

---

|        |                                                |      |                  |
|--------|------------------------------------------------|------|------------------|
| Title: | <b>Verification of the computer code HYBER</b> | No.  | :                |
|        |                                                | Rev. | :                |
|        |                                                | Page | : 1 of 16        |
|        |                                                | Date | : August 27 2004 |

---

|             |   |                |       |   |
|-------------|---|----------------|-------|---|
| Prepared by | : | Kjell Herfjord | Sign. | : |
| Verified by | : |                | Sign. | : |
| Approved by | : |                | Sign. | : |

---

## 1 INTRODUCTION

This Appendix gives the results from the simulations of the cases with strakes, and without bumpers. The strakes had the following geometry: Height  $h/D = 0.15$ , Pitch  $P/D = 10$ . The headline of each subsection gives the corresponding test number in the tests. Below the headline is a text line describing the condition of the test, according to the following syntax:

1. Current (tow) velocity (m/s), 2. Centre distance (number of diameters), 3. Inflow direction for current (deg), 4. Top tension (two figures separated by / if different for the two risers, upstream riser / downstream riser), 5. Top tension stiffness (N/m).

In the figures, the top part is from simulations, the bottom part is from measurements. Each of them is divided into distribution of number of hits along the length of the risers to the left, and distribution of velocities to the right. For the risers with strakes, there was a tendency of "hugging", i.e. once in touch, the risers clinged to each other. From the tests, the time ratio of clinging relative to the total recording time is also shown. The distribution of number of hits is shown with blue bars, and the time ratio of clinging is shown with pink bars. The sensors for recording hits in the tests were covering 5 meters of the mid part of the risers. There were 10 sensors, each covering 0.5 m. The sensors were covering a range corresponding to the range between  $-2.5$  and  $-7.5$  m in the figure for the computations. Sensor 1 is lowest, sensor 10 is highest.

## REPORT

---

Title: **Verification of the computer code HYBER**

No. :

Rev. :

Page : 2 of 15

Date : August 27 2004

---

## **2 Cylinders with strakes. Without bumpers**

### **2.1.1 Test No. 4010**

U=0.40 m/s, cc=10D, Dir=00 deg., Tension=300, Stiffness=1065 N/m

**No hit**

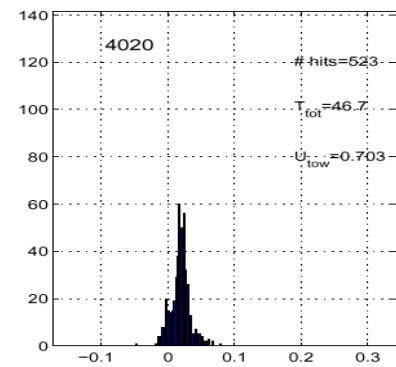
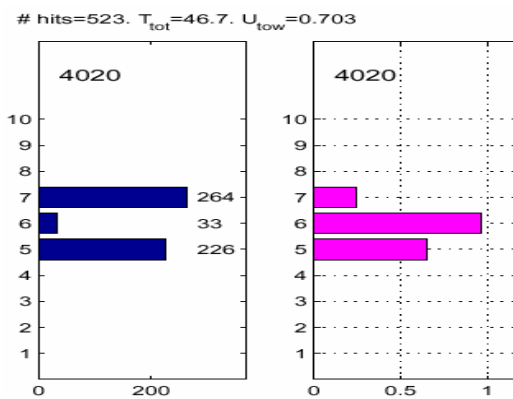
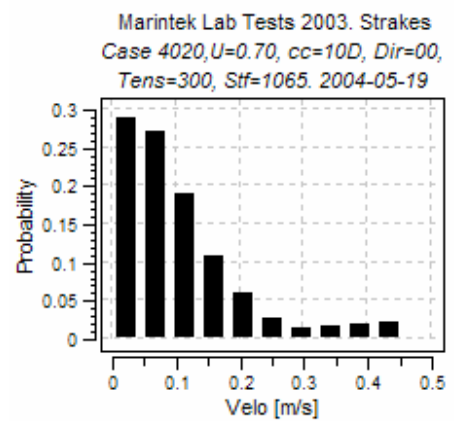
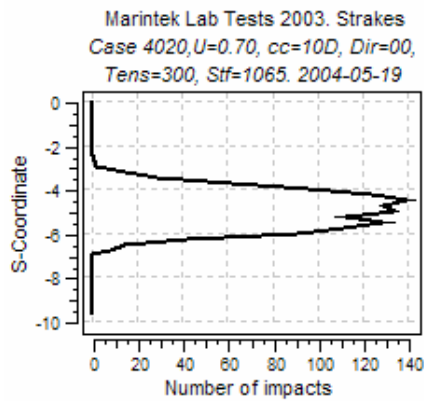
## REPORT

