FDR020

Document: MN-FDR020-G

Radioactive Fluid Density Tool

RADIOACTIVE FLUID DENSITY TOOL

$1^{11}/_{16}$″, ULTRAWIRE™ TELEMETRY

Operational & Maintenance Manual

Date: 10th March 1993

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0 ABOUT THIS MANUAL

0.1 MANUAL HISTORY

Date	**Issue**	**Description**	**Auth**	**Chk**	**App**
10/03/93	A	Original for $1^{11}/_{16}''$ tools.	RLH		RLH
01/01/97	B	Revised.			RLH
23/01/01	C	Revised and reformatted to use new templates.	PJ/DO	PJ	PJ
02/05/02	D	Updated to include FDR020 $1^{11}/_{16}''$ Tool.	SA	DO	RLH
10/02/06	E	Drawing/PL/CD updates: ECR1795, 2598, 1991, 2447, 2517, 2861, 2864.	FV	SA	RLH
20/02/07	F	ECR3920, 4074, 3962.	FV	RLH	RLH
16/05/08	G	Drawing updates: ECR4285 (AD-09455)	FV/RS	TG	TG

0.2 UPDATES TO BE USED WITH THIS MANUAL

Consult the CD Directory for the appropriate Manual Updates to be used with this Manual.

0.3 TECHNICAL HELP

For further technical help contact Sondex as follows:

Address: Unit 1, Saxony Way,
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0.4 FEEDBACK

Please help us improve future issues of this manual by sending your comments or corrections to Documentation-UK@sondex.com, referencing the document number.

Thank you.

Photographs and sketches are for illustration purposes only. Depending on the tool model that you have, certain features or dimensions may differ from those shown.

Documents from external sources (i.e. MSDS), supplied with/referenced in this manual, are considered the latest version at time of manual issue. However, the document can be altered by the external source without prior notice to Sondex.

1 EQUIPMENT

The Sondex FDR020 (Fluid Density Radioactive Tool) provides a reliable, durable and comparatively safe means of measuring fluid density at all well deviations and flow rates. The tool uses a low energy Americium-241 gamma ray source, with low radiation levels, and a scintillation gamma-ray detector. The tool has an outside diameter of $1^{11}/_{16}''$. The design of the tool provides very high count rates, which provide excellent statistics. The detector of the tool is shielded to reduce interference of radioactive scale.

Figure 1.1 FDR with Shield Fitted

Gamma rays, emitted by the RA source at one end of a measuring cell through which the well fluid passes, are detected at the opposite end by a scintillation detector and photomultiplier. The count rate is a logarithmic function of the fluid density. The detector is temperature stabilised and matched to the gamma energy of the source. The tool may be calibrated in air and fresh water, using Sondex supplied multipliers, to derive calibration values applicable to oil and salt water densities.

The electronics interface to the Sondex Ultrawire toolbus for use in memory or surface readout PL toolstrings. The single conductor passes through the tool carrying telemetry and power.

A radiation shield is provided, which can be locked on the tool, so the source can be left in in the tool between jobs.

1.1 PURPOSE

The purpose of the FDR is to measure fluid density of a sample as it flows through the tool. The average density of this volume is measured whether the flow is single or multiphase.

An increase in the average fluid density in the sample volume causes a reduction in received counts.

This measurement can be used to determine the proportions of two phases of different, but known, densities in a two phase fluid mixture. For example, water fraction may be calculated. If the total fluid mixture flowrate and the slippage of one phase relative to the other are also known, the calculations can be made to determine the flowrate of each of the two fluids along the axis of the well.

Note that fluid density outside the sample volume is not measured. The measure cavity is asymmetrical to prevent preferential hold up of a single phase.

1.2 APPLICATIONS

- Multiphase production profiling.
- Fluid Identification.
- Horizontal and highly deviated wells.
- High fluid flow rates.

1.3 SPECIFICATION

Parameter	FDR020	Remarks
Temperature (max)	177°C	
Pressure (max)	15,000psi	
Diameter	$1^{11}/_{16}$″ (43mm)	
Make-up Length	23.0″ (584mm)	
Shipping Length	26.8″ (680.7mm)	
Measure Point	4.3″ (109.2mm)	Measured from lower joint.
Weight in air	9.6lbs (4.36kg)	21.6lbs (9.8kg) in shield.
Operating voltage:		
Nominal	+18.0V DC	
Specified	+13.0 to +23.0V DC	
Absolute Max	+24.0V DC	
Current consumption at +18V	35mA	Typical.
Density:		
Range	0 to 1.25g/cc	
Resolution	0.01g/cc	
Accuracy	0.03g/cc	Based on 2% statistics and 2% drift.
Acquisition time	1 sec	Typical.
Radioactive source:		
Material	Americium 241	
BSI/ISO classification	C66544	GSR01 100mCi single encapsulated source or GSR02 150mCi double encapsulated source.
Detector:		
Type	NaI scintillation crystal	
Sensitivity threshold	20keV approx	
End threads (top/bottom)	$1^{3}/_{16}$″ UNF	(female/male)
End connectors (top/bottom)	4mm single conductor	(male/female)
Shield:		
Weight	12.0lbs (5.4kg)	
Length	10.5″ (266.7mm)	
Outside Diameter	2.8″ (71.1mm)	

2 SAFETY

2.1 RADIOACTIVE SOURCE

Warning! **RADIATION HAZARD!**

ALL LOCAL RULES AND REGULATIONS COVERING THE POSSESSION AND USE OF RADIOACTIVE MATERIAL MUST BE OBSERVED.

The tool uses a low energy 150 millicurie gamma ray Americium 241 source. This is only $^{1}/_{50}$th of the activity of sources used for open hole density measurement and with an energy ten times lower. A metal thickness of only 6mm is required for effective screening. Except while logging, radiation is held to very low levels by the Radiation Shield supplied with each tool. This shield provides a minimum wall thickness of 0.55″ in addition to the housing of the tool.

Radiation time should be kept to a minimum.

Distance and shielding should be maximised.

The source is highly directional so should be kept pointing away from personnel.

To ensure minimum exposure, the handling procedure is to leave the source in the tool and to further enclose it in the Sondex Radiation Shield, rather than installing and removing the source for every logging operation. The Shield is removed prior to logging. The greatest radiation risk occurs when the source is being transferred since shielding and distance to the operator are at a minimum. Any local rules must be observed.

Correct handling procedures and use of shields is essential. Source installation, use and removal of the Radiation Shield is described in *Section 4.1 Radioactive Source*.

DO NOT hold the tool close to the fluid entry slot.

The source is supplied by QSA International and their safety information must be studied before using the tool or unpacking the source. Refer to *Safety Instructions and Handling Instructions for Radioactive Sources and Radioactive Solutions (HI001)* for unpacking and use of low energy gamma and beta sources for more information.

Warning! **THE SOURCE MUST ALWAYS BE SHIPPED IN AN APPROVED CONTAINER.**

2.2 LOSS OF TOOL

Local rules must be observed with regard to loss of radiation sources.

2.3 CHEMICAL HAZARD

Warning!	The scintillation detector contains Thallium doped Sodium Iodide. **Thallium is a poison** and should the detector become cracked or otherwise leak, it must be packed in a sealed container and disposed of properly according to local regulations in force.

Old detectors, which are no longer in use, must also be disposed of properly.

2.4 HIGH VOLTAGE HAZARD

Warning!	High voltages (1.6kV) are generated in the Detector section HV PSU, which is sufficient to cause unpleasant shocks.

Care should be taken not to touch exposed HV components when removed from the housing, if power is applied. Test probes should only be moved when the line power is off.

A short circuit may also cause serious damage to the tool.

2.5 CARE OF PHOTOMULTIPLIER TUBE

Caution!	The Photo-multiplier Tube (PMT) **must** be kept in total darkness whenever the tool is powered up or the tube will be permanently damaged.

The PMT is a glass vacuum tube device which can be damaged by severe shock, particularly when dismantled from the Detector Pressure Housing.

Caution!	Do not store FDR with CCL or other magnetic tools. Keep at least 1 foot apart. Magnetic field may magnetise the pressure housing and seriously reduce FDR sensitivity.

2.6 HOT WORK

Warning!	**HOT WORK!** Sondex equipment may, under certain circumstances or failure modes, become a potential source of ignition. Using it must therefore be considered "HOT WORK" and appropriate precautionary procedures should be followed when testing at surface in areas where there is a risk of gas leaks or other potentially explosive atmospheres.

2.7 IRRITANTS

Liquid O-ring

LOR101 is used for lubricating the tool during maintenance. Contact with skin or eyes can be harmful. For more details, refer to the Material Safety Data Sheet for Liquid O-ring.

2.8 ELECTRO STATIC DISCHARGE

Caution!

Electro Static Discharge (ESD)

All tools with electronic boards that contain solid state circuits (transistors, diodes, semiconductors) may become damaged when contacted with an electrostatic charge.

When handling tools, which contain electronic parts that are ESD sensitive, the following guidelines should be followed to reduce any possible electrostatic charge build-up on the user's body and the electronic parts:

- Always ensure proper ESD precautions are taken when handling electronic parts that are ESD sensitive during maintenance.
- Avoid touching the tool electronics, unless stated otherwise in this manual.

Note that ESD is less likely to affect tools when the housing is fitted.

3 THEORY OF OPERATION

3.1 BLOCK DIAGRAM

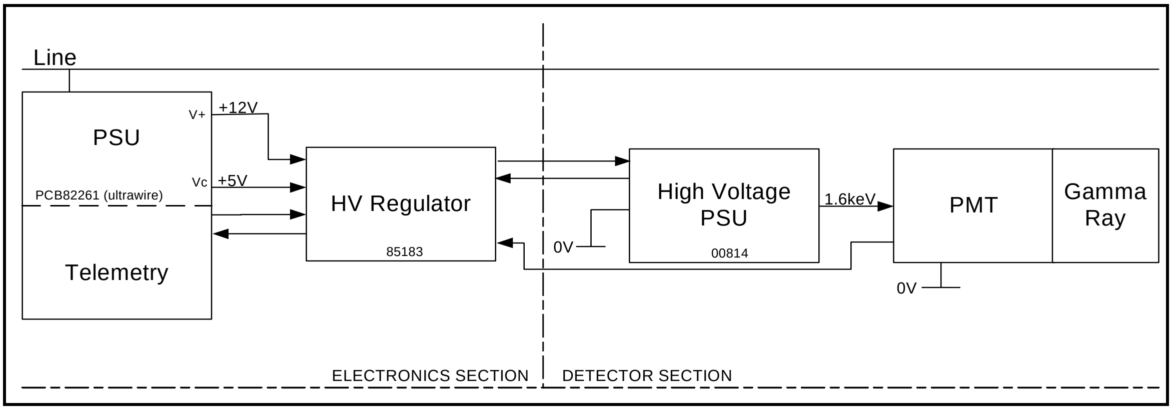


Figure 3.1 FDR Block Diagram

3.2 DESCRIPTION

3.2.1 DENSITY MEASUREMENT

The Fluid Density Radioactive tool measures **Electron Density** (ρ elec) and, by inference, the mass density of the fluid type. Oil, Gas and Water each have different densities, thus the FDR may be used as a fluid identification tool for all phases. When the downhole end point densities of the fluids are known, the tool can be used for quantitative calculation of phase holdups (fractions of each phase).

Compton scattering of gamma rays is done by the electrons surrounding each nucleus. In most elements, the number of electrons is close to half the number of neutrons and protons. However, in hydrogen the ratio is 1:1, which is important in well fluids as hydrogen is the principal component of water and hydrocarbon. Find below a table of comparisons of electron density (measured by the tool) and actual mass density. Note that the density of gases also depends on pressure. Approximations of ratios of measured density to actual density are tabulated below for several fluids.

Fluid	**Electrons**	**Atomic Mass**		**RATIO**
		Apparent	**Actual**	**($\rho_{ELEC}/\rho_{ACTUAL}$)**
Hydrogen (H_2)	1	2	1	2.000
Fresh water (H_2O)	10	20	18	1.110
Paraffins ($n[CH_2]$)	8n	16n	14n	1.143
Benzene (C_6H_6)	72	144	108	1.333
Methane (CH_4)	10	20	16	1.250
Ethane (C_2H_6)	18	36	30	1.200
Butane (C_3H_8)	26	52	44	1.182
Air ($0.2O_2 + 0.8N_2$)	14.4	28.8	28.8	1.000

For added safety, the tool uses a low power, low energy Americium 241 gamma ray source. The source is at the bottom of the tool, adjacent to a scintillation gamma ray detector. Between the source and the detector is a window, through which well fluids are directed.

High density fluids absorb more gamma rays, hence a low number of arrivals at the detector is indicated, low density fluids absorb less gamma rays hence a higher number of arrivals can be sensed. Because the emission of the gamma rays from the source is spontaneous, a certain amount of scatter (statistical variations) in the data is present.

