Hydrosteel 6500

Instrument User Manual V1.0



Pioneering Gas Sensing Technology.

ionscience.com

Register your instrument online for extended warranty

Thank you for purchasing your ION Science instrument.

The standard warranty of your Hydrosteel 6500 is for one year.

To receive your extended warranty, you must register your instrument online within one month of purchase (terms and conditions apply.)

Visit www.ionscience.com

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Declaration of Conformity

The EU Authorised Representative of the manufacturer Ion Science limited has sole responsibility, on the date this product accompanied by this declaration is placed on the market, the product conforms to all technical and regulatory requirements of the listed directives

Authorised Representative:	ISM Deutschland GmbH · Laubach 30 · D-40822 Mettmann, Germany
Product:	Hydrosteel 6500
Product description:	Hydrogen Flux corrosion monitor
Directive:	ATEX Directive (2014/34/EU) EMC Directive (2014/30/EU)
Type of protection	
(single and 4 port instruments):	 II 1 G Ex ia IIC T4 Ga
(single port instruments):	 I 1M Ex ia I Ma
Temperature range	
Single port no valves.	Normal (-40^{0}C ≤ Ta ≤ +60^{0}C) Charging (-40^{0}C ≤ Ta ≤ +45^{0}C)
Four port with valves	Normal (-20^{0}C ≤ Ta ≤ +60^{0}C) Charging (-20^{0}C ≤ Ta ≤ +45^{0}C)
Certificate Number:	SGS19ATEX0060X IECEx BAS 19.0049X
Notified body:	SGS Fimko 0598
Standards:	
EN 60079-0:2018	Electrical apparatus for explosive gas atmospheres. General requirements
EN 60079-11:2012	Explosive atmospheres. Equipment protection by intrinsic safety “I”
EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use – EMC requirements. Group 1, Class B equipment – (emissions section only)
EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements Basic Environment - (immunity section only)
EN 55011:2009 (+A1)	Electrical equipment for measurement, control and laboratory use – EMC requirements. Industrial location immunity – (immunity section only)
EN 61000-3-2:2014	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <=16A per phase)
EN 61000-3-3:2013	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <16A per phase and not subject to conditional connection
EN ISO/IEC 9001:2015	Quality Management System – Requirements
EN ISO/IEC 80079-34 :2011	Potentially Explosive Atmospheres – Application of Quality Systems

Name: Clemens A. Verley **Position:** Chief Executive Officer

Signature:  **Date:** 19/01/2021

Statements

Responsibility for Use

Hydrosteel 6500 flux monitor provides flux readings that are subject to interpretation. Ion Science Ltd can accept no responsibility for the incorrect use that may causes harm or damage to persons or property. Inadequate performance of the gas detection equipment described in this manual may not necessarily be evident and consequently equipment must be regularly inspected and maintained. Ion Science recommends that personnel responsible for equipment use to institute a regime of regular checks to ensure it performs within calibration limits and that a record be maintained which logs calibration check data. The equipment should be used in accordance with this manual, and in compliance with local safety standards.

- The user should contact the manufacturer before using the Hydrosteel in unusual Environments.
- The user should contact the manufacturer before using the Hydrosteel in close proximity to aggressive substances.

Warnings

1. "X" on the label refers to:
   1.1 The quick fit tube connectors used on the front face of the instrument.
   The tube connector ringed bezels are made of aluminium and must be protected from potentially incendive impact or abrasion.
   1.2 The USB connector and USB flying cap on the front face of the instrument.
   Both the USB connector and USB flying cap have an aluminium body and must be protected from potentially incendive impact or abrasion. The captive end stud of the cap is stainless steel.
   Date: April 2019

2. The old aluminium probe handles must not be used for the 6500 Instrument, only use stainless steel probe handles.

3. Please read and understand this User Manual fully before installing, operating or servicing the Hydrosteel 6500.

4. Ensure you are in a non-hazardous area before carrying out any type of maintenance on the Hydrosteel 6500 instrument.

5. For ambient charging up to 60 °C the batteries may be recharged at 100 mA in an intrinsic safe area or a non-hazardous area using the following specified source:
   Pepperl &Fuchs KFD0-SD2-Ex1.10100 and Ion Science 10 V voltage limiter P/N:6500133.
   Hydrosteel entry requirements: U_i = 10 V I_i = 271 mA P_i = 1.152 W C_i = 0 µF L_i = 0 µH.
   Maximum permitted cable parameters for interconnecting cable (Group IIC) C_c = 3 µF L_c = 484 µH or L_c / R_c = 33 µH / Ω

6. Batteries recharged in a non-hazardous area must be at ambient temperature not exceeding 45 °C.
   Use ISL supplied 230 Vac mains power supply delivering 10 V and 0.5 A for maximum charging rate

7. Substitution of components may impair intrinsic safety and result in unsafe conditions.

8. For safety reasons, the Hydrosteel must only be operated and serviced by qualified personnel.

9. Refer to the certificate for clarification of any aspects of intrinsic safety or contact Ion Science Ltd or your local Ion Science Ltd representative.

Label Parameters

Four Gas Ported Instrument

Hydrosteel 6500

Four ported instrument



Charging Port
(Non-hazardous area)

Upper ambient reduced to +45 °C during charging

U_m: 253 V rms

Charging Port
(Hazardous area)

Intrinsically safe parameters for fixed installations, derived from specified source:
P&F KFD0-SD2-Ex1.10100 and 10V Voltage Limiter
P/N: 6500133

(-20 °C ≤ Ta ≤ +60 °C)

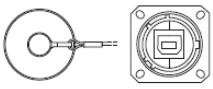
U_i : 10 V
I_i : 271 mA
P_i : 1.152 W
C_i : 0
L_i : 0

Maximum permitted cable parameters for interconnecting cable (Group IIC)

C_c : 3 µF
L_c :484 µF or
L_c/R_c : 39 µH/Ω

Hydrosteel 6500

Four ported instrument



USB Port Details

(Non Hazardous Area)

U_m: 253 V rms

(Hazardous Area)

Intrinsic Safety Parameters
(Group IIC)

U_i : 253 V rms	U_o : 5.1 V
I_i : 2 A	I_o : 0.306 A
	P_o : 0.45 W
C_i : 0 µF	C_o : 88 µF
L_i : 120 nH	L_o : 379 µH

Patents include:

US 6637253
UK 2358060
EP 1114992
UK 2538113

Manufactured Date:

Serial No.

Ⓔ II 1 G Ex ia IIC T4 Ga

(-20 °C ≤ Ta ≤ +60 °C)

SGS19ATEX0060X
IECEx BAS19.0049X

CE 0598

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Single Gas Ported Instrument

Hydrosteel 6500

Single ported instrument



Charging Port
(Non-hazardous area)

Upper ambient reduced to +45 °C during charging

U_m: 253 V rms

Charging Port
(Hazardous area)

Intrinsically safe parameters for fixed installations, derived from specified source:
P&F KFD0-SD2-Ex1.10100 and 10V Voltage Limiter
P/N: 6500133

(-40 °C ≤ Ta ≤ +60 °C)

U_i : 10 V
I_i : 271 mA
P_i : 1.152 W
C_i : 0
L_i : 0

Maximum permitted cable parameters for interconnecting cable

(Group I)

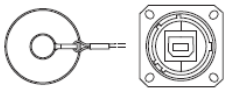
C_c : 180 µF
L_c : 6.354 µH or
L_c/R_c : 515 µH/Ω

(Group IIC)

C_c : 3 µF
L_c :484 µF or
L_c/R_c : 39 µH/Ω

Hydrosteel 6500

Single ported instrument



USB Port Details

(Non Hazardous Area)

U_m: 253 V rms

(Hazardous Area)

Intrinsic Safety Parameters
(Group I)

U_i : 253 V rms	U_o : 5.1 V
I_i : 2 A	I_o : 0.306 A
	P_o : 0.45 W
C_i : 0 µF	C_o : 1000 µF
L_i : 120 nH	L_o : 4.98 µH

(Group IIC)

U_i : 253 V rms	U_o : 5.1 V
I_i : 2 A	I_o : 0.306 A
	P_o : 0.45 W
C_i : 0 µF	C_o : 88 µF
L_i : 120 nH	L_o : 379 µH

Patents include:

US 6637253
UK 2358060
EP 1114992
UK 2538113

Manufactured Date:

Serial No.

Ⓔ II 1 G Ex ia IIC T4 Ga

I M1 Ex ia I Ma

(-40 °C ≤ Ta ≤ +60 °C)

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Quality Assurance

The Hydrosteel 6500 has been manufactured by Ion Science within a controlled environment to meet the required certified Intrinsically Safe Standards.

Disposal

Dispose of Hydrosteel 6500, its components in accordance with all local and national safety and environmental requirements. This includes the European WEEE (Waste Electrical and Electronic Equipment) directive. Ion Science Ltd offers a take back service. Please contact us for more information.

Calibration Facility

Ion Science Ltd offer a calibration service including the issue of certification using equipment which are themselves traceable to UK national standards.

Legal Notice

Whilst every attempt is made to ensure the accuracy of the information contained in this manual, Ion Science accepts no liability for errors or omissions, or any consequences deriving from the use of information contained herein. It is provided "as is" and without any representation, term, condition or warranty of any kind, either express or implied. To the extent permitted by law, Ion Science shall not be liable to any person or entity for any loss or damage, which may arise from the use of this manual.
We reserve the right at any time and without any notice to remove, amend or vary any of the content, which appears herein.

Important safety guidelines

For installation requirements, please refer to Installation and Technical Specification of this manual. Before attempting an installation, please fully read and understand this user manual, and for hazardous area (IS) installations, please also refer to the Hydrosteel 6500 Intrinsically Safe certification for further details.