Title: **Verification of the computer code HYBER**

No. :  
Rev. :  
Page : 3 of 15  
Date : August 27 2004

### 2.1.2 Test No. 4020

$U=0.70$  m/s,  $cc=10D$ ,  $Dir=00$  deg., Tension=300, Stiffness=1065 N/m



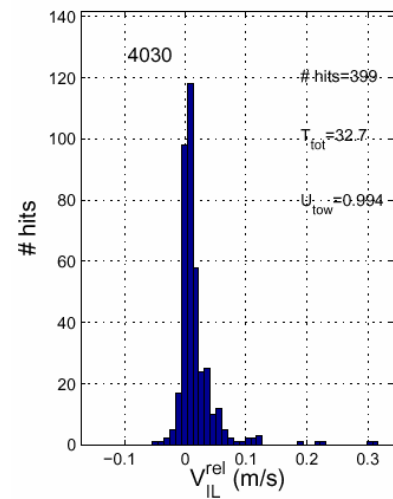
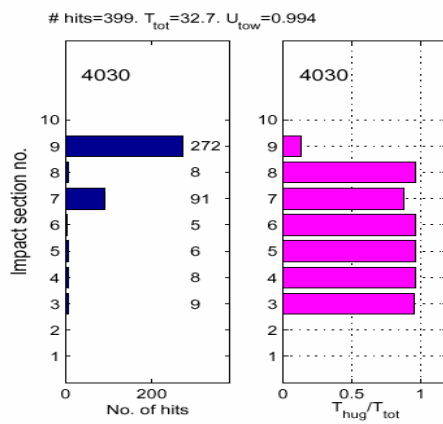
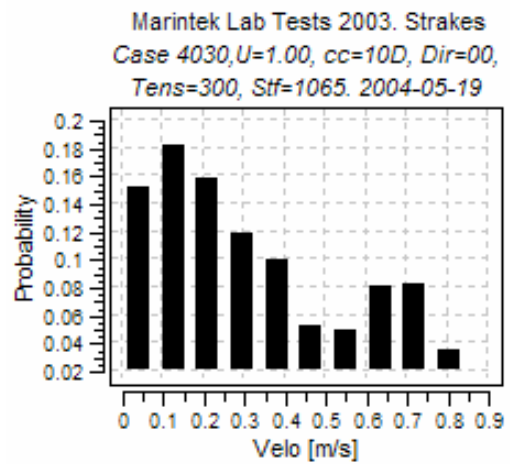
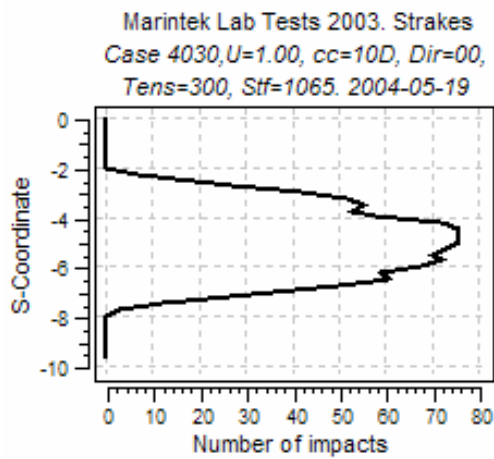
## REPORT

Title: **Verification of the computer code HYBER**

No. :  
Rev. :  
Page : 4 of 15  
Date : August 27 2004

### 2.1.3 Test No. 4030

$U=1.00$  m/s,  $cc=10D$ ,  $Dir=00$  deg., Tension=300, Stiffness=1065 N/m



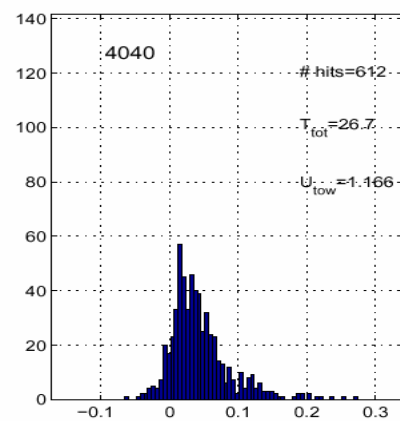
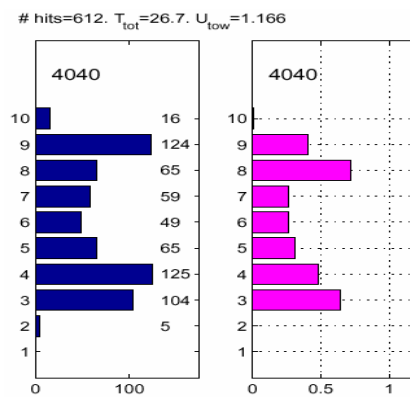
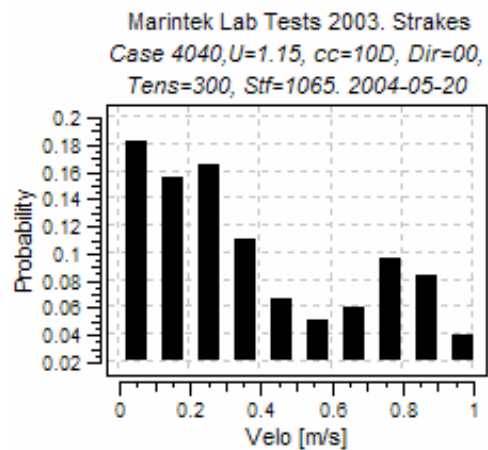
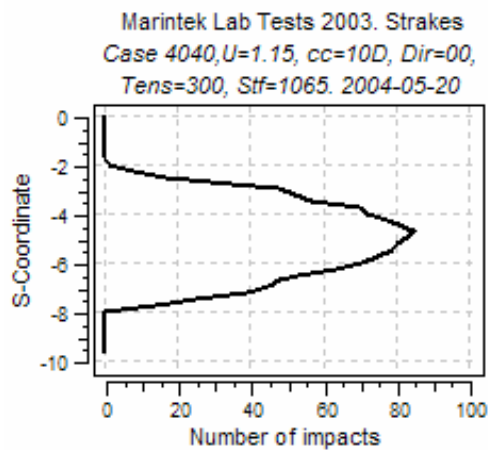
## REPORT

