



AGSO CAPABILITY STATEMENT

May 1994

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5. Remote Cable Leveler RCL-3 – Syntrol Inc Information Booklet
6. AGSO Marine – Health Safety & Environment Manual – Part report only

SUMMARY OF HIGH-RESOLUTION SEISMIC CAPABILITY OF RIG SEISMIC
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The seismic acquisition system presently used on RIG SEISMIC is very flexible, permitting acquisition of data varying from high-resolution near-surface needs to regional deep seismic reflections down to crustal depths.

The configuration for shallow to medium targets would be a 2400 metre seismic cable with twin GI-gun arrays with a total volume of 1200 cubic inches.

- (1) Primary targets at 500 to 2000 msec are amenable to the use of GI guns. It is feasible to use two 4-gun arrays operated in "True GI" mode at a repetition rate of 5 seconds with the compressor capacity available.
- (2) The array configuration will depend upon specific needs for peak pressure and primary-to-bubble ratio (see attached source signature from SSI).

The best solution is eight 45/105 guns giving maximum bubble suppression.

- (3) We have verified that we can acquire 4 second records at a shot rate of 5 seconds with 192 channels, 2 msec samples and 180 Hz High Cut filters.
- (4) Typical noise levels of about 5 uBars are obtainable for the far channels in good sea conditions with a 12.5 metre group length and the cable running at 5 metres depth using a Low Cut filter setting of 4 Hertz.

An upper limit of around 10 uBars is therefore achievable.

- (5) Data from previous surveys indicates that a 50/70 metre offset from the energy source to the first seismic channel is typically feasible with the existing armoured leader at a ship speed of 5 knots.

Cable positioning would be by compass birds along the length of the cable plus pseudo-differential GPS positioning of the tailbuoy. This will at least enable the cable position to be tracked. The tailbuoy includes an ARGOS satellite transmitter, and there is a similar emergency ARGOS transmitter attached to the cable in case of loss.

Real-time navigation is routinely by the Racal SKYFIX differential GPS system. Accuracy expected at the typical reference station range is about 5 metres RMS. A recent paper by Racal Survey at the 20th FIG Congress in Melbourne March 1994 suggests that use of their MULTIFIX software and other improvements should give closer to 3 metres RMS. Backup would be provided by a parallel SKYFIX system.

SUMMARY OF G.I.GUN ARRAY CHARACTERISTICS
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The likely performance characteristics of the GI gun arrays have been reviewed, using the source signature specifications provided by SSI in Houston.

There are six Price 300 scfm compressors on RIG SEISMIC which produce a nominal 1500 scfm with one compressor in reserve, AGSO's standard operating procedure. At an overall efficiency of 80%, 1440 cu.ins. at 1800 psi can be delivered every five seconds.

The existing GI gun system consists of two identical 4-gun arrays with the guns spaced 2.5 metres apart. There are many different ways of configuring GI guns with various sized inserts in either or both generator and injector chambers. As mentioned above, computations for this 8-gun array running at a depth of 6 metres are based upon SSI figures.

AGSO's approach is intended to maximise the primary-to-bubble ratio by using the maximum possible injector volume. This of course consumes more air than other methods for the same generator volume.

Gen/Inj volume	Z-Pk b-m	Pk-Pk b-m	P/B ratio	Array volume
45/105	12.8	25.6	14.6	1200

There are many other ways of setting up the GI gun array, limited only by the constraints of the gun filling time for a 3/8 inch hose length of 300 feet and the available compressor air capacity. The final choice on the gun array configuration will depend on fine-tuning of the survey requirements.

ANTICIPATED SEISMIC CABLE NOISE LEVELS
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Tests have been carried out at sea to determine tow noise levels that can be expected at a variety of depth and filter settings. This was tackled in two ways; by determining the background cable noise levels at varying speed using standard 8 Hz filters, and then with filters set at 4 Hz.

Speed thru' water	Noise @ 8Hz (uBar)			Noise @ 4Hz (uBar)		
	25m	12.5m	6.25m	25m	12.5m	6.25m
4.5	2.2	(5.0)	7.8	4.1	(6.5)	9.0
5.5	1.7	(4.2)	6.8	2.8	(5.2)	7.5
6.5	2.4	(5.4)	8.3	4.1	(5.8)	7.5

On a 600 metre cable, the acoustic noise generated by the ship tends to be well above the ambient tow noise, particularly with short group lengths. Therefore noise figures in such cases represent a somewhat worst case than with a typical long cable.

The background noise level that can be expected for a distant 12.5 metre group would be around 4 uBar with 8 Hz filters, with a minor increase with speed. There is an increase of about 1 uBar in opening up the filters to 4 Hz with a greater variability caused by surges in the noise level from ship movements.

- (1) A noise limit of twice the background noise can reasonably be achieved, hence a limit of 10 uBars for the far channels would be appropriate.
- (2) A limit of double that level or 20 uBars would be realistic for the near channels affected by ship generated noise.
- (3) A figure of 15 uBars for those channels close to the tailbuoy would allow for tugging and surge effects on the rear cable sections.
- (4) For those channels carrying depth controllers and the immediately adjacent channels each side, a level twice that of the typical channel at that offset would be realistic.

Note that this is with 180 Hz High Cut filters, rather than 128 Hz filters.

HIGH-RESOLUTION SEISMIC RECORDING PARAMETERS

Streamer length: 2400 metres
192 seismic channels
12.5 metre group length
5 water breaks

Streamer depth: 5 +/- 1.5 metres

Offset: 50-70 metres

Shot interval: 12.5 metres (nominal 4.9 secs)
96-fold CDP coverage

Record length: 4.0 seconds

Sample rate: 2.0 millisecs

Filters: Low cut 4 Hz with 18 dB/octave
High cut 180 Hz with 140 dB/octave

Recording medium: 3480 cartridge tapes

Data format: Demultiplexed SEG-Y floating point

Word structure: AGSO 16-bit binary floating point

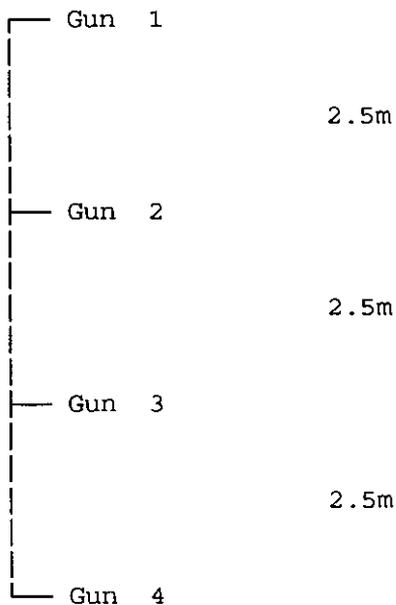
GI GUN ARRAY SEISMIC ENERGY SOURCE (1)

The current high-resolution energy source on RIG SEISMIC is comprised of eight identical GI guns from SSI in Houston, configured as two separate 4-gun arrays. The GI guns are spaced such that the interaction between them is minimal. Standard configuration for the guns is in "True GI" mode, using 45 cu.in. generator and 105 cu.in. injector to achieve maximum bubble suppression.

The guns are fired simultaneously to give an additive version of the power spectrum of a single gun. The loss of a gun does not therefore change the shape of the power spectrum. Minimum firing interval is 5.0 seconds (12.5m).

Gun type:	Seismic Systems Inc GI Gun
Gun volume:	105 cu.in generator, 105 cu.in. injector
Number of guns:	8 in two arrays, with no spares in array
Volume of total array:	1200 cu.in. (with 45 cu.in insert in generator)
Air pressure:	1800 psi
Gun depth:	3-5m for high-resolution, 6m for industry
Overall length of arrays:	7.5 metres
Separation of arrays:	15 to 25 metres as required

PORT ARRAY



STBD ARRAY



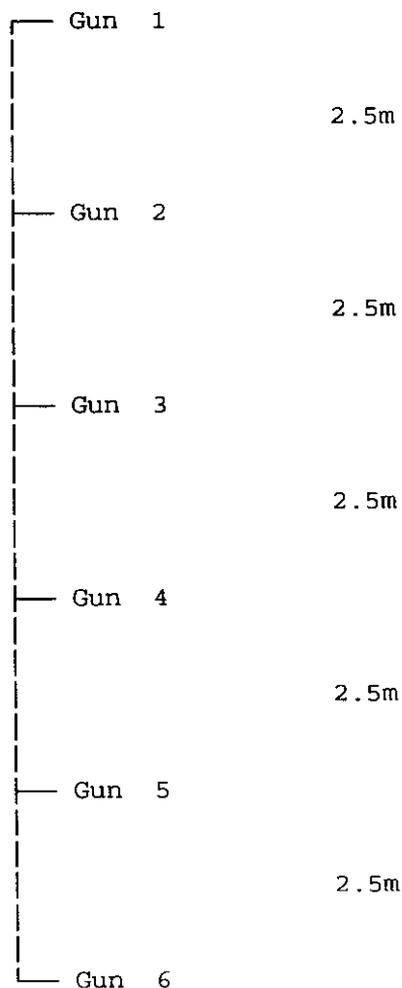
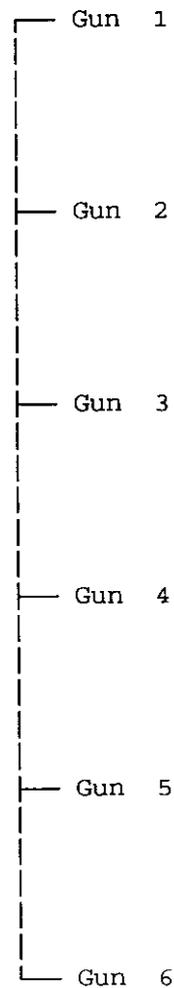
GI GUN ARRAY SEISMIC ENERGY SOURCE (2)
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An intermediate option with the seismic energy source on RIG SEISMIC uses 12 identical GI guns, configured as two separate 6-gun arrays. The guns are spaced such that interaction between them is minimal. Standard configuration for the guns is in "True GI" mode, using 45 cu.in. generator and 105 cu.in. injector to achieve maximum bubble suppression.

All guns are fired simultaneously to give an additive version of the power spectrum for a single gun. The loss of a gun does not therefore change the shape of the power spectrum. Minimum firing interval is 7.5 seconds (18.75m).

Gun type:	Seismic Systems Inc GI Gun
Gun volume:	105 cu.in generator, 105 cu.in. injector
Number of guns:	12 in two arrays, with no spares in array
Volume of total array:	1800 cu.in. (with 45 cu.in insert in generator)

Air pressure:	1800 psi
Gun depth:	3-5m for high-resolution, 6m for industry
Overall length of arrays:	12.5 metres
Separation of arrays:	15 to 25 metres as required

PORT ARRAYSTBD ARRAY

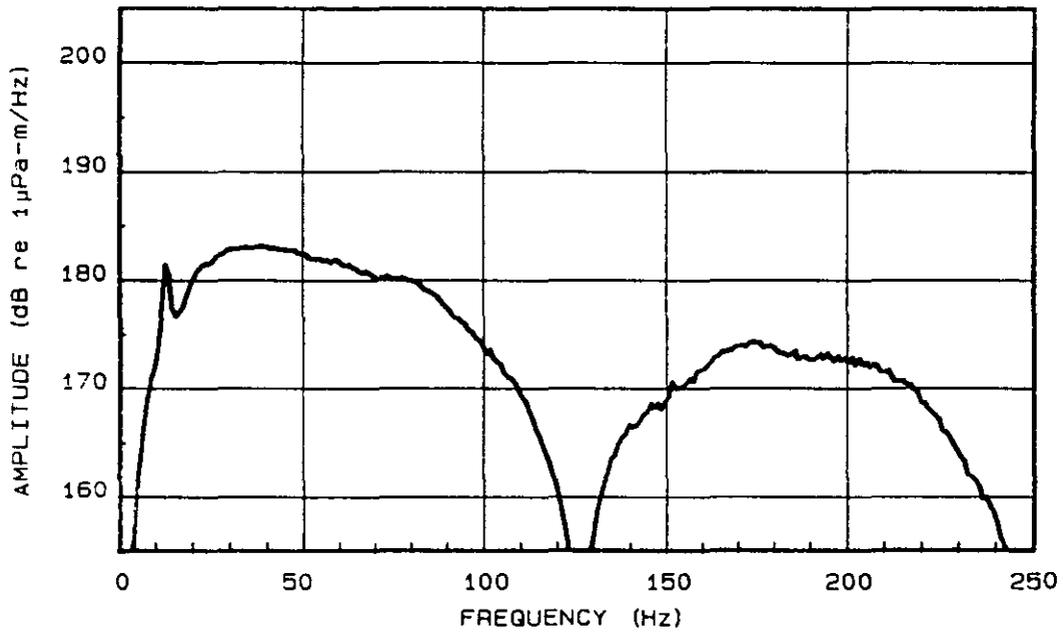
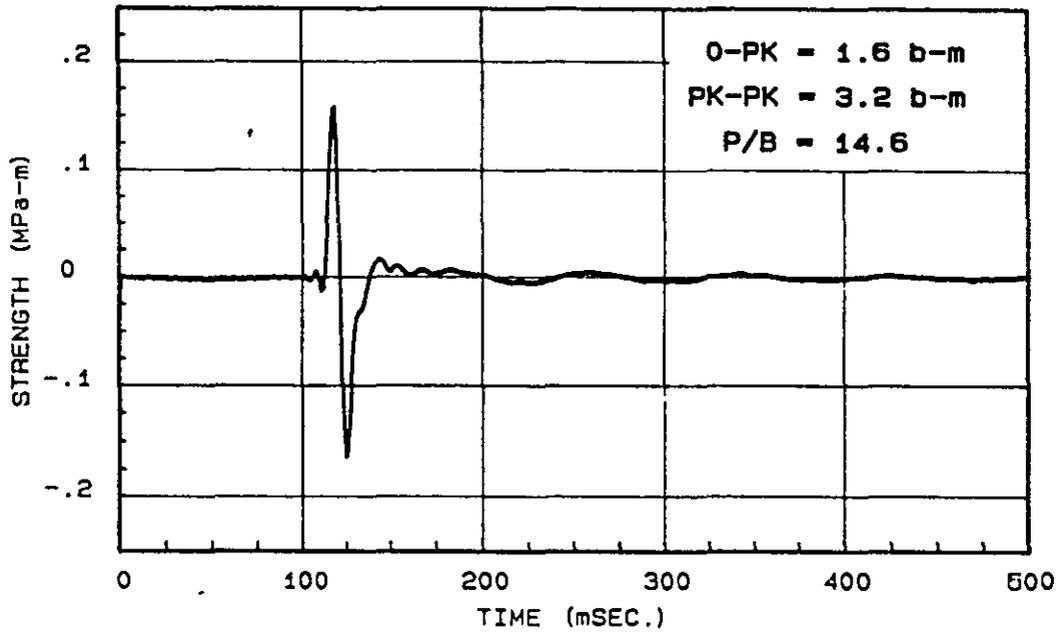
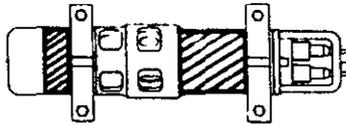