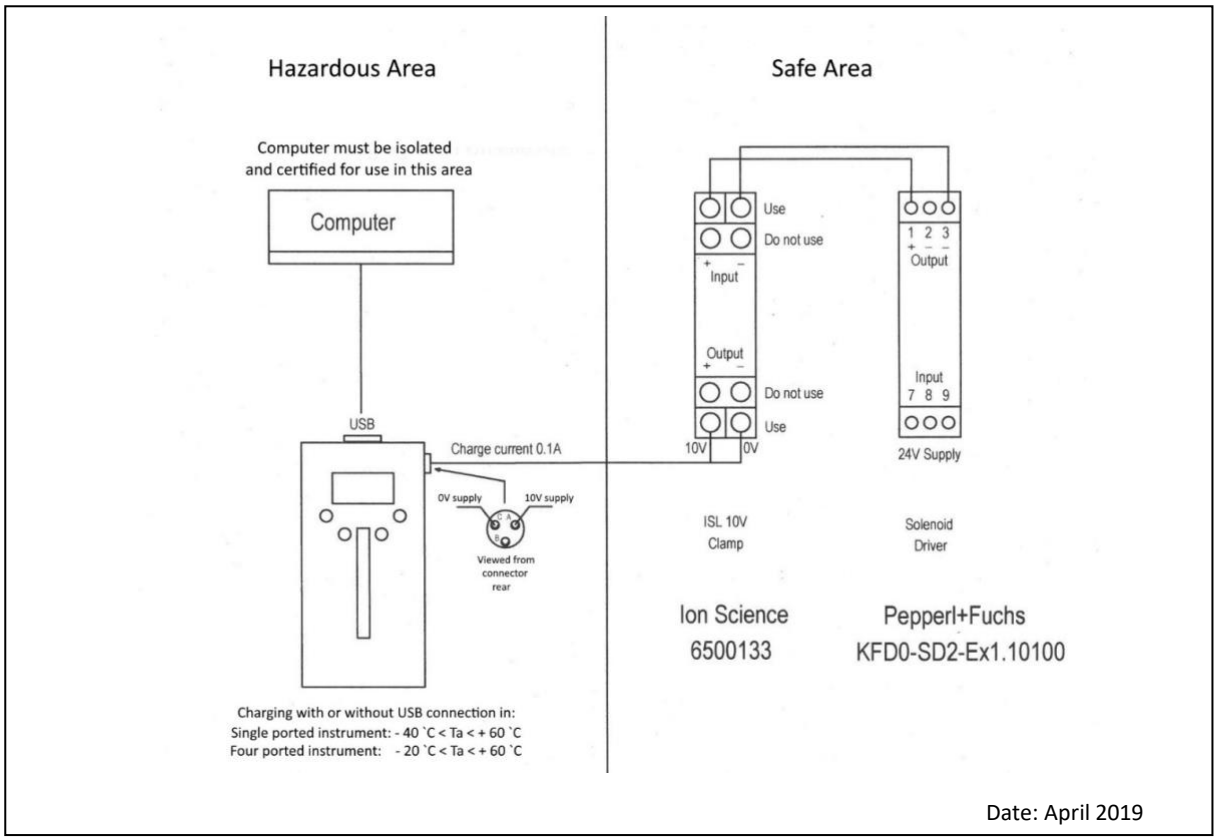
The safety rating permits its deployment in all hazardous areas of the quoted (or less demanding) rating. The rating can be found on the instrument side panel.

Hydrosteel 6500 requires regular calibration onsite: please see the Calibration section for more information.

Permanent installation is possible and this will require further guidance from Ion Science for specific usage. However, for certification purposes the basic requirement is given below.

An instrument connected in a fully discharged state will take about 80 hours to fully charge using the 100 mA 10 V intrinsically safe supply detailed in *Permanent Installation* below. It will take proportionately longer if the instrument is data collecting. Charging in non-hazardous areas using the 0.5 A 10 V charger supplied takes up to 16 hours from a fully discharged state.

Permanent installation



Any permanent installation should be wired in accordance to local regulations relating to the zone the instrument is placed within.

Packing list

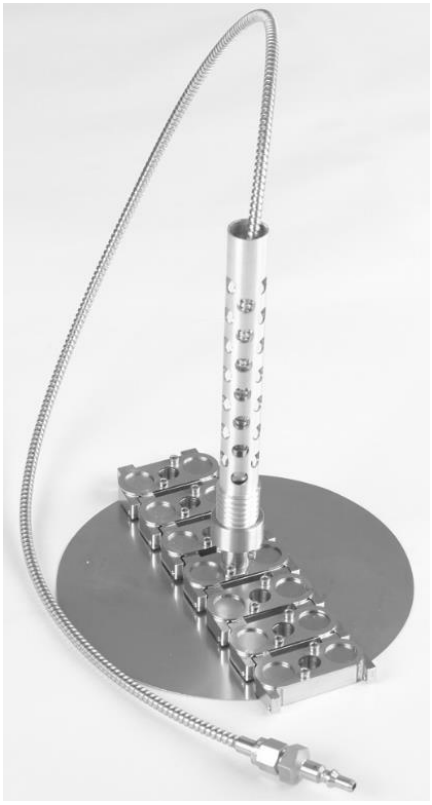
Item	Description	Qty.
1	Hydrosteel 6500 monitor	1
2	Leather carrying case	1
3	Foam filled hard shell case and foam plate holders	1
4	LR (large roaming) probe with fitted LR plate	1
5	SR (small roaming) probe with fitted SR plate	1
6	Spare LR plate	1
7	Spare SR plate	2
8	1 m conduit	1
9	2 m conduit	2
10	3 m conduit	1
11	Probe dismantling Allen key	1
12	Large spanner	1
13	Small (8 mm) spanner	1
14	Background/open gas port adaptor	1
15	USB Cable	1
16	Charging power adaptor (10 V)	1
17	Mains cable for power adaptor (IEC C7)	1
18	This Manual	1

Hydrosteel 6500 components



Hydrosteel 6500 monitor in leather case

LR-probe with conduit attached.





sample conduit



LR probe plate



8 mm spanner



Large spanner

SR probe plate

2 mm Allen key

SR probe

Introduction to Hydrosteel 6500

The Hydrosteel 6500 is an intrinsically safe instrument for the measurement of hydrogen flux from steel of pipes and vessels in corrosive service. The flux indicates active corrosive conditions, and circumstances which these deleterious processes and of control measures intended to mitigate them. It is also used in monitoring hydrogen bake-outs.

The Hydrosteel unit has two modes of operation:

A. Spot flux measurements.
B. Monitoring flux from fixed probes using one to four flux fixed probes.

This dual capability may be used, for example, to locate a few corrosion 'hot spots' which are then monitored for a number of days or weeks to enable an optimal means of corrosion control to be identified.

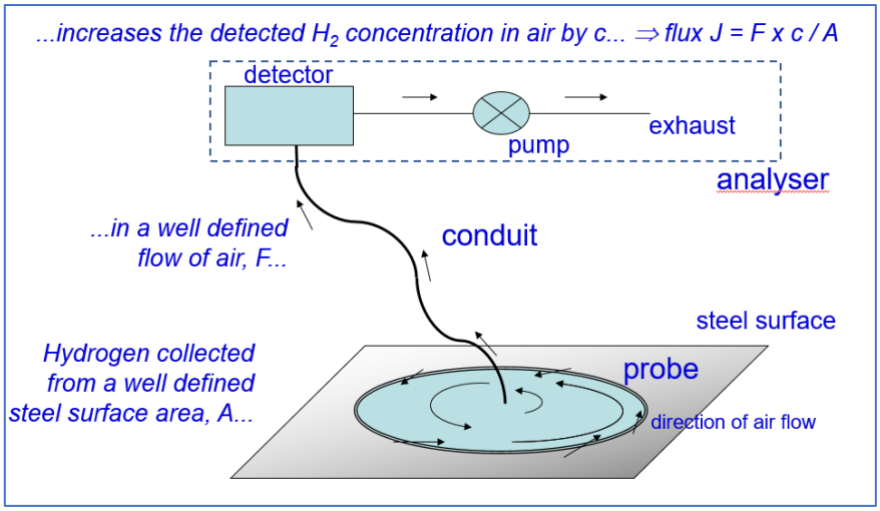
In survey mode, the instrument draws an air sample continuously from one pre-selected instrumental gas port out of four ports available. The gas port is connected to one of two roaming magnetically attachable and detachable probes (SR and LR) by means of flexible conduit of 1.5 m length. Typically, the instrument operator will engage the probe at multiple locations. The locations may be distributed over a large facility, or confined to a single location, being confined to a corroding pipe or vessel, for example. In this mode, the instrument and probes are conveniently carried in an instrument case provided with the instrument.

In fixed monitoring mode, up to all of the four gas ports may be engaged in the monitoring of flux from up to four corresponding probes. The probes (HT-S and HF) and are typically attached to the test metal surface with banding. The conduits may be up to 10 m in length, if the instrument monitoring time is for more than a few days, it is likely the instrument will be secured to a station or post, again using banding.

The Hydrosteel 6500 is designed for operator free maintenance for at least one year. During a flux monitoring episode, limited information is available from the instrument's display. Data is retrieved and batteries re-charged by removal of the fixed instrumentation to a non-hazardous area.

Principle of Operation

Hydrosteel 6500 provides a measurement of gaseous hydrogen flux (flow of hydrogen per unit area) emanating from a steel surface in up to four steel surface sites sequentially. The steel surface can be of variable curvature and surface condition.



To make the flux measurement, a stream of ambient air is caused to be drawn between the steel surface and a probe collector plate and into a capillary that connects the probe to a pump in the analyser. The collector plate is attached to the steel surface mechanically (usually with banding) or magnetically. In the analyser, the collected hydrogen is conveyed across the face of a hydrogen sensor.

The zero hydrogen datum point for Hydrosteel 6500 measurement is the background hydrogen concentration in air at sea level, namely 0.5 ppm. Rapid diffusion, and hence rapid dispersion of hydrogen in air, results in a very low and stable concentration prevailing in the ambient air of most environments, even indoors. This condition enables the technique to be used in measuring a very small flux of hydrogen that outgases from steels in certain circumstances. The integrity of the measured data depends on a stable ambient air hydrogen content, and this drift is usually very low. However, since the instrument has four channels, it is also possible to dedicate one channel to 'background hydrogen' measurement, and therefore correct for any hydrogen in air that is drawn into a flux probe.

The flow of the test-gas stream *F* across the steel surface is measured and regulated within the instrument as a pressure decay across a restriction to ensure that it remains smooth and constant. This also enables diagnostics to overcome flow blockage. Flow regulation is particularly important as the flux *J* of hydrogen emanating from the steel is given by:

$J = c \times F / A$

where *A* is the effective area over which hydrogen is captured, and *c* the enhanced hydrogen concentration resulting from hydrogen entrainment.

The current output from the sensor is proportional to the concentration of hydrogen presented to it. This current is amplified and scaled for display and logging as a hydrogen flux.

To summarise, the prowess of Hydrosteel 6500 technology stems from capturing the hydrogen flux from a well-defined area of steel surface in a known flow of air, and measuring the very small enhancement in hydrogen concentration entrained in the air stream. By this means, the very small hydrogen flux occasionally emanating from steel can be quantitatively measured easily, rapidly, and reliably.

Hydrosteel 6500 probes

Hydrosteel 6500 is a second-generation analyser device combining the flexible spot measurement and extended monitoring capability of obsolete Hydrosteel series 6000 and 7000. Hydrosteel is fully compatible with the use of the original probes as detailed below, except for aluminium handles which must be replaced with the new stainless steel version on old probes. Additionally, Hydrosteel 6500 can be sequentially monitor up to four probes simultaneously.

The diverse applications of flux measurement call for diverse *Modes of deployment* as detailed below. Correspondingly, there are four kinds of probe to accommodate these various applications. The probes are identified in the table below.

probe	LR	SR	AT-S	HT-S
measurement type	'roaming' probes		stationary probes	
Maximum test surface temperature tolerance	350 °C, 660 °F	350 °C, 660 °F	500 °C, 930 °F	500 °C, 930 °F
Resolution, pL/cm²/s	1	10	1	10
Maximum range, pL/cm²/s	3500	20000	3500	20000
Collector diameter	151 mm, 5.8 in	54 mm, 2.25 in	148 mm, 5.8 in	54 mm, 2.25 in
minimum test (pipe)diameter	12 cm, 5 in	9 cm, 3.5 in	9 cm, 3.5 in	7 cm, 2.5 in

Note that LR and SR probes are prone to damage and should be stored in the Hydrosteel field case when not in use. Routinely inspect these probes for damage: see *Routine maintenance*, p. 30.

