Paris, November 2011

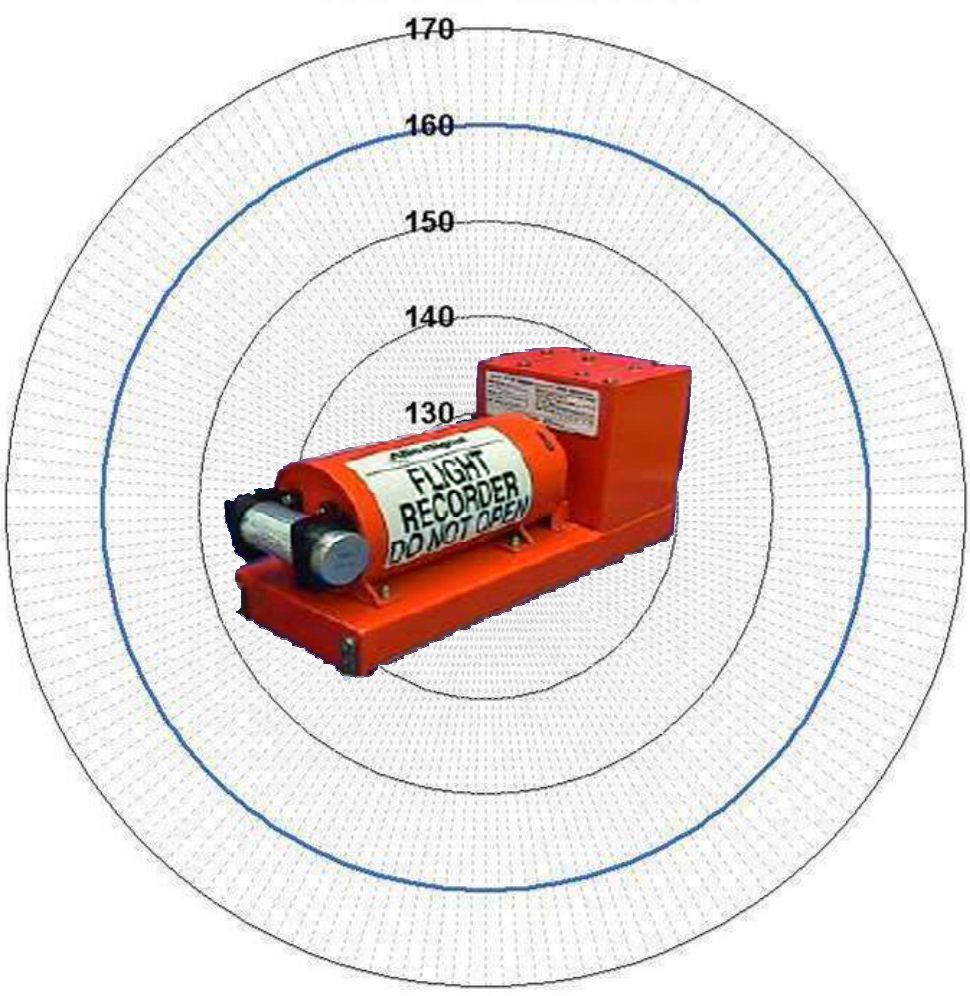
DGA

BEA

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

Measurement of acoustic beacon mounted on flight recorders

Document based on the DGA report N°2011-268 966/DGA TN/M3E/MSA Med/MA



Report on measurement of ULB-type emergency beacon

1 Introduction

In 2010, measurement of aircraft emergency beacons for the BEA was carried out by the General Directorate for Armament - Naval techniques (DGA Tn) and was the subject of a report (N° 2010 – 185 096/DGA TN/M3E/MSA Med/MA of 21/06/2010). In this context, DGA Tn developed an application enabling measurement of this type of product to be automated.

The BEA called on the DGA Tn once again, in order to measure emergency beacons, but this time, fitted on flight recorders in order to quantify the possible masking by the recorders of acoustic transmissions. A measurement campaign was therefore carried out at the DGA Castillon site at the end of August 2011.

This report is on the results of this measurement.

2 Measurement at Castillon

2.1 General presentation

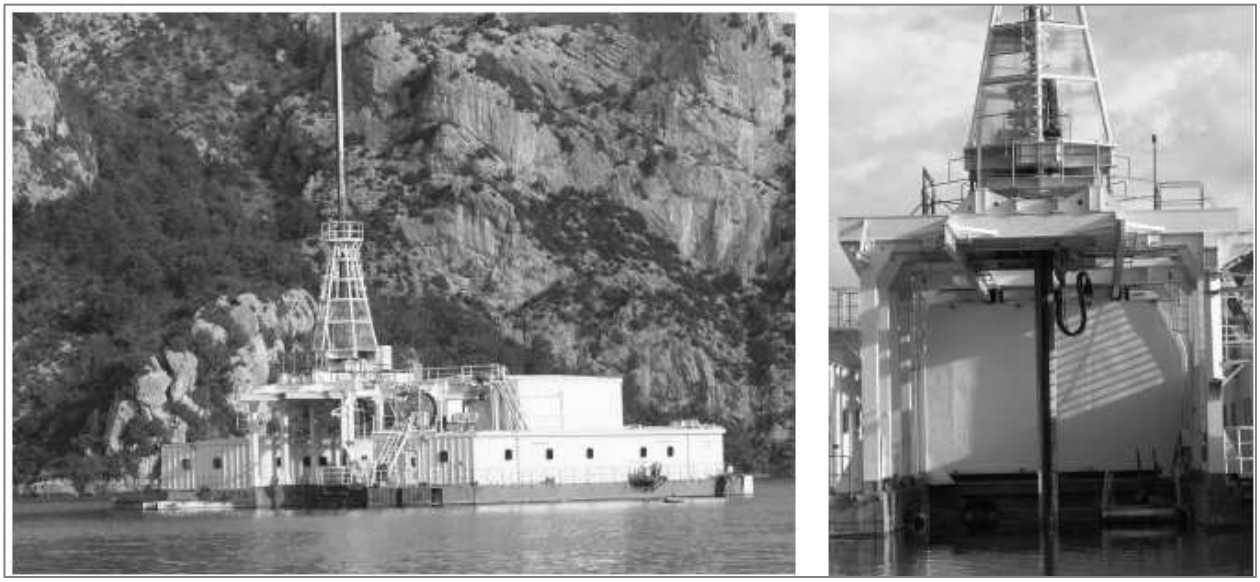
Emergency beacons are acoustic transmitters with a frequency of around 37.5 kHz. The reference sensors of the MSA-Med service are checked annually only in the 1 to 30 kHz frequency range. An initial operation therefore consisted of calibrating between 35,000 and 40,000 Hz the receivers used for the measurement operation, using the reciprocity method.

Twelve beacons were available for this test (6 Dukane beacons and 6 Benthos), they all underwent vertical static measurement in order to eliminate those that were potentially faulty. Among the validated beacons, two of each make were selected for the measurement to follow on brackets and flight recorders.

The beacons were then placed under the directivity mast of Castillon's measurement site, in order to check their acoustic propagation. They were positioned vertically then horizontally, first alone then with the three bracket systems and finally with the three flight recorders (brackets and recorders are called '*Fairchild*', '*Honeywell*' and '*Allied Signal*' as reported in the appendix) .

2.2 Presentation of the site and material

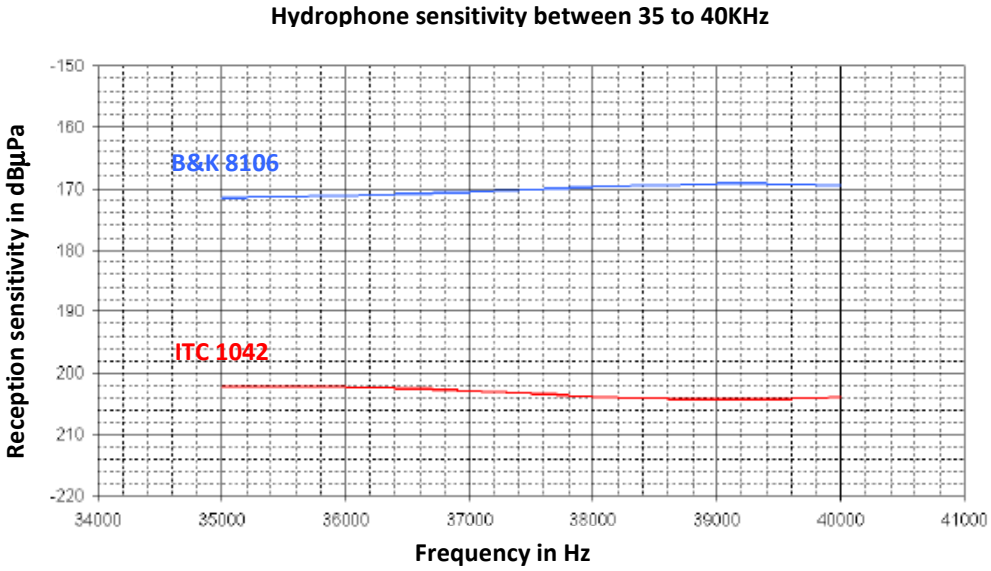
The measurements took place on the DGA Tn Castillon site. This site has two barges. One had a directivity mast which was used. The depth of water in the lake at the time of measurement was around 65 m.



2.3 Test preparation.

The hydrophones used for this measurement were a B&K 8106 and a ITC 1042.
These hydrophones were calibrated using the reciprocity method in the 35 to 40 kHz range.

Results for measurement of hydrophone sensitivity:



The sensitivity values taken into account for this measurement were:

- -170.2 dB for the B&K 8106
- -203 dB for the ITC 1042

2.4 Measurement of emergency beacons.

2.4.1 Static measurement.

All the beacons (6 Dukane DK 120 and 6 Benthos ELP 362 D) underwent static measurement.
The hydrophones and the beacons were immersed to 10 m. The distance between the beacon and the hydrophones was 3.75 m.

Results of static measurement:

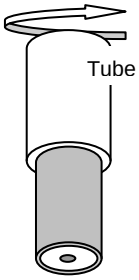
N° Attributed	MAKE	MODEL	Ref.	Date of Validity	Level	Recurrence	Duration	Signal*
1	Dukane	DK120	SC67204	OCT 2015	162.7 dB	1.069 sec.	9.38 ms	FP
2	Dukane	DK120	SC72955	MARS 2016	162.8 dB	1.067 sec.	9.34 ms	FP
3	Dukane	DK120	ST17247	JUIN 2014	159 dB	1.080 sec.	9.23 ms	FP
4	Dukane	DK120	ST30769	MAI 2016	162.2 dB	1.063 sec.	9.31 ms	FP
5	Dukane	DK120	ST14872	AVRIL 2014	162.5 dB	1.085 sec.	9.18 ms	FP
6	Dukane	DK120	SC31516	JANV 2013	163 dB	1.088 sec.	9.27 ms	FP
7	BENTHOS	ELP 362D	47975	JUILLET 2015	160.5 dB	1.011 sec.	11.69 ms	FM
8	BENTHOS	ELP 362D	35651	AVRIL 2014	160.8 dB	1.000 sec.	11.70 ms	FM
9	BENTHOS	ELP 362D	40125	AVRIL 2014	160 dB	1.030 sec.	12.88 ms	FM
10	BENTHOS	ELP 362D	46451	SEPT 2014	169.5 dB	1.138 sec.	15.26 ms	FM
11	BENTHOS	ELP 362D	45401	SEPT 2014	158.6 dB	1.021 sec.	12.65 ms	FM
12	BENTHOS	ELP 362D	48113	OCT 2015	161.3 dB	1.010 sec.	11.93 ms	FM

* The DK 120 beacon transmission signal is a pure frequency (FP) between 35.4 and 35.6 kHz.
* The ELP 362 D beacon transmission signal is a frequency modulation (FM descending) from 37.6 to 37.2 kHz.

