

G.I GUN®

The Air gun that controls its own bubble



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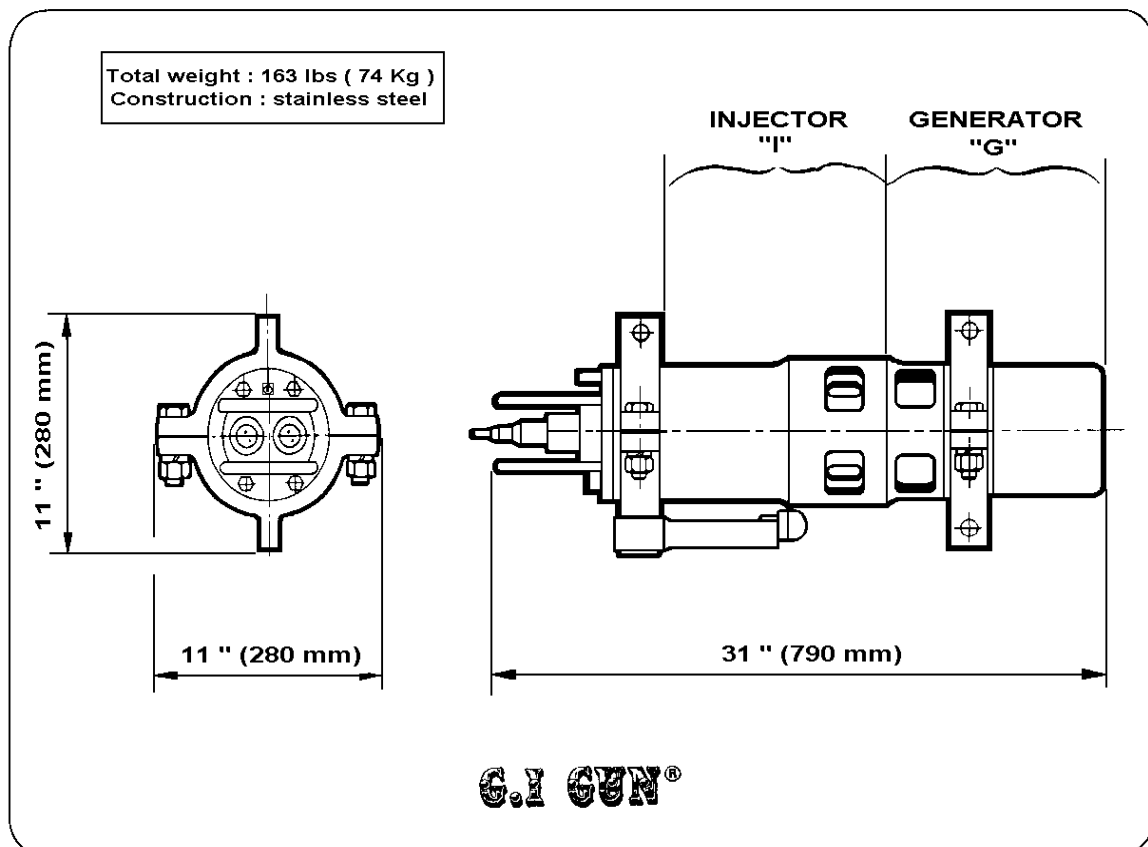
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INTRODUCING SSI GI GUN

The GI GUN is a pneumatic seismic source, which is constituted of 2 independent Air Guns within the same casing.

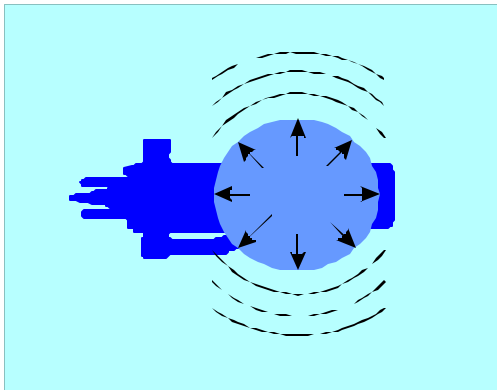
The first Air Gun is called the GENERATOR, as it generates the primary pulse. The second one is called the INJECTOR, as it injects air inside the bubble produced by the GENERATOR. It is used to control and to reduce the oscillation of the bubble created by the GENERATOR.



Each gun has its own reservoir, its own shuttle, its own set of exhaust ports, and its own solenoid valve. A common hydrophone provides both the Time Break and the shape of the Near Field signal. This gun phone is located inside the bubble and therefore it responds to the actual air blast of the GI GUN to which it is affixed, without being affected by the neighbor guns.

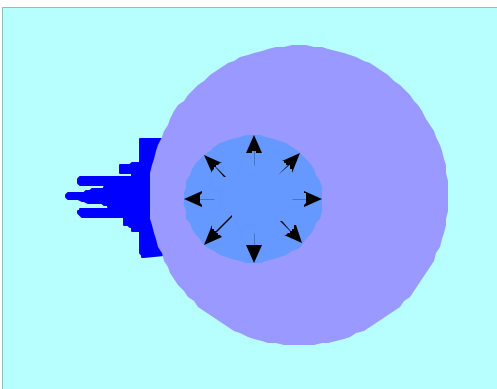


HOW IT WORKS



Phase 1:

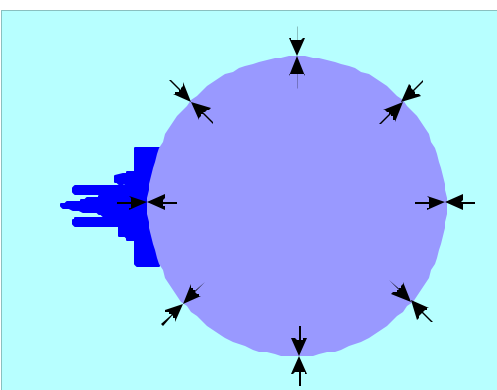
The GENERATOR is fired. The blast of compressed air produces the primary pulse and the bubble starts to expand.



Phase 2:

When the bubble approaches its maximum size, it encompasses the INJECTOR ports, and its internal pressure is far below the outside hydrostatic pressure.

At this time, the INJECTOR "I" is fired, injecting air directly inside the bubble. Due to the quasi-static state of the bubble, the timing of the INJECTOR is not critical.