FIG. 1 ONE SINGLE GI GUN 150 in³ (GI MODE)

Signature 0-128 Hz/72dB
and amplitude spectrum

- . Firing pressure : 2000 psi
- . Firing depth : 6 m



AGSO MARINE

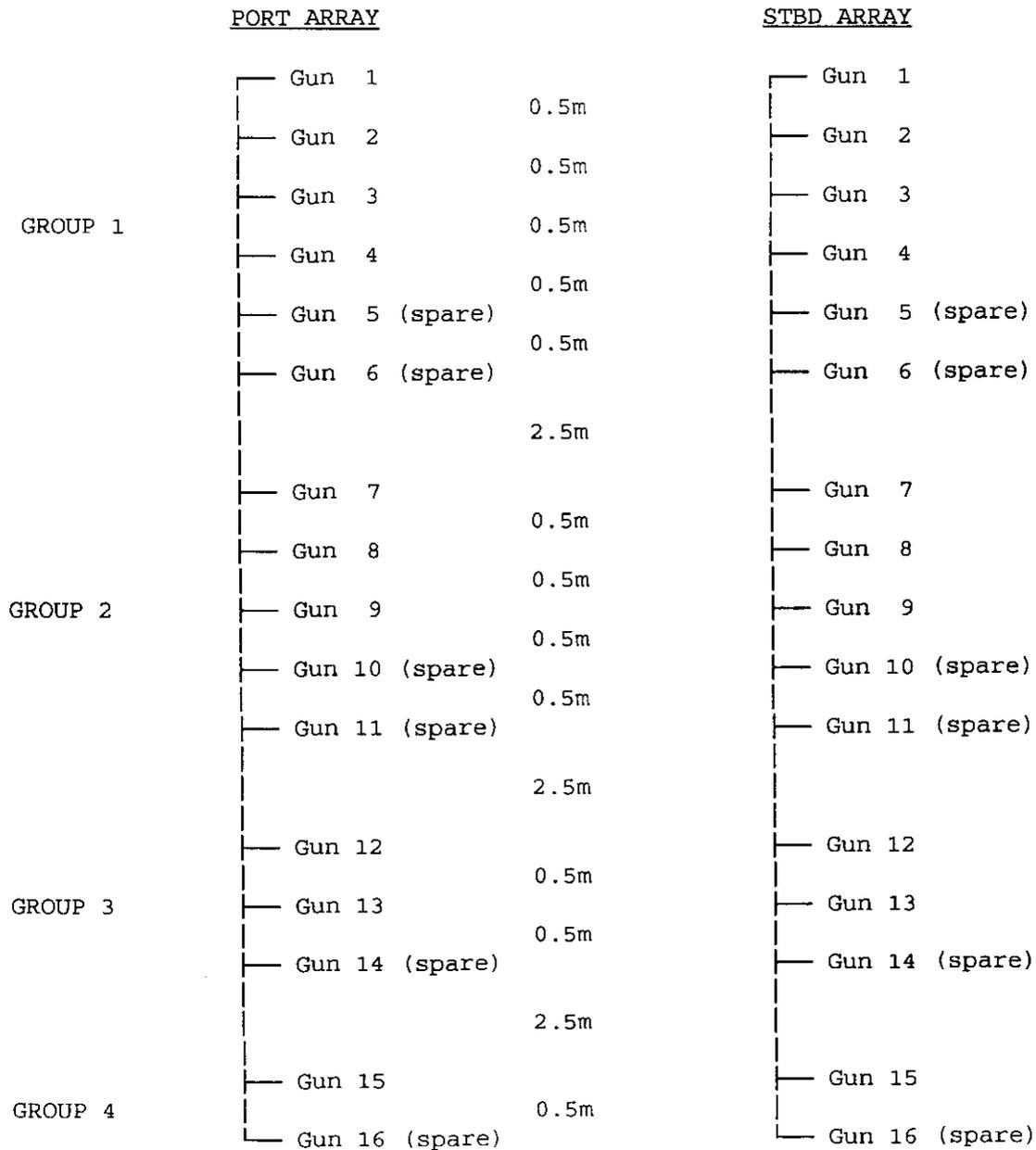
Operations Group

HGS SLEEVE GUN ARRAY SEISMIC ENERGY SOURCE

The energy source on RIG SEISMIC is comprised of 32 identical sleeve guns configured as two 16-gun arrays. The arrays are configured in groups of 6, 5, 3, and 2 guns from fore to aft respectively. Each array is normally fired as 4, 3, 2 and 1-gun groups with or without inserts.

Gun type: HGS Sleeve Gun II
 Gun volume: 150 cu.in. (110 cu.in with inserts)
 Number of guns: 20 (in 8 groups) + 12 spares
 Volume of total array: 3000 cu.in. (2200 cu.in. with inserts)

Air pressure: 1800 psi
 Gun depth: 10m for deep seismic, 6m for industry
 Overall length of arrays: 13.5 metres
 Separation of arrays: 15 to 25 metres as required



HALLIBURTON GEOPHYSICAL SERVICES INC.
SIGNATURE OF FINAL ARRAY BMRP6
TEST P, Depth=6m 08-28-1991

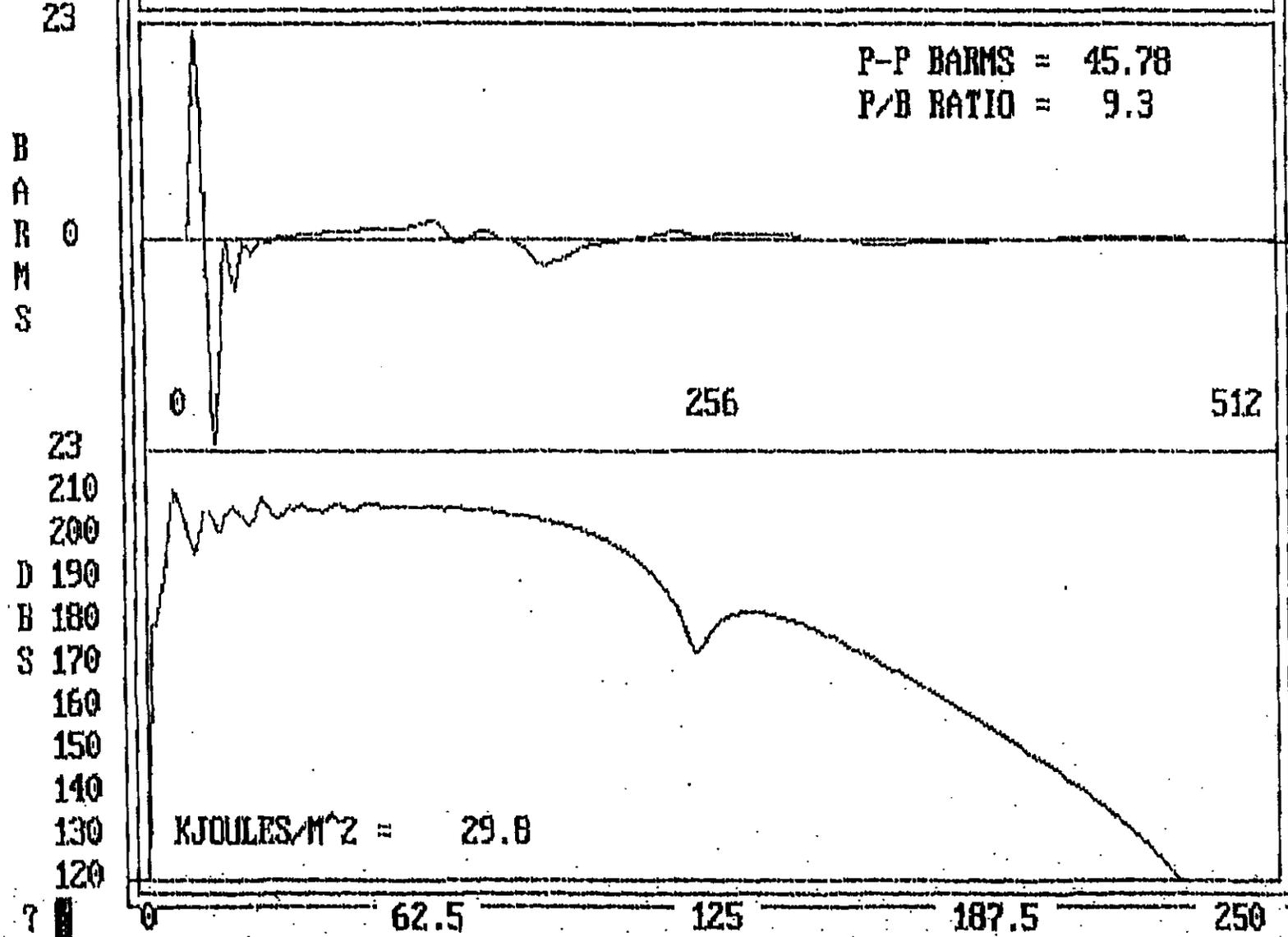


FIGURE 2.

Specifications of AGSO's marine research vessel *RV Rig Seismic*

Background

The *RV Rig Seismic* has dynamic positioning capability capable of carrying out operations world wide. The ship was built in Norway in 1982 and arrived in Australia to be fitted out for geoscientific research in October 1984. It has been chartered and equipped by AGSO to carry out the Continental Margins Program. It is registered in Newcastle (New South Wales) and is operated for AGSO by the Australian Maritime Safety Authority.

The *RV Rig Seismic* has so far collected over 100 000 line kilometres of deep crustal and high resolution seismic. It is equipped with an array of equipment capable of seismically imaging the crust/mantle boundary (Moho) at one end of the spectrum and sampling undisturbed surface sediments showing millimetre scale layering at the other. These seismic and sampling activities can be positioned using the most up-to-date navigation systems.

Specifications

Gross Registered Tonnage:	- 1545 tonnes
Length overall:	- 72.5 metres
Breadth:	- 13.8 metres
Draft:	- 6.8 metres
Engines: Main	Norma KVMB-12, 2640 HP @ 825 rpm
Engines: Generators	Three Caterpillar, 564 HP/482 KVA One Mercedes, 78 HP/56KVA
Engines: Shaft generator	AVK 1000 KVA; 440V/60Hz
Side thrusters:	Two forward, one aft, each 600 HP
Helicopter deck:	Twenty metres diameter
Accommodation:	Thirty-six single cabins/3 double cabins; forty-two persons in harbour; forty persons at sea

Scientific Equipment

FJORD Instruments charge coupled seismic streamer cable:	6.25m, 12.5m, 18.72m and 25m group lengths, up to 288 channels; up to 4800 metres active streamer length
Teledyne model 40289 charge coupled research mini streamer	with 4 x 6.25 metre groups
Syntron RCI-3 cable levelers	including remote control and depth readout.

Haliburton Geophysical Services 32 x 150 cubic in airguns in two 16 gun arrays	Normal operating is 2 x 10 guns, giving a total of 3000 cubic inches operating array volume at 1800 psi
Seismic Systems Inc GI gun array	consisting of two arrays of 4 x 45/105 cubic inch guns
Seismic Systems Inc S-15 and S-80 water guns	
Teledyne model high resolution mini-sparker	
HP air system	Six A-300 Price compressors, each providing 300 scfm at 2000 psi (62 litres/min at 14 MPa)
Digital seismic acquisition system designed and built by AGSO running on DEC u VAX 3500:	<ul style="list-style-type: none"> • 0.5 msec-4 msec sampling interval, 2 to 16 second record length • Phoenix A/D converter and instantaneous floating point amplifier • Data stored on 3480 Fujitsu cartridge tape drives • Data in demultiplexed modified SEG-Y format using 16-bit floating point words.
Reftek and Yaesu sonobuoy receivers	
Raytheon echosounders	with 3.5 KHz (2 KW), 16 transducer sub bottom profiler and 12 KHz (2KW)
Geometrics g801/803 magnetometer/gradiometer	
Bodenseewerk Geosystem Kss-31 marine gravity meter	
EG & G model 990 sidescan sonar	with 650 metres of cable
AWH deep sea winch	with 10 000 metres of 19 mm wire rope
Hydrographic winch	with 4000 M of 6mm wire rope
Coring and rock dredging systems	including a vibrocorer
Hydrocarbon extractor and gas chromatographs	for continuous Direct Hydrocarbon Detection in bottom water
Hydrocarbon gas analyses in sediments	
Geochemical analysis equipment of environmental monitoring	
A 15 metre A frame	with a 12.5 ton load capability

Navigation Equipment

Primary

Skyfix differential GPS leased from RACAI providing 5–20 metre accuracy when ranging up to 2000 kms from shore reference stations