This may be reduced by filtering, however Sondex does not recommend to filter by more than a 5 foot interval. Background counts make a negligible contribution, except in cases where radioactive scale has built up on the casing.

The relationship of the logarithm of the tool response (counts) to density is approximately linear over the density range 0.0 to 0.90g/cc. Well fluid with a density greater than 1.0g/cc is almost always associated with high concentrations of sodium chloride, as in brine. Above 1.0g/cc, the logarithmic response is also linear, but the high concentration of chlorine ions tends to absorb gamma rays, which changes the slope of the response (refer to *Figure 3.2 FDR Tool Response* below, based on a study of different well fluids).

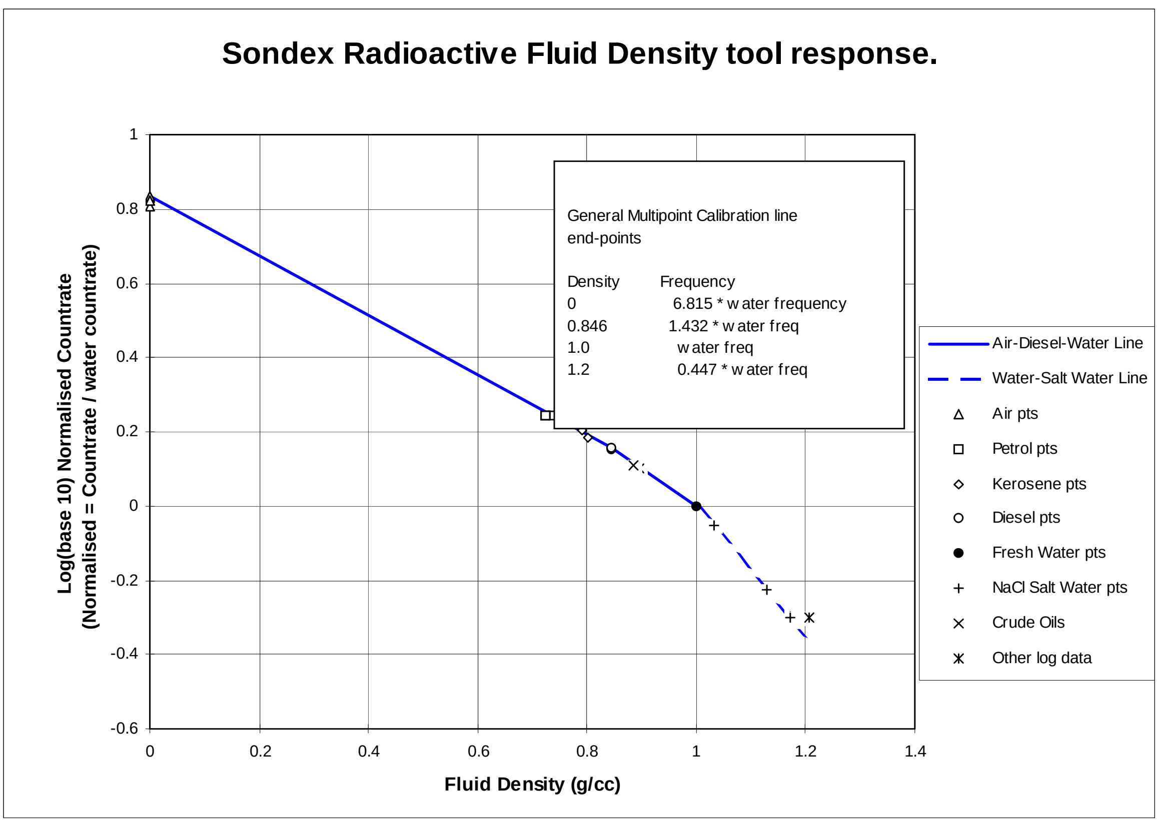


Figure 3.2 FDR Tool Response

When working with more than 2 phases, Sondex recommends to use the multi-point, semi-log calibration option in the software (see *Section 4.3 Calibration*). However, if only two phases are present in the well, a 2 point calibration will give better results, provided the end points correspond to the densities of the actual well fluids. If the operator is unsure which method to use, Sondex recommends to use the multi-point calibration method. If the change in response with salinity is not accounted for, the calculated density in salt water will be too high.

For example in a well with true density 1.13g/cc: If a 2 point air - fresh water calibration is applied the resulting calculated density is 1.21g/cc which is 0.08g/cc too high!

Note that the tool response is changed by the presence of chlorine ions, but that the readings can also be affected by other salts in the fluid. Therefore, if the well pressure is completely static during the job, the quartz pressure gauge in the PL toolstring can be used to perform a pressure gradient survey. After correction for well deviation, calculated density from the pressure gradient may be compared with measured density for a quality check.

3.2.2 STATISTICAL VARIATION

The FDR tool is subject to the normal statistics, associated with radioactive decay.

Note: The statistics refer to the ‘raw’ detected counts.

Statistical variation depends on the standard deviation (σ). For a Normal distribution, the σ is the square root of the number of counts in the sample.

The σ defines a confidence level: 1 x σ defines a 68% level and 2 x σ, 98%.

Example 1:	If 10,000 raw counts were detected in a 1 second sampling interval, you would be 98% confident that the true long term count rate was in the range 9,800 - 10,200 counts/sec.
Example 2:	If 40,000 raw counts were detected in 100 seconds, you would be 98% confident that the true long term count rate was in the range 396 - 404 counts/sec.

3.2.3 RADIOACTIVE SCALE

The previous density calculation assumes that the detected counts all originate from the tool’s Americium source. This calculation requires that any background counts (source removed from the tool) are subtracted from the ‘logging’ (source installed) count rate. This is not performed, since background counts are usually negligible compared to those from the source. If this is not the case, the measured count rate will be higher than expected count rate, corresponding to a lower than true density being calculated. In low densities, however, high background can mask the Americium counts, causing an apparent increase in density.

Wells have been logged where a highly radioactive scale has caused a density error of 10-20%. Therefore, Sondex has introduced an approvement in this tool, which eliminates 90% of the false counts due to scale (or error). In addition, there is a second available layer of protection, which can be added as an option: the ‘side cheeks’. This additional protection, although provided with every tool, does not need to be fitted, unless a persistent radioactive scale effect is sensed with the basic tool. If required, Sondex can provide advice on this topic when it is encountered.

3.2.4 GAMMA DETECTION

A gamma ray, passing through the sodium iodide crystal, may excite an atom sufficiently to cause a photon of light to be emitted. A photon of light striking the photo-cathode in the photomultiplier tube (PMT) may emit one or more electrons. As there is a potential difference of approximately 130V between dynodes in the PMT chain, any electrons emitted will be accelerated onto the next and the collision causes an increasing amount of electrons to be emitted. These are accelerated onto the third and multiplied as well. The 10 stage multiplication will thus provide in the order of 5^{10} electrons per photoelectron leaving the cathode. This is a measurable charge pulse.

3.2.5 ELECTRONICS

The HV PSU generates the +1.6kV Anode potential. A resistor network distributes this over the PMT Dynodes.

The PMT anode output pulse is AC coupled and wired through the HV PSU to the detector electronics. Here the charge pulse is amplified and detected by a comparator. The threshold is set for best temperature stability. High energy pulses are not counted if they trigger a second comparator.

Gamma detections are stored in FPGA logic and read out over the Ultrawire toolbus in response to requests from the Telemetry Controller e.g. MPL, XTU or other Crossover. Various commands are supported in the protocol.

4 OPERATING PROCEDURE

Warning!	**RADIATION HAZARD!**
	IF YOU HAVE NOT READ *Section 2 Safety*, DO SO NOW.

4.1 RADIOACTIVE SOURCE

4.1.1 INTRODUCTION

Ref.: Radioactive Source Transit/Storage Kit *09432*

The GSR003 Gamma Ray Radioactive Source assembly comprises:

- Americium 241 source in a holder ready to fit into FDR tool.
- Small lead pot for source holder.
- Stainless Steel storage pot.
- Yellow plastic transport case with lock.
- Handling tool.

The source, contained in the lead pot, steel storage pot and locked transport case is approved (certified) for transport.

The source in lead pot and steel pot may be removed from the yellow transport case for storage in an approved radioactive locked safe.

The source should be removed prior to any servicing of the Sensor section, and prior to fitting or removal of the cheeks. Proper safety procedures must be observed.

4.1.2 RADIATION SHIELD

The shield must be fitted to the tool whenever the source is installed, except when the tool is logging.

1. Before fitting the shield, check the inside is clean and the O-ring is fitted.
2. The female thread protector must be removed from the bottom of the tool.
3. Ensure the two O-rings on the bottom of the tool are undamaged.
4. Remove the padlock and pin.
5. Push the tool into the shield and pass the pin through the shield and tool fluid sample slot.
6. Secure with padlock.

Note: The locking pin absorbs radiation passing up the tool axis.

The tool is a push fit and is not screwed into the shield.

4.1.3 Side Cheeks

FDR020 is shielded from radioactive scale. However, additional shielding can be added by fitting the optional side cheeks. Cheeks should be needed in rare cases only and should not be assumed to be standard. The source must be removed while fitting or removing the side cheeks.

Warning!

RADIATION HAZARD!

Ensure the source is removed before fitting and removing the cheeks.

The side cheeks reduce the rate of fluid flow through the slot.

Both installation and removal are easier with the tool horizontal and one side of the sample slot facing upwards.

Installation involves placing the relevant cheek into the slot, lining up the holes and inserting the pin. Turn the tool over (i.e. rotated 180º around the axis) and perform the same operation for the other cheek.

Removal of the cheeks is exactly the reverse, again ensuring first that the radioactive source has been removed from the tool. When the two cheeks and 4 pins have been removed, they should be carefully preserved in a sealable plastic bag for possible future use.

4.2 PRE-LOGGING CHECKS

4.2.1 Mechanical

1. Clean and grease upper and lower O-ring seals. Replace O-rings if damaged.
2. Ends of fluid slot should be clean.
3. Ensure that upper and lower electrical connectors are clean, dry and undamaged.

4.2.2 Electrical

1. Using a Multimeter, measure the upper to lower pin resistance. Should be less than 0.5Ω.
2. Using a Multimeter, measure the pin (+ve probe) to housing (-ve probe) resistance. Should be between 3 - 4MΩ, depending on the meter.

4.2.3 Operating

The operating checks can be omitted if a wellsite calibration is performed, see *Section 4.3 Calibration*.

The FDR must be electrically connected to a toolstring controller for power and control, or sync generator and 12V PSU. Checks can be made without assembling the complete logging system. The source is required to be fitted in the tool.

1. **High density:** Radiation shield including locking pin fitted, or other high density material in the sample volume slot. The raw count rate will be similar to background, e.g. less than 10 counts per sec.

2 **Low density:** With the locking pin removed from the sample slot, a high count rate should be observed. The reading should be within 1% of the last calibration air reading.

4.3 CALIBRATION

This should be performed in the shop to check the tool. The tool response can be derived from the calibration check. This would normally not change. At the wellsite, only the reading of the tool in water and air, before and after logging, requires checking.

1. Screw on the lower female thread protector to provide a waterproof seal.
2. With the tool held vertically, record at least 100 secs of the tool reading in as many of the following as possible; air, petrol, kerosene, diesel, fresh water and a strong salt solution. A minimum fluid depth of 30cm (12″) is required.
3. Measure the density of the liquids with a hydrometer.
4. Normalise each count rate by dividing the countrate by the countrate in fresh water. Take the logarithm to base 10 of each normalised countrate.
5. Compare the log normalised tool response with the example of generalised multipoint calibration. If it does not match the example, contact Sondex.
6. The detail of calibration to engineering units is dependent on the user’s data acquisition system. The following relates to calibration, using Sondex’s MEMLOG software.
7. Create an ASCII file, named ***<tool number>.FDR***, to be used as the multipoint calibration when converting the log data to density with VISUAL MERGE.

Density	Countrate (cps)	Comments
4		4 lines of data in this file
0.0012	Countrate of the tool in air	Enter the countrate in cps
D	Countrate in diesel D g/cc	Enter D and countrate in cps
1.00	Countrate in fresh water	Enter the countrate in cps
S	Countrate in salt water of density S g/cc	Enter S and the countrate in cps

Note: The mixing of oil/water mixtures in the presence of air tends to trap air in the mixture, which can render the calibration inaccurate even if the density of the mixture is also measured with a hydrometer.

The FDR response to chlorine (in salt waters) is to indicate that the salt water is more dense than it really is. Consequently, one of the calibration points for the FDR should be in the salt water, to be found downhole if at all possible. Note that actual density of the air depends on the pressure.