LR: Large roaming probe.

This probe utilises a collector plate of 6 in diameter to deliver the maximum sensitivity of the flux monitor. It is magnetically attachable to steel of 3.5 in., 9 cm diameter or greater, of surface temperature <350 °C, 660 °F, or 400 °C, 750 °F for brief periods (~1 minute). The probe must be protected from wind of speeds greater than 2 m/s.



SR probe with conduit attached



LR probe with conduit attached

SR: Small Roaming probe

This utilises a small collector plate to give the instrument the maximum dynamic range more commonly obtained from hot steel. The roaming probe is designed to enable access to insulation clad steel surfaces via standard inspection ports. Being smaller, it is also more readily deployed at pipe bends.



AT-S all temperature stationary probe
This probe is 6 inches in diameter and designed to be semi-permanently attached to a steel surface by means of banding, enabling repeatable routine measurements at pre-determined measurement sites.. The probe can be attached to steel at temperatures up to 500 °C, 930 °F. It delivers the same responsivity as the LR probe and is a fully compatible replacement for the Hydrosteel replacement for the AT-S probe.



HT-S: High temperature stationary probe
A small collector, corresponding to the large AT-S probe It is designed for semi-permanent attachment to pipe bends, where corrosion can be significantly enhanced, and with steel pipes with a diameter as small as 1.5 in., 4 cm, at temperatures up to 500 °C, 930 °F. It is interchangeable with the LR probe and is a fully compatible replacement for the Hydrosteel HT-S probe.

Modes of deployment

Hydrosteel 6500 is designed to meet very diverse flux measurement objectives of exploratory surveys, routine spot measurement campaigns and continuous monitoring carried out over months or even years. In the following sections, we consider types of flux measurement survey, and routines for carrying them out.

Exploratory hydrogen flux survey
In the vast majority of steel in both industry and commerce, the hydrogen flux exiting steel is insignificant. We can be sure of this because the causes of *measurable* hydrogen flux are very few, and the calculated and measured flux from arising from these causes are small. What is more, when hydrogen flux from steel is active, it is liable to vary from one location to the next, especially when it is due to complex corrosion process. Out of such considerations, it is often advisable to carry out an exploratory survey of flux measurements before undertaking a scheduled survey or continuous monitoring. In the exploratory survey, flux 'hotspots' are identified, as both an indication of severity of an emergent issue, and to provide a reference for flux variation measured subsequently.

The Hydrosteel analyser defaults are configured to enable immediate deployment in this 'exploratory' mode of operation. The user only needs to ensure the instrument is charged, become familiar with its basic operation, and obtain appropriate permissions to proceed with a survey. In its default mode, the instrument displays the real time calculated flux measurement from gas drawn through an analyser gas port to which a roaming flux probe (LR or SR) is attached on site. The analyser registers 50% of the measured flux within about 20 s after probe engagement, and stable readings in about 90 s. Typically 30 to 60 minutes is required to identify three corrosion 'hot spots' on a sizeable vessel or 50 m length of pipe. The locations are noted and identified for future testing. See also *Appropriate sites for flux measurement.*

Short-term spot measurement survey
If an exploratory survey confirms extensive locations of high hydrogen flux activity, congruent with some corrosive process which it is intended to control over a matter of hours or days or a few weeks. It is then often expedient to carry out frequent measurements with one of the the roaming probes (L-R or S-R). The procedure for making measurements is the same as above. In carrying out such a survey, the analyser can be readily programmed to provide a continuous log of flux measurements, which may be useful in discerning subsequently whether a measurement set was prone to inaccuracies due to a significant variable hydrogen

background. During intense short term surveys the probe plates should be frequently inspected and replaced if damaged (see *Routine maintenance* p.27) and the analyser frequently bump tested and if necessary calibrated (see *Calibration* p. 25).

Routine spot measurements

For evaluation of long-term corrosion control and mitigation, inaccuracies in roaming flux measurement can be avoided by use of fixed probes. *Appropriate sites for flux measurement* are provided below. The AT-S or HT-S probes are installed in fixed positions, using banding or magnet. See *Installation of AT-S and HT-S probes* p. 34. Flux are measured typically on a weekly or monthly basis, see *Fixed probe (AT-S, HT-S) spot measurement procedure* p 18.

Continuous long-term measurements

AT-S and HT-S probes are used in long term flux monitoring. Continuous flux measurements are often undertaken to provide a metric of progressive real time corrosion activity. Variables that affect corrosion, such as process stream composition, acidity, water content, temperature, flow velocity *etc*, are then correlated with variations in corrosivity. It has also been used to assess hydrogen damage risk to steel over long time scales.

By deployment of four fixed probes, or three fixed probes plus a background probe, the analyser can be pre-programmed to measure flux sequentially at up to four locations at intervals between 15 minutes and one month – see See *Analyser operation menu - Data logging operation.*

Pre-weld hydrogen bake out monitoring

This unique application of flux measurement requires the installation of 3 or more L-F probes from which flux is measured over the course of typically 8 to 24 hr. It is usually carried out with LS-F probes.

Laboratory assessments and novel flux measurements

Many laboratory assessments call for flux measurement over the course of trials lasting from a few days to a few weeks. Generally, monitoring is required throughout the trail. Sometimes bespoke probes are needed.

Initial appraisal

A number of accessories accompany the Hydrosteel 6500 analyser. When first received, please check the contents against the Packing List. If any item is damaged or missing, notify your supplier, stating the serial number stamped on the rear of the handheld analyser, together with your order number and the supplier's invoice number. Familiarise yourself with the components of the Hydrosteel 6500 as depicted in *Contents of the Hydrosteel 6500*.

Application considerations

Flux measurements are often called upon to address infrequent scenarios, such as the consequences of unexpected process upsets. The user should be familiar with *Modes of use* identified above and explored in more detail in Part II of this manual.

Measurement site considerations

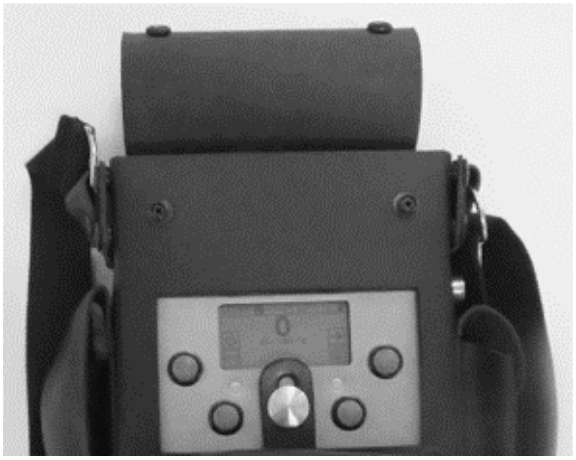
Before engaging with Hydrosteel, the reader should be familiar with where it can be used. See *Appropriate sites for flux measurement*, below.

Equipment considerations

Analyser Calibration enables you to check that your equipment is performing within specification and calibrate if necessary.

Whether using Hydrosteel 6500 for the first time or after an extended period of dormancy, as a first assessment check the battery level of the instrument at the top right of display window. If the instrument is installed in its leather field case, button and affix the front leather panel to reveal the analyser screen as shown below.





Now press any of the coloured keys for at least 3 s. This will turn on the analyser and illuminate the screen as shown below.

If the battery icon does not indicate sufficient instrument power for the intended instrument usage, then recharge the batteries as indicated in *Battery Recharge.*

System assembly and start-up



Hydrogen flux measurements are sometimes undertaken under the duress of emergent process control issues. The user should acquaint him or herself with the *Analyser operation menu*. Apart from that, Hydrosteel 6500 can be operated 'out of the box', to provide facile measurement of hydrogen flux.

1. Turn the Hydrosteel 6500 instrument on by pressing any key on the front panel for at least 3 s. The analyser factory default setting is for an exploratory flux survey with the LR probe, with continuous gas sampling from Port 1. However, on power up, the instrument always returns to its most recent setting.
2. Ensure sufficient battery power and configure instrument for the required field use. A full battery offers about four days of continuous measurements.
3. Use of the leather jacket is recommended, even upon retrieving from and returning instruments to a fixed site following battery recharging. Ensure that all items required for flux measurements (marker, notebooks, fixings…) are included with the kit. The case with full contents should be adjusted so that it fits comfortably and snugly to the person transporting it to the field.
4. Ensure the instrument screen is protected by closure of the leather screen cover.
5. Proceed with the appropriate measurement procedure described below.

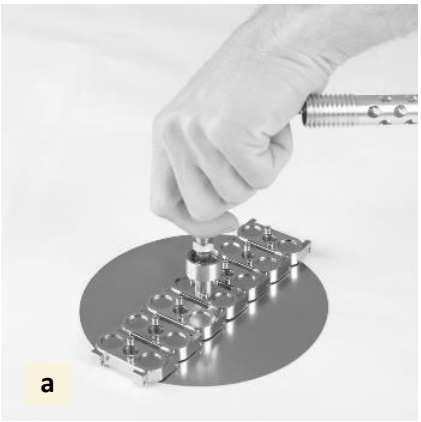
Roaming probe (LR, SR) spot measurement procedure

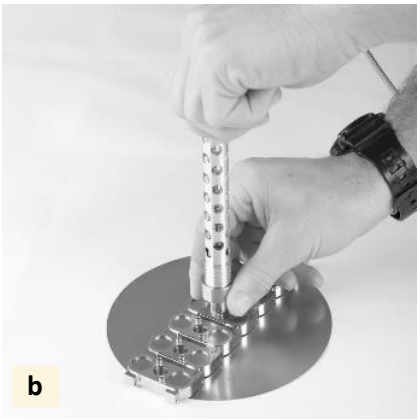
Step 1. Away from any source of hydrogen, turn the instrument on. Ensure sufficient battery power is display for the duration of the survey. A full battery offers about two days of continuous measurements. Ensure that the probe sampling port is identified as Gas port 4. The probe type should be identified as LR unless the smaller SR probe is to be used. Close the analyser display flap [picture].

Step 2. Ensure the kit includes at least the one 1 m sample conduit, both the LR and HR flux probes, marker pens (for identifying flux measurement sites), and a note pad for recording flux measurements. A wire brush is also useful for the removal of loose paint or rust.

Step 3. Place your arms through the leather case. Although the leather case provides the analyser considerable protection, the cotton straps should be adjusted to ensure that the analyser sits comfortably for you, and will not swing about such as to collide with cages, gantries, stanchions *etc* during its transport to site. The analyser can be left on during transportation to the target site of measurements. This will facilitate an indication of any hydrogen background in the following step.

Step 4. On arrival on site, retrieve and assemble the desired probe and connect to the analyser as shown in the sequences below. Reposition the analyser so that you can see the display without hands. Check that the analyser indicates a zero or near zero reading (3 pL/cm^2/s or less). If not, re-zero by pressing the on/off key twice.