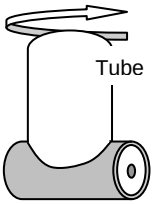
2.4.2 Measurement of directivity on single beacons.

The beacons selected from the 12 beacons were: the 1 and 4 for Dukane and the 7 and 12 for Benthos. These last 4 beacons were installed under the directivity mast and measured vertically then horizontally.

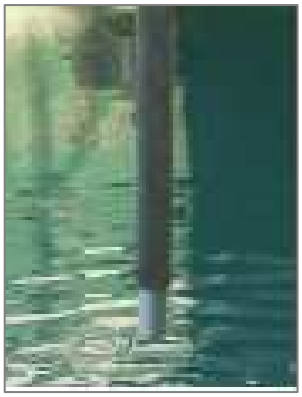
Vertical directivity measurement



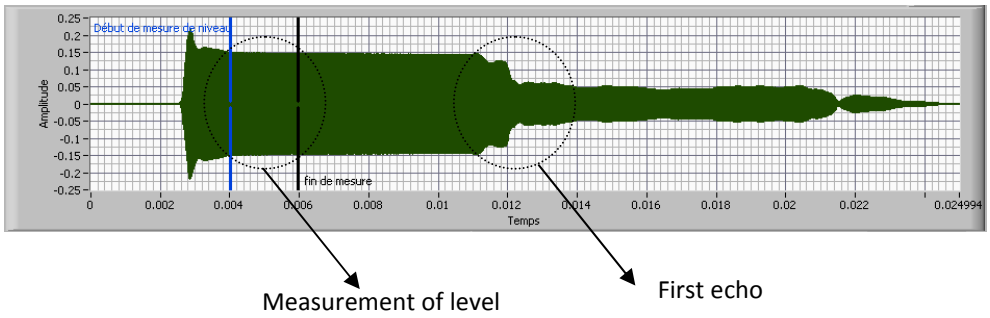
Horizontal directivity measurement



View of test mounting (for vertical measurement)



Reception diagram:

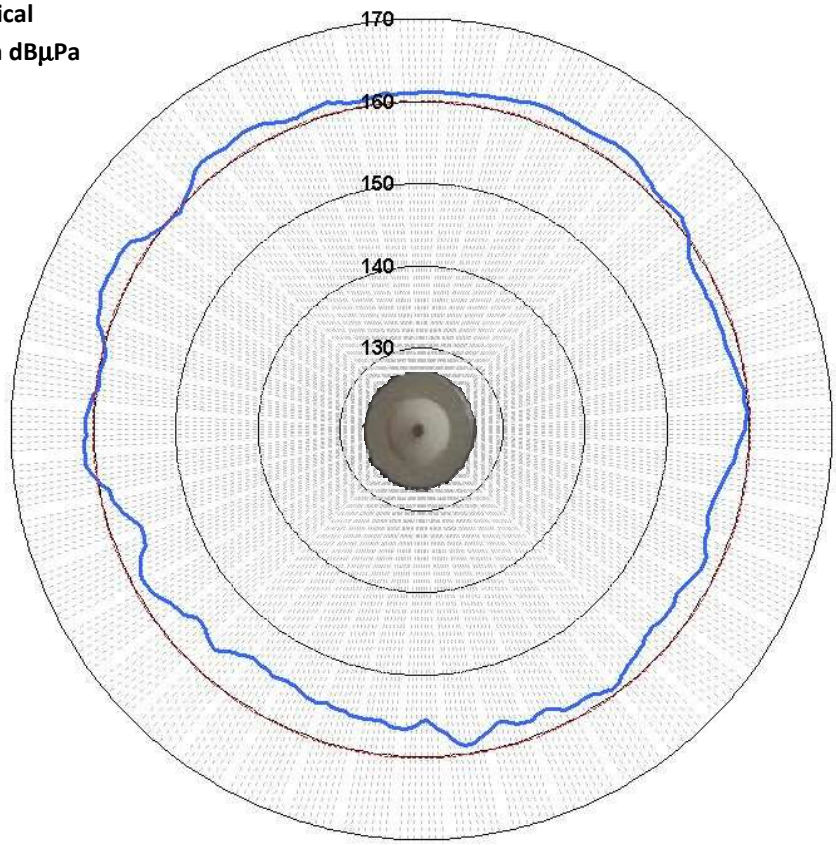


Measurement was carried out at a depth of 10 m, the hydrophone being 9 m from the source. The first echoes appear after 8 ms. All the level measurements were carried out at the same time, between 1 and 3 ms after the start of the signal.

2.4.2.1 Diagram of single beacon directivity:

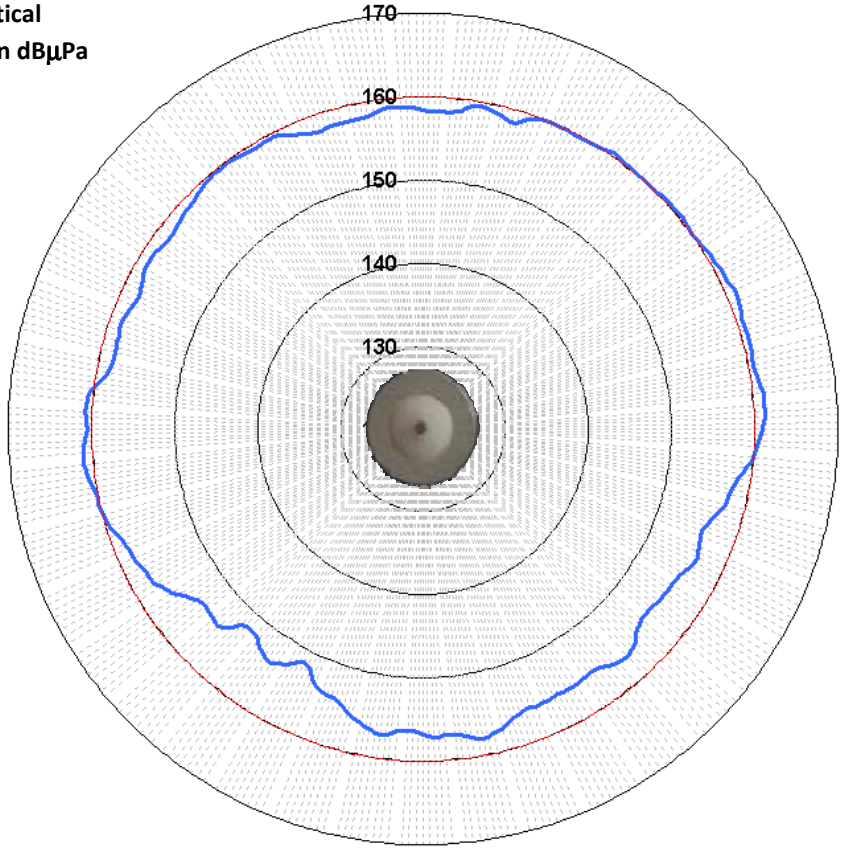
Beacon n° 1 Vertical:

Directivity on single beacon : Dukane DK120
Position : vertical
Source level in dBµPa



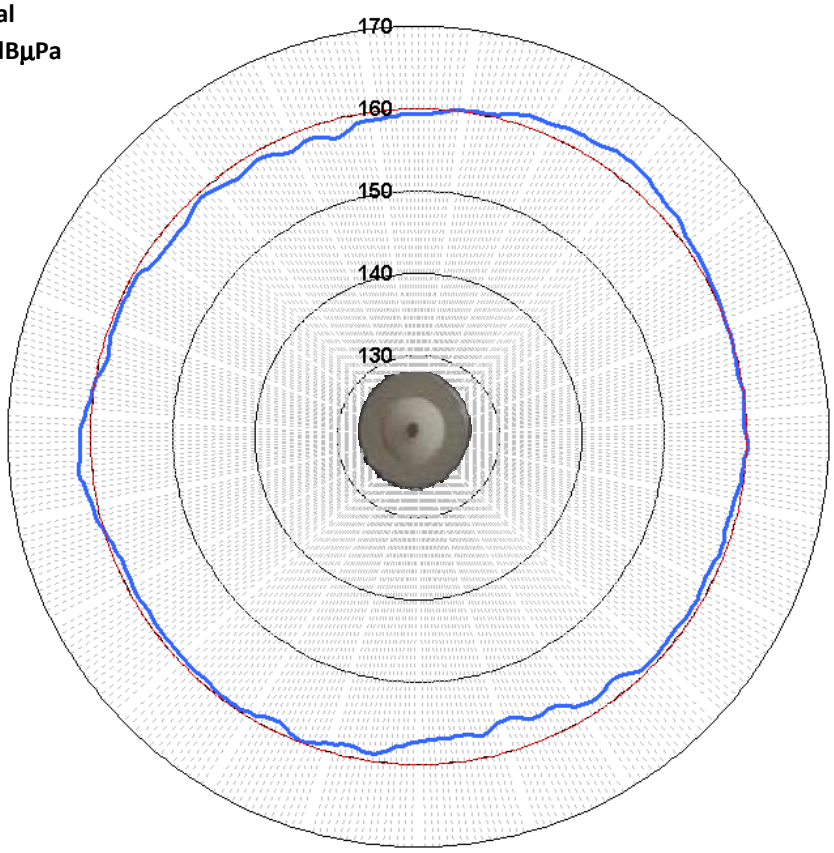
Beacon n° 4 Vertical:

Directivity on single beacon : Dukane DK120
Position : vertical
Source level in dBµPa



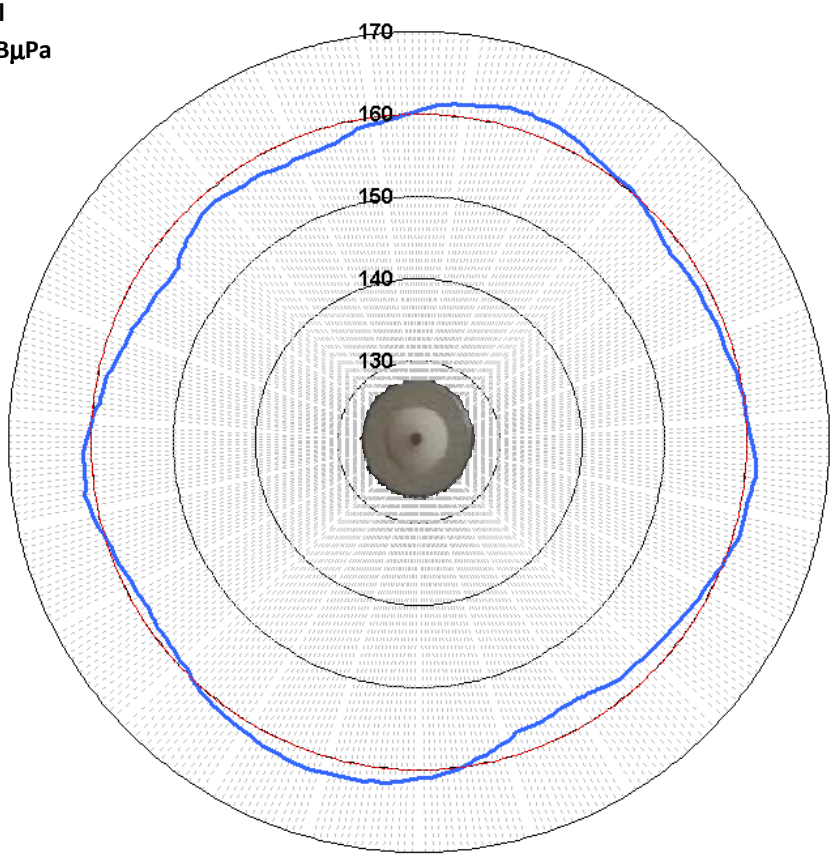
Beacon n° 7 Vertical:

Directivity on single beacon : Benthos ELP362D
Position : vertical
Source level in dBµPa