Secondary

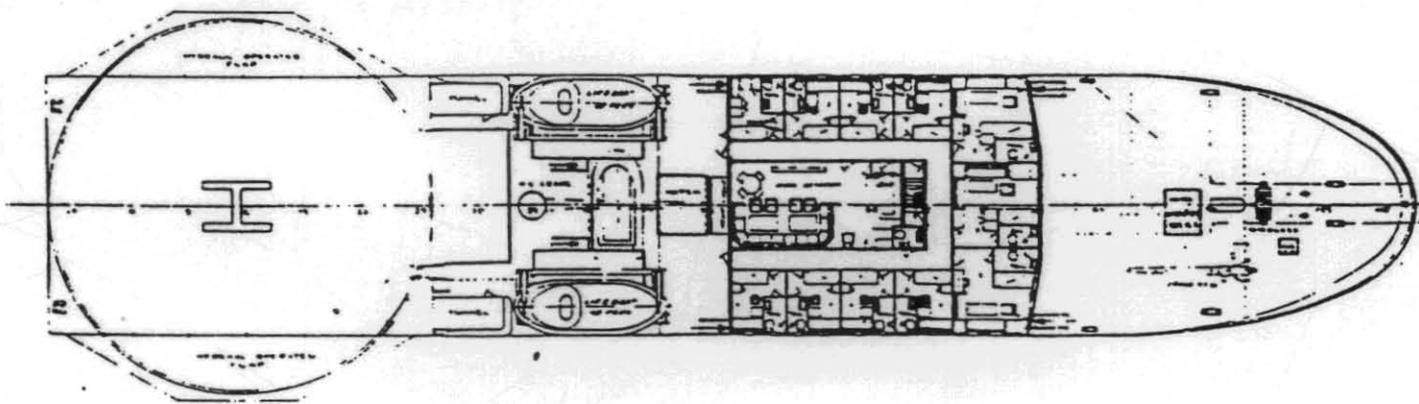
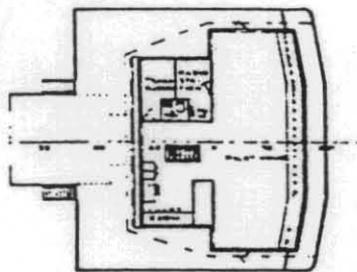
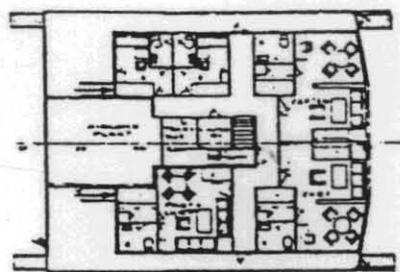
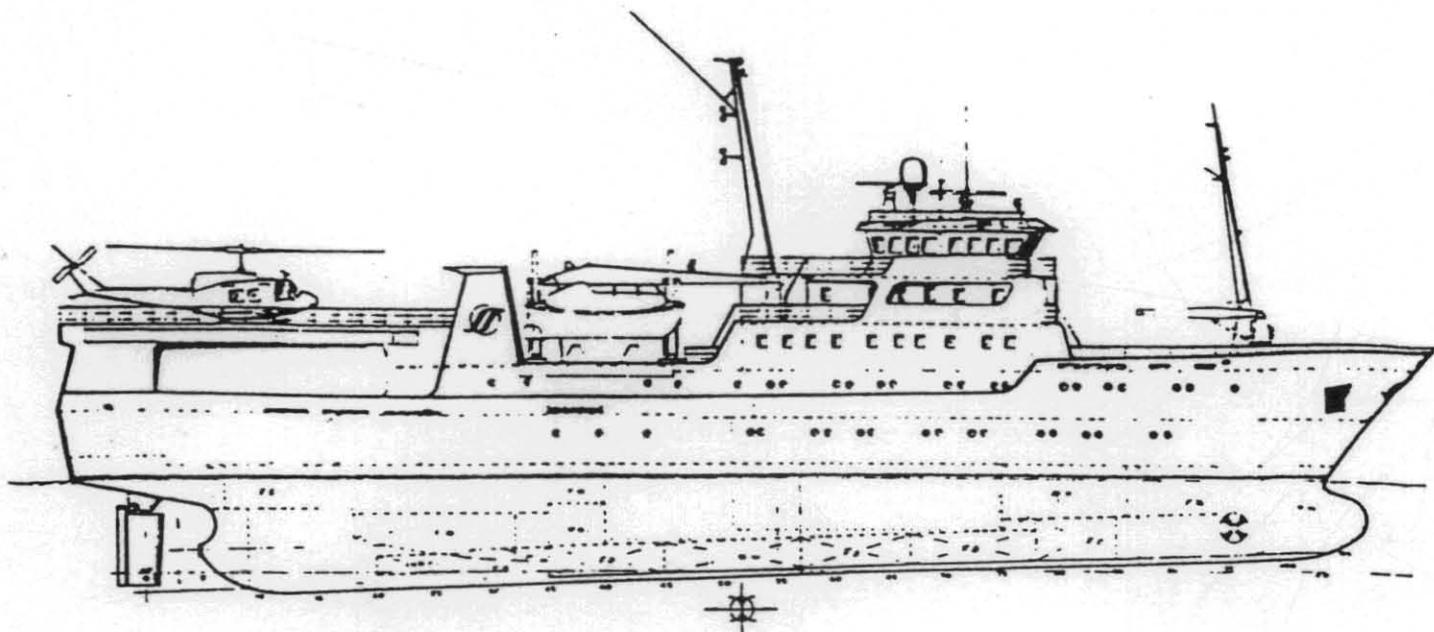
Backup Skyfix dGPS

Tertiary

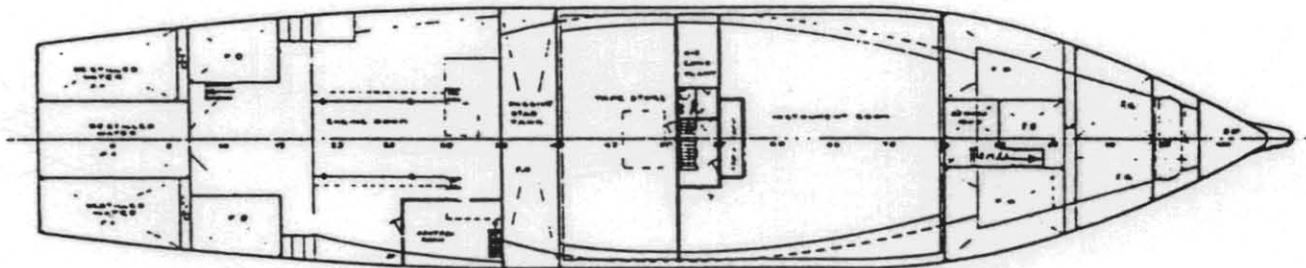
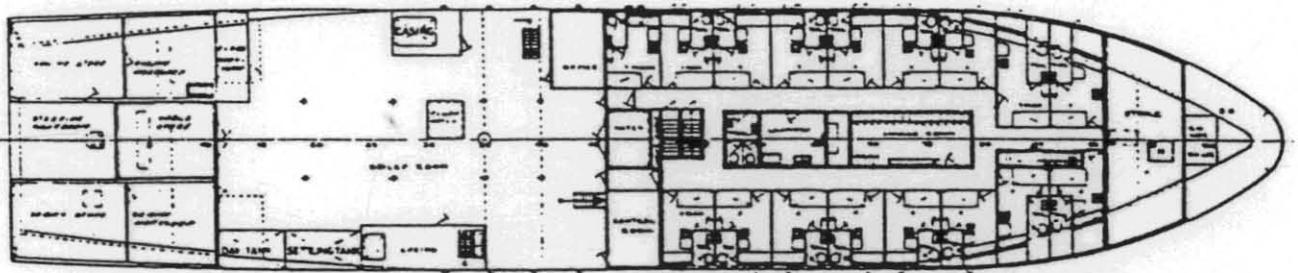
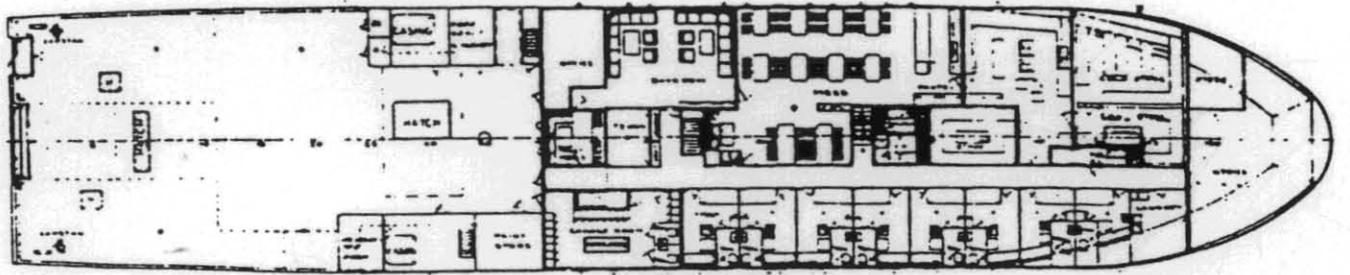
Magnavox MX 610D and Raytheon DSN 450 sonar dopplers combined with 2 x Sperry Mark 37 survey gyro-compasses

Magnavox MX100 GPS navigator

to give GPS positioning of seismic cable tailbuoy

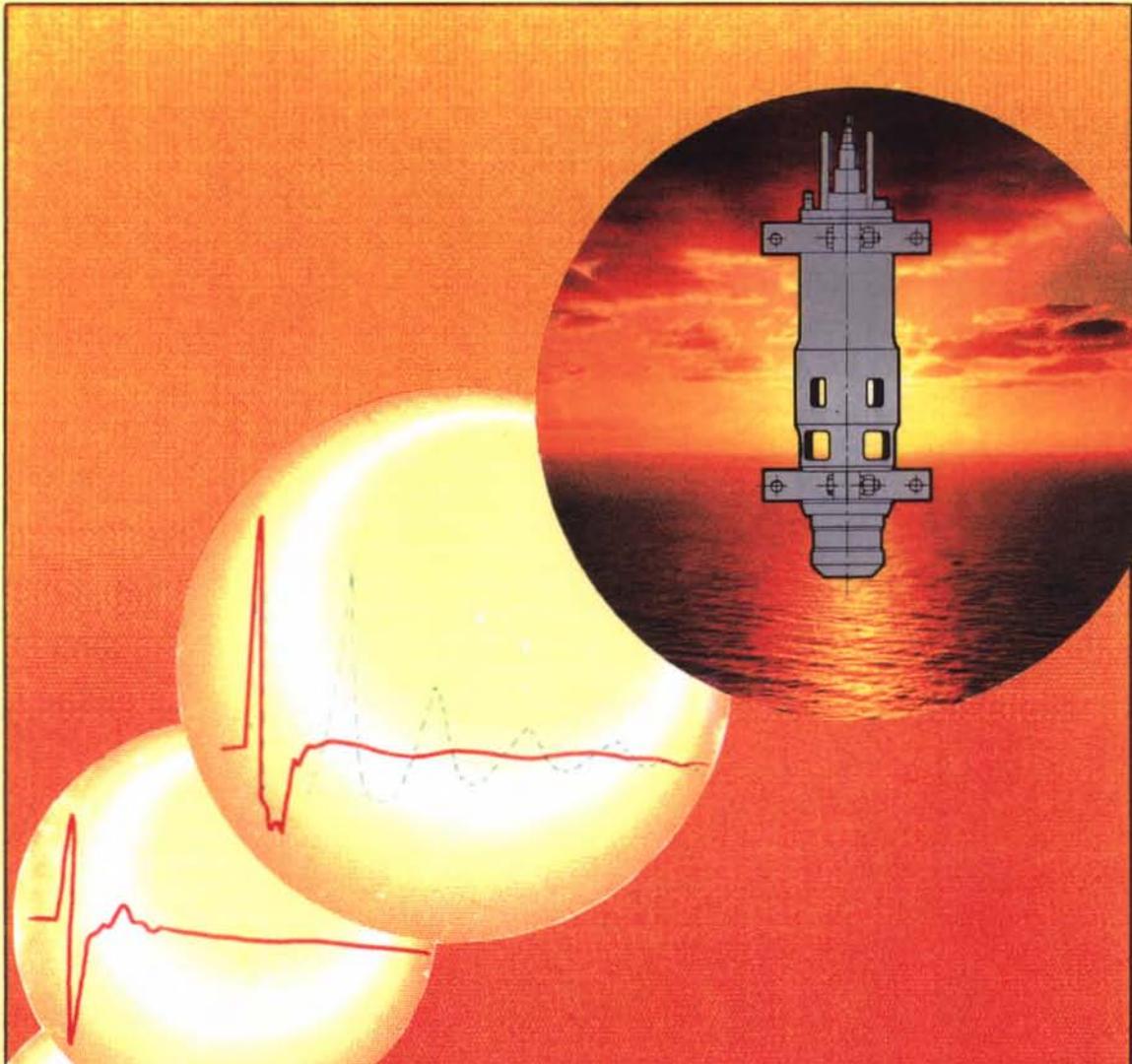


5 cm



5 cm

G.I GUN™



G.I GUN™

"The Bubble-free airgun"

A NEW SPECIES
TO SOLVE
THE OLDEST PROBLEM



Seismic Systems, Inc.

8925 Lipan, Houston, Texas 77063

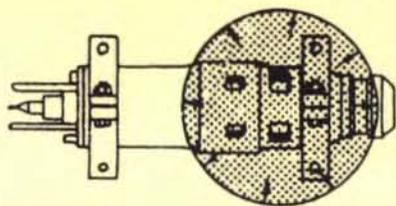
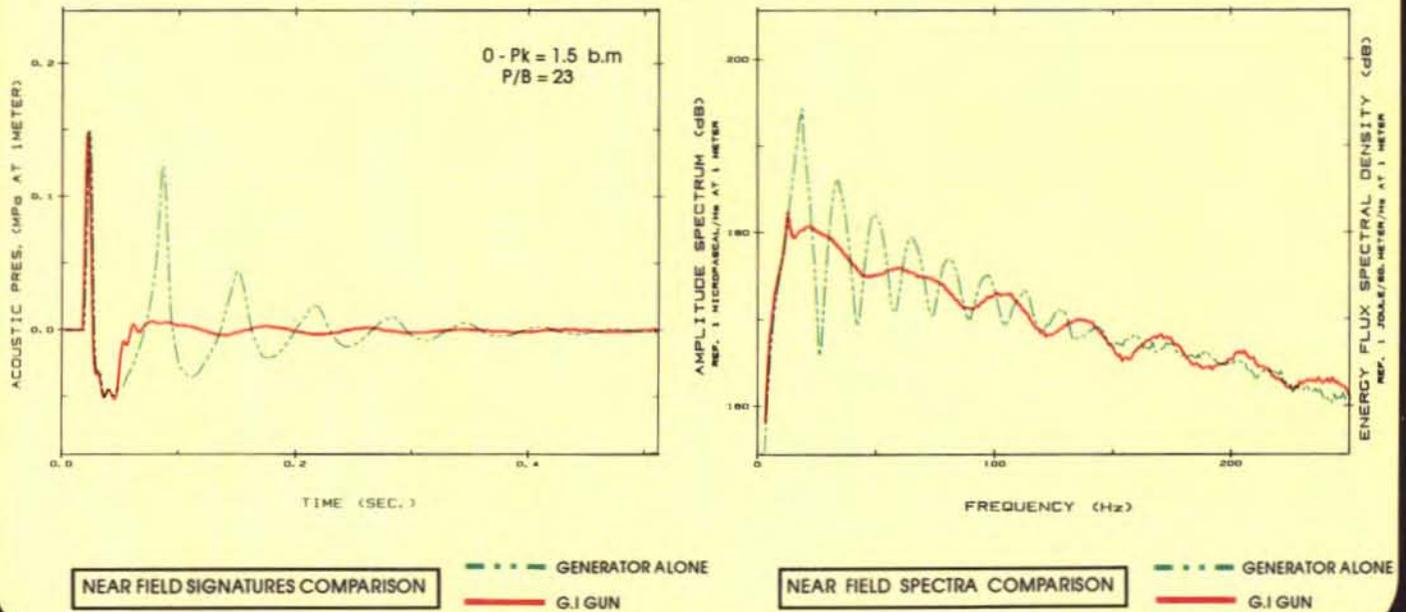
Phone: (713) 782-2586, Telex: 762435, Fax: (713) 782-0534

... answering a quarter-century Quest

While air gun arrays use the individual oscillations of different bubbles against each other in destructive interference between the radiated wavelet, G.I Gun fully suppress the oscillations of each individual bubble.

