## TEST REPORTS

### LIST OF DOCUMENTS INCLUDED IN THIS SECTION:

| DOCUMENT NUMBER | ISSUE | TITLE |
|---|---|---|
| RICSYS-RP-CGS-022 | 1 | RICH FM VIBRATION TEST REPORT |

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ORIGINALE ARCHIVIO

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# RICH SYSTEM

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| Tipo Doc.: *Doc.Type:* | TEST REPORT | | | N° DRD: *DRD N°:* | NA |
| N° Doc.: *Doc. N°:* | **RICSYS-RP-CGS-022** | Ediz.: *Issue:* **1** | Data: *Date:* **21/12/2007** | Pagina *Page* **1** Di *Of* **76** | |
| Titolo : *Title :* | RICH FM VIBRATION TEST REPORT | | | | |

| | Nome & Funzione *Name & Function* | Firma *Signature* | Data *Date* |
|---|---|---|---|
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| REGISTRAZIONE DELLE MODIFICHE / *CHANGE RECORD* | | | |
|---|---|---|---|
| EDIZIONE<br>*ISSUE* | DATA<br>*DATE* | AUTORIZZAZIONE<br>*CHANGE AUTHORITY* | OGGETTO DELLA MODIFICA E SEZIONI AFFETTE<br>*REASON FOR CHANGE AND AFFECTED SECTIONS* |
| 1 | 21/12/2007 | | First emission |
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# 1. SCOPE

This document contains the results of the RICH SYSTEM Flight model (FM) vibration test executed in the INTA facility in 09-11/10/2007 (test setup), 15-19/10/2007 (test setup, RICH SYSTEM vibration test X and Y completed and Z direction stopped opening the NCR) and 10-13/12/2007 (test setup, RICH SYSTEM vibration test Z completed closing the NCR)
The test has been performed according to test procedure AD1.
Details of test setup and results are contained in ANNEX 1 (INTA facility test report).
Test conclusions and comments are summarized in chp 21 and 22.

# 2. DOCUMENTS

## 2.1 APPLICABLE DOCUMENTS

| AD # | Doc Number | Issue | Date | Rev | Title |
|---|---|---|---|---|---|
| AD 1 | RICSYS-PR-CGS-007 | 3 | 20/08/2007 | | RICH FM VIBRATION TEST PROCEDURE |

## 2.2 REFERENCE DOCUMENTS

| # | Doc Number | Issue | Date | Rev | Title |
|---|---|---|---|---|---|
| RD 1 | RICSYS-RP-CGS-009 | 2 | 09-11-2005 | | RICH STRUCTURAL ANALYSIS REPORT |
| RD 2 | RICHSYS-TN-CGS-005 | 1 | July 2007 | | RICH SYSTEM SINGLE GRID X CORRELATION REPORT AND RVT PRELIMIARY PREDICTIONS |
| RD 3 | RICHSYS-TN-CGS-006 | 1 | Aug 2007 | | RICH SYSTEM RANDOM VIBRATION TEST PREDICTIONS |
| RD 4 | JSC 28792 | | August 2003 | Rev. C | Alpha Magnetic Spectrometer – 02 Structural Verification Plan for the Space Transportation System and the International Space Station |
| | | | | | |
| | | | | | |
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# 3. ACRONYMS

| | |
|---|---|
| A.D. | APPLICABLE DOCUMENTS |
| FEM | FINITE ELEMENT MODEL |
| FM | FLIGHT MODEL |
| I/F | INTERFACE |
| MEFL | MAXIMUM EXPECTED FLIGHT LEVEL |
| QM | QUALIFICATION MODEL |
| R.D. | REFERENCE DOCUMENTS |
| UUT | UNIT UNDER TEST |

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## 4. TESTED ITEMS

Tested item, called UUT is:

| MODEL | ITEM | C.I. | Drawing Number/Part Number | S/N | NOTES |
|---|---|---|---|---|---|
| FM | RICH-SYSTEM | RICH-FM01 | 10-RICSYS-00.000 | FM01 | |

The agreed test configuration with INFN is composed by the following sub-items:
CGS tested Hardware :

- Main structure (FM)
- Secondary structure (FM)
- Mirror (FM)
- TCS components (heaters an thermostats FM)

INFN tested Hardware:

- Assembled PMT grids (FM)
- Electronics (FM)
- Harness (FM+dummies)
- Debris shielding (FM)

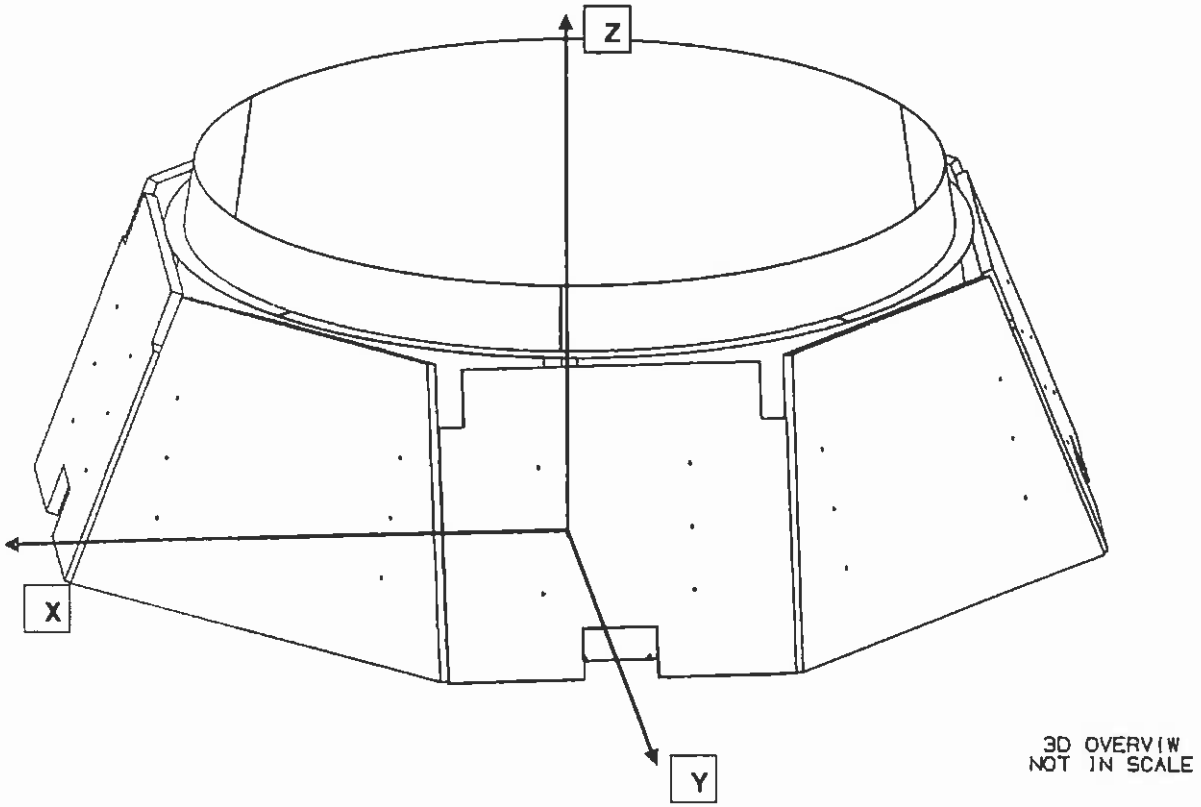


*Figure 4-1: Model of the UUT*

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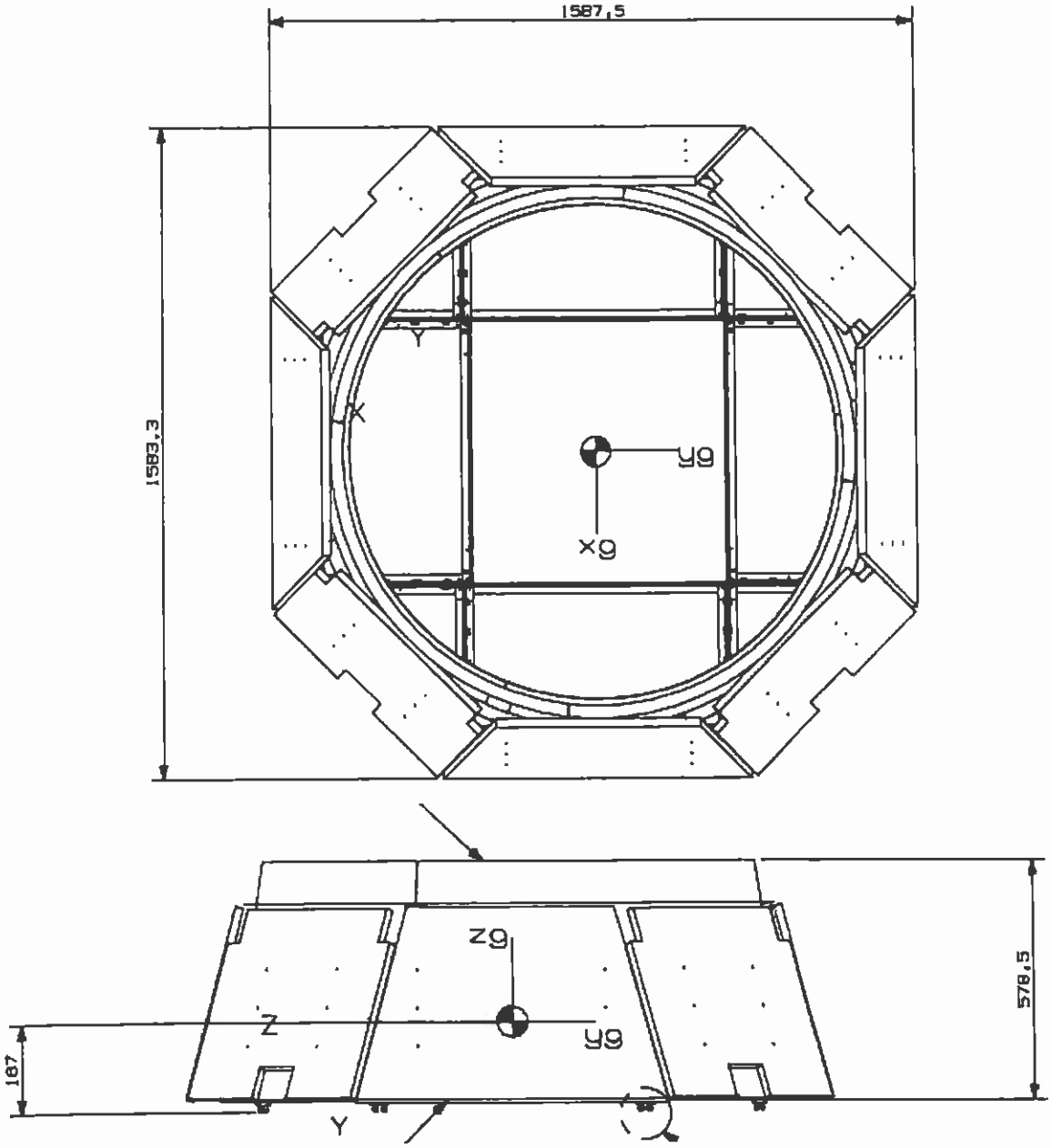


*Figure 4-2: UUT DIMENSIONS*

For the UUT, mass property and envelope are:

Mass: 179.9Kg (+\-10%)
Dimension: 1405mm length, 1410mm width and 619.4mm height

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## 5. TEST OBJECTIVE

This test is required to demonstrate the unit to withstand the MEFL, to verify the absence of material-workmanship defects.
The UUT has been subjected to a visual inspection before and after test.
Functional check has been performed before and after test campaign by the AMS-02 collaboration.
THE UUT HAS BEEN POWERED OFF DURING VIBRATION.