Fluid	Actual Density g/cc	Ratio	Electron Density (Measured by FDR)
Fresh water	1.000	1.110	1.110
Kerosene (n[CH_2])	0.790	1.143	0.903
Benzene (C_6H_6)	0.843	1.333	1.124
Air (0.2O_2 + 0.8N_2)	0.0013	1.000	0.0013

4.3.1 EXPECTED READINGS

The absolute countrates will vary with source strength and position, but the ratio of the readings according to the fluid density should be repeatable and of the following order of magnitude.

Density	Fluid	Relative count rate (water = 1)
ρ = 0.0012 g/cc	(air)	6.815[a]
ρ = 0.846 g/cc	(paraffin oil)	1.432[a.]
ρ = 1.00 g/cc	(water)	1.000
ρ = 1.20 g/cc	(salt water)	0.447[a.]

a. These ratios are approximate and should be measured for each tool prior to use in a multipoint semi log calibration file, see *Section 4.3 Calibration* above.

4.4 CONNECTING TO TOOLSTRING

Upper and lower tool joint O-rings and seal surfaces should be clean, undamaged and lightly greased.

The FDR may be inserted into the toolstring in any location. The tool may require centralising since it should not run in contact with casing, which will reduce the fluid flow through the sample volume. The fluid composition away from the centre may be less representative of the average, especially in deviated wells.

Warning!

REMEMBER - THIS TOOL CONTAINS A RADIOACTIVE SOURCE

Follow any local rules concerning signs and precautions, see *Section 2 Safety*.

4.5 LOGGING

See also: *Section 3.2.2 Statistical Variation*
Section 3.2.3 Radioactive Scale

The following are guidelines only and must be used in conjunction with local policy and specific well site conditions both downhole and at surface. The table below is appropriate for near vertical wells and must be adjusted accordingly when in deviated wells. Use of a Head Tension Unit is highly recommended.

Note: Do not exceed the calculated safe working load of your selected weakpoint. If in doubt, use a head tension unit, especially in deviated wells where calculation from surface tension is less accurate.

Depth (ft)	Speed Pulling Out of Hole	Speed Running in Hole
In/out of catcher (pressure rig up only)	Dead slow or manual.	
30 to 150	30ft/min	
150 to 400	60ft/min	
>400 clear cased hole	Surface tension not to exceed 120% of tension when tool stationary. Speed not to exceed 150ft/min.	Surface tension should not be less than 80% of tension when tool stationary. Speed not to exceed 150ft/min.
>400 clear open hole	Surface tension not to exceed 130% of tension when tool stationary. Speed not to exceed 150ft/min.	Surface tension should not be less than 70% of tension when tool stationary. Speed not to exceed 150ft/min.
Approaching potential obstacles[a]	30ft/min	
Logging Data	**Do not exceed the above speeds.** Recommended speed is <30ft/min.	

a. For example: Reduced diameters, gas lift mandrels, fluid levels, valves, tubing shoes, packers, cross overs and other downhole equipment.

The tool should not run in contact with casing as explained in *Section 4.4 Connecting To Toolstring*.

4.5.1 STATISTICAL FLUCTUATIONS

The standard deviation of the counts received over the acquisition time limits the accuracy of the density measurement. This becomes worse as less counts are received. Data averaging over a longer time increases the accuracy. This time averaging determines the logging speed for a required depth resolution.

Statistical errors should not need to be considered except for acquisition times of less than 0.5 sec.

During the averaging time, the average fluid density is assumed constant. If this varies, e.g. in multiphase flow, a false low average density will be calculated. If the density (rather than the counts) is averaged from many short time intervals, a more accurate density will be derived. i.e. average the logarithm of countrates rather than calculating the logarithm of average countrate.

4.6 POST LOGGING DISASSEMBLY

The tool should be cleaned before the toolstring is disassembled.

Ensure that well fluid does not reach the electrical connectors. Disassemble in a horizontal position wherever possible.

Return tool to the Radiation Shield and fit the locking pin, the lower (female) thread protector must not be fitted. To ensure that the lower tool connection remains clean and dry.

Note: Ensure the Sensor section is dry before being inserted into the shield. Check the inside of the Shield is clean and dry before inserting the tool.

4.7 TRANSPORT, HANDLING & STORAGE

Store with end threads lightly greased and with water tight top (male) thread protectors fitted.

The tool may be stored and transported with the source fitted, providing the radiation shield is installed and the locking pin is fitted. The shield is an approved (certified) radioactive source container.

Alternatively the tool may be stored and transported with the source removed (see *Section 5.2.1 Radioactive Source Removal*) and the lower (female) thread protector fitted. The radioactive source must then be stored in the Sondex GSR003 container.

Caution! Do not store the FDR with a CCL or other magnetic tool next to it. Keep at least 1 foot apart. Magnetic field may magnetise the pressure housing and seriously reduce FDR sensitivity.

Caution! Do not subject tool to extreme shock, such as dropping or hitting with a hard object. Side impact is especially likely to damage the detector.

5 MECHANICAL DESCRIPTION

5.1 DESCRIPTION

The FDR020 comprises 3 main units, which remain screwed together, unless access to the interior is required. The radioactive source is inserted through the lower head.

Electronics Section

- Pressure Housing.
- Telemetry circuit board.
- HV Regulator and Detector circuit board.
- Upper End fitted with monoconductor pin.
- Lower End with 10 pin ‘Lemo’ connector socket.

Detector Section

- High Voltage PSU with 10 pin ‘Lemo’ connector plug.
- Photomultiplier/Sodium Iodide Crystal assembly.

Sensor Section

- Pressure Housing incorporating fluid sample volume and detector housing.
- Radiation Windows, which are integral and do not require any O-ring seals.
- Source Holder (containing source and intergral monoconductor socket assembly).

5.2 DISASSEMBLY

Warning!

RADIATION HAZARD!

IF YOU HAVE NOT READ *Section 2 Safety*, DO SO NOW.

5.2.1 RADIOACTIVE SOURCE REMOVAL

See also: *Section 4.1 Radioactive Source*

Ref.:	General Assembly	*09455*
	GSR003 Source & Transporting	*09432*

Notes:

- All item numbers refer to the General Assembly, unless stated otherwise.
- Remove the source from the bottom of the tool only.
- Only remove in a clean, safe, well-lit environment where any dropped items can easily be located, and cannot fall down inaccessible holes.
- Always use monitoring equipment.

1 Wash down the outside of the FDR before removing the source.

2 Clamp the tool horizontally over a flat floor. Expose the Retaining Ring (item 11) by removing the tool, shield or thread protector, attached to the bottom of the tool. **DO NOT** place hands on the tool near the source.

3 Open the Source Storage Container (item 3, 09432) and check it is clean.

4 Open the jaws of the source handling tool (item 6, 09432) into the castellations of the Retaining Ring (item 11). Unscrew the Retaining Ring (item 11) and carefully remove it, so as not to drag the source with it.

5 Firmly clamp the handling tool onto the source holder end.

6 Remove the source holder from the tool and place it immediately into the source carrying shield, without pointing the source at limbs or people.

Warning! **RADIATION HAZARD!**

7 Lock the source in the carrying shield.

8 Clean the bottom of the FDR, and replace the Retaining Ring (item 11) in its thread.

Note: When the source has been removed, there is no electrical connection to any tools below. A dummy source holder (non-radioactive) is available. However, Sondex does not recommend having dummy sources available, except in rare circumstances. Confusion between real and dummy source holders could be extremely dangerous.

5.2.2 TOOL DISASSEMBLY

Ref.:		
	General Assembly	*09455*
	FDR Quick Release Section	*02099*

Warning! The radioactive source must be removed before disassembly is attempted. Refer to *Section 5.2.1 Radioactive Source Removal*.

Caution! Ensure the Electronics Section is removed **prior to** unscrewing the Intermediate Bulkhead relative to the Sensor Body, refer to *Section 5.2.2 Tool Disassembly*.

1 Holding top of Detector Housing (item 2, 02099) with a 'C' spanner, unscrew Housing (item 1).

DO NOT allow Detector Housing (item 2, 02099) unscrewed relative to Sensor Body (item 1, 02099).

Note: The larger top chassis cover of the Electronics Cartridge (item 2) may be removed by removing 6x M3 screws, if required.

2 To remove the Electronics Cartridge (item 2) from the Detector Housing (item 2, 02099), screw 3x M6 Grub Screws (ref: 93265) **inwards** and pull cartridge away.

Note: **DO NOT** screw the Grub Screws too far inwards & **DO NOT** twist the Electronics Cartridge (item 2) as this may damage the connector on the HV PSU (item 4).

3 Unscrew Detector Housing (item 2, 02099).

Note: The Detector and HV PSU (items 3 & 4) remain fixed to the Sensor Housing (item 1, 02099).

Further disassembly is not recommended. Return the tool to Sondex if the HV PSU or Detector is faulty.

Warning! ***DO NOT*** disassemble the Detector section. Improper disassembly may cause damage to the wire line, which will render the tool inoperative. When a faulty detector is suspected, return to Sondex.

5.3 REASSEMBLY

Warning! **IF YOU HAVE NOT YET READ *Section 2 Safety*, DO SO NOW.**

5.3.1 TOOL REASSEMBLY

Ref.:	General Assembly	*09455*
	FDR Quick Release Section	*02099*

1 Check O-ring (item 14) on the HV PSU Assembly (item 4) and replace if required.

2 Check the O-rings (item 3, 02099 & item 5, 02099) on both sides of the Sensor Housing (ref: 02560) and replace if necessary.

3 Refit Detector Housing (item 2, 02099) onto the Sensor Housing (item 1, 02099).

4 Check the O-rings (item 4, 02099) on the Detector Housing (item 2, 02099) and replace if necessary.

5 Connect the Electronics Section (item 2) onto the HV PSU Assembly (item 4).

Note: Take care not to damage the pins of the connector and ensure the connectors mate properly. **DO NOT** twist the Electronics Cartridge (item 2) as this may damage the connector.

6 Screw 3x M6 Grub Screws (ref: 93265) **outwards** to secure the Electronics Cartridge (item 2)**.**

7 Check the O-ring (item 15) on the Electronics Section (item 2) and replace if necessary.

8 Tighten the Pressure Housing (item 1) onto the Detector Housing (item 2, 02099).

Note: Take care not to damage any O-rings.

5.3.2 RADIOACTIVE SOURCE INSERTION

See also: *Section 4.1 Radioactive Source*

Ref.: General Assembly *09455*
GSR003 Source & Transporting *09432*

Warning! **IF YOU HAVE NOT YET READ *Section 2 Safety*, DO SO NOW.**

Notes:

- All item numbers refer to the General Assembly, unless stated otherwise.
- The source-handling tool (item 6, 09432) is required for this operation.
- It is recommended that this procedure be practised without actually using the source before inserting the source into the FDR for the first time.
- Ensure the parts of the source handling tool are clean and working freely.
- Have suitable radiation monitoring equipment ready and in operation.
- Perform insertion over a flat surface without rains, gratings or other holes where the components will remain easily accessible if dropped.

1 Hold the FDR tool firmly horizontal with the bottom end at a height of about 3ft.

Note: Ideally this is achieved by clamping the tool into a vice or similar arrangement.

2 Check the condition of the lower head O-ring seals (item 5, 02099) and replace if necessary. This should be done now and not after the source is inserted.

3 Using the source handling tool as a "screw driver", unscrew the castellated source retaining ring (item 11) from the bottom recess of the tool.

4 Check and note that the retaining ring is firmly held by spring force on the outside of the jaws, when the jaws are adjusted to an optimum position. Place the retaining ring handy to one side. Open the jaws of the handling tool fully.

5 Ensure any dose-rate monitoring equipment is in place and operational. Have the FDR Shield (item 7) ready.

6 Remove the Radioactive source (item 2, 09432) from the GSR003 transport container using the handling tool (item 6, 09432). Rotate the handling tool sleeve so that the jaws grip the inverted cone at the top of the source.

7 Lift the source out of the container and push the source holder into the tool source recess as quickly as possible, while holding the source handling tool by the end away from the source, ensuring that it is properly located. The source is located correctly when the visible end of the source is roughly level with the bottom of the tool.

Note: The main direction of radiation output is in a cone pointing away from the handling tool. **DO NOT POINT** the source so that people or limbs are in this beam of radiation. Once the source is in the tool, the sideways radiation is strongly reduced.

Warning! **RADIATION HAZARD.**

8 Release the clamping mechanism of the handling tool, by unscrewing the outer sleeve.

9 Detach from the source, taking extreme care not to drag the source out of its recess. The source is located correctly when the visible end of the source is roughly level with the bottom of the tool.

10 When the handling tool jaws are nearly fully opened, the castellated source retaining ring (item 11) will be held on the end by the force of the spring, which holds the jaws open. Open the jaws, and push the jaws into the castellated source retaining ring (item 11) to pick it up.

11 Screw the castellated nut into the bottom of the tool, so as to lock the source in place, while holding the handling tool by the end away from the source. Do not overtighten! Remove the handling tool.