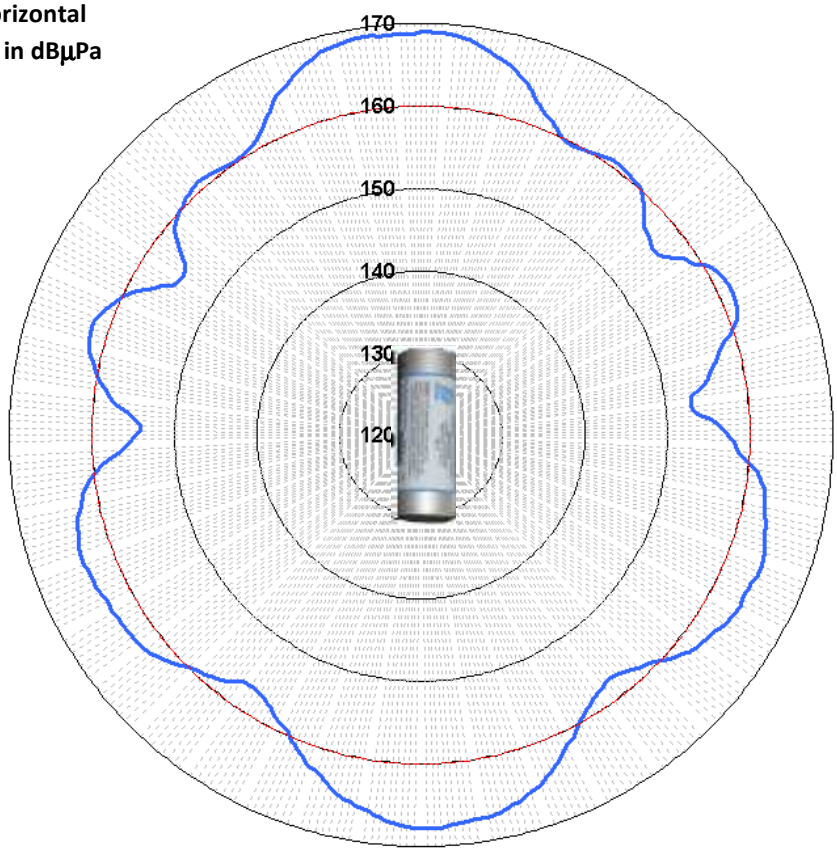
Beacon n° 12 Vertical:

Directivity on single beacon : Benthos ELP362D
Position : vertical
Source level in dBµPa



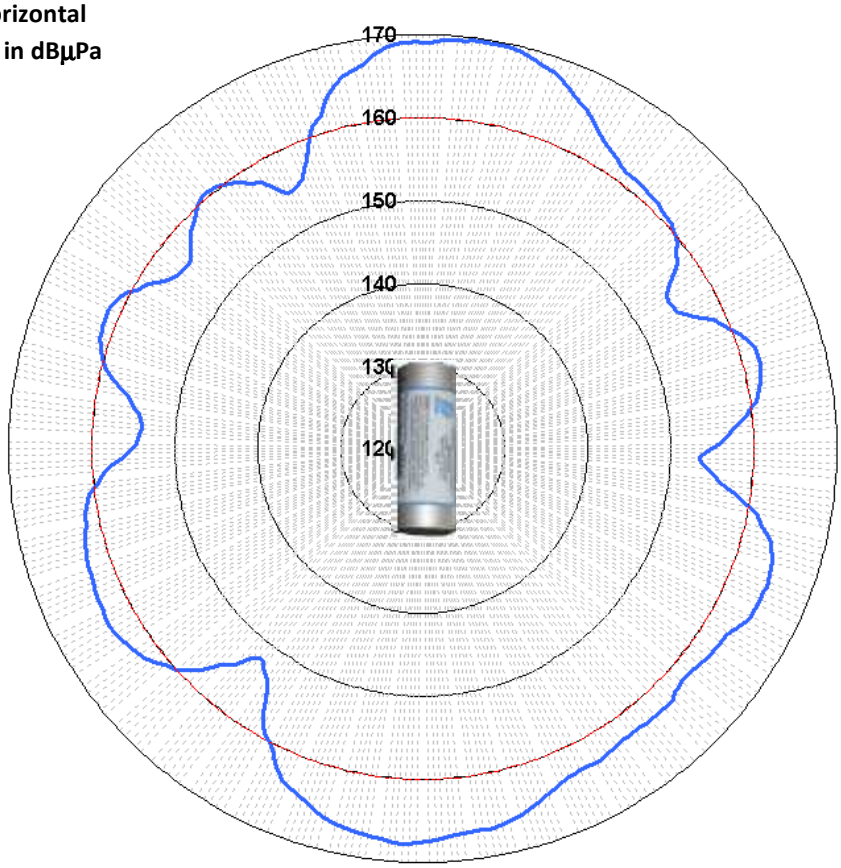
Beacon n° 1 Horizontal:

Directivity on single beacon : Dukane DK120
Position : horizontal
Source level in dBµPa



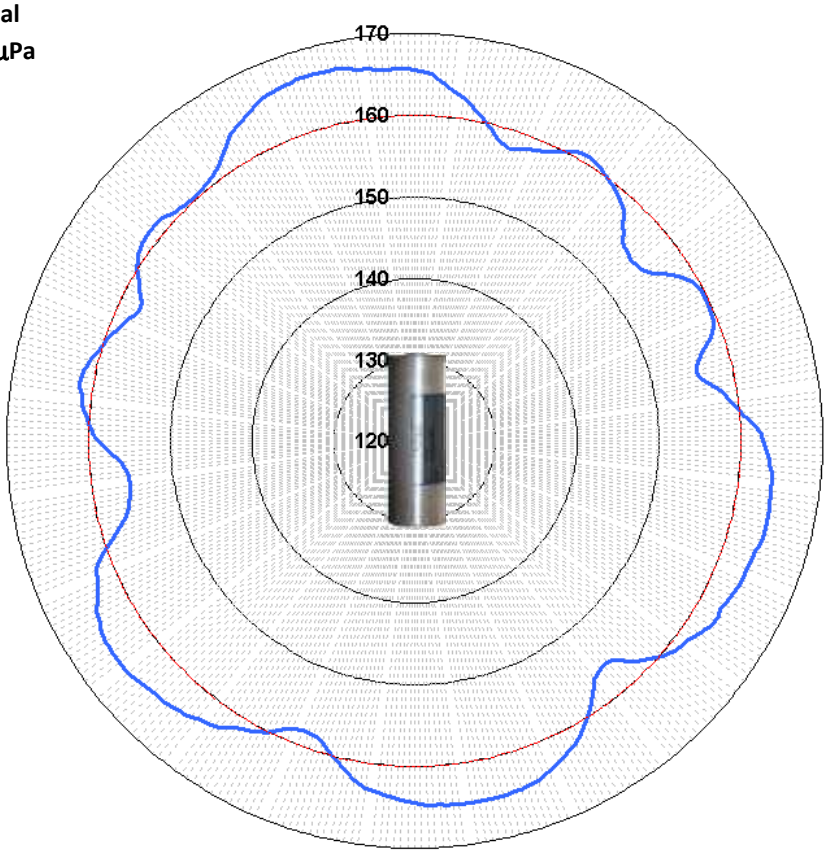
Beacon n° 4 Horizontal:

Directivity on single beacon : Dukane DK120
Position : horizontal
Source level in dBµPa



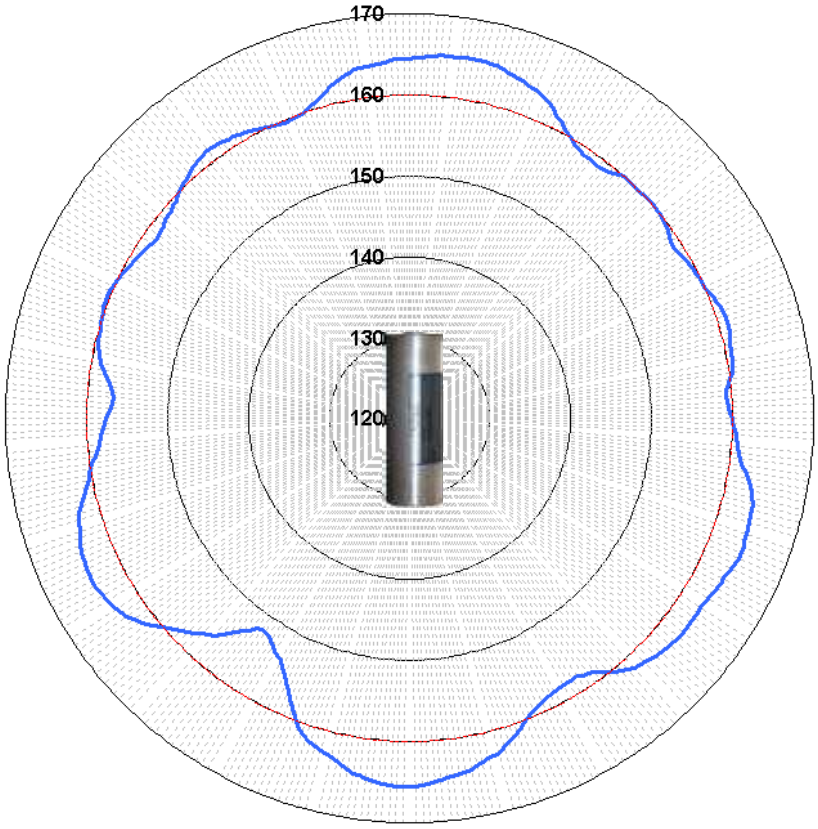
Beacon n° 7 Horizontal:

Directivity on single beacon : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



Beacon n° 12 horizontal:

Directivity on single beacon : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



Summary of measurement of directivity of single beacons:

The 4 beacons had relatively similar performance.

2.4.3 Measurement of directivity of beacons with their mounting brackets

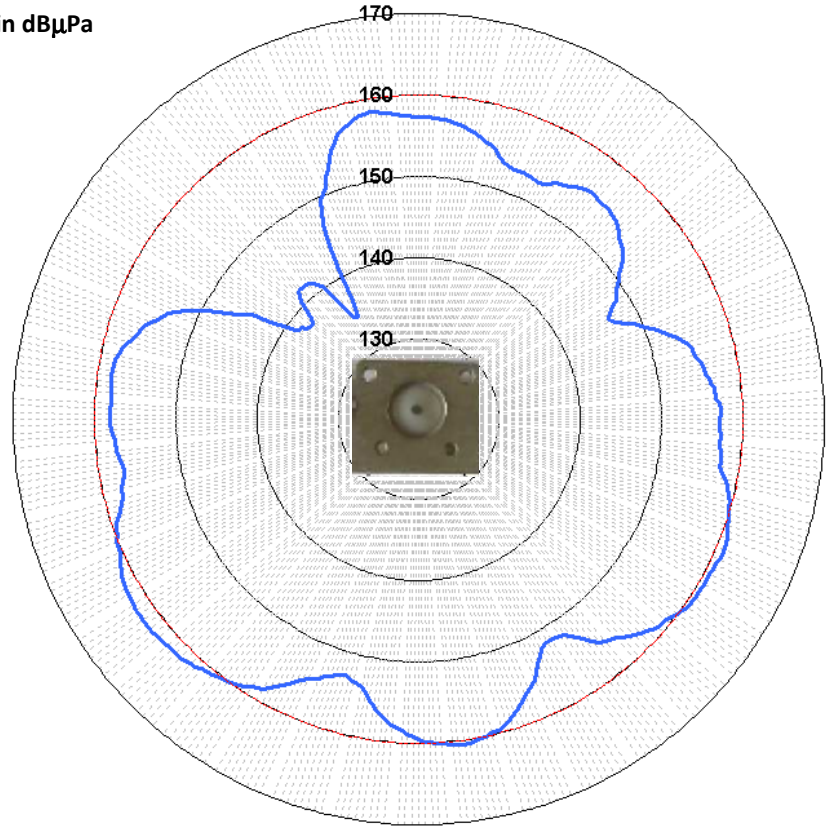
In the light of the results of single beacon measurement, beacon n° 1 for Dukane and beacon n°7 for Benthos were taken into account for measurement of directivity on mounting brackets and on flight recorders.

