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Spinner Array Tool

SPINNER ARRAY TOOL

6-SENSOR SPRINGBOW, 2.125″, ULTRAWIRE™

Operational & Maintenance Manual

CE

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0 ABOUT THIS MANUAL

0.1 MANUAL HISTORY

Date	Issue	Description	Auth	Chk	App
17/12/10	A	Initial Release.	GT/CW	GT	PR

0.2 TECHNICAL HELP

For further technical help contact GE Oil & Gas as follows:

Address: Building X107
Range Road
Cody Technology Park
Farnborough
Hampshire
GU14 0FG
United Kingdom

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Fax +44(0)1252 862 349
Web: www.ge-energy.com/oilfield

0.3 FEEDBACK

Please help us improve future issues of this manual by adding your comments or corrections to www.ge-energy.com/oilfield, 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 Spinner Array Tool (SAT) is designed to solve the problem of accurate fluid velocity identification in horizontal or highly deviated wells. It is run centralised within the wellbore.

The tool has an array of six specially developed miniature spinners, mounted on the inside of a set of springbows. Each spinner of the array measures the fluid velocity and direction of the surrounding fluid close to the well casing. Rotation is sensed by a Flux Angle Sensor, which eliminates drag and epitomizes measurement flow rates. The normal output is 2-pulses per revolution with indication of direction.

All six values are transmitted simultaneously to either the Surface or into a Memory section. Because the measurements are taken in a single plane across the diameter of the wellbore, rather than spaced along it, an accurate cross-sectional plot can be generated. Optional software can be used to provide a 3D image of the phases along the well.

The use of springbows allows the tool to be used when running in or out of the well and minimises power requirements, particularly when deployed using Memory recording.

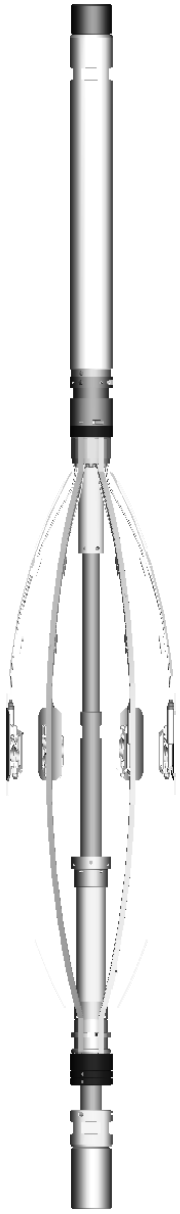


Figure 1.1 SAT

1.1 OPERATING PRINCIPLE

The SAT is designed for use in horizontal and deviated wells. In such cases, there is often a separation of the oil, water and gas components and traditional Production Logging (PL) tool readings in the centre of the well bore are not representative in this situation.

The tool can identify a velocity and direction profile in these cases and thus provides previously unattainable information for PL interpretation.

In combination with other flow imaging tools, the tool can provide comprehensive volumetric flow information of water/oil/gas distribution.

1.2 APPLICATIONS

- Fluid identification in horizontal and highly deviated wells
- Plotting of fluid velocity and direction along the wellbore
- Changes of wellbore fluids with time or different production rates
- Injection Flow Measurement

1.3 INTERFACING & TOOL COMBINATIONS

- Simultaneous operation with other Sondex Ultrawire™ tools
- Memory or SRO operations
- Combines with PIA to give well inclination
- Standard $1^{3}/_{16}$″ UN 12tpi Sondex or GO end connectors

1.4 SPECIFICATION

Parameter	Specification	Remarks
Max. Pressure	15,000psi	
Max. Temperature	177°C	
Nominal Diameter	2.125″ (53.975mm)	Minimum closing diameter. Springbow fully closed.
Make-up Length	45.5″ (1155.7mm)	
Overall Length	49.3″ (1252.2mm)	Including thread protectors.
Depth Offset	16.5″ (419.1mm)	From bottom of tool to sensors.
Weight	6.5kg (14.3lbs)	
Number of spinners	6	1 sensor per springbow.
Width of springbow	0.25″ (6.35mm)	
Recommended Casing sizes	3″ - 7″	
Telemetry	Ultrawire™	
Tool Address	30 dec.	Set by links on telemetry board.
Operating Voltage: • Nominal • Range • Absolute Max	 +18V DC +13V to 23V DC +24V DC	
Operating Current (logging mode) Typical:	 25mA	
Max. Frame Rate	2Hz	Polling interval usually limited by bus controller/wireline telemetry speed & Warrior configuration.
Relative Bearing accuracy (Rotation)	5°	
Relative Bearing Range	>5° to <175°	From vertical
End threads (top/bottom)	$1\frac{3}{16}$″ 12 UN2A GO (female/male)	
End connectors (top/bottom)	4mm single conductor (male pin/female socket)	Sondex Ends

2 SAFETY

In normal use, there are few specific safety instructions for the safe handling of the SAT. The following are guidelines only and should be followed in addition to any specific company and regional regulations.

2.1 HOT WORK

WARNING!

HOT WORK!

The SAT005 may, under certain circumstances or failure modes, become hot because of the high temperatures to which the tool can be subjected.

For this reason, using the SAT005 must be considered 'HOT WORK'. The temperature of the tool could cause injury to the skin of any person who touches it.

Follow the appropriate precautionary procedures when testing at the surface in areas where there is a risk of either gas leaks or other potentially explosive atmospheres.

Sondex Wireline Ltd. recommend suitable protective gloves are worn when handling the SAT005.

2.2 DAMAGE TO EQUIPMENT

CAUTION!

Spinner Damage!

The spinners may be damaged when the tool is dropped.

To protect the spinners, the closing ring must be fitted around the spring bows to avoid damaging the spinners.

The tool must be transported in its flight case.

2.3 IRRITANT

2.3.1 LIQUID-O-RING® LUBRICANT

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

Wear approved protective gloves when using Liquid-O-Ring® type 101.

Wear approved protective goggles / glasses when using Liquid-O-Ring® type 101.

Wash hands after using Liquid-O-Ring® type 101.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

DO NOT store Liquid-O-Ring® type 101 with strong oxidizers.

Use the local authorised industrial waste disposal site and comply with environmental regulations. Burning is **NOT** recommended.

DO NOT just throw away Liquid-O-Ring® type 101.

Should it be necessary to dispose of Liquid-O-Ring® type 101, the disposal **MUST** be in accordance with all Local Rules & Regulations (Directives) that are in force in the country where the disposal is to take place. Should there not be any Local Rules & Regulations (Directives), then International Rules & Regulations (Directives) **MUST** be obtained and followed.

2.3.2 *LOCTITE® 243 THREAD LOCKER*

IRRITANT!

Loctite® 243 THREAD LOCKER

Loctite® 243 **is designed for the locking and the sealing of threaded fasteners that require normal dis-assembly with standard hand tools.**

Wear approved protective gloves when using Loctite® 243.

Wear approved protective goggles / glasses when using Loctite® 243.

Wash hands after using Loctite® 243.

For more details, refer to the Material Safety Data Sheet (MSDS) for Loctite® 243.

Use the local authorised industrial waste disposal site and comply with environmental regulations. Burning is **NOT** recommended.

DO NOT just throw away Loctite® 243.

Should it be necessary to dispose of Loctite® 243, the disposal **MUST** be in accordance with all Local Rules & Regulations (Directives) that are in force in the country where the disposal is to take place. Should there not be any Local Rules & Regulations (Directives), then International Rules & Regulations (Directives) **MUST** be obtained and followed.

2.3.3 *WD-40® SPRAY*

IRRITANT!

WD-40® SPRAY

WD-40® Spray **is used to apply a protective oil film to various surfaces of the SAT005.**

Wear approved protective gloves when using WD-40® Spray.

Wear approved protective goggles / glasses when using WD-40® Spray.

Wash hands after using WD-40® Spray.

For more details, refer to the Material Safety Data Sheet (MSDS) for WD-40® Spray.

WARNING!

FLAMMABLE!

***WD-40® Spray* has a low flash point.**

Do NOT use where either air temperatures or surfaces are either at or above this value.

Do NOT smoke anywhere in the area where WD-40® Spray is used!

For more details, refer to the Material Safety Data Sheet (MSDS) for WD-40® Spray.

Avoid extreme temperature.

Use the local authorised industrial waste disposal site and comply with environmental regulations. Burning is **NOT** recommended.

DO NOT just throw away WD-40®.

Should it be necessary to dispose of WD-40®, the disposal **MUST** be in accordance with all Local Rules & Regulations (Directives) that are in force in the country where the disposal is to take place. Should there not be any Local Rules & Regulations (Directives), then International Rules & Regulations (Directives) **MUST** be obtained and followed.

2.3.4 Isopropyl Alcohol (IPA)

IRRITANT!

Isopropyl Alcohol (IPA)

***Isopropyl Alcohol (IPA)* (a rubbing alcohol) is used as a cleaning agent for the tool.**

Wear approved protective gloves when using Isopropyl Alcohol (IPA).

Wear approved protective goggles / glasses when using Isopropyl Alcohol (IPA).

Wash hands after using Isopropyl Alcohol (IPA).

For more details, refer to the Material Safety Data Sheet (MSDS) for Isopropyl Alcohol (IPA).

WARNING!

FLAMMABLE!

***Isopropyl Alcohol (IPA)* has a relatively low flash point.**

Do NOT smoke anywhere in the area where IPA is used!

Do NOT use IPA near any open flames, sparks or high-heat appliances.

Avoid extreme temperature.

Use the local authorised industrial waste disposal site and comply with environmental regulations. Burning is **NOT** recommended.

DO NOT just throw away Isopropyl Alcohol.

Should it be necessary to dispose of Isopropyl Alcohol, the disposal **MUST** be in accordance with all Local Rules & Regulations (Directives) that are in force in the country where the disposal is to take place. Should there not be any Local Rules & Regulations (Directives), then International Rules & Regulations (Directives) **MUST** be obtained and followed.

2.4 ELECTROSTATIC DISCHARGE

The tool contains very sensitive electronic circuitry. Consequently the tool should be handled with care.

CAUTION!

Electrostatic Discharge (ESD)

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

When handling tools that 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 make sure 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: ESD is less likely to affect tools when the housing is fitted.

2.5 STORED ENERGY

2.5.1 TRAPPED PRESSURE

WARNING!

TRAPPED PRESSURE!

The SAT005 has components that in a failure mode may retain pressure. This pressure can be released at any time without warning.

Wear an approved protective faceshield when you handle a tool that may contain trapped pressure.

Wear an approved protective apron when you handle a tool that may contain trapped pressure.

Logging tools are subjected to harsh conditions downhole. High hydrostatic-pressure, high-temperature, shock, vibration and contact with corrosive substances can all contribute to causing possible leaks into sealed housings. Leak paths include but are not limited to:

- Permeation through the seals
- Seal failures
- Hairline cracks in welds

Should such a leak occur downhole, then as the tool is removed from the well and the external hydrostatic-pressure reduces the liquid/gas that has leaked into the tool is expected to leak out

again through the path by which it entered. However, some of the liquid/gas may be retained and, occasionally, the leak path may either partially or completely re-seal. This will trap the liquid/gas inside the tool. In this case, when the tool returns to the surface, it can potentially have a significant volume of liquid/gas stored inside with a significant amount of potential energy!

The trapped and pressurised fluid/gas could pose a safety hazard during handling, transportation or storage as well as when the tool is dismantled for maintenance.

When the SAT005 displays any of the following characteristics it should be considered as potentially containing trapped and pressurised fluid/gas:

- Telemetry failures downhole
- Signs of mechanical damage
- Unusual seepage of fluid out of the tool or bubbling / hissing noises
- Tools that have been fished
- Tools that have been downhole for more than 24hrs continuously
- Hard to undo housings or housing split nuts

2.5.1.1 REMEMBER - Do NOT do the Following

1 **DO NOT** point parts of the tool (that may become projectiles) at either yourself or others.

2 **DO NOT** try to release the pressure by removing filler plugs or other small plug items, unless the instruction manual indicates specifically (*Section 4.5.1 Relief of Trapped Pressure*) that this is the correct method to release the trapped pressure.

3 **DO NOT** ignore the risk of trapped pressure and return the tool to its transportation packaging. The tool may explode at any time due to sudden mechanical shock or changes in atmospheric pressure. This could be dangerous dependant on the method of transport of the tool. For example, when the tool is being transported within an aircraft.

4 **DO NOT** open the tool either in a confined space or inside a building as there could be a risk of releasing toxic chemicals.

2.5.1.2 Recommended Precautions to Follow - DO the Following

1 **Always** wear Personal Protective Equipment (PPE) - hard toe boots, safety glasses and fluid resistant gloves are a minimum.

2 **Always** leave the tool to stand in a cordoned-off safe area (preferably outside) marked with hazard signs, for as long as possible (not less than 24hrs). Pressure may leak out slowly and (with sufficient time) the pressure will reduce to a less dangerous and more manageable level.

3 **Always** put (in a prominent position) a noticeable warning indicator on the tool (marker pen, sticky label, etc.) to tell others that it is suspected the tool contains trapped pressure. It is advisable also to display large signs that can be read clearly and convey the same warning.

4 **Always** make all colleagues and other operators in the area aware that the tool may contain trapped pressure.

5 **Always** allow time for the tool to cool down to the ambient (room) temperature. Fluids (especially gases) have more stored potential energy at a high temperature than at the ambient (room) temperature. When the tool is allowed to cool down, it will reduce this potential energy.

6 **Always** be aware that the well fluid inside the tool may be hazardous or toxic. For example, it may contain Hydrogen Sulphide (H_2S). Take the appropriate precautions to prevent harm to operators, such as attempting to open the tool outside and the use of toxic-chemical monitoring equipment.

7 **Always** be aware that the well fluid inside the tool may be a flammable gas or mist. Open the tool away from sources of ignition or sparking.

8 **Always** make sure the suspect tool is disassembled until all volumes inside have been found to be safe and free of pressure.

Refer to *Section 4.5.1 Relief of Trapped Pressure*.

2.6 RECOMMENDATIONS

WARNING! The product should be installed, adjusted and serviced by qualified electrical maintenance personnel. Improper installation or operation of the equipment may cause injury to personnel or equipment. Before beginning any installation or commissioning work ensure that electrical power is disconnected and locked out.

NOTE: Installation must meet National Wiring Regulations in accordance with IEC/UL 61010 latest revision.

WARNING 1: The outer casing of the product should be connected to a known good system ground before making any other electrical power connection. This system ground to be maintained until all electrical power connections are disconnected and locked out.

WARNING 2: Units with exposed Electrical Connectors are supplied with protective insulating end caps bearing a warning of High Voltage. These end caps should only be removed when Electrical Power is disconnected and locked out for the purposes of interconnection to other Units. Under no circumstances should equipment be operated with the Electrical Connectors exposed.

WARNING 3: Units with moving parts such as callipers can be activated immediately on application of Electrical Power. A safe area should be established around any such Units before the application of Electrical Power.

WARNING 4: Units with moving parts such as springs can retain significant Potential Energy. Great care should be exercised when removing Closing Rings or handling over tightened assemblies.

WARNING 5: Units containing seals may entrap pressure. Disassembly should only be carried out in accordance with recommended procedures ensuring the release of pressure prior to the disengagement of cap threads.

WARNING 6: When the equipment is not installed, commissioned and used in accordance with the manufacturer's specifications, protection provided may be impaired.

CAUTION!

Standard Personal Protective Equipment

Standard PPE must be worn at all times including but not limited to: Safety glasses, gloves and steel-toed boots.

Equipment exceeding 18Kg in weight should be handled with extreme care. Heavy items should be mechanically lifted. Any installation of equipment over 10Kg to be lifted over 1 metre should be at least a two man lift. Good lifting practice should be exercised at all times including but not limited to:

- Use of correct personal safety gear.
- Lift using legs not back
- Not proceeding with a lift in the presence of any doubt of completing the lift safely
- Use of mechanical lifting aids wherever possible
- Ensuring work area is free of clutter and tripping hazards

2.7 TRANSIT TUBE

The transit tube is used to reduce the risk of accidental damage to the sensors on the springbows. The tool should be kept in the tube, until required, to reduce shock load to the sensors should the tool be accidentally dropped or moved.

3 THEORY OF OPERATION

3.1 BLOCK DIAGRAM

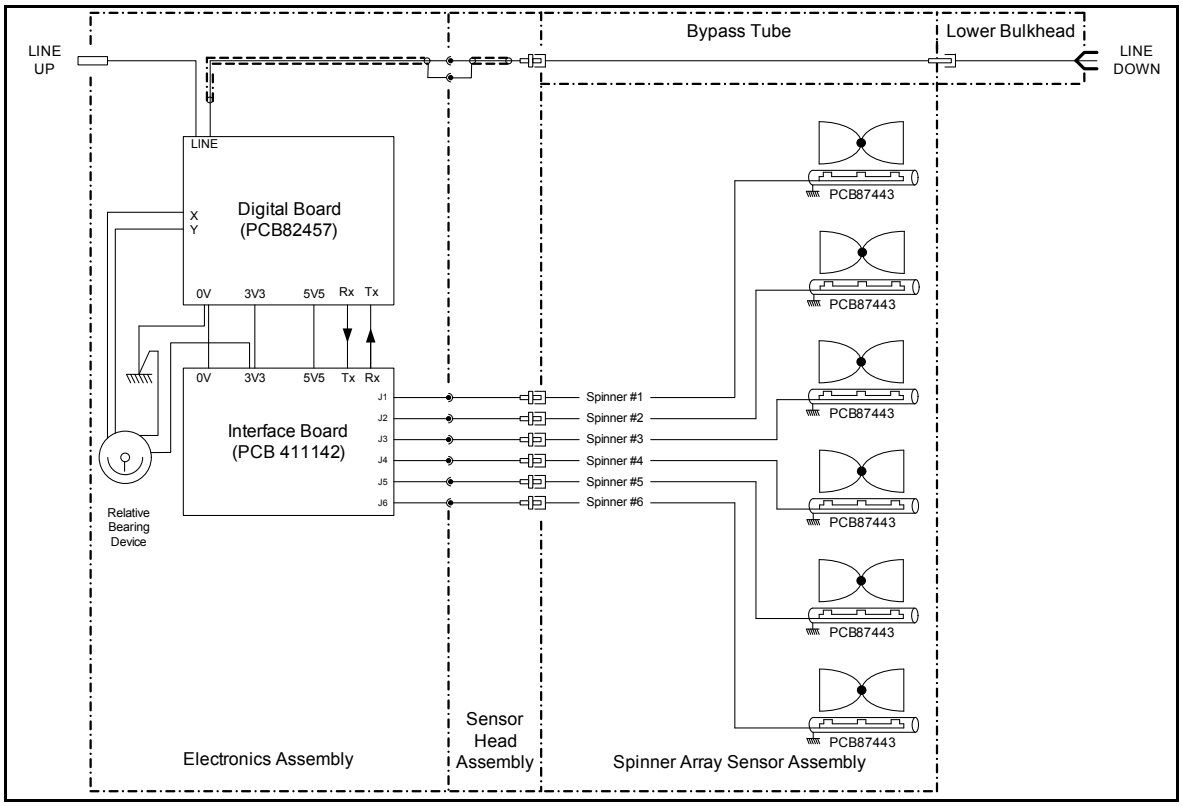


Figure 3.1 Block Diagram

3.2 DESCRIPTION

3.2.1 GENERAL

The Spinner Array Tool incorporates six miniature-spinners that are deployed toward the Internal Diameter (ID) of the tubing via springbows. The tool is closed while running in hole and opens automatically when it leaves the tubing and enters the larger diameter of the casing. Should the tool pass any restrictions, either up or down, the bow springs will collapse to prevent damage to the spinners.

The sensor bodies are clipped onto the springbow and house sensor electronics, including the Flux Angle Sensor and a temperature sensor. The spinner is mounted between two pivots and houses jewelled bearings at each end and a magnet in the centre.

3.2.2 FLUX ANGLE SENSOR

The Flux Angle Sensor provides sine and cosine outputs corresponding to the incident magnetic flux angle. The flux angle changes as alternate magnetic poles sweep past one side of the sensor and this is used to calculate both spin speed and direction. See *Figure 3.2* for a graphic representation of the magnet and flux angle sensor location.

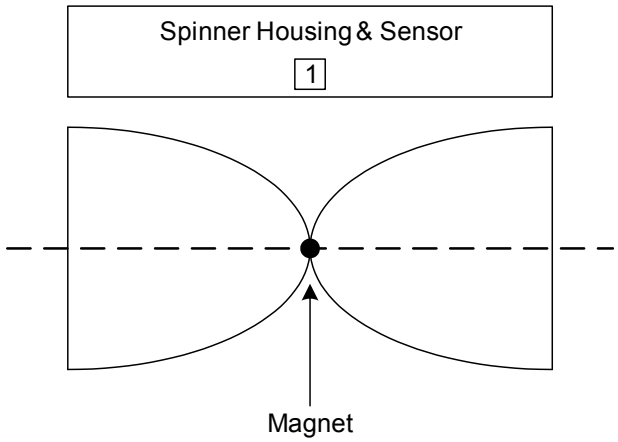


Figure 3.2 Magnets & Hall Effect Sensor Location

3.2.3 ELECTRONICS

The tool operates on Ultrawire™ telemetry and can collect data in excess of 100 frames per second. However, other parts of the system (e.g.: wireline telemetry speed) will usually limit the maximum frame rate significantly. For example, the default configuration of the Warrior logging software is set at 24 samples/foot.

Further details can be found in *Section 6 Electrical Description*.

3.2.4 RELATIVE BEARING DEVICE

The relative bearing device is a pendulum based device that is used to measure tool rotation. It is not intended to be a survey instrument, but merely to indicate which spinner is uppermost.

Calibration of the Relative Bearing Device is done at the factory and can not be repeated by the customer.

3.3 CALIBRATION THEORY

3.3.1 SPINNER ROTATION

The rotational velocity of the spinner is measured to provide the flow velocity.

The rotation frequency of a real spinner is given by Equation 3.1 below. This assumes that the friction (i.e.: around the bearings) has no viscous component and that the viscous effect is to slow fluid moving along the blade face. This equation only applies to a rotating spinner; it does not apply to a stationary spinner in a very slow flow:

$$f = aV - \left(\frac{b}{\rho}\right)V - c\sqrt{\frac{V\mu}{\rho}} \qquad \textbf{Equation 3.1}$$

where:
- f is the frequency of rotation of the spinner cps (Hz).
- V is the fluid velocity.
- a is a constant depending on blade pitch.
- b is a constant depending on ratio of friction to blade moment of inertia.
- c is a constant depending on skin friction of fluids moving over the blade surface.
- ρ is fluid density.
- μ is fluid viscosity.

Neglecting friction and inertia terms:

$$f = aV \qquad \textbf{Equation 3.2}$$

3.3.2 Fluid Velocity Determination

The operating procedure in the well allows the flowmeter to be calibrated by recording several passes at different logging speeds, see *Section 4.2* for information on tool calibration. Plots of logging speed versus tool reading enable the apparent fluid velocity (V_{app}) to be determined.