## 6. TEST PARTICIPANTS AND RESPONSABILITIES

The test has been attended by :

| NAME | COMPANY\INSTITUTE | ROLE | RESPONSABILITY |
|---|---|---|---|
| A.Bursi<br>M.Olivier | CGS | Test conductor | - Test conduction<br>- Compilation of Step by step procedure<br>- PA\QA management |
| G. Laurenti | INFN | Customer | - Test supervisor |
| C. D. Grinzo | CIEMAT | Test Engineer | - UUT transportation and integration<br>- Support to Facility manager for integration of UUT on fixture<br>- Support to test conductor |
| A. Hurtado | INTA | Facility test manager | Facility management and interface to Test Conductor |

*Tab. 6-1 RICH vibration test participants and responsibility.*

## 7. TEST SCHEDULE

| DATE | ACTIVITY DESCRIPTION | REMARKS |
|---|---|---|
| 08/10/2007 | RICH functional test after transportation | |
| 09/10/2007 | RICH accelerometers installation and test setup preparation started | |
| 10/10/2007 | Test setup preparation completed and first resonance search in X direction performed | |
| 11/10/2007 | X axis test up to the full level input (notching is required) | |
| 15/10/2007 | X axis test completed.<br>Functional test after vibration performed, Y axis test started. | |
| 16/10/2007 | Y axis test completed.<br>Functional test after vibration performed | |
| 17/10/2007 | Z axis test setup preparation | |
| 18/10/2007 | Z axis test started | |
| 19/10/2007 | Z axis test stopped after the detection of an high amplification level on PMTs grids. Additional runs have been performed to collect more data as possible to investigate the phenomenon (low level sine sweep not overstressed the structure.) | NCR-RICHSYS-CGS-C-020 Is 2 |
| 22/10/2007 | Final investigation performed changing the control system shape. | Annex A to NCR |
| 10/12/2007 | Z axis test resumed. Functional test performed after the detector transportation, a fixture unloaded resonance search has been performed | |
| 11/12/2007 | RICH accelerometers installation and test setup preparation | |
| 12/12/2007 | Z axis test started | |
| 13/12/2007 | Z axis test completed | NCR-RICHSYS-CGS-C-020 Is 2 closed |

Tab. 7-1 RICH vibration test schedule

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# 8. FACILITY DESCRIPTION

The vibration tests shall be executed at INTA (Madrid) external laboratory in a proper area.

## 8.1 TEST SETUP (SHAKER AND SLIDING TABLE)

For Z direction vibration a shaker shall be used, for X and Y direction a sliding table shall be used.
The shaker and sliding table characteristics shall be annexed to the test data report as provided by the test laboratory.

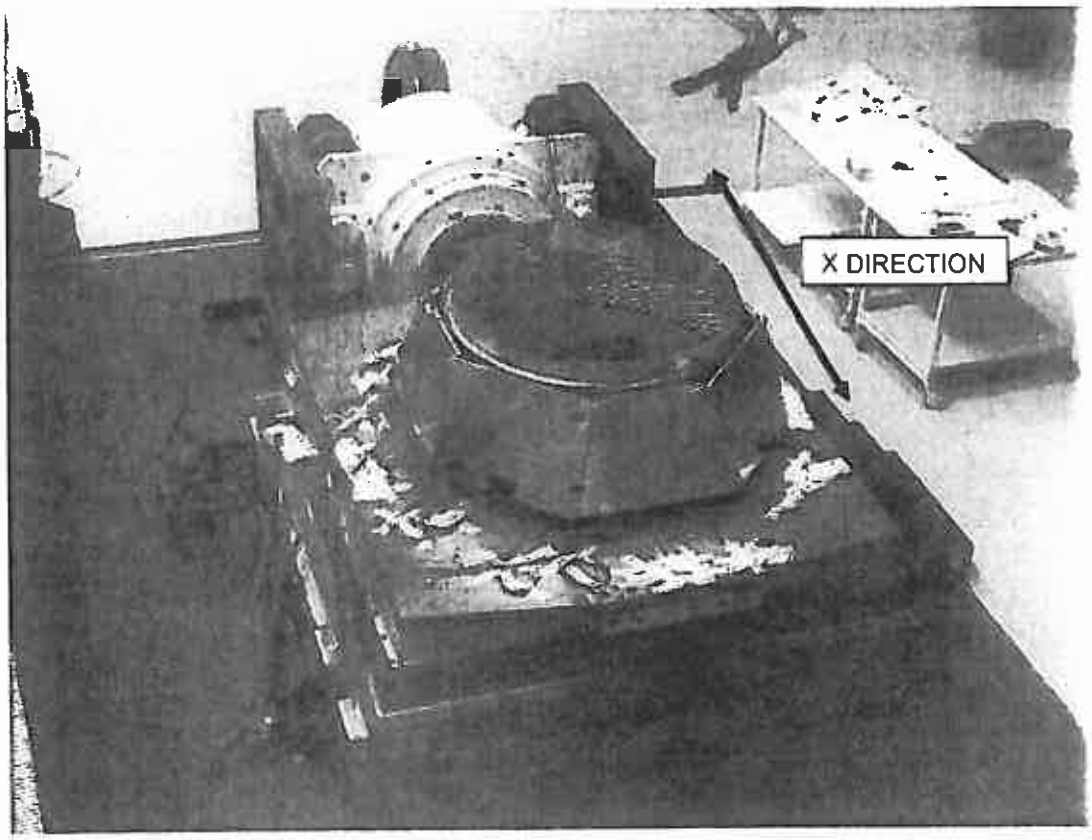


*Figure 8-1: Shaker in position for the X directions of test*

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*Figure 8-2: Shaker in position for the Y directions of test*

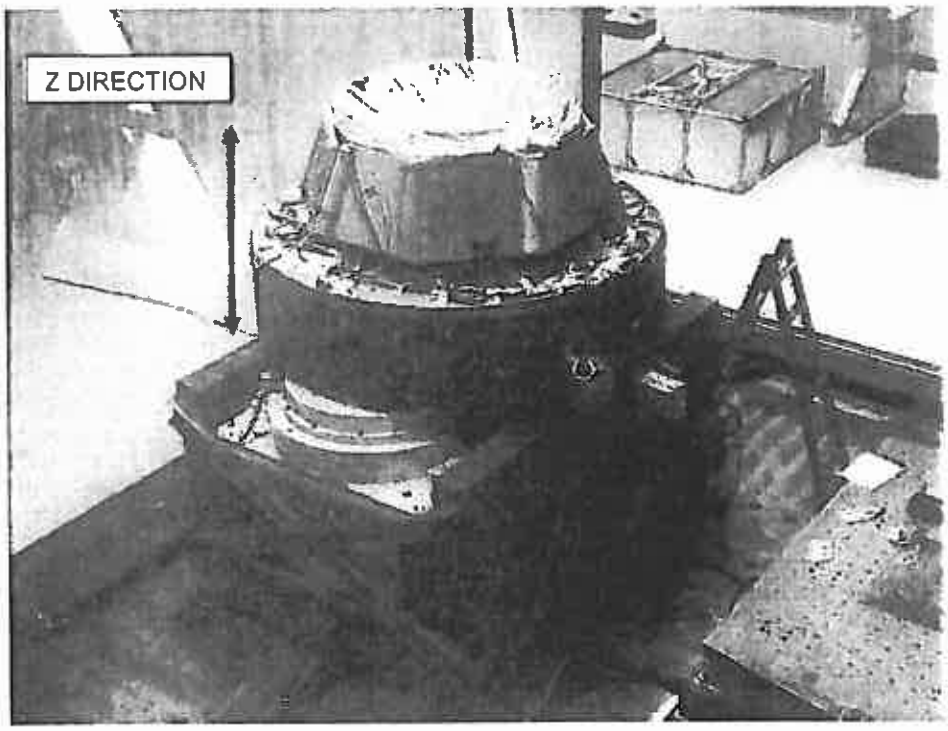


*Figure 8-3: Shaker in position for the Z direction of test*

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## 8.2 FIXTURE CHARACTERISTICS

The test adapter is designed to guarantee that the input vibration levels are transmitted from the exciter to the UUT without relevant amplification/degradation.
Moreover the selected design allow to install the RICH on the shaker without dismounting the reflector between one axis and the other. I
The picture of the fixture is shown in Figure 8-4, and the RICH I\F pattern is shown in Figure 8-6.

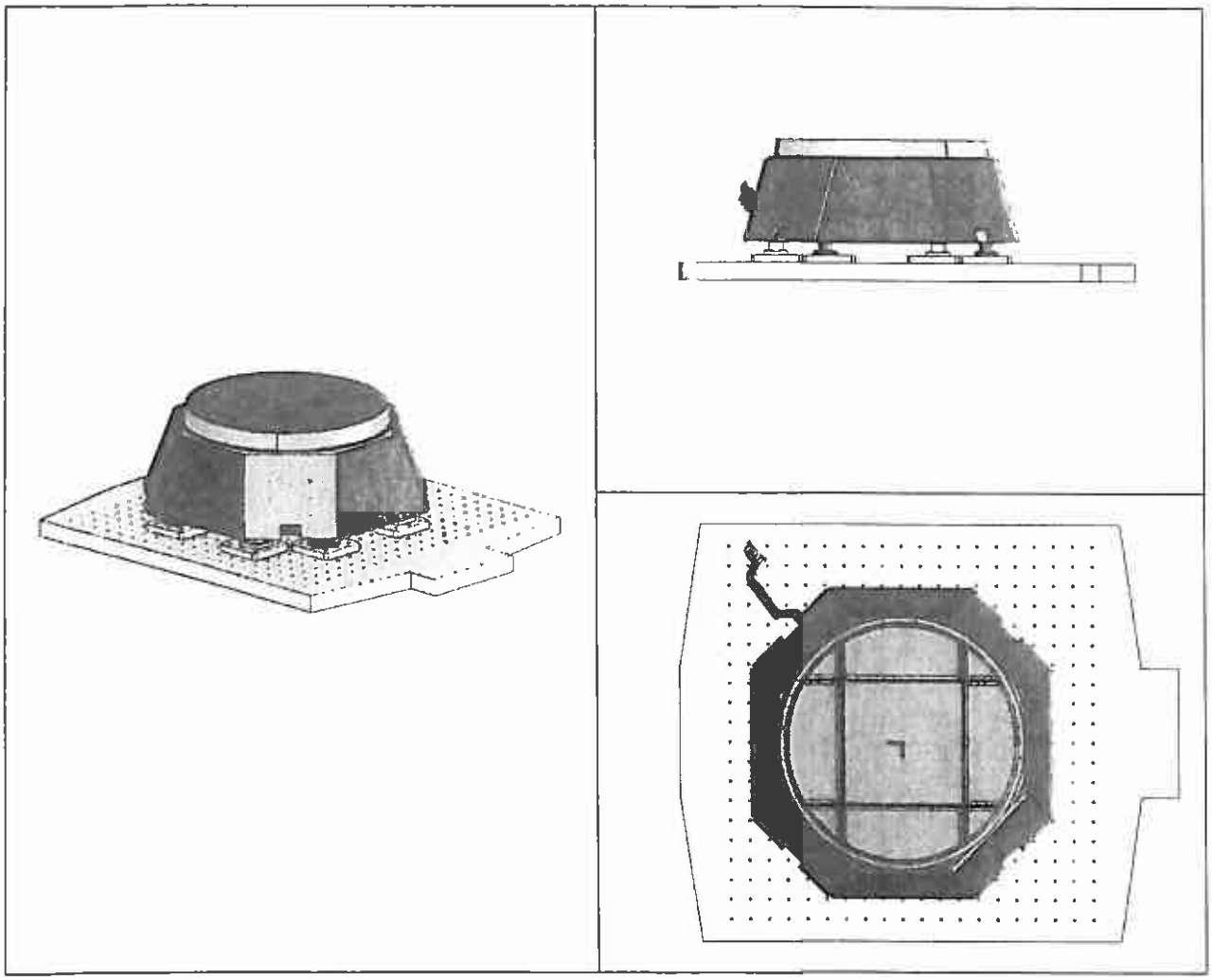

*Figure 8-4: Fixture Design*

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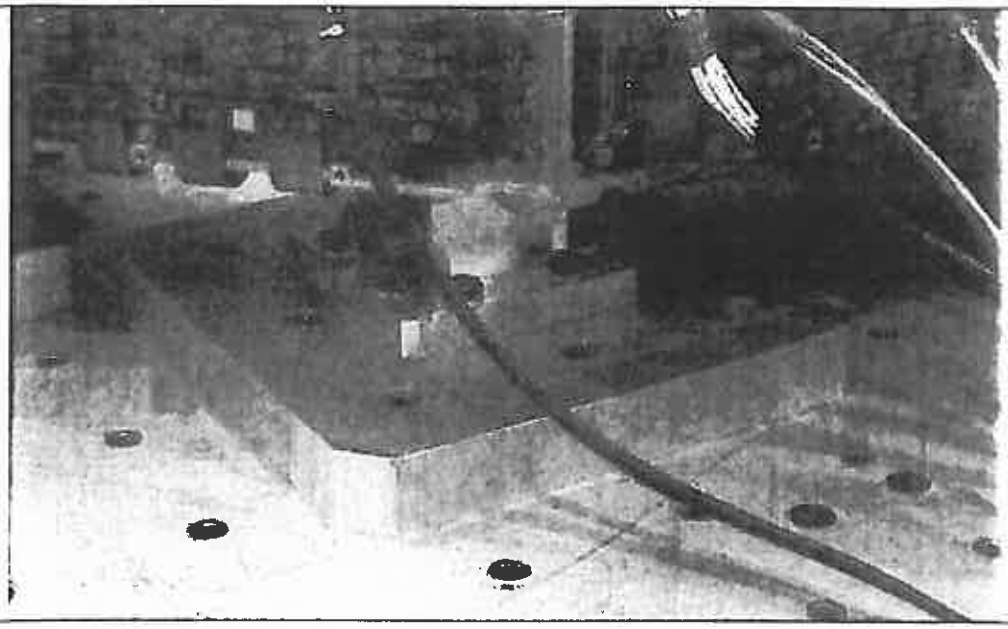