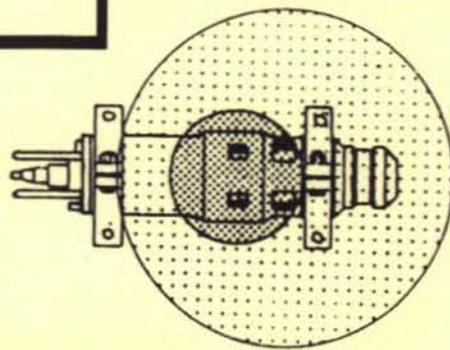
G.I GUN comprises of a pulse GENERATOR "G" and a bubble suppressor "I".

G.I GUN preserves the primary pressure pulse while eliminating the secondary pulses through the precise tuning of an air injection within the bubble.

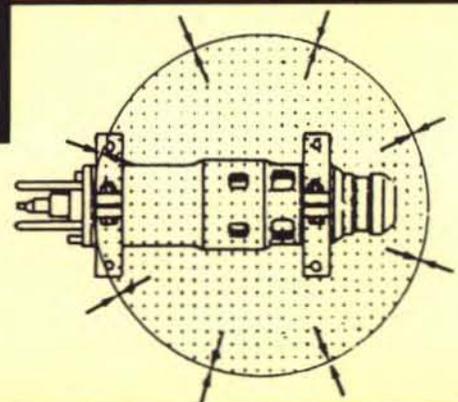


1 - GENERATOR "G" is fired

PULSE IS EMITTED



2 - When the bubble approaches its maximum size, INJECTOR "I" is actuated.



3 - The volume of air injected balances the hydrostatic pressure, stabilizing the bubble.

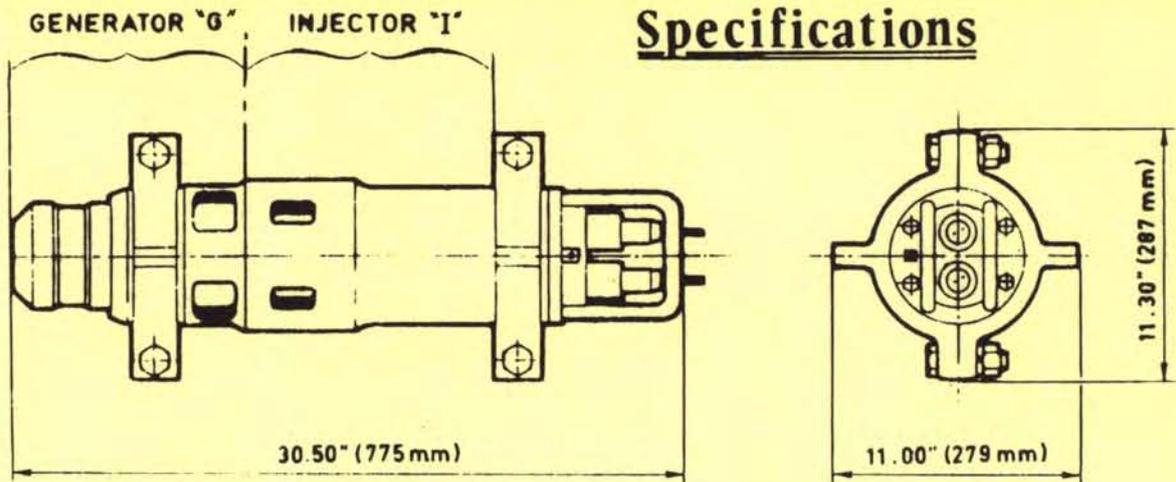
NO SECONDARY PULSE

HOW
IT
WORKS

US Patent No. 4,735,261
and others pending

5 cm

G.I GUN™ Model 150



Specifications

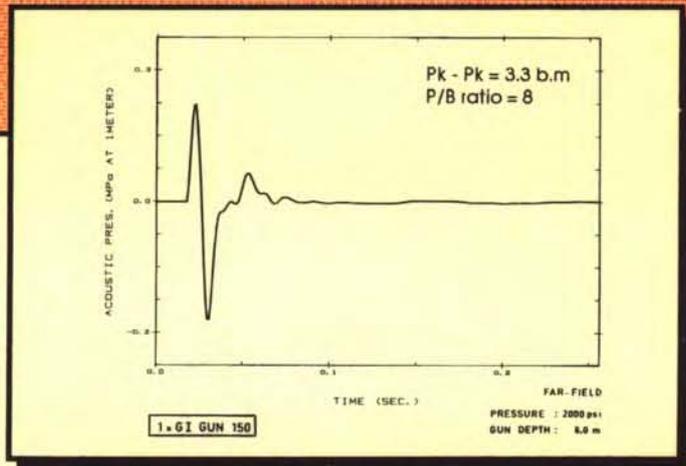
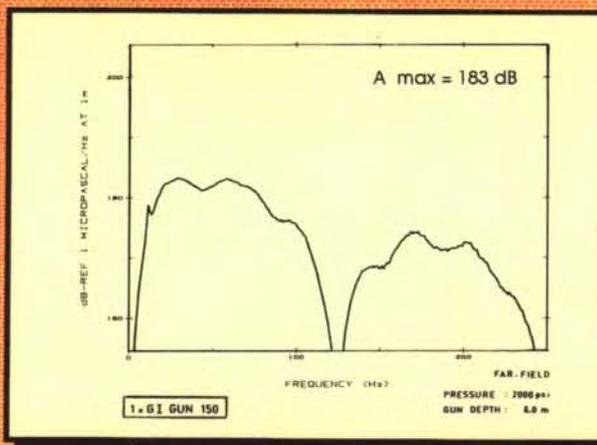
Physical :

- Construction : Stainless Steel
- Weight : 154 lbs (70 Kg)
- Built-in annular chambers
- Maximum volume : 150 cu.in (2.5 L)

Operational :

- Air pressure : 1,000 to 3,000 psi
(70 to 210 bar)
- Minimum firing interval : 4 seconds
- Total air requirement : 13 std. ft³/shot
(370 NL/shot) at 2,000 psi (140 bar)

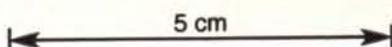
F.F. Amplitude spectrum (dB)



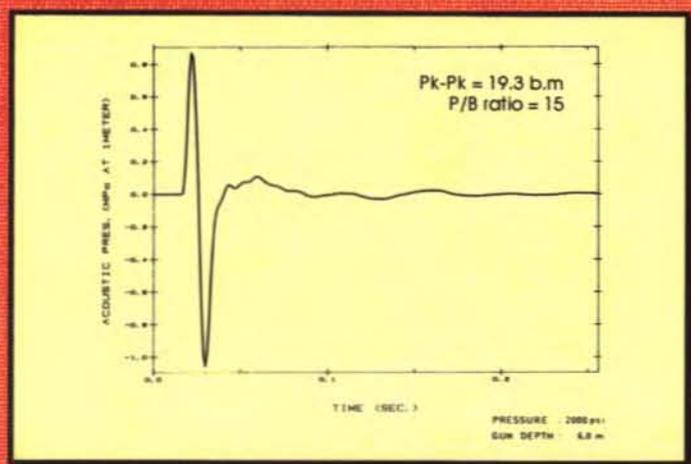
F.F. Signature 0-128 Hz 72dB/o

G.I GUN™ can be operated in different modes by just changing the firing sequence.

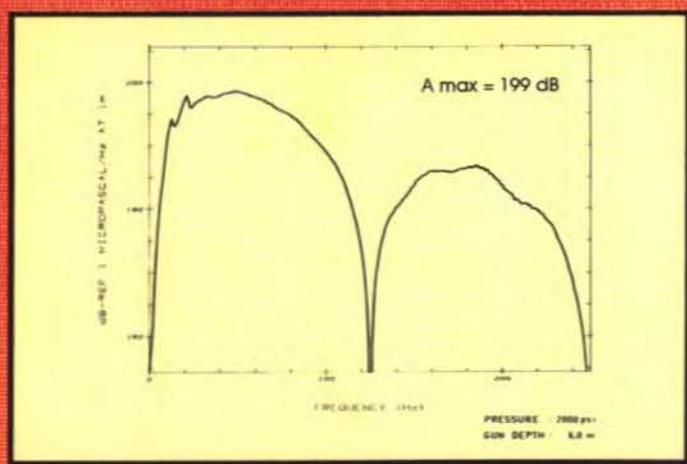
- Air Gun Mode : G or I or G+I synchronized
- GI Mode : GI tuned → the Bubble-free airgun
- Harmonic Mode : GI detuned



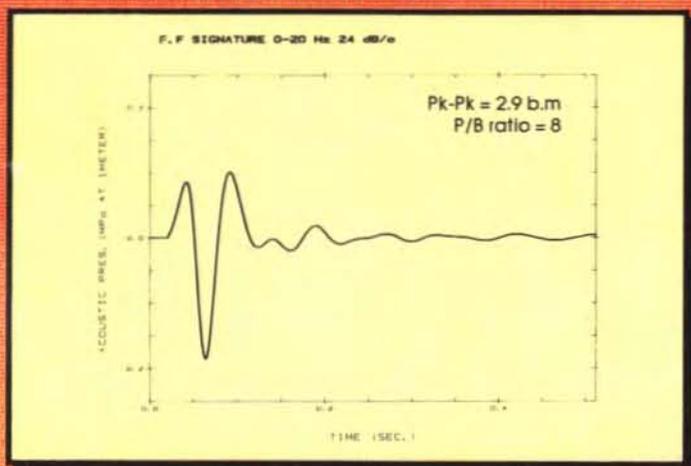
G.I GUN™ 150 in ARRAYS



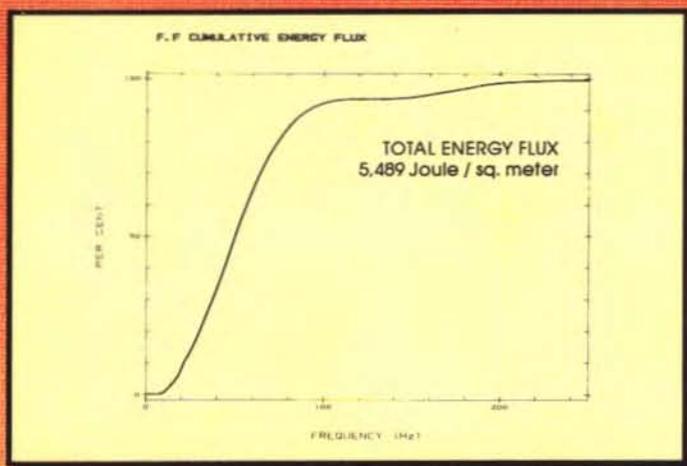
F.F. Signature 0-128 Hz 72 dB/o



F.F. Amplitude spectrum (dB)



F.F. Signature 0-20 Hz 24 dB/o



F.F. Cumulative energy flux

ARRAY of 6 G.I GUN 150



Seismic Systems, Inc.

8925 Lipan, Houston, Texas 77063

Phone: (713) 782-2586, Telex: 762435, Fax: (713) 782-0534

A wide range of Sleeve Guns.

10 in³20 in³40 in³300 in³450 in³150 in³100 in³70 in³

Fifty percent fewer components.

The HGS Sleeve Gun is available in a wide range of sizes offering the geophysicist the versatility required for today's sophisticated source array design techniques. The Sleeve Gun yields a significant improvement in amplitude and spectral content over conventional acoustic sources.

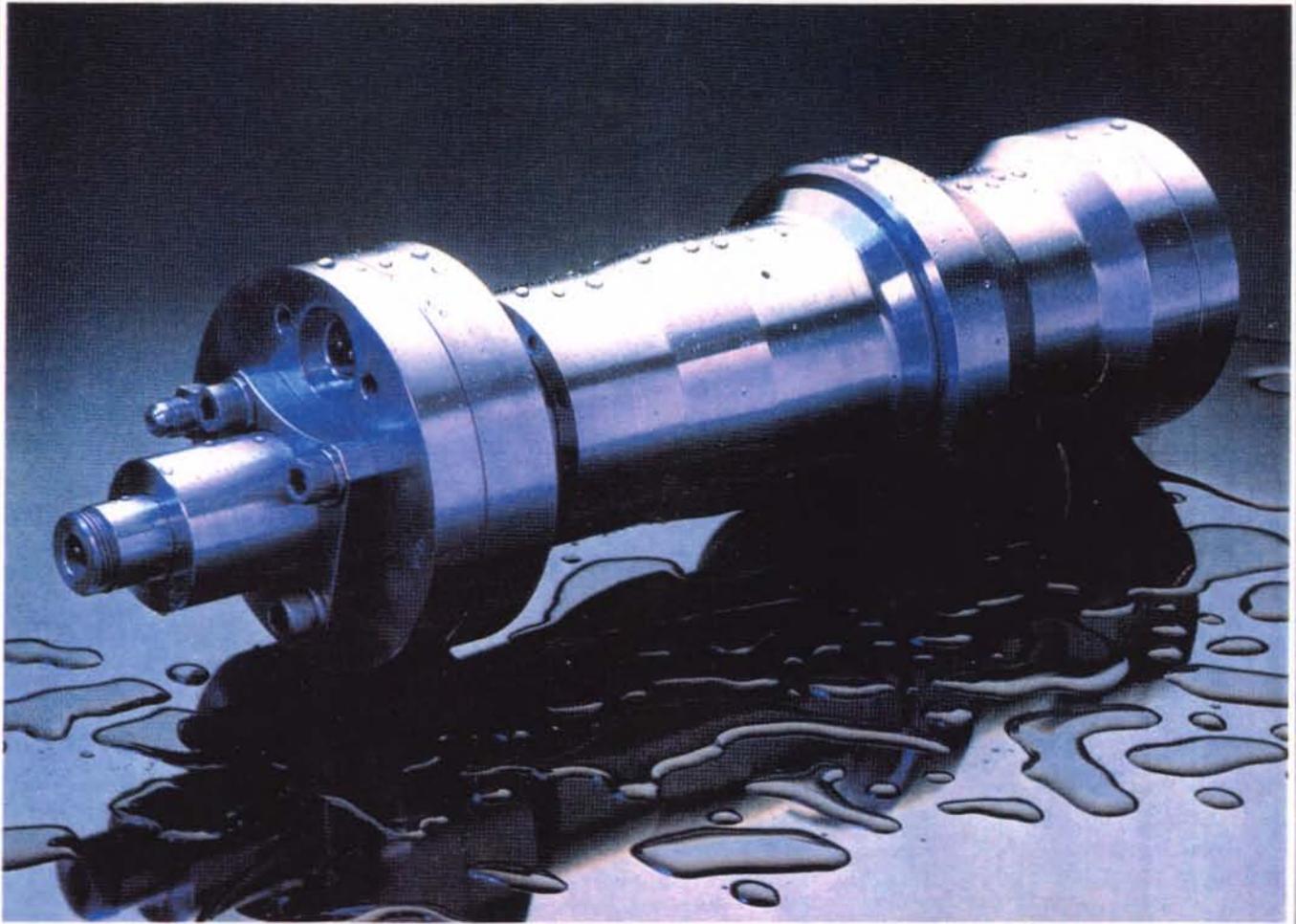
In addition to producing a signature with a higher acoustic peak and a broader frequency range, the Sleeve Gun offers these unique advantages:

- Larger, 360 degree exhaust port, which vents air more efficiently.

