows the message –

NO SINGLE LOOP
INSTRUMENT CONNECTED

RETRY (Y)es or (N)o

The search must now be made for a Multi-drop instrument. Press N for No, and the option for OFFLINE programming suggested. This is rejected by pressing N and then MULTI-DROP PROGRAMMING is offered, which is accepted.

```
**** MULTIDROP ****  
Simple-addressing  
Extended-addressing
```

Here the option between SIMPLE and EXTENDED addressing is chosen. If SIMPLE addressing is chosen
SIMPLE ADDRESSING

```
** SIMPLE ADDRESS **  
Select  
Poll  
Change
```

Three routes are now offered. If the transmitter address (1-15) is known, it can be accessed using the SELECT option, which will then advise that is found at that address.

```
ENTER ADDRESS  
MLT100 FOUND  
TAG TANK 4  
ACCESS( Y)es or (N)o
```

On accessing the transmitter data the first screen will give the tag number (P01) and description (P02) to confirm the transmitter interrogated.

```
MLT100  
TAG TANK 4  
MLT100 XDUCER  
ACCEPT (Y)es or (N)o
```

If the transmitter addresses are unknown, each address (1-15) can be interrogated in turn by selecting the POLL function. This will identify all the equipment located on the Bus.

The CHANGE function is the only function that allows the system to interface between addresses 1-15 and address 0. The screens prompt entry of address numbers – an example would be

```
ENTER OLD ADDRESS  
1  
ENTER NEW ADDRESS  
0
```

Here the Multi-drop/Bus system transmitter address 1 is having its address amended to 0 – i.e. it is being changed back to a single loop 4-20mA transmitter function. On pressing EXE the change is requested confirmed –

```
CHANGING ADDRESS 1  
TO ADDRESS 0  
ACCEPT (Y)es or (N)o
```

EXTENDED ADDRESSING

The alternative of EXTENDED addressing has two selections

```
* EXTENDED ADDRESS *  
Tag-number  
Identifier
```

The Tag Number can therefore be used directly, or alternatively the Identifier option can be selected to recall equipment, type and sensor serial number

```
INSTRUMENT TYPE NO  
2  
SERIAL NUMBER  
1102
```

D.16.5 Initial Multi-drop loop creation

This requires care and logic to avoid confusion. In most cases the equipment supplied will be loaded with the ex-factory standard parameters, which will all have the simple address 0. (Special factory programming of the transmitter may have set up a different address for each transmitter, but this will be the exception). Since all units with address 0 are 4-20mA transducers, installation immediately on a Multi-transmitter single power supply loop might cause excessive current drain on the loop. A separate problem is that each sensor will require individual connection to a loop so that it is the only one having address 0, to allow the SMART Communicator to change this to the desired address between 1-15.

It is therefore recommended that each transmitter is set up in the workshop on a simple loop, and that the initial address is amended, taking note of the unique transmitter number (on the label outside the transmitter but also recorded on D08). Then when the transmitters are installed on the plant, this same transmitter number (read from the label) can be recorded against the tank description or tag number, so allowing the correct calibration of the transmitter for this tank (later from the control room).

In order not to confuse the "average" operator, MULTI-DROP addressing is not mentioned on interrogating a simple 4-20mA level transmitter. To access the MULTI-DROP menus it is necessary to reject the instrument found at address 0.

Then Press Y, EXE, to reach the Simple Address Screen

```
** SIMPLE ADDRESS **  
Select  
Poll  
Change
```

D.17.0 Unknown Instrument

This limited support for unknown transmitter is provided so that the identification and basic performance of any transmitter can be obtained without having to change to another HHC. This is of particular use in multi-drop networks where all the currently occupied addresses need to be identified when selecting an address for an additional transmitter on the loop.

If the transmitter detected is not an DT Series or MSP100 then Unknown Transmitter is displayed and an access to the parameters is prompted for. If this is selected then the parameters that are present on all transmitters are uploaded, after first setting up any files that are required.