12 If the tool is not to be used immediately, check the inside of the shield is clean and empty and place the bottom of the tool into the shield (item 7).

13 Install the bolt and padlock (item 8 & 6) to lock the tool in the shield. Remove the FDR from this shield only when ready for logging.

The tool is now assembled and ready for use. Great care must always be taken when adding other tools to minimise exposure to the source, also during moving the assembled tool to the well.

Note: Do not hold the tool by hand in the area near the source, especially just above the source, near the sample slot.

6 ELECTRICAL DESCRIPTION

6.1 TELEMETRY CIRCUIT BOARD

Ref.: Circuit Diagram (PCB82269) *CD-82261*

The Ultrawire™ Tool Telemetry Board is based on a common PCB (82260) which is populated and programmed according to the tool in which it is fitted. The main functional blocks of the circuit are the power supply, the Ultrawire™ interface (together with its drivers and receivers) and the sensor interface.

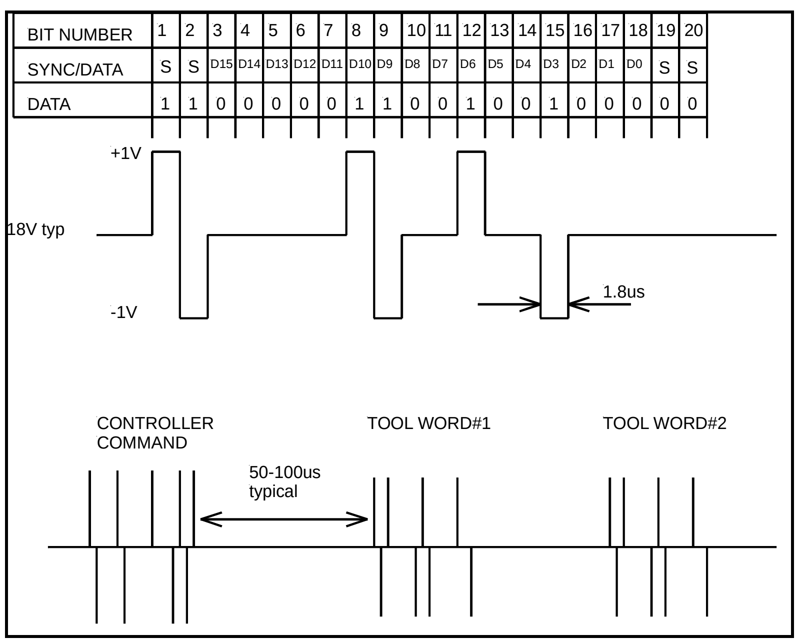
Control is implemented by a PIC microcontroller in conjunction with FPGA logic. The code in the PIC differs according to the tool.

Communication between the Telemetry Controller and the tool is via the Ultrawire™ toolbus. This is a single pin bus, which carries power to the tool in addition to its telemetry function. The return for both power and signal is via the chassis.

The Ultrawire™ line carries 18V DC (nom). Power is supplied to the SMPS via Q7, which with associated components generates local power rails at 12V and 5V.

The tool is protected by fuse (F1), which in conjunction with diode (D1) gives overvoltage and reverse polarity protection.

The telemetry is modulated onto the line as 1V AMI (alternate mark inversion) pulses at 500kbaud, see below a typical tool response.



The Ultrawire™ telemetry is a master slave protocol. The controller, which is always the master, sends a command to the tool. This may be a global command (to all tools) or a tool specific command which contains the address of the target tool. Tool specific commands are acknowledged by the tool, global commands are executed but do not generate a response.

For rate-meter type tools, count pulses are collected from the sensor on inputs 1 - 7 of the PCB. These are counted in hardware by the FPGA logic, (U1) and accumulated by the PIC (U3).

When the controller is in logging mode, it will periodically send a global sample command to all the tools and then poll each tool individually for data. The sample command causes the latest count to be frozen in a shadow register, and this count is then passed to the controller in response to the data request.

Electrically, the telemetry is a.c. coupled from the line to the drivers and receivers by capacitor (C7). The received data is removed from the line by a comparator (U4), and passed to the FPGA logic, which validates the address. The command is interpreted by the PIC which if necessary generates the response packet and passes it to the FPGA logic for placement on the line.

Ultrawire words are 20 bits long. The first and last two bits are for synchronisation. The first bit is always ‘1’. The intervening 16 bits are tool data.

6.2 HV REGULATOR & DETECTOR CIRCUIT BOARD

Ref.: Circuit Diagram *CD-85183*

This circuit supplies the High Voltage Power Supply in the Detector Section with a low voltage (10V approx. at room temperature), regulated to produce a final voltage of 1.6kV at the Photomultiplier tube.

The current limit controlled by R2, R3 and R4 is set to approximately 30mA.

The HV Photomultiplier current returns to 0V through R5 and R6. The Zener diode voltage across D1 must also appear across R5 and R6. Since the PMT is largely resistive (43MΩ) current flow in R5 and R6 (approximately 38µA) causes 1.6kV to appear at the input to the PMT. R5 is adjusted at room temperature to achieve this. C1 is required for stability.

The temperature coefficient of D1 and hence of the PMT HV supply, can be positive or negative depending on current flow. Low current produces a negative coefficient and high current, positive. R1 is selected in the range 10k to 30k to produce a zero temperature coefficient up to 150°C. If this cannot be achieved, D1 is replaced since the characteristics of the BZX79C5V6 varies between devices.

The REGULATED SUPPLY will still rise to around 11V at 150°C due to a reduction in efficiency of the HV PSU Oscillator, thus maintaining temperature compensation of the PMT HV supply.

In the DETECTOR section of this board, zener D2 develops a nominal 5.5V to which all analogue circuitry is referenced. U1A froms a charge amplifier with the height and width of the 60KeV Americium pulse set to 0.55V and 1.5ms by C2 and R2. Typical values are 10pF and 47kΩ. U2A is a comparator with its reference level (pin 3) determined by R7 and R12. Negative pulses of 5V are generated at pin 1 and are output to the telemetry board as F1. U2B is also a comparator, with its reference level (pin 5) set to a higher level than U2A, so that it only responds to high energy pulses. These are output to the telemetry board as INH. The FPGA Logic on the telemetry board subtracts the high energy pulses form the lower energy Americium pulses.

6.3 HIGH VOLTAGE POWER SUPPLY

Ref.: Circuit Diagram *CD-85180*

This is a single transistor inverter followed by a Cockroft ladder doubler. The transformer is wired for positive feedback and transistor Q1 oscillates between the saturated and open conditions. Since the step up ratio of the transformer is 1:40, the 10V regulated supply is converted to 400V peak (800V peak to peak). The doubler multiplies this up to 1.6kV. The frequency of oscillation, which should lie in the range 30-70kHz, is determined by the characteristics of the transformer and the input supply voltage. Although the efficiency of the HV PSU decreases with increasing temperature, it is within the feedback loop to the HV Regulator, which will increase the "+10V" input to maintain 1.6kV to the PMT.

6.4 PHOTOMULTIPLIER TUBE

The HV is distributed over the dynode array with a resistor ladder. The current taken by the PMT is negligible compared to the resistor ladder hence the HV can be determined by measuring the HV RETURN current rather than by measuring the HV directly.

Photons are emitted from gamma ray excited atoms in the sodium iodide crystal.

A photon of light striking the PMT cathode may emit one or more electrons. As there is a potential difference of approximately 130V between dynodes in the PMT chain, any electrons emitted will be accelerated onto the next and the collision causes many more electrons to be emitted. These are accelerated onto the third and multiplied as well. The 10 stage multiplication will thus provide in the order of 5^{10} electrons per incident photon. This charge pulse is coupled via a capacitor to the Detector circuit.

Warning!

The Photomultiplier Tube must be kept in total darkness whenever the tool is powered up or the tube will be permanently damaged.

The efficiency of the PMT decreases with increasing temperature. On FDR tools the detector threshold is normalised to the average peak energy to compensate.

7 EXTENDED CHECKS

7.1 PREVENTATIVE MAINTENANCE

7.1.1 GREASE & LUBRICANTS

Sondex recommends the use of “Liquid O-ring type 101” (p/n LOR101) on threads and O-rings.

All O-rings and housing threads are assumed to be and must be lightly greased, unless specifically indicated otherwise.

Correct use of grease and lubricants is essential to the maintenance of all Sondex downhole equipment.

Note that some threads are internal, which can cause grease to get inside the tool. Do not use excessive quantities.

Sondex does not recommend Copper loaded greases since some types can cause electrical leaks. Some types for grease are not suitable for use on O-rings. Silicone grease may be used on O-rings, but must be kept clear of threads, especially stainless steel to stainless steel.

Caution! The use of certain greases, which contain volatile content, (e.g. some types of Lubriplate) can cause electrical failure due to production of corrosive gasses inside the tool when burned off.

7.1.2 MECHANICAL

1 Remove dirt and old grease from pressure housing threads and O-rings and replace with fresh.

2 Inspect O-rings for damage or ageing/hardening and replace where required.

3 Check for:

- Damaged wires.
- Wires that are loose and likely to be crushed on re-assembly.
- Damaged components.
- Loose screws/nuts/components/connectors.

Note: If RTV or similar compound is used to secure loose components, it must be fully cured before housing is replaced.

- Electrical components shorting to chassis.
- Heat or chemical damage (discoloured components).
- Incorrect thread grease or excessive quantity, see *Section 7.1.1*.

4 Check connectors for cleanliness and loose/bent pins before replacing.

5 Check all fixings for tightness.

6 Check grub screws are tight.

7 Check the sloping flat surface at each end of the fluid slot for damage. The Titanium metal thickness is as thin as possible so as not to reduce radioactive count rate. Damage may reduce the pressure rating. If in doubt, remove electronics and detector and perform a pressure test.

7.1.3 ELECTRICAL

1 Using a Multimeter, measure the upper to lower pin resistance. Should be less than 0.5Ω.

2 Using a Multimeter, check tool current 31-35mA at 18V.

3 Using a Multimeter, measure the pin (+ve probe) to housing (-ve probe) resistance. Should be between 3 - 4MΩ, depending on the meter.

4 Connect to Logging System and check for correct data. Apply some gentle vibration and rotation to expose potential failure.

5 With an Oscilloscope, check line for +1V and -1V, 2μs pulses. Make sure to check tool pulses not those from the controller which occur first, *refer to Figure 6.1*.

Pulses should have no ringing, if ringing, also attach a Ultrawire terminator at the bottom of the toolstring (e.g. Ultrawire bullnose terminator (BUL006) or a suitable Ultrawire bottom end flowmeter).

7.1.4 DETECTOR SENSITIVITY/CALIBRATION CHECK

The FDR detector, which includes the HV PSU, PMT and Crystal, leave Sondex with a known sensitivity for that particular tool. Any failing or ageing of any of these 3 components reduces the sensitivity. The PMT ageing and dynode circuit leakage have the most effect. Heat also reduces sensitivity. Loss of sensitivity may be obvious from previous logs.

1 With the source fitted, monitor P2 on PCB85183 assembly. This is set to give a 0.50-0.55V pulse at room temperature. There will be a small number of larger and smaller pulses. If the pulse is less than 0.50V at room temp, sensitivity has dropped and downhole counts may be lower than expected. Unless logging at low temperature, preventative action is required, see *Section 7.3 Troubleshooting*.

2 Check calibration, see *Section 7.3 Troubleshooting*. Count rate should be within 1% of previous check.

7.1.5 AGEING OF ELECTRONICS

At 150°C, significant electronic ageing failures are expected after 4000hrs typical use, hence PCB replacement should be considered at this point. Every additional 10°C halves the time. Also accelerated by vibration and corrosive gas inside the chassis. Visual inspection and logging previous history is recommended, but is unlikely to predict premature failure.

Tools, that may be suspected of reliability problems due to age or unusual log response, may be heated to 120°C, which would not normally age the electronics, and then subjected to moderate vibration. A moderately hard blow from a wooden hammer is recommended. **DO NOT USE METAL HAMMERS**.

7.1.6 HEAT TESTING ABOVE 150°C

his is not generally recommended since it shortens tool life expectancy.

Heat testing may be required for contractual reasons, tool out of use for a long period or job with unusually high well temperature. The test should be carried out only slightly above expected well temperature and the tool should not be kept at temperature for more than 1 hour.

7.2 EXTRAORDINARY MAINTENANCE

See also: *Section 4.2 Pre-logging Checks*

Ref.: General Assembly *09455*
FDR Quick Release Section *02099*

The following O-rings need replacement after every run:

- 1x item 15, 09455.
- 2x item 5, 02099.

The Following O-rings need replacement every 5 runs or every 3 months, whichever comes first:

- 1x item 14, 09455.
- 2x item 4, 02099.
- 2x item 3, 02099.