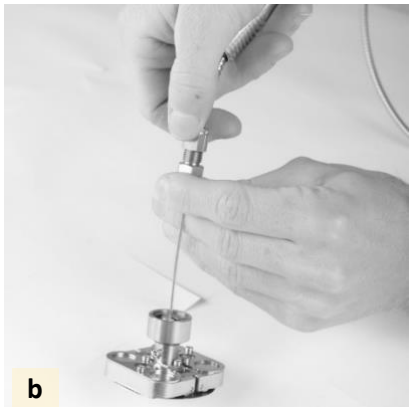


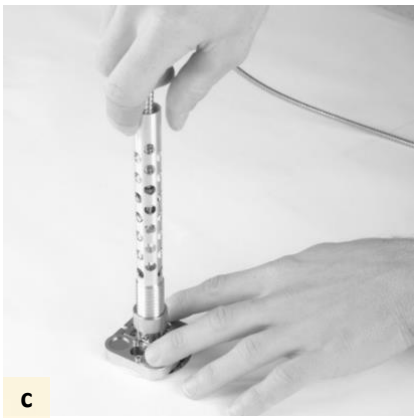


LR probe on-site assembly: ***a*** push screw fitting end of conduit through probe handle and screw manually into the probe assembly. ***b*** screw handle into central probe plinth. ***c*** insert other end of probe into appropriate analyser port.

SR probe on site assembly: ***a*** unscrew handle from probe and push threaded end of conduit through it.







b screw conduit nut manually onto SR probe capillary nut. ***c*** screw handle into central probe plinth. ***c*** insert other end of probe into appropriate analyser port.

Step 5. Identify an appropriate flux measurement site (see *Appropriate sites for flux measurement*). The effectiveness of Hydrosteel in registering flux depends upon a probe making an intimate seal with the steel surface. Confirm there are no deep grooves or ridges running across the test area. Sometimes the suitability of geometry can only be identified by attaching the probe. Be sure the the steel *temperature* is less than 350 °C, 660 °F as higher temperatures will damage the probe. (The steel temperature is very important for the evaluation of flux measurements and should be recorded at this time, if not obtainable from process data). Demarcate the site if necessary.

Step 6. Take a background hydrogen reading. Observe the instrument reading for at least one minute (this can be done at intervals during Step 5). Record the maximum displayed background reading X.

Step 7. Engage the probe. Orientate the LR (or SR) probe to the steel surface as shown below. Note the magnetic segments on the probe should be aligned with the longitudinal axis of the steel under test. Present the probe directly to the steel surface so that the magnets in the probe engage the collector plate 'all at once' rather than edge on. Visually inspect the probe in position. There needs to be intimate contact especially at the extreme of probe plate deformation, as illustrated below. If the probe is located unsatisfactorily, remove the probe as per step 9 and repeat this step. Never drag the probe across the steel surface.

Step 8. Record the attached probe reading. After one minute record the displayed reading Y. The flux is given by Y-X.

Step 9. Remove the probe as shown and move to the next measurement site, proceeding from Step 7.

Step 10. Upon completing the survey, turn the instrument off, repack probes and conduit, and return all equipment to the workshop. Ensure kit is clean and dry before storage.

Special considerations on using roaming probes to measure high temperature corrosion

If you are planning to engage the roaming probes to detect hydrogen flux from high temperature surfaces, consider the need for

- thermally insulating gloves
- high temperature crayons to demarcate new measurement sites
- a wire brush for removal of loose rust

Despite extensive lagging, the ambient temperature in the vicinity of high temperature equipment is frequently be 10 to 20 °C, 20 to 40 °F higher than elsewhere. This is sufficient to cause the Hydrosteel analyser to temporarily register a shift in baseline measurement. The baseline recovers in about 5 to 15 minutes as the analyser temperature equilibrates. To minimise this effect, prevent the analyser being exposed to direct radiation from large expanses of unlagged equipment.

On attachment of a roaming probe to a hot test surface, flux is often seen to peak, decrease, then increase again a steady value over the course of a few minutes, particularly if the probe has not already been heated during measurements nearby. This relates to the steel surface cooling on contact of the steel, causing a suppression of hydrogen flux, which recovers as the surface and the probe are heated by the wider steel bulk. The probe reading should be noted only after the flux reading has stabilised.

On removing the SR probe from a hot test surface, care should be taken as the collector plate and adjoining components will be at a temperature approaching that of the steel surface. In particular, at least for five

minutes after the probe has been engaged on hot surfaces continue to wear thermally insulated gloves on handling the probe, and avoid probe contact with plastics. This can result in the plastic melting on the probe, giving rise to a false flux reading when the probe is next used (due to thermal degradation of plastics to give hydrogen).

Special attention is needed on using the SR probe on high temperature surfaces. The effectiveness of Hydrosteel in registering flux depends upon intimate engagement between the probe and test steel surface. Through an inspection port this contact cannot be seen. Therefore, prior to measurement, ensure a clear path to enable the SR probe to be inserted without trapping shreds of rock wool or other detritus. Confirm there are no deep grooves or ridges running across the test area. Check site surface is free from loose rust. If necessary, remove detritus using the wire brush.

When the SR probe is engaged on high temperature surface through an inspection port, the user should not rely on the high temperature magnets to support the probe on the surface. Instead, continue to hold the S-R probe whilst the measurement is made.
[Picture holding SR probe]

Fixed probe (AT-S, HT-S) spot measurement procedure

Step 1. Away from any source of hydrogen, turn the instrument on. Ensure sufficient battery power is display for the duration of the survey. A full battery offers about two days of continuous measurements. Ensure that the probe sampling port is identified as Gas port 4. The probe type should be identified as AT-S or HT-S depending on which probe is to be engaged. Close the analyser display flap.

Step 2. Ensure the kit includes at least one 1.5 m sample conduit, and a note pad for recording flux measurements.

Step 3. Wear the analyser. Although the leather case provides the analyser considerable protection, the cotton straps should be adjusted to ensure that the analyser is reasonably close against the torso, so as not to bump into cages, gantries, stanchions etc during its transport to site. The analyser can be left on during transportation to the target site of measurements. This will facilitate an indication of any hydrogen background in the following step.

Step 4. On arrival on site, attach the conduit to the Gas Port 4. Reposition the analyser so that you can see the display without hands. Check that the analyser indicates a zero or near zero reading (3 pL/cm^2/s or less). If not, re-zero by pressing the on/off key twice.

Step 5. Note as appropriate the date and time and site of measurement.

Step 6. Take a background hydrogen reading. Observe the instrument reading for at least one minute (this can also be undertaken at intervals during Step 5). Record the maximum displayed background reading X.

Step 7. Engage the probe. Remove the stationary fixed probe cap. Connect the free sample conduit end to the fixed probe.

Step 8. Record the attached probe reading. After one minute record the displayed reading Y. The flux is given by Y-X.

Step 9. Detach the probe from the conduit. Replace the probe cap. Move next measurement site, proceeding from Step 7.

Step 10. Upon completing the survey, detach and return the conduit to the analyser case pocket, and return all equipment to the workshop. Ensure kit is clean and dry before storage.

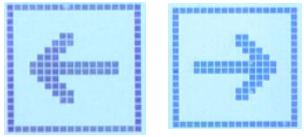
Analyser Operation Menu



Analyser front panel. The Tools menu is shown, together with menu keys A to D corresponding to displayed menu functions (↔) and gas ports 1 to 4 corresponding to their probe assignments (↔).

Basic principles of operation

The Hydrosteel analyser menu is navigated by means of four menu keys identified as A,B,C,D above. The function provided by each key is identified in the four respective corners of the display as shown. Instrument menu navigation is provided by four keys:



Left and Right keys: move highlighted option left or right.

 Select key: select highlighted option  Exit key: exit to previous menu level.

When initially turned on, the instrument enters *dynamic monitoring*. Settings are changed entirely by means of the operating menu. Gas is sampled from a single specified gas port, assigned to a specified probe type as indicated by arrows as indicated in the illustration above. The analyser continues to sample from the highlighted port until and unless this is changed. Data recording can be started and stopped at any time in this process. Changes to the instrument settings are identified in the recorded data.

Alternatively, the instrument may at any time be set to *stationary monitoring* of one to all four specified gas ports in a selected sequence, and at pre-defined intervals. The monitoring sequence can be specified *via* computer interface, or set up manually, using the instrument menu.

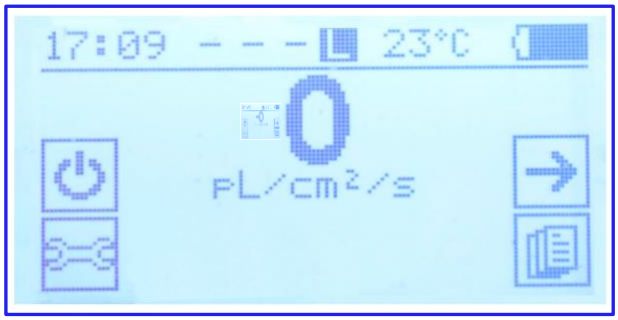
The main menu

Turning the instrument off and on.

To turn the instrument on, press any key (A to D) for at least two seconds. With sufficient battery power the instrument will start up, and the Main Menu will be displayed. The instrument can be turned off by pressing the key sequence identified by the on-off icon 

power off

tools menu



change active gas port

data logging

Main menu

Instrument status.

The instrument status is indicated in the top line of the Main menu.

The time is set by the *PC operating programme* – see below. Note that this time is not used in the logging of data: that is set by the PC to which data is downloaded. To

Gas port assignations are indicated in the top panel of the of the main menu. The key is as follows:

Symbol	Description
L	LR – Large roaming probe
S	SR – Small roaming probe
A	AT-S – Large stationary probe
H	HT-S – High temperature (small) stationary probe
O	Open gas port for background measurement
-	Closed gas port.

The actively sampled probe and gas port is highlighted in reverse contrast. For example:



Active sampling from Gas Port 1, with HT-S probe attached. Gas ports 2 and 3 not used. Background measurement from Gas Port 4.



Gas ports 1 to 3 not used. Active sampling from station 4, attached to LR probe.

The *instrument temperature* is displayed. If the temperature is changing in the instrument by more than 1 °C per second, the temperature displayed flashes, as this rate of temperature change affects the zero measurement and should generally be allowed to abate when for example, entering a hot location. If the indicated temperature exceeds 50 °C there is a serious risk of damaging the instrument sensor, and the instrument should be removed to a cooler location.

Finally, top right, is a battery indicator that empties in approximate proportion to the instrument battery capacity. The icon flashes when batteries are near exhaustion.

Changing the actively sampled gas port during dynamic sampling.

From the main menu, press the right arrow key: 

The highlighted symbol will move to the next available probe port and instrument switch flow to that port instantaneously.

Changing the type of hydrogen flux probe engaged.

From the Main menu, press the tools menu key,  to highlight and select the Probe icon, 

to access the following screen:



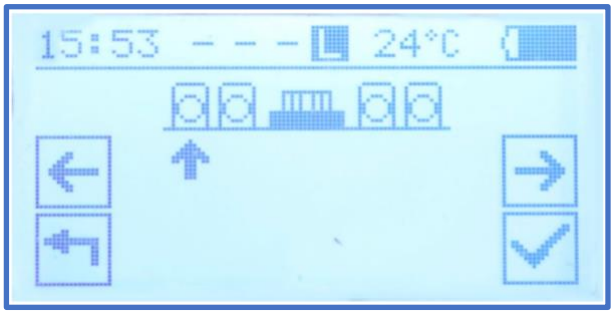
Use the left and Right keys to scroll through the desired probe options:

LR, SR, AT-S or HT-S,

then use the Select or Escape keys to save or ignore the selection and return to the Main menu. Any gas ports previously allocated to a flux probe will now identify the new designated probe.