The more linear the tool response, the more accurate is the velocity determination. Non-linearity, for example bearing friction and viscosity, can be accounted for in the above plots. The plots also compensate for the alteration to flow velocity due to the insertion of the toolstring. Sondex flowmeters are linear over their full operating range under normal well conditions.

3.3.3 Total Flowrate Determination

The velocity of fluids is largest at the centre of the pipe and varies to zero at the pipe wall. Spinner flowmeters generally read a fluid velocity close to that of the centre. However, the SAT measures at the pipe wall. The true average fluid velocity (Vt) is therefore somewhat more than that indicated by the spinner flowmeter (Vapp) and requires correction. This correction factor (K) is a function of the spinner blade diameter with respect to the inside diameter of the pipe and the Reynolds number of the flow. Typical approximate corrections necessary to determine true average flow velocity (Vt) in turbulent flow from the velocity measured by the spinner are:

$$V_t = V_{app} x K \qquad \textbf{Equation 3.3}$$

Total flowrate can be directly calculated by multiplying the flowrate by the casing internal cross-sectional area (and a scaling factor). The following converts directly to barrels per day (bpd).[1]

$$\text{Total Flowrate (bpd)} = 1.4 \times V_t(\text{ft/min}) \times (\text{casing I.D. (inch)})^2 \qquad \textbf{Equation 3.4}$$

3.3.4 Approximate Spinner Rotation Rates

The figures shown in the table below are to be used to derive the *approximate* spinner rotation rate for a given fluid velocity, or to derive the *approximate* fluid velocity for a given spinner response. *Accurate* fluid flowrate can only be derived by multipass calibration of the spinner in the flow downhole.

$$\text{rps} \cong \frac{\text{fpm}}{5 \text{ x pitch (inches)}} \qquad \textbf{Equation 3.5}$$

Design pitch	Flow loop slope	Nominal Slope	
inch/revolution	rps/fpm	fpm/rps	rps/fpm
2	0.1	10	0.1

1. For a more detailed discussion, see “Cased-hole Log Analysis and Reservoir Performance Monitoring”, R.M. Bateman, 1984. (ISBN 90-277-1922-5).

4 OPERATING PROCEDURE

Note: Also refer to *Section 7.2 Extraordinary Maintenance*.

4.1 PRE-LOGGING CHECKS

4.1.1 MECHANICAL

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

IRRITANT!

WD-40® SPRAY

***WD-40® Spray* is used to apply a protective oil film to various surfaces of the LDT001.**

See *Section 2.3.3 WD-40® Spray*

For more details, refer to the Material Safety Data Sheet (MSDS) for WD-40® Spray.

Complete these pre-logging mechanical checks:

1 Check that O-Rings and sealing surfaces are undamaged, clean and greased.

2 Remove the closing rings.

3 Check that all springbows are in good condition.

4 Check that all spinners are free to rotate and located securely within the appropriate springbow. The spinners should be free running and come to a slow stop. Should adjustment be necessary see *Section 5.4.3.2*.

5 Check that the locking ring is hand-tight, so that the sensors are held in the sensor head. Also check that the locking ring is locked down to the Main Shaft by ensuring that the appropriate grub screws are tight.

6 Check that the bow clamp locking rings are tight.

7 Check that the inner split ring on the sensor head is tight and also that the grub screws are tightened to prevent it from unscrewing.

8 Ensure that there are no iron scrapings on the magnet, as this will influence the tool accuracy. When iron scrapings are visible, flush the magnet with a light oil, like WD-40®. Ensure the magnet is not damaged, replace when necessary.

9 Check that there is no dirt or debris between the bearings and the pivots, which might impair the free movement of the shaft. Flush with a light oil when required.

10 Check that the spinners are balanced.

4.1.2 ELECTRICAL

Complete these pre-logging mechanical checks:

1 Make sure the upper and lower electrical connectors are clean, dry and undamaged.

2 Using a Multimeter, check the through-resistance between the top and bottom LINE connections. The resistance should be <0.5Ω.

Note: The resistance of the connecting leads should be taken into account when taking this measurement.

3 Using a Multimeter, check the resistance between the LINE connections and the chassis (effectively the D.C. resistance of the internal electronics). The resistance should be > 100kΩ.

4.1.3 OPERATIONAL

1 Connect the SAT to a suitable telemetry controller, and to a logging system via a wireline cable or suitable dummy cable.

2 Attach a Bullnose Ultrawire™ Terminator *(BUL006)* to the bottom of the toolstring. Although the tool may appear to work without the Bullnose, it will be more susceptible to telemetry errors when the Bullnose is not used.

3 Switch on the logging system.

4 The SAT tool current should be approximately 25mA.

5 Slide the closing ring off the tool so that the springbows open.

6 Check that all springbows are opened correctly and that the sensors are held correctly within them.

7 No counts should be observed when the spinner is not rotating.

8 Counts should occur at the rate of 2-counts per revolution when rotating.

Check both *forward* and *reverse* direction of rotation and make sure decoding by the data acquisition system is correct.

4.2 CALIBRATION

Calibration data is not supplied with the tool as it is best performed in the well. Calibration is a standard procedure for flowmeters of this type. There is little variation between Sondex tools of the same type.

Log data must be obtained over several passes in both up and down directions at different speeds during every logging operation. More than one set of data should be collected, for example before and after a survey. This enables a cross plot of *spinner rps* against *speed* to be made at any depth. From this cross plot, the apparent flow velocity (V_{app}) can be determined (see *Section 3.2.2 Flux Angle Sensor*).

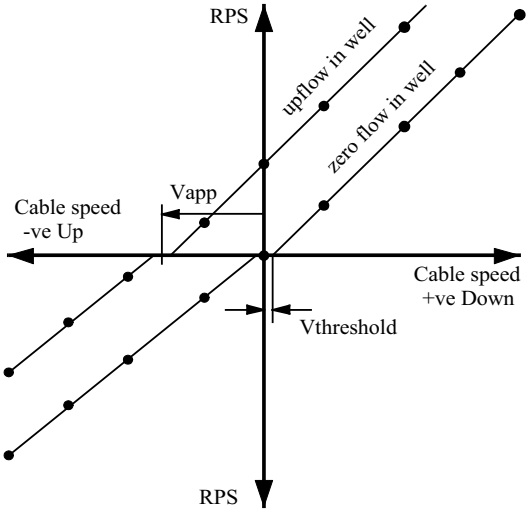


Figure 4.1 Flowmeter Fluid Velocity Response

Calibration data may be transferred to other logging runs, but this is not recommended since the response curve of *Equation 3.1* may have altered due to a change in fluid properties or bearing friction.

Plots must be made of tool reading against cable (tool) velocity.

Note: Sensitivity to flow in one direction or the other may be reduced by the shielding effect of the toolstring above or below the spinner.

Flow in the well shifts the zero rotation point along the cable velocity axis by the apparent average flow in the centre of the well V_{app}. Note that no calibration, other than this crossplot, is needed.

Note: In high flowrate wells it may not be possible to apply sufficient upward tool velocity to produce a zero tool reading (spinner stationary). In this case there are two options:

1 Since the tool response (*Figure 4.1*) is closely linear and any zero offset will be negligible, extend the best straight line through the plotted readings until it cuts the cable speed axis. The cable speed reading here will be V_{app}.

2 Refer to a calibration data set run with the well shut in. This will include readings close to zero. There may be a lower section of the same well where determination of the threshold is possible.

4.3 CONNECTING TO TOOLSTRING

4.3.1 GENERAL

In terms of measurement, the position of the SAT within the toolstring is not critical. However, other tools can affect where the SAT can be placed. This is mainly where other PL tools, any XSH and/or a tractor are used. The main criteria is to ensure that the SAT is centralised.

4.3.2 CENTRALISATION

Centralisation is very important, and becomes a critical issue in horizontal wells. When the SAT is below centre, all the spinners will be below their desired positions, resulting in an overestimate of the water fraction. When the tool is very significantly de-centralised, the uppermost sensor may not get close enough to the casing (especially in 7” casing). In such cases, any oil flowing along the top side of the well may go undetected.

A common mistake is to believe that just because a toolstring supports itself on the ground, it will centralise in a horizontal well. This is not necessarily the case, for the following reasons:

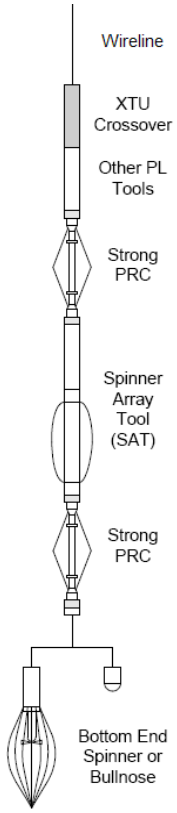


Figure 4.2 Recommended Toolstring configuration

1 Firstly, the supporting force from centralisers decreases as they are compressed. Thus, achieving centralisation even in 7” casing requires care and becomes more difficult as the casing diameter decreases.

2 Secondly, toolstrings flex as they become longer. This can cause significant decentralisation of the SAT when there are too many tools between the SAT and its centralisers.

3 Thirdly, when self-supported on the ground, there will be two arms of a centraliser supporting the tool. In a horizontal well, the centraliser may be oriented such that only one arm is supporting the tool.

4 Finally, the supporting force of Centralisers may decrease when moving. This is due to the frictional component between the casing and centraliser roller being less when moving than when stationary (i.e.: the static friction is greater than the dynamic friction).

As a minimum therefore:

- There should be no tools between the SAT and its nearest centraliser.
- Consider the use of strong centralisers (e.g.: 70lbs to 100lbs) at each end of the SAT; 40lb centralisers may not be sufficient in small (3″ diameter) casing.

Great care must be taken when other tools are added to the toolstring. When possible, assemble the string in sections, based on casing diameters found in the well to be logged. When this cannot be done, use more centralisers than thought to be absolutely necessary.

Knuckle joints may also be used as appropriate, particularly when weight bars are used.

It is a useful exercise to assemble the tool horizontally in sections of 6″ casing to see the effect of adding extra tools. Even the effect of adding an extra tool between the SAT and a centraliser is usually quite significant. In 3″ casing or tubing the centralisation problems are even greater.

4.3.3 Alignment of Multiple Array Tools

When more than one flow imaging tool (i.e.: CAT & SAT) are run in one string, it is advisable to keep the distance between the imaging tools to a minimum.

When multiple array tools are combined in a toolstring, a Rotational Alignment Sub (RAS) can be used to ensure all sensors on the array tools are aligned with each other.

Refer to *A.2 Ancillary Equipment* for part numbers and O-Ring replacement for the RAS.

4.3.4 Use of Restrictor Rings with MAP Tools

The SAT tool will open out to a nominal 7" diameter in its standard form. When logging is required and the tool is not required to open to its maximum diameter, a restrictor ring can be fitted beneath the springbow opening tension spring. Three sizes of restrictor rings are available giving nominal maximum opening sizes of 6-inches, 5-inches and 4-inches. Fitting instructions are shown in *Appendix C Fitting of Restrictor Rings*.

4.4 LOGGING

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 (HTU) is highly recommended.

Note: Do not exceed the calculated safe working load of your selected weak point. When in doubt, use a Head Tension Unit (HTU), 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	

Depth (ft)	Speed Pulling Out of Hole	Speed Running in Hole
>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.

Logging can (and normally would) be done whilst logging both up and down. However, the down-passes can sometimes produce superior data to the up-passes. This is because the relative fluid velocity is greater when running downhole. Also, due to the unique design of the tool, it is recommended that stationary passes are taken at zones of particular interest.

4.5 POST LOGGING DISASSEMBLY

4.5.1 RELIEF OF TRAPPED PRESSURE

WARNING!

TRAPPED PRESSURE!

The SAT005 has components that in a failure mode may retain pressure. This pressure can be released at any time without warning.

See *Section 2.5.1 Trapped Pressure*.

For further information about how to relieve trapped pressure in specific circumstances, see *Section 5.2 Relief of Trapped Pressure*.

When the SAT005 displays any of these characteristics it should be considered as potentially containing trapped and pressurised fluid/gas:

- Telemetry failures downhole
- Signs of mechanical damage
- Unusual seepage of fluid out of the tool or bubbling / hissing noises
- Tools that have been fished
- Tools that have been downhole for more than 24hrs continuously
- Hard to undo housings or housing split-nuts

When there are signs of trapped pressure, refer to *Section 2.5.1 Trapped Pressure* and *Section 5.2 Relief of Trapped Pressure* for SAT005 specific instructions.

IRRITANT!

WD-40® SPRAY

***WD-40® Spray* is used to apply a protective oil film to various surfaces of the LDT001.**

See *Section 2.3.3 WD-40® Spray*.

For more details, refer to the Material Safety Data Sheet (MSDS) for WD-40® Spray.

When there are signs of trapped pressure:

1 Clean the tool before disassembly, paying particular attention to the spinners.

2 Clean and lightly oil the bearing assembly with WD-40™ or similar to prolong the life of the pivots.

3 Keep electrical connectors clean and dry.

4 Refit thread protectors.

4.6 TRANSPORT, HANDLING & STORAGE

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

Store with end threads lightly greased with Liquid O-Ring® type 101 and with water tight thread protectors fitted.

When not in use, keep the tool inside the transit tube inside the flight case.

The tool should be transported to site in the transport case provided.

Do not subject the tool to extreme shock, such as dropping or hitting with a hard object.

Do not lift or support the tool from the area surrounding the spinners.

5 MECHANICAL DESCRIPTION

5.1 OVERVIEW

The tool consists of three main sections:

- Electronics Section
- Sensor Assembly
- Main Shaft Assembly.

The electronics section plugs into the sensor head to allow for easy removal.

The sensor head acts as a hub for the 6 sensor assemblies; the sensors plug into the sensor head and have an O-Ring Seal, which allow for easy replacement. The single wire of the sensor assembly (plus the chassis ground) provides power to the sensors, and in addition, the frequency signal from the sensor is sent back down this single wire to the main tool electronics. The chassis ground is ensured by utilising a canted spring on the sensor tube. Make sure this spring is in good condition.

The 6 flexible tubes of the sensor assembly, which flex with the springbow, are guided under its corresponding springbow by metallic clips and each springbow carries a single wire from the springbow-mounted spinners to the sensors. The clips guide the sensor assembly tubes to allow the sensors to keep a set distance from the springbow and therefore lessen the shielding effect on the flow from the springbows.

The springbows are anchored at the sensor head end and actuated by an expansion spring at the other end. The springbows are fixed to the tool by a clamping ring at each end, which can be backed off to allow replacement of all or individual springbows.

5.2 RELIEF OF TRAPPED PRESSURE

WARNING!

TRAPPED PRESSURE!

The SAT005 has components that in a failure mode may retain pressure. This pressure can be released at any time without warning.

See *Section 2.5.1 Trapped Pressure*.

For further information about how to relieve trapped pressure in the post logging stage, see *Section 4.5.1 Relief of Trapped Pressure*.

5.2.1 PRESSURE IS RELIEVED THROUGH HOUSING SEALS

Ref.: SAT005 General Assembly *09822*

The tool has been designed to release trapped pressure directly through the Electronics Housing (item 9, *09822*) joint. The threads in the joint are sufficiently strong to retain trapped pressure until the housing seals fully disengage from the seal bore relieving the volume inside to the atmosphere.

When signs of trapped pressure are suspected, make sure the Post Logging Checks (Refer to *Section 4.5 Post Logging Disassembly*) have been completed **AND** refer also to *Section 2 Safety*.

To relieve the trapped pressure, complete these actions:

1 Place a rag over the Electronics Pressure Housing joint of the tool. This will diffuse any jet of gas or fluid emerging from around the seals.

2 Slowly disconnect the housing from the tool. If there is trapped pressure inside the housing, the joint may well be tighter than usual and require more torque the normal to undo.

3 At some point, before the threads of the joint have become disengaged, fluid release will occur. As soon as any hissing or fluid appearance happens, the disconnection process should cease and the pressure inside the housing should be allowed to dissipate. Stop disconnecting the housing from the tool until all the pressure has escaped. This is because the pressure load on the housing joint can be safely retained by the threads that remain engaged.

4 Once the operator is satisfied that no more fluid is escaping, SLOWLY resume unscrewing the housing joint. When further signs of fluid escape are evident, immediately cease the unscrewing and allow the pressure to dissipate.

5 Repeat these steps until all trapped pressure is released and there is no pressure loading on the housing joint.

5.3 DISASSEMBLY

5.3.1 ELECTRONICS SECTION REMOVAL & ACCESS

5.3.1.1 Electronics Section Removal

Ref.: SAT005 General Assembly *09822*
Electronics Assembly *410519*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

1 Make sure the Transportation Closing Ring (Item 37, *09822*) is removed from the bow springs.

2 Unscrew the Pressure Housing (Item 9, *09822*) from the Sensor Head Assembly (item 1, *09822*).

3 Lightly screw in grub screws (3 x Item 15, *410519*) **clockwise** into the electronics assembly until flush (see *Figure 5.1*).

Note: Do not apply excessive torque, as this will hamper removal and possibly damage the LEMO connector in the electronics assembly (Item 9, *410519*).

4 The Electronics Assembly (Item 2, *09822*) can now be unplugged from the Sensor Head Assembly (Item 1,*09822*) by simply pulling them apart, see *Figure 5.1*.

Figure 5.1 Separating Electronics from Sensor Head Assembly

5.3.1.2 Electronics Access

Ref.: SAT005 General Assembly *09822*
Electronics Assembly *410519*

1 Unscrew Pressure Housing (Item 9, *09822*) from the Sensor Head Assembly (Item 1, *09822*).

2 The Electronics Boards (Item 3, *410519* and Item 4, *410519*) can be accessed by removing the Upper Half Shell (item 7, *410519*).

Note: The lower half shell should not be removed unless access to the wiring of the Relative Bearing Assembly (item 2, *410519*) is required. The upper half shell is fitted with 6 screws (item 17, *410519*); the lower half shell has 10 screws (item 17, *410519*) as the additional 4 screws (item 17, *410519*) hold the Relative Bearing Assembly (item 2, *410519*) in place.

5.3.2 SPRINGBOW REMOVAL

Ref.: SAT005 General Assembly *09822*
Sensor Head Assembly *411214*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

5.3.2.1 Removing the Springbows

1 Using two 'C' spanners, loosen the bow clamp locking rings (Item 18,*09822*).

Figure 5.2 Loosen Bow Clamp Locking Rings

2 Slide the Lower Bow Clamp Ring (Item 19, *09822*) away from the springbows. It is now possible to disengage the Springbow (Item 4,*09822*) from its location holes.

Figure 5.3 Sliding lower bow clamp ring away

Note: When only a small number of springbows are to be removed, the lower bow clamp ring (Item 19, *09822*) can be used to lock the remaining springbows onto the lower bow end termination body (Item 17, *09822*) by re-tightening the bow clamp locking rings (Item 18, *09822*). Make sure that the pegs of each springbow are correctly aligned.

3 At the other end of the springbow, screw in the bow clamp inner split ring (Item 3, *411214*) and slide the bow clamp outer ring (Item 2, *411214*) and bow clamp outer ring bursting disc (Item 4, *411214*) away from the springbows in a similar fashion as in *Step 2*.

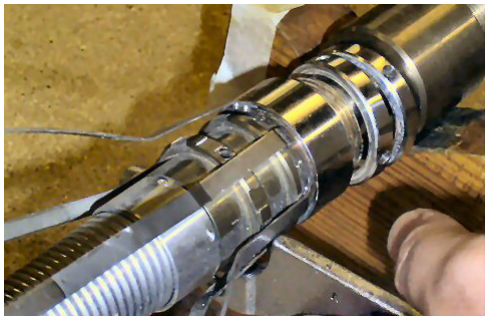


Figure 5.4 Loosening Bow Clamp Split Rings

4 Disengage the Springbow (Item 4,*09822*) from its location holes.

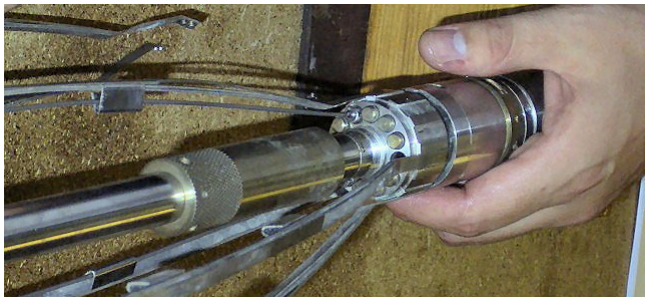


Figure 5.5 Disengage Springbow

Note: When only a small number of springbows are to be removed, the Bow Clamp Outer Ring (Item 2, *411214*) and Bow Clamp Outer Ring Bursting Disc (Item 4, *411214*) can be used to lock the remaining springbows onto the Sensor Head Assembly, by unscrewing the Bow Clamp Inner Split Ring (Item 3, *411214*). Make sure that the pegs of each springbow are correctly aligned, and that the Bow Clamp Outer Ring (Item 2, *411214*) is aligned with the keyway in the sensor head assembly.

5.3.2.2 Springbow Removal from SAT Sensor Assembly

1 Carefully push the springbow assembly (Item 4, *09822*) towards the lower bow end termination body (Item 17, *09822*) until the spinner section is free from the springbow assembly (Item 4, *09822*).

2 Unclip the SAT Sensor Vee Bearing Assembly (Item 3, *09822*), fitted to the clips on the Springbow Assembly (Item 4, *09822*).

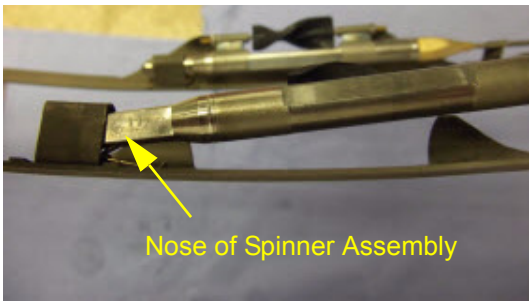


Figure 5.6 Sensor Assembly Removal

3 Carefully pull the SAT Sensor Vee Bearing Assembly (Item 3, *09822*) towards the Sensor Head Assembly (Item 1, *09822*) and out of the Springbow Assembly (Item 4, *09822*).

4 The SAT Sensor Assembly should first be released from the clip closest to the spinner. This can be done by applying sufficient force behind the tube to overcome the spring force of the clip and simultaneously levering the clip open.

5 Retain the Z-spring with the Sensor Assembly.

6 Repeat for each springbow to be replaced.

5.3.3 REPLACING SENSORS

Ref.:		
	Sensor Head Assembly	*411214*
	Assembly Tube Sensor $1^{11}/_{16}$″ vee bearing	*42758*
	Basic Spares Kit	*KITB-SAT*
	O-Ring Spares Kit	*KITO-SAT*

IRRITANT!