Measurement of directivity on brackets was carried out in the same conditions of measurement as for the single beacons.

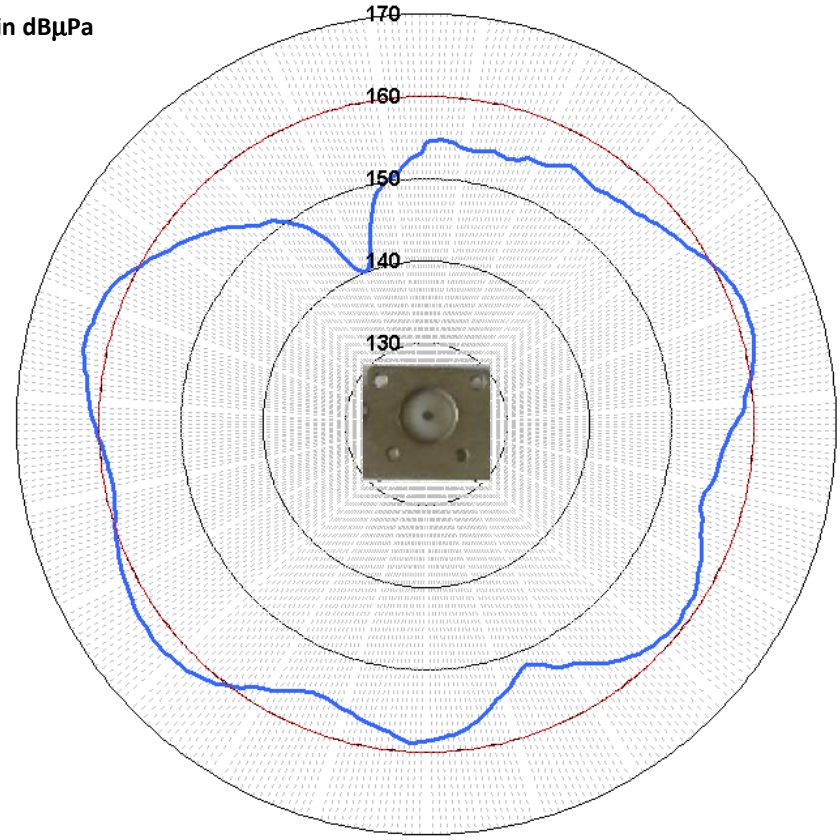
Examples of installation:

2.4.3.1 Diagram of beacon on bracket directivity:

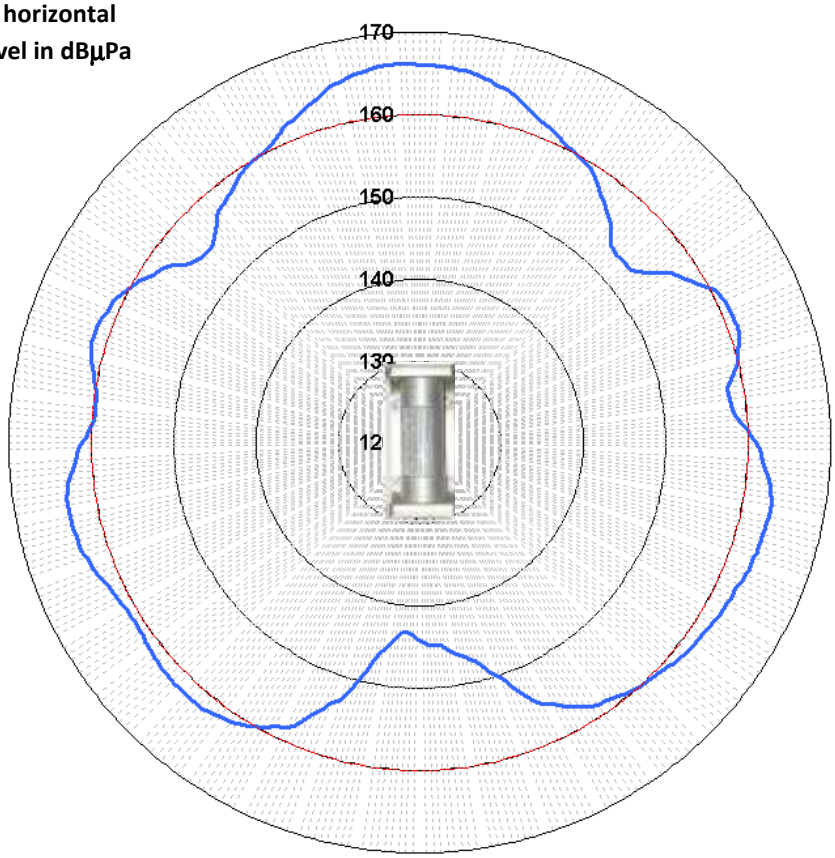
Directivity on Fairchild brackets : Dukane DK120
Position : vertical
Source level in dBµPa



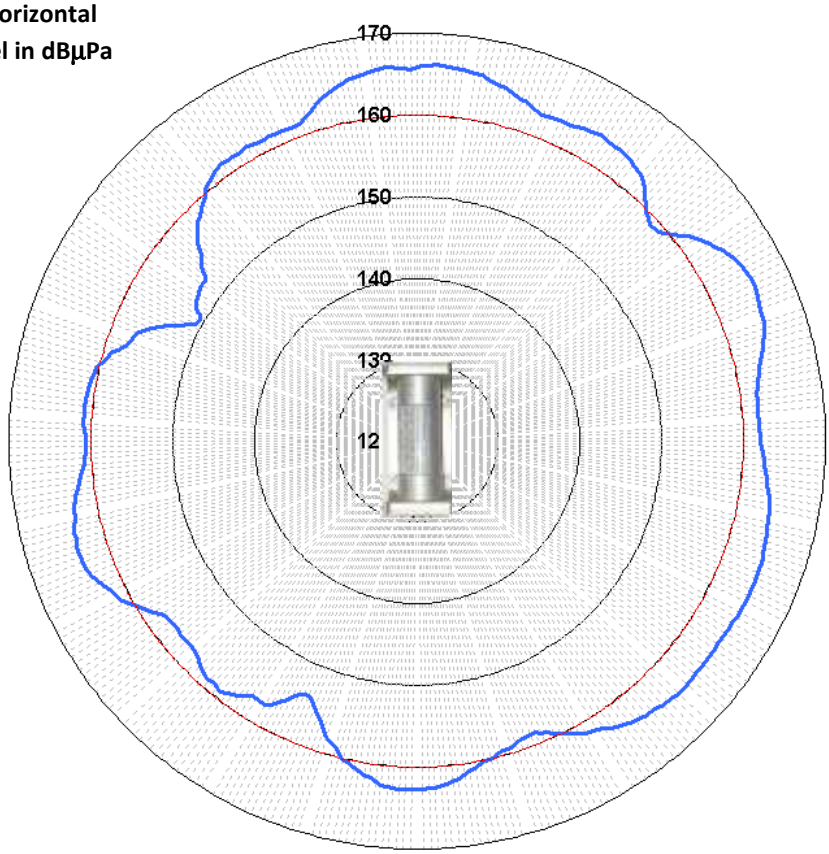
Directivity on Fairchild brackets : Benthos ELP 362D
Position : vertical
Source level in dBµPa



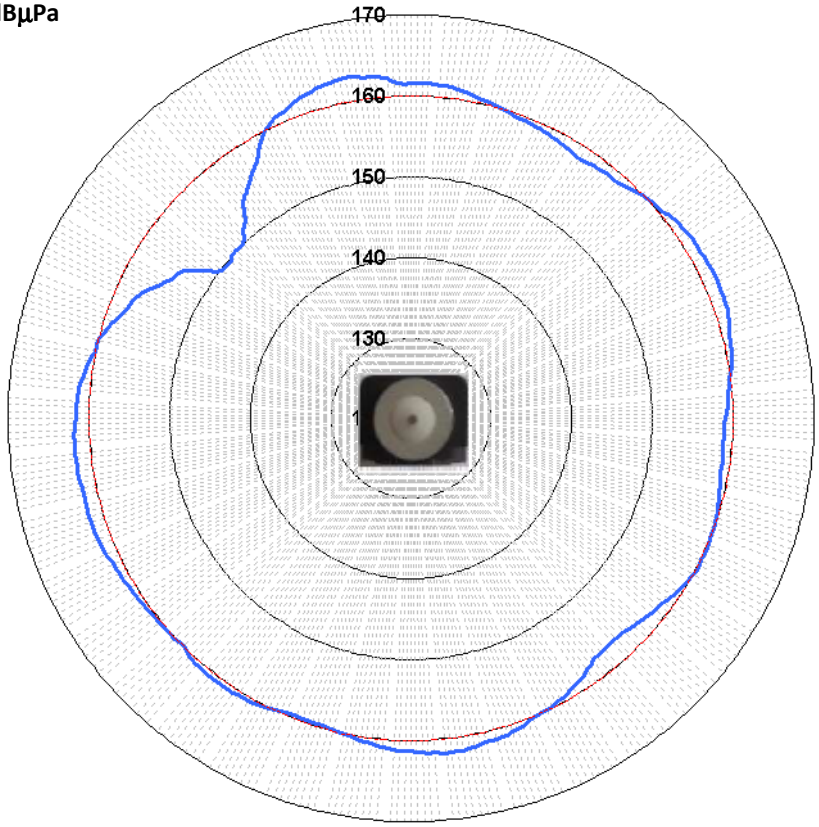
Directivity on Fairchild brackets : Dukane DK120
Position : horizontal
Source level in dBµPa



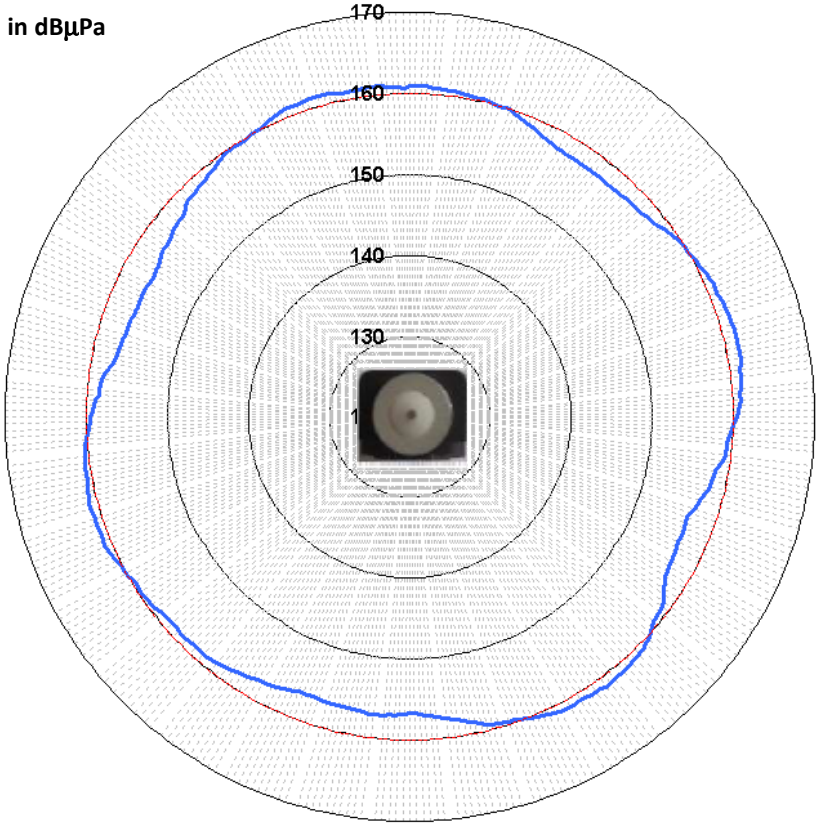
Directivity on Fairchild brackets : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