Phase 3:

The volume of air released by the INJECTOR increases the internal pressure of the bubble, and prevents its violent collapse.

The oscillations of the bubble and the resulting secondary pressure pulses are reduced and re-shaped.

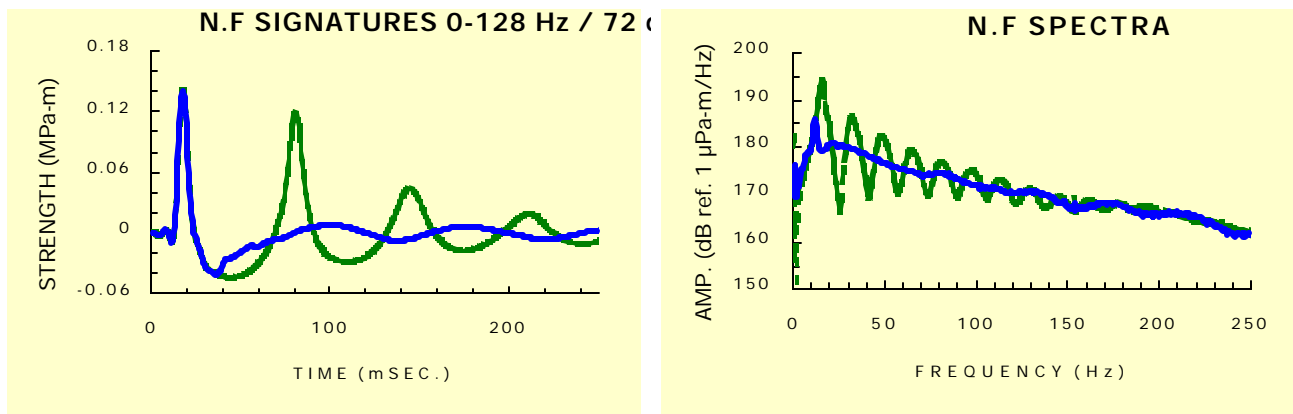


The signature of a single GI GUN can be shaped virtually at will by adjusting:

- The volume of the GENERATOR from 25 to 250 cu.in. This is achieved by means of plastic volume reducer for volumes ranging from 25 to 105 cu.in., and by changing the reservoir for volumes 150 and 250 cu.in.
- The volume of the INJECTOR from 25 to 105 cu.in. This is achieved by means of plastic volume reducer.
- The time when the injection starts. This adjustment is conveniently done at the instrument room.
- The duration of the injection by means of exhaust ports reducers.

The figure below, shows how the Near Field signature and spectrum of the GENERATOR alone (dashed green line) is re-shaped by an optimally tuned injection (solid blue line).

This type of setting is called "TRUE GI MODE" and results in an almost total bubble suppression of the bubble oscillation.



NEAR FIELD SIGNATURES AND SPECTRA COMPARISON
(Dashed green line: GENERATOR alone - Solid blue line: TRUE GI MODE)



Next page illustrates the Far Field signatures generated by two different GI GUN configurations using the same volume of air (150 cu.in.) and compare them to the signature of an Air Gun of the same volume.

Top (a) : Typical signature of an Air Gun with volume of 150 cu.in.
The Peak-to-peak output is maximum, but the Primary-to-bubble ratio is poor.

Middle (b) : Signature generated by a single GI GUN where the GENERATOR and the INJECTOR have the same volume (75 cu.in.) and the firing of the INJECTOR has been delayed from the firing of the GENERATOR by approximately half the period of the GENERATOR fired alone. This configuration is called: "HARMONIC MODE". Compared to the Air Gun, the Peak-to-peak output has been reduced by 24%, but the Primary-to bubble ratio has been multiplied by 4.

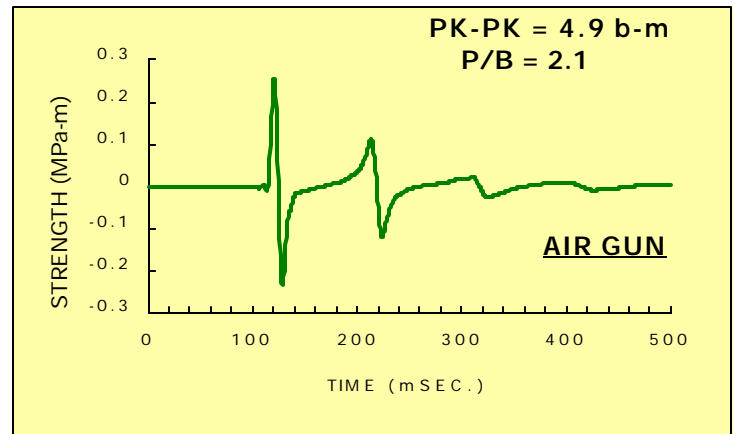
Bottom (c) : Signature generated by a single GI GUN used in the "TRUE GI MODE". The GENERATOR has a volume of 45 cu.in. and the INJECTOR has a volume of 105 cu.in. Here too, the firing of the INJECTOR has been delayed by about half the period of the GENERATOR fired alone.
Compared to the Air Gun, the Peak-to-peak output has been reduced by 40%, but the Primary-to-bubble ratio has been multiplied by nearly 7, thus reaching almost 14 with one single gun.



FAR FIELD SIGNATURES COMPARISON with same total volume (150 cu.in.)

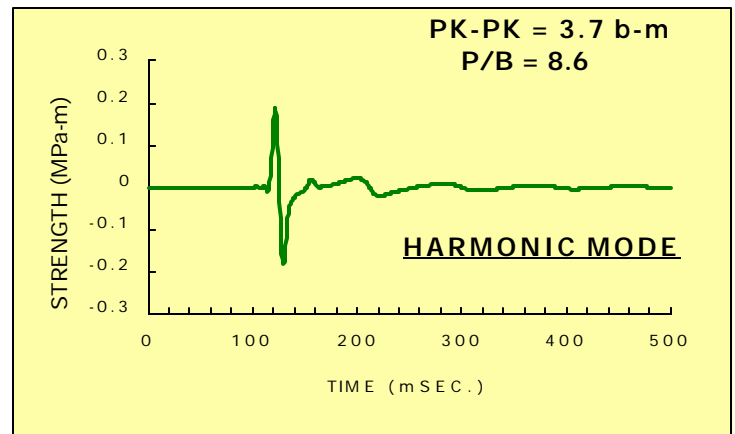
PRESSURE = 2,000 PSI - DEPTH = 6.0 METERS
FILTERED DFS 0-128 Hz 72 dB/o

a) AIR GUN: Volume = 150 cu.in.