- Virtually non-autofiring.
- Fewer parts—approximately 50 percent fewer components than conventional guns, for increased reliability and reduced maintenance costs.
- Smaller size—to improve deployment concentration and versatility in today's larger arrays—with increased output and no increase in required compressor capacity.
- 100-200 microsecond timing deviation.
- Internal timing coil provides precision timing on peak of stroke and is robust in the presence of leakage.

Halliburton Geophysical Services

SLEEVE GUN™



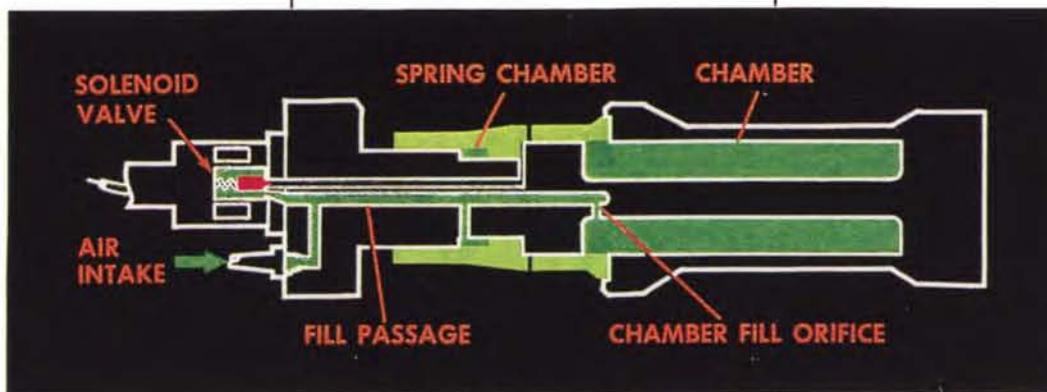
Revolutionary air gun design means better seismic resolution.



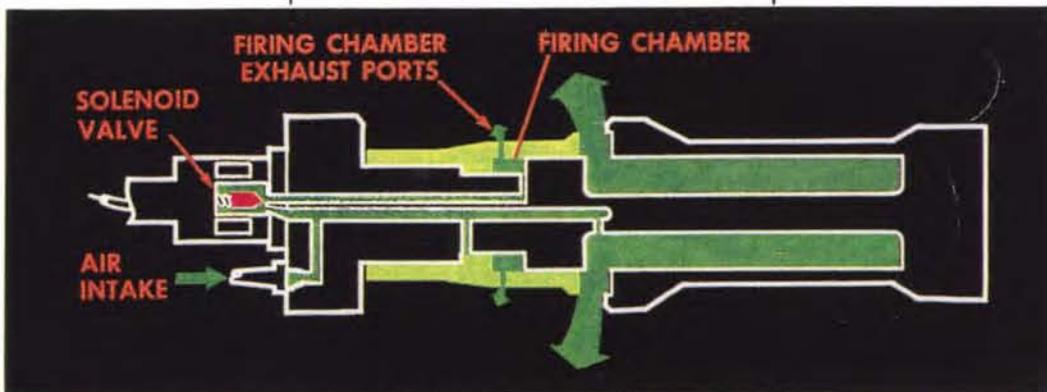
Halliburton Geophysical Services

 A Halliburton Company

An inside look at how it works.



Sleeve Gun in charged stage.



Sleeve Gun during firing stage.

To understand more clearly the difference between the Sleeve Gun and a conventional gun, let's take a closer look at how the new gun operates.

The diagram at the top shows a cutaway view of the Sleeve Gun, fully charged. Air has entered the fill passage and spring chamber areas, forcing the external sleeve shuttle closed.

At the same time, the fill passage has provided air to the sleeve chamber. When the sleeve chamber and spring chamber pressures reach supply pressure, the gun is then ready for firing.

The gun is triggered by sending an electrical pulse to the solenoid valve. The solenoid plunger raises and permits air to flow into the firing chamber. The sleeve now has the same pressure acting on both sides of it, and because the firing

chamber sleeve area is greater than the spring chamber sleeve area, the sleeve starts to open.

With the full chamber pressure acting on the sleeve in combination with the firing chamber force, a very large opening force is created which quickly moves the sleeve to its full open position. The chamber air exhausts into the water and generates the acoustic pulse.

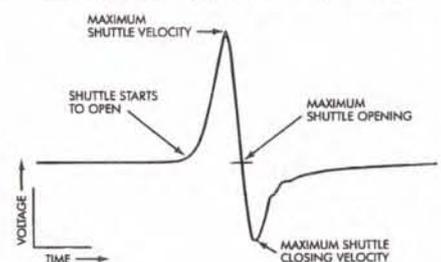
As the sleeve moves into the full open position, the firing chamber exhaust ports are uncovered. This vents the firing chamber air and drops the pressure to ambient.

In the exhausted condition, the main chamber and firing chamber pressures are near ambient. Now the full supply pressure acts on the spring chamber, which moves the sleeve back to its closed position. The cycle is now complete, and the gun recharges.

Consistent, Reliable Timing

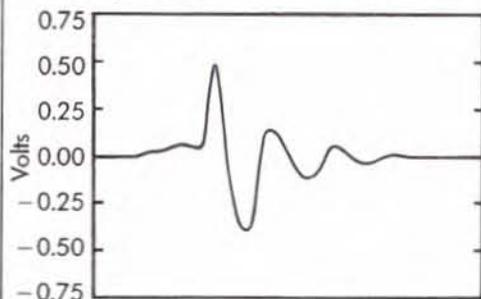
The Sleeve Gun is equipped with a patented internal timing sensor to provide a precise and reliable signal for gun synchronization. A timing coil is installed on the gun body, and magnets are incorporated within the top of the shuttle, so that as the gun is fired, the shuttle accelerates, forcing the magnets towards the timing coil thus inducing a current proportional to the motion of the shuttle.

TYPICAL SLEEVE GUN TIMING PULSE

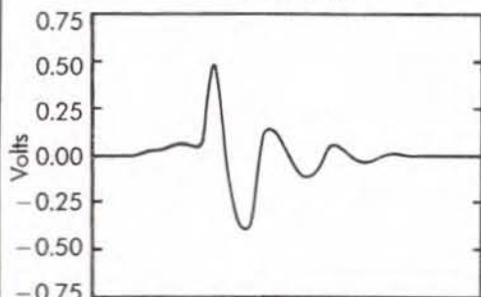


Superior acoustic signature. Smaller size. Fewer parts. Greater reliability.

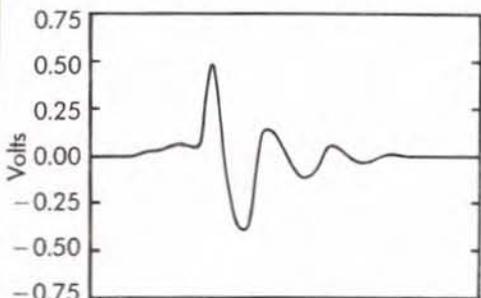
Tests to determine functionality of the method indicate that consistent gun timing is possible even with severe leakage between timing coil leads.



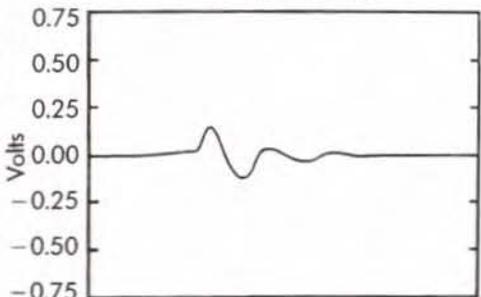
No Leakage



Leakage—1000Ω



Leakage—800Ω



Leakage—13Ω

The Benefits of a 360° Port are Obvious!



Exhaust bubble of a conventional air gun.



Exhaust bubble of a Sleeve Gun.

Sleeve Gun Condensed Specifications

CHAMBER VOL. IN ³	SCF/SHOT	WEIGHT LBS.	LENGTH IN.	MAX O.D. IN.	OUTPUT, 0 TO PEAK, B-M	
					UNFILTERED	(0-128 HZ)
10	0.73	39.0	15.2	5.00	1.67	0.36
20	1.45	42.0	17.3	5.00	1.83	0.57
40	2.91	56.0	21.4	5.00	2.08	0.73
70	5.50	105.0	22.5	7.25	2.96	1.66
100	7.90	114.0	25.0	7.25	3.19	1.78
150	11.80	130.0	29.1	7.25	3.35	1.98
210	15.70	224.0	29.3	9.19	3.6*	—
300	22.40	250.0	33.8	9.19	4.0*	—
450	33.60	265.0	33.8	9.19	4.1*	—
ALL GUNS	SOLENOID VALVE FIRING VOLTAGE: 40-60 Volts DC TIMING COIL OUTPUT: 1 Volt DC Peak to Peak Typical					

*Predicted

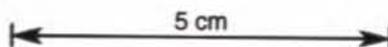
FOR MORE INFORMATION:

HALLIBURTON GEOPHYSICAL SERVICES, INC.
6909 SOUTHWEST FREEWAY
P.O. BOX 36827
HOUSTON, TEXAS 77236
PHONE: (713) 774-7561
FAX: (713) 778-3487
TELEX: 76-2899



Discover the potential. Worldwide.

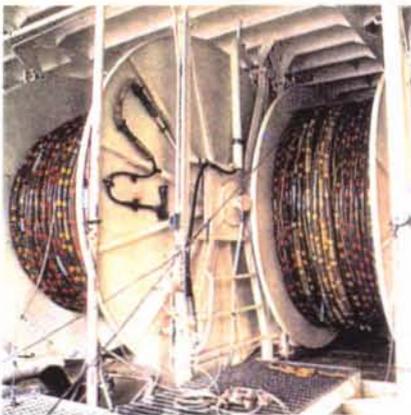
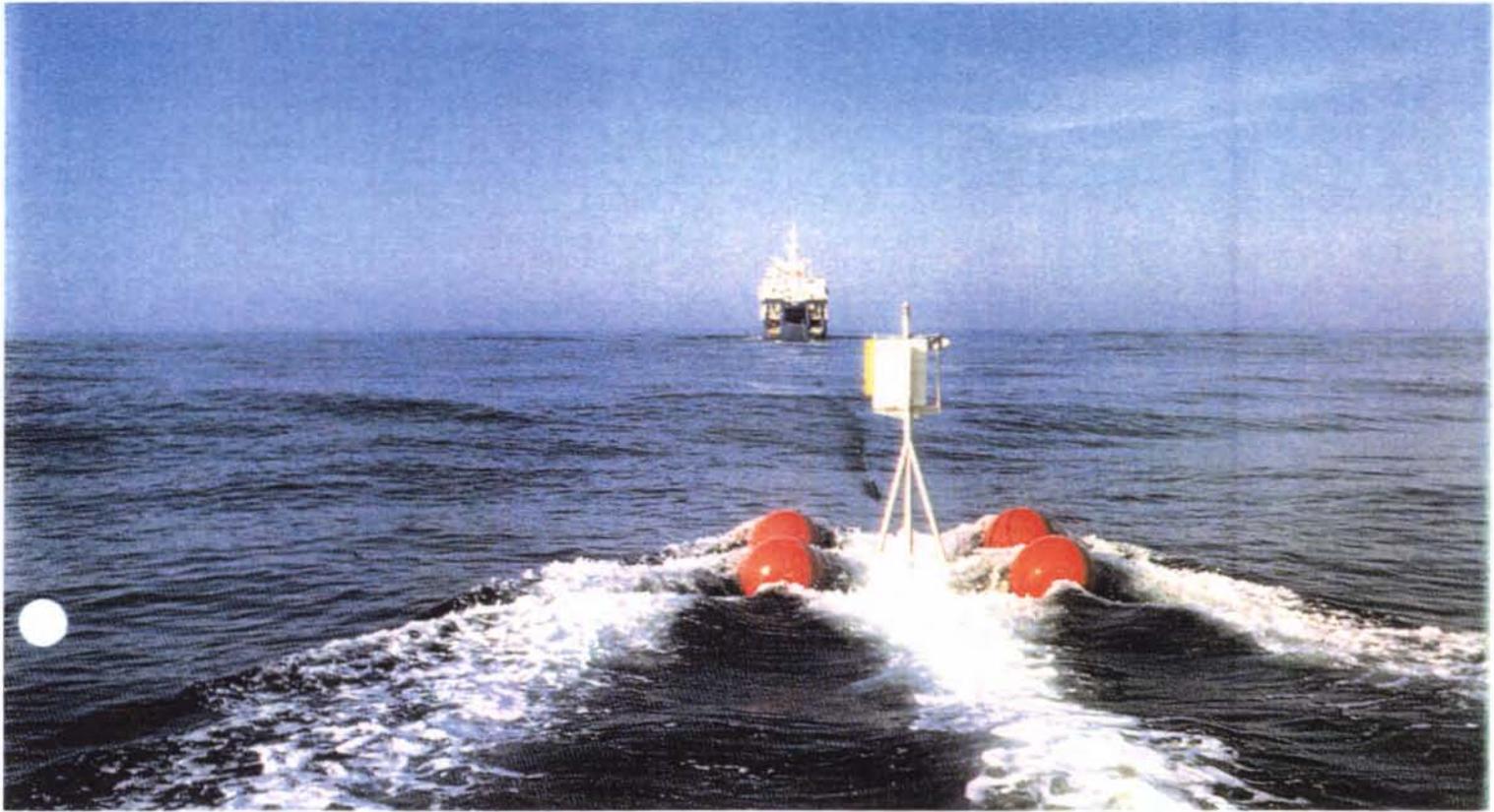
Halliburton Geophysical Services, Inc., reserves the right to make specification changes at any time as required in supplying the best product possible.