Note: All other O-rings do not require replacement, as they are used as frictional locks only.

If the tool experiences H_2S gas or temperatures above 150°C, ALL O-rings, mentioned above, must be replaced.

No other special maintenance is required.

7.3 TROUBLESHOOTING

Refer to *Section 5.2 Disassembly*and *Appendix B Drawings & Parts Lists* where necessary.

Warning! ***DO NOT*** disassemble the Detector section. Improper disassembly may cause damage to the line wire, which will render the tool inoperative. When a faulty detector is suspected, return to Sondex.

An Oscilloscope, Multimeter and other basic test equipment will be required.

Initial inspection	Check for: • Damaged wires. • Damaged components. • Electrical components shorting to chassis. • Heat or chemical damage (discoloured components). • Incorrect thread grease or excessive quantity, see *Section 7.1.1*. Also check all fixings are tight.

Excessive current	Disconnect wires to isolate fault to: • Upper head isolation assembly. • 82269 circuit board. • Line wire through lower pressure feedthrough and connector. • PCB85183 (detector disconnected). Apply Line Signal or 18V direct to PCB82269 line connection. Fault find or replace PCB82269. Upper Head, Detector line wire and lower connector may be tested to 250V relative to chassis to check for electrical leak. **Line connection to PCB82269 must be disconnected**. Resistance should exceeed 100MΩ. Upper head and lower pressure feedthrough and connector may be disassembled to locate fault. **The lower socket is part of the source and should not be dissassembled.**

Warning! **The PMT must only be powered in complete darkness.**

High current detector	Detector current, supplied by PCB85183, is typically 10mA. Separate HV PSU from PMT. HV PSU takes 5mA approx., attaching PMT accounts for the other 5mA approx. High current PMT: Ensure PMT base PCB is clean and dry. Remove 100pF signal capacitor. . High current HV PSU: Check for shorts and wire damage. Check for broken tranformer core. Otherwise HV PSU and PMT are not user serviceable, replace complete if faulty.
Little or no current	On PCB82269, check LINE = 18V, 5V and 0V. Fault find or replace PCB.
No telemetry counts	On PCB82269, check LINE = 18V, 5V and 0V. Fault find or replace PCB.
No telemetry reply	On PCB82269, check LINE = 18V, 12V, 5V and 0V. Fault find or replace PCB. On PCB82269, check P6 for 4MHz clock. Replace X1 if faulty. Reduce R14 value if clock <3V amplitude. Check line for +1V and -1V, 2µS pulses from the controller and similar pulses from the tool. Logic pulses should be present on PCB82269 P2 - 5 and temperature fre-quency on pin 7 (FT). If no tool response words on the Line, fault find or replace PCB82269.

Low counts	See 'Low Current Detector'. See 'High Current Detector'. Replace PMT/Crystal Detector; this assembly is not field repairable.

Warning! **The PMT must only be powered in complete darkness.**

Low current detector	Detector current, supplied by PCB85183, is typically 10mA. The 1.6kV output is not normally measured directly since a 1:100 HV probe must be used. The PMT base must be completely clean and dry. Probes of a lower resistance will not measure correctly. Check PCB85183 and HV PSU.

APPENDIX A EQUIPMENT & RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	FDR020	Fluid Density Radioactive Tool, $1^{11}/_{16}''$	1	Ultrawire™ Tool.
2	09432	GSR003 Source Holder Assembly	1	150mCi Am241

A.1 ANCILLARY EQUIPMENT

Radiation Equipment

Item	Part No	Description	Qty	Remarks
1	02512	Radioactive Shield $1^{11}/_{16}''$	1	Supplied with FDR.
2	02582	Shipping Container	1	Supplied with GSR003.
3	02583	Side Cheeks	1	Set of 2. Optional for RA scale.

Calibration Fixtures

Item	Part No	Description	Qty	Remarks
1	A suitable container is required to immerse the Sensor during calibration.			

A.2 MAINTENANCE EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	91050	Hand Tool Kit for $1^{11}/_{16}''$ tools	1	
2	00352	Source Handling tool	1	
3	LOR101	Grease for O-rings and threads	1	5oz pot.
4	LOR101L	Grease for O-rings and threads	1	16oz pot.

A.3 RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	KITB-FDR1 3/8	Basic Spares Kit	1	To support 1 run in hole.
2	KITR-FDR1 3/8	Recommended Spares Kit	1	Supports 25 runs in hole.

Note: Spares kits for remote logging operation can be supplied upon request.

Note: Refer to *MN-PIH* for service guidelines of and spares kits for the Pressure Isolation Head.

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
09432	B		NGH	DJF	DJF
			Date: 17/04/2001	Date: 24/04/2001	Date: 24/04/2001

Description:
Radioactive Source, Transit/Storage Kit & Handling Tool

CHANGE HISTORY

Iss	Date	Remarks	Chkd	Appr
A	24/04/2001	Initial Release	DJF	DJF
B	26/08/2005	ECR 3081 Refers - Restructured		

RELATED DOCUMENTS

#	Documents	Issue	Notes
01	AD-09432	B	Assembly Drawing

PARTS LIST

Item	Part No.	Issue	Description	Component Value	Qty	Units	Remarks
001	M39030	A	KIT-S Radioactive Source,Transit/Storage Kit & Handling Tool		1	EACH	
002	11528	B	Assy, Radioactive Gamma Source, Am241, 5.5GBq(150mCi)		1	ea	
003	02582	B	Intermediate Container for Radioactive Source		1	ea	
004	91337	-	Carry Case (Pelicase 1300), Yellow		1	ea	
005	91326	-	Padlock, Combination, 165/40 (Abus)		1	ea	
006	00352	D	Assy, Extraction Tool		1	ea	

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
91050	-		NGH	PD	DJF
			Date: 14/01/2002	Date: 14/01/2002	Date: 14/01/2002

Description:
Tool Kit for all 1 11/16 Tools SX and GO

CHANGE HISTORY

Iss	Date	Remarks	Chkd	Appr
-	14/01/2002	Initial Release	PD	DJF

RELATED DOCUMENTS

#	Documents	Issue	Notes

PARTS LIST

Item	Part No.	Issue	Description	Component Value	Qty	Units	Remarks
001	91005	-	Spanner Open Ended 42mmx38mm		2	ea	
002	91019	-	Spanner C 50mm 35mm		1	ea	
003	10038	A	Spanner Box 3/8 x 5/16 Modified		2	ea	
004	91028	-	Spanner 3/8x5/16		1	ea	
005	91027	-	Spanner Single Open End 18mm		1	ea	
006	91029	-	Key Hex Metric		1	ea	
007	91030	-	Punch Pin Parallel set		1	ea	
008	00615	A	Assy Spanner PKJ		1	ea	
009	91293	PT1	Screwdriver Parallel tip (3 0 x 75)		1	ea	
010	91105	-	Toolroll With SX Badge Large Black		1	ea	
011	91104	-	Screwdriver Parallel tip (5 5 x 200)		1	ea	
012	91103	-	Pliers Circlip 812 Chrome/Van		1	ea	
013	91102	-	Pliers Mini Flat Nose 5 Inch		1	ea	
014	10037	A	Bar Tommy		2	ea	
015	10051	A	Kemlon tool Sondex - 4BA Hex Socket		1	ea	
016	91280	-	Hammer, 4oz ball pein		1	ea	
017	91130	-	Pin C Spanner 35-50mm		1	ea	

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
KITB-FDR1 11/16	A		RH	PJ	PJ
			Date: 22/02/2002	Date: 04/03/2002	Date: 04/03/2002

Description:
Kit, Spares, Basic, FDR

CHANGE HISTORY					RELATED DOCUMENTS			
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*#*	*Documents*	*Issue*	*Notes*
A	--/--/--							

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	99026	-	O Ring Viton 90 Type 026		2	ea	
002	99124	-	O Ring Viton 90 Type 124		2	ea	
003	99211	-	O Ring Viton 90 Type 211		2	ea	

(AR = As Required)

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
KITR-FDR1 11/16	A		RH	PJ	PJ
			Date: 22/02/2002	Date: 04/03/2002	Date: 04/03/2002

Description:
Kit, Spares, Recommended(25Run), FDR(1 11/16)

CHANGE HISTORY					RELATED DOCUMENTS			
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*#*	*Documents*	*Issue*	*Notes*
A	--/--/--							

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	01082	A	Screw Grub Skt Hd M6x5mm Lg SS MOD		3	ea	
002	93333	-	Pin Spirol 3/32 x 1 Long St/Steel		4	ea	
003	95113	-	O Ring Viton 75 Type 113		2	ea	
004							
005	99026	-	O Ring Viton 90 Type 026		20	ea	
006	99124	-	O Ring Viton 90 Type 124		50	ea	
007	99211	-	O Ring Viton 90 Type 211		50	ea	
008	99901	-	O Ring 310 Silicon		2	ea	

(AR = As Required)

APPENDIX B DRAWINGS & PARTS LISTS

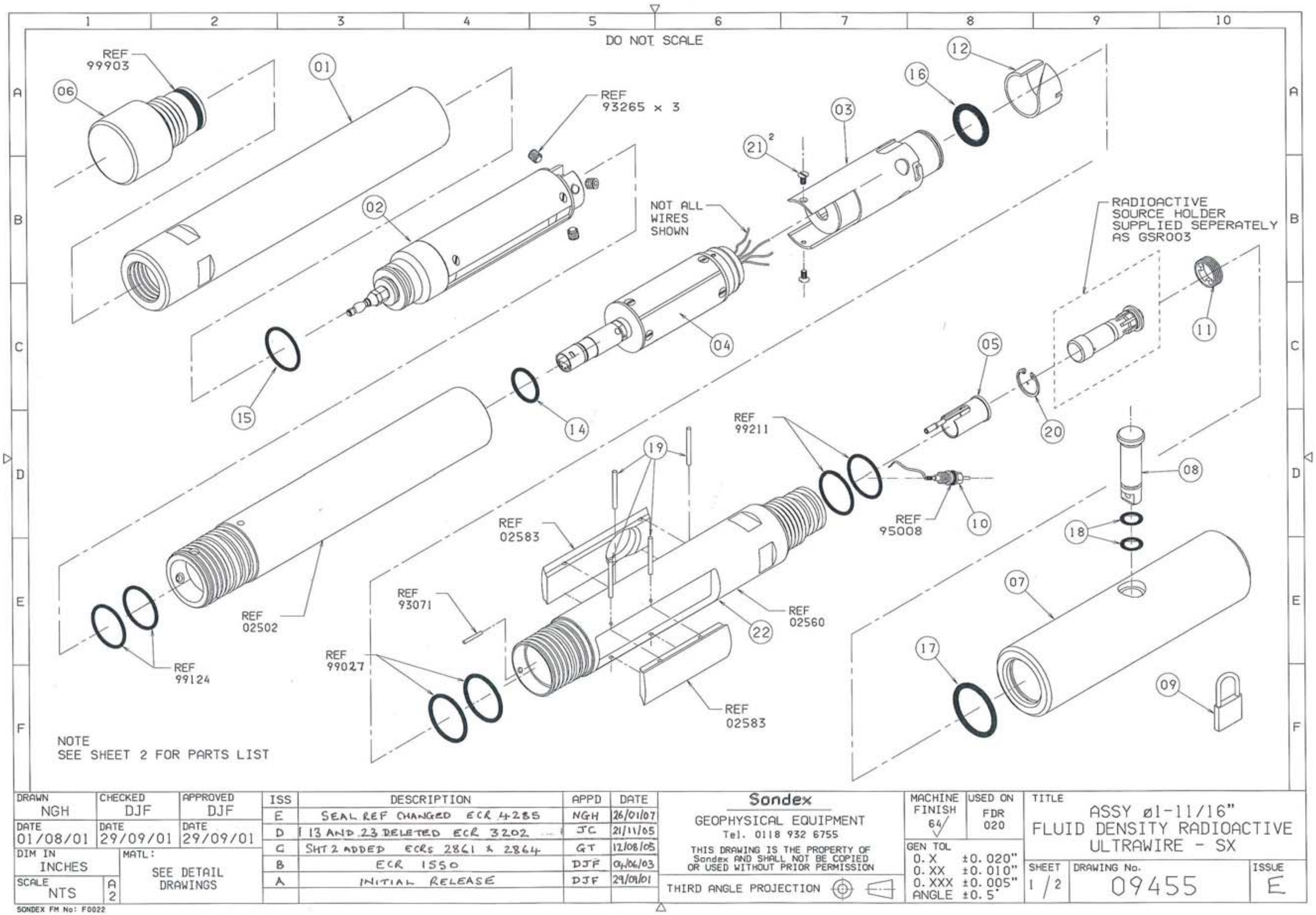
B.1 MECHANICAL DRAWINGS

Description	Drawing	Parts List
General Assembly	*09455-E*	*09455-E*
FDR Quick Release Section	*02099-K*	*02099-J*

B.2 ELECTRICAL DIAGRAMS

Description	Type	Drawing
Ultrawire™ FDR Electronics Assembly	Wiring Diagram	*WD-85341-F*
Ultrawire™ Telemetry (PCD82269) - 2 Sheets	Circuit Diagram	*CD-82261-F00xx*
Detector/Regulator Assembly	Circuit Diagram	*CD-85183-D*
HV PSU[a]	Wiring Diagram	*WD-85180-C*
HV PSU[a.]	Circuit Diagram	*CD-85180-B*

a. The HV PSU Board is fitted in the Sensor/HV PSU section, which should normally not be disassembled. If a fault is suspected on the HV PSU board or in the Detector Assembly, return tool to Sondex.