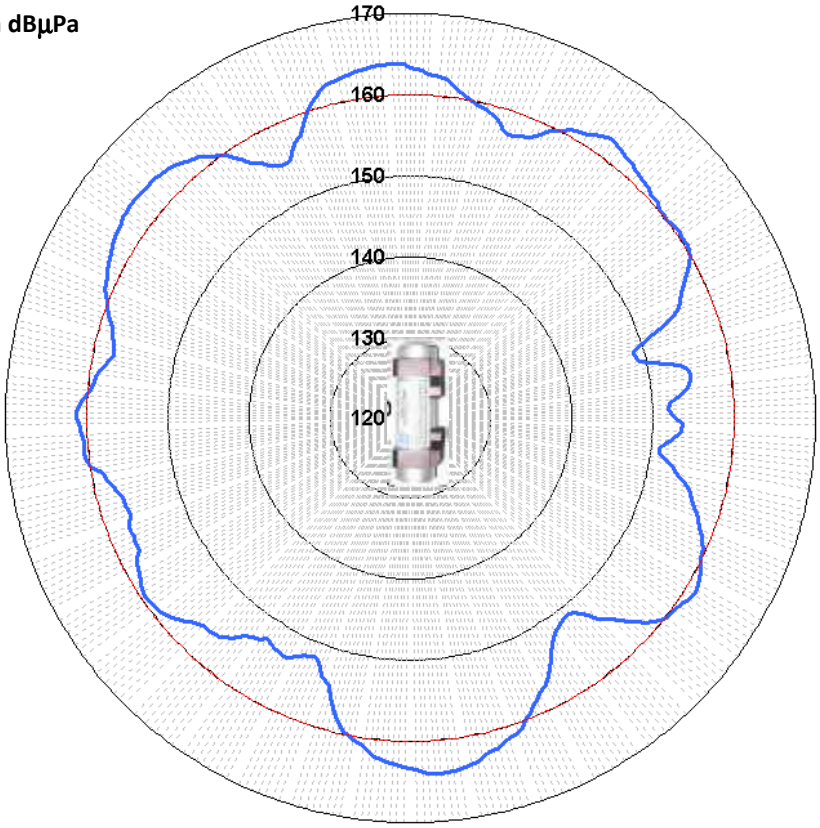
Directivity on Honeywell brackets : Dukane DK120
Position : vertical
Source level in dBµPa



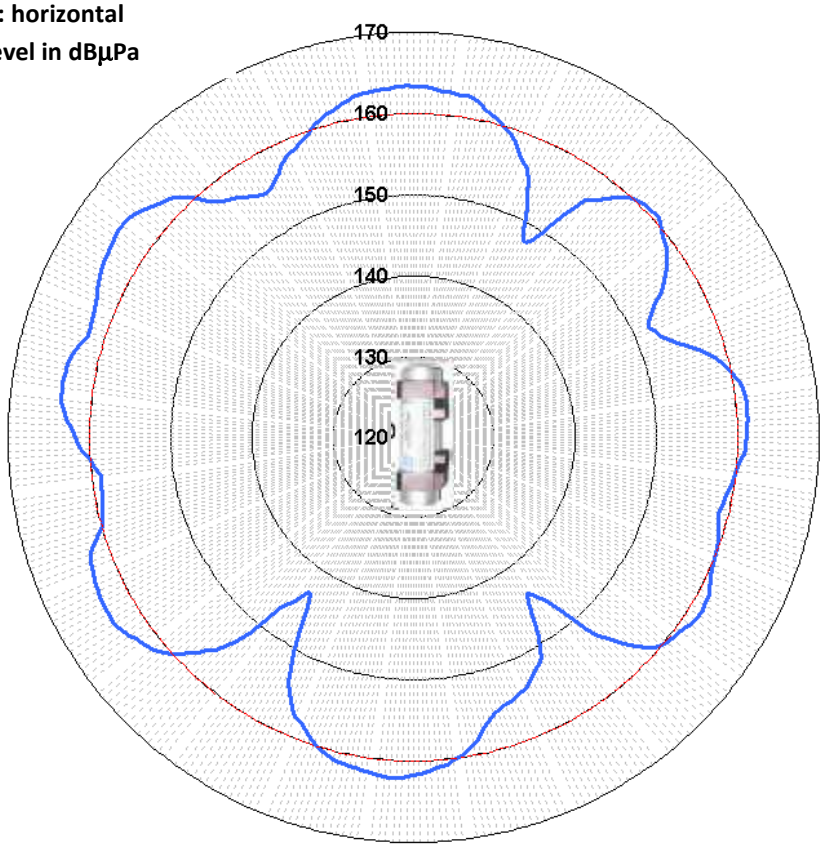
Directivity on Honeywell brackets : Benthos ELP 362D
Position : vertical
Source level in dBµPa



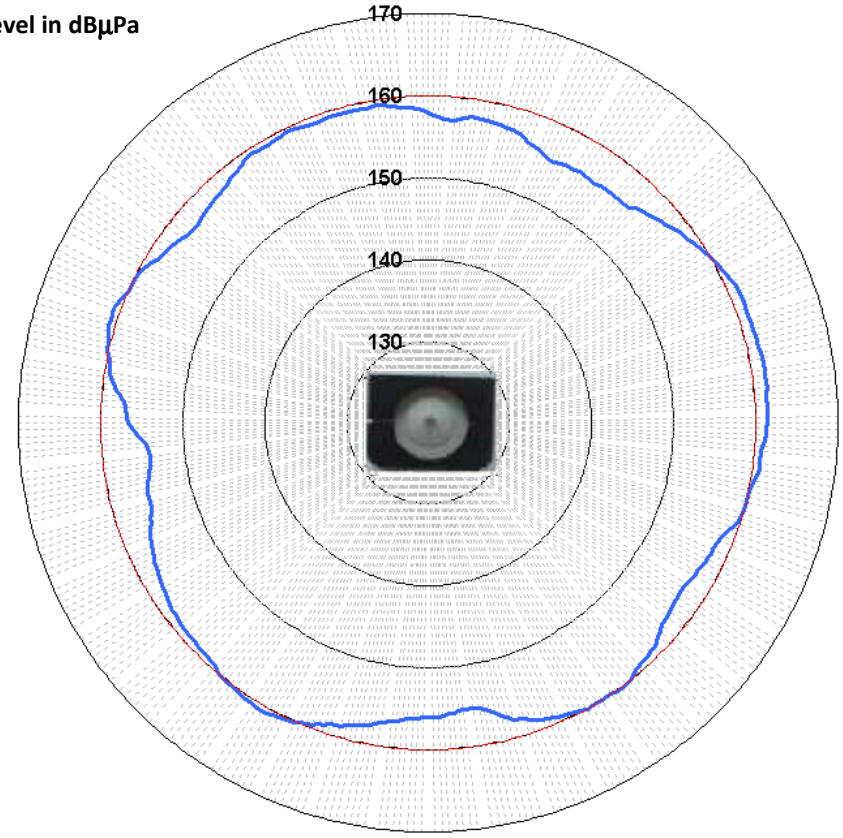
Directivity on Honeywell brackets : Dukane DK120
Position : horizontal
Source level in dBµPa



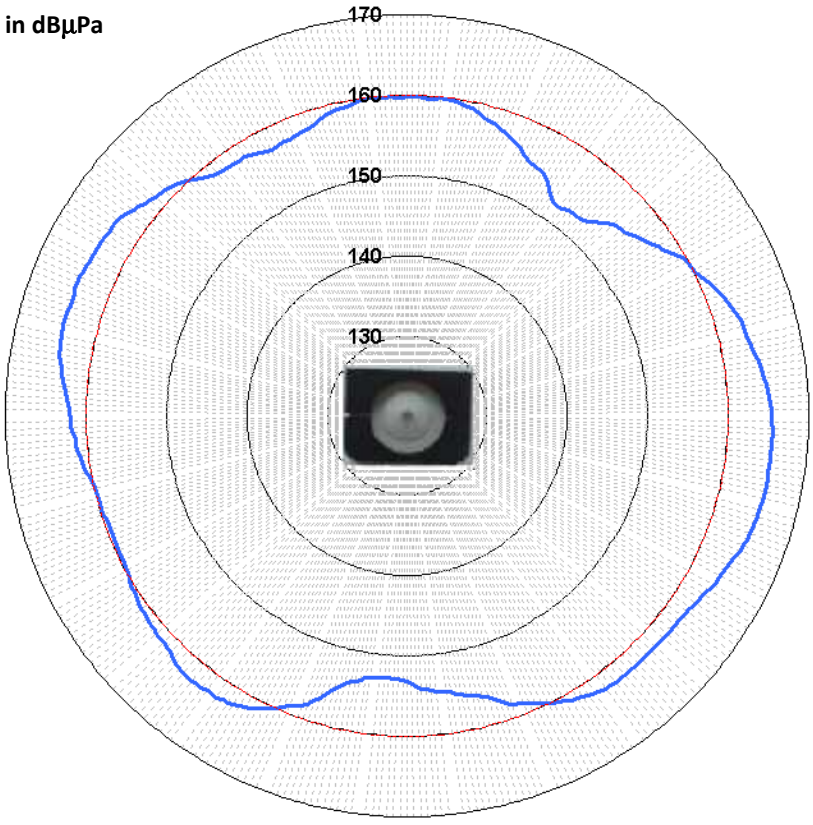
Directivity on Honeywell brackets : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



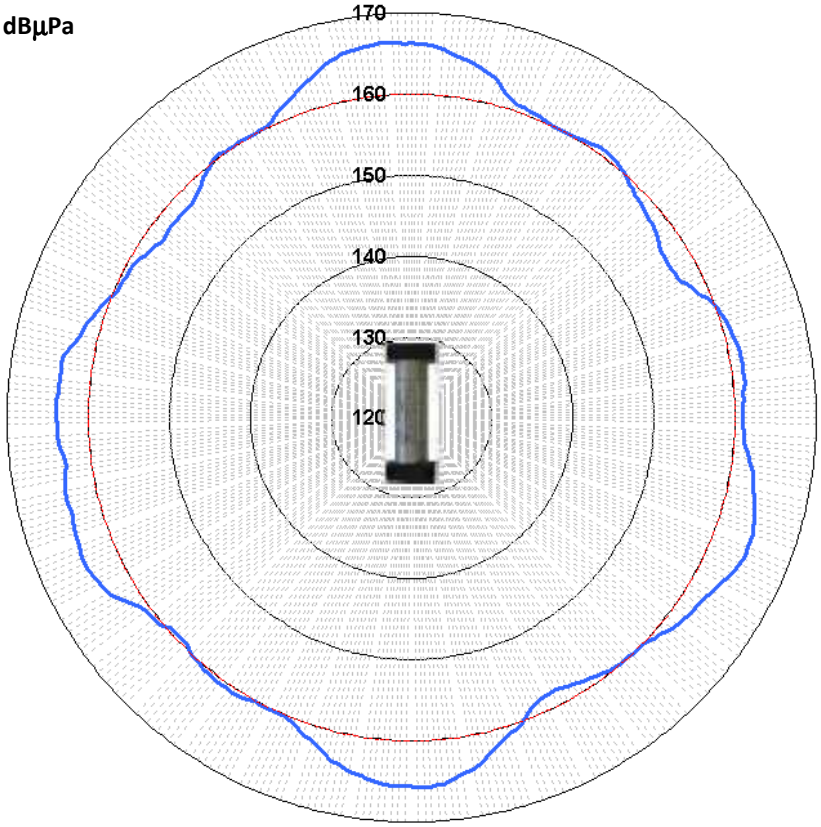
Directivity on Allied Signal brackets : Dukane DK120
Position : vertical
Source level in dBµPa