Title: **Verification of the computer code HYBER**

No. :  
Rev. :  
Page : 5 of 15  
Date : August 27 2004

### 2.1.4 Test No. 4040

$U=1.15$  m/s,  $cc=10D$ ,  $Dir=00$  deg., Tension=300, Stiffness=1065 N/m



## REPORT

Title: **Verification of the computer code HYBER**

No. :

Rev. :

Page : 6 of 15

Date : August 27 2004

### 2.1.5 Test No. 4111

U=0.40 m/s, cc=10D, Dir=00 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**

### 2.1.6 Test No. 4120

U=0.70 m/s, cc=10D, Dir=00 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**

### 2.1.7 Test No. 4130

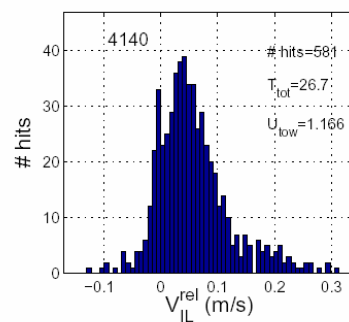
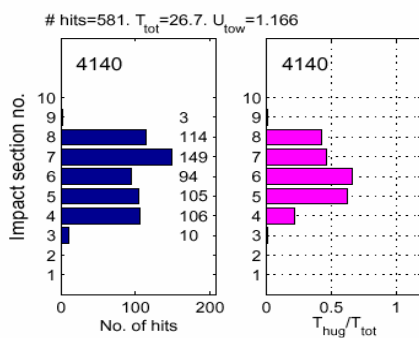
U=1.00 m/s, cc=10D, Dir=00 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**

### 2.1.8 Test No. 4140

U=1.15 m/s, cc=10D, Dir=00 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**



## REPORT

Title: **Verification of the computer code HYBER**

No. :

Rev. :

Page : 7 of 15

Date : August 27 2004

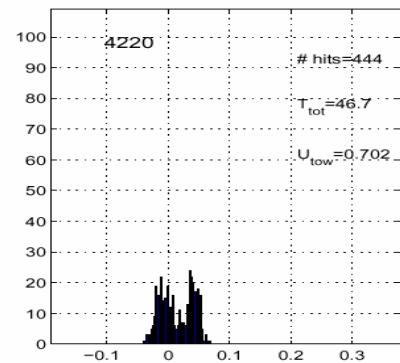
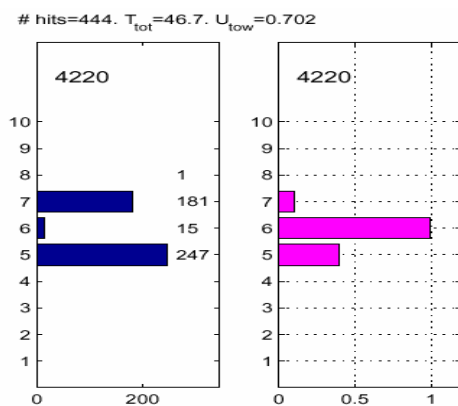
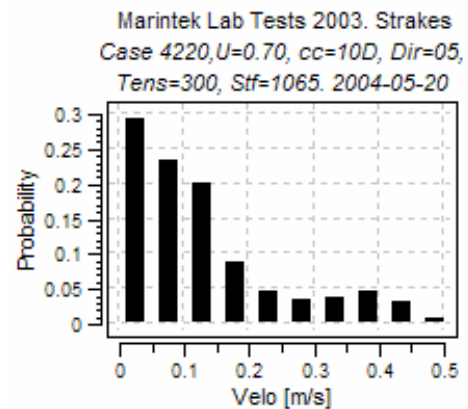
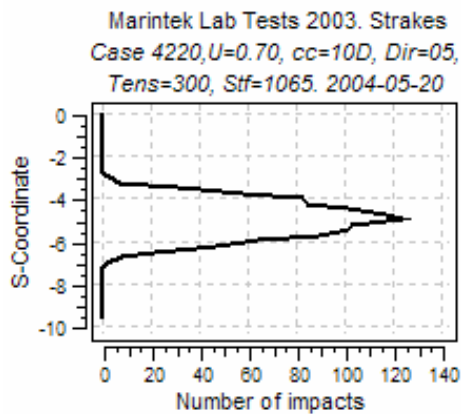
### 2.1.9 Test No. 4210