*Figure 8-5: Fixation point detail*

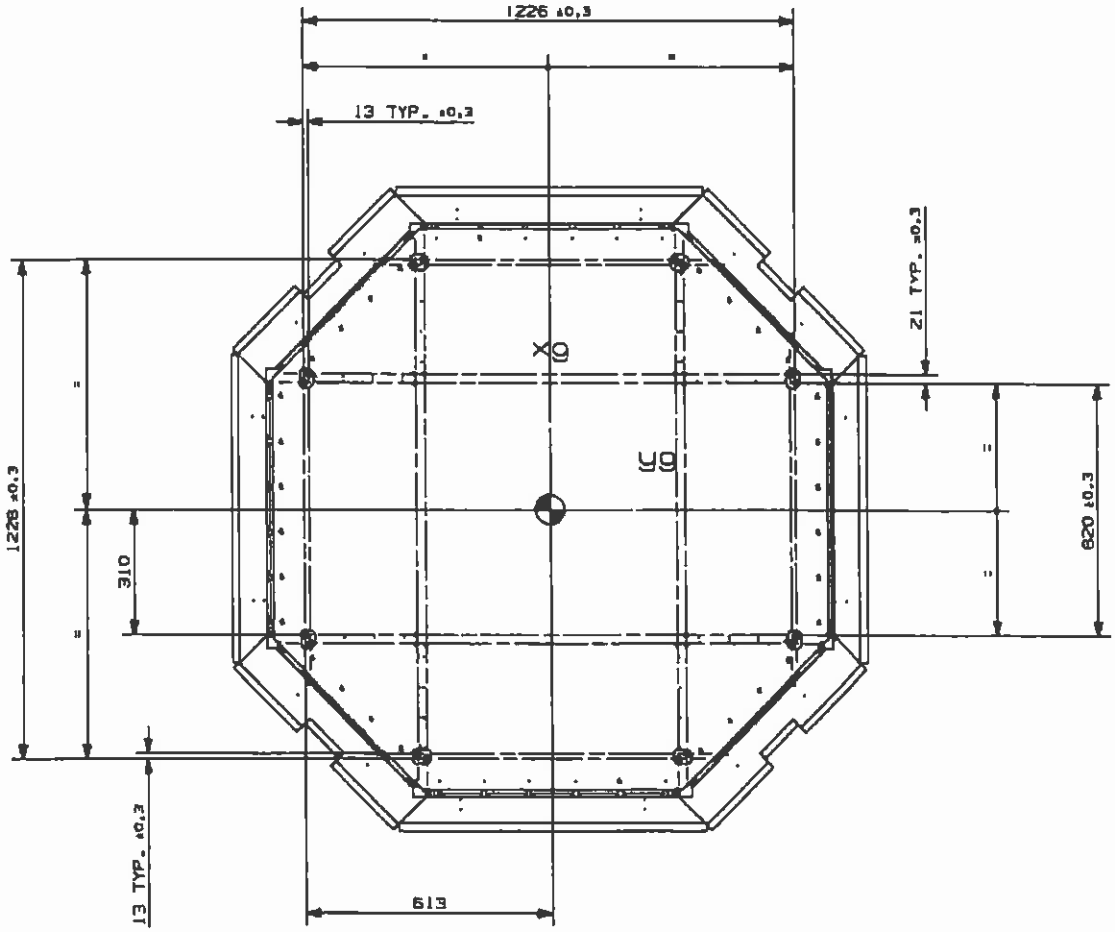


*Figure 8-6: RICH- Fixture I\F Pattern*

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Threaded inserts for NAS 1351-5 bolts shall be used.

Threaded inserts length shall be 2d minimum.

## 8.3 ACCELEROMETER CHARACTERISTICS

The accelerometer characteristics have been annexed to the test data report provided by the test laboratory.

# 9. TEST CONDITIONS

The UUT shall be mounted on the vibrator exciter by bolting it onto a rigid fixture in launch configuration.

The transmissibility characteristic of the rigid fixture will guarantee that the input vibration levels are transmitted from the exciter to the unit without relevant amplification/degradation (Table 11-1).

The UUT shall be powered OFF for all the test duration.

Unless otherwise specified, all the measurements are to be performed at the following ambient conditions:

| | |
|---|---|
| Temperature: | 20℃ ±5℃ |
| Relative humidity: | 60% ±20% RH |
| Pressure: | Ambient |
| Cleanliness | Visibly clean |

# 10.TEST RESPONSIBILITY

CGS is responsible for the application of all requirements stated in the applicable documents.

The technical responsibilities for testing and test results is of the Engineering department.
Project and test managers are responsible for the test program. The test engineer is responsible for the correct execution of the test program and for the fulfillment of the requirements, for measurement and recording and for the preparation of the test report.

Laboratories General disposition has been applied to maximize personnel safety from potential hazards.

INFN skilled personnel provided support to handling and UUT preparation and was responsible for the INFN provided hardware under test ( see chp 4 ).

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# 11.SUCCESS CRITERIA

## 11.1 MECHANICAL CRITERIA

The random vibration tests shall be performed in the following way (for each axis):

| *FM* | ***SUCCESS CRITERIA*** |
|---|---|
| Fixture calibration | The transmissibility characteristic of the rigid fixture will guarantee that the input vibration levels are transmitted from the exciter to the unil without relevant amplification/degradation (less than 3dB between 5 and 500 Hz and ± 6 dB between 500 and 2000 dB). |
| Resonance search before random vibration | No relevant amplification below 50Hz |
| Random vibration level | No structural yielding or failure |
| Resonance search after random vibration | No relevant differences with respect to the previously recorded sine resonance search data (15% on frequency shift, 30% on amplitude) |

*Table 11-1: Success criteria*

Functional tests shall be carried out before and after the overall vibration test campaign.

## 11.2 FUNCTIONAL CRITERIA

Functional tests have been carried out before and after the overall vibration test campaign by collaboration personnel.
The flow chart (see chapter 18) highlights that a functional test has been performed at CIEMAT (Madrid); afterwards, the UUT has been the transported to the vibration test site, where the presence of the documentation stating the results of the functional test has been checked and noted in the "step by step" RICH FM VIBRATION TEST REPORT; this was the required input to start with the vibration test.
After the vibration test, whose mechanical success criteria has been defined in the previous paragraph, the UUT has been transported to the aforementioned collaboration site, where the second functional test has been performed.
The success criteria for this test is the following one:

| | |
|---|---|
| Functional test | No more than 2% of RICH detector PMTs damaged after vibration test |

*Table 11-2: Functional success criteria*

A report of this test, stating the result about the aforementioned criteria, will be sent to CGS by the collaboration personnel.

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# 12.OPERATIONAL RESTRICTIONS

All used instruments met the necessary accuracy and not degraded the UUT performance.

## 12.1 RICH HANDLING

- Lifting and handling of the RICH have been performed under supervision of INFN\AMS-02 Collaboration responsible using dedicated hoisting fixtures.
- Latex gloves have been used.
- All the assembly activities related to the mirror and debris installation have been performed by skilled collaboration personnel and CGS personnel.
- Alcohol and other volatile solvents weren't used near to the RICH for sensitivity of the used materials of the light guides.
- The Light guides and mirror have been protected between one vibration run and the other covering the UUT.
- Adequate protection means for contamination during operations in the vibration Facility have been provided by the Collaboration

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## 12.2 RICH HOISTING FIXTURE

The following dedicated hoisting fixture shall be used to handle the RICH during vibration test session:

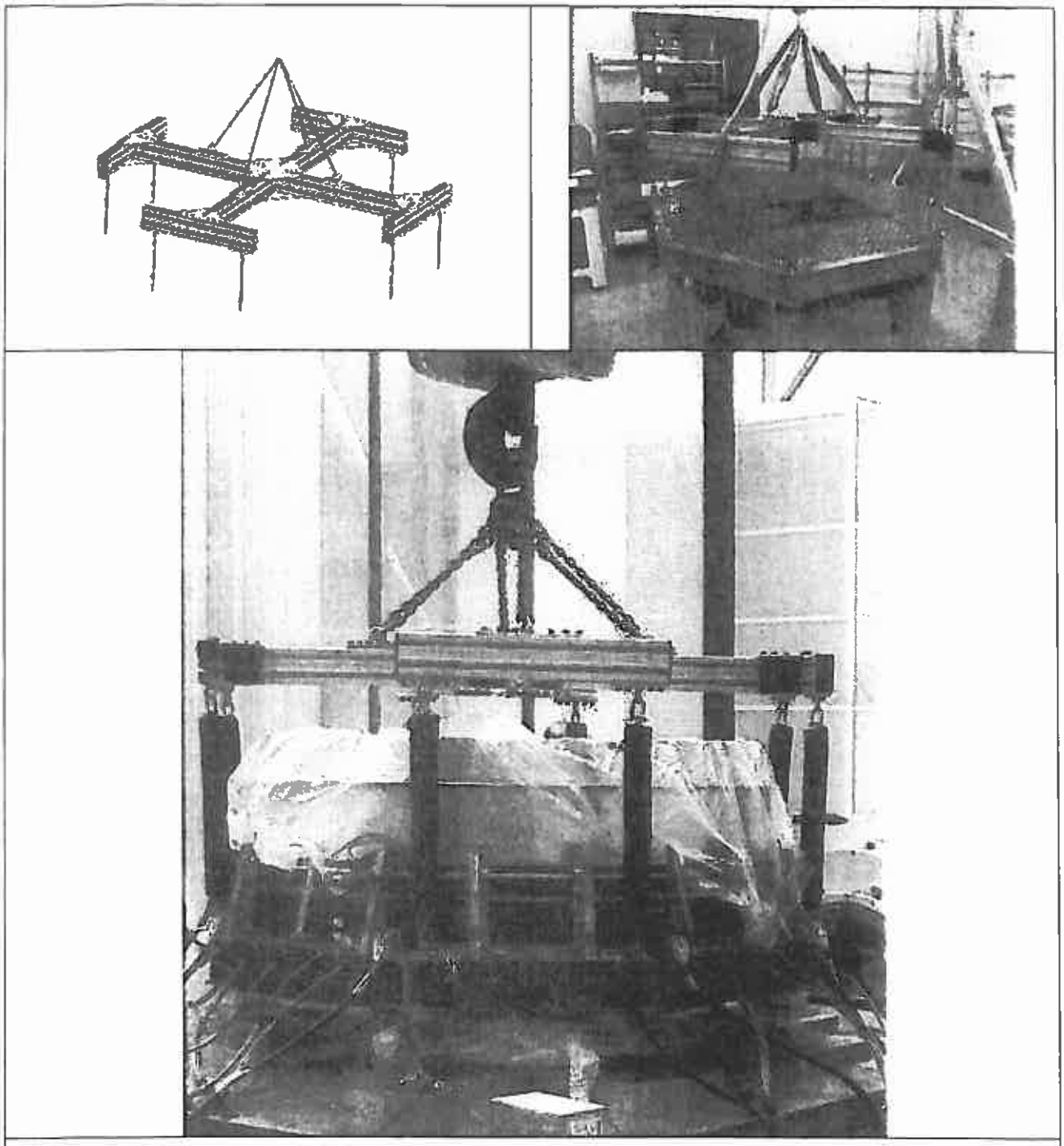

*Figure 12-1: Rich hoisting fixture*

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# 13.PARTICIPANTS REQUIRED

## 13.1 GENERAL

All tests have been performed under QA surveillance in accordance with and following detailed procedure of CGS PA Plan.

Skilled personnel has been employed.

The test has been notified to the Customer as applicable.

## 13.2 QA WITNESS OF TESTS AND SIGN-OFF

QA delegate witnessed all tests described in this procedure and signed the test data sheet.

# 14.NON-CONFORMANCE AND FAILURES

During the first low level random (- 12 dB) along the Z axis ( step 4.2.z of RICSYS-PR-CGS-007 issue. 3) of the RICH FM Vibration test , it has been noticed that the response of some unit measurements points of the PMTs grids is higher than predicted (at -12 dB the lower skin maximum $g_{RMS}$ level was 6.4).
In order to preserve the UUT and to perform additional investigation the test has been stopped.

The investigation result is reported in the NCR-RICHSYS-CGS-C-020 Is 2 and the conclusion is that the test setup is the responsible of the higher amplification than the prediction; in particular the input at RICH interface was higher than the desired one.
By increasing the control point number (FROM 2 TO 4 CPs) the input was well controlled and the unexpected amplifications have been eliminated.
An additional NCR results is an updated notching strategy for the RICH PMTs. In particular the acceptable maximum $g_{rms}$ level on lower skin is 6.8 $g_{rms}$..
The NCR outputs are described in the PVS 5-13.