DO NOT SCALE
REF 99903
06
01
REF 93265 x 3
21
03
16
12
02
NOT ALL WIRES SHOWN
RADIOACTIVE SOURCE HOLDER SUPPLIED SEPERATELY AS GSR003
04
11
15
14
05
20
REF 99211
19
08
REF 95008
10
18
REF 02583
REF 93071
REF 02502
REF 99124
REF 99027
22
REF 02560
07
17
09
REF 02583
NOTE
SEE SHEET 2 FOR PARTS LIST
DRAWN NGH
CHECKED DJF
APPROVED DJF
DATE 01/08/01
DATE 29/09/01
DATE 29/09/01
DIM IN INCHES
MATL: SEE DETAIL DRAWINGS
SCALE NTS
A2
ISS | DESCRIPTION | APPD | DATE
E | SEAL REF CHANGED ECR 4285 | NGH | 26/01/07
D | 13 AND 23 DELETED ECR 3202 | JC | 21/11/05
C | SHT 2 ADDED ECRS 2861 & 2864 | GT | 12/08/05
B | ECR 1550 | DJF | 04/06/03
A | INITIAL RELEASE | DJF | 29/01/01
Sondex
GEOPHYSICAL EQUIPMENT
Tel. 0118 932 6755
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THIRD ANGLE PROJECTION
MACHINE FINISH 64
USED ON FDR 020
GEN TOL
0.X ±0.020"
0.XX ±0.010"
0.XXX ±0.005"
ANGLE ±0.5°
TITLE
ASSY ø1-11/16"
FLUID DENSITY RADIOACTIVE
ULTRAWIRE - SX
SHEET 1/2
DRAWING No. 09455
ISSUE E
SONDEX FM No: F0022

DO NOT SCALE

REFERENCE PARTS LIST M39019 WHERE INDICATED *

Item	Part No.	Qty	Description	
01	01020-1	1	Housing Pressure 1 11/16. 1 Module	*
02	85341	1	Assy 1-11/16 FDR Electronics (Ultrawire)	
03	85162	1	Assy Detector PMT/Crystal shielded type. FDR 1 11/16"	
04	00814	1	Assy HV PSU	
05	02565	1	Assy Connector Female	*
06	10148	1	Thread Protector. Male. Standard. (Upper End) with O'Ring	*
07	02512	1	RA Tool Shield	*
08	02515	1	Pin Tool Shield	*
09	91326	1	Padlock. Combination. 165/40 (Abus)	
10	02566	1	Assy Connector Pressure Isolation MOD	*
11	02561	1	Retaining Ring. Source Holder Assy	*
12	02577	1	Lead Shield	*
13				
14	99901	1	O Ring 310 Silicon	*
15	95211	1	O Ring Viton 75 Type 211	
16	91213	A/R	Rubber Silicone dia 1/4	*
17	95132	1	O Ring Viton 75 Type 132	*
18	95113	2	O Ring Viton 75 Type 113	*
19	93333	4	Pin Spirol 3/32 x 1 Long St/Steel	*
20	93227	1	Circlip VH Light Duty 0 656 SS	*
21	01029	2	Screw. Csk Hd(Slotted). M3 x 06mm Lg. St/Steel	*
22	02099	1	Assy Detector & Window Body (Quick Release Type) SX	*
23				

SEE SHEET 1 FOR ASSEMBLY DETAILS

NOTES

1. REMOVE ALL BURRS AND SHARP EDGES

DRAWN	CHECKED	APPROVED
NGH	DJF	DJF
DATE 01/08/01	DATE 29/09/01	DATE 29/09/01
DIM IN INCHES	MATL: SEE DETAIL DRAWINGS	
SCALE NTS	A3	

ISS	DESCRIPTION	APPD	DATE
E	SEAL REF CHANGED ECR 4285	NGH	26/01/07
D	! 13 & 23 DELETED ECR 3202	JC	21/11/05
C	SHT 2 ADDED ECRS 2861 & 2864	GT	12/08/05
B	ECR 1550	DJF	04/06/03
A	INITIAL RELEASE	DJF	29/09/01

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THIRD ANGLE PROJECTION

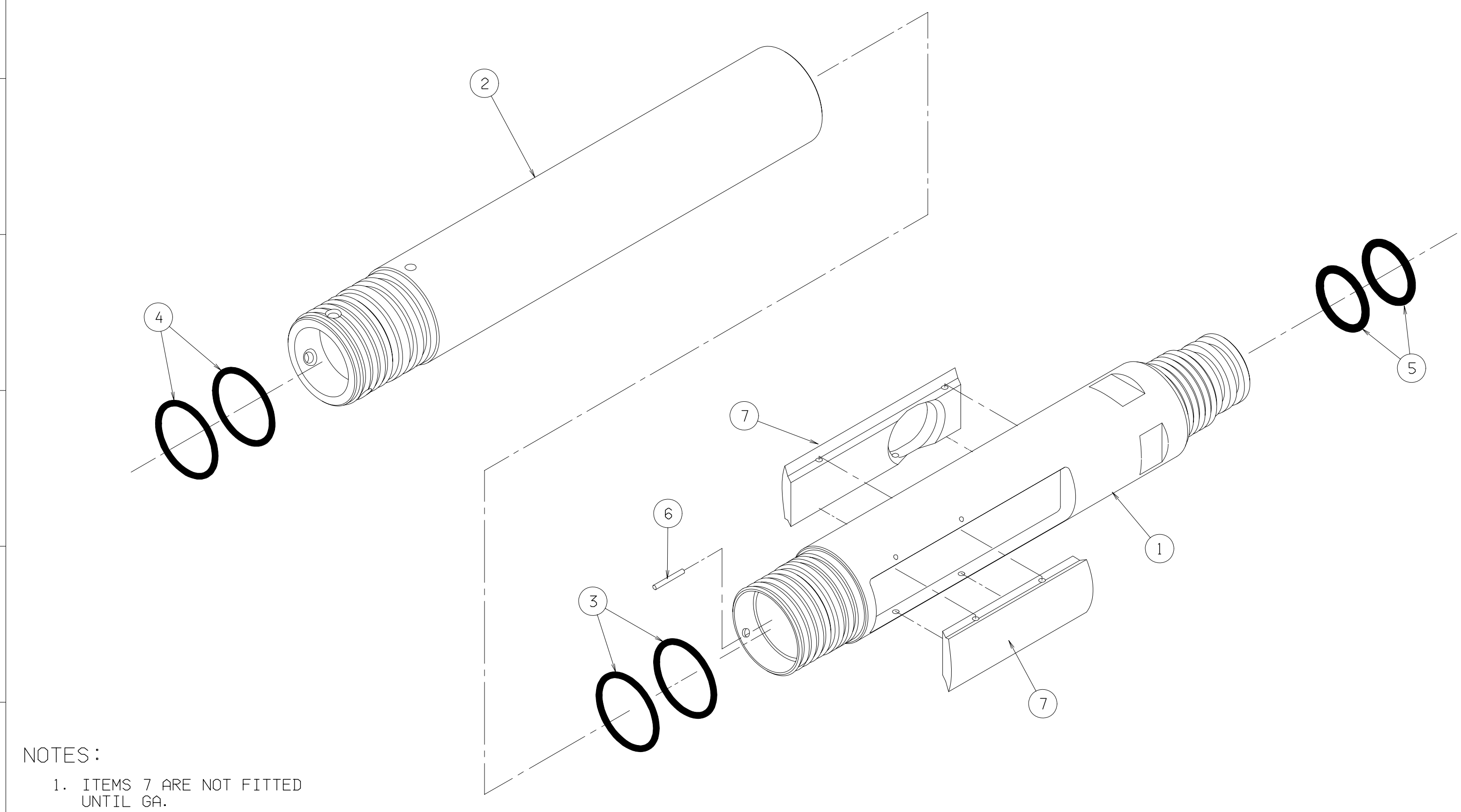
USED ON: FDR 020

MACHINE FINISH: 63

GEN TOL: 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°

TITLE: ASSY ø1-11/16" FLUID DENSITY RADIOACTIVE ULTRAWIRE - SX

SHEET: 2/2 | DRAWING No.: 09455 | ISSUE: E



DRAWN	CHECKED	APPROVED	ISS	DESCRIPTION	APPD	DATE
JD	AJB	DJF	K	ECR 3202 REFERS - SHT 2 DELETED	JC	21/11/05
DATE 16/01/93	DATE 15/12/93	DATE 15/12/95	J	RE: ECR 1550	DJF	04/06/03
DIM IN INCHES	MATL: SEE DETAIL DRAWINGS		H	SIDE SHIELDS MODIFIED. REF ECR452	DJF	27/04/01
			G	SEE ECR347	DJF	15/12/95
SCALE NTS	A2		F	DESIGN MODIFIED	DJF	27-10-97
			E	ITEM 1 AMENDED, REFER C/R 107(APR96)	DJF	28-06-96

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THIRD ANGLE PROJECTION

MACHINE FINISH 64	USED ON FDR 016/017	TITLE ASSY ø1 11/16" FDR, QUICK RELEASE SONDEX ENDS
GEN TOL 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°	SHEET 1/1	DRAWING No. 02099 — ISSUE K

SONDEX FM No: F0022

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
02099	J		AJB	DJF	DJF
			Date: 20/07/1996	Date: 01/10/1997	Date: 01/10/1997

Description:
Assy Detector & Window Body (Quick Release Type) SX

CHANGE HISTORY

Iss	Date	Remarks	Chkd	Appr
G	26/05/1999	See ECR 347	AJB	WSB
H	27/04/2001	Side shield design modified. Ref ECR452.	NGH	DJF
I	04/06/2003	Re: ECR 1550	DJF	DJF
J	13/04/2007	ECR 4285 Applied	GT	NGH