$U=0.40$  m/s,  $cc=10D$ ,  $Dir=05$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m

No hit

### 2.1.10 Test No. 4220

$U=0.70$  m/s,  $cc=10D$ ,  $Dir=05$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m

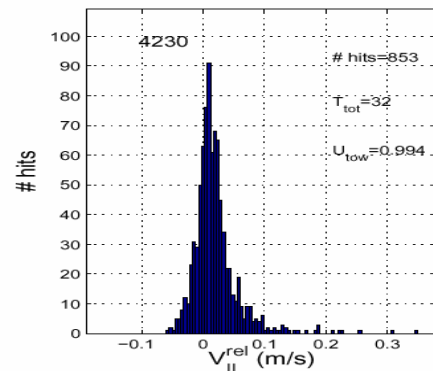
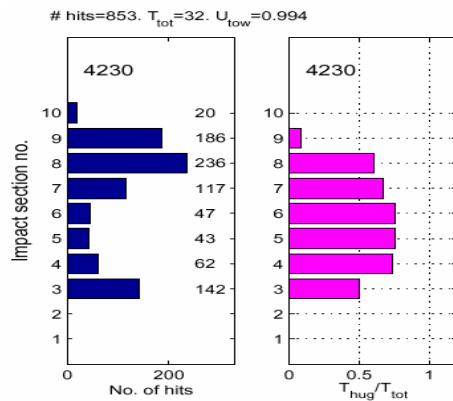
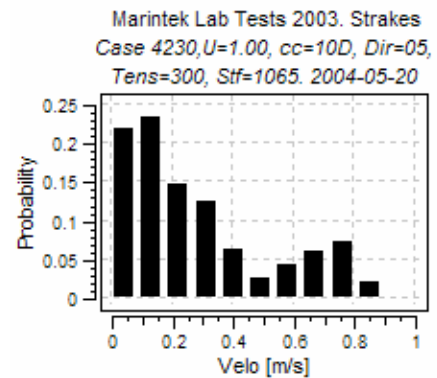
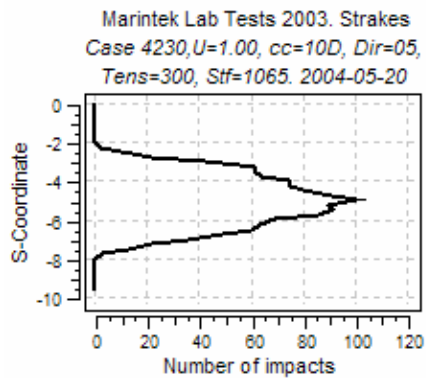


Title: **Verification of the computer code HYBER**

No. :  
Rev. :  
Page : 8 of 15  
Date : August 27 2004

### 2.1.11 Test No. 4230

$U=1.00$  m/s,  $cc=10D$ ,  $Dir=05$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m

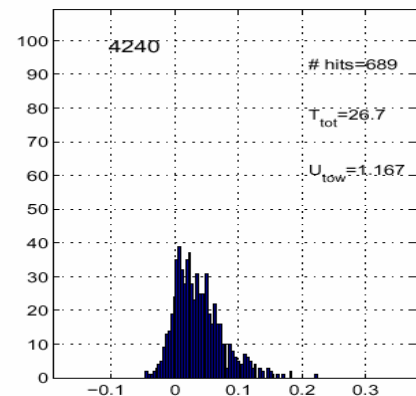
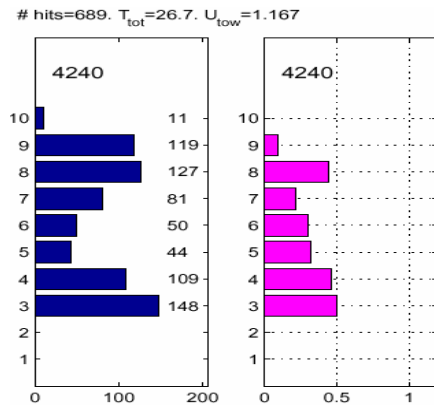
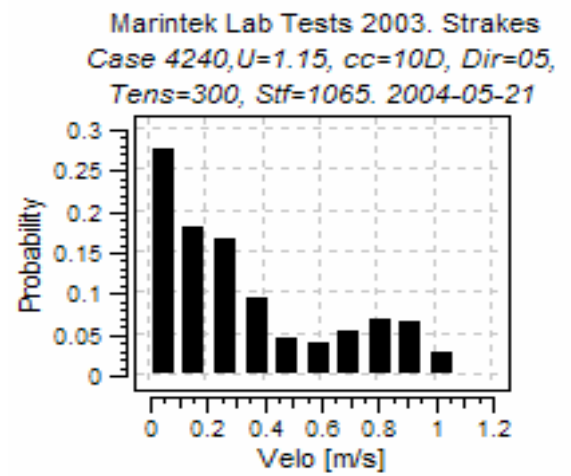
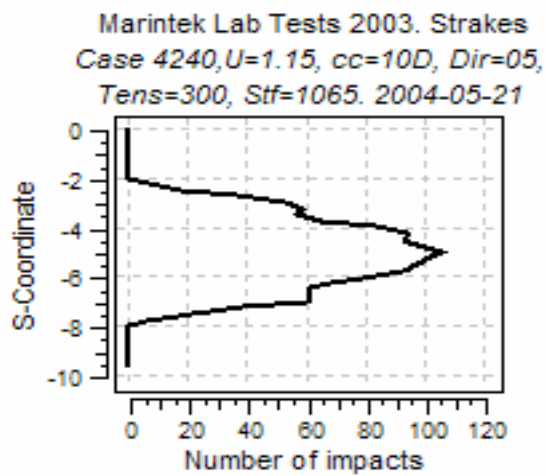