# 15.CALIBRATION REQUIREMENTS

All instruments used for testing have been calibrated.
Evidence of certification was provided by a label attached to the instruments itself, showing the calibration date, the expire date and the signature of the operator.

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## 16.MEASUREMENT ACCURACY

Test parameter tolerances shall be as follows:

Resonance search.

sweep rate = 2 oct/min ±5%. (1 sweep-up and down ), amplitude g

Random vibration.

frequency: ±2%

power spectral density:

| | |
|---|---|
| - 20 to 500 Hz (filter bandwidth 25 Hz or narrower) | ±1.5 dB |
| - 500 to 2000 Hz | ±3.0 dB |
| - Overall $g_{RMS}$ | ±1.5 dB |

## 17.TEST PROCEDURE VARIATION SHEET

The 14 performed PVS are collected here follow.

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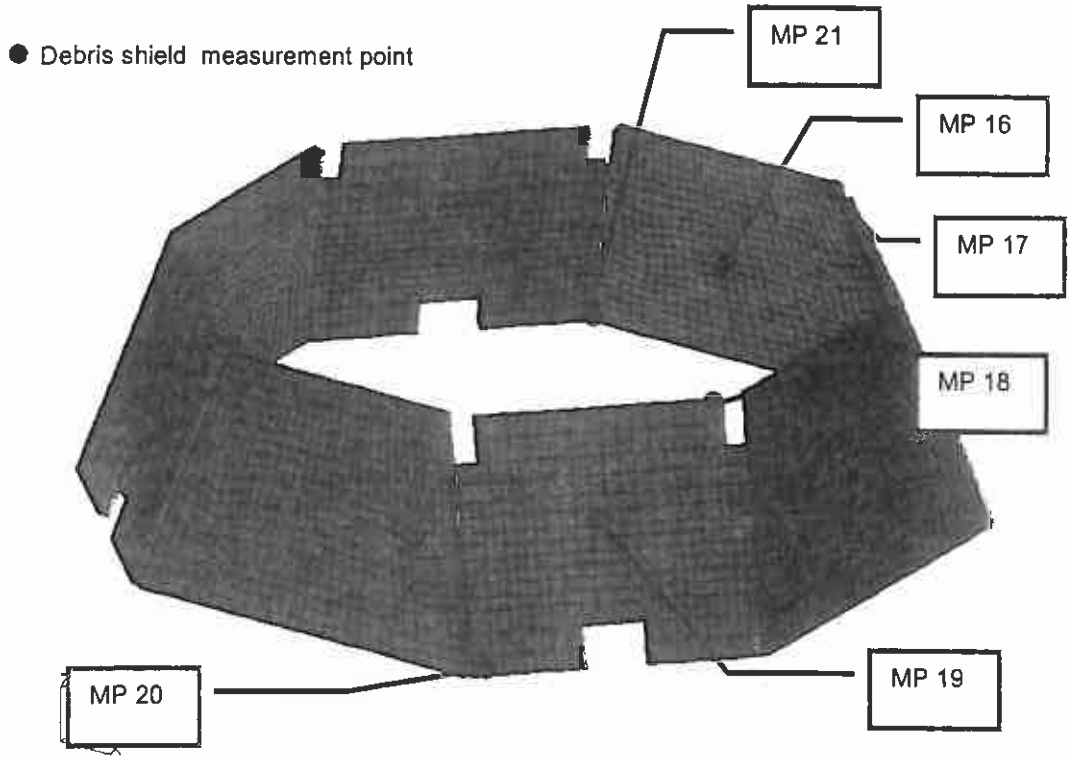
## 17.1 PVS 1

**PROCEDURE VARIATION SHEET ref. N°1 (page 1 of 2 )**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | 27 | 18 |

Description of Change: Debris Shield Accelerometer Position Modification
The foreseen accelerometer position on the RICH debris shield was:




Where:

| SENSOR | LOCATION DESCRIPTION | MEASURED AXIS | REMARKS |
|---|---|---|---|
| MP 16-21 | UUT – debris shields | X, Y and Z | |

*Table 17-1: Debris Shields accelerometers previous position.*

**CONCURRENCE**

| Test Conductor<br>M. Olivier | QA | System Eng | | Customer |
|---|---|---|---|---|
| Date 09/10/07 | Date 09.10.07 | Date 9/10/07 | | Date |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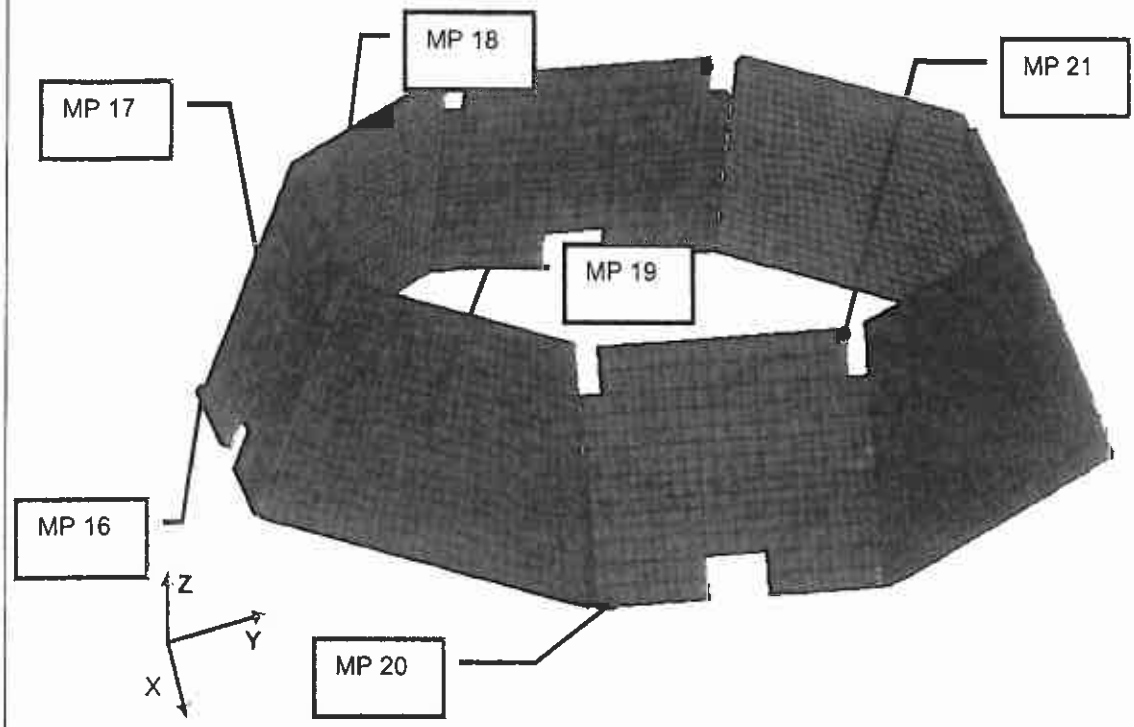
## PROCEDURE VARIATION SHEET ref. N°1 (page 2 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | 27 | 18 |

Description of Change: Debris Shield Accelerometer Position Modification




Where:

| SENSOR | LOCATION DESCRIPTION | MEASURED AXIS | REMARKS |
|---|---|---|---|
| MP 16-18 | UUT – debris shields | Y | |
| MP 19 | UUT – debris shields | Out-off axis (XY) | |
| MP 20-21 | UUT – debris shields | X | |

*Table 17-2: Debris Shields accelerometers used position.*

Reason for Change:
No enough channels were available in INTA, therefore new positions have been identified in order to guarantee relevant data acquisition during the test.

**CONCURRENCE**

| Test Conductor<br>M. Olivier | QA | System Eng | | Customer |
|---|---|---|---|---|
| Date 09/10/07 | Date 23.10.07 | Date 9/10/07 | | Date |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## 17.2 PVS 2

**PROCEDURE VARIATION SHEET ref. N°.2 (page 1 of 2 )**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Steps: 2.2.1-3.2.1 | 21 |

Description of Change: Additional Runs
Additional low level vibration tests were added for X and Y axes before the full level vibration test.

**X direction.**
The following tables report the added steps:

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 2.2.1 B1 | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-9dB) | OK | OK | |
| 2.2.1 B2 | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 2.2.1 B3 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK<br>gRMS OK | Freq. OK<br>gRMS OK | The gRMS extrapolated value for the full on grid (near the PMTs) is high. If the next low level confirms this trend notching has to be performed for the full level |
| 2.2.1 C1 | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-6dB) | OK | OK | |
| 2.2.1 C2 | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 2.2.1 C3 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK<br>gRMS OK | Freq. OK<br>gRMS OK | The acceleration trend on PMTs observed at -9dB is confirmed. |

After these additional steps the test procedure has been resumed at step 2.2.2.

**CONCURRENCE**

| Test Conductor<br>M. Olivier | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 11-16/10/07 | Date 16.10.07 | Date 16/10/07 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°.2 (page 2 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Steps: 2.2.1-3.2.1 | 21 |

Description of Change: Additional Runs
**Y direction.**
The following tables report the added steps:

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 3.2.1 B1 | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-9dB) | OK | OK | |
| 3.2.1 B2 | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 3.2.1 B3 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK<br>gRMS OK | Freq. OK<br>gRMS OK | The gRMS extrapolated value for the full on grid (near the PMTs) is high. If the next low level confirms this trend notching has to be performed for the full level |
| 3.2.1 C1 | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-6dB) | OK | OK | |
| 3.2.1 C2 | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 3.2.1 C3 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK<br>gRMS OK | Freq. OK<br>gRMS OK | The acceleration trend on PMTs observed at -9dB is confirmed. |

After these additional steps the test procedure has been resumed at step 3.2.2.

Reason for Change:
INFN asked to add the low level runs in order to be careful and to better characterize the RICH behavior considering a low energy input.

### CONCURRENCE

| Test Conductor | QA | System Eng. | | Customer |
|---|---|---|---|---|
| A. Bursi | | | | |
| Date 11-16/10/07 | Date 16. 10. 07 | Date 16/10/07 | | Date |

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## 17.3 PVS 3

**PROCEDURE VARIATION SHEET ref. N°3 (page 1 of 2 )**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test levels | Pg. 19 | 17.1 |

Description of Change: RICH qualification test level modification X direction
The X direction random vibration full level was notched according to INFN.
In particular the vibration level was the MEFL:

| MEFL X Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.0025 |
| 58 | 0.0025 |
| 125 | 0.025 |
| 300 | 0.025 |
| 900 | 0.001 |
| 2000 | 0.001 |
| | |
| Duration: 60 sec.<br>Overall $g_{RMS}$= 3.1 | |

*Table 17-3 X direction MEFL vibration spectrum*

The used vibration level is:

| Notched Level X Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.0025 |
| 58 | 0.0025 |
| 90 | 0.008 |
| 220 | 0.008 |
| 270 | 0.025 |
| 300 | 0.025 |
| 900 | 0.001 |
| 2000 | 0.001 |
| | |
| Duration: 60 sec.<br>Overall $g_{RMS}$= 2.71 | |

*Table 17-4 X direction applied vibration level*

**CONCURRENCE**

| Test Conductor<br>M. Olivier | QA | System Eng.<br>MOlive | | Customer |
|---|---|---|---|---|
| Date 15/10/07 | Date 15.10.07 | Date 15/10/07 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°3 (page 2 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test levels | Pg. 19 | 17.1 |

Description of Change: RICH qualification test level modification X direction
The following figure show the comparison between the MEFL and vibration notched level:

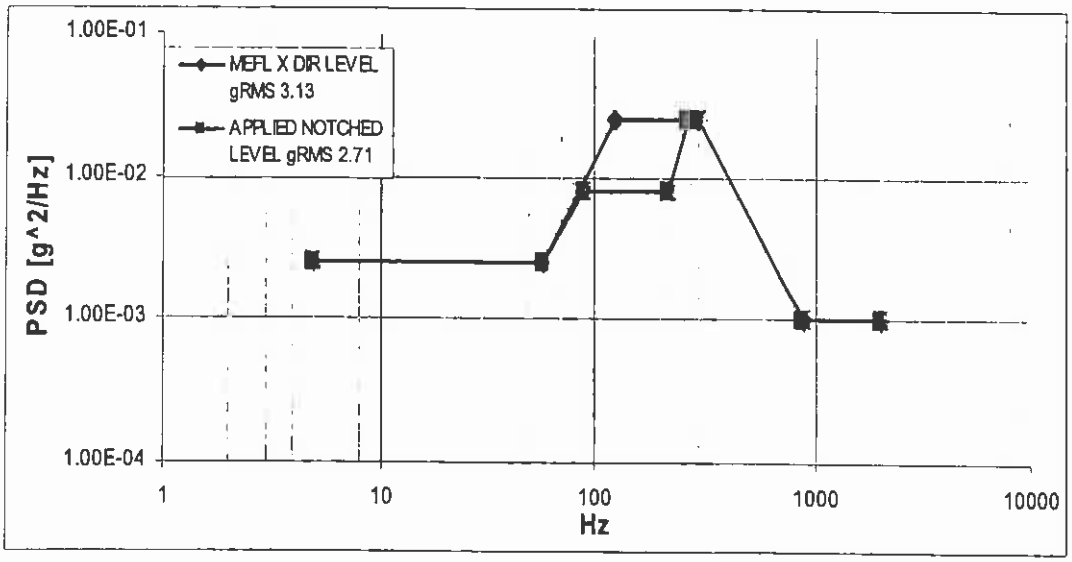


*Figure 17-1 MEFL and notched level X direction comparison*

Reason for Change:

Output predicted to PMTs (MP4 ) is 7.8 $g_{RMS}$ at full level. Notching of full level performed, with agreement of INFN, to limit the output on PMTs to 6.8 $g_{RMS}$ .
The maximum obtained value on MP2 is 6.12 $g_{RMS}$.