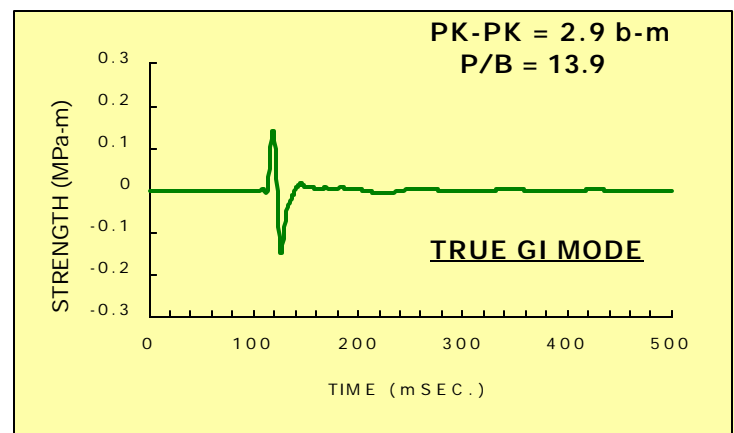
b) GI GUN "HARMONIC MODE":

- G = 75 cu.in.
- I = 75 cu.in. - Delayed



c) GI GUN "TRUE GI MODE" :

- G = 45 cu.in.
- I = 105 cu.in. - Delayed



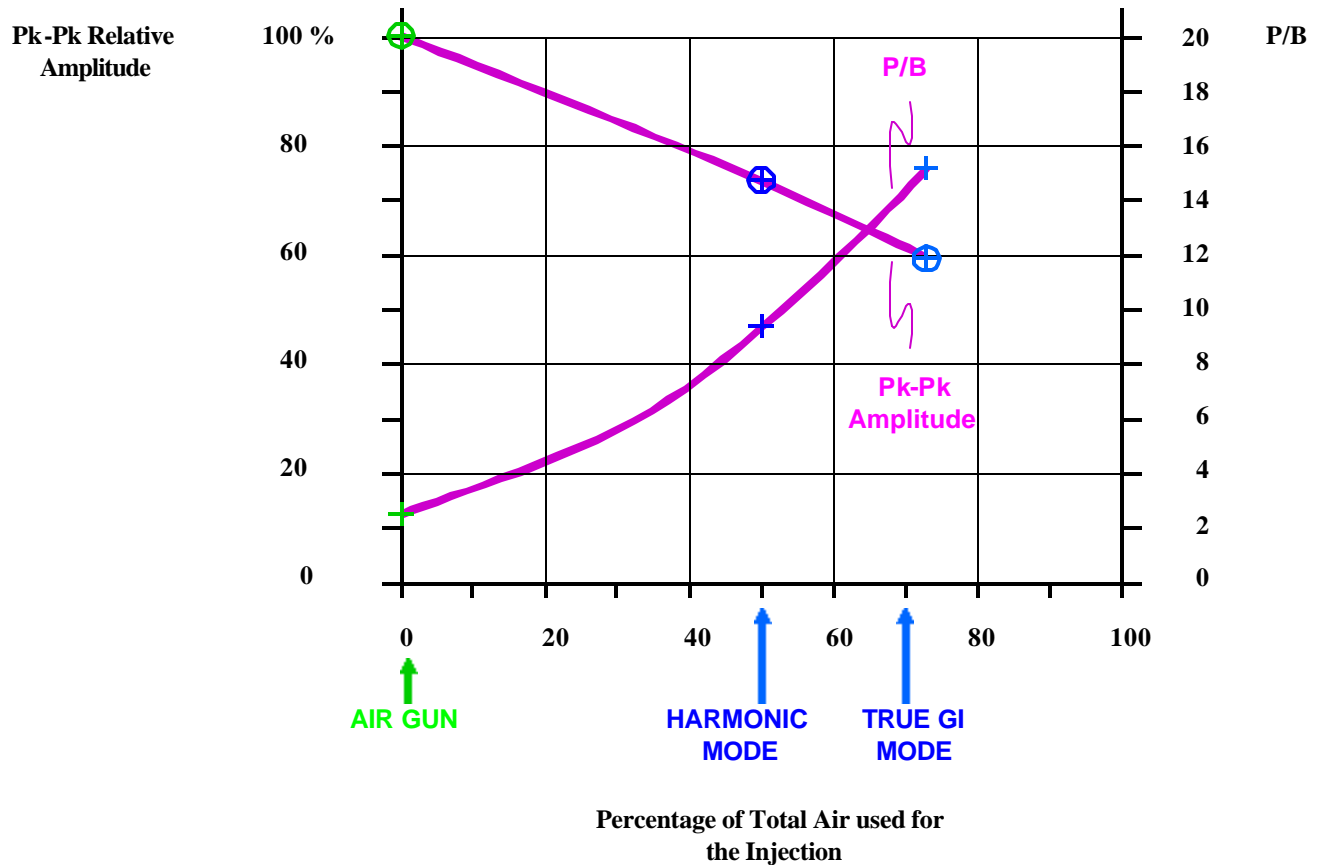


The following figure, demonstrates the variations of both the Peak-to-peak output and the Primary-to-bubble ratio when the percentage of the total volume used for the injection increases: the total volume being constant (150 cu.in).

The Peak-to-peak amplitude is plotted as a percentage of its maximum value; when all the air is used in the GENERATOR, and no injection is made (Air Gun).

The results given in the previous pages are plotted on the curve.

Again, those results have been obtained using a single GI GUN, and they demonstrate the



VARIATIONS OF PEAK TO PEAK RELATIVE AMPLITUDE AND P/B RATIO VERSUS THE PERCENTAGE OF TOTAL VOLUME USED FOR THE INJECTION

great flexibility (versatility) of the GI GUN which allows the user to select the characteristics of the signature without having to change source



The figure on the previous page teaches us about the efficiency of the process of bubble reduction in terms of Peak-to-peak output or, in other words, about the price we have to pay to reach an acceptable Primary-to-bubble ratio. It seems that by using internal injection to reduce the bubble, we have paid a price in terms of Peak-to-peak reduction:- 24%, in the case of the HARMONIC MODE for instance, to multiply the Primary-to-bubble ratio by 4.