Isopropyl Alcohol (IPA)

Isopropyl Alcohol (IPA) **(a rubbing alcohol) is used as a cleaning agent for the tool.**

See *Section 2.3.4 Isopropyl Alcohol (IPA)*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Isopropyl Alcohol (IPA).

To replace the sensors:

1 Remove the springbows as described in *Section 5.3.2*.

Note: When only a small number of sensors are to be removed, it is not necessary to remove every springbow.

2 Slacken the grub screws (3 x Item 17, *411214*) in the locking ring (Item 16, *411214*).

3 Prior to unscrewing the locking ring, rotate the SAT radially so the line marker, indicating the first sensor, is facing down. Do not lose the Ball Bearing (Item 22, *09822*), located under the Locking Ring (Item 16, *411214*) in the groove of the Shaft, which locks the Shaft (Item 10, *09822*) to the sensor head.

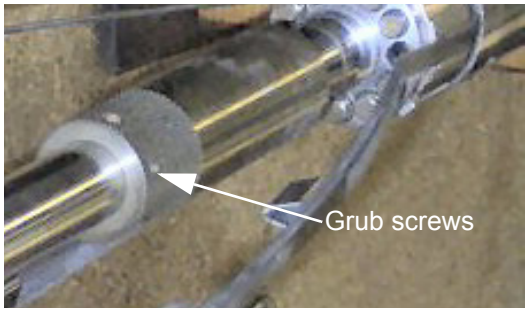


Figure 5.7 Slackening Grub Screws

4 Unscrew the Locking Ring (Item 16, *411214*) from the sensor head.

5 Using a small screwdriver, carefully lever out the desired sensors from the sockets in the sensor head. There is a recess in each sensor for this purpose.

6 Clean out the corresponding sockets in the sensor head to make sure that there are no traces of well fluid left. Isopropanol or a similar solvent can be used. Dry out the socket with soft tissue paper or similar.

7 When a sensor has leaked, it may be necessary to service the sensor head, see *Section 5.3.5*.

8 Check the condition of the O-Rings and canted coil springs.

9 Lubricate the O-Rings before refitting the sensors.

Note: When replacing the sensors, check that the connector and corresponding socket in the sensor head are clean and thoroughly dry.

10 When replacing the sensors, take care when inserting them back into the sensor head. This will reduce the risk of damage to the O-Ring (*P/N: 99007*, KITO) and canted coil spring (*P/N: 92158*, KITB).

11 Re-tighten the grub screws (3 x Item 17, *411214*) in the locking ring (Item 16, *411214*).

12 Refit the springbows (see *Section 5.4.3*) and clip the sensors back into the springbows.

5.3.4 Adjusting Spinner Assembly

Note: The spinner operation should be checked prior to every run, to make sure optimum performance when in operation. (See *Section 5.4.3.2*)

5.3.5 Sensor Head Disassembly

Ref.:

SAT005 General Assembly	*09822*
Sensor Head Assembly	*411214*
Wiring Diagram	*WD-40560*

WARNING!

TRAPPED PRESSURE!

The SAT005 has components that in a failure mode may retain pressure. This pressure can be released at any time without warning.

Refer to *Section 5.2 Relief of Trapped Pressure* for the relief of any trapped pressure.

Note: O-Rings (Item 6, *411214*) can be replaced without disassembling the sensor head.

CAUTION! The sensor head should not be removed, unless a leak has occurred. Servicing the sensor head assembly involves rewiring the sensor head and is not recommended, except in extreme circumstances.

1 Remove the Electronics Assembly (see *Section 5.3.1*), springbows (see *Section 5.3.2*) and sensors (see *Section 5.3.3*).

2 Remove the Locking Ring (Item 16, *411214*) from the Sensor Head (item 1, *411214*), see *Figure 5.7*).

Note: Take care not to lose the ball bearing (Item 22, *09822*), located under the locking ring (Item 16, *411214*) that locks the shaft (Item 10, *09822*) to the sensor head.

3 Remove 3 ball bearings from sensor head before unscrewing shaft.

4 Unscrew the main shaft (Item 10, *09822*) from the Sensor Head (Item 1, *09822*).

Note: There is a flat spanner surface on the Main Shaft for this purpose.

5 The sensor head is now isolated. Using a punch, remove the Spirol™ Pin (Item 18, *411214*) See *Figure 5.8*.

Figure 5.8 Removing the Spirol™ Pin

6 Gently pull LEMO Connector Assembly (Item 14, 13, and 12, *411214*) out of the Sensor Head (Item 1, *09822*) See *Figure 5.9*.

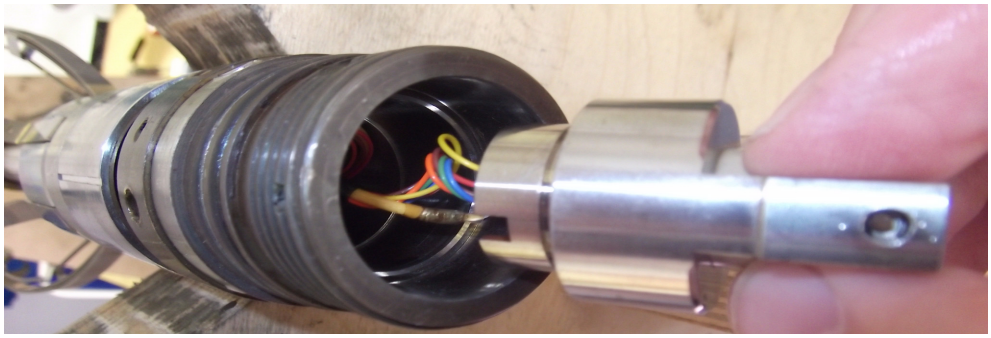


Figure 5.9 The LEMO Connector Assembly

7 Unscrew the Kemlon Connector (Item 11, *411214*), using the Kemlon Tool (Item 21, *P/N: 15263,* 40886).

8 De-solder the appropriate wire(s) from the LEMO connector (Item 13, *411214*), refer to the Wiring Diagram (*WD-40560*).

9 Using a Feedthrough Retaining Nut Assembly Tool (*P/N: 15283*, located in the Hand Toolkit), unscrew the Feedthrough Retaining Nut (Item 9, *411214*).

Note: When replacing the Feedthrough Retaining Nut (Item 9, *411214*), do not tighten excessively. It should only be lightly hand-tight.

10 Insert the Kemlon Removal Tool (*P/N: 15263*) into the sensor head (from the LEMO side), and using a hammer, carefully punch out the desired sensor Kemlons. Take care not to damage the wiring.

5.3.6 Disassembly of Main Shaft Assembly

Ref.: SAT005 General Assembly *09822*

1 Remove the springbows (see *Section 5.3.2*) and unscrew Main Shaft assembly from the Sensor Head (see up to *Step 4* of *Section 5.3.5*).

2 Unscrew grub screws (3 x Item 33, *09822*) from the Lower End Sub (Item 14, *09822*) and tap the Lower End Sub (Item 14, *09822*) with a hammer to release or at least loosen the ball bearings (3 x Item 23, *09822*).

3 Unscrew the Lower End Sub (Item 14, *09822*) from the Main Shaft (Item 10, *09822*). This will release the rest of the ball bearings (Item 23, *09822*) that did not fall out when tapped with the hammer.

4 Should it be desired, the Bypass Cable Assembly (Item 6, *09822*) can now be pulled out of the Main shaft (Item 10, *09822*).

5 Also when desired, the Lower Connector Assembly (Item 5, *09822*) can be removed from the Lower End Sub (Item 14, *09822*) by removing the Internal Circlip (Item 24, *09822*).

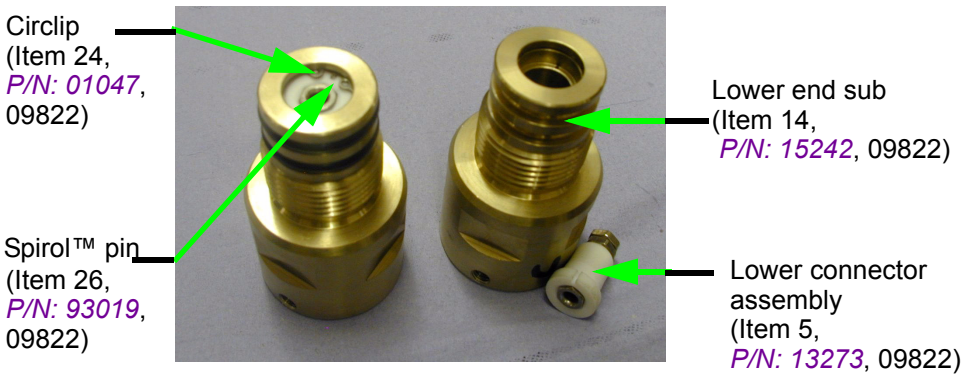


Figure 5.10 Removing Lower Connector Assembly

6 Using a punch, remove Spirol™ Pins (2 x Item 25, *09822*) that secure the Spring Retaining Ring (Item 16, *09822*) to the Lower End Bow Termination Body (Item 17, *09822*).

7 Slide back Spring Retaining Ring (Item 16, *09822*) from the Lower End Bow Termination Body (Item 17, *09822*), and using a small 'C' spanner, unscrew the Modified Extension Spring (Item 21, *09822*) **clockwise** off the Lower End Bow Termination Body (Item 17, *09822*).

8 The Lower End Bow Termination Body (Item 17,*09822*) and the assembled Spring Retaining Ring (Item 16, *09822*) can now be removed from the Main Shaft (Item 10, *09822*).

5.4 RE-ASSEMBLY

5.4.1 RE-ASSEMBLY OF MAIN SHAFT ASSEMBLY

Ref.: SAT005 General Assembly *09822*

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

1 Slide a Spring Retaining Ring (Item 16, *09822*) over the Extension Spring (Item 21, *09822*) and screw the spring (Item 21, *09822*) **anti-clockwise** onto the Lower End Bow Termination Body (Item 17, *09822*).

Note: A small amount of grease may aid with this assembly.

2 Secure the Spring Retaining Ring (Item 16, *09822*) to the Lower End Bow Termination Body (Item 17,*09822*) with Spirol™ pins (2x Item 25, *09822*).

3 Slide the second Spring Retaining Ring (Item 16, *09822*) over the spring (Item 21, *09822*) and slide the assembly onto the Main Shaft (Item 10, *09822*), along with the Spring Retaining Ring (Item 16, *09822*) from the other end.

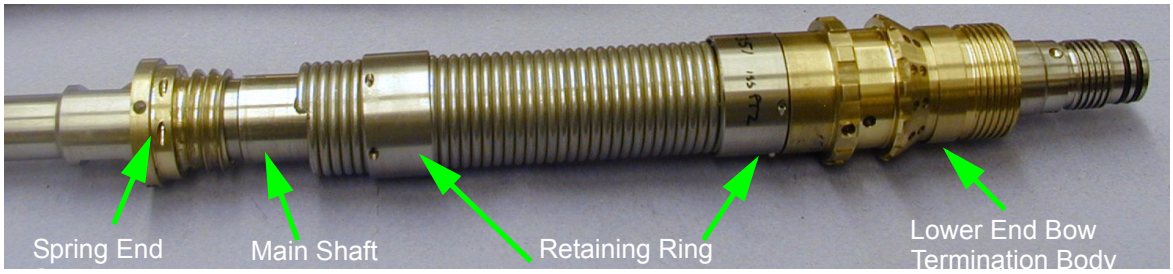


Figure 5.11 Main Shaft Assembly

4 Screw the Extension Spring (Item 21, *09822*) **anti-clockwise** to the Spring End Stock (Item 15, *09822*).

Note: A small amount of grease applied to the end stock will aid with this assembly.

5 Fit one of the Retaining Rings (Item 16, *09822*) over the spring (Item 21, *09822*) and secure to the Spring End Stock (Item 15, *09822*) with Spirol™ Pins (2 x Item 25, *09822*).

Note: The assembly should now be assembled as shown in *Figure 5.11*.

6 Fit the Lower Bow Clamp ring (Item 19, *09822*) and Clamp Locking Rings (Item 18, *09822*) to the Lower End Bow Termination Body (Item 17,*09822*).

7 Insert the Bypass Cable Assembly (Item 6, *09822*) into the Main Shaft (Item 10, *09822*).

8 Grease the grooves on the Main Shaft (Item 10, *09822*) and the O-Rings with Liquid-O-Ring®.

Note: Grease the grooves on the Main Shaft (Item 10, *09822*) and the O-Rings with Liquid-O-Ring® type 101 prior to fitting the O-Rings.

9 Fit the O-Rings (2 x Item 29, *09822*) to the lower end of the Main Shaft (Item 10, *09822*).

10 Fit the O-Ring (Item 30, *09822*) to the Lower End Seal Sub (Item 14, *09822*) and apply Liquid-O-Ring® type 101.

11 When removed during disassembly, fit the Spirol™ Pin (Item 26, *09822*) to the Lower End Seal Sub (Item 14, *09822*) and insert the Lower Connector Assembly (Item 5, *09822*). Secure the Lower Connector Assembly (Item 5,*09822*) to the Lower End Sub (Item 14, *09822*) using a Circlip (Item 24,*09822*).

12 Screw the Lower End Sub (Item 14, *09822*) onto the end of the Main Shaft (Item 10, *09822*). Lock in position using the Ball Bearings (3 x Item 23, *09822*) and Grub Screws (3 x Item 33, *09822*).

13 Make sure the Lower End Sub (Item 14, *09822*) is fully tightened onto the Main Shaft (Item 10, *09822*).

14 Grease the O-Rings with Liquid-O-Ring® then fit the O-Rings (2 x Item 27, *09822*) to the Lower End Sub (Item 14, *09822*).

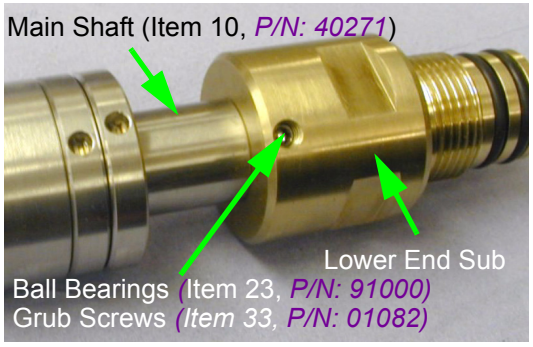


Figure 5.12 Lower End Sub screwed onto Main Shaft

15 Lubricate the O-Ring grooves on the Main Shaft (Item 10, *09822*) and the O-Rings (2 x Item 28, *09822*) with Liquid-O-Ring®.

16 Fit the O-Rings (2 x Item 28, *09822*) to the end of the Main Shaft (Item 10, *09822*) that screws into the Sensor Head Assembly (Item 1, *09822*).

5.4.2 SENSOR HEAD RE-ASSEMBLY

Ref.:

SAT005 General Assembly	*09822*
Sensor Head Assembly	*411214*
Wiring Diagram	*WD-40560*

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

Note: Replacement of the O-Ring (P/N: 99007, *KITO-SAT*) is easier before the springbows are refitted, see *Section 5.4.3*.

1 Grease O-Rings on the Kemlon Sensors (Item 11, *411214*) with a little Liquid-O-Ring® type 101.

2 Insert each Feedthrough Kemlon Connector (Item 11, *411214*) into the Sensor Head Assembly (Item 1, *411214)* by hand as far as possible. Then, gently but firmly, punch it fully home, using the Kemlon Removal Tool *(P/N: 15263*).

3 Lock it in place with a Feedthrough Retaining Nut (Item 9, *411214*) using the Feedthrough Retaining Nut Assembly Tool (P/N: 15283). This should be hand tightened only.

4 Insert the Mono Connector Pressure Isolation Pin (Item 10, *411214*) into the Sensor Head Assembly (Item 1, *411214)* using the Kemlon Tool *(P/N: 10051*).

5 Re-solder all wires to the LEMO connector (Item 13, *411214*) as indicated on the wiring diagram.

Note: Make sure that the line connection is thoroughly shielded. Thoroughly check that all connections are correct.

CAUTION! Should the line wire be inadvertently connected to a sensor, the corresponding sensor **will** be destroyed.

6 Carefully feed the wire loom back into the Sensor Head Assembly (Item 1, *411214)*.

7 Insert the LEMO connector assembly (Items 14, 13 and 12, *411214*) back into the Sensor Head Assembly (Item 1, *411214)* and lock in place with a Spirol™ Pin (Item 18, *411214*).

8 Fit and screw the Main Shaft (Item 10, *411214*) back onto the Sensor Head (Item 1, *411214*).

Note: There is a flat spanner surface on the Main Shaft for this purpose.

9 Insert ball bearings into each of the 3 holes in the Sensor Head. These lock the Shaft to the Sensor Head.

10 Refit the locking ring (Item 16, *411214*) onto the Sensor Head (item 1, *09822*).

11 Refit the electronics assembly (see *Section 5.4.4*), springbows (see *Section 5.4.3*) and sensors (see *Section 5.3.3*).

12 Adjust the Closing Guide (Item 11, *09822*) and Closing Collar (item 12, *09822*) to suit the sensors. See *Section 5.4.3.4*.

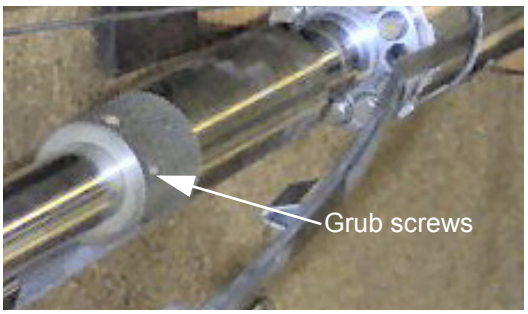


Figure 5.13 Tightening Grub Screws

5.4.3 SPRINGBOW RE-ASSEMBLY

Ref.:	SAT005 General Assembly	*09822*
	Sensor Head Assembly	*411214*

Note: Item numbers refer to the General Assembly, unless stated otherwise.

5.4.3.1 Refitting the SAT Sensor Assembly

1 The Sensor Assembly (Item 3, *09822*) should first be fitted with a Z-spring (Item 13, *09822*) secured in the recess.

Figure 5.14 Sensor Assembly with Z-spring

2 Then fit the Sensor Assembly into the clip furthest away from the Sensor Head (Item 1, *09822*).

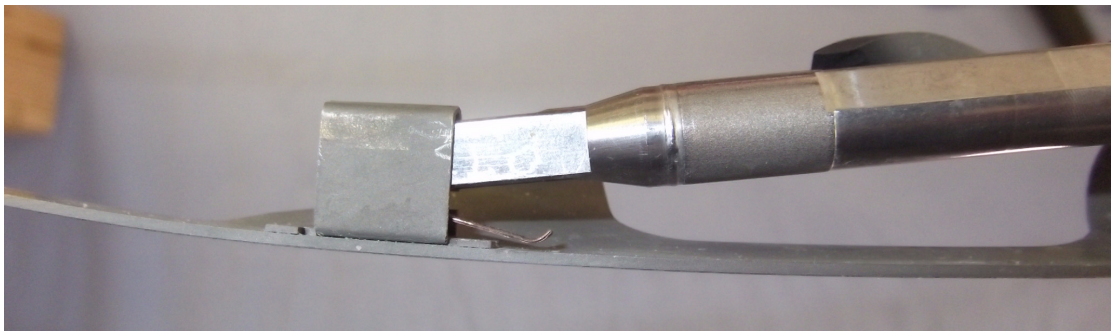


Figure 5.15 Sensor Assembly fitted into clip

3 Carefully push the Sensor Assembly 2 $^{1}/_{8}$" Vee Bearing (Item 3, *09822*) into of the Sensor Head Assembly (Item 1, *09822*).

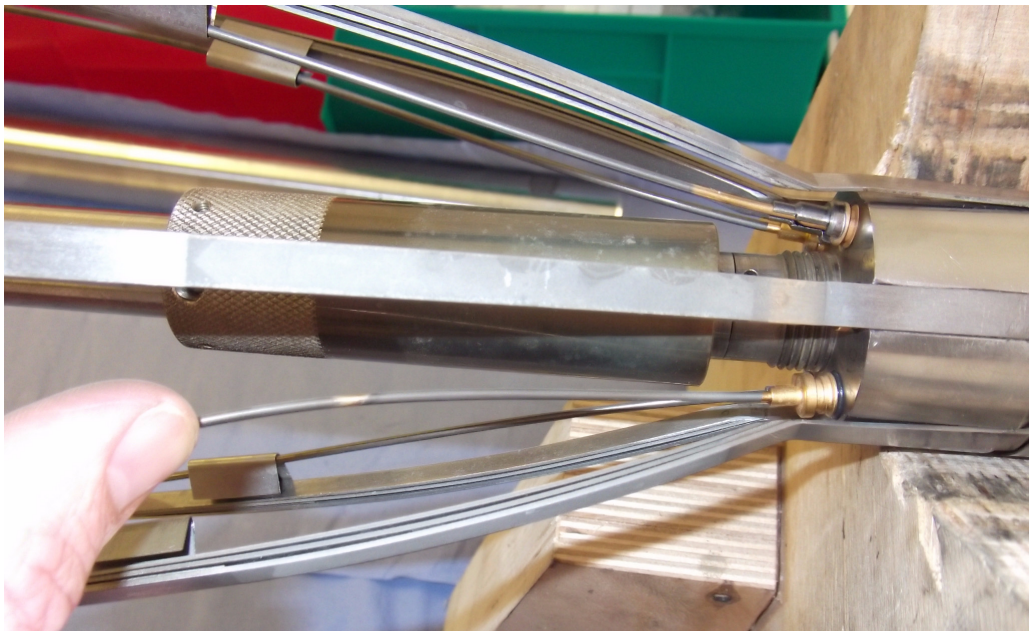


Figure 5.16 The Sensor Assembly fitted to the Sensor Head

4 Then the Sensor Assembly and clip should be fitted into the clip at the back of the sensor, and in turn, into the clip nearest to the Sensor Head (Item 1,*09822*).

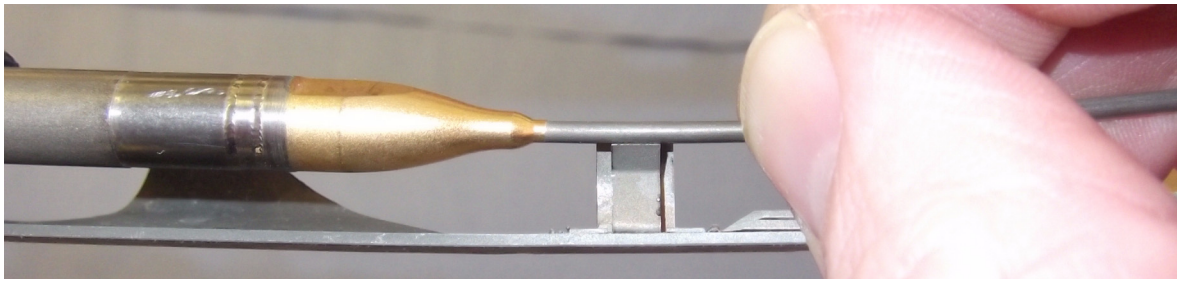


Figure 5.17 The Sensor Assembly and clip fitted to the Sensor Head

CAUTION! Take care that the sharp edges on the Sensor Head or the over-bending of the sensor tube do not damage the sensors on the SAT sensor assemblies.