To change the probe allocation of the four gas ports.

From the Main menu, press the tools menu key, then use the Left key to highlight and select the Gas port Icon,  to access the Probe Allocation menu:



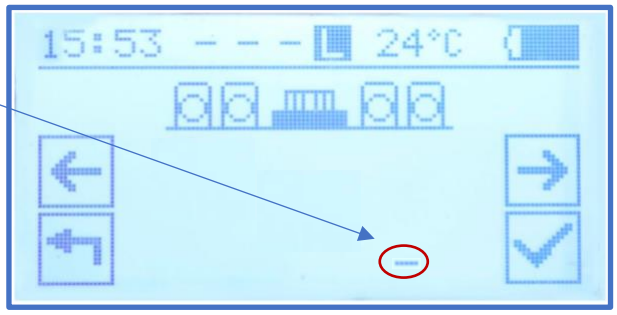
The arrow indicates the selected probe whose probe allocation is to be changed. Use the Left or Right keys to move the selection. Escape to Main menu or Select a port for new probe allocation.

On specifying a port one of three options is presented in the subsequent menu, changeable with the Left and Right keys:

- : closed port, or

O : background probe, or

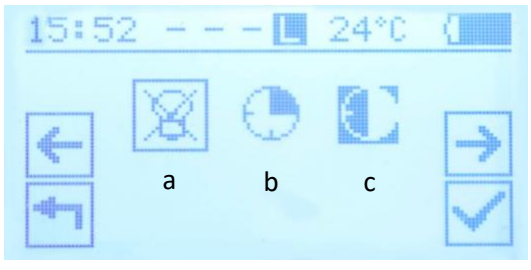
current probe selection (LR, SR, AS, HS)



Use the Select key to allocate the identified probe type to the selected gas port, and return to the Probe Allocation menu.

To change the temperature scale between °C and °F from the Main menu, press the tools menu key  then select 

To change the display illumination settings from the Main menu, press the tools menu key  then select  to obtain the display.



illumination menu. Use left and right keys select or escape keys to choose between the following options:
a: no screen illumination
b: menu illuminated for 15 s
c: menu illuminated for 30 s

Changing the sequential flux logging measurement time.

from the Main menu, press the tools menu key,  then select  to obtain the flux measurement time menu:

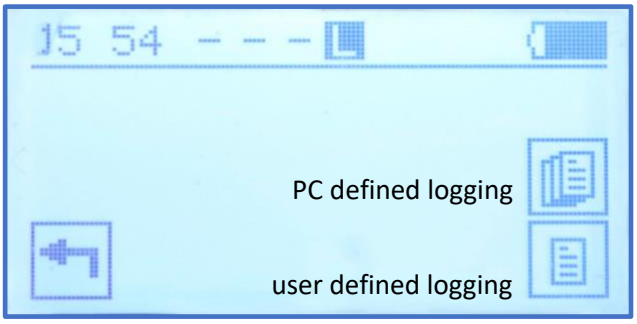


Use ← and →, then select ✓ or escape ↩ as appropriate. The default setting is 60 s. Longer times are recommended at temperatures below 0 °C. Also, with probes attanched to 10 m conduit, 90 s is recommended.

Data logging operation

User defined continuous and sequential data logging

From the Main menu press the data logging key  to access the Logging selection menu



Logging Selection menu

then select user defined logging. You will then be presented various user defined monitoring options:

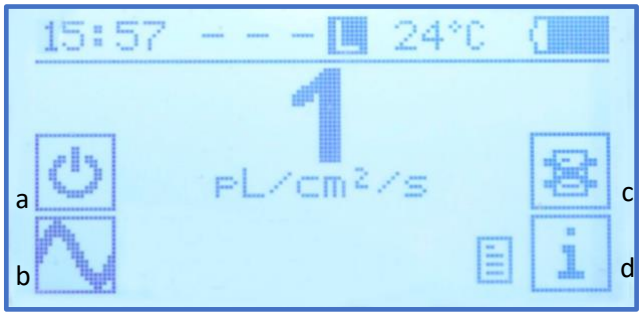


Use ↑ and ↓ to select thee desired cycle time, , then select ✓ to proceed to log data with the highlighted cycle time or or escape ↩ as appropriate.

Continuous monitoring: The instrument will immediately start logging every 5 s from the highlighted flux probe (AT-S in station 4 in the screen illustrated).

1 min, 15 min, …, 1 day, 2 day cycle times: the options vary from a minimum time which is circumscribed by the flux measurement time (say 90 s,) and the number of probe ports open. The monitoring sequence from each open station from station 1 to station 4. Readings are monitored every 5 s.

Immediately following the selection of a logging regime, the following is displayed:



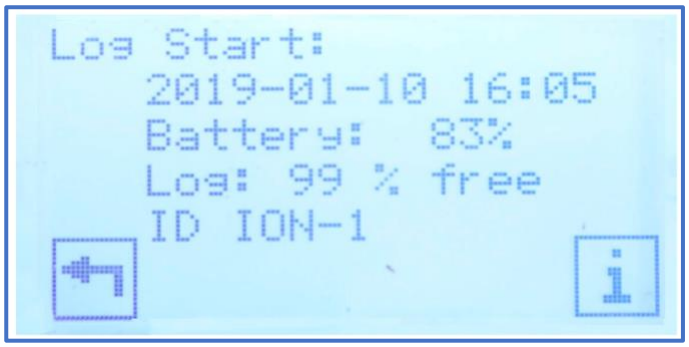
Note that the symbols at the top of the display are as identical as used in the Main menu. The icon to the left of the information key icon indicates that user defined logging is active.

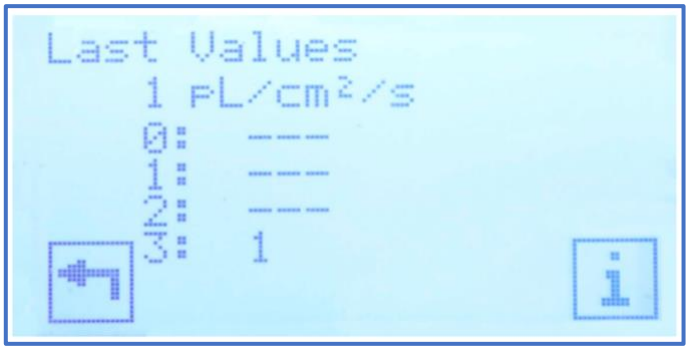
The four key options are:

a: power off. The log will be terminated before the instrument powers down.
b: change monitoring sequence cycle time (see above)
c: Stop data logging. Note that to change the probe allocation logging must be terminated.

d: logging information (see below)

Logging information
This is presented in three sequential screens as below.







PC defined logging.
All monitoring options that can be set by the user can also be pre-programmed into the instrument (see PC software).

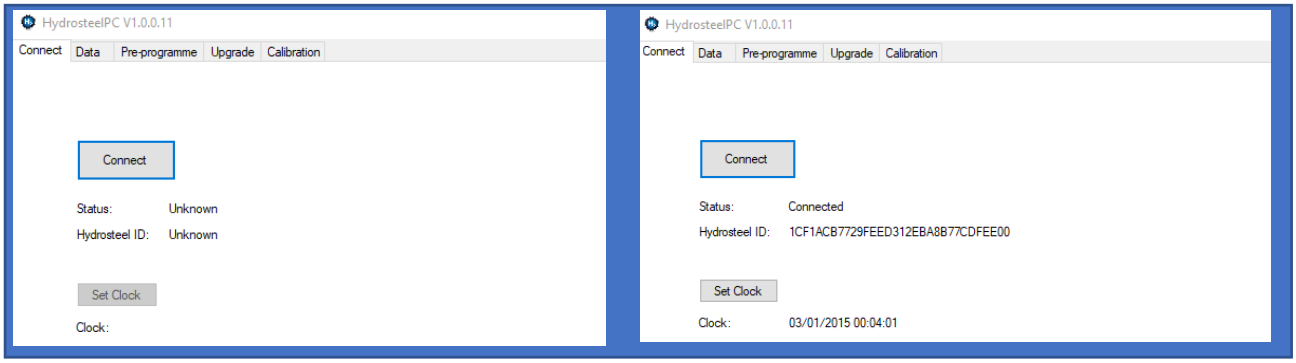
From the main menu select the logging tab to access the Logging Selection menu, then select again. Use and , then select or escape as appropriate. The default setting is 60 s.

Hydrosteel PC software

Hydrosteel PC software is used to set up of the instrument clock, calibrate the instrument, and pre-set data logging routines, handle instrument data and upgrade firmware. It is supplied on a memory stick with the instrument kit but also is downloadable from the internet.

Set-up

1. Access Hydrosteel PC software from the web or a local drive. Run the program 'Setup'. This will install the software on your computer. You may need your Administrator's permission to load the software.
2. Turn on your Hydrosteel 6500 instrument
3. Unplug the instrument USB cap and use the USB connector to connect to the instrument to your computer.
4. Run HydrosteelPC.exe from your PC. The window, below left, will appear:



5. Press 'Connect' to obtain the screen above right.

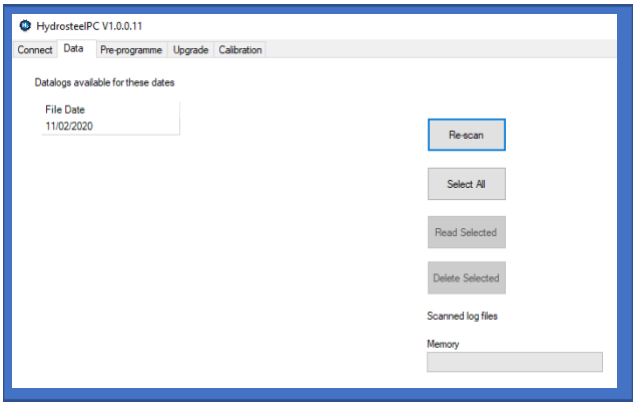
The software can now be used for *Data handling*, *Setting the instrument clock*, and *Calibration* as described in the following sections.