GECO

Streamer systems

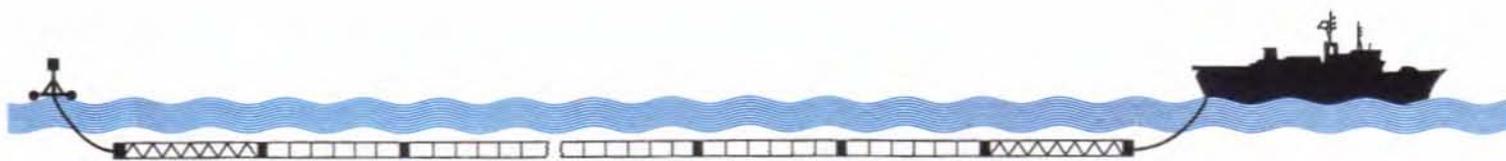


120 - 1000 channels
Analog - Digital

Array flexibility
Operational reliability



GECO seismic streamers



Flexibility

As an integral part of its renowned marine seismic data acquisition capability, GECO provides a wide range of streamer configurations designed to meet any challenge and match any requirement. Versatility in design and reliability in operation are the key words describing all GECO analog and digital streamer systems.

In the analog streamers, all active sections are individually formattable to accommodate variable group lengths. This is achieved by using processor units to configure several short hydrophone subgroups to form larger groups. These processor units can be reconfigured in the field, and operational efficiency and flexibility are maintained by the use of quick-action couplers. The group interval may be chosen to provide either high resolution or conventional survey objectives. Special purpose streamer configurations utilizing variable group intervals are easily implemented in all GECO streamers.

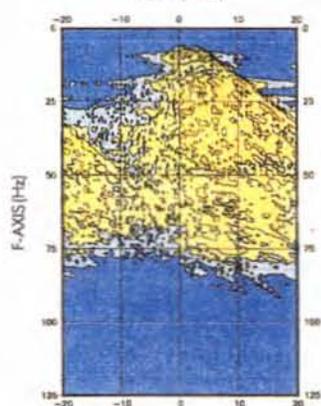
Multi-streamer operation

For reasons of cost and efficiency, multi-streamer operations are increasingly used for 3D surveys. Dual streamer acquisition techniques increase the demands for flexibility and reliability in the streamer systems. Extensive testing and production experience has demonstrated convincingly that streamers designed and manufactured by GECO fully meet these requirements.

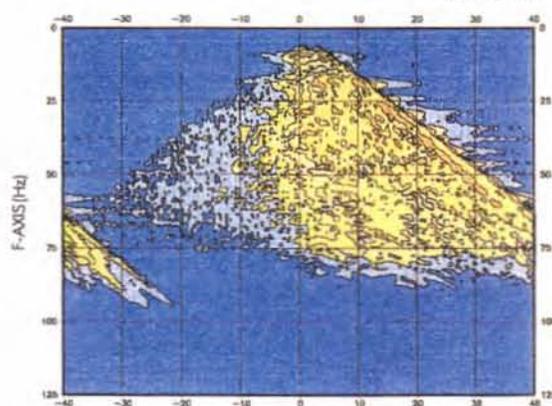
GECO cable factories

GECO has two cable factories of its own: the GECO US Cable Facility at LaMarque, Texas, and Fjord Instruments A/S in Bergen, Norway. Both are wholly dedicated to the development, manufacture and repair of seismic streamers and associated equipment, and have facilities for intensive testing and quality control. A suitable vessel is rigged as a mobile test station, permitting full-scale testing under near operational conditions. Production at the GECO factories includes both analog and digital streamers: analog up to 240 channels and digital up to 1000 channels.

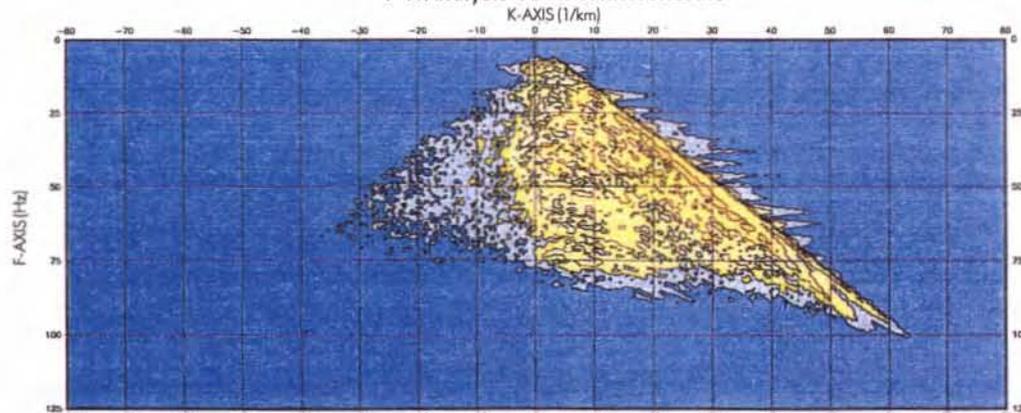
F-K Analysis 120 channel shot file
K-AXIS (1/km)



F-K Analysis 240 channel shot file
K-AXIS (1/km)



F-K Analysis 480 channel shot file
K-AXIS (1/km)



5 cm

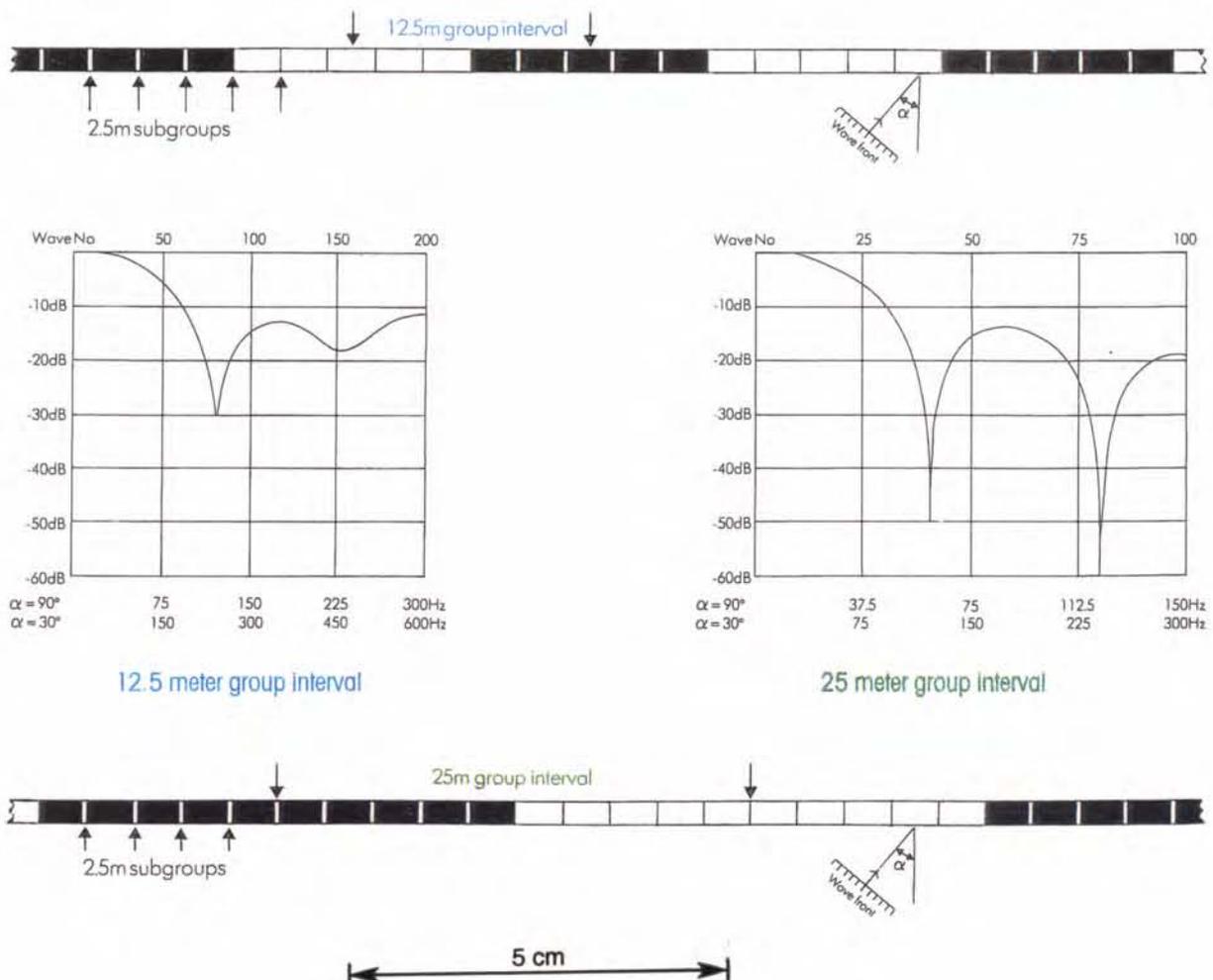
240 channel streamer system

In order to record up to 240 data channels, GECO has further enhanced analog streamer technology to uniquely bridge the gap between conventional and digital streamers. A very high degree of flexibility is achieved by specially developed processing modules, located in each active section, which sum the signals from a selectable number of hydrophone subgroups. This innovative design permits a very wide variety of arrays to be configured to meet different survey requirements. Cable reconfiguration and trouble-shooting in the field are simplified by the use of GECO's GX-600 quick-action couplers, and by the use of 'universal' sections which can be placed anywhere in the cable. The design of GECO's analog streamers ensures the optimum placement of hydrophones, spacers and other key components, resulting in systems which are unsurpassed in their ability to suppress cable surges and other ambient noise.

Each 75-meter active section comprises 30 identical hydrophone subgroups, 2.5 meters in length and comprising four hydrophones connected in parallel. The subgroups form the basic building blocks from which various group lengths are constructed. The outputs from all the subgroups within a section are fed to a processor module, located at the centre of the section. By plugging in the correct type of module, group lengths in multiples of 2.5 meters can be obtained. Optimum electrical characteristics are achieved by connecting groups in series, in parallel, or in a combination thereof. The on-board electronics permits the configuration of linear, weighted or overlapped groups, while the versatility of the system is further increased by the use of extension carriers which permit inter-section linking of hydrophone subgroups.



Wave number plots for two typical hydrophone group configurations





FJORD 240 channel streamer - formatable hydrophone group-lengths



Variable group lengths and comprehensive quick disconnect couplers represent two important improvements achieved with the 240 channel streamer.

Sub-array processor modules incorporated in every active section accordingly make it easy to change hydrophone group lengths, while the GX-600 quick disconnect coupler takes up to 300 pairs.

The variable group length facility contrasts with conventional streamer systems, which contain fixed groups targeted for either high resolution or standard seismic profiling. Many of these streamers set hardware limits on provision of group flexibility.

In Fjord's 240 channel solution, the sub-arrays serve as building blocks in each active section that can be interconnected to form groups of desired configurations.

Coupling and decoupling sections is accomplished quickly and conveniently with the GX-600 series, which can handle up to 300 carriers for seismic and auxiliary data.

All active sections used in the standard 240 channel streamer are 75 metres long, and consist of 30 sub-arrays of 2.5 metres each.

The latter are brought to a sub-array processor at the centre of each section.

These sub-array processors electrically configure the 2.5 metre sub-arrays into desired lengths, and the resulting groups are then properly transferred through the streamer to the recording instruments.

The processor modules are designed to allow easy access to the sub-array processors, which can be reconfigured in the field.

Thanks to the versatility provided by the sub-array building blocks, the 240 channel system permits configurations customised to user-specific requirements.

Standardisation of active sections further enhances system compatibility and availability.

FJORD INSTRUMENTS

Fjord Instruments A/S - a member of the GECO group

Knarvik, P.O.Box 3 - N-5100 Isdalstø, Norway

Tel.: +47 5 35 11 80 - Telefax: +47 5 35 13 37 - Telex: 40861 fjord n

Typical specification:

LEAD-IN CABLE

A specially-constructed tow cable with double external armour, this unit features high-quality insulation carefully selected for low noise and use with charge amplifiers.

Conductors:

305 twisted pairs. The single cores are made of a special copper conductor (0.3 mm diameter solid) and insulated with high-quality plastic.

The pair groups and each layer are wrapped with a semi-conductive foil, contacted in each layer with a copper contact strand.

Insulation:

Three-fold plastic jacket (outer dia. about 36 mm).

Armouring:

Two contra-twisted layers of galvanised high-tensile steel-wire strands.

Electrical properties:

DC resistance at 20°C, about 280 Ω /km.

Insulation resistance at 20°C: > 10M Ω /km.

Operating voltage: 50V.

Mechanical properties:

Overall dia: max. 52 mm.
Bending dia: 1000 mm.
Working load: max. 10 tonnes.

Weight:

About 6500 kg/km.

ACTIVE STREAMER SECTION

Mechanical:

Length: 75 m
Jacket: polyurethane
OD x wall: 75 x 3 mm
Stress members: 3 x 4 mm galvanised steel ropes
Breaking strength: 45 kN
Max. tow force: 25 kN
Max. operating depth.: 100 m
Effective density (oil adjustable): 1 to 1.03 kg/l
Coupler: GX-600

Hydrophone groups:

(Programmable group lengths in multiples of 2.5 m).