5.4.3.2 Replacing the Pivot Assembly

Ref.: SAT005 General Assembly *42758*

IRRITANT!

Loctite® 243 THREAD LOCKER

***Loctite® 243* is designed for the locking and the sealing of threaded fasteners that require normal dis-assembly with standard hand tools.**

See *Section 2.3.2 Loctite® 243 Thread Locker*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Loctite® 243.

1 Loosen the Locking Nut (item 4, *42758*), as shown in the photo below:

Figure 5.18 Loosening the Locking Nut

2 Unscrew the Pivot Assembly (item 3, *42758*) from the Spinner Housing Assembly Tube 2 $^{1}/_{8}$" (item 1, *42758*). The use of a Trim Tool (P/N: 412110) may help.

Figure 5.19 Unscrewing the Pivot Assembly with a Trim Tool

3 Remove the Nut (item 4, *42758*) from the Pivot Assembly (item 3, *42758*).

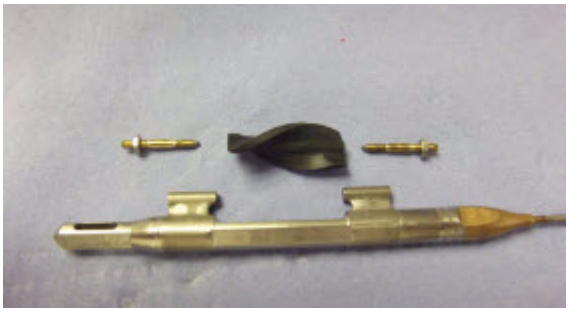


Figure 5.20 Removing the Nut from the Pivot Assembly

4 Add a small drop of thread locker (*Loctite® 243*) to the threaded sections of the new Pivot Assembly (item 3, *42758*) where the Locking Nut (item 4, *42758*) is fitted. Screw the new Pivot Assembly (item 3, *42758*) in to the Spinner Housing (item 1, *42758*).

Note: The front threaded section should be kept free of thread locker.

5 Locate the Shaft of the Spinner Assembly (item 2, *42758*) onto the Pivots (item 3, *42758*). Adjust the position of each pivot to retain the magnet of the Spinner Assembly (item 2, *42758*) centrally between the 2 'uprights' of the Housing Assembly (item 1, *42758*). Lightly tighten one Pivot Assembly (item 3, *42758*) to stop the Spinner Assembly (item 2, *42758*) from rotating. (See *Figure 5.18*).

Note: There is a tolerance band of 1.5mm (approx.) either side of the centre that still allows the sensor to function properly. Should the spinner be set too far either side of the centre, the magnet may not be detected.

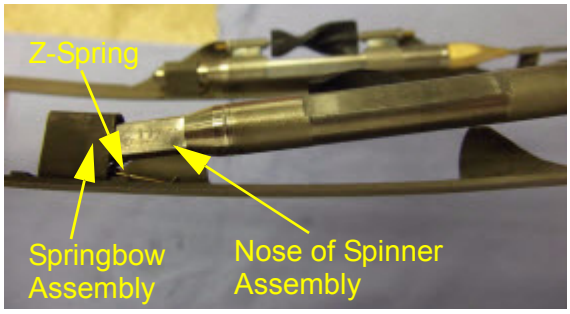
6 Fit a Retaining Nut (item 4, *42758*) onto one Pivot Assembly (item 3, *42758*) and tighten the Retaining Nut (item 4, *42758*) against the Housing Assembly (item 1, *42758*) to secure it in position.

Figure 5.21 Spinner Assembly with magnet positioned centrally on Housing Assembly

7 Back off the remaining Pivot Assembly (item 3, *42758*) by approx. $^1/_8$ of a turn to allow the Spinner (item 2, *42758*) to rotate freely with minimal axial movement.

8 Fit the Retaining Nut (item 4, *42758*) onto the Pivot Assembly (item 3, *42758*) and tighten it against the Housing Assembly (item 1, *42758*) to secure in position. Make sure the Spinner (item 2, *42758*) spins freely.

5.4.3.3 Refitting the Springbows

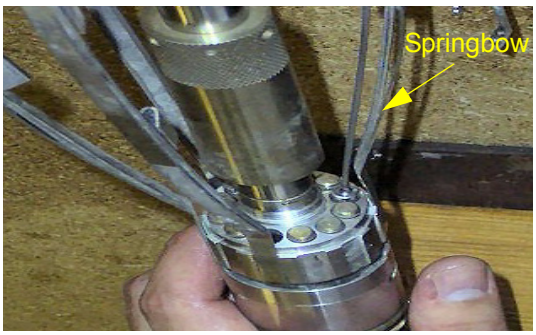


1 Fit the Z-shape Spring (item 13, *09822*) in the nose of the Sensor Assembly (item 3, *09822*) Carefully push the Springbow Assembly (Item 4, *09822*) over the nose of the spinner section until the nose of the spinner section is engaged in the Springbow Assembly (Item 4, *09822*).

2 Clip the SAT Sensor Assembly item 3, *09822*) into the clips on the springbow assembly (item 4, *09822*).

3 Fit the Springbow Assembly (item 4, *09822*) on the Sensor Head Assembly (item 1, *09822*), orientated so the sensor tube clips are towards the Sensor Head (item 1, *09822*) end.

4 There is a keyway that consists of a groove and two peg holes at the Sensor Head, which the lower end of the Spring Bow clips into. Care should be taken to make sure that this aligns correctly.



5 When the springbows are new, it may be convenient to use an elastic band at each end to hold them in place until the bow clamp rings are tightened. This is not usually necessary once they have been tightened into place for some time. Repeat this procedure for each of the remaining springbow assemblies

6 Slide the Bow Clamp Outer Ring (Item 2, *411214*) and Bow Clamp Outer Ring Bursting Disc (Item 4, *411214*) in place and tighten the Bow Clamp Inner Split Ring (Item 3, *411214*).

7 Using two 'C' spanners, loosen the Bow Clamp Locking Rings (Items 19 & 18, *09822*) on the lower end of the tool.

8 Slide the Lower Bow Clamp Ring (Item 19, *09822*) away from the springbows.

9 Fit a Springbow Assembly (Item 4, *09822*) and secure the springbows by re-tightening the rings with two 'C'-Spanners.

10 Tighten the grub screws in the Bow Clamp Inner Split Ring (Item 3, *411214*) to lock it onto the Sensor Head (Item 1, *411214*).

5.4.3.4 Sensor Guide and Closing Collar Positioning

1 Slide the Mounting Front Sensor Guide (item 11, *09822*) and the Mounting Sensor Collar (item 12, *09822*) onto the Main Shaft and make sure they are orientated correctly. See *Figure 5.22*.

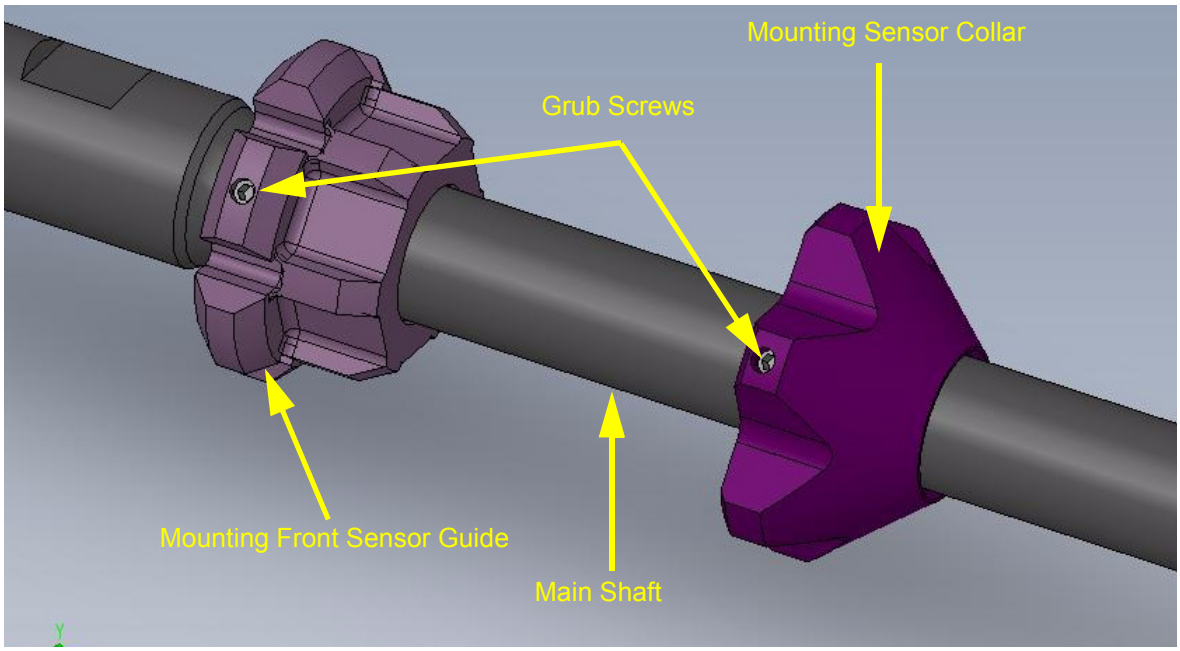


Figure 5.22 Fitting the Mounting Front Sensor Guide and Mounting Sensor Collar onto Main Shaft

2 Loosely fit the Grub Screws into the Mounting Front Sensor Guide. See *Figure 5.23*.

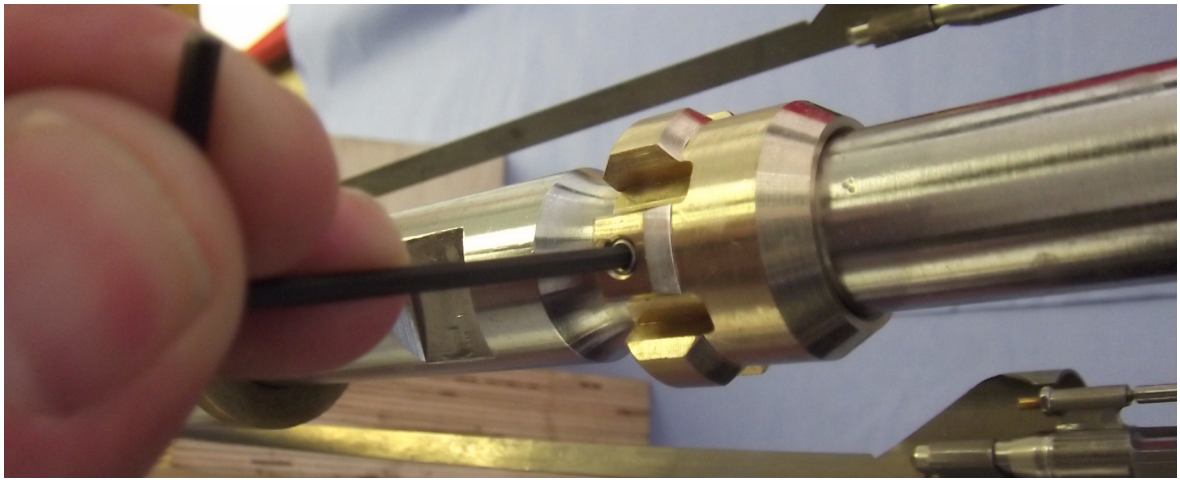


Figure 5.23 Fit Grub Screws into the Mounting Front Sensor Guide

3 Loosely fit the grub screws into the Mounting Sensor Collar. See *Figure 5.24*.

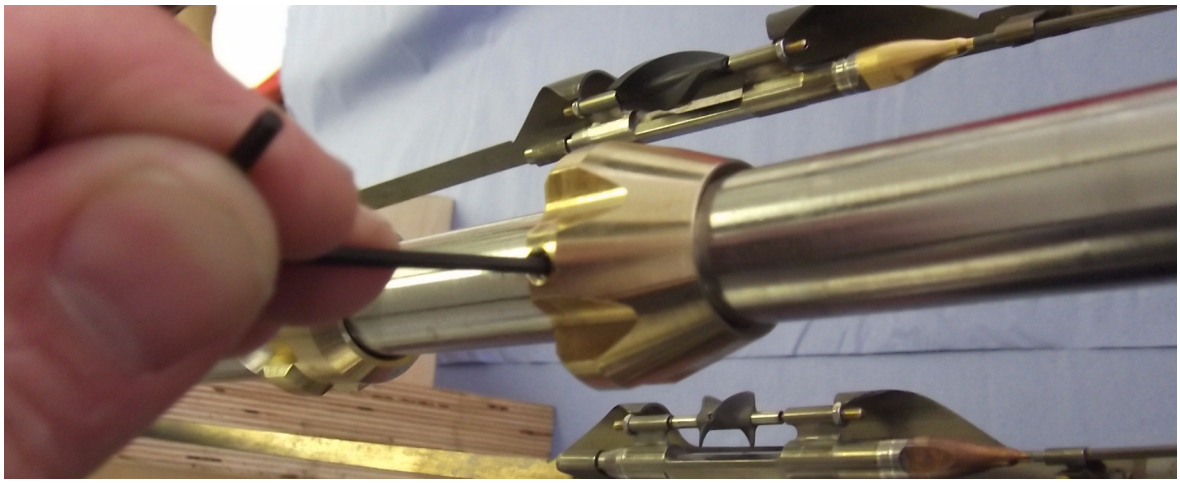


Figure 5.24 Fit Grub Screws into the Mounting Sensor Collar

4 Close down the springbows to allow the sensors to nest into the recesses of the Mounting Front Sensor Guide and the Mounting Sensor Collar. See *Figure 5.25*.

Figure 5.25 The Springbows nesting into the recesses of the Sensor Guide and Closing Collar

5 Secure the Mounting Front Sensor Guide and Mounting Sensor Collar in their final position by tightening the 3-off M6 grub screws in each item. See *Figure 5.26*.

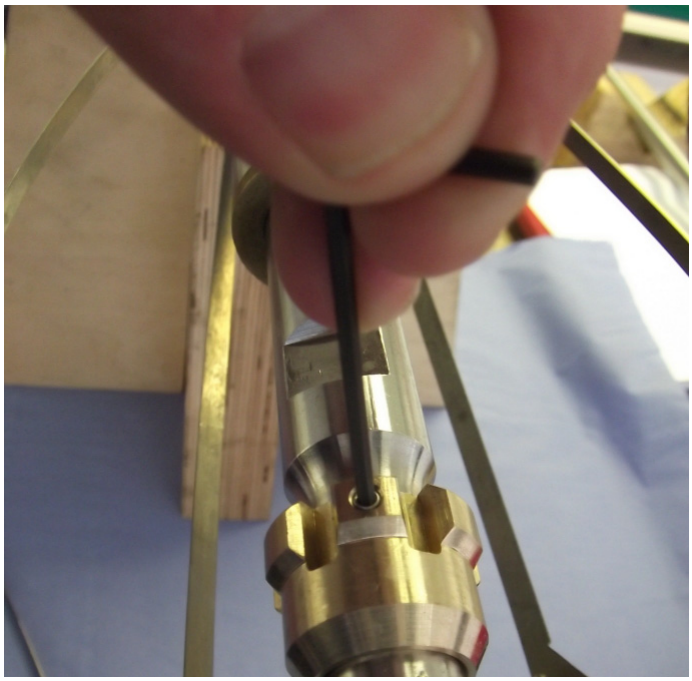


Figure 5.26 Securing the Sensor Guide and Closing Collar

6 Make sure the Guides do not foul on any other parts of the spinner assembly.

5.4.4 ELECTRONICS SECTION RE-ASSEMBLY

Ref.: SAT005 General Assembly *09822*
Electronics Assembly *410519*

IRRITANT!

Liquid-O-Ring® Lubricant

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

1 Plug the Electronics Assembly (Item 2, *09822*) into the Sensor Head Assembly (Item 1, *09822*).

Note: Note the orientation of the LEMO Connector (item 5, *410519*).

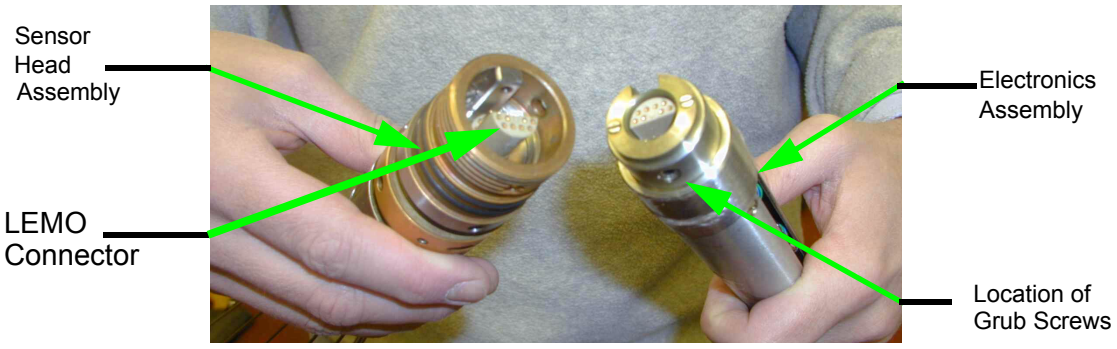


Figure 5.27 Connecting Electronics to Sensor Head

2 Lightly screw grub screws (3 x Item 33, *410519*) **anti-clockwise**, securing the Electronics Assembly (Item 2, *09822*) to the Sensor Head Assembly (Item1, *09822*).

3 Refit the O-Ring (item 11, *410519*) on the Pressure Isolation Head (Item 1, *410519*). Apply Liquid-O-Ring® type 101 to the O-Ring before refitting.

4 Refit the Pressure Housing (Item 9, *09822*), using a 38mm Spanner and a 'C'-Spanner.

6 ELECTRICAL DESCRIPTION

Ref.: Block Diagram *Figure 3.1*
Wiring Diagram *WD-410519*

6.1 TELEMETRY

The telemetry is modulated onto the line as 1.5V AMI (Alternate Mark Inversion) pulses at 500kbaud. See *Figure 6.1* for a typical tool response.

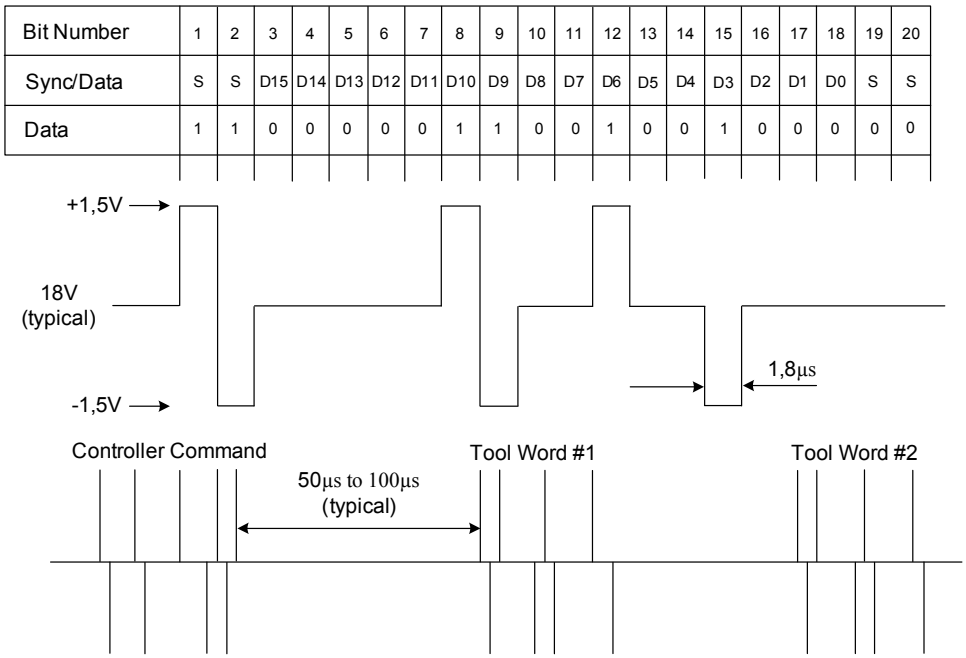


Figure 6.1 Ultrawire™ Telemetry

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.

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 SAT SPINNER ELECTRONICS

The SAT incorporates six spinners or impellers each of which has a small printed circuit board containing rotation sensors, a temperature sensor and a 'one-wire' interface. The spinners are connected to an interface board in the tool body.

The rotation sensing circuit comprises a single flux angle sensor connected to a PIC micro controller. A single long magnet fitted across the diameter of the spinner blade is positioned so as to pass one side of the sensor allowing the spin count and direction to be calculated twice per revolution.

The micro controller scans the flux angle sensor outputs at high speed, calculating speed and direction, and increments or decrements a counter accordingly.

The temperature sensor is a precision thermistor which is monitored by a ADC channel.

The one-wire interface operates using coded current pulses; the micro-controller pulls 'long' and 'short' pulses of current from the supply to signal data to the SAT interface board. This pulse code transmission is initiated by the interface momentarily taking the spinner supply (the 'one-wire') to a higher voltage.

6.3 INTERFACE BOARD

Ref.: Interface Board (PCB 411142) *CD-411143*

The SAT interface board collects data from the six spinners and an orientation electro-level and passes this to the Ultrawire™ interface board using a 250kBaud serial interface.

The spinners are interrogated by momentarily switching their supply voltage to 5.5V from a nominal 3.3V. This initiates the current pulse data transfer, referred to above. A PIC micro-controller, U10, in conjunction with a HC138 decoder selects which of the switches U1 to U6 will operate. Current pulses are detected by U7 and U9 and routed to a PIC micro-controller input. The PIC measures and decodes the pulses to extract spin count, temperature and time of last count information.

The electro-level (often referred to as a tilt sensor or 'alcopot') is energised by the PIC in a particular sequence and various readings taken by the PIC ADC channels.

The PIC is clocked at 4MHz, which is obtained from the Ultrawire™ board 8MHz clock through the divider U11. This facilitates a 250kBaud asynchronous serial interface, which sends the data to the Ultrawire™ interface board.

6.4 DIGITAL BOARD

Ref.: Digital Board (PCB 82457) *WD-410519*

The SAT Digital Board contains 3 main functional blocks. These are the switched mode power supply, the Ultrawire™ bus interface and the system control electronics.