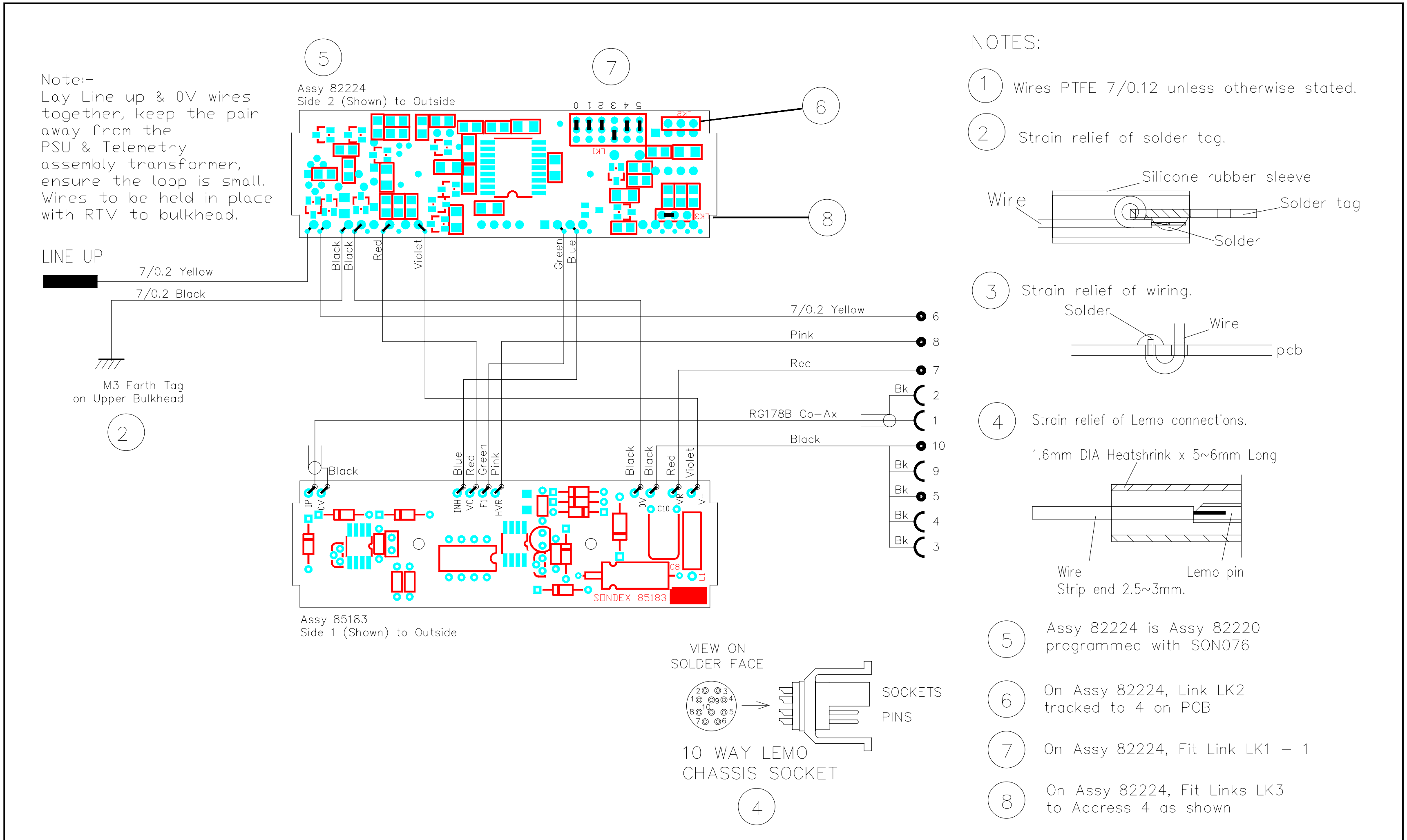
RELATED DOCUMENTS

#	Documents	Issue	Notes

PARTS LIST

Item	Part No.	Issue	Description	Component Value	Qty	Units	Remarks
001	02560	D	Body Quick Release- Wide Source- with Pressure Isolation		1	ea	
002	02502	F	Housing Pressure 1 11/16 SS		1	ea	
003	99027	-	O-ring 027 Viton 90		2	ea	
004	99124	-	O-ring 124 Viton 90		2	ea	
005	99211	-	O-ring 211 Viton 90		2	ea	
006	93071	-	Pin Spirol 2mm x 16mm LG MCK SS		1	ea	
007	02583	PT1	Side shields, drilled, 1 11/16 FDR		1	pr	
800	AD-02099	K	Assembly Drawing			(AR)	

(AR = As Required)

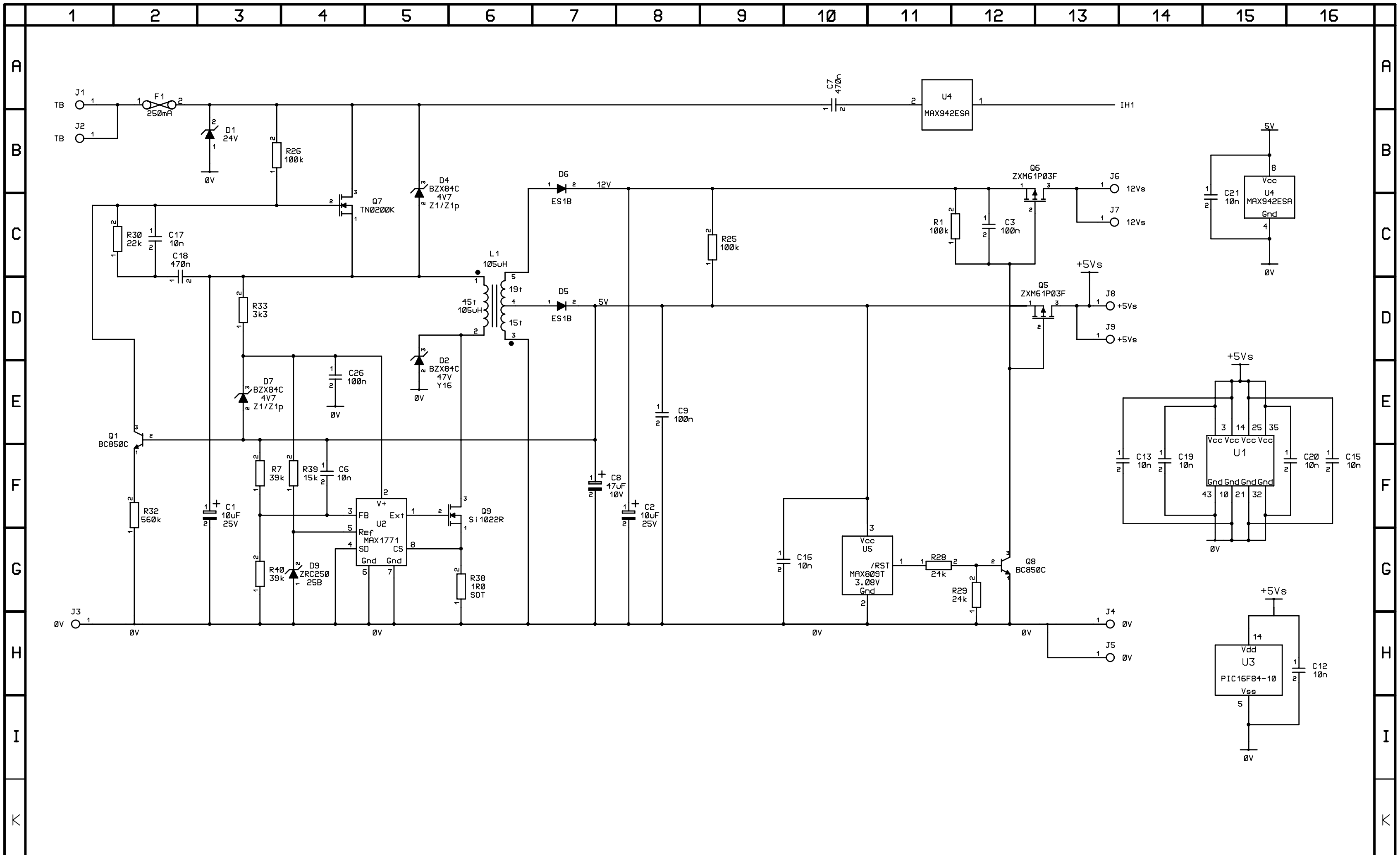


C	23.9.04	ECR1692. Redrawn. Assy 82269 was 82224	(PR)	(PR)
D	24.9.04	ECR1991 Assy 85183 updated	(PR)	(RH)
E	18/07/06	ECR3962 Note added	VH	RH
F	13/09/06	ECR4074 82224 was 82269	RH	RH

WIRING DIAGRAM
RA Fluid Density, Ultrawire
Tool Electronics 1_11/16”

RLH	(RLH)	(RLH)
21/01/04	25/04/02	25/04/02

WD 85341 F



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
C	01		PR	PR	21/11/03
D	00		DJ	PR	23/07/07
D	00		PEJR	PEJR	06/01/05
D	01		PEJR	PEJR	08/06/05
D	02		PEJR	PEJR	03/8/05
F	00		PEJR	PEJR	29/06/06

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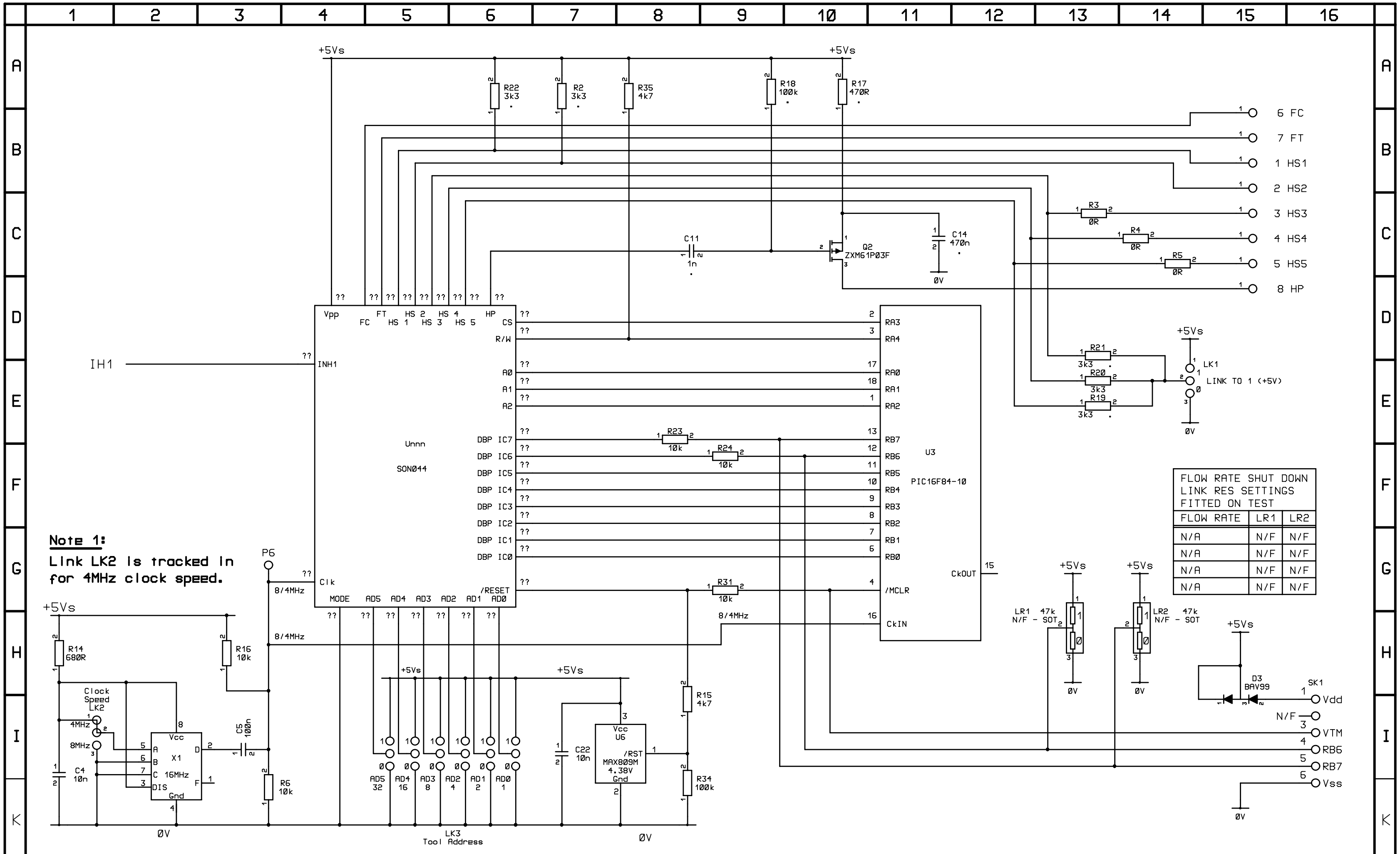
TITLE
Ultrawire PSU & Telemetry
CTF Tool
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-82261	F	00x

DRAWN	CHECKED	APPROVED
PEJR	DJ	PR
DATE 17/04/03	DATE 05/08/03	DATE 05/08/03

SHEET 1 OF 2



FLOW RATE	LR1	LR2
N/A	N/F	N/F
N/A	N/F	N/F
N/A	N/F	N/F
N/A	N/F	N/F

ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
C	01		PR	PR	21/11/03
D	00		DJ	PR	23/07/07
D	00		PEJR	PEJR	06/01/05
D	01		PEJR	PEJR	08/06/05
D	02		PEJR	PEJR	03/8/05
F	00		PEJR	PEJR	29/06/06