Number of sub-groups per section: 30
Distance between groups (centre to centre): 2.5 m
Length of hydrophone group: 2 m
Number of hydrophones per sub-group: 4
Wiring for transformerless operations.
Charge-pressure sensitivity of a sub-group: 2.45 C/bar

Frequency response of sensitivity depend on charge amplifiers and conductor length.

Capacity of sub-group: 72 nF

Hydrophone type in accordance with client requirements.

Conductors (twisted pairs):

Copper, polyester insulated, going to groups: 2 x 15 pairs AWG 28
Cu, pol.ins., going through: 273 pairs AWG 28
Cu, pol.ins., going through: 5 pairs AWG 26
Cu, pol.ins., going through: 3 single conductors AWG 24

Resistivity of pairs, roundtrip: 34 ohm at AWG 28

Resistivity of pairs, roundtrip: 18 ohm at AWG 26

Resistivity of pairs, roundtrip: 9 ohm at AWG 24

Capacity of pairs (ϵ diel. const. of oil) AWG 28: about 6.5 nF at $\epsilon = 2$

We recommend building depth-sensors into active sections, but these can also be incorporated into separate sections.

STRETCH SECTION

Relaxed length: 48.5 m
Jacket, polyurethane
OD x wall: 77 x 4 mm
Stress members: 3 x 12 mm polyamid ropes
Breaking strength: 45 kN
Max. tow force: 25 kN
Effective density: about 1.0 kg/l
Quick coupling connectors with: 600 contacts

Conductors (twisted pairs):
Copper, polyester insulated, going through: 292 pairs AWG 28
Copper, polyester insulated, going through: 5 pairs AWG 26
Copper, polyester insulated, going through: 3 single conductors AWG 24

Resistivity of pairs, roundtrip: 32 ohm at AWG 28

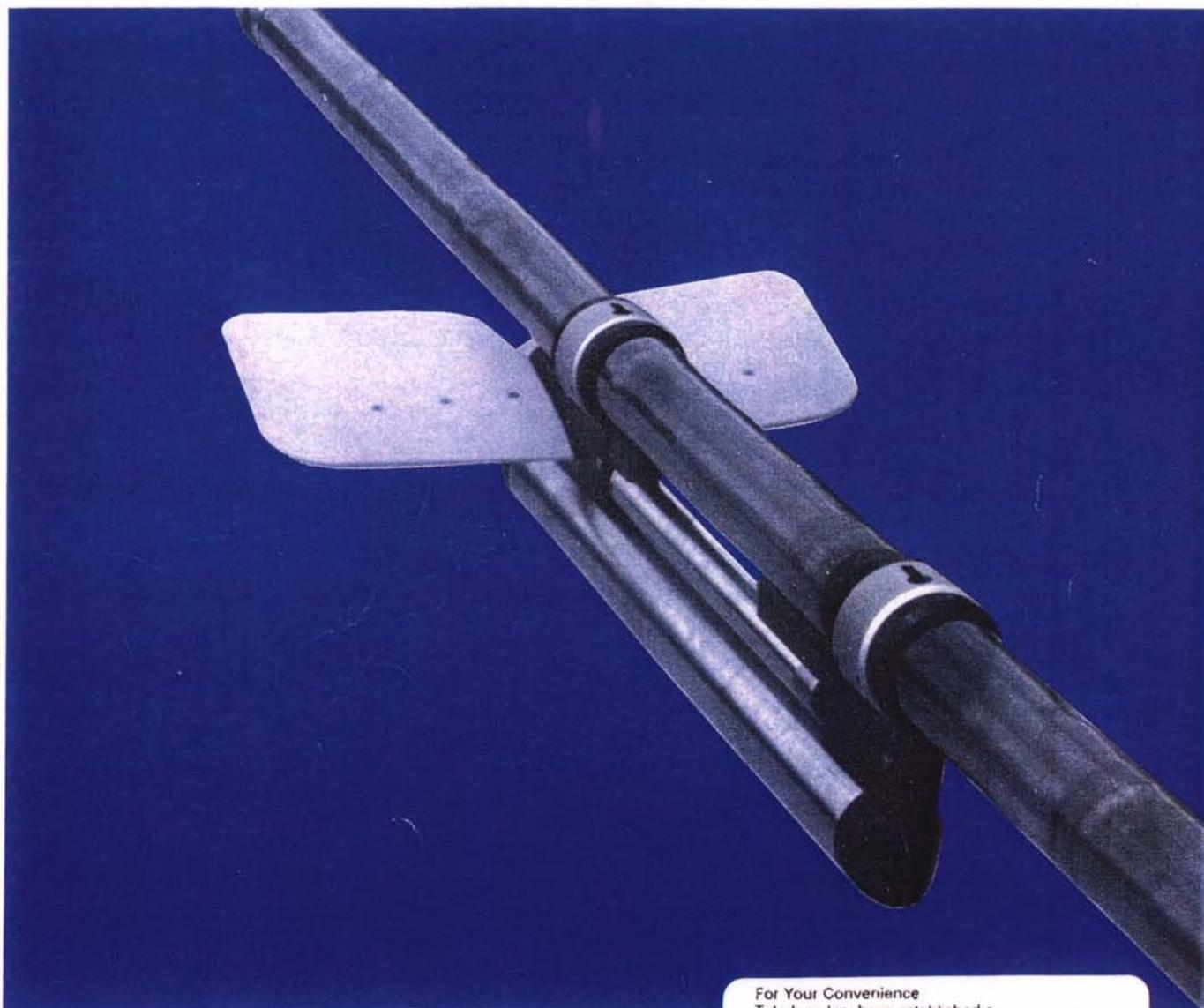
Resistivity of pairs, roundtrip: 16 ohm at AWG 26

Resistivity of pairs, roundtrip: 8 ohm at AWG 24

Capacity of pairs (ϵ diel. const. of oil): about 6.5 nF at $\epsilon = 2$

518032

REMOTE CABLE LEVELER
RCL-3



Synttron, Inc.®

For Your Convenience
Teledyne Inc. have established a
Corporate International Office as:
**TELEDYNE INDUSTRIES
INTERNATIONAL INC.**
Ground Floor, 285 Whitehorse Road, Balwyn, 3103
P.O. Box 349, Balwyn, 3103.
Tel: (03) 836 7177, Tlx: AA 38264, Fax: (03) 836 1964.
Please contact us for any further information.

The RCL-3 Remote Cable Leveler is an advanced microprocessor-based depth control device which is externally mounted onto a seismic streamer cable. When used in conjunction with the CUS-8301 shipboard command console, reliable digitally multiplexed ship-to-sensor communications is established.

The RCL-3 provides several operational enhancements over previous cable leveler designs. The microprocessor-based digital feedback system can be optimized for a wide range of sea-state conditions. Depth is measured to an accuracy of 1 foot over an operating range of 0 to 200 feet and is telemetered back to the ship just as it is for a Remote Compass Unit. Cable depth information is thereby available for recording onto the header and can serve as an excellent check against other depth measuring systems. The depth measuring circuitry is autozeroing and requires no field calibration. The diving plane angle of the leveler is also telemetered to the ship. Valuable cable balance information can be obtained from this data as the wing angle directly represents the lift and depressive forces acting on the cable. An improved aerodynamic wing design provides excellent lift characteristics with reduced cable noise.

The RCL-3 also keeps the important features of previous cable leveler designs. The unique collar mounting technique increases operational efficiency by allowing fast installation and removal of the leveler on any size streamer. A diving plane guard minimizes the risk of entanglement with underwater obstructions. The stainless steel housing protects the leveler from damage in the harsh marine environment. The ability to dive the streamer in the event of a pending collision with other boats and the ability to surface in the event of an abrupt decrease in water depth have been kept fast and simple by the use of single keystroke commands.

Leveler Specifications

Depth Sensor	
Type	Strain gauge
Operating Range	0-200 feet of seawater
Accuracy	1 foot
Plug in Battery Pack	
Type	Rechargeable Nickle-Cadmium
Life	Typically 4-6 weeks
Charger Type	Syntron P/N BC-803
Streamer	
Communications	
Type	Frequency Shift Keyed
Frequency	27 kilohertz
Coding	Phase encoded
Mechanical	
Body Length	34 inches
Body Diameter	2.5 inches
Wing Span	18 inches
Diving Plane	
Type	Symmetrical (uncambered)
Specification	NACA 0010
Aspect Ratio	2.25
Lift	40 pounds at 5 MPH

Leveler Operation

The operating depth of the Remote Cable Leveler is controlled by a microprocessor based digital feedback system. The operator commands the Remote Cable Levelers individually or collectively to the desired depth from the CUS-8301 System Controller. A digitally encoded command signal is transmitted to each leveler and a response verifying reception of the correct target depth is expected. In the event the response is not received the system will continue to retry and flag the improper response to the

operator until all units have correctly responded. Thereafter, the depth of the leveler is periodically measured by a strain gauge depth sensor and adjustments to its diving planes are made by a closed loop servo system to achieve the desired depth. In the event a surface command is given, all units are commanded to full climb wing position. For a dive command all units are commanded to full dive wing position until a programmable, preset depth is reached.



3000 Hayes Road
Houston, Texas 77082
713 531-1100
Domestic TLX: 774132
International TLX: 4620400

518034

5 cm

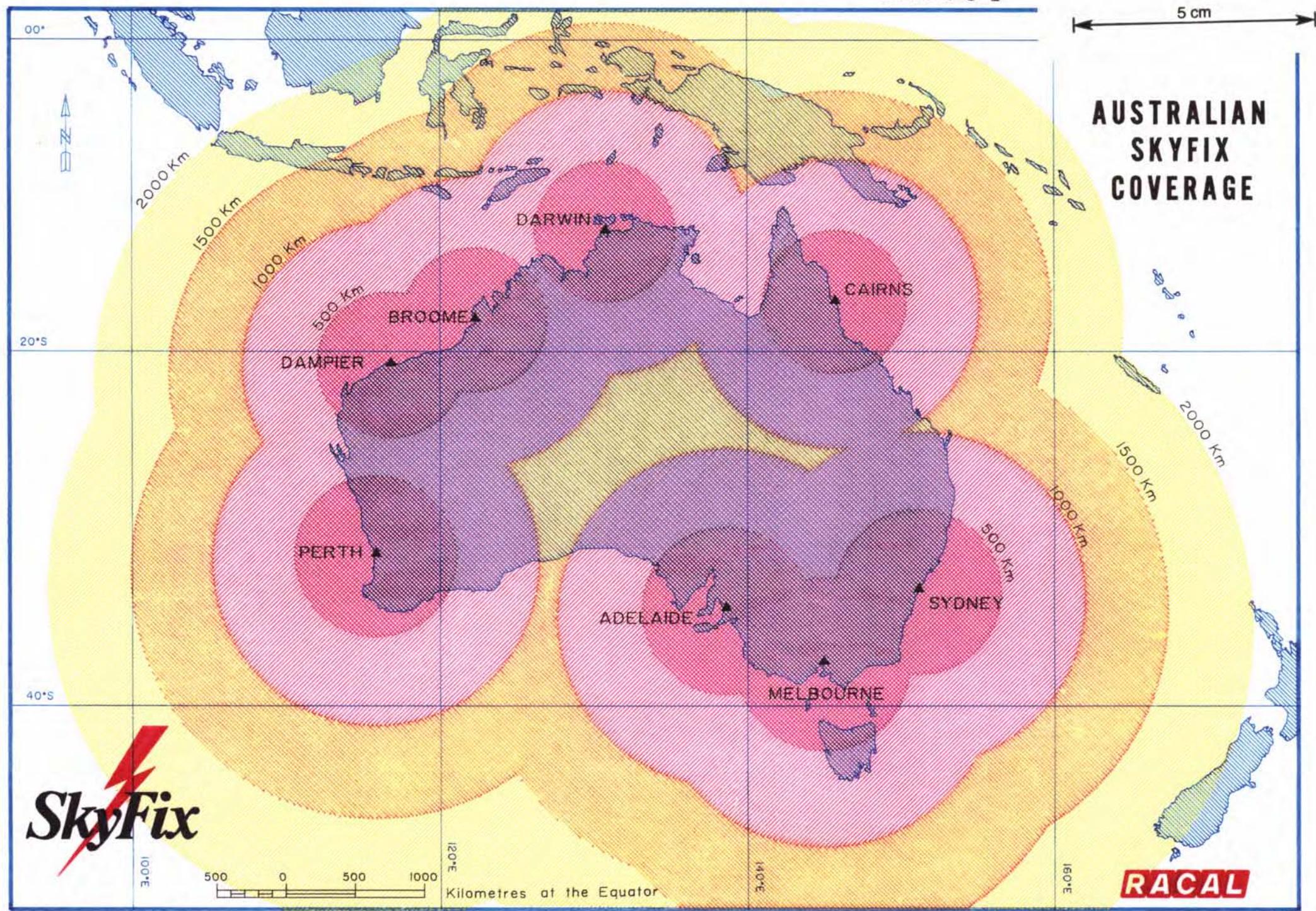
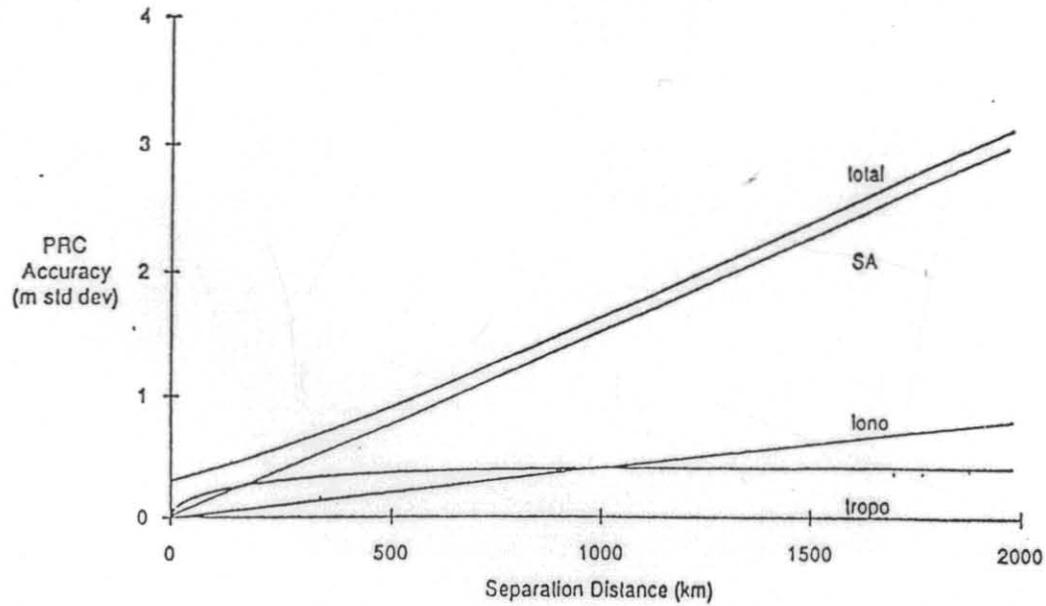


FIGURE 3.