Setting the instrument clock

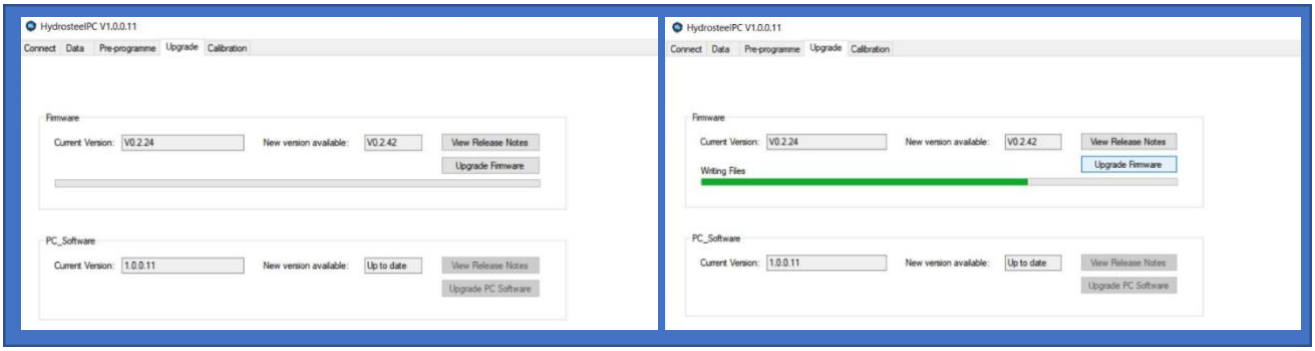
From the Hydrosteel PC software *Connect* window, select 'Set clock' and follow instructions. Note the analyser time and date will be set to the PC ctime and date.

Data handling

With the instrument connected to Hydrosteel PC software, select *Data* to obtain the screen shown. Select files for download. The files can then be read or deleted as per the menu panel on the right of the screen.



Upgrading Hydrosteel 6500 firmware



With your PC connected to the internet and Hydrosteel 6500 connected to Hydrosteel PC software, select *Upgrade* to obtain the screen on the left. Select *Upgrade firmware*. Upgrade progress is indicated as shown in the right screen

Calibration

Accurate Hydrosteel flux measurement is dependent on three system characteristics:

- the engagement of an undamaged probe
- sample gas flow rate
- calibrated hydrogen sensor response

Probe damage is addressed in *Routine maintenance*. Sample gas flow is automatically adjusted by the analyser: in the event of blockage, please see *Troubleshooting.*

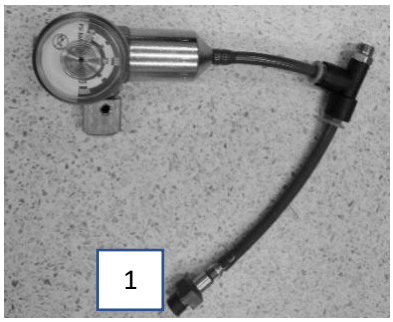
Sensor response is not prone to variation but may fail over many months of use, particularly if the sensor is exposed to temperatures exceeding 50 degC. In most cases, the sensor responsivity to hydrogen decays over extended times, but with appropriate storage it may retained for two years or more.

To ensure the need for calibration, it is strongly recommended that the instrument be bump tested first. It is in any case, important to confirm all components necessary for calibration are present and correct, including adequate span gas, before proceeding with calibration.

Only authorised and qualified persons should calibrate the Hydrosteel analyser, using all normal safety practices.

To carry out the function test you require:

- a PC with *HydrosteelPC* software installed and enabled.
- the Hydrosteel 6500 analyser
- a cylinder of 100 ppm hydrogen in balance artificial air (see illustrations), containing at least 4 bar test gas.
- the Hydrosteel 6500 calibration adaptor (right)
- 1 m sample gas conduit
- a clean flat work surface





Step 1. Place analyser on the flat work surface in an environment known to be remote from any source of hydrogen. Such sources of hydrogen are rarely encountered, but may for example be an open window near to a hydrogen processing equipment.

Step 2. Attach 1 m sample conduit to the analyser gas port 1. Turn the instrument on. Ensure the device is configured to sample from gas port 1.

Step 3. Attach the fixed flow regulator adaptor to the gas cylinder outlet as shown in the illustration, and turn on.

Step 4. Turn the cylinder on to confirm a pressure of hydrogen is available (at least 0.5 bar).

Step 5. Position the span gas assembly on its side on the flat work surface, near to the analyser.

Step 6. Connect the instrument to your PC using the USB B cable provided.

Step 7. Run Hydrosteel PC software. Press 'connect'.

Step 8. Select from the tab menu 'Calibration'.

Step 9. When the ADC measurement indicated has stabilised (usually within 1 minute of when it was turned on: the zero should generally settle to within +-0.5 ppm), press 'Record Zero Now'.

Step 10. Connect the open end of the 1 m sample gas conduit to the calibration adaptor at position "1" as indicated in the picture above.

Step 11. Allow 2 min for the reading to be fully established. During this time, input the span gas hydrogen concentration in ppm. Press 'Record span now'.

Step 12. Remove the instrument from the calibration gas cylinder and turn the analyser gas off. Remove the PC connection and restart the analyser. Assign the active (sample) port to the LR probe. If the reading (in pL/cm^2/s) varies over short time scales by more than +-1 pL/cm^2/s repeat the calibration, having re- checking that all connections have been made securely, that there is sufficient gas pressure in the gas bottle and that the instrument was zeroed in air free from any hydrogen background.

Battery recharge

Batteries should only be recharged in a non-hazardous area using the ISL provided battery charger specified at 10V 0.5 A.



Place the analyser on a firm surface.

Connect the charger to the battery charge port. Note that the connection requires alignment of connector notches.

Screw in the connector outer shell until the red check line is not visible.

Supply power to the battery charger. The instrument will self-power up after 10 s. The battery icon will indicate the level of charge.

The batteries fully charge from empty within 16 hr.

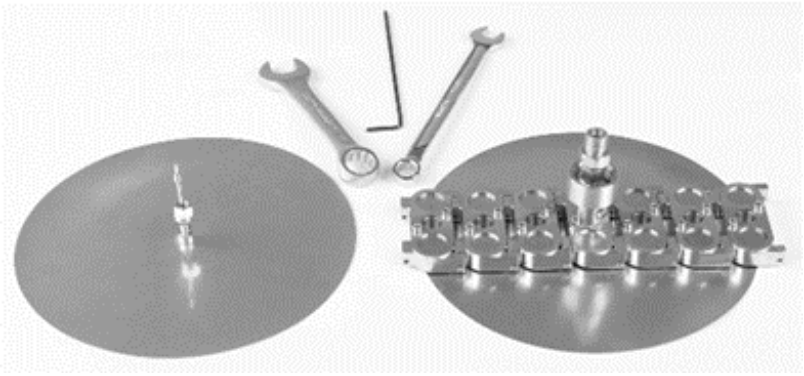
Routine maintenance

Analyser repair and service

In the event of the analyser requiring repairs or service, the analyser should be returned to an approved service centre as identified at the end of this manual.

LR probe plate replacement

The LR probe plate should be replaced when it becomes severely ridged or dented as that will affect the efficiency with which hydrogen is collected by the probe.



To change the LR plate you will require the LR probe to which it is attached, with its handle removed. detached, the small and large spanner and 2 mm Allen key.

1. Using the two spanners, engage and unscrew the collector plate conduit adaptor from the probe assembly as shown.





2. Next, using the Allen key, remove the probe handle adaptor by removing the two side screws as illustrated.

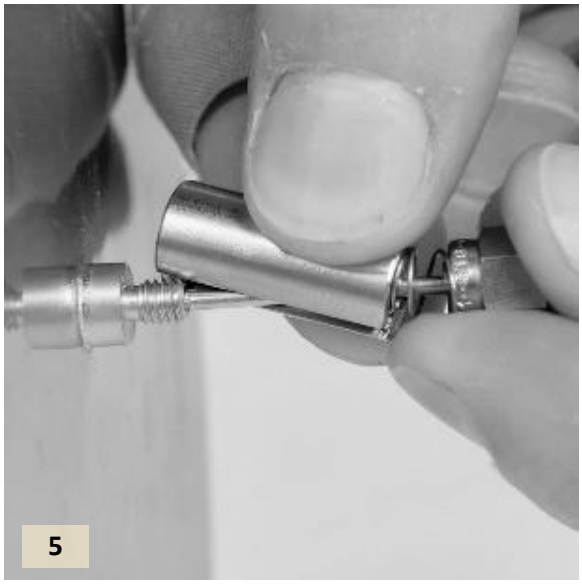
3. Lift the entire ‘caterpillar’ assembly of magnets from the old probe plate as shown. Place the magnetic assembly to one side. The magnets are powerful, and care should be taken to avoid them picking up ferrous metals.





4. Unscrew the collector plate plinth from the old probe plate.

5. Now remove the plinth from the base by pulling it away from the extension spring on the collector plate and twisting it free.



6. You will now have completely dismantled the LR probe, as illustrated. To reassemble the probe, carry out the exact reverse of procedural steps 1 to 5.

6

7. Attach the collector plate plinth to the new collector plate by pushing the unthreaded end down against the extension spring on the collector plate (see 5 above).



8. Ensure the plinth is central and snug against the plate capillary, then screw the plinth to the collector plate (see 4 above).

9. Ensure the magnetic assembly has not picked up any ferrous detritus. Place the magnetic assembly over the collector plate plinth (see 3 above).

10. Ensure the assembly is fully engaged, then insert the probe handle adaptor over the collector plate plinth. Using the Allen key, screw in the two side screws to secure the adaptor against the collector plate capillary (see 2 above).

11. Finally, using the two spanners, attach the collector plate conduit adaptor to the collector plate terminal nut (See 1 above).

12. The LR collector assembly is complete. Ensure the plate is protected when not in use.

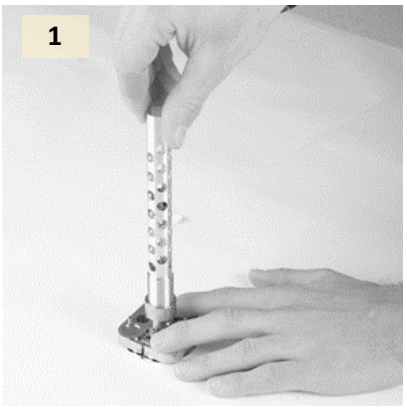
SR probe plate replacement

The SR probe plate should be replaced when it becomes severely ridged or dented as that will affect the efficiency with which hydrogen is collected by the probe.

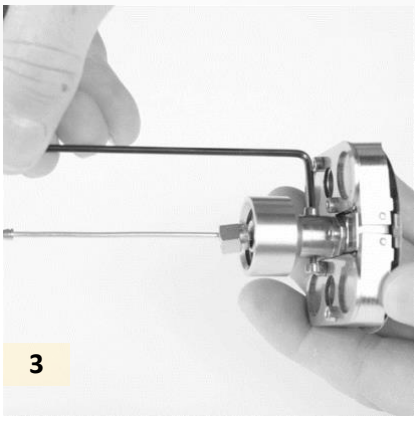
To change the SR plate you will require the SR probe to which it is attached, a new SR probe plate, the large and small spanners and 2 mm Allen key.



1. Manually unscrew the handle from the LR probe.
2. Using the two spanners, engage and unscrew the collector plate conduit adaptor from the probe assembly as shown.