Another way to increase the Primary-to-bubble ratio is to cluster two Air Gun for instance. In this case, it is well known that in order to multiply the Primary-to-bubble ratio by 2.5, the Peak-to-peak output is reduced by 15 to 20 percent. But to reach this result, at least two (2) guns must be used, so that the process is less efficient in terms of number of guns.



THE HARMONIC MODE

As seen, when the INJECTOR has about the same volume as the GENERATOR, the oscillation of the bubble created by the GENERATOR:

- is re-shaped into a smooth quasi harmonic oscillation,
- its amplitude is reduced so that the primary-to-bubble is increased between 7 and 10 or more.

The page on the right shows three different HARMONIC MODE Far Field signatures from a single GI GUN using three different volumes; 90 cu.in., 150 cu.in. and 210 cu.in.

Two remarks can be made:

First,

The signature of a single GI GUN in HARMONIC MODE is similar to the signature generated by a 2 Air Gun cluster, so that 2 independent and identical GI GUN compare favorably with a 2 Air Gun cluster of the same total volume.

For instance, a 2 Air Gun cluster with total volume of 300 cu.in. ($2 * 150$ cu.in.) gives an output Peak-to-peak (DFS 0-128 Hz) = 6.9 bar-meter and a primary-to-bubble ratio of 7.7. While 2 independent GI GUN in HARMONIC MODE, 150 cu.in. each, give an output Peak-to-peak (DFS 0-128 Hz) = 7.4 bar-meter and a Primary-to-bubble ratio of 8.6.

But, unlike the Air Gun cluster, the signature produced by the two GI GUN is not sensitive to their separation or their actual firing depths, so that in operation, the signature stability is far better.

Second,

The smooth HARMONIC oscillation allow to build a sub-array made of just two GI GUN having different volumes, so that the primaries add up, while the final oscillation is further reduced by destructive interference and therefore, the Primary-to-bubble ratio can reach a value of 14 with only two guns. This can be seen when adding the signature of one GI GUN 90 cu.in. (top) with the signature of one GI GUN 210 cu.in. (bottom). This leads to a 2 GI GUN 300 cu.in. sub-array that will be described next, and that could be the building block for larger, more powerful arrays.

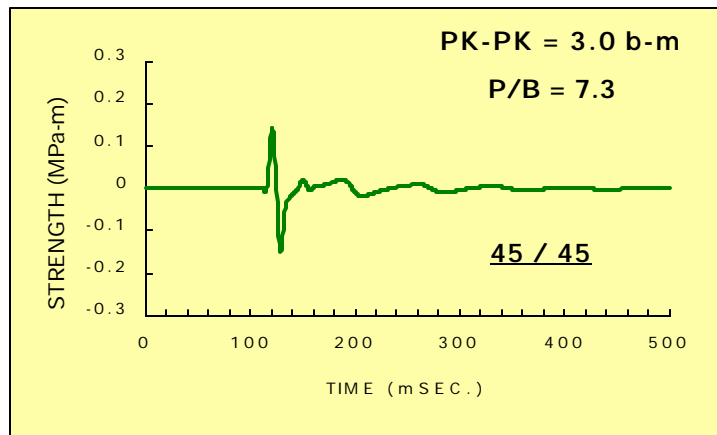


GI GUN HARMONIC MODE - 3 BASIC VOLUMES

PRESSURE = 2,000 PSI - DEPTH = 6.0 METERS
FILTERED DFS 0-128 Hz 72 dB/o

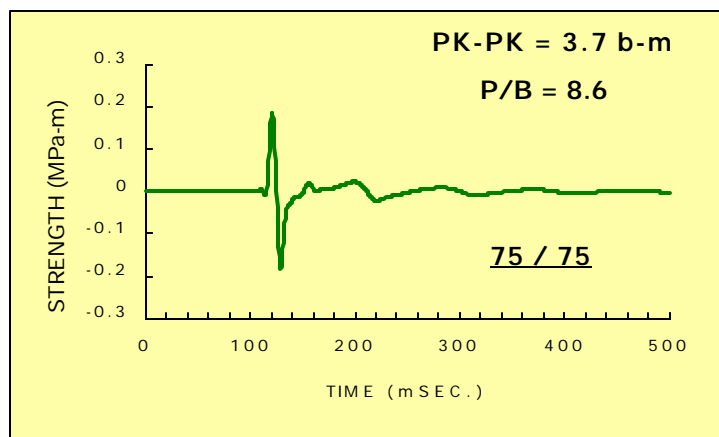
GI GUN 90 cu.in.

G = 45 cu.in.
I = 45 cu.in.
DELAYED



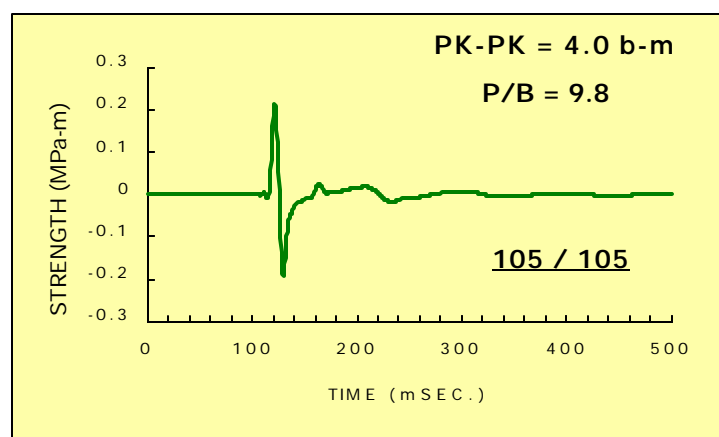
GI GUN 150 cu.in.

G = 75 cu.in.
I = 75 cu.in.
DELAYED



GI GUN 210 cu.in.