**CONCURRENCE**

| Test Conductor M. Olivier | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 15/10/07 | Date 15.10.07 | Date 15/10/07 | | Date |

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## 17.4 PVS 4

**PROCEDURE VARIATION SHEET ref. N°.4 (page 1 of 2 )**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test levels | Pg. 19 | 17.1 |

Description of Change: RICH qualification test level modification Y direction
The Y direction random vibration full level was notched according to INFN.
In particular the vibration level was the MEFL:

| MEFL Y Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.008 |
| 90 | 0.008 |
| 100 | 0.01 |
| 300 | 0.01 |
| 650 | 0.001 |
| 2000 | 0.001 |
| | |
| Duration: 60 sec.<br>Overall $g_{RMS}$= 2.28 | |

*Table 17-5 Y direction MEFL vibration spectrum*

The used vibration level is:

| Notched Level Y Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.008 |
| 90 | 0.008 |
| 100 | 0.01 |
| 150 | 0.01 |
| 170 | 0.0065 |
| 220 | 0.0065 |
| 250 | 0.01 |
| 300 | 0.01 |
| 650 | 0.001 |
| 2000 | 0.001 |
| | |
| Duration: 60 sec.<br>Overall $g_{RMS}$= 2.22 | |

*Table 17-6 Y direction applied vibration level*

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 16/10/07 | Date 16.10.07 | Date 16/10/07 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°4 (page 2 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test levels | Pg. 19 | 17.1 |

Description of Change: RICH qualification test level modification Y direction
The following figure show the comparison between the MEFL and vibration notched level:

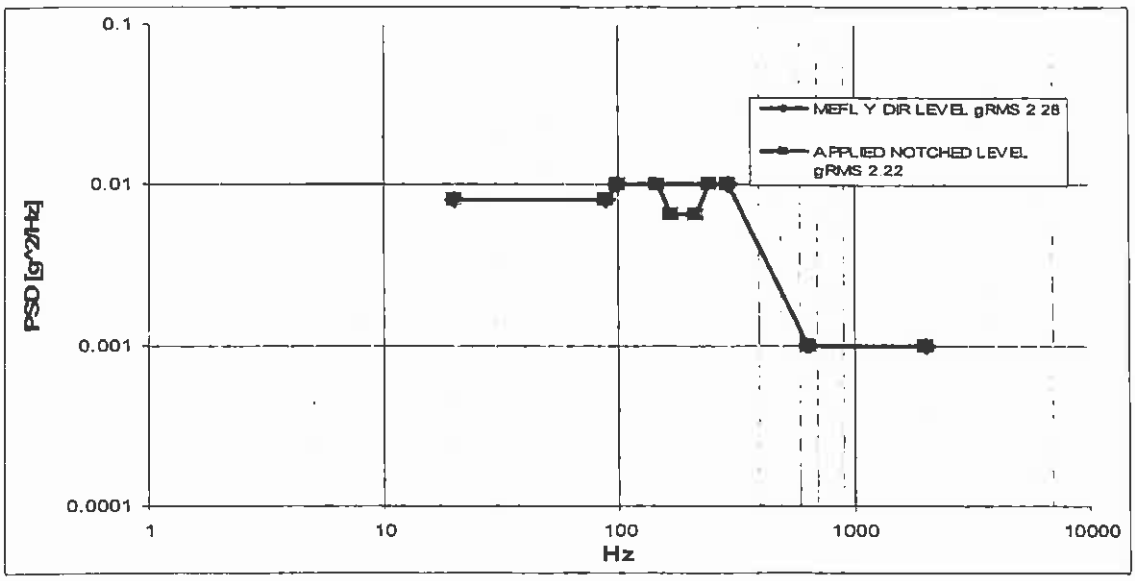


*Figure 17-2 MEFL and notched level Y direction comparison*

Reason for Change:

Output predicted to PMTs (MP5) is 7.57 $g_{RMS}$ at full level. Notching of full level performed, with agreement of INFN, to limit the output on PMTs to 6.8 $g_{RMS}$ .
The maximum obtained value on MP5 is 6.00 $g_{RMS}$.

**CONCURRENCE**

| Test Conductor A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 16/10/07 | Date 16.10.07 | Date 16/10/07 | | Date |


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## 17.5 PVS 5

### PROCEDURE VARIATION SHEET ref. N°.5 (page 1 of 1 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs
Resonance search..
The following table reports the added steps:

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.1.5 B1 | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 4.1.5 B2 | VERIFY FIXTURE TRASMISSIBILITY | OK | OK | |
| 4.1.5 B3 | | | | |
| 4.1.5 B4 | PERFORM A RANDOM RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ).<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | | | |
| 4.1.5 B5 | COMPARISON BETWEEN THE SINE SWEEP RESONANCE SEARCH AND THE RANDOM RESONANCE SEARCH | OK | OK | No discrepancies between the sine sweep results. Both of them show an unexpected high amplification above the 200 Hz frequency range on RICH grids. The full level extrapolation gives acceleration level too high on PMTs.<br>See PVS 6-13 |

Go to the step 4.1.5 C1 (PVS 6)

Reason for Change:

The shaker controller was not able to prosecute the frequency sine sweep over 1600 Hz, therefore a random resonance search using a flat random input with the same energy level of the sine sweep (0.3 $g_{RMS}$) has been performed to characterize the RICH behaviour in Z direction considering the full frequency range

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 18/10/07 | Date 18.10.07 | Date 18/10/07 | | Date |

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## 17.6 PVS 6

**PROCEDURE VARIATION SHEET ref. N°.6 (page 1 of 3)**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs
Two random vibration low level runs have been added during the Z direction random vibration test:

-RVT MEFL low level -12dB;
-RVT notched level -9dB.

The notched -9 dB level is reported in the following table and figure.

| Notched Low Level (-9 dB) Z Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.001125 |
| 45 | 0.001125 |
| 125 | 0.003125 |
| 150 | 0.003125 |
| 190 | 0.0008 |
| 240 | 0.0008 |
| 270 | 0.003125 |
| 300 | 0.003125 |
| 900 | 0.000125 |
| 2000 | 0.000125 |
| | |
| Duration:30 sec.<br>Overall $g_{RMS}$= 1.05 | |

*Table 17-7 Z direction notched random vibration low level (-9dB)*

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 18/10/07 | Date 18.10.07 | Date 18/10/07 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°.6 (page 1 of 3)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs

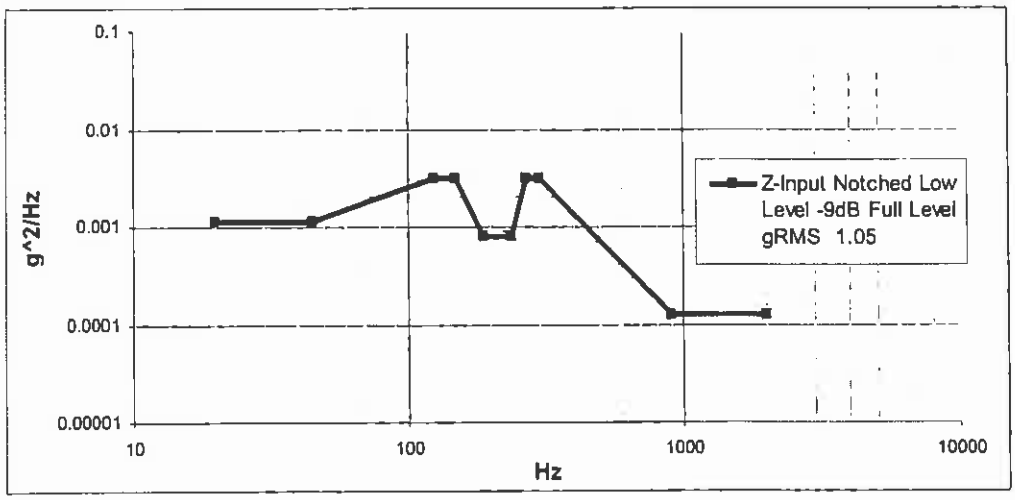


*Figure 17-3 Z direction -9dB applied notched spectrum*

The application of these level added the following step to the procedure.

| | | | | |
|---|---|---|---|---|
| 4.1.5 C1 | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-12dB) | OK | OK | |
| 4.1.5 C2 | VISUAL INSPECTION OF THE TEST ARTICLE | OK | OK | |
| 4.1.5 C3 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK<br>gRMS OK | Freq. OK<br>gRMS OK | The acceleration trend, shown in STEP4.1.5 B2, is confirmed. The PMTs acceleration level using this input is near to the acceleration limits reported in AD1. Non-linearity phenomenon has to be investigated increasing the input level to a notched -9dB random vibration level |

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 18/10/07 | Date 18.10.07 | Date 18/10/07 | | Date |


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## PROCEDURE VARIATION SHEET ref. N°6 (page 1 of 3)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs

| | | | | |
|---|---|---|---|---|
| 4.1.5 D1 | PERFORM THE RANDOM VIBRATION TEST AT NOTCHED LOW LEVEL (-9dB) WITH THE SPECTRUM OF Table 17-7 | OK | OK | |
| 4.1.5 D2 | VISUAL INSPECTION OF THE TEST ARTICLE | OK | OK | |
| 4.1.5 D3 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK<br>gRMS OK | Freq. OK<br>gRMS OK | No non linearity effect detected. The acceleration behavior on PMT is confirmed. The RICH vibration test has to be stopped to allow investigation and to decide how to proceed. |

Go to the step 4.1.5 E1 (PVS 7)

Reason for Change:
During the Z direction Resonance Search (both sine sweep and random) an unexpected amplifications was detected, as described in NCR-RICHSYS-CGS-C-020 Is 2.
In order to better evaluate RICH amplifications and $g_{RMS}$ response on the measurement points a Random Vibration test at MEFL -12dB and -9dB (at notched level) have been performed.

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 18/10/07 | Date 18.10.07 | Date 18/10/07 | | Date |

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## 17.7 PVS 7

### PROCEDURE VARIATION SHEET ref. N°.7 (page 1 of 1)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs to close the first session of Z direction test
Two resonance searches (sine sweep and random) have been added to close the first session of Z direction test campaign.
Here following the additional steps of the test procedure are shown.

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.1.5 E1 | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ).<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | |
| 4.1.5 E2 | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 4.1.5 F1 | PERFORM A RANDOM RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ).<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | |
| 4.1.5 F2 | COMPARISON BETWEEN THE SINE SWEEP RESONANCE SEARCH AND THE RANDOM RESONANCE SEARCH | OK | OK | |
| 4.1.5 F3 | VERIFY DISCREPANCIES WITH RESPECT TO PREVIOUS RESONANCE SEARCH | OK | OK | No discrepancies with the previous results (STEP 4.1.5 B2). The test campaign is stopped. An NCR is opened |

Go to step 4.1.5 G1 (PVS8)

Reason for Change:

Using the -12dB and -9dB random vibration test data, the full level extrapolation showed a 24 $g_{RMS}$ on PMT's monitoring points wrt 10Grms predicted (RD3); therefore the vibration test has been suspended for investigation on such discrepancy between predicted data and test results.
Before closing the test campaign a RS was necessary to check the detector structural integrity.
The NCR-RICHSYS-CGS-C-020 Is 2 was opened.

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 18/10/07 | Date 18.10.07 | Date 18/10/07 | | Date |

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## 17.8 PVS 8

### PROCEDURE VARIATION SHEET ref. N°:8 (page 1 of 1)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs for control setup investigation
An additional sine sweep has been performed, using the control configuration and the accelerometer positions described in NCR-RICHSYS-CGS-C-020 Is 2 Annex A.
In particular the following steps were added to the test procedure.