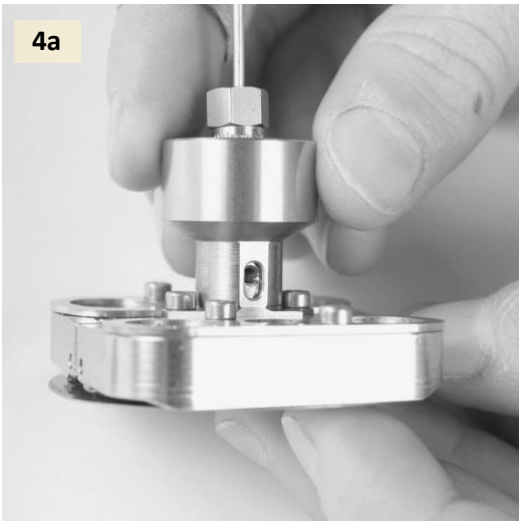






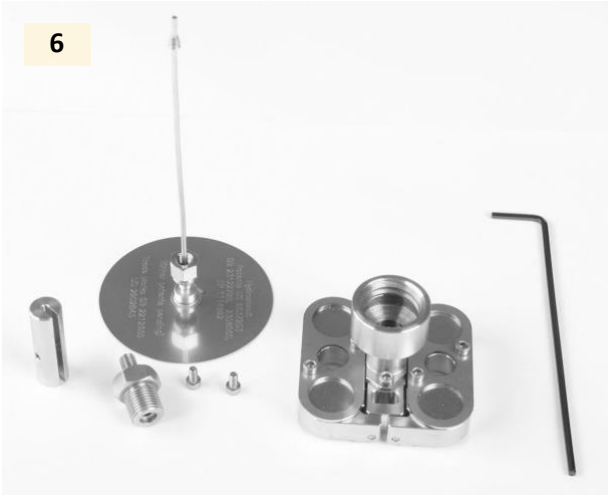
3. Use the Allen key to remove the two side screws in the probe handle adaptor. Make sure the screws are carefully set to one side, and do not get lost.

4. The probe handle adaptor is not separated the assembly. Instead, the magnetic assembly connected to the adaptor, should now be released from the old collector plate. Place the magnetic assembly to one side. The magnets are powerful, and care should be taken to avoid them picking up ferrous metals.





5. Unscrew the collector plate plinth from the old probe plate.
6. You will now have completely dismantled the LR probe as illustrated. To reassemble the probe, carry out the exact reverse of procedural steps 1 to 5.





7. Screw the replacement collector plate into the collector plate plinth (see 5 above).

8. Ensure the magnetic assembly has not picked up any ferrous detritus. Place the magnetic assembly over the collector plate plinth (see 4 above).

9. Ensure the assembly is fully engaged, then insert the probe handle adaptor over the collector plate plinth. Using the Allen key, screw in the two side screws to secure the adaptor against the collector plate plinth (see 3 above).

10. Using the two spanners, attach the collector plate conduit adaptor to the collector plate terminal nut (See 2 above).

11. Reattach the probe handle (See 1 above).

12. The SR collector assembly is complete. Ensure the plate is protected when not in use.

Cleaning

Clean the analyser and equipment using a damp cloth and mild detergent. Care must be taken around the analyser inlet and all pneumatic openings (sample tube etc.) to ensure that water does not enter. Dry immediately with suitable towel.

The magnets may with time attract magnetic and ferromagnetic particles. These can easily be removed using an air jet from a typical air supply (100 psi / 7 bar). Simply play the jet across the surface wiping where necessary to blow the particles away.

Warning; Organic solvents such as IPA should not be used to clean the analyser or collector plates. The solvent vapour in strong concentrations may affect the sensor readings.

Attention must be made to keep the following areas clean:
All pneumatic joints
Analyser inlet.
Surface of collector plates.
Bottom of probe assembly collector plate free from grit and metal filings that may be collected by magnetic attraction.

Continuous flux monitoring guidelines.

Continuous hydrogen flux monitoring is often engaged on equipment in corrosive service for which there is a threat of hydrogen damage before some long-established scheduled replacement of the equipment. Flux monitoring may then be required for many months. Data retrieval can be conveniently combined with battery recharge, at weekly to few monthly intervals, depending on the measurement frequency.
For long-term application, the Hydrosteel analyser should be firmly mounted on stanchion as near to the measurement sites(s) of interest as possible. Conduits connecting the Hydrosteel to fixed probes can be of up to 10 m length without significant loss of hydrogen.

The analyser should be protected from driving rain. It must not be exposed to temperatures prone to exceed 50 ^{o}C.

On removal of the analyser from the measurement location for data download and battery recharge, use the leather case to transport the analyser to and from the service area. On site, first turn the analyser off, then remove all conduits from the analyser before inserting it into the leather case.

Appropriate sites for flux measurement

Coatings, rust and surface condition preparation

In the majority of target locations for flux measurement, the steel contains a sufficiently thin epoxy or alkyd resin coating (<1 mm) for hydrogen to be effectively transparent to hydrogen. There is no need to remove the coating and if the surface and steel meet the criteria below: a flux measurement can proceed immediately. A bare steel surface, or one containing a thin contiguous and homogenous rust layer bonded to the target area is also perfectly hydrogen permeable. Occasionally steel may include rust dust or loose paint that should be removed, preferably some hours before flux measurement, as on removal may cause an initial depletion in surface hydrogen and thus a low unstabilised hydrogen flux reading.

Zinc coatings tend to be severely hydrogen impermeable and must be completely removed to enable flux measurement.

Hydrogen flux is of particular interest in evaluating high temperature acid corrosion (particularly naphthenic acid corrosion, NAC). If steel sustaining this corrosion is of low manganese content and has had a long service history, or been exposed to external corrosion, often under insulation (CUI), the external surface may support a thick and loose layer of rust. If there is a prevalent hydrogen flux permeating the steel, this will be partially trapped within the rust layers, and partially released on attaching a probe, delivering an unquantifiable flux spike response. On the other hand, if the loose rust is mechanically removed, the steel surface is invariably disturbed, with the introduction of numerous empty trap sites for hydrogen. At least a day is required to fill these trap sites before a measurable flux can be secured. Thus measurement sites of this type are generally only appropriate for the use of the stationary probes and certainly not appropriate for roaming probe flux surveys.

Occasionally steel surfaces supporting multiple historic coatings are encountered, in which the coating is disbonded from the steel. In this case, hydrogen is liable to migrate across the gaseous interlayer between steel and coating, preventing meaningful flux measurement. If measurements are required at such a location, the coating must be removed, and again, at least a day is required before meaningful hydrogen flux measurement can be made.

Steel type

At steel temperatures below about 120 °C, low alloy steel permeates hydrogen weakly. It requires severely hydrogen occluding corrosion to drive a measurable flux of hydrogen through steel, exiting at the external face of the corroding steel pipe or vessel. Only hydrogen promoting corrodants such as sour gas and HF can produce this flux

At increasing temperatures much lower hydrogen activity is required to deliver a measurable hydrogen flux, and higher alloy steels become amenable to flux measurement, as set out inn the details below.

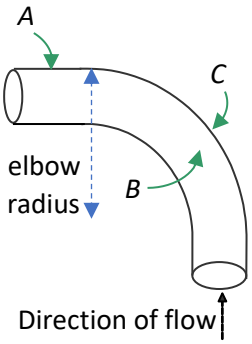
Temperature	Permeable steel
0 to 120 °C	Mild steel to <5% alloy
120 to 200 °C	<10% alloy
200 to 300 °C	<13% alloy
300 to 400 °C	All non-austenitic steel

Steel geometry

Erosion-corrosion phenomena often are manifest at pipe elbows, particularly where the sheer velocity of corrosive fluids is high, and causes the removal of otherwise passivating corrosive films.

All Hydrosteel 6500 probe plates are deformable in one direction, enabling the entire probe to closely contact the surface of a cylindrical object such as a pipe. If that surface is curved in two dimensions, as with a domed vessel or curved pipe, then the probe is liable to crease (imagine a piece of paper pressed on the test surface). However, because the probe, particularly the SR and HT-S probes, are only ~2.5 in (60 mm) in diameter, they can accommodate some pipe curvature. It may also be possible to monitor hydrogen flux just downstream of a pipe elbow, such as position A in the diagram below. It should also be noted that there is less two-dimensional curvature at position B than position C. The ‘tolerance’ to two curvature of pipe elbows is given in the table below.

Pipe Radius	Probe Position	LR and AT-S minimum elbow radius	SR and HT-S minimum elbow radius
6-10 in.	A	any	any
6-10 in.	B	N/A	24 in
6-10 in.	C	N/A	32 in
> 10 in.	A	any	any
> 10 in.	B	45 in	18 in
> 10 in.	C	60 in	24 in



For domed surfaces, the curvature is generally least at the top of the dome. Curvature corresponding to a radius of 60 in is acceptable for the large LS and AT-S probes, 24 in for the small SR and HT-S probes.

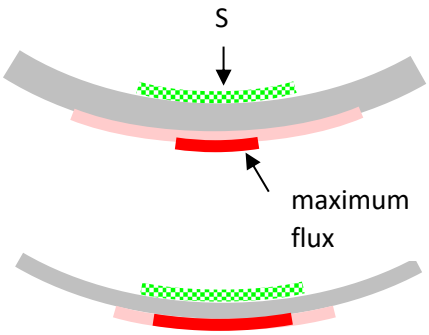
Steel wall integrity: delamination and blisters

Hydrogen flux measurements are often undertaken at sites where steel has previously been prone to hydrogen damage. The damage is caused by the very hydrogen that permeates steel, and therefore hydrogen flux is strong evidence for prospective active hydrogen damage. However, once the steel is delaminated or cracked, further permeation of hydrogen to the outside wall is considerably retarded by the intervening cavity. (Even though hydrogen pressure in a blister may be a few hundred bar this is tiny as compared to the activity of hydrogen in steel that causes cracking, chemically equivalent to 10^6 bar).

Flux dispersion through wall

Hydrogen flux entry due to corrosion in a steel pipe or vessel may be very localised. This is particularly true where corrosion is determined by a surface condition, such as condensation, wetting, or the absence of a passivating scale, or due to salt deposits. Flux measurements should therefore be undertaken outside the boundaries of any identified hydrogen blisters or delamination.

The flux permeating through steel from a corrosive zone disperses sideways. The effect is exacerbated by the preferential diffusion parallel to the steel surface, caused by the elongation of steel grains and enhanced hydrogen permeation in that direction. The accompanying diagram shows schematically hydrogen permeation spreading from very localised source S, in two pipe sections of different thickness. It can be seen that in the case of the thick walled pipe, the dispersion of hydrogen effects the magnitude and variation of flux exiting the steel. This must be considered particularly when measurements relating to localised corrosion on steel of thickness greater than ~5 cm.



Installation of AT-S and HT-S probes

Pre-requirements

In the field, the site of fixed monitoring should be identified, following attention to the previous section on *Appropriate sites for flux measurements*.

Insulation and cladding over a target measurement site must be removed before mounting fixed probes. For pipes and vessels of less than ~32 in., 80 cm diameter, probe attachment is usually achieved with banding. 12 mm stainless steel banding is recommended. A circumferential strip of cladding of at least 12 in, 30 cm in width is removed prior o probe installation.

Banding may be cut to length before relocation to the installation site. To affix an AT-S or HT-S probe, two equal lengths of will be fitted around the pipe or vessel circumference. The banding will be cut to sufficient length to completely encircle the pipe with at least 30 cm extra length to spare.

For diameters larger than ~32 in or other reasons, affixing the probe with banding becomes impractical, and instead, four magnets per probe should be used instead to attach the probe to the steel surface, following removal of at least 12 in, 30 cm circle of cladding centred on the intended probe location.