Because the transmitter is Unknown some parameters can only be read.

A single menu allows access to all the available parameters.

```
UNKNOWN INSTRUMENT
Identity Fixed _data
Monitor Output
Sensor_info
```

D.17.1 The following three groups of parameters have the same meaning as those for an DT Series.

IDENTITY	P0 to P5
FIXED DATA	D0 to D8
MONITOR	D10 to D15

D.17.2 The last two groups provide a subset of instrument's calibration data :-

OUTPUT	P10 to P16
P10 Alarm Code	This shows whether the current will go to maximum if the sensor fails in the instrument.
P11 Transfer	This can be used to apply a non-linear relationship between the measured value and the digital and analog outputs.
P12 Range Units	The units used on the next two parameters.
P13 Calibration Max	The Primary Variable value for 20mA output.
P14 Calibration Min	The Primary Variable value for 4mA output.
P15 Damping	The smoothing to be applied to the digital and analog outputs.
P16 Write Protect Code	The state of any parameter write protection.
SENSOR INFO P20 to P23	
P20 Limit/Span Units	The units used for the next three parameters
P21 Upper Limit	The maximum value the sensor will measure.
P22 Lower Limit	The minimum value the sensor will measure.
P23 Minimum Span	The smallest allowable difference between calibration max (P13) and calibration min (P14).

If the instrument conforms to revision 5 or higher of the HART protocol then the manufacturer of the instrument will be available. If it is of an earlier revision then only the model number will be available.

D18.0 SMART Interfaces – Compatibility

D18.1 Introduction

The SMART Level Measurement Transmitter uses the HART digital communications protocol. This was originally developed by Rosemount Inc. in USA, and uses Bell 202 Frequency Shift Key signalling on top of a 2 wire DC loop supply. The system conforms to Revision 5.1 of the HART protocol.

Various other manufacturers use this same HART protocol and produce sensor equipment that can be attached to 4-20mA or digital loops. Similarly there are other hand held communicators that use the HART protocol to interrogate transmitters in such loops. Not all manufacturers' equipment conforms to the Revision 5.3 of the protocol.

At present the major SMART communicators working to a HART protocol are

CK1 and –CK2
HART Communicator Model 275 manufactured by Rosemount
Rosemount Model 268
Measurement Technology MTL 611 and CNF 41
H-View

This is a rapidly developing field, and the specification of these units is continually being updated. Each updating produces better interoperability and user friendly operation. However, even equipment conforming to the same Revision of the protocol from different manufacturers cannot be regarded as compatible, because each sensor has a unique programme structure.

D18.2 Communicators recognising transmitters

As at May 1992 only the Arcom System HLINE and the CK1 or CK2 SMART Communications kits recognise and can fully interrogate the transmitters.

Other HART protocol Revision 5 communicators can talk to the transmitter but only register this on their display as an "Unknown Instrument" (DD available mid 98 which will allow 275 to be used).

D18.3 Transmitters recognised by the SMART Communicators

The CK1 and –CK2 SMART Communicators can identify and interrogate all variants of the DT Series and MSP100 ultrasonic level transmitters.

If a SMART Communicator is connected to a loop with another type of transmitter, for example the Rosemount 1151 pressure transmitter, it will record the presence of an "Unknown instrument". Various parameters can be read (see Section D17.0) and a limited set of common parameters can be changed.

D18.4 Use of multiple SMART Communicators

The HART SMART protocol allows only two SMART digital communicators to be active on the same loop at once. Only one of these can be a hand held communicator (known as "Secondary Master") such as the CK1 or the Rosemount 275 : the second must be a permanent monitoring system such as H-View (which is designated as a "Primary Master").

If two hand held communicators are connected to the same loop at the same time and both try to communicate at once there will be a conflict in the messages and neither unit will function correctly.

Block Diagram / Flowchart

Fig. E1 below shows the processing of the data within the transmitter. The transmitter is set up by P parameters and, as the data is processed, diagnostic information is produced which is available as D parameters. These parameters are identified alongside the diagram.