G = 105 cu.in.
I = 105 cu.in.
DELAYED

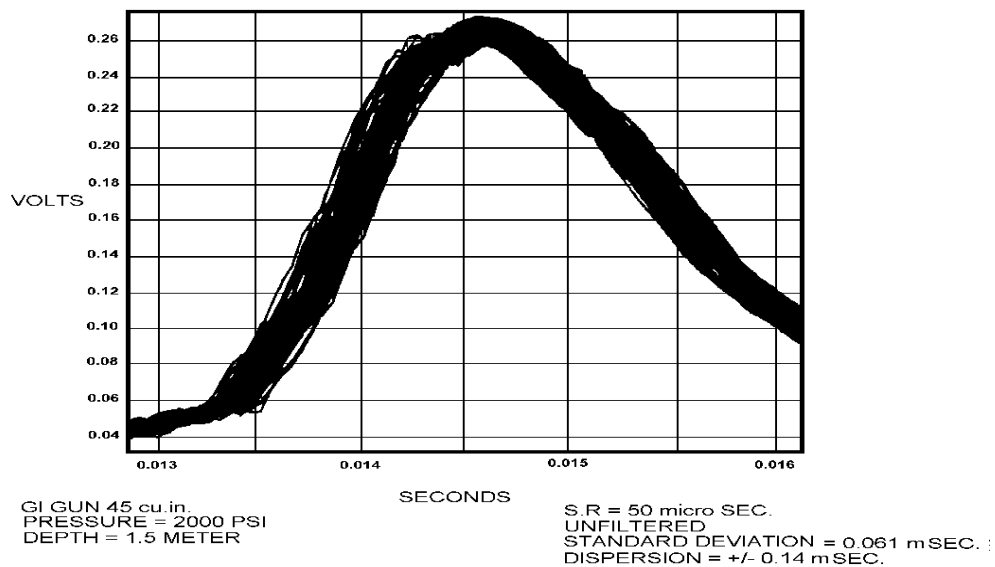




REPEATABILITY

As an example the figure below shows the recording of 100 primary pressure pulses emitted by the GENERATOR of the GI GUN with volume of 45 cu.in., and recorded through a Near Field hydrophone located one (1) meter below the gun.

The dispersion of ± 0.14 mSEC. has been confirmed in operation involving a large number of guns.



REPEATABILITY ON GENERATOR 45 cu.in. OF GI GUN - 100 SHOTS

SIGNATURE QC

A time break hydrophone mounted on the gun, and located inside the bubble (as soon as the GENERATOR has been fired), allows the display of the signature of the GI GUN, on which the hydrophone is mounted, without being influenced by the neighbor gun.

The page on the right, compares the signals given by a Near Field hydrophone (left) with the signals given by the Time Break hydrophone (TB) located inside the bubble (right), and this for three different delays between the GENERATOR and the INJECTOR.

As can be seen, the shapes of the signals given by both hydrophones are similar and the optimized tuning of the gun can be achieved using the Time Break signal, which can be used also for the QC of the signature emitted by each individual gun at every shot.

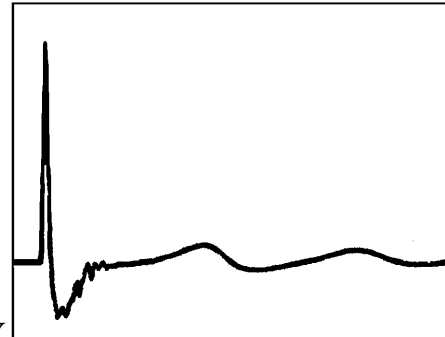
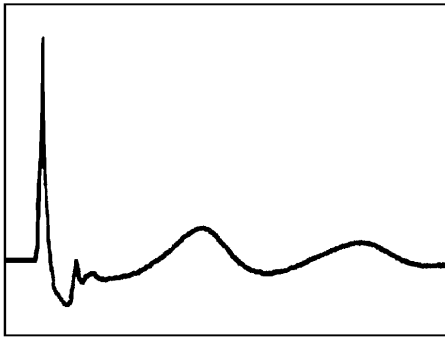


NEAR FIELD HYDROPHONE and TIME BREAK SIGNATURES COMPARISON

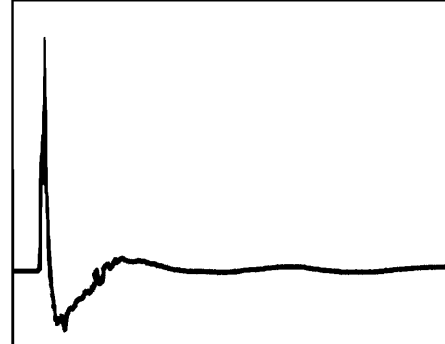
PRESSURE = 2,000 PSI - DEPTH = 6.0 METERS

NEAR FIELD HYDROPHONE

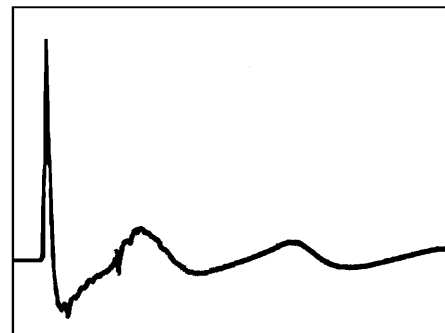
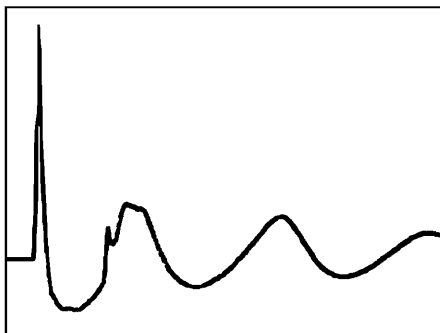
GI GUN TIME BREAK



SHORT DELAY
23 mSEC.



OPT. DELAY
33 mSEC.



LONG DELAY
43 mSEC.