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.1.5 G1 | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ) FIXTURE LOADED MONITORING BOTH THE UUT AND THE FIXTURE. IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | |
| 4.1.5 G2 | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | **EXPANDER:** TWO PEAKS @ f1=222 Hz and f2=325 Hz AMPLIFICATIONS RANGE FROM 2.5 TO 3.33.<br>THESE PEAKS ARE COINCIDENT WITH TWO RICH RESONANCE FEREQUENCIES. A POSSIBLE MODAL COUPLING IS TO TAKE INTO ACCOUNT. ADDITIONAL INVESTIGATION HAS TO BE PERFORMED. |

Go to step 4.1.5 H1 (PVS9)

Reason for Change:

In order to evaluate if part of the detected amplification was caused by a non uniform input at shaker expander level, an additional resonance search has been performed monitoring all the eight interface columns of the detector. The test setup has been maintained, but some accelerometers have been removed from the detector (5 accelerometers from lower skin, two accelerometers from the mirror and 5 accelerometers from debris shields) and placed on the expander, detector supports, and RICH external structure as near as possible to the 8 support interfaces.

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 19/10/07 | Date 18.10.07 | Date 19/10/07 | | Date |

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## 17.9 PVS 9

| PROCEDURE VARIATION SHEET ref. N°9 (page 1 of 2) | | |
|---|---|---|
| Test Procedure Ref.:<br>RICH vibration test sequence | Page Revised:<br>Step 4.1.5 | Paragraph Revised:<br>21 |

Description of Change: Additional Runs for control setup investigation
In order to finish the investigation a sine sweep was performed changing the control set up, adding two control points. The following figure shows the control setup modification:

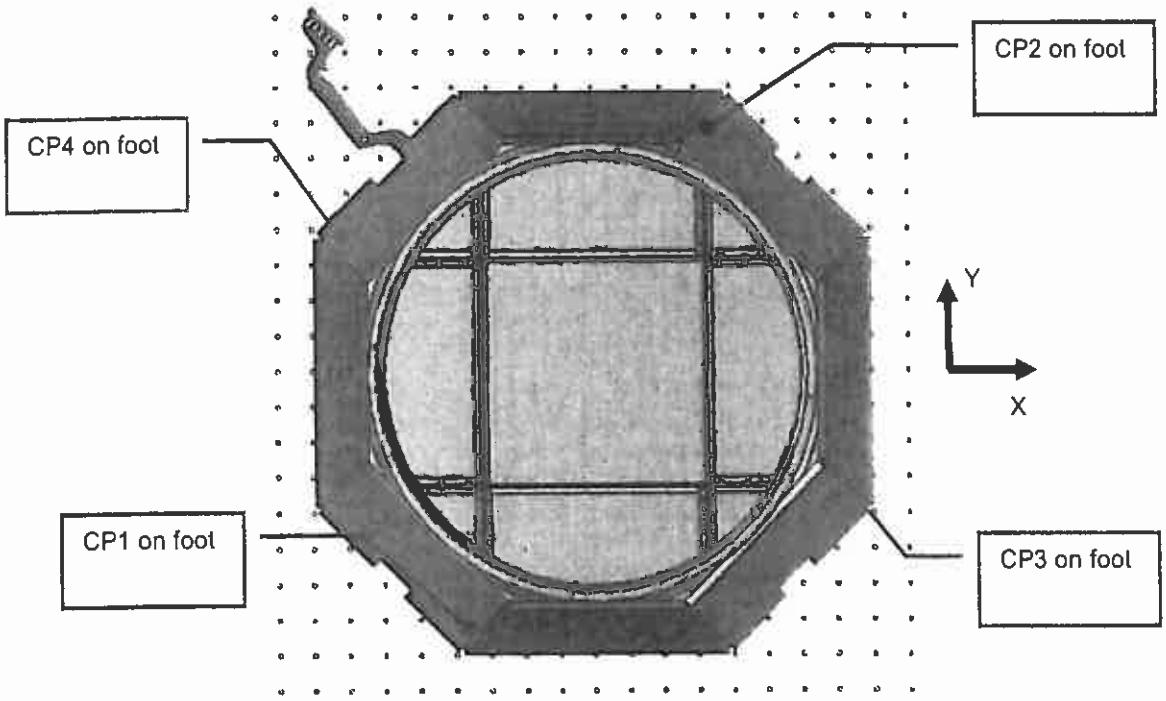


*Figure 17-4 New control points positions*

| CONCURRENCE | | | | |
|---|---|---|---|---|
| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
| Date 22/10/07 | Date 22.10.07 | Date 22/10/07 | | Date |


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## PROCEDURE VARIATION SHEET ref. N°9 (page 2 of 2)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs for control setup investigation
The following steps were added to the test procedure..

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.1.5 H1 | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ) FIXTURE LOADED MONITORING BOTH THE UUT AND THE FIXTURE USING FOUR FOUR INPUT CONTROL IS USED SELECTING HIGHEST POINT STRATEGY | OK | OK | |
| 4. 1.5 H2 | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | THE MODAL COUPLING OF EXPANDER AND RICH IS CONFIRMED SINCE USING THE FOUR CONTROL POINTS THE EXPANDER MODES ARE BETTER CONTROLLED (THE AMPLIFICATION DECREASES) AND THE PMTs RESPONSE IS SIMILAR TO THE PREDICTED ONE |

Go to step 4. 1.5 I1 (PVS11)

Reason for Change:

The PVS 7 output was that the expander modes induced an over-excitation in the RICH response.
In order to limit this effect two additional control points were placed on the expander and a sine sweep has been performed to evaluate the effectiveness of this control setup improvement.

### CONCURRENCE

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 22/10/07 | Date 22.10.07 | Date 22/10/07 | | Date |

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## 17.10 PVS 10

| PROCEDURE VARIATION SHEET ref. N°:10 (page 1 of 1 ) | | |
|---|---|---|
| Test Procedure Ref.:<br>RICH vibration test sequence | Page Revised:<br>29 | Paragraph Revised:<br>20 |

Description of Change: Notching Criterion Modification
The notching criterion based on the PMTs acceptable acceleration level has been updated as output of the NCR-RICHSYS-CGS-C-020 Is 2.
According to INFN, CGS considered representative of the flight environment and adequate to verify mission success to notch the first (~100Hz) and the second (~210Hz) modes reducing locally the PMT response peaks limiting the $g_{RMS}$ level to 6.8gRMS.

Reason for Change:
In order to evaluate the RICH modal amplifications in flight configuration in the NCR-RICHSYS-CGS-C-020 Is 2 Annex A the results of an investigation about the RICH dynamic environment are reported.
The principal considerations are:

- The amplifications seen at PMT level during the random vibration test are due to hard-mounted response of the RICH deriving from a very sharp pump mode in Z direction combined with a vertical excitation coming from the shaker interface that is a conservative test approach if compared to the actual interface to the USS, which allows some compliance.
- All the mechanical junctions between the STS and the RICH (through the USS) dissipate energy during the vibration providing additional reduction between primary structure and RICH interfaces.
- The acoustic vibration does not affect the Z direction vibration of the RICH detector plane acting on the debris shields.
- The RICH Z direction first mode frequency (100 Hz) is quite higher than the first AMS (primary structure) frequency in Z direction (20 Hz, experimentally verified from the AMS STA test);
    - the first structural mode of the USS filters the next modes responses at the equipment level for structure-borne vibration.
      This implies that the Maximum Expected Flight Level (MEFL) injected at primary structure interfaces will be reduced by dynamic effect and the real input spectrum to the RICH interfaces will be lower than the MEFL in the range above (approximately) 50 Hz.

**MOST IMPORTANT:** According to AMS Structural Verification Plan, the vibration transmitted through the primary structure to the experiment components will be smaller than Minimum Workmanship Levels (MWL), namely 6.8 grms.
From the SVP: "... for mission success it is recommended that vibration testing of the individual electronics components (i.e. PMT) shall be performed to MWL".
In the RICH specific case the MWL envelopes, both in terms of overall $g_{RMS}$ and acceleration PSD levels frequency-wise, the worst case response foreseen in any RICH experiment component (PMTs included) due to structure borne and acoustic excitation.

| CONCURRENCE | | | | |
|---|---|---|---|---|
| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
| Date 10/12/07 | Date 10.12.07 | Date 10/12/2007 | | Date |

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## 17.11 PVS 11

**PROCEDURE VARIATION SHEET ref. N°.11 (page 1 of 2)**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs to resume the Z direction vibration test
The detector support blocks were installed on the expander.
The fixture unloaded resonance search has been performed using the following fixture instrumentation plan.

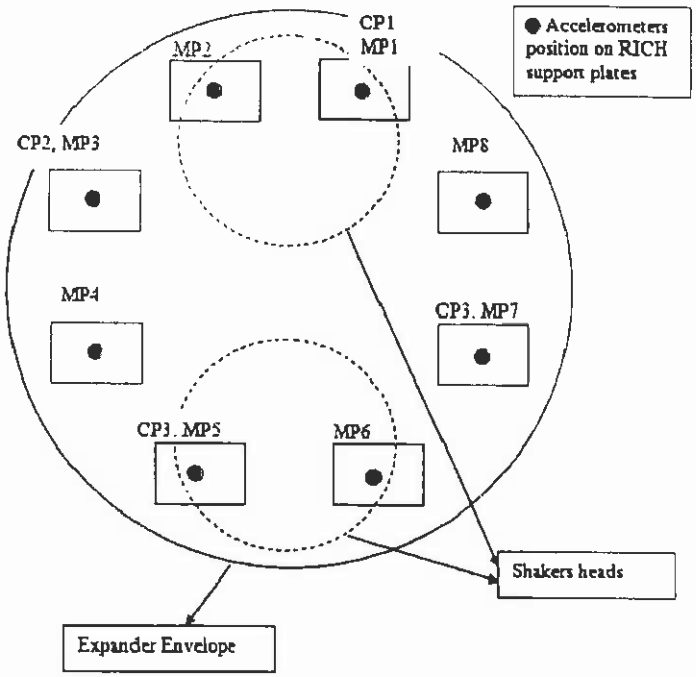


*Figure 17-5 Fixture unloaded instrumentation plan*

| SENSOR | LOCATION DESCRIPTION | MEASURED AXIS | REMARKS |
|---|---|---|---|
| CP 1-4 | RICH SUPPORT PLATES | Excited axis | Pilot on exciled axis |
| MP 1,3,5,7 | RICH SUPPORT PLATES NEAR THE CONTROL POINTS | X, Y Axes | |
| MP 2,4,6,8 | RICH SUPPORT PLATES | Z | |

*Table 17-8 Accelerometer positions and channels description*

**CONCURRENCE**

| Test Conductor A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 10/12/07 | Date 10. 12. 07 | Date 10/12/2007 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°.11 (page 2 of 2)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs to resume the Z direction vibration test
The following steps were added in the test procedure.

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.1.5 I1 | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ).<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | |

Go to the step 4.1.6 (Chp 23)

Reason for Change:

A resonance search on the fixture unloaded has been performed as starting point, in order to verify to have the same condition observed when the vibration test campaign was stopped,

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 10/12/07 | Date 10.12.07 | Date 10/12/07 | | Date |

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## 17.12 PVS 12

### PROCEDURE VARIATION SHEET ref. N°.12 (page 1 of 1)

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.1.5 | 21 |

Description of Change: Additional Runs to resume the Z direction vibration test
After the accelerometer placing, as described in chapter 20, and the UUT installation on the fixture a resonance search has been performed on RICH.
In particular the following steps were added to the test procedure.

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.2.1 B1 | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO CHP. 19.2.1 ).<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | - | |
| 4.2.1 B2 | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | | |

Reason for Change:

The resonance search has been performed to identify the detector behaviour before the random vibration test.