A hot work permit is not normally required for installation of Hydrosteel fixed probes as the installation is non-electrical, and non-intrusive. It is worth taking the fixed probes to the target site in their foam cases to prevent damage.

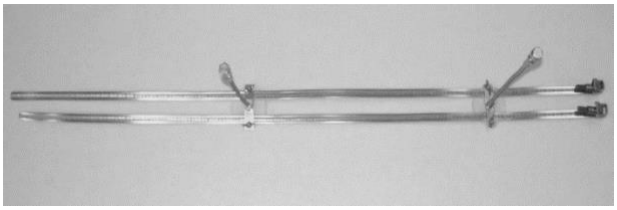
Installing fixed probes with banding.

Use banding, is recommended as above, together with a band tensioning tool or banding kit. A stiff wire brush may be needed to remove loose rust from the test site if necessary.

Step 1: Check again that the entire circumference of the target pipe section's surface is free from detritus. Check the probe site itself is is free from loose rust, grooves or ridges – for example, due to a weld seal. . Use the wire brush to remove residual rust if necessary. Relocate the site for the prove to avoid grooves and ridges.

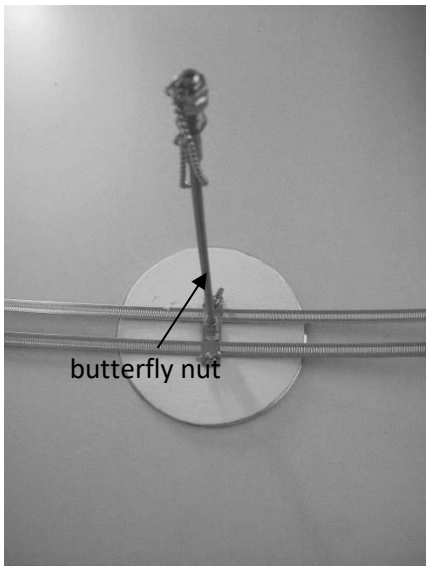
Step 2: Pass one length of banding round the pipe circumference and cut to 12 in, ~30 cm excess length if necessary.

Step 3. Thread the banding through one of the probe banding slots (see illustrations) through the banding.



A pre-prepared assembly, comprising two HT-S probes, showing how banding is threaded.

AT-S probe with banding fitted

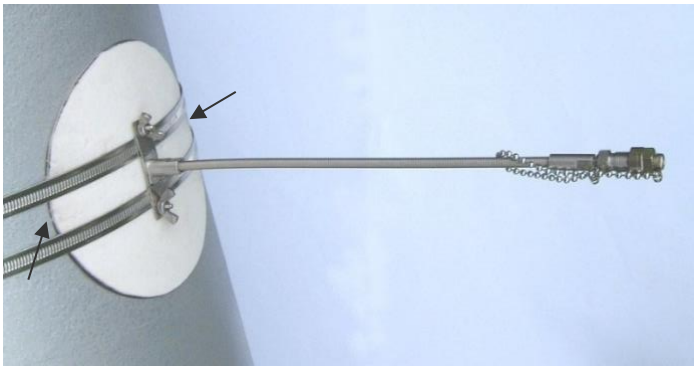


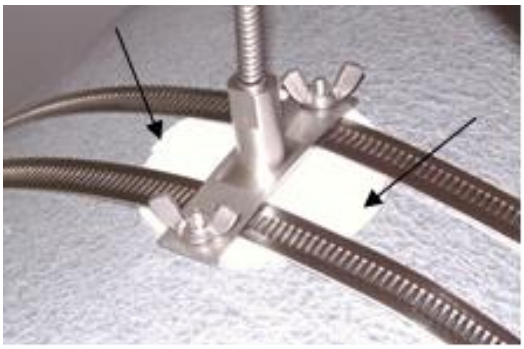
Step 4. Connect the banding ends and tension according the manufacturer's instructions. During this critical step, it is helpful for assistance in keeping the probe and banding in approximate position.

*Step 5.*Repear steps 2 to 4 with a second banding length.

Step 6. Ensure the two banding lengths are parallel and snuggly fit against the steel surface over its entire circumference. Re-tension both banding lengths. Tighten both probe banding slot butterfly nuts.

Step 7: Check that the probe is held correctly in position by the banding, and fully pressed against the entire surface I contact with it, particularly at the probe perimeter points identified in the accompanying diagrams.



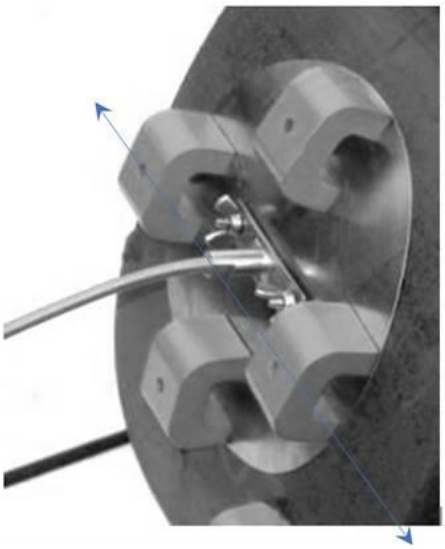


Step 8. If the steel is to be clad, loosely place insulation over the steel circumference. Allow a few minutes to allow for banding to heat up and expand, before re-tensioning the banding for a final time.

Step 9. Make sure the probe cap is in place. During recladding, press insulation layers over the collector capillary conduit so that the probe capillary punctures through it. Make a slit or hole in the cladding cavity to enable the probe capillary to emerge approximately radially from the pipe. In this process, be assured that the capillary conduit will withstand several distortions to about 2" radius during re-insulating and cladding; the main concern should be that the collector plate is firmly in place and is not distorted by tugging of the capillary conduit. Often, an inspection port is fabricated at the probe location as illustrated.



Installing fixed probes with magnets.
Four unpainted 40 x 25 x 25 mm Alnico horseshoe magnets can be used in place of banding to fix he probe to steel at a temperature less than about 350 °C. Arrange magnets as shown in the illustration: arrows indicate the axis of symmetry of the vessel or pipe.



Instrument warranty and service

Warranty

Standard Warranty can be extended to up to 1 years on the Hydrosteel 6500 when registering your instrument via our website: https://www.ionscience.com/gas-and-leak-detectors/customer-support/register-your-instrument/

To receive your Extended Warranty, you need to register within one month of purchase (Terms and Conditions apply). You will then receive a confirmation email that your Extended Warranty Period has been activated and processed.

Service

At Ion Science we recommend that all of our gas detection instruments be returned for service and factory calibration once every 12 months.

Note: the instrument's rechargeable batteries should not commonly require replacement during the lifetime of the product. If they do, they should be only be replaced at an approved service centre in a safe environment.

Contact Ion Science or your local distributor for service options in your area. Do not attempt analyser repairs as this may invalidate the instrument certification and warranty.

Find your local distributor by visiting: www.ionscience.com

Contact details

ION Science Ltd – UK/Head Office

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Hydrosteel 6500 Specifications

Dimensions	
Analyser:	320 x 150 x 100 mm
Probe extension:	15 cm high x 150 mm dia.
Collector:	20 cm high x 150 mm dia.
Analyser weight:	3.1 kg
Power requirements	
Batteries:	2 x 3.8 V internal Li-ion
Time operable with batteries:	70 hr accumulated operation
Environmental operating conditions	
Hydrosteel 6500 1 Port model Ambient temperature range:	-40°C ≤ Ta ≤ (+60°C (Normal) +45°C (during charge)) EX I 1M Ex ia I Ma
Hystosteel 6500 4 Port model Ambient temperature range:	-20 °C to +60 °C, -4 °F to 140 °F Ex II 1 G Ex ia IIC T4 Ga
Measurement surface:	Steel of >3.5-inch diameter cross section. temperature range < 230 ˚F (110 °C) 265°F (130°C) is possible for quick spot measurements only.
Test gas pressure tolerance:	±5% ambient pressure
Test gas humidity tolerance:	continuous 15% to 100% non- condensing, <15% for a few hours

Notes: *Volumetric specifications are quoted at 20 °C and one atmosphere ambient pressure.*
Pre-set input flow, deploying 27-inch (70 cm) gas sampling conduit and LT-R collector unless otherwise specified.
1 pL = 10^{-12} litres

Full range:	*0-2500 pL/cm²/s.*		
Resolution:	*< 2 pL/cm²/s hydrogen emanating from steel*		
Linearity:	*Linear over full range*		
Reproducibility:	*5% or 1 pL/cm²/s, whichever is greater.*		
Rate of response:			
%FSD	***1%***	***50%***	***90%***
27-inch (70 cm) conduit	*8 s*	*24 s*	*42 s*
78-inch (200 cm) conduit	*17 s*	*36 s*	*55 s*
Cross sensitivity *(versus hydrogen = 100%):*			
CO <1%; H_2S <20%; NO, <30%; C_2H_4, 80%			
Relative response *(versus100 ppm @ 20 °C = 1.00):*			
30 °C = 1.03; 40 °C =1.11; 50 °C =1.21			
Pre-set input flow rate:	*30 ±1 mL/min*		
Background signal drift:	*<50 pL/cm²/s equivalent per year,* *<1 pL/cm²/s per hr.* *< 0.5 pL/cm²/s per °C*		

Operating lifetime:	*sensor, 1 year pump, >1500 hr*

Trouble shooting guide

Error	Criteria	User advice	Causes:	Service advice
Flow errors:				
Line X blocked	Pabs > 20 mBar for 15 s	Ensure probe connected to inlet, press ↻	Nothing plugged in to inlet ports	
		Clear blockage, press ↻	Line blocked (water, rust?)	Test valves for correct switching
		Try different conduit (i.e. unblocked one)		
		Try shorter conduit	Conduit too restrictive > 10 m	
	If only one line:	Return to service	Filter blocked	Replace filter
Line X Low pressure	Pabs < 1 mBar for 60 s	Return to service	Pump fail - no pressure generated	Replace pump
			Piping disconnect upstream of pump	Verify all piping connected correctly
			Severe blockage of restrictor	Inspect and replace restrictor (and filters)
			Output port fully blocked	Inspect and replace tubing downstream of pump
Line X Flow fault	Flow error > 20% for 90 s	Return to service	Pump fail - max flow too low (leaky or valv	Test and replace pump
			Output port partially blocked	Inspect and replace tubing downstream of pump
Power on errors:				
SD card	Some SD card failure	Return to service?	SD card ejected	Reseat SD card
			SD card failed	Replace SD card, recalibrate.
Flow temp sensor	No I2C comms with pump	Return to service?	Cable loose, or electroincs failure	Replace cable, or replace pump + sensor board
Pump Control	No I2C comms with pump	Return to service?	Cable loose, or electroincs failure	Replace cable, or replace pump + sensor board
Sensor temp sensor	No I2C comms with sens	Return to service?	Cable loose, or electroincs failure	Replace cable, or replace pump + sensor board
Battery low	Battery < 5%	Charge device, ~3 days operational left*	Battery flat, battery cold	Charge device
Battery Flat	battery < 3.3 V	Charge device according to manual	Battery flat, battery cold	Charge device