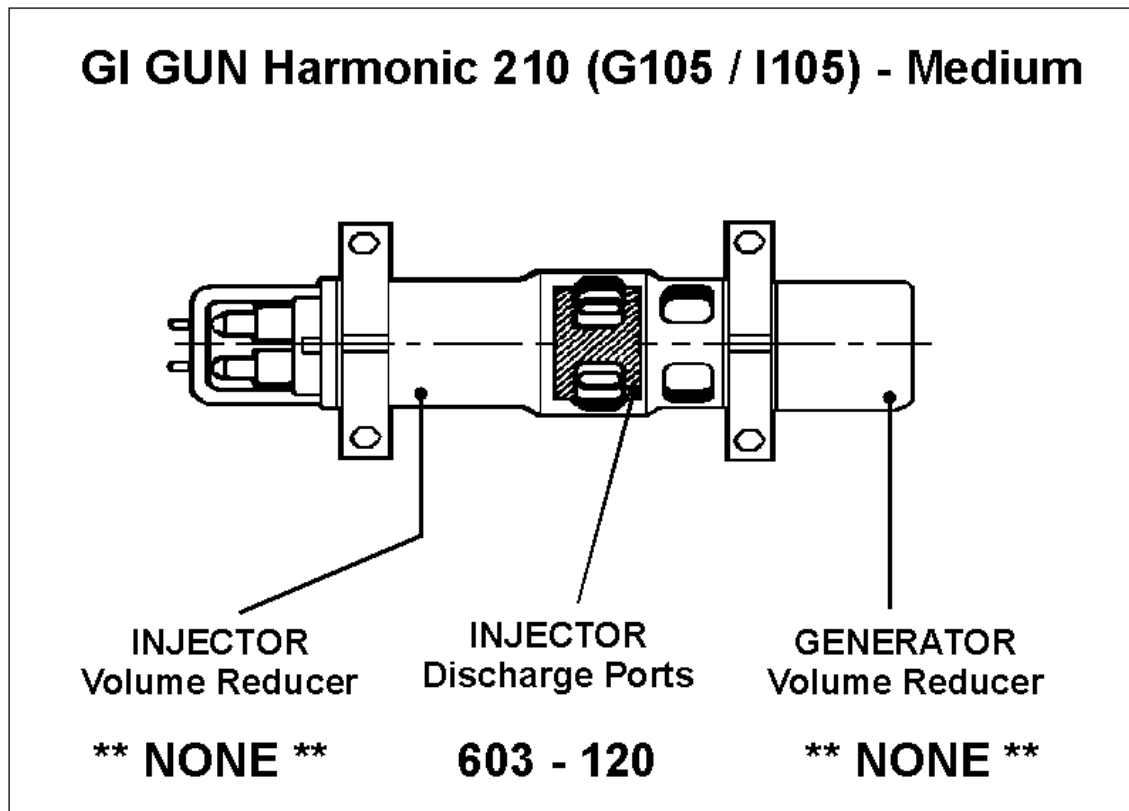


GI GUN COMPLETE EQUIPMENT

STANDARD DELIVERY

The GI GUN is supplied fully equipped for "HARMONIC MODE" operation, that is:

- GENERATOR volume: 105 cu.in.
- INJECTOR volume: 105 cu.in.
- INJECTOR Discharge Ports: MEDIUM



OPTIONAL EQUIPMENT

- Volume reducers for the GENERATOR and the INJECTOR.
- Discharge ports for the INJECTOR.
- GENERATOR Reservoirs: 45, 150 and 250 cu.in.



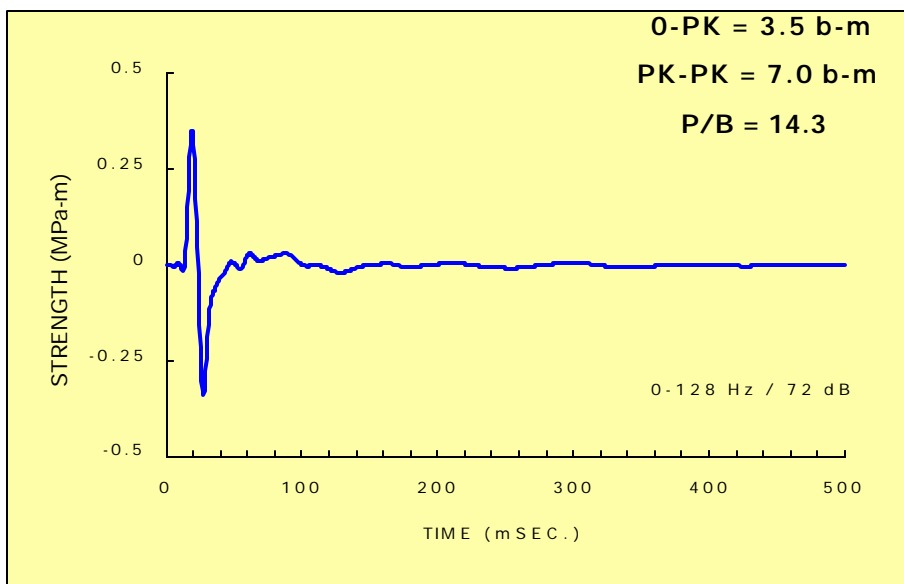
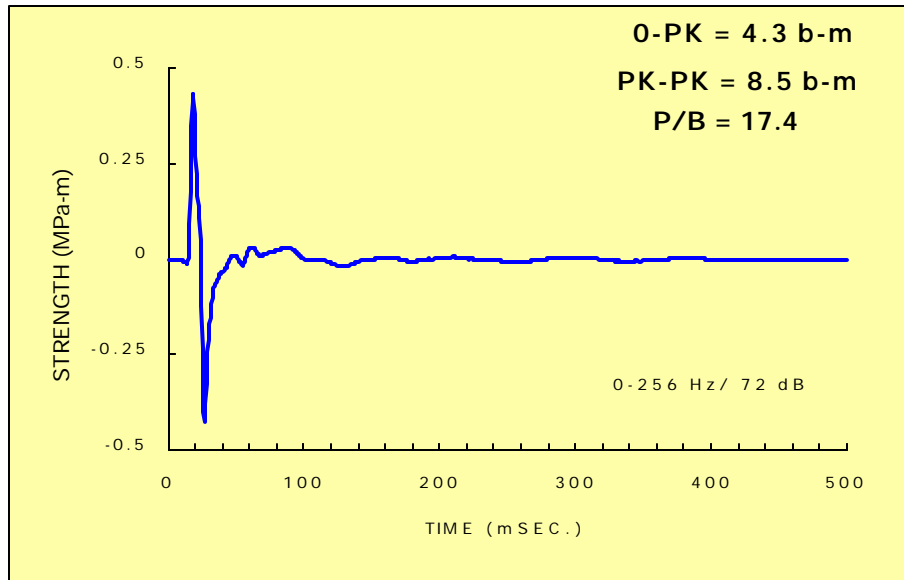
GI GUN[®]