GPS

518035

Degradation of PRC Accuracy with Distance

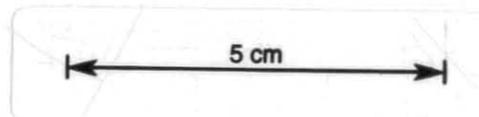


Navigation accuracy figures from graph:

Range	0km	500km	1000km	1500km	2000km
PRC Accuracy	0.3	1	1.5	2.5	3.25
NAV Accuracy 1 sigma HDOP=1.5	0.5	1.5	2.25	3.75	5

FIGURE 4.

RACAL



GPS

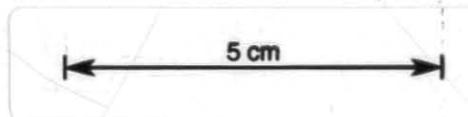
518036

DGPS ERROR BUDGET WITH DISTANCE

(Brown, Journal of 10N, Autumn 1990)

Source/Range	0 KM	200 KM	900 KM	1800 KM	3600 KM	Extended DGPS 3600KM
Clock	0	0	0	0	0	0
Ephemeris	0	0.1	0.5	1	2	1
S.A	0	0	0	0	0	0.3
Ionosphere	0	2	5	6	8	2
Troposphere	0	2	2	2	2	0.3
Receiver Noise	1	1	1	1	1	1
UERE	1	3	5	7	8.5	2.5
NAV Accuracy 1 Sigma HDOP=1.5	1.5	4.5	7.5	10.5	12.75	4

FIGURE 5.



RACAL

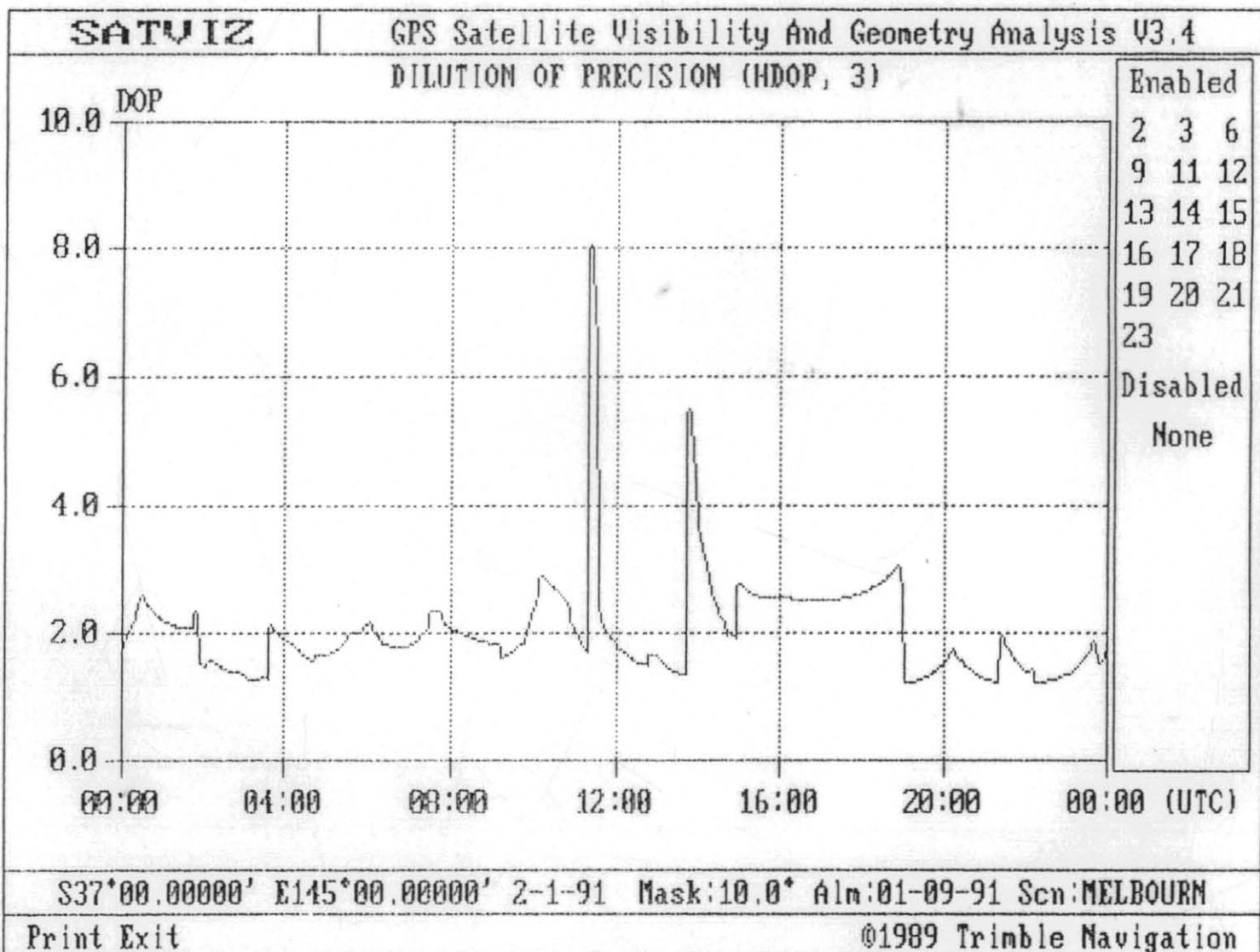
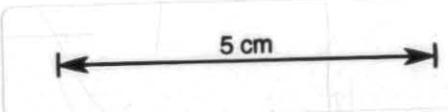


FIGURE 6.

AUSTRALIAN GEOLOGICAL SURVEY
ORGANISATION

HEALTH
SAFETY
&
ENVIRONMENT
MANUAL

FOR

MARINE OPERATIONS

ON

R/V RIG SEISMIC

4. SHIP'S SAFETY SYSTEM

4.1. OBJECTIVES OF SAFETY SYSTEM

The ship's safety system is designed to create, maintain and enhance safety awareness in all the operations carried out on board RIG SEISMIC. This can best be done by creating a system that handles its demands in the same way that quality control and costing are monitored.

In order to manage hazards and assess risk to personnel, it is essential to establish order, method and consistency in carrying out any operation. It is for this reason that procedures are adopted. The elements are:

- (a) The number of personnel involved, the person in charge, and the safety equipment that should be worn to adequately protect people while on the job.
- (b) Necessary inter-action with other departments, e.g. Bridge, Instrument Room.
- (c) The task of each member within the team.
- (d) The sequence of events to be followed.
- (e) Assessing hazards and adopting measures to reduce the risk.

The ship's Organisation Chart is given in the HSE Manual Part 2 (Attachments).

4.2. SAFETY TRAINING POLICY

This section applies to safety training that is carried out both onshore and offshore. Generally, ALL personnel will have attended courses approved by the Australian regulating authorities for offshore survival and fire fighting, according to their level of work offshore.

Before starting work on the ship, all personnel will have received sufficient training to carry out their jobs in a safe and efficient manner.

As set out in the E & P Forum Schedules and E & P Forum/IAGC Training Guidelines:

- (a) The Ship Manager and section heads will have attended an industry based management course, or an equivalent acceptable course
- (b) If helicopter crew changes are envisaged, at least one person will be on board at all times who has received specialist training in the handling of helicopters, and has an HLO Certificate of Competence.
- (c) At least one crew member will be on board at all times who has attended an advanced First Aid course, and has the appropriate Certificate of Competence.
- (d) At least 4 members of the crew will have attended a recognised fire-fighting course.

4.3. SAFETY ORIENTATION ON JOINING THE SHIP

A full safety induction will be given to all personnel joining RIG SEISMIC for the first time, or rejoining after a significant break, or after a major refit. This induction will be to a formal designed plan to ensure that all relevant safety matters are covered. A log of all inductions will be maintained on board the ship, and a summary included in the safety report to Canberra.

New crew members joining will be taken on a conducted tour of the vessel; the survey side will be carried out by a senior member of the AGSO crew and the maritime side by a senior member of the AMSA crew. The person(s) conducting the tour will have a detailed checklist. See the HSE Manual Part 2 (Attachments) for the essential elements. This is required to be signed in the appropriate section on completion of the tour by the person being inducted.

The tour should be conducted within 24 hours of joining the vessel or as soon thereafter as is practicable, preferably before sailing. People will also be issued with a "Welcome on Board" booklet which they are required to read. New staff will be required to watch selected training videos to introduce them to other safety aspects.

In every cabin there is a copy of the AMSA "Survival at Sea" training and instruction manual. This must be read after joining the ship as it contains important safety information.

A copy of the AGSO Health Safety & Environment manual can be found in all public places; on the Bridge, in the Engine Room, the AGSO Office, Instrument Room and Gun Shack.

4.4. SAFETY OFFICER

The Safety Officer shall be appointed by AGSO to provide a focus for all safety activities on board the ship. He will liaise with and report to Marine Operations Group in Canberra on safety matters of concern to the crew on RIG SEISMIC.

Responsibilities will include chairing the safety committee, convening safety meetings, and keeping up-to-date documentation on current safety practices. His role will be compatible with the procedures laid down in the Occupational Health and Safety (Commonwealth Employment) Act 1991 - see HSE Manual Part 2 (Attachments).

The duties of the Safety Officer include ensuring that committee and staff meetings are held at regular intervals, and that these are reported on to Head Office. He will attend to day-to-day problems as they arise in concert with heads of departments and individuals as appropriate. Current certificates for lifting equipment, tigger winches and high pressure equipment are to be maintained with copies provided to Canberra.

The Safety Officer shall keep a file, the basic content of which should consist of:

- (a) Safety Committee Meeting minutes
- (b) General Safety Meeting minutes
- (c) Accident/Incident/Hazard/Near Miss Reports
- (d) Cruise Safety Summaries
- (e) Feedback from Marine Operations Group on safety matters
- (f) Audits and Inspections
- (g) Test Certificates

4.5. SAFETY COMMITTEE

Safety Committee Meetings play a most important part in establishing co-operation and coordination between departments, as well as providing a ready forum for exchange of views. The objective of the committee is to provide a mechanism for rapidly tackling the day-to-day needs of the crew, as well as to advise AGSO management of weightier safety issues.

- (a) The appointed members of the Committee will consist of the AGSO Safety Officer and one representative each from within the engineering and science areas of the AGSO technical crew, plus an equivalent membership from both the deck and engineering departments of the AMSA maritime crew.
- (b) In addition the AGSO and AMSA crew may choose two people each to provide input to health and safety deliberations and to represent their interests to best advantage. Amongst these people will be included the Designated Work Group representatives chosen by the crew under Commonwealth OH&S guidelines.
- (c) The Master of the vessel will be an ex-officio member of the Safety Committee. Meetings should also be attended by the client representative where appropriate.
- (d) Safety Committee meetings are to be held at approximately weekly intervals at times that members can conveniently meet. It is expected that the Committee will operate on a consensus basis.
- (e) Content should include; a review of the previous crew's handover notes and safety meeting minutes; assessment of any foreseen hazards and measures that could be taken to eliminate, reduce or control such risks; any requirements for future safety training; the effectiveness of safety drills; and consideration of feedback from Head Office.
- (f) An agenda for the General Safety Meeting should be established at which Committee findings are to be presented to the combined AGSO and AMSA crew.
- (g) All action items shall be numbered for easy reference.
- (h) Meetings will be chaired by the Safety Officer and minutes recorded. The names of those attending shall be noted in the minutes.

4.6. GENERAL SAFETY MEETINGS

Minor safety issues should not await a general safety meeting, but should be tackled either directly by the individual or group, by bringing it to the attention of any of the members of the Safety Committee, or having it raised at a Committee meeting.

- (a) All AGSO staff shall attend a pre-cruise safety induction meeting on board the ship.
- (b) Both AGSO and AMSA personnel shall attend at least one safety meeting during a cruise in addition to the pre-cruise safety induction meeting.
- (c) All members of the combined crews shall attend a final cruise de-briefing meeting.
- (d) An "ad hoc" safety meeting will be held after any serious safety incident on board ship, or on other occasions when warranted. This should take place whether or not any injury or loss has occurred. The meeting should discuss the incident with a view to preventing a further recurrence, or reducing the risk of a similar situation occurring.
- (e) All meetings will be convened by the Safety Officer and the minutes recorded by an assistant. The names of crew members attending shall be recorded in the minutes.

4.7. REPORTING OF ACCIDENTS ETC

It is the policy of AGSO that all incidents within its management will be reported openly and without detriment to the individuals or sub-contractor companies involved. The object must always be to prevent recurrence.

The following incidents must be reported to Head Office:

- (a) Any fatality must be reported immediately.
- (b) All other injuries other than minor first aid cases within 24 hours.
- (c) Minor injuries or incidents resulting in damage to property or equipment within 7 days.
- (d) Any incident to be reported under statutory or local regulations within 7 days.
- (e) Near miss/dangerous occurrence that could have resulted in serious injury to persons or significant damage to property within 7 days.
- (f) Any environmental incidents within 7 days.

In Australia there is a legal obligation to report certain incidents. Any such statutory reporting is in addition to AGSO's incident reporting requirements.

Reporting of more serious incidents (these include loss of life, fracture of major bones/skull, amputation, loss of sight, acute illness) must be made by the Safety Officer or a responsible person by the quickest practicable means to the appropriate authorities and to Head Office.

An example of the Accident/Incident report form and reporting procedure can be found amongst the Attachments.

4.8. SAFETY REPORTING AND CRUISE SUMMARIES

Copies of the minutes of committee and general meetings are to be forwarded to the Safety Coordinator in the Marine Operations Group in Canberra by FAX at the earliest opportunity, generally within 48 hours. Acknowledgement with proposed follow up will be returned within one week of receipt.

All original Accident/Incident forms for AGSO staff and copies of the appropriate page of the equivalent forms for AMSA staff are to be forwarded to Canberra at the end of a cruise.

Summaries of all safety related activities are to be sent to Canberra at the end of every cruise or trials period. A list of the items to be included in the summary is given in the Attachments.

Copies of relevant papers are to be provided to AMSA through the Master of the ship.