Title: Verification of the computer code HYBER

No. :  
Rev. :  
Page : 9 of 15  
Date : August 27 2004

### 2.1.12 Test No. 4240

$U=1.15$  m/s,  $cc=10D$ ,  $Dir=05$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m



## REPORT

Title: **Verification of the computer code HYBER**

No. :  
Rev. :  
Page : 10 of 15  
Date : August 27 2004

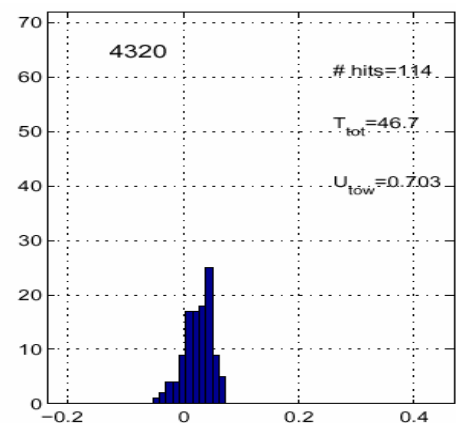
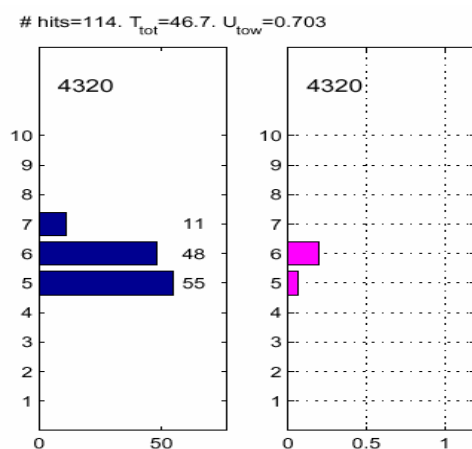
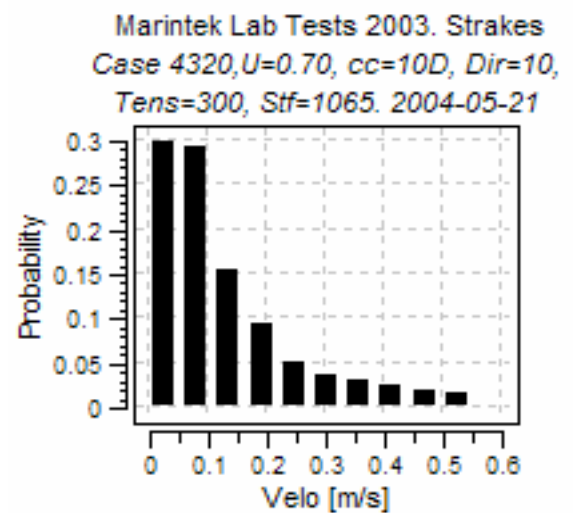
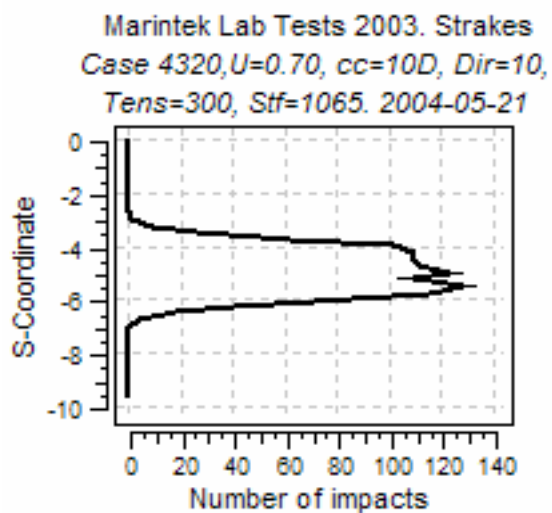
### 2.1.13 Test No. 4310