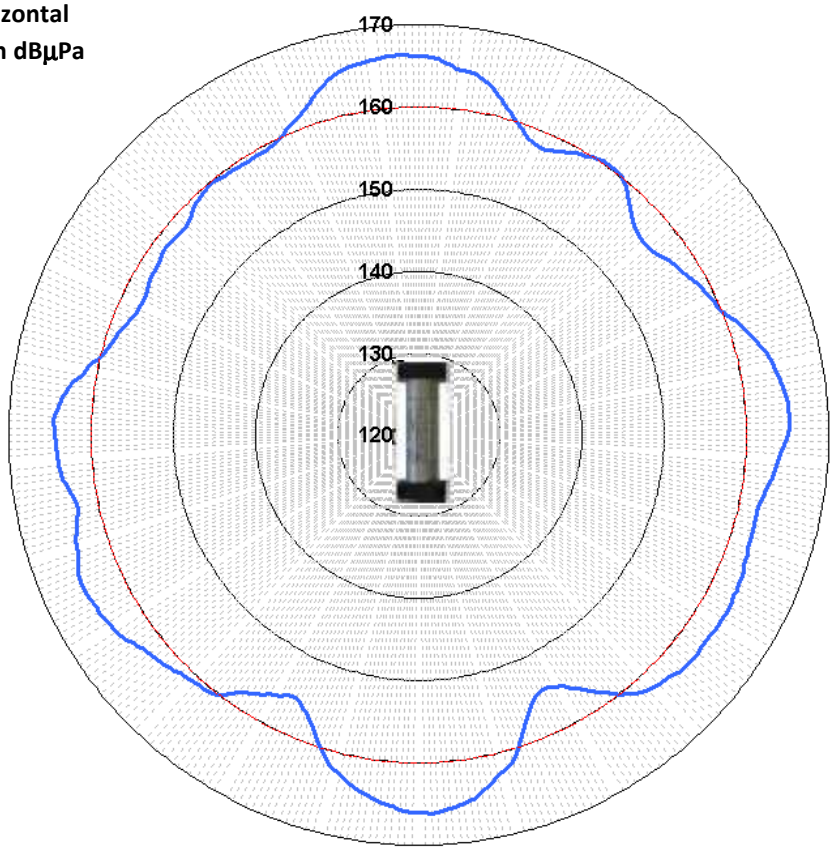
Directivity on Allied Signal brackets : Benthos ELP 362D
Position : vertical
Source level in dBµPa



Directivity on Allied Signal brackets : Dukane DK120
Position : horizontal
Source level in dBµPa



Directivity on Allied Signal brackets : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



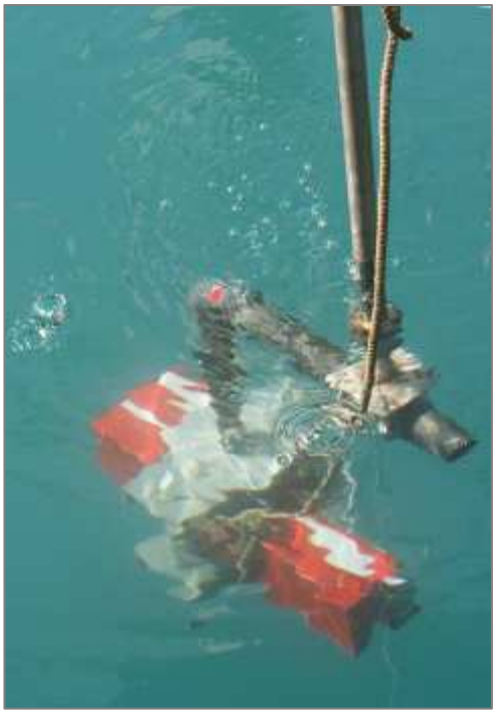
Summary of measurement of directivity of beacons installed on mounting brackets:

- The installation of mounting brackets on emergency beacons provokes, in some angular zones, dips in the diagram of transmission directivity. These drops in level can very occasionally reach 20 dBµPa in the case of Fairchild brackets, and 10 dBµPa for other types of fixation.
- The influence of brackets on acoustic transmission directivity is relatively independent of the type of beacon (Dukane or Benthos)

2.4.4 Measurement of directivity on beacons installed on flight recorders.

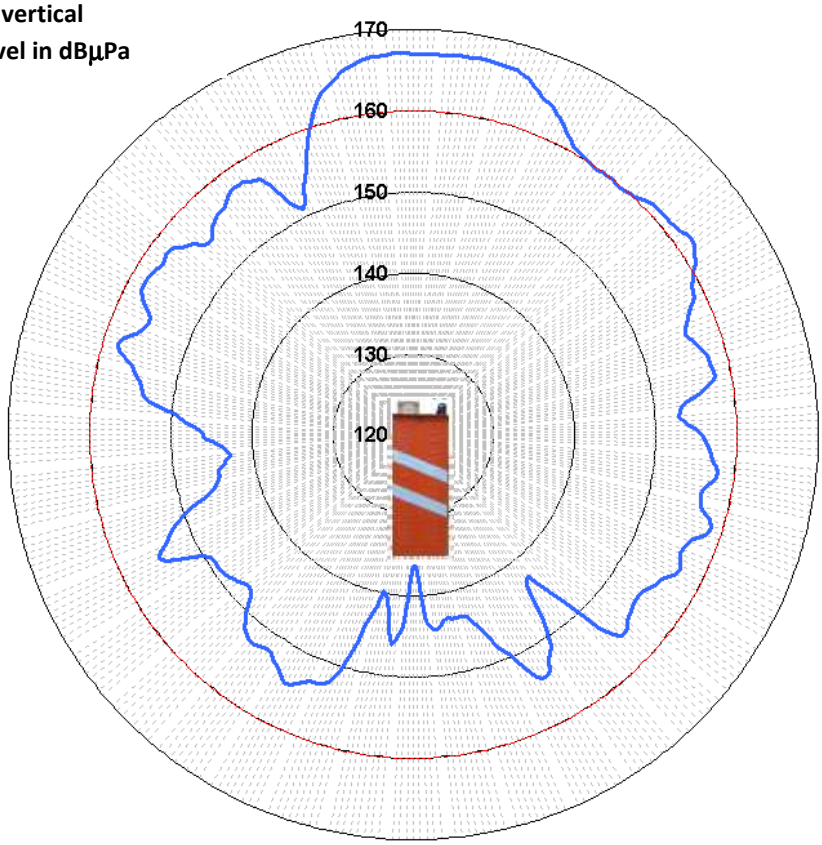
An attachment fitting was carried out. This fitting did not contain any metallic elements to avoid disrupting the measurement process.

Example of flight recorder fitting on the directivity mast:

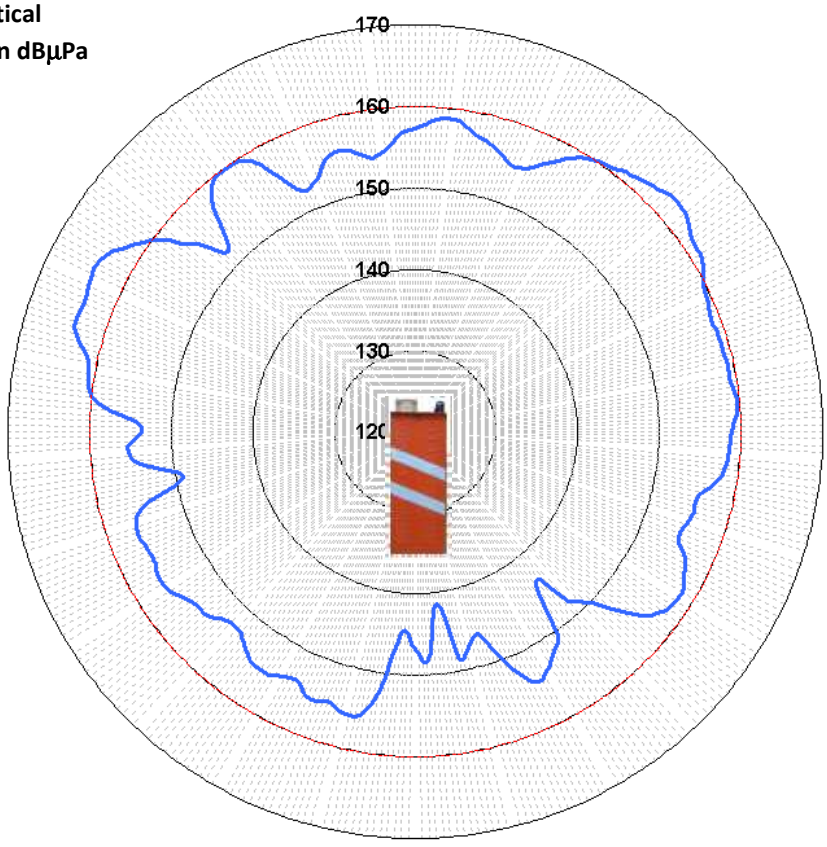


2.4.4.1 Diagram of directivity of beacons on flight recorders:

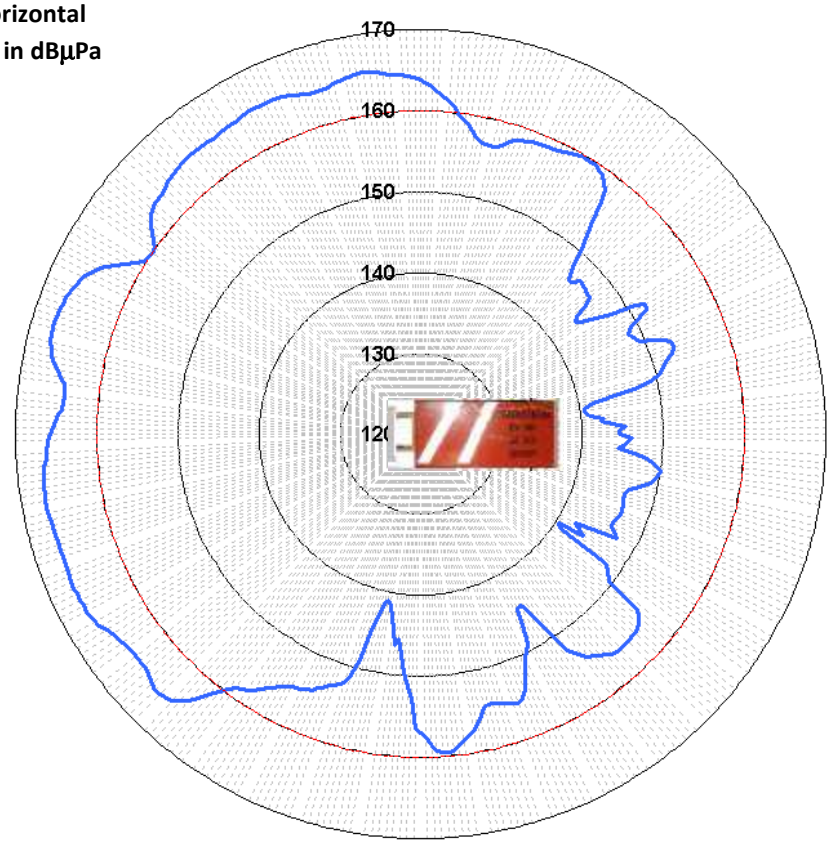
Directivity on Fairchild recorder : Dukane DK120
Position : vertical
Source level in dBµPa