### CONCURRENCE

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 12/12/07 | Date 12.12.07 | Date 12-12-2007 | | Date |

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## 17.13 PVS 13

### PROCEDURE VARIATION SHEET ref. N°.13 (page 1 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.2.1 | 21 |

Description of Change: Z direction Random Vibration Low level modification
The updated RV low level was the following

| Freq. [Hz] | PSD [$g^2$/Hz] |
|---|---|
| 20 | 0.00113 |
| 45 | 0.00113 |
| 75 | 0.00181 |
| 95 | 0.00013 |
| 120 | 0.00013 |
| 140 | 0.00313 |
| 180 | 0.00313 |
| 190 | 0.00175 |
| 260 | 0.00175 |
| 280 | 0.00313 |
| 300 | 0.00313 |
| 900 | 0.00013 |
| 2000 | 0.00013 |
| | |
| Duration:30 sec.<br>Overall $g_{RMS}$= 1.03 | |

*Table 17-9 Notched spectrum used for the low level random vibration test*

### CONCURRENCE

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 12/12/07 | Date 12.12.07 | Date 12/12/2007 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°.13 (page 2 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test sequence | Step 4.2.1 | 21 |

Description of Change: : Z direction Random Vibration Low level modification

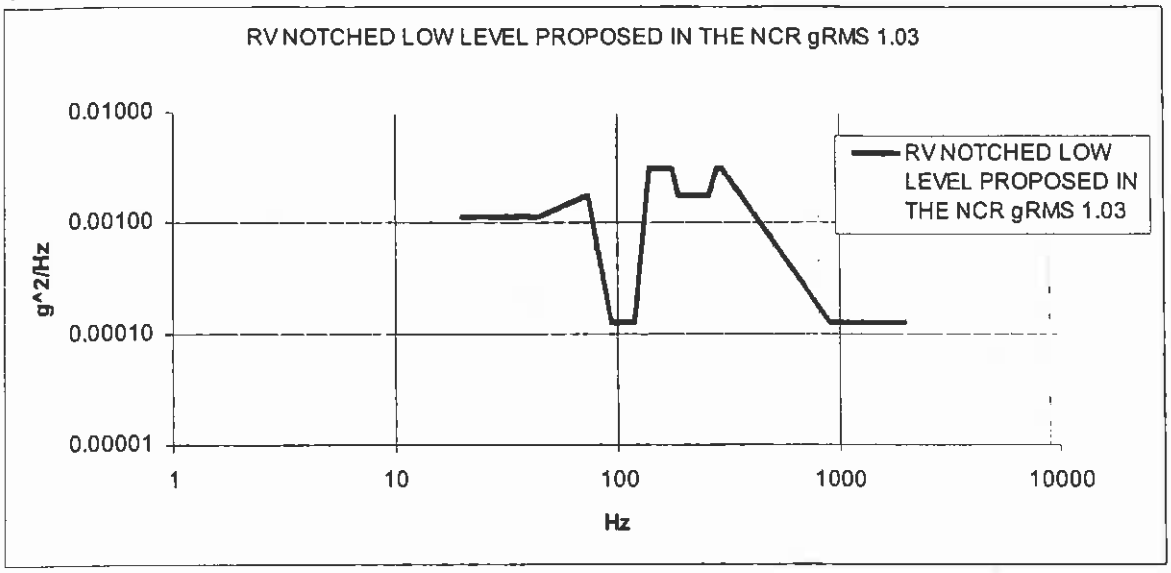


*Figure 17-6 Low level Notched spectrum*

In the test procedure the following steps were added:

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.2.1 L1 | PERFORM THE RANDOM VIBRATION TEST AT NOTCHED LOW LEVEL (-9dB) | OK | | |
| 4.2.1 L2 | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | OK | | |

Test proseculed with step 4.2.2 of the procedure.

Reason for Change:
The test is resumed implementing the notched approach defined in NCR-RICHSYS-CGS-C-020 Is 2 Annex A. The low level notched random vibration was necessary to identify by using the test data the optimized notching shape to be applied to the RICH.

**CONCURRENCE**

| Test Conductor A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 12/12/07 | Date 12.12.07 | Date 12/dec/2007 | | Date |


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## 17.14 PVS 14

**PROCEDURE VARIATION SHEET ref. N°:14 (page 1 of 2 )**

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test levels | Pg. 19 | 17.1 |

Description of Change: RICH qualification test level modification Z direction
The Z direction random vibration full level was notched according to INFN.
In particular the vibration level was the MEFL:

| MEFL Z Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.009 |
| 45 | 0.009 |
| 125 | 0.025 |
| 300 | 0.025 |
| 900 | 0.001 |
| 2000 | 0.001 |
| | |
| Duration: 60 sec.<br>Overall $g_{RMS}$= 3.24 | |

*Table 17-10 Z direction MEFL vibration spectrum*

The used vibration level is:

| Notched Level Z Direction | |
|---|---|
| FREQ [Hz] | PSD [$g^2$/Hz] |
| 20 | 0.009 |
| 45 | 0.009 |
| 75 | 0.0145 |
| 95 | 0.003 |
| 120 | 0.003 |
| 140 | 0.025 |
| 180 | 0.025 |
| 200 | 0.0055 |
| 280 | 0.0055 |
| 300 | 0.025 |
| 900 | 0.001 |
| 2000 | 0.001 |
| | |
| Duration: 60 sec.<br>Overall $g_{RMS}$= 2.74 | |

*Table 17-11 Z direction applied vibration level*

**CONCURRENCE**

| Test Conductor<br>A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 12/12/07 | Date 12. 12. 07 | Date 12/12/07 | | Date |

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## PROCEDURE VARIATION SHEET ref. N°.14 (page 2 of 2 )

| Test Procedure Ref.: | Page Revised: | Paragraph Revised: |
|---|---|---|
| RICH vibration test levels | Pg. 19 | 17.1 |

Description of Change: RICH qualification test level modification Z direction
The following figure show the comparison between the MEFL and vibration notched level:

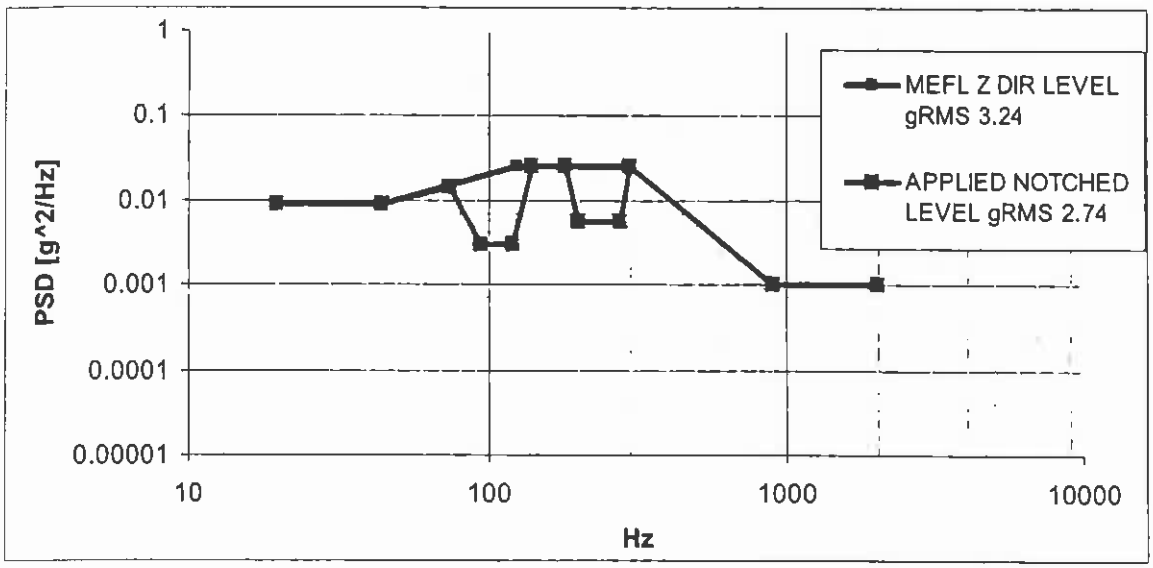


*Figure 17-7 MEFL and notched level Z direction comparison*

Reason for Change:

According to NCR-RICHSYS-CGS-C-020 Is 2 Annex A and in agreement with INFN the flight representative random vibration input in Z direction has not to induce a PMTs response higher than 6.8 $g_{RMS}$.
Using the notched level the test results (STEP 4.2.1 L1) based prediction was 6.6 $g_{RMS}$ on MP3 (<6.8 $g_{RMS}$).

**CONCURRENCE**

| Test Conductor A. Bursi | QA | System Eng. | | Customer |
|---|---|---|---|---|
| Date 12/12/07 | Date 12.12.07 | Date 12-12-07 | | Date |


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# 18.GENERAL PROCEDURE

For each vibration axis the following sequence is applicable:

- Fixture calibration
- Resonance search before random vibration
- Random vibration test low levels (X and Y direction -9dB, -6dB and -3dB, Z direction -12dB, -9dB and -3dB)
- Random vibration qualification full level
- Resonance search after random vibration

# 19.TEST LEVELS

In the next pages the complete test sequence followed during the test is reported.
It was properly filled during test performance and form part - in addition to test results and analysis - of the relevant test report.

## 19.1 RANDOM TEST LEVEL

As described in the PVS 2-3-13 the AD 1 test levels have been notched.
The following tables show the qualification test environments for the UUT (from AD1)

| X Axis | |
|---|---|
| Frequency (Hz) | PSD ($g^2$/Hz) |
| 20 | 0.0025 |
| 58 | 0.0025 |
| 90 | 0.008 |
| 220 | 0.008 |
| 270 | 0.025 |
| 300 | 0.025 |
| 900 | 0.001 |
| 2000 | 0.001 |
| | |
| Composite: 2.71 $g_{RMS}$<br>Duration: 60 sec<br>Direction: X axis | |

*Table 19-1: Environmental test level for RICH **X Axis***

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| Y Axis | |
|---|---|
| Frequency (Hz) | PSD ($g^2$/Hz) |
| 20 | 0.008 |
| 90 | 0.008 |
| 100 | 0.01 |
| 150 | 0.01 |
| 170 | 0.0065 |
| 220 | 0.0065 |
| 250 | 0.01 |
| 300 | 0.01 |
| 650 | 0.001 |
| 2000 | 0.001 |
| | |
| Composite: 2.2 $g_{RMS}$<br>Duration: 60 sec<br>Direction: Y axis | |

*Table 19-2: Environmental test level for RICH* ***Y Axis***

| Z Axis | |
|---|---|
| Frequency (Hz) | PSD ($g^2$/Hz) |
| 20 | 0.009 |
| 45 | 0.009 |
| 75 | 0.0145 |
| 95 | 0.003 |
| 120 | 0.003 |
| 140 | 0.025 |
| 180 | 0.025 |
| 200 | 0.0055 |
| 280 | 0.0055 |
| 300 | 0.025 |
| 900 | 0.001 |
| 2000 | 0.001 |
| | |
| Composite: 2.74 $g_{RMS}$<br>Duration: 60 sec<br>Direction: Z axis | |

*Table 19-3: Environmental test level for RICH* ***Z Axis***

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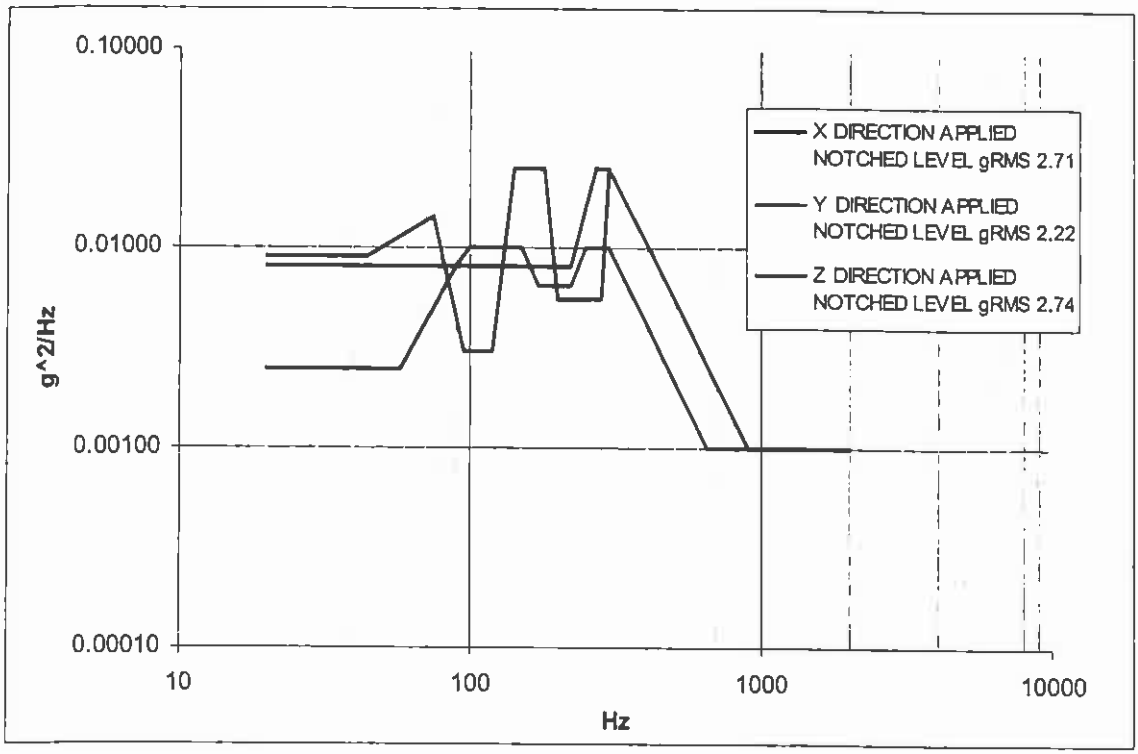