The switched mode power supply (SMPS) takes DC power from the Ultrawire™ tool bus and generates two outputs, a 3.3V rail that powers all the analogue and digital circuitry in the sensing section and a nominally 5.5V rail, used solely on the Interface Board. The SMPS is isolated from the Ultrawire™ toolbus by an active choke consisting of Q5 and associated circuitry. The filter, formed by this active choke together with capacitor (C6), prevents switching currents, generated by the SMPS from appearing on the Ultrawire™ bus, where they would cause data corruption, and ensures that the tool takes a steady DC current. The tool is protected against over-voltage and reverse connection by fuse (F1) and zener diode (D1).

The SMPS is controlled by SMPS controller (U1), which together with MOSFET (Q4) and transformer (L1) form the core of the power supply. U8 provides a 2.048V reference for the supply, and inductor (L2) and capacitor (C7) form an output filter on the 3.3V output. The 5.5V rail is un-filtered.

The SMPS operating frequency is variable and increases with increased demand on the output rails. This design of power supply is inherently protected against a short circuit on either output rail, making it extremely robust.

The Ultrawire™ PLD (U5) is effectively a UART, handling communications between the system microprocessor (U7) and the Ultrawire™ bus. The various control lines between the two enable the microprocessor to receive commands and data from the bus and to transmit data on the bus.

System control is performed by the microprocessor (U7), which in addition to communicating with the Ultrawire™ bus via PLD (U5), controls the acquisition of data from the various sensors within the sensing section.

Serial lines TX and RX form a high speed (250kBaud) connection to the SAT Interface Board.

The relative bearing sensor comprises two weighted servo potentiometers in anti-phase. The track ends connect to P5:2 and P5:1 which are configured as digital outputs, and the wipers connect to P10:2 and P10:1 which are configured as ADC inputs.

U3 is a voltage monitor and system reset generator that only allows the tool to operate when the 3.3V power rail is stable.

X1 is a crystal oscillator, generating the system clock for the sensing section. Under normal operation this an 8MHz clock signal, but may be switched down to 64kHz by the microprocessor (via PLD U5 CPU_CLK_SPD line) to save power while the tool is idle.

7 EXTENDED CHECKS

7.1 PREVENTATIVE MAINTENANCE

7.1.1 GREASE & LUBRICANTS

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

GE Oil & Gas 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.

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

Note: Some threads are internal and this can cause grease to get inside the tool. Do not use excessive quantities of grease.

GE Oil & Gas 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!

Lubriplate

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

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

Refer to *Section 5 Mechanical Description* as required for disassembly / re-assembly instructions.

1 Remove dirt and old grease from pressure housing threads and O-Rings

2 Apply Liquid-O-Ring® to the O-Rings.

3 Inspect O-Rings for damage or ageing/hardening and replace where required.

4 Check for:

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

Note: When 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 Grease & Lubricants*.

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

6 Check all fixings for tightness.

7.1.3 ELECTRICAL

Ref.: SAT Electronics Wiring Diagram *WD-410519*

1 With the electronics cartridge removed, make the following meter checks at the LEMO connection at the bottom of the electronics assembly. Use a standard Multimeter and not a high voltage Megohm Meter for these tests. See *Figure 7.1* below for pin/socket position.

Socket 14 to chassis	Spinner #1	> 1MΩ
Socket 16 to chassis	Spinner #2	> 1MΩ
Socket 10 to chassis	Spinner #3	> 1MΩ
Socket 12 to chassis	Spinner #4	> 1MΩ
Pin 6 to chassis	Spinner #5	> 1MΩ
Pin 2 to chassis	Spinner #6	> 1MΩ
Pin 3 to chassis	GND	< 0.2Ω
Pin 4 to Upper Banana Pin	Through Line	< 0.2Ω
Pin 4 to chassis	Through Line	> 1MΩ

Pins 7 and 8 are not connected, the remainder of the pins and sockets (pins/sockets 1, 5, 9, 11, 13 and 15) are connected but not used. Testing is not necessary.

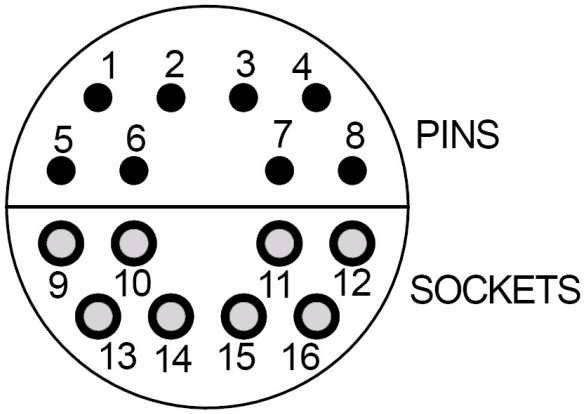
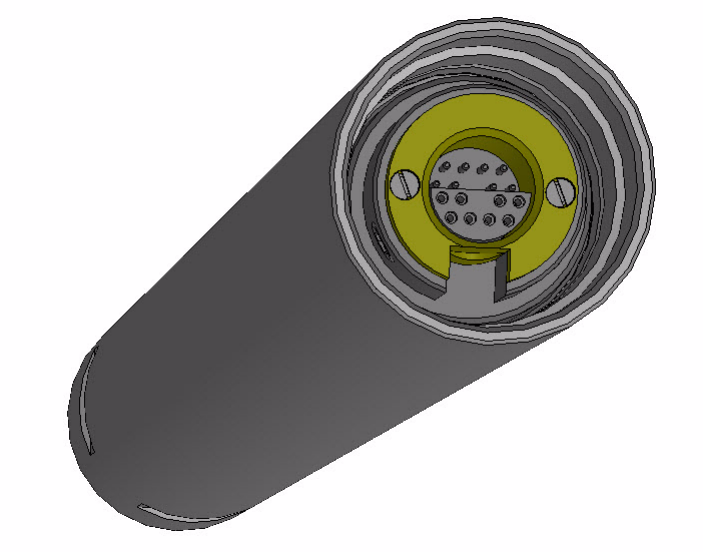


Figure 7.1 LEMO pin/socket positions (Front View)

2 Replace the electronics cartridge.



3 Check through line resistance and tool current, see *Section 4.1.2 Electrical*.

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

5 Take velocity and direction readings.

7.1.4 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. It is 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 are 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 subject them to moderate vibration. A moderately hard blow from a wooden hammer is recommended.

DO NOT USE METAL HAMMERS.

7.1.5 Heat Testing Above 150°C

This is not generally recommended since it shortens tool life expectancy. Heat testing may be required for contractual reasons, when the tool is out of use for a long period or required for a 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

7.2.1 O-RING REPLACEMENT

Ref.:		
	SAT005 General Assembly	*09822*
	Sensor Head Assembly	*411214*
	Flowmeter Sensor Assembly	*42758*

The following guidelines are appropriate for normal operating conditions. Should the tool experience harsher conditions (e.g.: high pressure, temperature, H_2S), then more thorough servicing is recommended.

To determine contact with H_2S, check for discoloration of the Lower Termination Body (item 17, *09822*) and Lower Sub (Item 14, *09822*). This parts are made of Al/Bronze and will turn black when in contact with H_2S. Local well site knowledge will also contribute to determine the possibility of H_2S exposure.

7.2.1.1 Every Run

Minimum recommendation is to replace the O-Rings at the bottom of the tool (Item 27,*09822*) every time the tool joint is broken, when the tool has been under pressure, It is also recommended that the O'-Rings on the Sensor Head under the Pressure Housing (Item 6, *411214*) are replaced prior to every job.

7.2.1.2 Every 3-Runs

Replace both of the Vee Bearing Pivot Assemblies (Item 3, *42758*) on each of the sensor assemblies to make sure there is free movement of the Spinner Assembly. Dependant on the well conditions, this may need to be done more frequently. Adjust as per *Section 5.4.3.2*.

7.2.1.3 Every 5-Runs

IRRITANT!

Liquid-O-Ring® type 101 LUBRICANT

Liquid-O-Ring® type 101 (*P/N: LOR101*) is used for lubricating various components of the tool during maintenance. Contact with the skin or the eyes can cause irritation.

See *Section 2.3.1 Liquid-O-Ring® Lubricant*.

For more details, refer to the Material Safety Data Sheet (MSDS) for Liquid-O-Ring® type 101.

In addition to the O-Rings that should be changed prior to every job, it is recommended that all "wet" O-Rings (i.e. O-Rings that experience well pressure) should be changed every 5 jobs. These are:

- 2x O-Rings (Item 29, *09822*).
- 2x O-Rings (Item 30, *09822*).
- 6x O-Rings (Item 8, P/N: 99007, *KITO-SAT*)

When replacing the sensor O-Rings, **ensure that Liquid-O-Ring® is applied into the O-Ring groove prior to sliding on the new O-Ring. A small amount of Liquid-O-Ring®**

should also be applied to the outer side of the O-Ring. Immersing the O-Rings in hot water will also soften them and aid their insertion, refer to *Section 7.2.1 O-Ring Replacement*.

During replacement of the O-Rings, the tool is stripped down to its base assemblies, allowing the tool to be cleaned and serviced thoroughly.

7.2.2 Servicing Sensor Head

This should rarely be necessary, unless there has been a leak. Should this happen, the Kemlons inside the sensor head can be cleaned and the O-Rings on them changed. Ordinarily, none of the Kemlons are exposed to well fluid or pressure. Servicing the sensor head assembly involves rewiring the sensor head and is not recommended, except in extreme circumstances.

7.2.3 Use of Pressure Test Blank Assembly

Pressure Test Blank Assemblies (Item 9, P/N: 41063, *KITR-SAT005*) can be inserted into the Sensor Head in place of a sensor.

They are primarily used for in-house testing purposes; however they can also be used in the field and there are two main reasons for this:

- Should a sensor fail and no spares are available, one of these can be inserted into the Sensor Head. This will prevent the associated Kemlon in the Sensor Head from being contaminated with well fluid.
- In very low diameter tubing, there may be concerns over whether the tool will obstruct the flow too much, possibly causing it to be blown out of the well. In such cases, one may wish to operate the tool with fewer sensors. The Pressure Test Blank Assemblies can then be inserted into the unused positions in the Sensor Head.

7.3 TROUBLESHOOTING

Refer to *Section 5 Mechanical Description* for disassembly instructions and *Appendix B Drawings & Parts Lists* where necessary.

7.3.1 ELECTRICAL

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 Grease & Lubricants* Also check all fixings are tight.
Excessive Current	Remove the electronics assembly and spinner arrays from the sensor head to isolate fault to electronics or sensor head / shaft assembly or spinner array. Disconnect wires to isolate fault to: • Interface board (PCB411142) • Digital board (PCB82457) • Upper head connector • LEMO connector on electronics • Sensor head assembly • Shaft assembly (incl. bypass tube) Fault find or replace PCB when necessary With the electronics assembly removed, the line connection at the bottom of the tool may be tested at 250V relative to chassis to check for electrical leak. Resistance should exceed 100Ω. Disassemble to locate fault.
Little or no current	On PCB 82457 check 18V on both sides of fuse F1. Check 0V wire connects to chassis. Check 3.3V on J16 pin 1. Fault find or replace PCB.
No telemetry reply	On PCB 82457, check power supply as above. Check 8MHz clock on X1, pin2. Check line for +1.5V and -1.5V, 1.8μs pulses from the board and similar pulses from the tool. +1.5V line pulses should appear as positive 3.3V logic level pulses on TP29, -1.5V line pulses should appear as positive 3.3V logic level pulses on TP25. Fault find or replace PCB.
All Sensor data reads zero	On PCB 411142 check approximate 5.5V on C8/D2 junction. Fault find or replace PCB. • On PCB 82451, check for 500kbaud asynchronous logic level signals on J11 and J10. J11 is the single character request for data from the 82457 PCB and J10 is the multiple character reply

Single faulty Sensor	Swap sensors to determine when the sensor is faulty. Replace when necessary. When the fault is not with the sensor, check the wiring from the PCB, through the LEMO connectors, to the Kemlons on the sensor head. When a sensor has leaked, it should be replaced.
Rotation faults	With the tool horizontal, check that pendulum rotates freely. The voltages on ROTx and ROTy should increase as the tool rotates clockwise (looking down the tool). Check that they are offset by approximately 180º. This can only be checked roughly, but when ROTx is at 5V, ROTy should be approximately 2.5V.

7.3.2 MECHANICAL

Damaged O-Rings	Visually inspect O-Rings. Check that the O-Rings are clean and greased. Replace the O-Rings when the following occurs: • Cracks or tears in the O-Rings • The O-Rings will have an excessive size when taken out of the hole (due to moisture intake) • The tool experienced temperatures in excess of 150ºC • The tool experienced contact with H_2S gas
Damaged Magnets	Visually inspect the magnets. Replace complete spinner assembly when: • Data is spiked • Irregular count rate or missed counts are noticed • Magnets are damaged (e.g. chipped) When iron scrapings are visible, they might be washed away with a light oil.
Spinner does not rotate smoothly or does not rotate at all	• Ensure the bearings are clean and the bearings are not damaged. Replace when necessary • Check that there is no dirt or debris between the bearings and the pivots, which might impair the free movement of the shaft. Flush with a light oil when required • Should the spinner not appear to be balanced, replace or contact GE Oil & Gas for alternative options. Refer to *Section 0.3 Feedback* • Ensure that the pivot pin tips are not damaged. Replace the Pivot Assembly (P/N: 411209, *KITR-SAT005*) when necessary. • Ensure the pivot assembly has been backed off sufficiently to allow the spinner to rotate, with minimal axial movement

APPENDIX A EQUIPMENT & RECOMMENDED SPARES

A.1 MAIN EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	SAT005	Spinner Array Tool, $2^1/_8$″, Ultrawire™	1	---

A.2 ANCILLARY EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	15265	Flight Case, $2^1/_8$″	1	---
2	40196	Rotational Alignment Sub (RAS001).[a]	AR	Not supplied with the tool.

a. The RAS001 has 4 O-Rings in total, which might need replacing. Refer *Appendix A.4.1*. Apply Liquid-O-Ring® to O-Rings and threads before fitting.

A.3 MAINTENANCE EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	15263	Kemlon Removal Tool	1	Included in *40886*
2	15283	Feedthrough Retaining Nut Assembly Tool	1	Included in *40886*
3	20322	O-Ring Removal Tool	1	Included in *40886*
4	20332	Tool Assembly O-Ring Sensor	1	---
5	LOR101	Liquid-O-Ring®	AR	---
6	WD-40®	Multi-purpose lubricant, spray	AR	---
7	IPA	Isopropyl Alcohol (rubbing alcohol)	AR	---
8	Loctite® 243	Thread Locker	AR	---

A.4 RECOMMENDED SPARES

Item	Part no.	Description	Qty	Remarks
1	*KITB-SAT*	Basic Spares Kit	1	To support 1 run in hole
2	*KITO-SAT*	O-Ring Spares Kit	1	---
3	*KITR-SAT005*	Recommended Spares Kit	1	To support 25 runs in hole
4	*KITU-MAPS*	Kit Upgrade	1	---

Item	Part no.	Description	Qty	Remarks
	41171	Kit-Spacer Rings		Supplied in KITU-MAPS Refer to *Appendix C* for fitting

A.4.1 ROTATIONAL ALIGNMENT SUB (RAS001)

The recommended spares for the RAS001 are as follows:

Item	Part no.	Description	Qty	Remarks
1	99124	Viton O-Ring 90 Type 124.	2	Parts for RAS001 not included in spares kits.
2	99211	Viton O-Ring 90 Type 211.	2	

All spares kits and parts, mentioned in this section, can be supplied upon request. However, GE Oil & Gas recommends the purchase of these kits and parts to properly support your logging tools from job to job. Contact GE Oil & Gas and quote the part number of the spares kit or part for additional information or when ordering the item. Refer to *Section 0.3 Feedback*.

As a guidance:

- A Basic Spares Kit mainly contains essential maintenance equipment, O-Rings and parts, which are likely to need replacing on a run-by-run basis (including spare parts for the initial tool run) or parts that can be lost easily (like grub screws)
- A Recommended Spares Kit has got a multitude of the same parts as a Basic Spares Kit, supplemented by parts that might need replacement at a lower frequency (i.e.: 5-runs and/or 25-runs)

Note: The information above is a guidance only and GE Oil & Gas reserves the right to change the contents of the Spares Kits as required.

PARTS LISTING

Part	*Issue*
40886	P2

Description

HAND TOOL KIT - 1 11/16 MAPS TOOLS

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	91005	Spanner Open Ended 42mmx38mm	2	EA	
0002	91019	Spanner C 50mm 35mm	2	EA	
0003	10038	Spanner Box 3/8 x 5/16 Modified	2	EA	
0004	94262	SCREWDRIVER FLAT BLADE 2.5 x 75MM	1	EA	
0005	91409	Spanner Open-Ended 18x19mm	1	EA	
0006	91029	Key, Hex Metric (Set)	1	EA	
0007	91030	Punch Pin Parallel set	1	EA	
0008	40883	BOX SPANNER MODIFIED	1	EA	
0009	91293	Screwdriver Parallel tip (3 0 x 75)	1	EA	
0010	91105	Toolroll With SX Badge Large Black	1	EA	
0011	91104	Screwdriver Parallel tip (5 5 x 200)	1	EA	
0012	91103	Pliers Circlip 812 Chrome/Van	1	EA	
0013	91102	Pliers Mini Flat Nose 5 Inch	1	EA	
0014	10037	Bar Tommy	2	EA	
0015	10051	Kemlon tool Sondex - 4BA Hex Socket	1	EA	
0016	91280	Hammer, 4oz ball pein	1	EA	
0017	91130	Pin C Spanner 35-50mm	1	EA	
0018	91822	Medium Flat Blade Screwdriver, 5mm	1	EA	
0019	91255	T15 Torx driver, Sandvik Belzer 8915	2	EA	
0020	20322	Assembly Tool - Sensor O'ring MTT	1	EA	
0021	15263	Tool Removal Connector Kemlon	1	EA	
0022	15283	Assy Tool Feed-Through Retaining Nut	1	EA	
0023	10099	Miniature Kemlon tool Sondex - Modified	1	EA	
0024	16210	Tool Axle Nut Screwdriver MDT	1	EA	
0025	91197	Pliers Long Nose (Small)	1	EA	
0026	91229	Medium Pozi Screwdriver	1	EA	
0027	LOR101	Film Form Lube 5oz Pot Liq O Ring typ101	1	ML	

PARTS LISTING

Part	*Issue*
KITB-SAT	A

Description

Kit, Spares, Basic, SAT

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	KITO-SAT	Kit, Spares, O-Rings, SAT	1	EA	
0002	411209	Assy Pivot Vee Bearing	6	EA	
0003	91611	Bearing Ball 2mm Chrome Steel	3	EA	
0004	93043	Scr Grb Skt Hd M3x04mmLG SS-A2 (DIN 916)	3	EA	
0005	91000	Bearing Ball 3/16 Hard	6	EA	
0006	01082	Scr Grb Skt Hd M6 x 5 LG SS FLAT POINT	3	EA	
0007	01047	CIRCLIP INTERNAL 5/8 SS N1300	2	EA	
0008	01029	Screw Csk Hd(Slotted) M3 x 06mm LG SS	10	EA	
0009	410138	SPRING - Z SHAPE	3	EA	

PARTS LISTING

Part	*Issue*
KITO-SAT	A

Description

Kit, Spares, O-Rings, SAT

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	95008	O-ring 008 Viton 75	1	EA	
0002	95009	O-ring 009 Viton 75	1	EA	
0003	95011	O-ring 011 Viton 75	1	EA	
0004	95111	O-ring 111 Viton 75	1	EA	
0005	95112	O-ring 112 Viton 75	1	EA	
0006	95114	O-ring 114 Viton 75	2	EA	
0007	95211	O-ring 211 Viton 75	1	EA	
0008	99007	O-ring 007 Viton 90	6	EA	
0009	99007	O-ring 007 Viton 90	12	EA	
0010	99012	O-ring 012 Viton 90	2	EA	
0011	99016	O-ring 016 Viton 90	2	EA	
0012	99026	O-ring 026 Viton 90	1	EA	
0013	99125	O-ring 125 Viton 90	2	EA	
0014	99211	O-ring 211 Viton 90	10	EA	
0015	99903	O-ring 211 Nitrile 70	1	EA	
0016	92128	Spg Coil Canted 7mm Bore,4.6mm ID BeCu	2	EA	

PARTS LISTING

Part	*Issue*
KITR-SAT005	A

Description

KIT SPARES RECOMMENDED (25 RUN)SAT005

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	KITB-SAT	Kit, Spares, Basic, SAT	0	2	
0002	KITO-SAT	Kit, Spares, O-Rings, SAT	0	5	
0003	42758	Assy Sensor 2 1/8" Vee Bearing	0	3	
0004	410524	Assy Springbow 2 1/8 SAT005	0	6	
0005	43104	ASSEMBLY SPINNER 2.125	0	6	
0006	410138	SPRING - Z SHAPE	0	12	
0007	411209	Assy Pivot Vee Bearing	0	84	
0008	93152	Nut Hex M2 SS	0	36	
0009	41063	PLUG BLANK SENSOR	0	6	

PARTS LISTING

Part	*Issue*
KITU-MAPS	P1

Description

Kit upgrade MAPS restricted opening kit

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	41171	KIT-SPACER RINGS	1	EA	

PARTS LISTING

Part	*Issue*
41171	P1

Description

KIT-SPACER RINGS

PARTS LIST

Item	*Part No*	*Description*	*Qty*	*Units*	*Remarks*
0001	41142-1	SPACER RING 6"	1	EA	
0002	41142-2	SPACER RING 5"	1	EA	
0003	41142-3	SPACER RING 4"	1	EA	
0004	93111	Pin Coiled 2.5mm x 20mm LG - SPIROL MCK	12	EA	