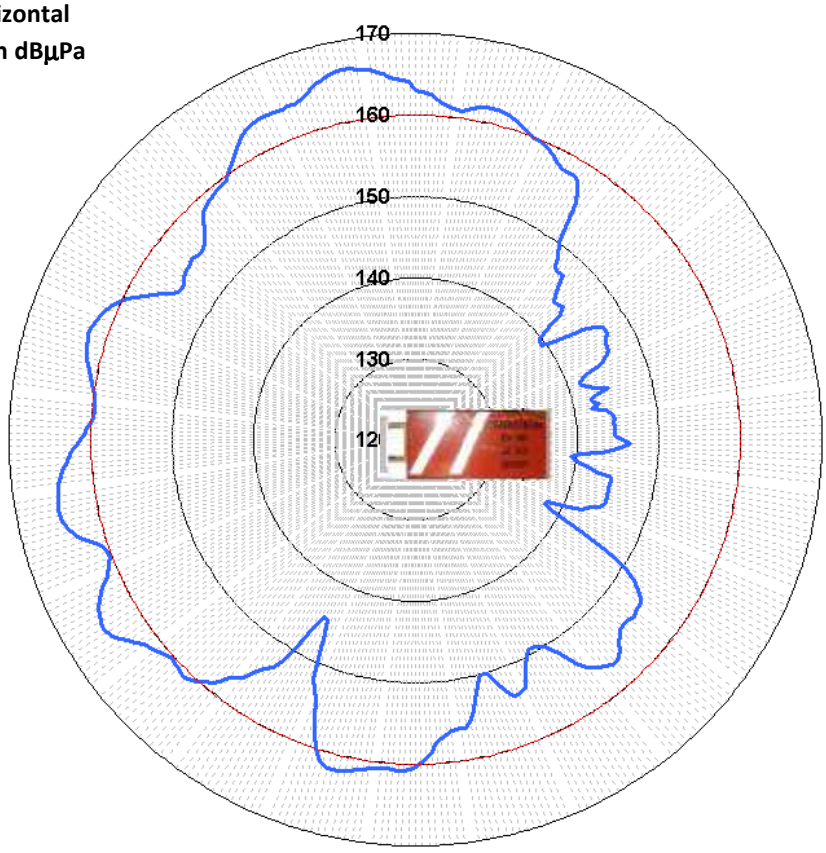
Directivity on Fairchild recorder : Benthos ELP 362D
Position : vertical
Source level in dBµPa



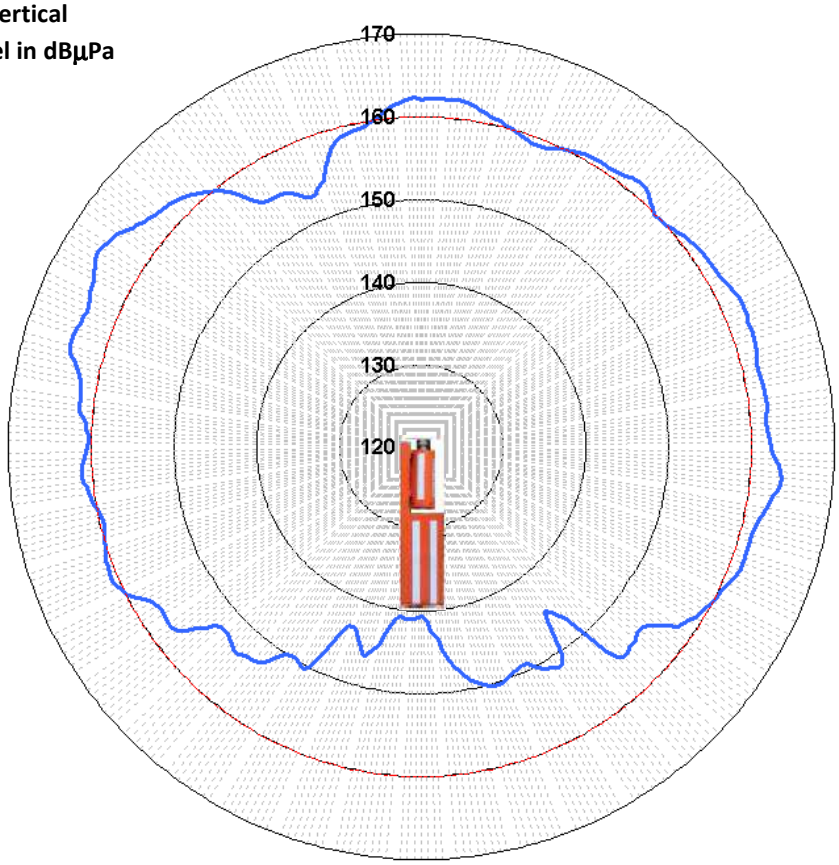
Directivity on Fairchild recorder : Dukane DK120
Position : horizontal
Source level in dBµPa



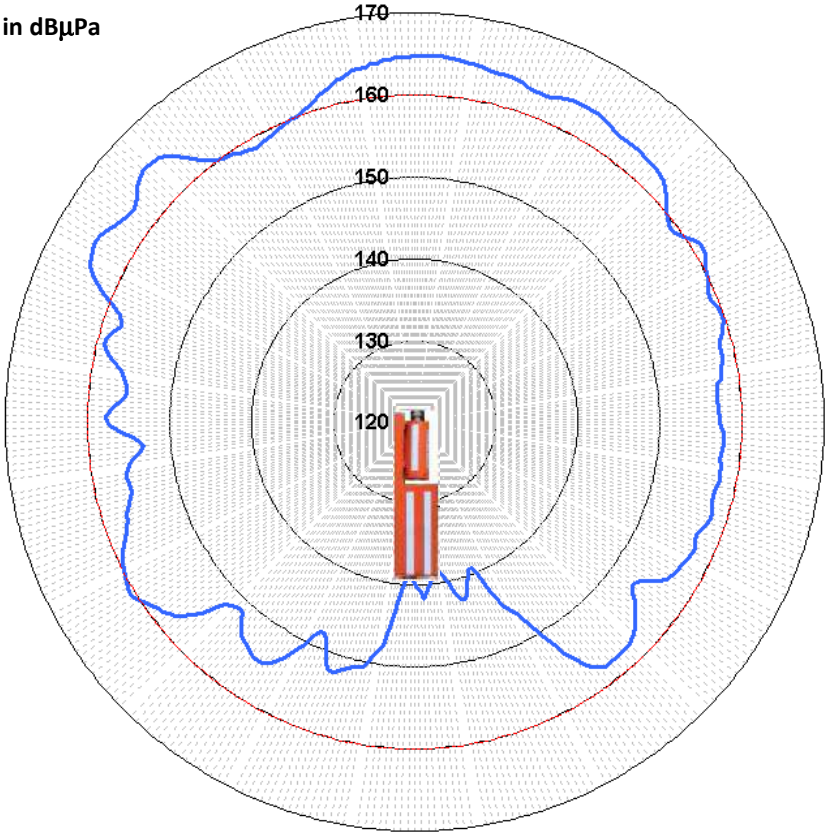
Directivity on Fairchild recorder : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



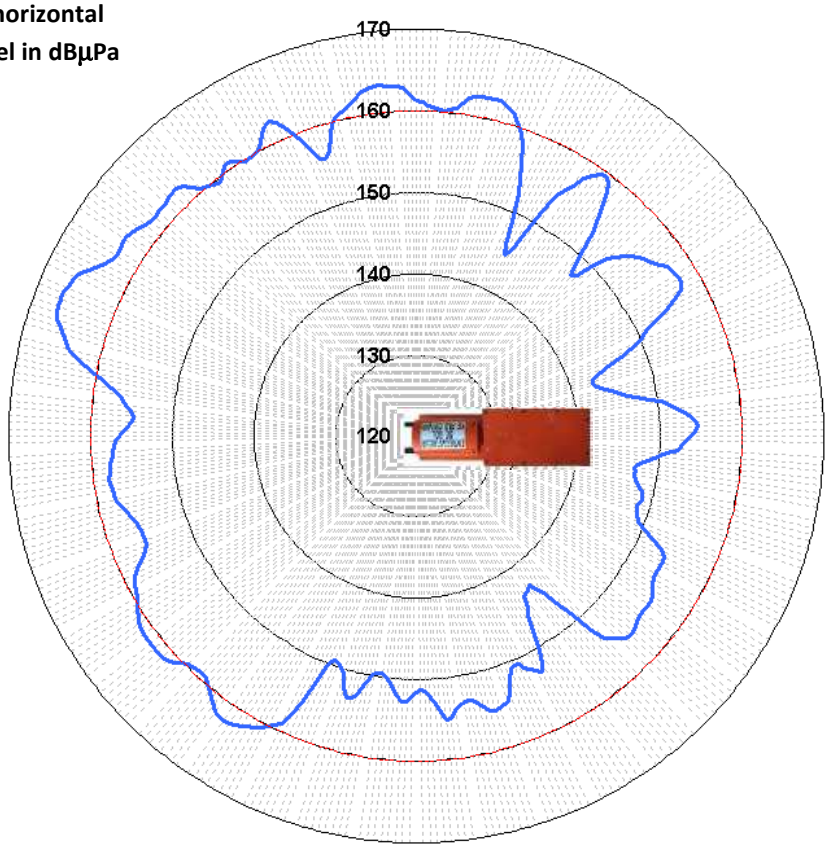
Directivity on Honeywell recorder : Dukane DK120
Position : vertical
Source level in dBµPa



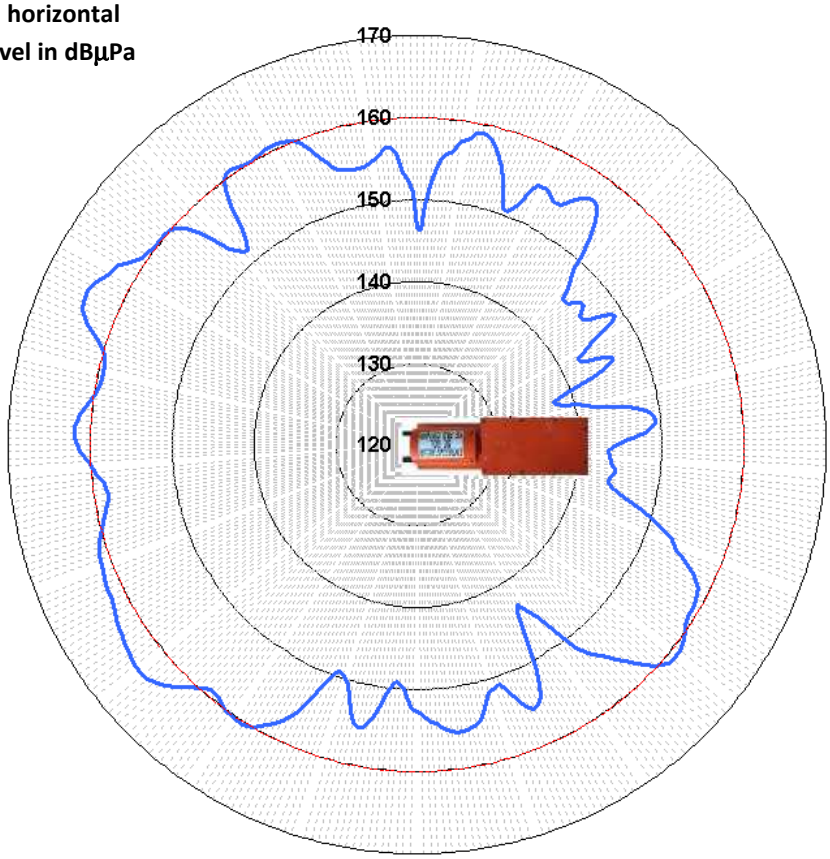
Directivity on Honeywell recorder : Benthos ELP 362D
Position : vertical
Source level in dBµPa