$U=0.40$  m/s,  $cc=10D$ ,  $Dir=10$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m

**No hit**

### 2.1.14 Test No. 4320

$U=0.70$  m/s,  $cc=10D$ ,  $Dir=10$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m

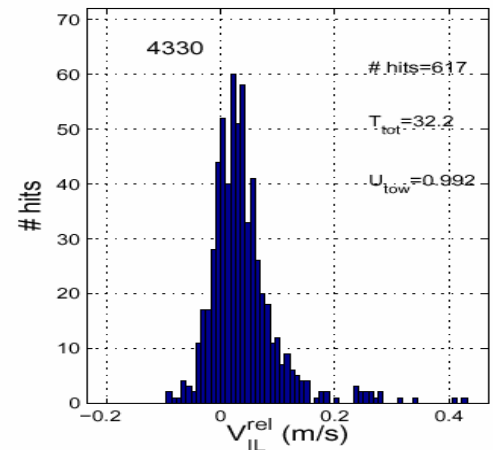
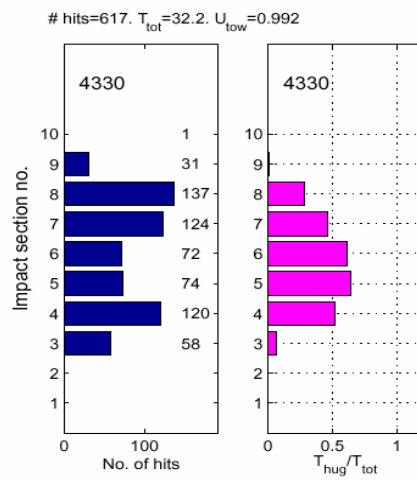
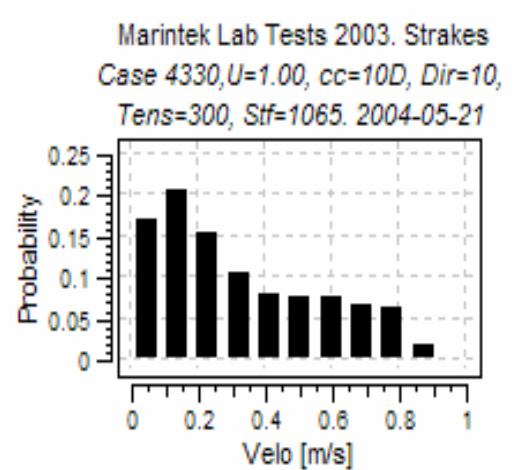
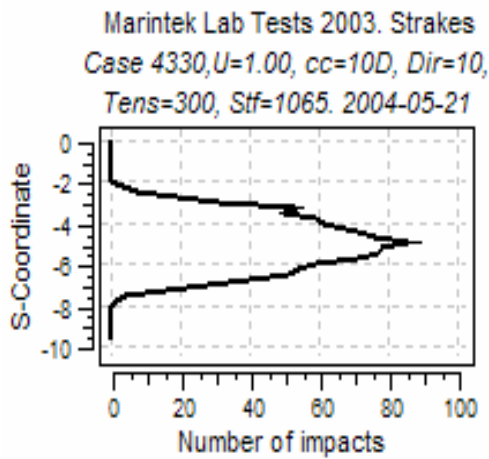


Title: **Verification of the computer code HYBER**

No. :  
 Rev. :  
 Page : 11 of 15  
 Date : August 27 2004

### 2.1.15 Test No. 4330

U=1.00 m/s, cc=10D, Dir=10 deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m