for

DEEP PENETRATION

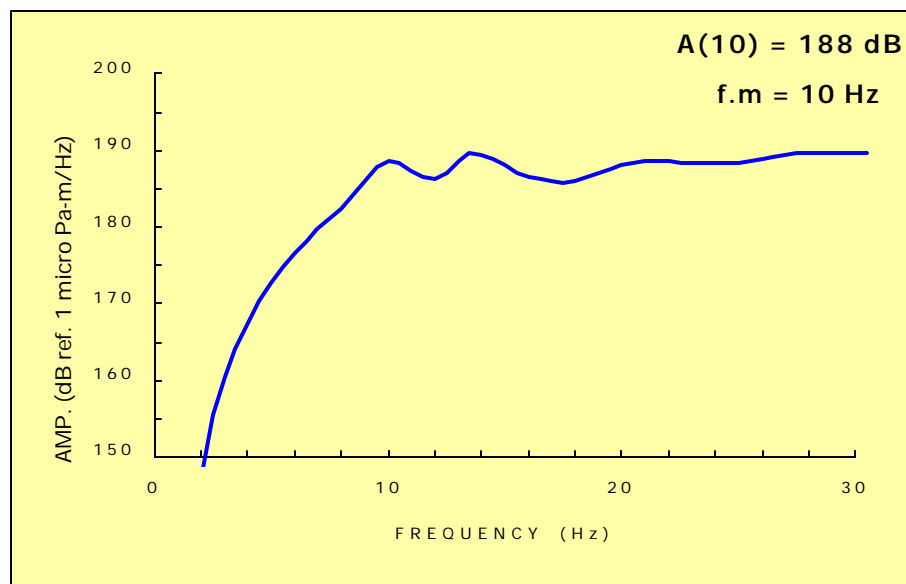
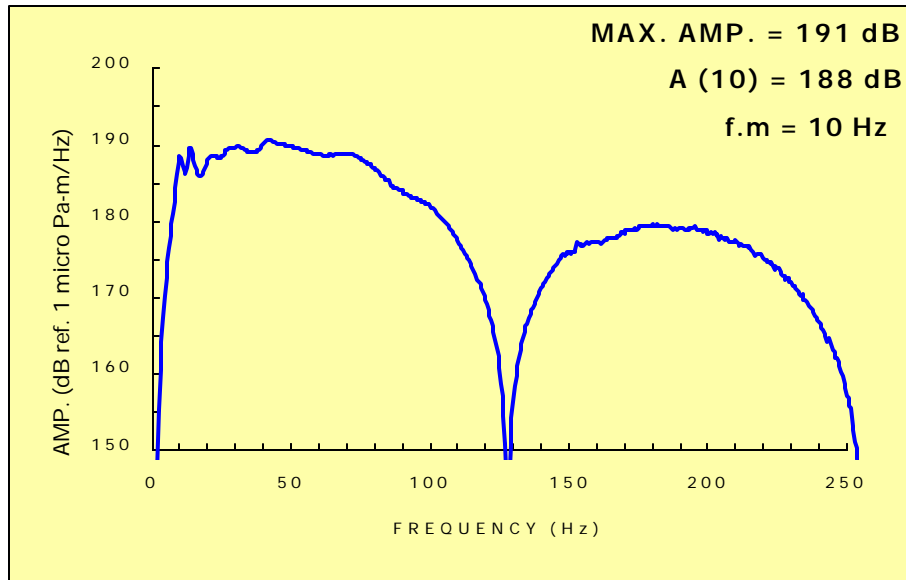
2 * GI GUN / 300 cu.in. SUB-ARRAY

- Far Field Signature 0-256 Hz 72 dB (DFS Filter)
- Far Field Signature 0-128 Hz 72 dB (DFS Filter)
- Far Field Spectrum over 0-250 Hz
- Far Field Spectrum over 0-30 Hz



FAR FIELD SIGNATURES

2 * GI GUN (G45 / I45) + (G105 / I105) / 300 cu.in. SUB-ARRAY
PRESSURE = 2,000 PSI
DEPTH = 6.0 METERS



FAR FIELD SPECTRA

2 * GI GUN (G45 / I45) + (G105 / I105) / 300 cu.in. SUB-ARRAY
PRESSURE = 2,000 PSI
DEPTH = 6.0 METERS





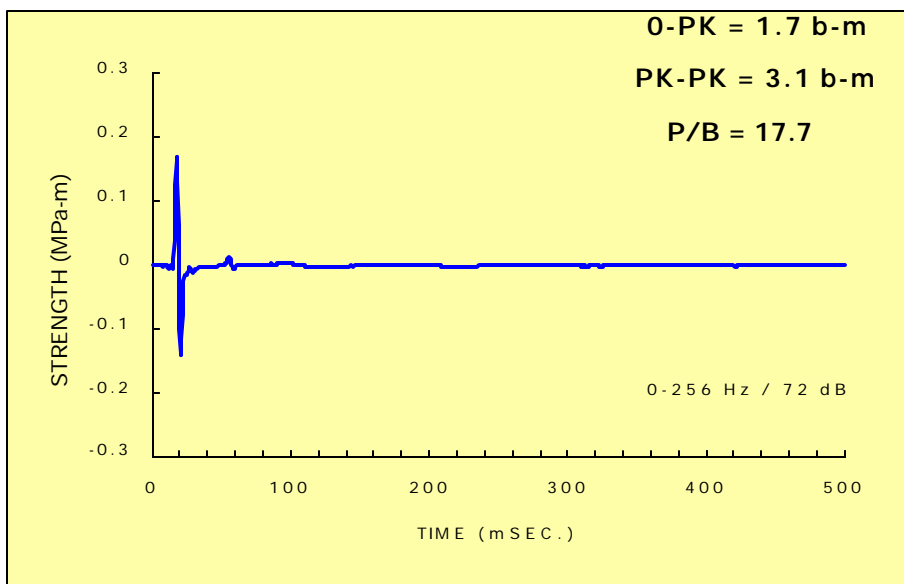
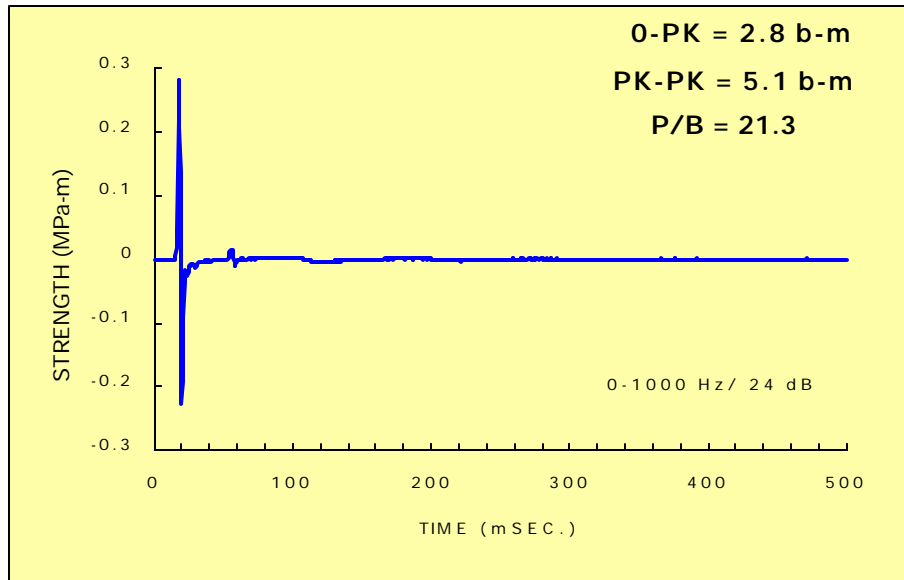
GI GUN[®]