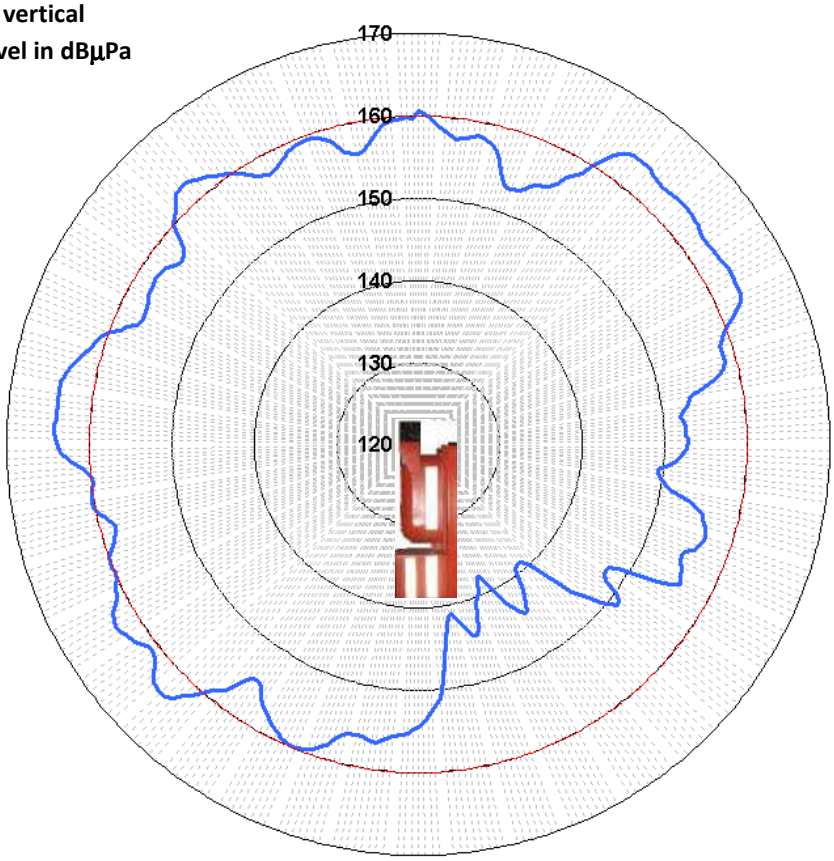
Directivity on Honeywell recorder : Dukane DK120
Position : horizontal
Source level in dBµPa



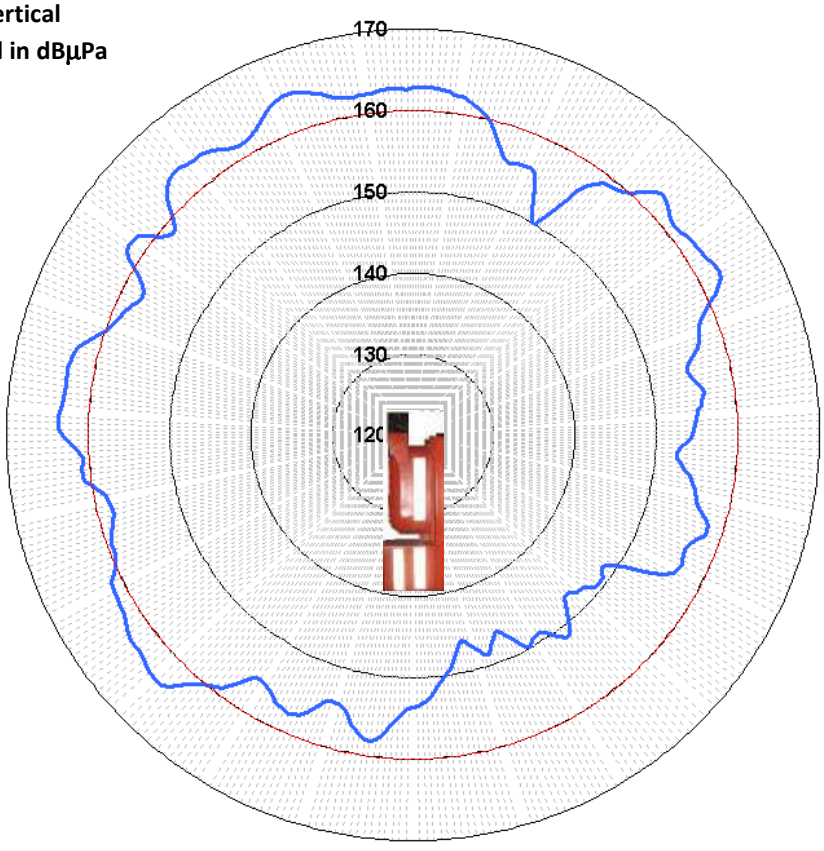
Directivity on Honeywell recorder : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



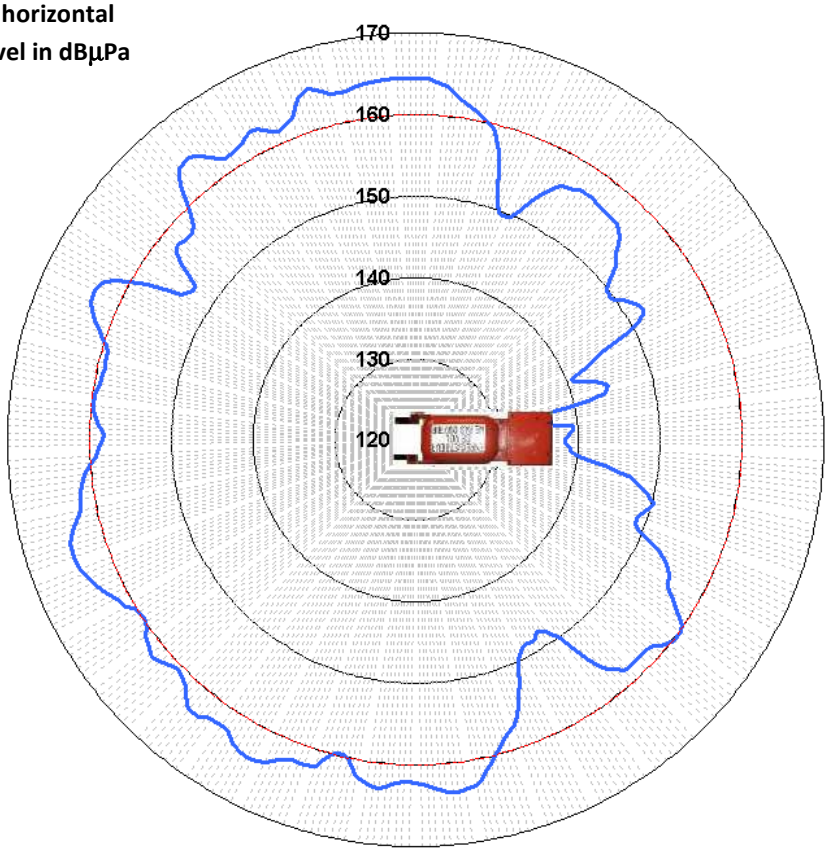
Directivity on Allied Signal recorder : Dukane DK120
Position : vertical
Source level in dBµPa



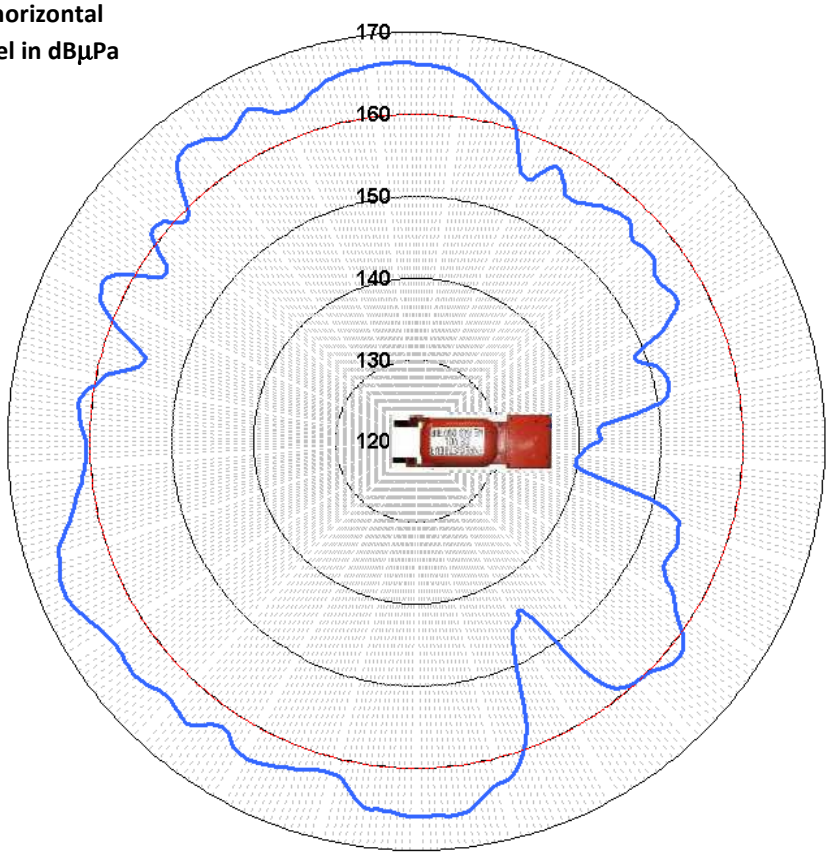
Directivity on Allied Signal recorder : Benthos ELP 362D
Position : vertical
Source level in dBµPa



Directivity on Allied Signal recorder : Dukane DK120
Position : horizontal
Source level in dBµPa



Directivity on Allied Signal recorder : Benthos ELP 362D
Position : horizontal
Source level in dBµPa



Summary of measurement of directivity of beacons installed on flight recorders:

- It is clear, in the light of these directivity diagrams that the form of flight recorders significantly influences emergency beacon transmission, even over large angular areas.
- Masked areas are present on the beacon's vertical axis as well as the horizontal axis, leaving the possibility of significant of "shadow" zones.
- The influence of flight recorders on the directivity of acoustic transmission is relatively independent of the type of beacon (Dukane or Benthos).

- It should be remembered that each time the level falls 6 dBµPa, the signal's theoretical range falls by half. For beacons attached in this way on a flight recorder this can be very noticeably reduced, depending on orientation, in relation to the theoretical range of a single beacon.

Appendix

June 2011 / Trial from DGA Tn by BEA :

Directivity measurement of the acoustic source (ULB) once installed on most common type of recorders fitted on civilian air transportation aircraft in France and Europe.

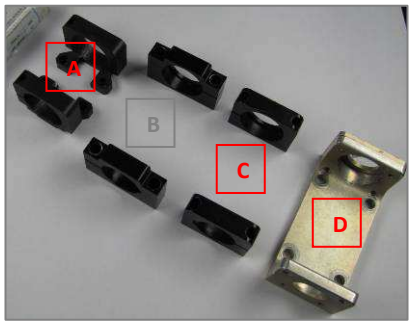
Three step scheduled:

Step 1 – directivity of the single beacon (free field measurement)

Performed on most common ULB type attached to recorders in France and Europe :

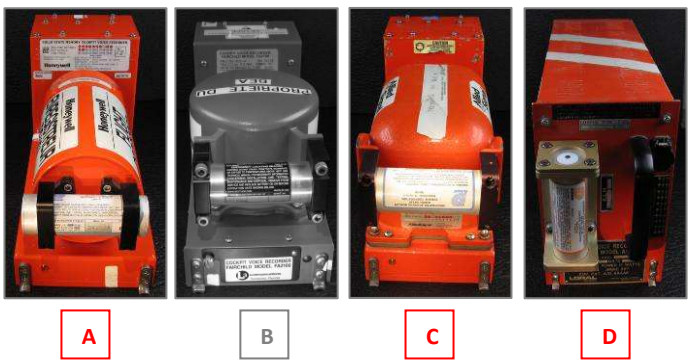
- Dukane DK120
- Benthos ELP 362D

Step 2 – directivity of the previous beacons with their mounting brackets



- A - refered to as 'Honeywell'
- B - refered to as 'L3-Com' *
- C - refered to as 'Allied Signal'
- D - refered to as 'Fairchild'

Step 3 – directivity of the previous beacons once mounted on their recorders



- A - refered to as 'Honeywell'
- B - refered to as 'L3- Com' *
- C - refered to as 'Allied Signal'
- D - refered to as 'Fairchild'

* *L3-Com equipment (brackets and recorders) were not delivered to DGA Tn because no L3 out of service recorder was available in BEA Laboratory.*