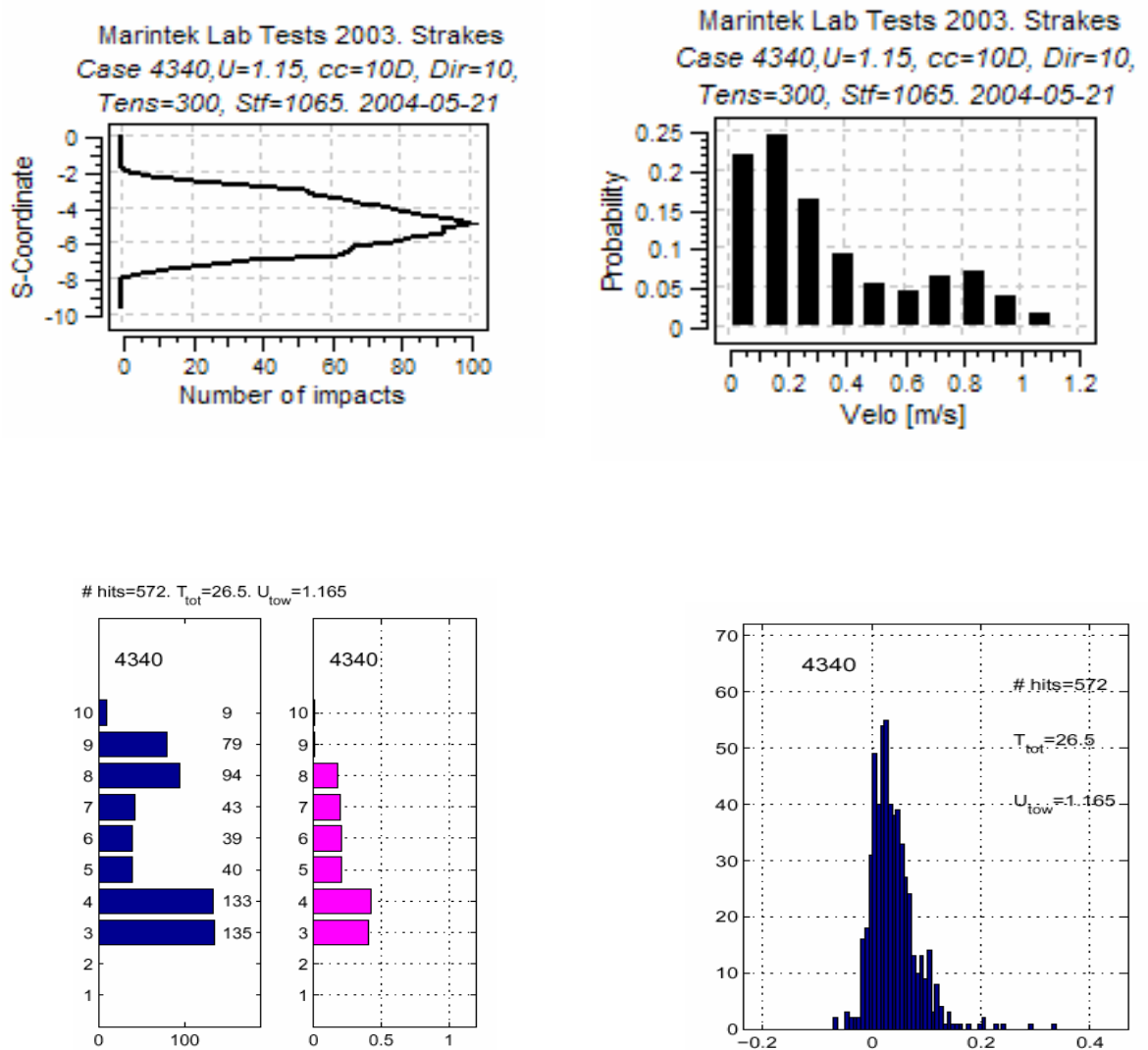


Title: **Verification of the computer code HYBER**

No. :  
 Rev. :  
 Page : 12 of 15  
 Date : August 27 2004

### 2.1.16 Test No. 4340

$U=1.15$  m/s,  $cc=10D$ ,  $Dir=10$  deg., Tension=300 N R1 / 300 N R2, Stiffness=1065 N/m



## REPORT

Title: **Verification of the computer code HYBER**

No. :  
Rev. :  
Page : 13 of 15  
Date : August 27 2004

### 2.1.17 Test No. 4410

U=0.40 m/s, cc=10D, Dir=10 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**

### 2.1.18 Test No. 4420

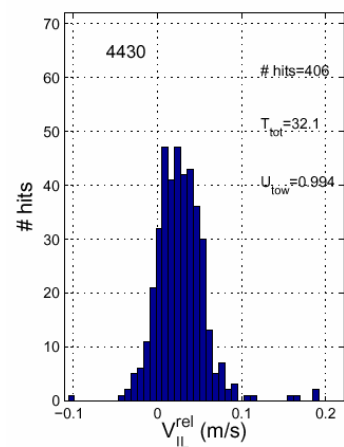
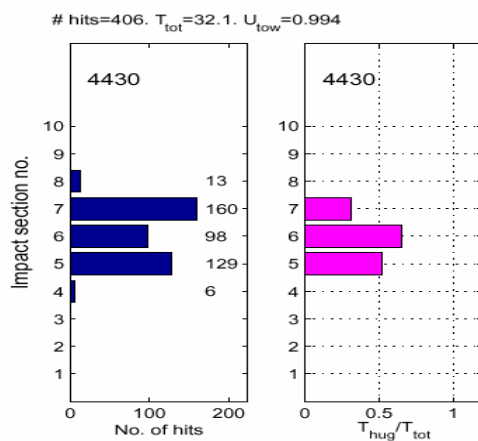
U=0.70 m/s, cc=10D, Dir=10 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**

### 2.1.19 Test No. 4430

U=1.00 m/s, cc=10D, Dir=10 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**