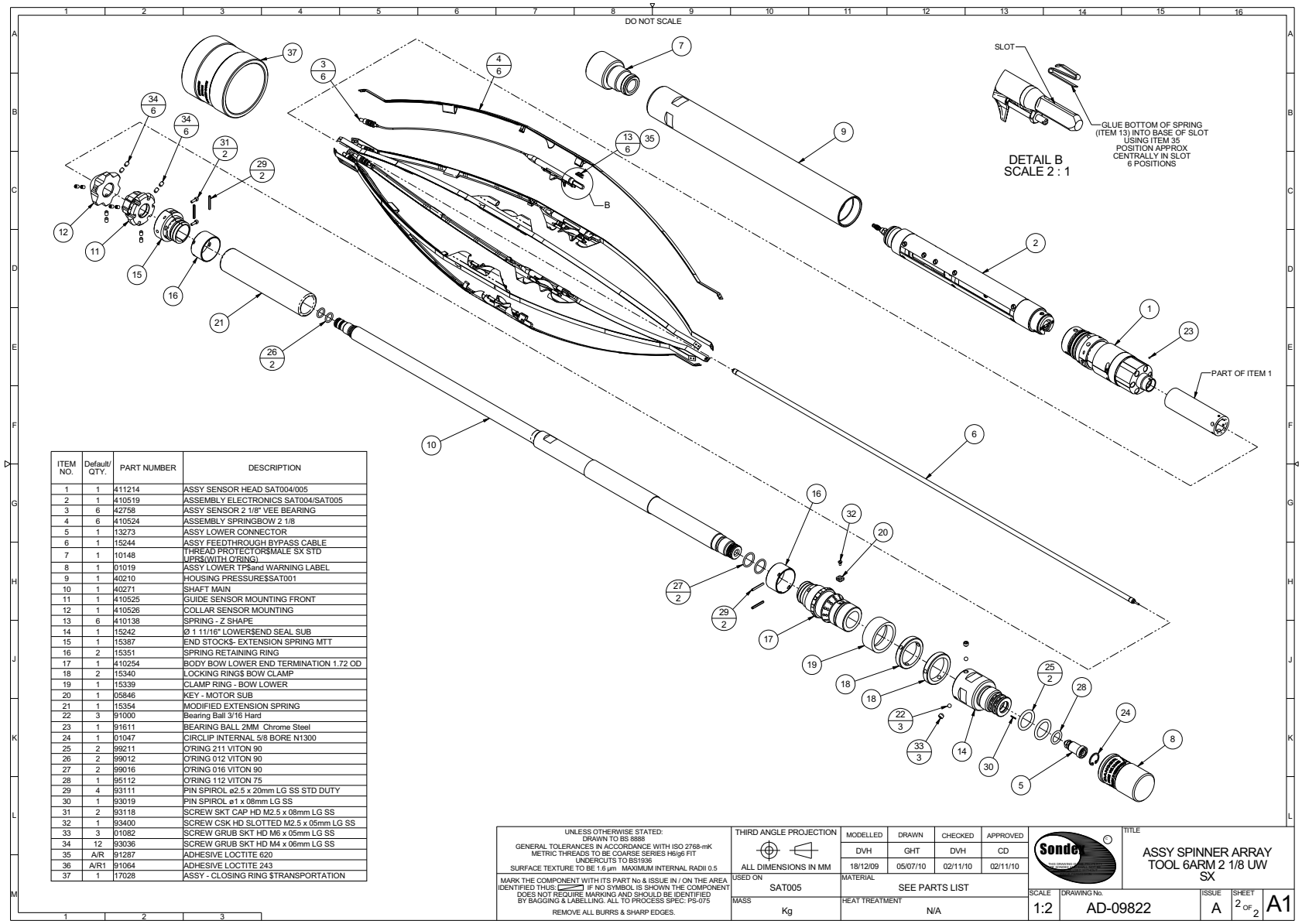
APPENDIX B DRAWINGS & PARTS LISTS

B.1 MECHANICAL DRAWINGS

Description	Drawing	Parts List
SAT005 General Assembly - 2 sheets	AD-09822-A	See Drawing
Electronics Assembly	AD-410519-A	See Drawing
Sensor Head Assembly	AD-411214-A	See Drawing
Sensor $2^{1}/_{8}$" Vee Bearing Assembly	AD-42758-A	See Drawing
Spinner $2^{1}/_{8}$" Vee Bearing Assembly	AD-411119-A	See Drawing

B.2 ELECTRICAL DIAGRAMS

Description	Type	Drawing
Electronics Assembly	Circuit Diagram	WD-410519-A
Sensors Head	Wiring Diagram	WD-40560-A
Interface Board (PCB 411142)	Circuit Diagram	CD-411143-A
Digital Board (PCB 82457) - 2 sheets	Circuit Diagram	CD-82458-Fx



ITEM NO.	Default/ QTY.	PART NUMBER	DESCRIPTION
1	1	411214	ASSY SENSOR HEAD SAT004/005
2	1	410519	ASSEMBLY ELECTRONICS SAT004/SAT005
3	6	42758	ASSY SENSOR 2 1/8" VEE BEARING
4	6	410524	ASSEMBLY SPRINGBOW 2 1/8
5	1	13273	ASSY LOWER CONNECTOR
6	1	15244	ASSY FEEDTHROUGH BYPASS CABLE
7	1	10148	THREAD PROTECTOR$MALE SX STD UPR$(WITH OTRING)
8	1	01019	ASSY LOWER TP$and WARNING LABEL
9	1	40210	HOUSING PRESSURE$SAT001
10	1	40271	SHAFT MAIN
11	1	410525	GUIDE SENSOR MOUNTING FRONT
12	1	410526	COLLAR SENSOR MOUNTING
13	6	410138	SPRING - Z SHAPE
14	1	15242	Ø 1 11/16" LOWER$END SEAL SUB
15	1	15387	END STOCK$- EXTENSION SPRING MTT
16	2	15351	SPRING RETAINING RING
17	1	410254	BODY BOW LOWER END TERMINATION 1.72 OD
18	2	15340	LOCKING RING$ BOW CLAMP
19	1	15339	CLAMP RING - BOW LOWER
20	1	05846	KEY - MOTOR SUB
21	1	15354	MODIFIED EXTENSION SPRING
22	3	91000	Bearing Ball 3/16 Hard
23	1	91611	BEARING BALL 2MM Chrome Steel
24	1	01047	CIRCLIP INTERNAL 5/8 BORE N1300
25	2	99211	O'RING 211 VITON 90
26	2	99012	O'RING 012 VITON 90
27	2	99016	O'RING 016 VITON 90
28	1	95112	O'RING 112 VITON 75
29	4	93111	PIN SPIROL ø2.5 x 20mm LG SS STD DUTY
30	1	93019	PIN SPIROL ø1 x 08mm LG SS
31	2	93118	SCREW SKT CAP HD M2.5 x 08mm LG SS
32	1	93400	SCREW CSK HD SLOTTED M2.5 x 05mm LG SS
33	3	01082	SCREW GRUB SKT HD M6 x 05mm LG SS
34	12	93036	SCREW GRUB SKT HD M4 x 06mm LG SS
35	A/R	91287	ADHESIVE LOCTITE 620
36	A/R1	91064	ADHESIVE LOCTITE 243
37	1	17028	ASSY - CLOSING RING $TRANSPORTATION

UNLESS OTHERWISE STATED:
DRAWN TO BS 8888
GENERAL TOLERANCES IN ACCORDANCE WITH ISO 2768-mK
METRIC THREADS TO BE COARSE SERIES H6/g6 FIT
UNDERCUTS TO BS1936
SURFACE TEXTURE TO BE 1.6 µm MAXIMUM INTERNAL RADII 0.5

MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: ▭ IF NO SYMBOL IS SHOWN THE COMPONENT DOES NOT REQUIRE MARKING AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075

REMOVE ALL BURRS & SHARP EDGES.

THIRD ANGLE PROJECTION

ALL DIMENSIONS IN MM

USED ON: SAT005

MASS: Kg

	MODELLED	DRAWN	CHECKED	APPROVED
	DVH	GHT	DVH	CD
	18/12/09	05/07/10	02/11/10	02/11/10

MATERIAL: SEE PARTS LIST

HEAT TREATMENT: N/A

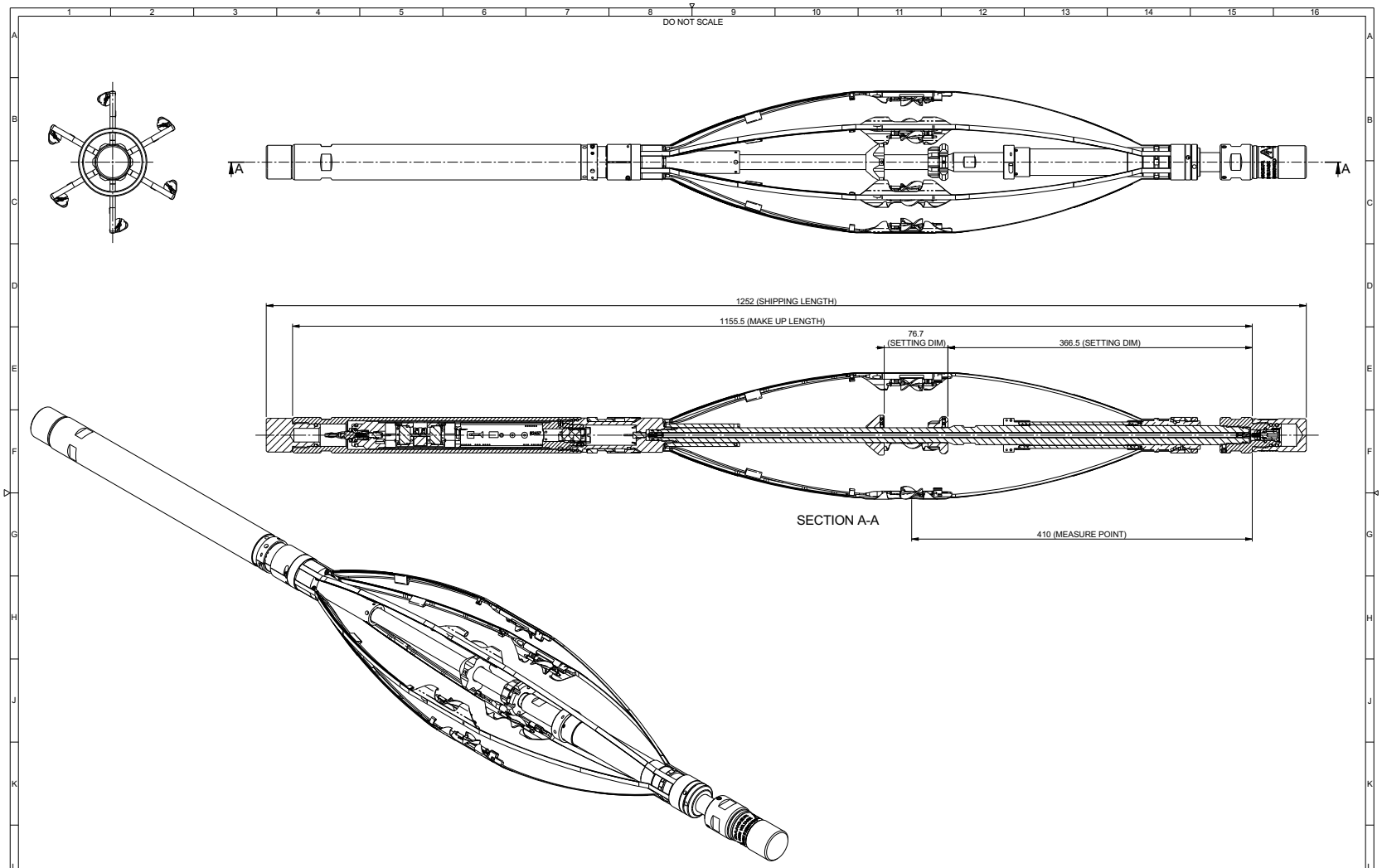
Sondex

TITLE: ASSY SPINNER ARRAY TOOL 6ARM 2 1/8 UW SX

SCALE: 1:2 | DRAWING No.: AD-09822 | ISSUE: A | SHEET: 2 OF 2 | A1

Spinner Array Tool

SAT005



A	INITIAL RELEASE		02/11/2010
NC			21/04/2010
ISS	DESCRIPTION	APPR'D	DATE

UNLESS OTHERWISE STATED:
DRAWN TO BS 8888
GENERAL TOLERANCES IN ACCORDANCE WITH ISO 2768-mK
METRIC THREADS TO BE COARSE SERIES H6/g6 FIT
UNDERCUTS TO BS1936
SURFACE TEXTURE TO BE 1.6 µm MAXIMUM INTERNAL RADII 0.5

MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: IF NO SYMBOL IS SHOWN THE COMPONENT DOES NOT REQUIRE MARKING AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075
REMOVE ALL BURRS & SHARP EDGES.

THIRD ANGLE PROJECTION
ALL DIMENSIONS IN MM
USED ON: SAT005
MASS: kg

MODELLED	DRAWN	CHECKED	APPROVED
DVH	GHT	DVH	CD
18/12/09	05/07/10	02/11/10	02/11/10

MATERIAL: SEE PARTS LIST
HEAT TREATMENT: N/A

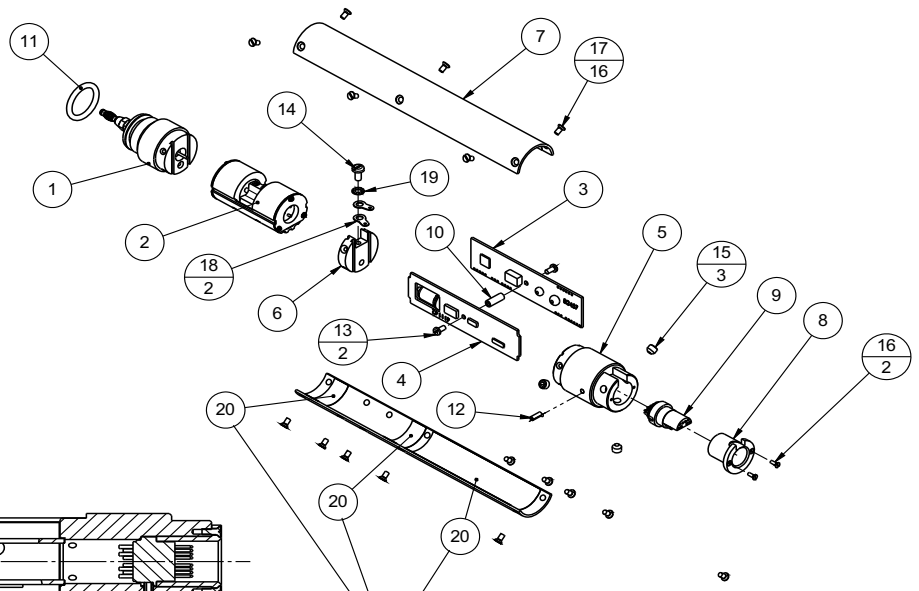
TITLE: ASSY SPINNER ARRAY TOOL 6ARM 2 1/8 UW SX

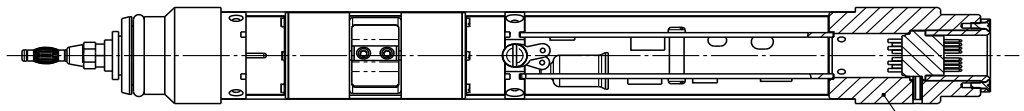
SCALE: 1:2 | DRAWING No.: AD-09822 | ISSUE: A | SHEET: 1 OF 2 | A1

Spinner Array Tool *SAT005*

DO NOT SCALE

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	10537	ASSY ELECTRONICS BULKHEAD SX(ISOLATION) MEM
2	1	11517	Assy Relative$Bearing Device
3	1	82457	Assy, PCB, Digital Board SAT programmed
4	1	411142	ASSY PROGD INTERFACE BOARD
5	1	15240	BULKHEAD LEMO CONNECTOR
6	1	01002	Bulkhead, Intermeadiate
7	1	40209	Halfshells electronics$ SAT001
8	1	40565	TUBE LEMO RETAINER
9	1	14021	INSERT 16 WAY LEMO 4$MODIFIED
10	1	93261	SPACER - M3 THRU$4.75mm OD x 12.7mm LG
11	1	95211	O'RING 211 VITON 75
12	1	93252	PIN SPIROL ø3 x 08mm LG SS
13	2	93048	SCREW PAN HD SLOTTED M3 x 06mm LG SS
14	1	93173	SCREW PAN HD SLOTTED M4 x 08mm LG SS
15	3	01082	SCREW GRUB SKT HD M6 x 05mm LG SS
16	2	93352	SCREW CSK HD SLOTTED M2 x 06mm LG SS
17	16	01029	SCREW CSK HD SLOTTED M3 X 06mm LG SS
18	2	93086	SOLDER TAG M4
19	1	93029	WASHER LOCK SERRATED EXTERNAL M4 SS (DIN6798A)
20	40cm	T004-008AP	TAPE TYGAFLOR 208AP/03T 80mm X 30M

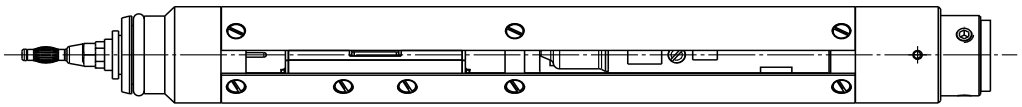




PLAN VIEW WITH UPPER HALF-SHELL REMOVED

SECTION ON CENTRE LINE

FIT TAPE TO INSIDE OF BOTH HALF SHELLS TRIM AROUND ITEMS 1, 2, 5 & 6.



UNLESS OTHERWISE STATED:
DRAWN TO BS 8888
GENERAL TOLERANCES IN ACCORDANCE WITH ISO 2768-mK
METRIC THREADS TO BE COARSE SERIES H6/g6 FIT
UNDERCUTS TO BS1936
SURFACE TEXTURE TO BE 1.6 µm MAXIMUM INTERNAL RADII 0.5

MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: IF NO SYMBOL IS SHOWN THE COMPONENT DOES NOT REQUIRE MARKING AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075
REMOVE ALL BURRS & SHARP EDGES.

THIRD ANGLE PROJECTION

ALL DIMENSIONS IN MM

USED ON SAT004/5

MASS Kg

MODEL'D	DRAWN	CHECK'D	APPV'D
RTM	GHT	RTM	CD
29/04/10	21/06/10	28/06/10	28/06/10

MATERIAL N/A

HEAT TREATMENT N/A

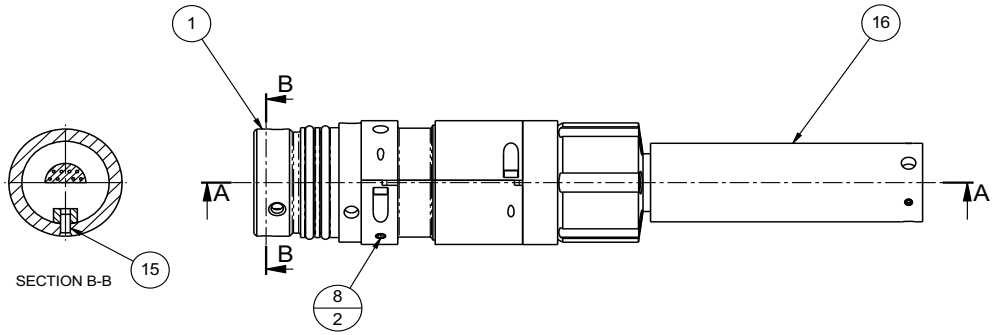
TITLE: ASSEMBLY ELECTRONICS SAT004/SAT005

SCALE 1:2 | DRAWING No. AD-410519 | ISSUE A | SHEET 1 OF 1 | A2

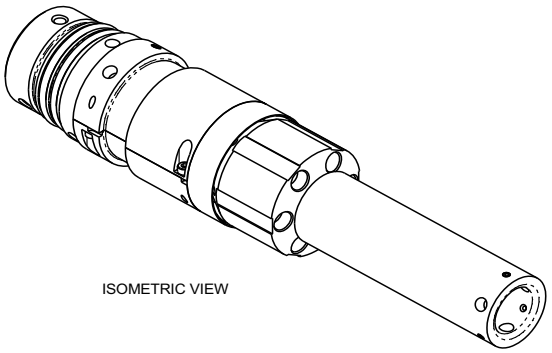
A	INITIAL RELEASE - 5.68266 REFERS		28/06/2010
NC			29/04/2010
ISS	DESCRIPTION	APPR'D	DATE

Spinner Array Tool — *SAT005*

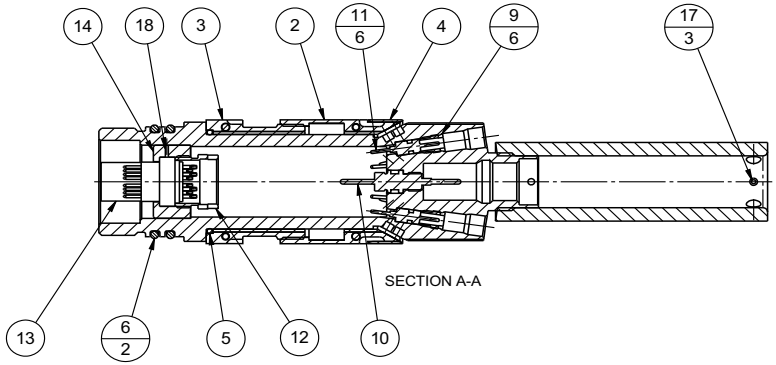
DO NOT SCALE



SECTION B-B



ISOMETRIC VIEW



SECTION A-A

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	411213	ASSY SENSOR HEAD$WELDED
2	1	15332	ASSY RING OUTER SPLIT$BOW CLAMP
3	1	15331	ASSY RING INNER SPLIT$BOW CLAMP
4	1	15333	BOW CLAMPING OUTER RING BURSTING DISC
5	1	99026	O'RING 026 VITON 90
6	2	99125	O Ring Viton 90 Type 125
7			
8	2	93016	SCREW GRUB SKT HD M4 x 05mm LG SS
9	6	15234	FEEDTHROUGH RETAINING NUT
10	1	92030	Connector Mono Pressure Isolation Pin 0 062 OD x 1 55 SHORT
11	6	J029-1514G	Connector, Kemlon, Feedthrough, K-16-PMS, Gold plated
12	1	07226	Nut Lemo Series 4
13	1	15249	lemo 16 way modified
14	1	15239	LEMO HOUSING
15	1	93588	PIN SPIROL ø1/8 x 1/4" LG SS STD DUTY
16	1	15237	LOCKING RING
17	3	93043	SCREW GRUB SKT HD M3 x 04mm LG SS
18	1	93141	PIN SPIROL ø1 x 05mm LG SS

UNLESS OTHERWISE STATED:
DRAWN TO BS 8888
GENERAL TOLERANCES IN ACCORDANCE WITH ISO 2768-mK
METRIC THREADS TO BE COARSE SERIES H6/g6 FIT
UNDERCUTS TO BS1936
SURFACE TEXTURE TO BE 1.6 µm MAXIMUM INTERNAL RADII 0.5

MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: IF NO SYMBOL IS SHOWN THE COMPONENT DOES NOT REQUIRE MARKING AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075 REMOVE ALL BURRS & SHARP EDGES.