for

HIGH RESOLUTION

1 * GI GUN 90 cu.in. (G45 / I45) High Frequency

- Far Field Signature 0-1000 Hz 24 dB
- Far Field Signature 0-256 Hz 72 dB (DFS Filter)
- Far Field Spectrum over 0-1000 Hz
- Far Field Spectrum over 0-500 Hz

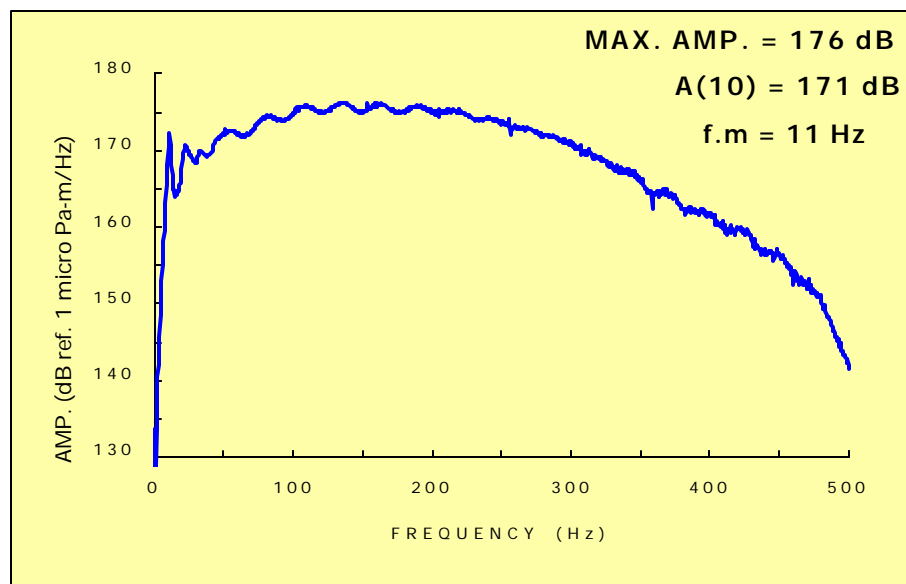
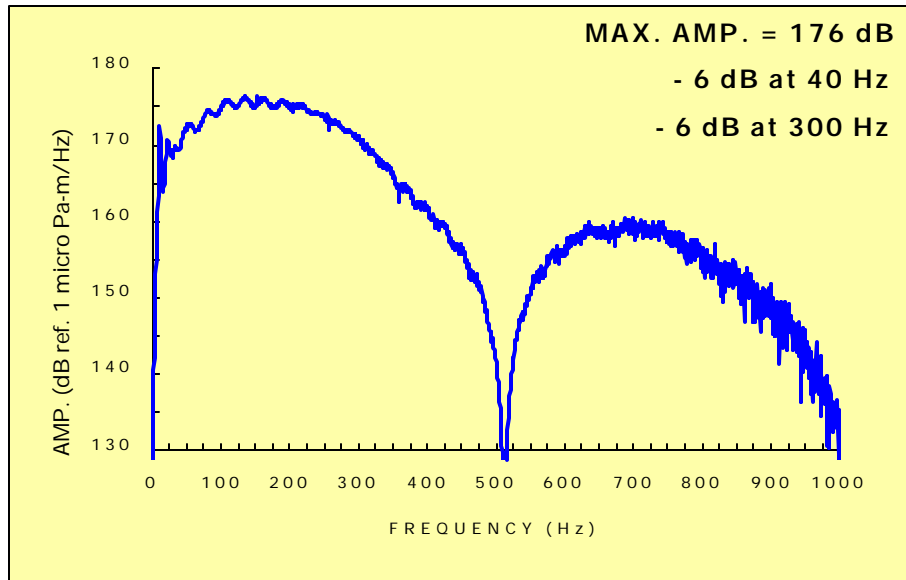


FAR FIELD SIGNATURES

1 * GI GUN 90 cu.in. High Frequency / (G45 / I45)

PRESSURE = 2,000 PSI

DEPTH = 1.5 METER



FAR FIELD SPECTRA

1 * GI GUN 90 cu.in. High Frequency / (G45 / I45)

PRESSURE = 2,000 PSI

DEPTH = 1.5 METER



TO THE READER

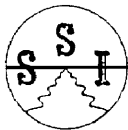
This booklet does not constitute an exhaustive directory for all possible applications of the GI GUN.

Its only purpose is to initiate a new way of thinking when it comes to the most judicious choice of a seismic source.

The typical examples shown in this handbook have been chosen for their obvious demonstrativeness.

The quasi-unlimited versatility of the GI GUN should help in overcoming many more problems.

We will be pleased to assist you for further details or particular demands.



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