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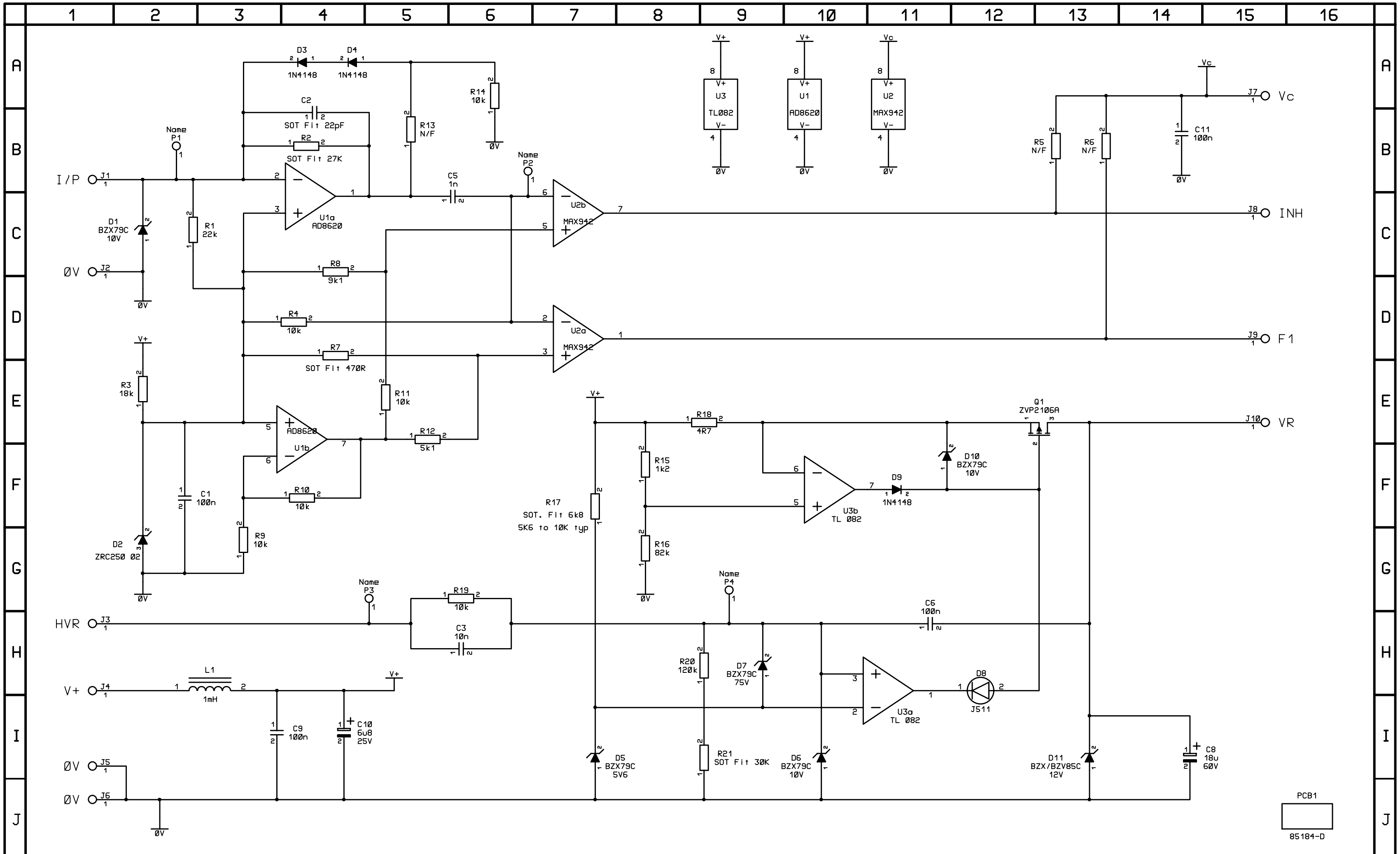
TITLE
Ultrawire PSU & Telemetry
CTF Tool
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-82261	F	00x

DRAWN	CHECKED	APPROVED
PEJR	DJ	PR
DATE 17/04/03	DATE 05/08/03	DATE 05/08/03

SHEET 2 OF 2



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
B	01	ECR1645. U1,2R3,4,5,8,10,11,12,C5,8 changed	RS	RH	15/04/04
C		ECR1991 PCB Artwork updated	DJ	PR	20/08/04
C	01	ECR2447 Add Wire Link			18/02/05
D	00	ECR2517 Update AW ECR2598 C2,R2,R4,R7	PR	PR	29/03/05

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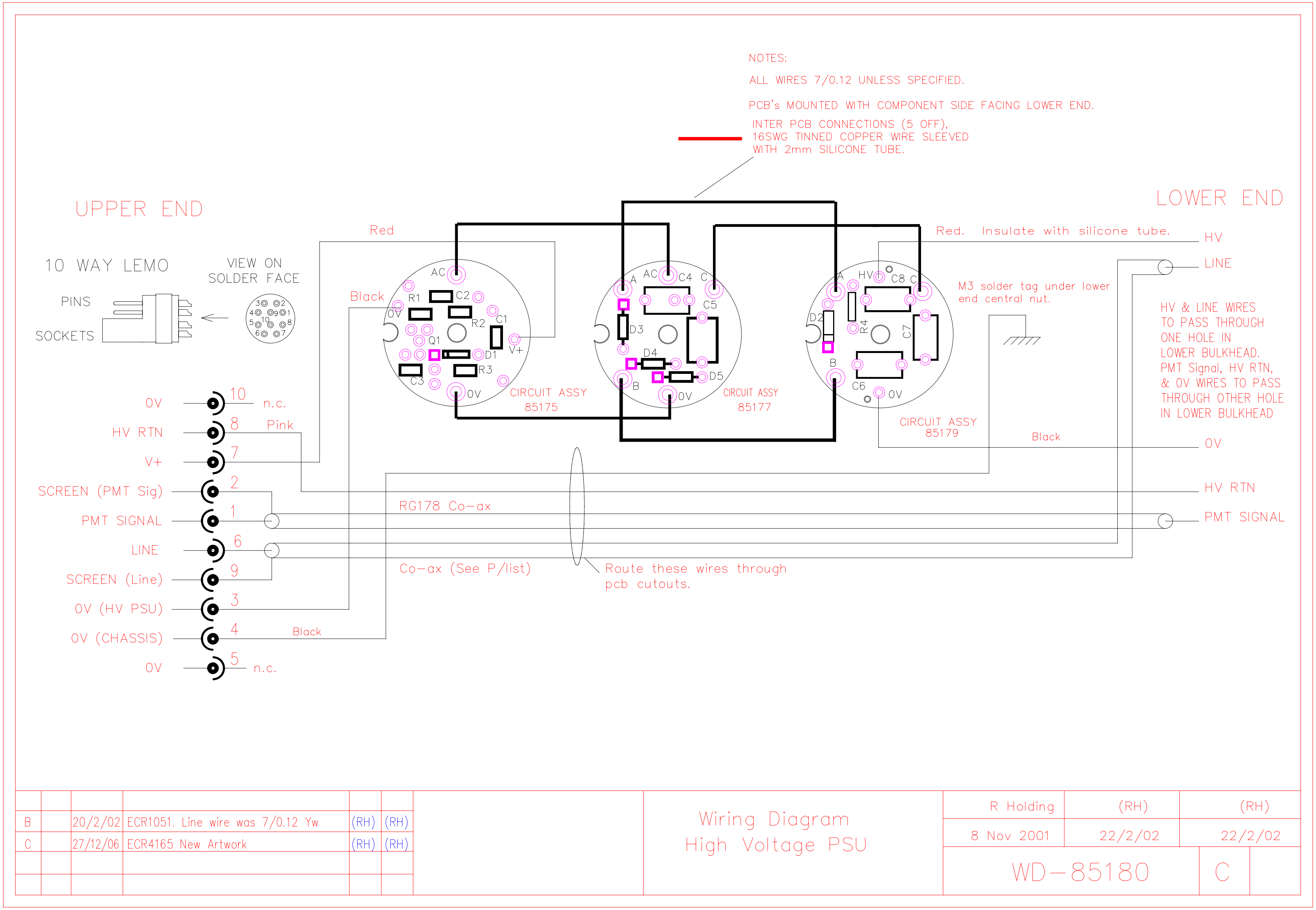
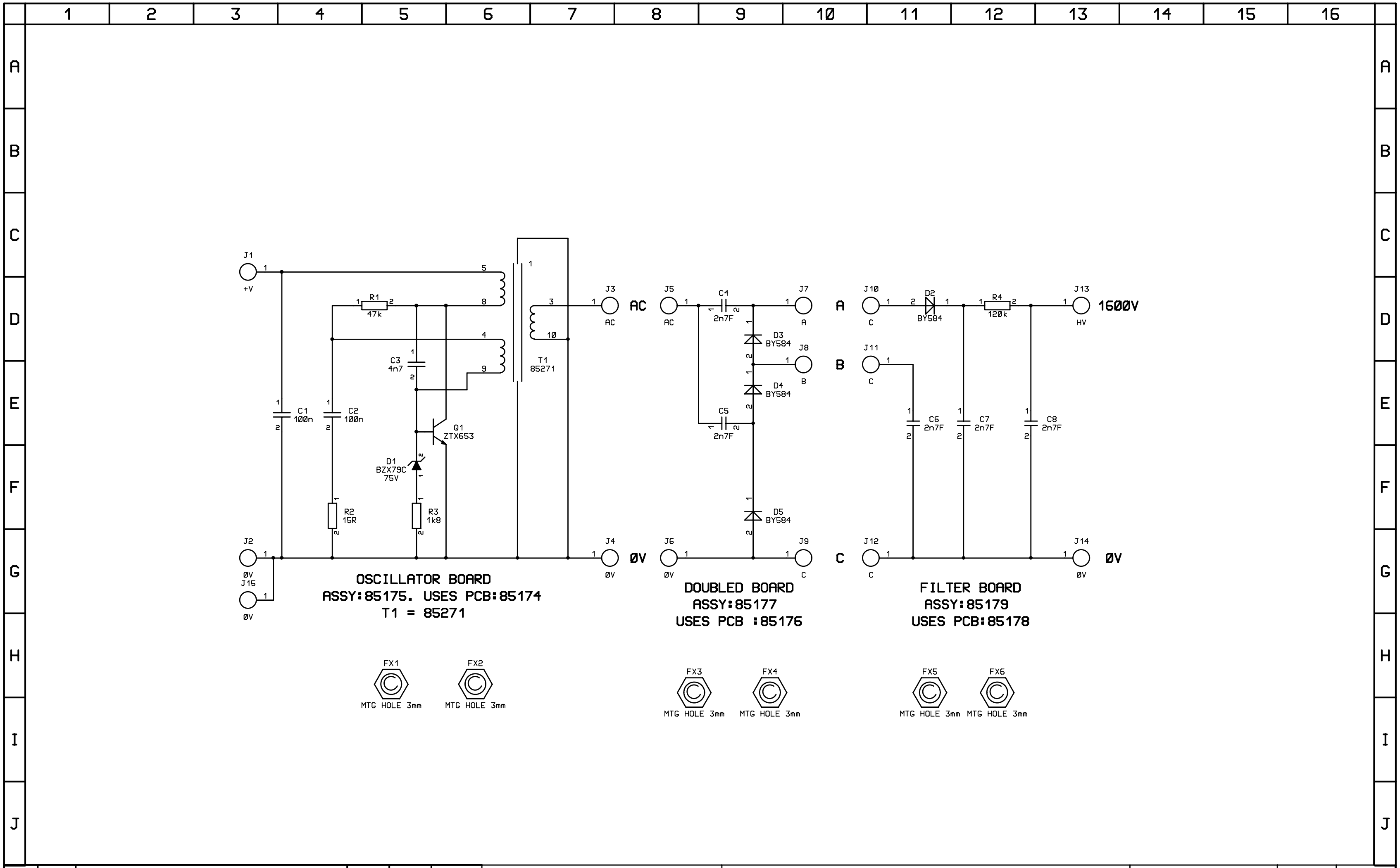
TITLE
FDR Detector Regulator Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-85183	D	00

DRAWN	CHECKED	APPROVED
DJ	RS	RH
DATE 20/02/04	DATE 15/04/04	DATE 15/04/04

SHEET 1 OF 1


NOTES:
ALL WIRES 7/0.12 UNLESS SPECIFIED.
PCB's MOUNTED WITH COMPONENT SIDE FACING LOWER END.
INTER PCB CONNECTIONS (5 OFF), 16SWG TINNED COPPER WIRE SLEEVED WITH 2mm SILICONE TUBE.
UPPER END
LOWER END
10 WAY LEMO
VIEW ON SOLDER FACE
PINS
SOCKETS
Red
Black
Red. Insulate with silicone tube.
HV
LINE
M3 solder tag under lower end central nut.
HV & LINE WIRES TO PASS THROUGH ONE HOLE IN LOWER BULKHEAD. PMT Signal, HV RTN, & 0V WIRES TO PASS THROUGH OTHER HOLE IN LOWER BULKHEAD
CIRCUIT ASSY 85175
CIRCUIT ASSY 85177
CIRCUIT ASSY 85179
Black
0V
HV RTN
PMT SIGNAL
0V 10 n.c.
HV RTN 8 Pink
V+ 7
SCREEN (PMT Sig) 2
PMT SIGNAL 1
LINE 6
SCREEN (Line) 9
0V (HV PSU) 3
0V (CHASSIS) 4 Black
0V 5 n.c.
RG178 Co-ax
Co-ax (See P/list)
Route these wires through pcb cutouts.
B 20/2/02 ECR1051. Line wire was 7/0.12 Yw (RH) (RH)
C 27/12/06 ECR4165 New Artwork (RH) (RH)
Wiring Diagram
High Voltage PSU
R Holding (RH) (RH)
8 Nov 2001 22/2/02 22/2/02
WD-85180 C



ISS	REV	ECR NUMBER, REMARKS	CHKD	APPR	DATE
A	01	ECR1612 C3 was 1nF	RH	RH	17/01/05
B	00	ECR4165 Ranger Design	RH	RH	11/6/03

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HV PSU 1 3/8"

Circuit Diagram

CD-85180	B	00
N Elliot	RH	RH
18/10/00	10/12/01	10/12/01
SHEET 1 OF 1		