THIRD ANGLE PROJECTION

ALL DIMENSIONS IN MM

USED ON: SAT004/5

MASS: Kg

MODEL'D	DRAWN	CHECK'D	APPV'D
GHT	GHT	DVH	CD
07/07/10	31/08/10	14/09/10	15/09/10

MATERIAL: SEE PARTS LIST

HEAT TREATMENT: N/A

TITLE: ASSY SENSOR HEAD SAT004/005

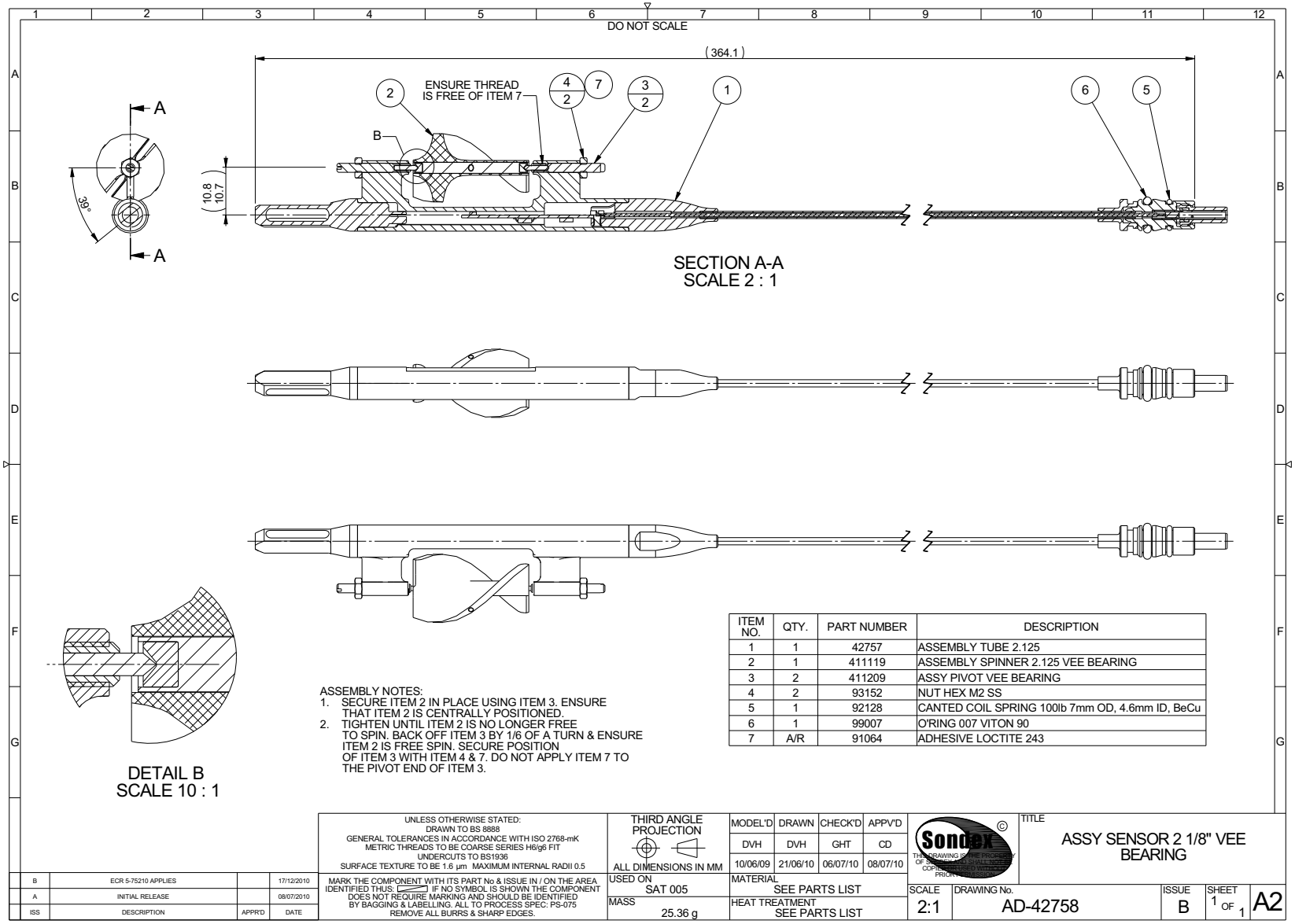
SCALE: 1:1

DRAWING No.: AD-411214

ISSUE: A

SHEET: 1 OF 1

A2



ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	42757	ASSEMBLY TUBE 2.125
2	1	411119	ASSEMBLY SPINNER 2.125 VEE BEARING
3	2	411209	ASSY PIVOT VEE BEARING
4	2	93152	NUT HEX M2 SS
5	1	92128	CANTED COIL SPRING 100lb 7mm OD, 4.6mm ID, BeCu
6	1	99007	O'RING 007 VITON 90
7	A/R	91064	ADHESIVE LOCTITE 243

ASSEMBLY NOTES:
1. SECURE ITEM 2 IN PLACE USING ITEM 3. ENSURE THAT ITEM 2 IS CENTRALLY POSITIONED.
2. TIGHTEN UNTIL ITEM 2 IS NO LONGER FREE TO SPIN. BACK OFF ITEM 3 BY 1/6 OF A TURN & ENSURE ITEM 2 IS FREE SPIN. SECURE POSITION OF ITEM 3 WITH ITEM 4 & 7. DO NOT APPLY ITEM 7 TO THE PIVOT END OF ITEM 3.

UNLESS OTHERWISE STATED:
DRAWN TO BS 8888
GENERAL TOLERANCES IN ACCORDANCE WITH ISO 2768-mK
METRIC THREADS TO BE COARSE SERIES H6/g6 FIT
UNDERCUTS TO BS1936
SURFACE TEXTURE TO BE 1.6 µm MAXIMUM INTERNAL RADII 0.5

THIRD ANGLE PROJECTION
ALL DIMENSIONS IN MM

MODEL'D	DRAWN	CHECK'D	APPV'D
DVH	DVH	GHT	CD
10/06/09	21/06/10	06/07/10	08/07/10

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TITLE: ASSY SENSOR 2 1/8" VEE BEARING

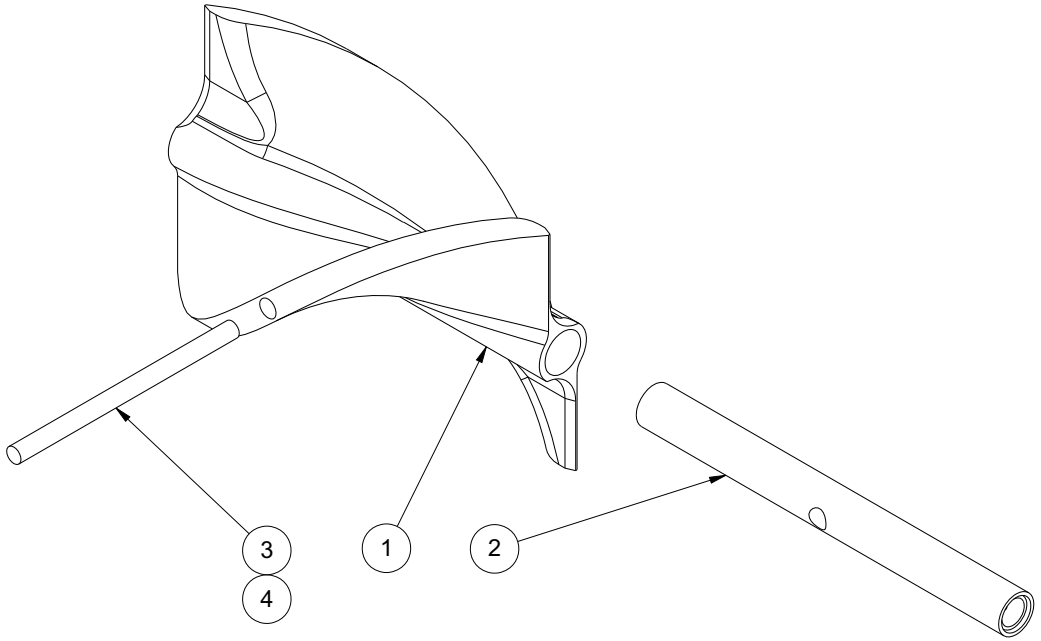
ISS	DESCRIPTION	APPR'D	DATE
B	ECR 5-75210 APPLIES		17/12/2010
A	INITIAL RELEASE		08/07/2010

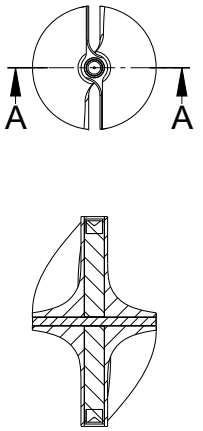
MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: ▭ IF NO SYMBOL IS SHOWN THE COMPONENT DOES NOT REQUIRE MARKING AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075
REMOVE ALL BURRS & SHARP EDGES.

USED ON: SAT 005
MASS: 25.36 g
MATERIAL: SEE PARTS LIST
HEAT TREATMENT: SEE PARTS LIST

SCALE: 2:1 | DRAWING No.: AD-42758 | ISSUE: B | SHEET: 1 OF 1 | A2

DO NOT SCALE





SECTION A-A
SCALE 2 : 1

NOTES
1. APPLY ITEM 4 TO ITEM 3 AT BOTH ENDS TO RETAIN IN POSITION.

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	42878	SPINNER 2.125
2	1	43090	ASSEMBLY SHAFT SPINNER VEE
3	1	43105	MAGNET 1 DIA x 15.3 LG
4	A/R	91064	ADHESIVE LOCTITE 243

UNLESS OTHERWISE STATED:
DRAWN TO BS 8888
GENERAL TOLERANCES IN ACCORDANCE WITH ISO 2768-mK
METRIC THREADS TO BE COARSE SERIES H6/g6 FIT
UNDERCUTS TO BS1936
SURFACE TEXTURE TO BE 1.6 µm MAXIMUM INTERNAL RADII 0.5

MARK THE COMPONENT WITH ITS PART No & ISSUE IN / ON THE AREA IDENTIFIED THUS: IF NO SYMBOL IS SHOWN THE COMPONENT DOES NOT REQUIRE MARKING AND SHOULD BE IDENTIFIED BY BAGGING & LABELLING. ALL TO PROCESS SPEC: PS-075
REMOVE ALL BURRS & SHARP EDGES.

THIRD ANGLE PROJECTION
ALL DIMENSIONS IN MM.

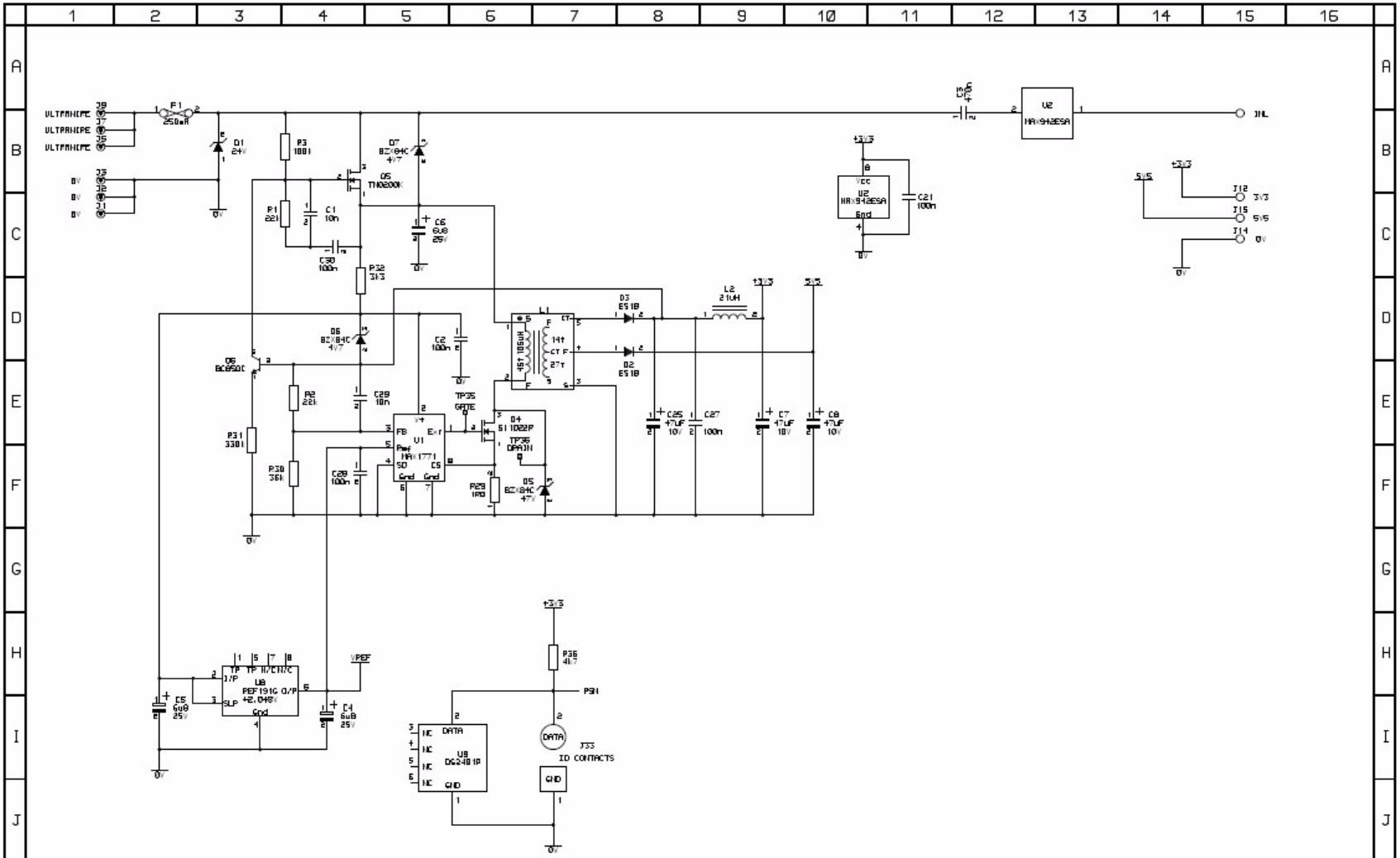
	MODELLED	DRAWN	CHECKED	APPR'D
	GHT	GHT	RTM	CD
	13/07/09	21/06/10	28/06/10	28/06/10

USED ON: SAT005
MASS: 3.593 g
MATERIAL: SEE PARTS LIST
HEAT TREATMENT: N/A

TITLE: ASSEMBLY SPINNER 2.125 VEE BEARING

ISS	DESCRIPTION	APPR'D	DATE
A	INITIAL RELEASE - 5.68266 REFERS		28/06/2010

SCALE 5:1 | DRAWING No. AD-411119 | ISSUE A | SHEET 1 OF 1 | A3



REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
A	Initial Release	.	.	.
B	ECP4594 C9 added	KRW	KRW	19/04/07
C	ECP5525 C7,C8,C25 was 47u 6v3	KRW	KRW	22/04/08
D	ECP59595 R26 & D3 was Fitted	PEJR	PEJR	13/05/09
E	ECP60008 Add Mods Into Design	PEJR	PEJR	06/08/09
F	ECP75298 L1 Value was 150uH	BET	PEJR	07/10/10

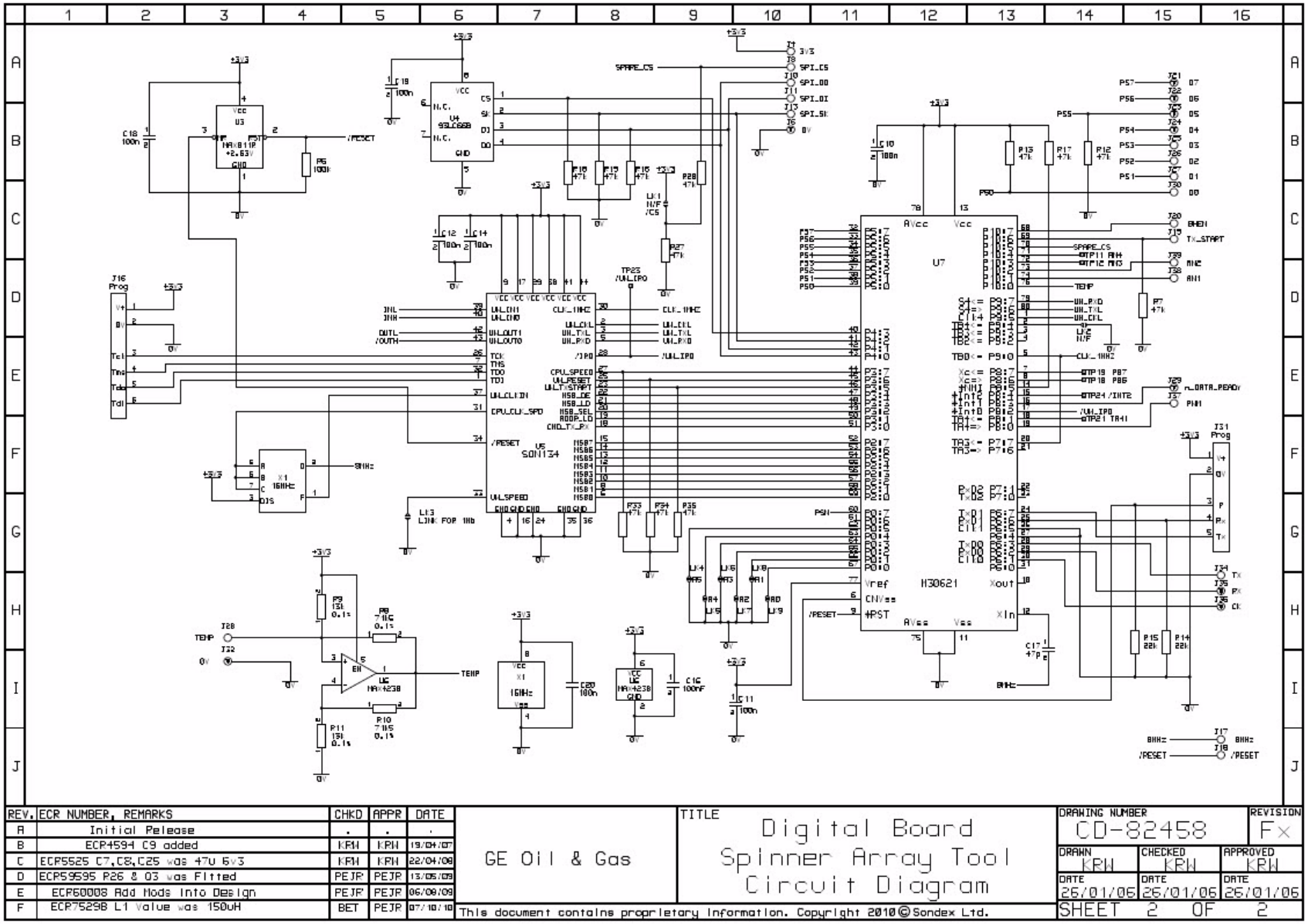
GE Oil & Gas

TITLE: Digital Board Spinner Array Tool Circuit Diagram

DRAWING NUMBER: CD-82458 REVISION: Fx

DRAWN	CHECKED	APPROVED
KRW	KRW	KRW
DATE 26/01/06	DATE 26/01/06	DATE 26/01/06

SHEET 1 OF 2



REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
A	Initial Release	.	.	.
B	ECP4594 C9 added	KPW	KPW	19/04/07
C	ECP5525 C7,C8,C25 was 47u 6v3	KPW	KPW	22/04/08
D	ECP59595 R26 & 03 was Fitted	PEJP	PEJP	13/05/09
E	ECP60008 Add Mods Into Design	PEJP	PEJP	06/09/09
F	ECP75298 L1 Value was 150uH	BET	PEJP	07/10/10