## REPORT

Title: **Verification of the computer code HYBER**

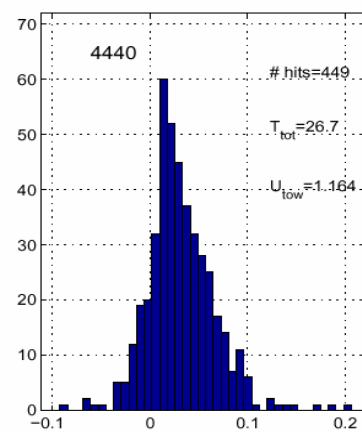
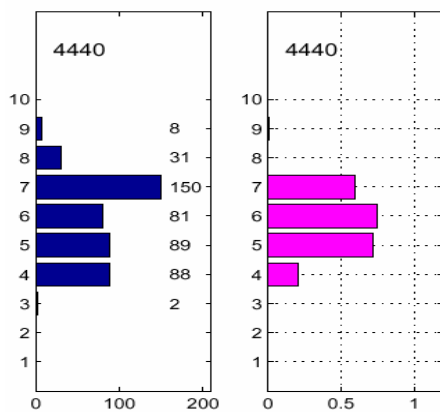
No. :  
Rev. :  
Page : 14 of 15  
Date : August 27 2004

### 2.1.20 Test No. 4440

U=1.15 m/s, cc=10D, Dir=10 deg., Tension=300 N R1 / 200 N R2, Stiffness=1065 N/m

**No hit**

# hits=449.  $T_{tot}=26.7$ .  $U_{tow}=1.164$



## REPORT

Title: **Verification of the computer code HYBER**

No. :

Rev. :

Page : 15 of 15

Date : August 27 2004

### 2.2 Comparison between experiments and computations

| Test No. | Tow velocity m/s | CC spacing top end | CC spacing bottom end | Inflow angle deg. | Top ten. R1 N | Top ten. R2 N | Heave comp. stiff. N/m | Number of hits |       |
|----------|------------------|--------------------|-----------------------|-------------------|---------------|---------------|------------------------|----------------|-------|
|          |                  |                    |                       |                   |               |               |                        | Test           | Comp. |
| 4010     | 0.40             | 10 D               | 10 D                  | 0                 | 300           | 300           | 1065                   | 0              | 0     |
| 4020     | 0.70             | 10 D               | 10 D                  | 0                 | 300           | 300           | 1065                   | 523            | 1250  |
| 4030     | 1.00             | 10 D               | 10 D                  | 0                 | 300           | 300           | 1065                   | 399            | 1254  |
| 4040     | 1.15             | 10 D               | 10 D                  | 0                 | 300           | 300           | 1065                   | 612            | 1448  |
| 4111     | 0.40             | 10 D               | 10 D                  | 0                 | 300           | 200           | 1065                   | 0              | 0     |
| 4120     | 0.70             | 10 D               | 10 D                  | 0                 | 300           | 200           | 1065                   | 0              | 0     |
| 4121     | 0.70             | 10 D               | 10 D                  | 0                 | 300           | 200           | 1065                   | 0              |       |
| 4130     | 1.00             | 10 D               | 10 D                  | 0                 | 300           | 200           | 1065                   | 0              | 0     |
| 4140     | 1.15             | 10 D               | 10 D                  | 0                 | 300           | 200           | 1065                   | 581            | 0     |
| 4210     | 0.40             | 10 D               | 10 D                  | 5                 | 300           | 300           | 1065                   | 0              | 0     |
| 4220     | 0.70             | 10 D               | 10 D                  | 5                 | 300           | 300           | 1065                   | 444            | 1190  |
| 4230     | 1.00             | 10 D               | 10 D                  | 5                 | 300           | 300           | 1065                   | 853            | 1369  |
| 4240     | 1.15             | 10 D               | 10 D                  | 5                 | 300           | 300           | 1065                   | 689            | 1531  |
| 4310     | 0.40             | 10 D               | 10 D                  | 10                | 300           | 300           | 1065                   | 0              | 0     |
| 4320     | 0.70             | 10 D               | 10 D                  | 10                | 300           | 300           | 1065                   | 114            | 1232  |
| 4330     | 1.00             | 10 D               | 10 D                  | 10                | 300           | 300           | 1065                   | 617            | 1200  |
| 4340     | 1.15             | 10 D               | 10 D                  | 10                | 300           | 300           | 1065                   | 572            | 1507  |
| 4410     | 0.40             | 10 D               | 10 D                  | 10                | 300           | 200           | 1065                   | 0              | 0     |
| 4420     | 0.70             | 10 D               | 10 D                  | 10                | 300           | 200           | 1065                   | 0              | 0     |
| 4430     | 1.10             | 10 D               | 10 D                  | 10                | 300           | 200           | 1065                   | 406            | 0     |
| 4440     | 1.15             | 10 D               | 10 D                  | 10                | 300           | 200           | 1065                   | 449            | 0     |