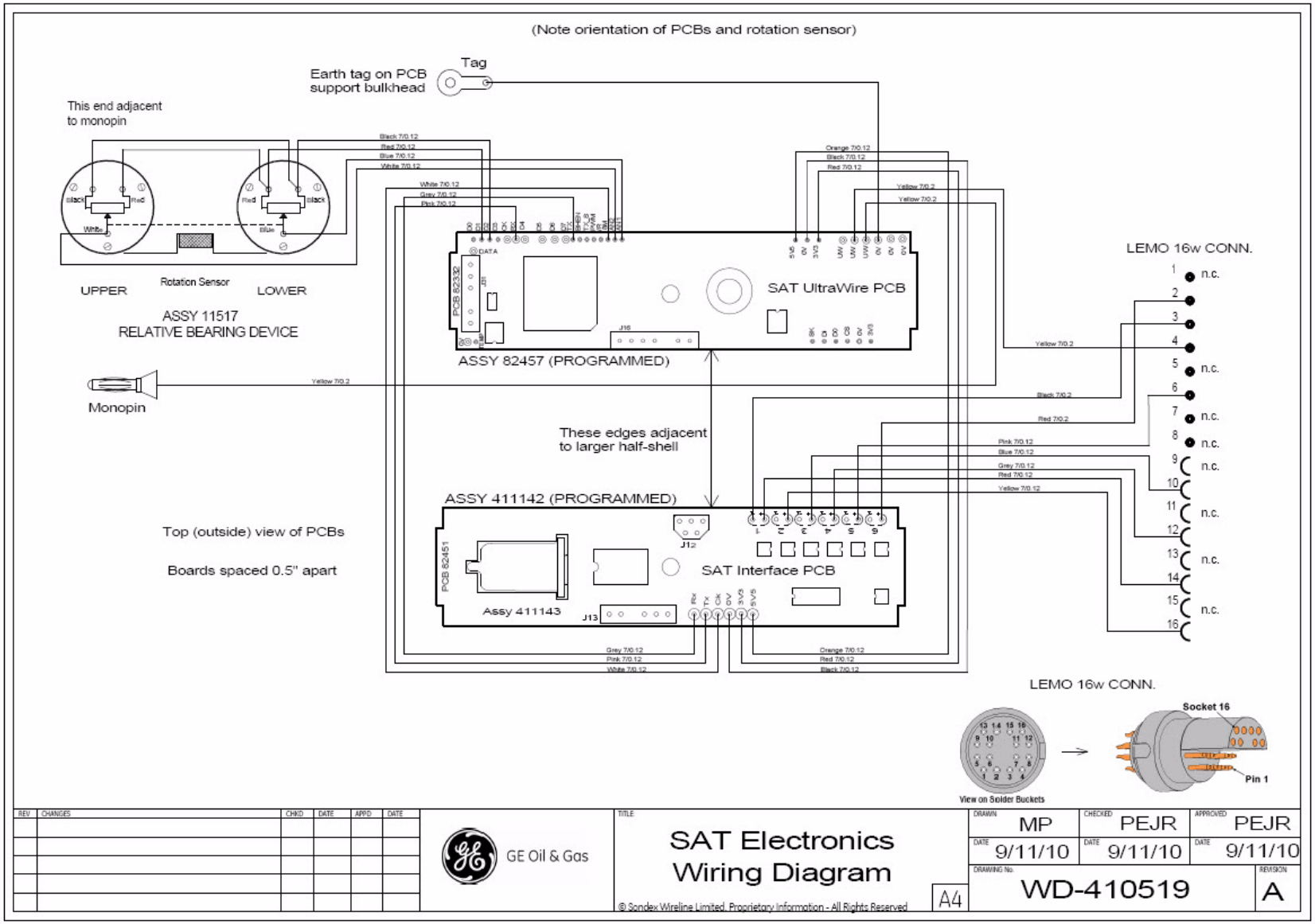
GE Oil & Gas

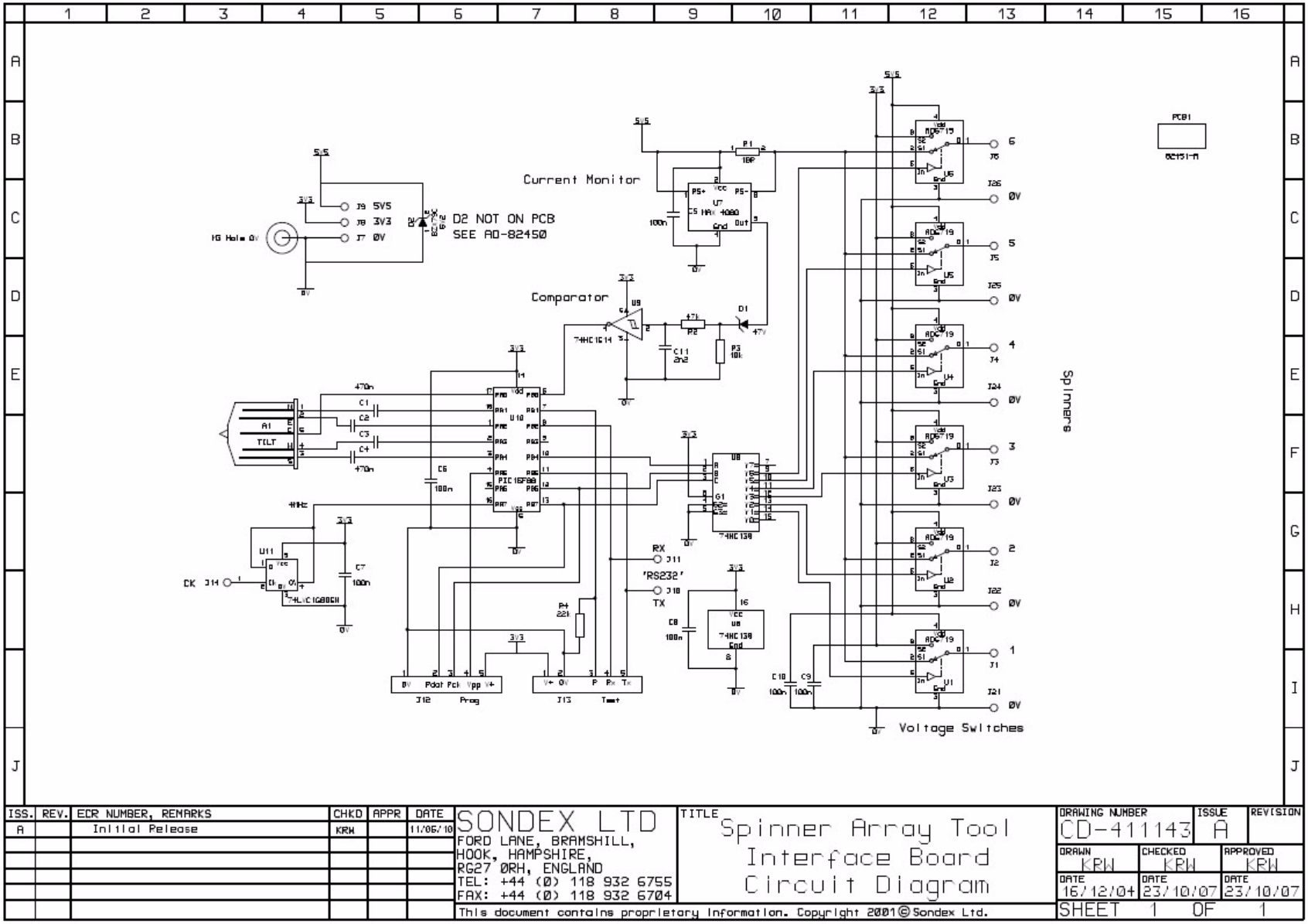
TITLE: Digital Board Spinner Array Tool Circuit Diagram

DRAWING NUMBER: CD-82458 REVISION: Fx

DRAWN	CHECKED	APPROVED
KPW	KPW	KPW
DATE 26/01/06	DATE 26/01/06	DATE 26/01/06

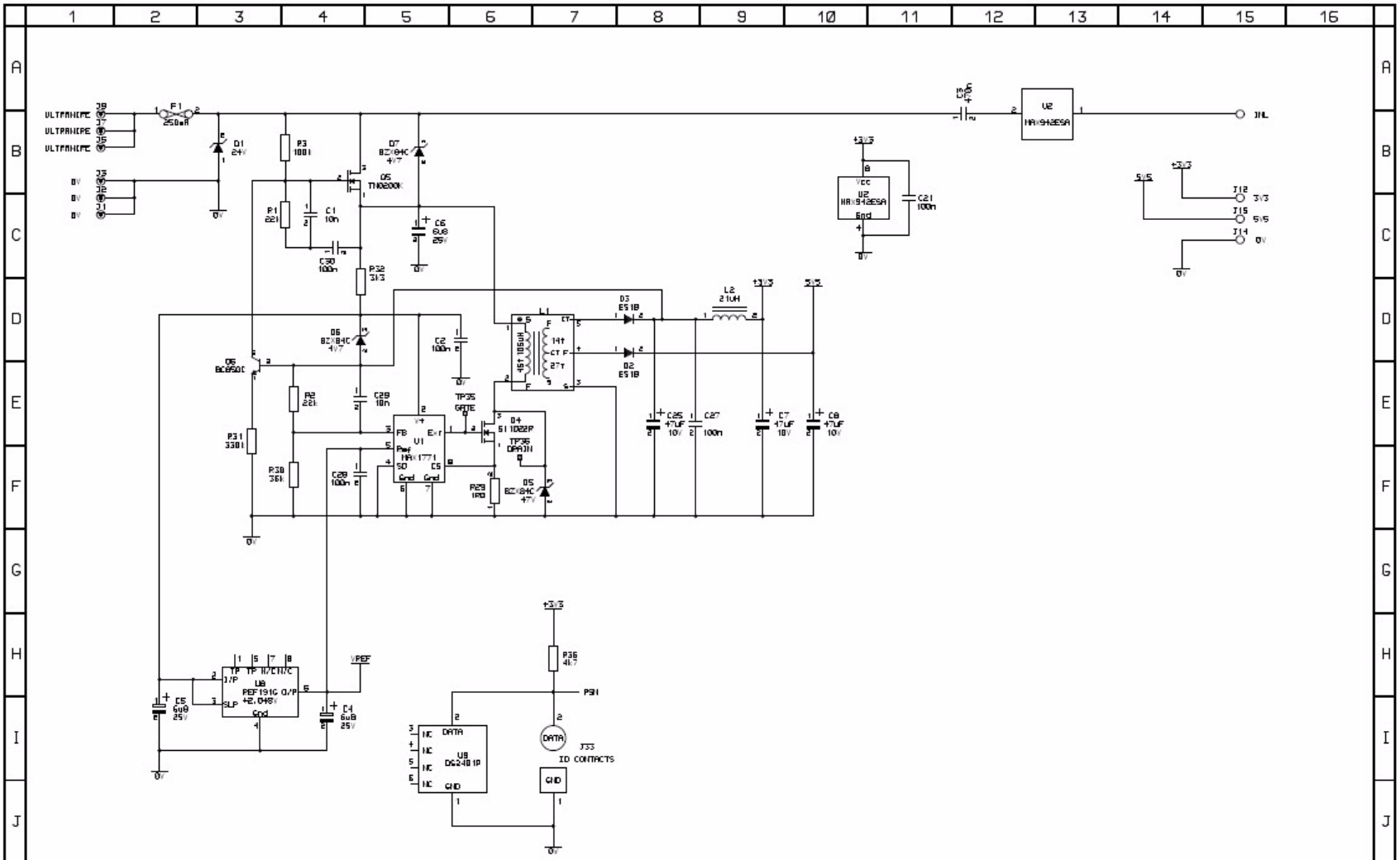
SHEET 2 OF 2





ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
A		Initial Release	KRW		11/06/10

DRAWN	CHECKED	APPROVED
KRW	KRW	KRW
DATE 16/12/04	DATE 23/10/07	DATE 23/10/07



REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
A	Initial Release	.	.	.
B	ECP4594 C9 added	KRW	KRW	19/04/07
C	ECP5525 C7,C8,C25 was 47u 6v3	KRW	KRW	22/04/08
D	ECP59595 R26 & D3 was Fitted	PEJR	PEJR	13/05/09
E	ECP60008 Add Mods Into Design	PEJR	PEJR	06/08/09
F	ECP75298 L1 Value was 150uH	BET	PEJR	07/10/10

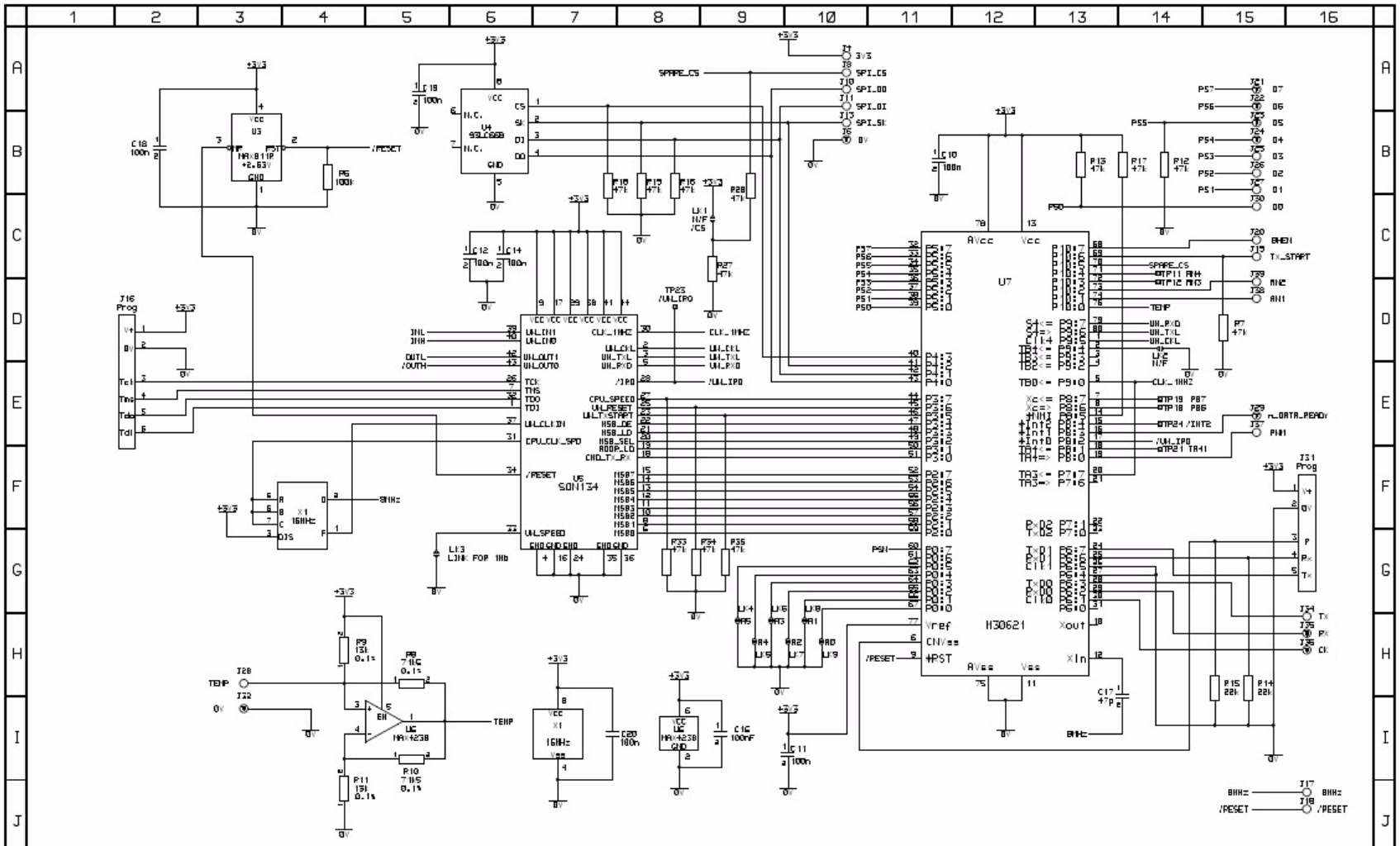
GE Oil & Gas

TITLE: Digital Board Spinner Array Tool Circuit Diagram

DRAWING NUMBER: CD-82458 REVISION: Fx

DRAWN	CHECKED	APPROVED
KRW	KRW	KRW
DATE 26/01/06	DATE 26/01/06	DATE 26/01/06

SHEET 1 OF 2



REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
A	Initial Release	.	.	.
B	ECR4594 C9 added	KRW	KRW	19/04/07
C	ECR5525 C7,C8,C25 was 47U 6v3	KRW	KRW	22/04/08
D	ECR59595 R26 & 03 was Fitted	PEJR	PEJR	13/05/09
E	ECR60008 Add Mods Into Design	PEJR	PEJR	06/09/09
F	ECR75298 L1 Value was 150uH	BET	PEJR	07/10/10

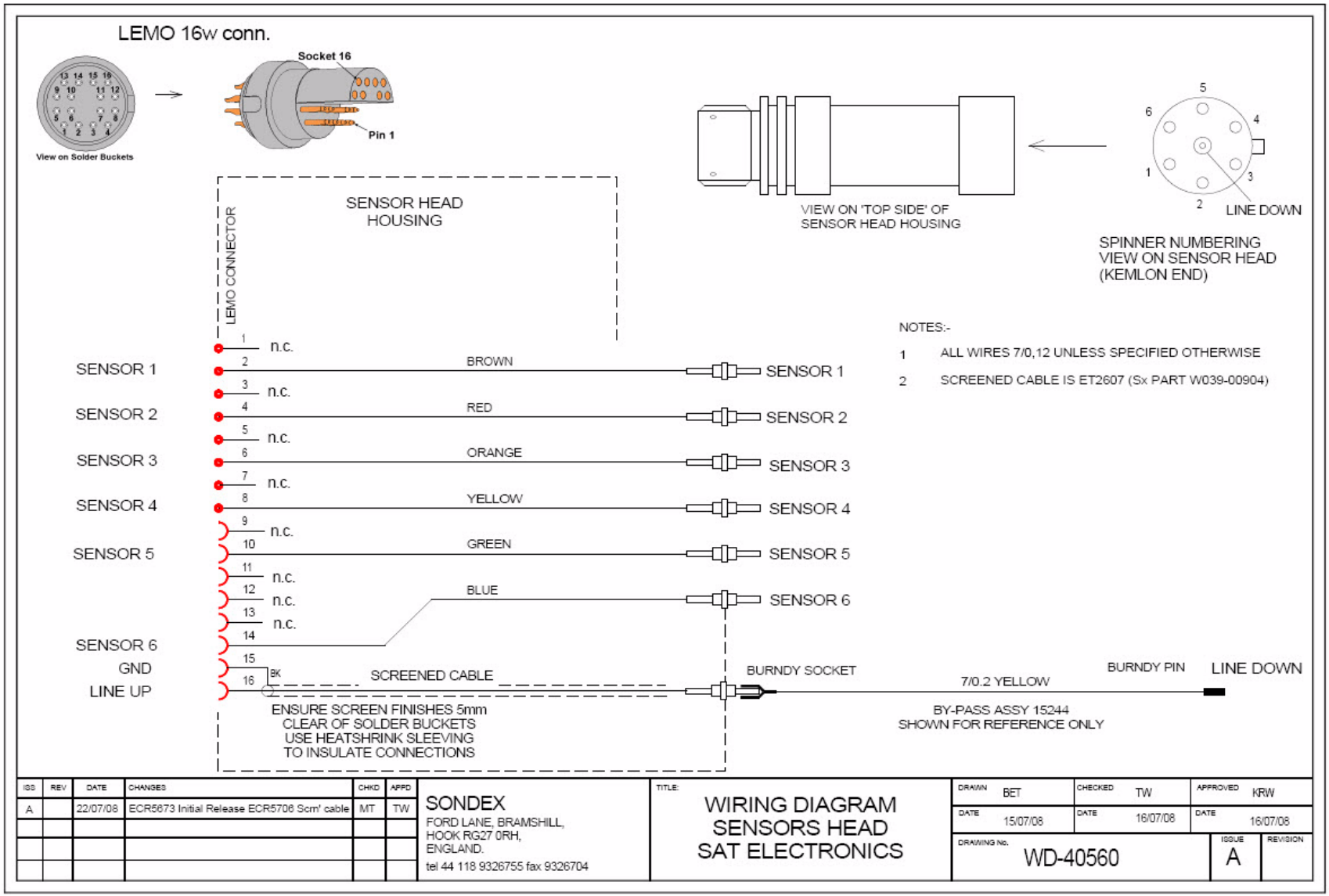
GE Oil & Gas

TITLE: Digital Board Spinner Array Tool Circuit Diagram

DRAWING NUMBER: CD-82458 REVISION: Fx

DRAWN	CHECKED	APPROVED
KRW	KRW	KRW
DATE 26/01/06	DATE 26/01/06	DATE 26/01/06

SHEET 2 OF 2



APPENDIX C FITTING OF RESTRICTOR RINGS

Ref: General Assembly *09822 Sheet 2* & *41171*(P/N 41142)

WARNING!

TRAPPED PRESSURE!

The SAT005 has components that in a failure mode may retain pressure. This pressure can be released at any time without warning.

Refer to *Section 5.2 Relief of Trapped Pressure* for the relief of any trapped pressure.

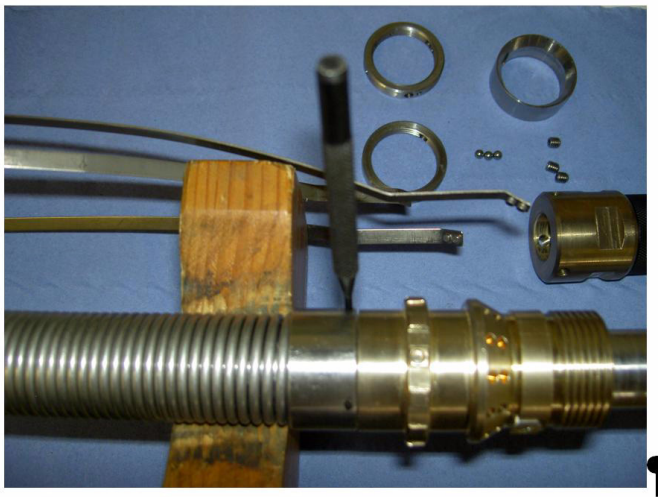
A set of three restrictor rings are available to limit the opening of the springbows on the tool:

- The shortest ring (*P/N: 41142-1*, 41171) will only allow the springbows to open to a 6 inch diameter
- The medium ring (*P/N: 41142-2*, 41171) will only allow the springbows to open to a 5 inch diameter
- The longest ring (*P/N: 41142-3*, 41171) will only allow the springbows to open to a 4 inch diameter

The rings are fitted beneath the long tension spring at the lower end of the tool:

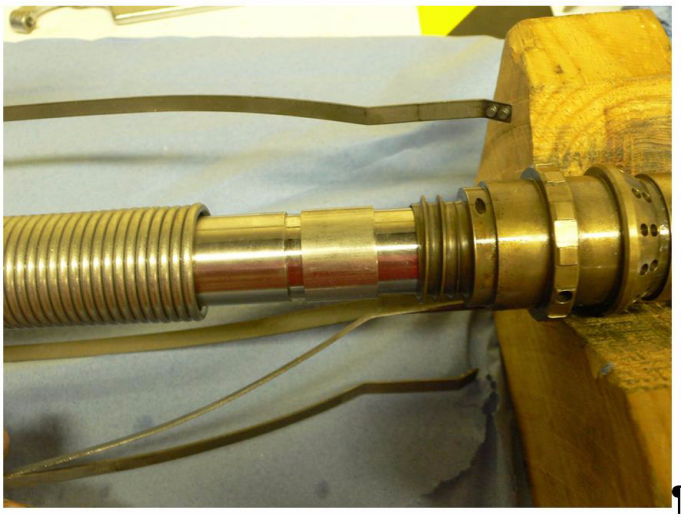
1 Remove the Lower End Sub Seal (*item 14*, 09822) by unscrewing the three grub screws (*item 33*, 09822) and releasing the $^{3}/_{16}$" balls (*item 26*, 09822). Unscrew the sub from the shaft.

2 Release the springbows from the Lower End Termination Body (*item 17*, 09822) by releasing the two Locking Rings (item 18, *item 18*, 09822) and sliding back the Lower Bow Clamp Ring (*item 16*, 09822).

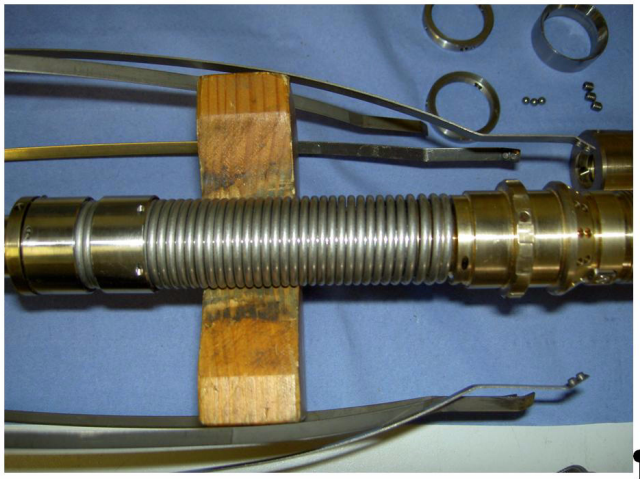


3 Drive out the two 2.5mm Spirol™ Pins from the Lower Spring Retaining Ring (*item 16*, 09822).

4 Unscrew the Lower End Termination Body (*item 17*, 09822) from the spring (left-hand thread) and remove.



5 Slide the required size of Restrictor Ring onto the shaft up to the first shoulder. The ring will restrict the travel of the Lower End Termination Body and the Springbow's maximum travel.



6 Replace the Lower End Termination Body and slide the Spring and the Restrictor Ring over the Shaft and screw onto the Lower End Termination Body.

7 Fit the Lower Spring Retaining Ring (*item 16*, 09822) using two new Spirol™ Pins (*item25*, 09822).

8 Refit the springbows onto the Lower End Termination Body and hold in place with the Clamp Ring (*item 19*, 09822).

9 Hold the clamp ring in position with the Locking Ring (*item 18*, 09822) with the additional M3 tapped holes. Then screw on the second locking ring.

10 The M3 tapped holes are used as a calibration aid for the rotation sensors. Align one of the M3 holes with the axis of spinner No. 1 before locking the rings in their final position. This will allow rotation calibration points at 90° intervals to be taken.

11 Screw the Lower End Sub (*item 14*, 09822) onto the end of the Main Shaft (*item 10*, 09822). Make sure that the Lower End Sub is fully tightened onto the Main Shaft. Lock in position using 3x $^{3}/_{16}$" Ball Bearings (*item 23*, 09822) and grub screws (*item 33*, 09822).