*Figure 19-1: Test Random Vibration Levels X, Y and Z axes*

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## 19.2 RANDOM TEST AXES

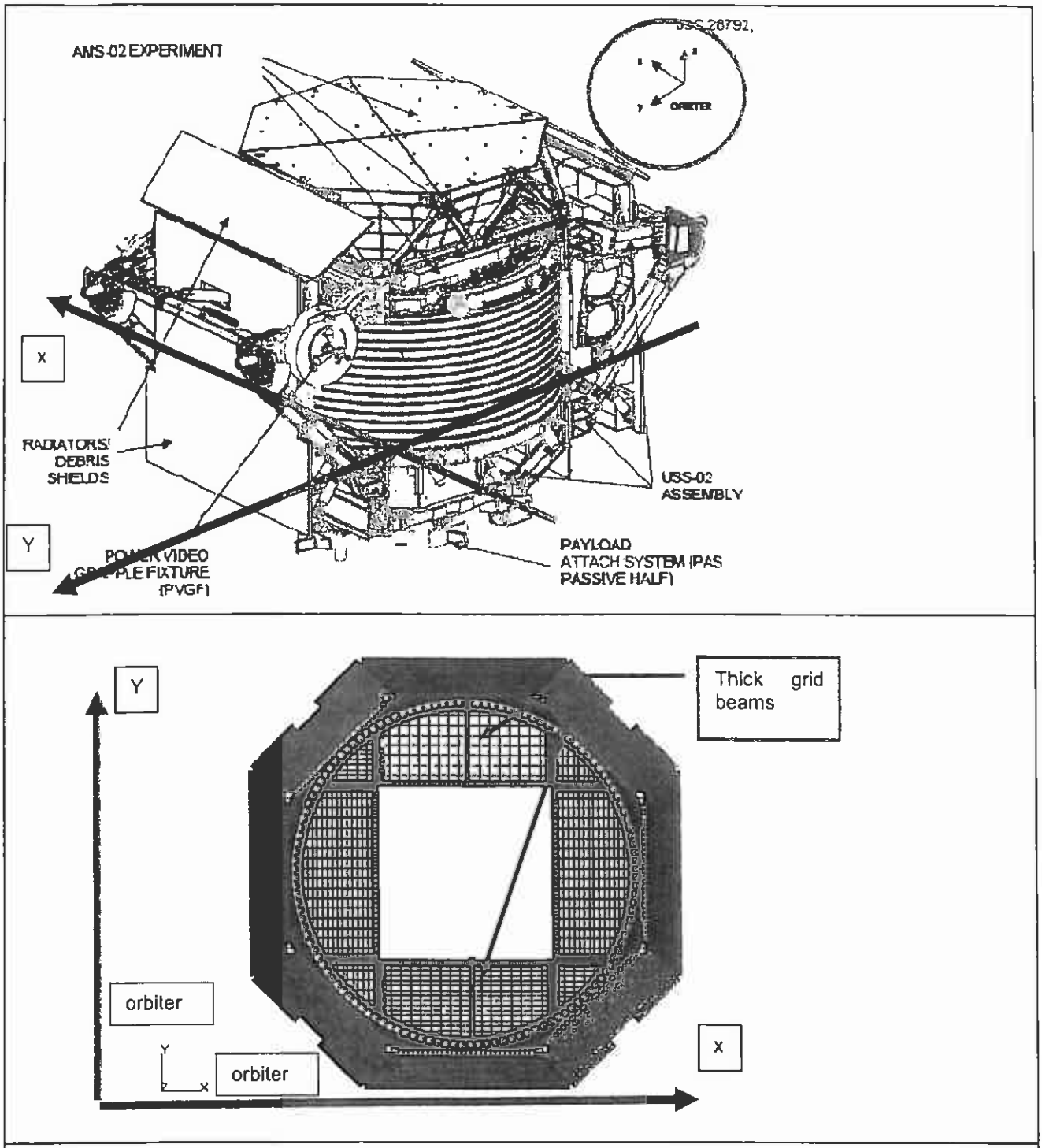


*Table 19-4: Alpha Magnetic Spectrometer – 02* ***Axes and RICH test axes***


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### 19.2.1 TEST LEVEL FOR RESONANCE SEARCH

The program for the shaker is explained in the following operations:

- Linear Frequency Scan
- Band: 5-2000 HZ
- Scan Speed 2 oct/min (Sweep Up Only)
- Level 0.3 g (Peak)

When the sine sweep resonance search was not able to complete the frequency range (5-2000 Hz) a random resonance search has been performed with the following shaker program:

- Flat profile value 4.3e-5 $g^2$/Hz
- Band: 5-2000 HZ
- Level 0.3 $g_{RMS}$

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## 20.UUT ACCELEROMETER DISPOSITION

The following instrumentation plan shall be used. The accelerometers position shall be reported (picture) on the test report.

| SENSOR | LOCATION DESCRIPTION | MEASURED AXIS | REMARKS |
|---|---|---|---|
| CP 1-2 | FIXTURE | Excited axis + CROSS AXES | Pilot on excited axis |
| CP 3-4 | FIXTURE | Excited axis | Pilot on Z axis. Used to perform only the Z direction test. Not used for X and Y directions. |
| MP 1-6 | UUT – grids | X, Y and Z | |
| MP 7-11 | UUT – main structure | X, Y and Z | |
| MP 12-15 | UUT – reflector | X, Y and Z | |
| MP 16-18 | UUT – debris shields | Y | |
| MP 19 | UUT – debris shields | Out-off axis (XY) | |
| MP 20-21 | UUT – debris shields | X | |

*Table 20-1: Accelerometers disposition.*

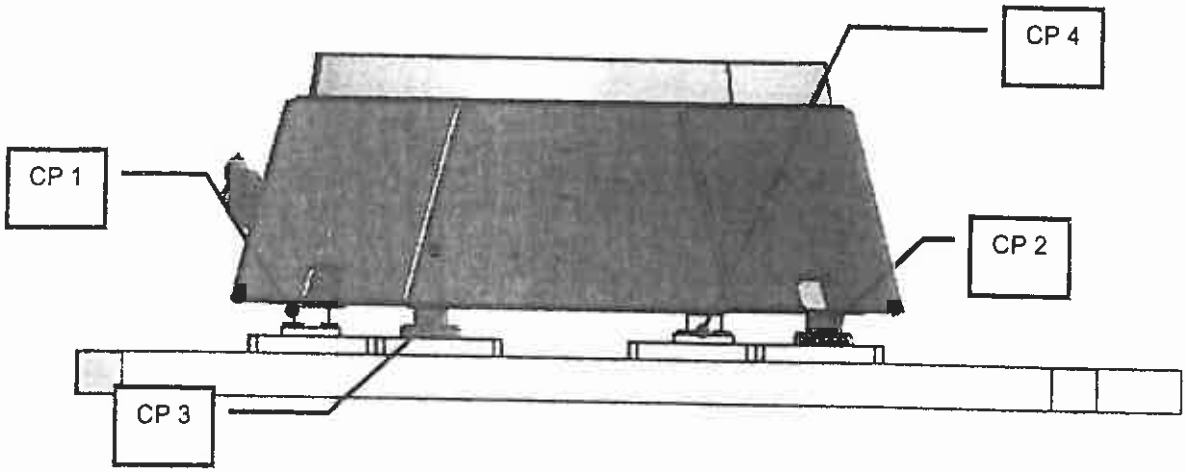


*Figure 20-1: Pilot Accelerometers disposition lateral view*

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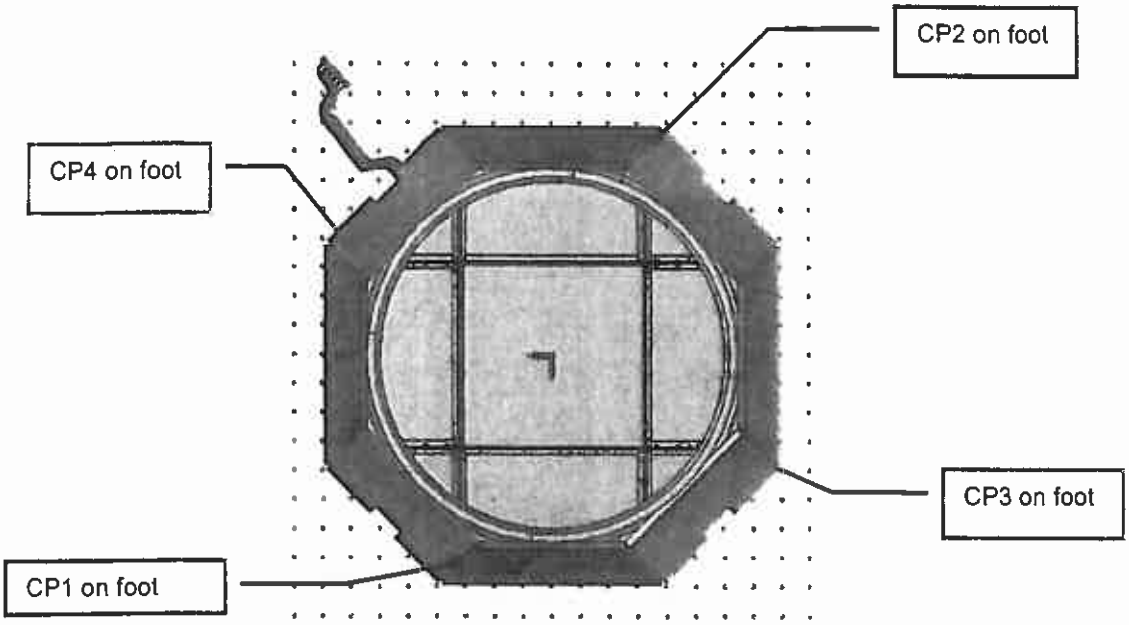


*Figure 20-2: Pilot Accelerometers disposition top view*

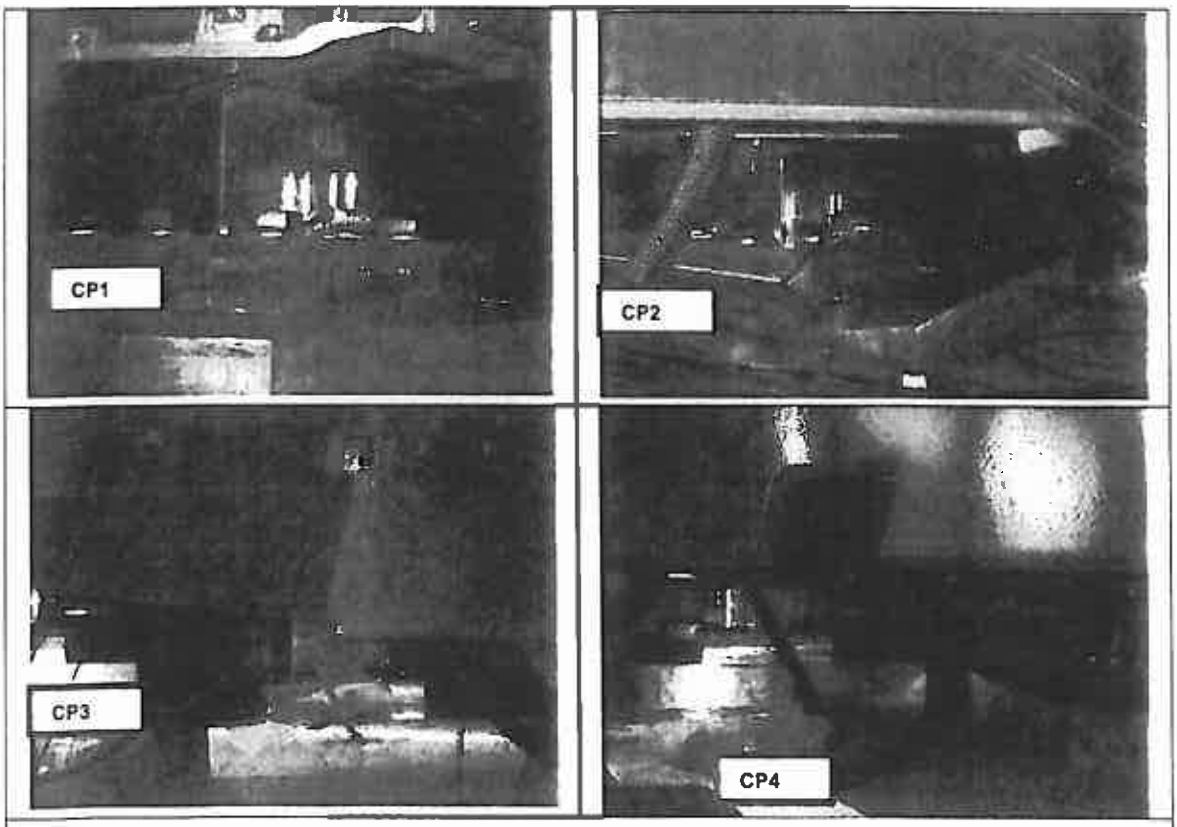


*Figure 20-3 Control Point positions detail*

The following figure shows the accelerometer selected areas evaluating the $g_{RMS}$ maps for lower skin.

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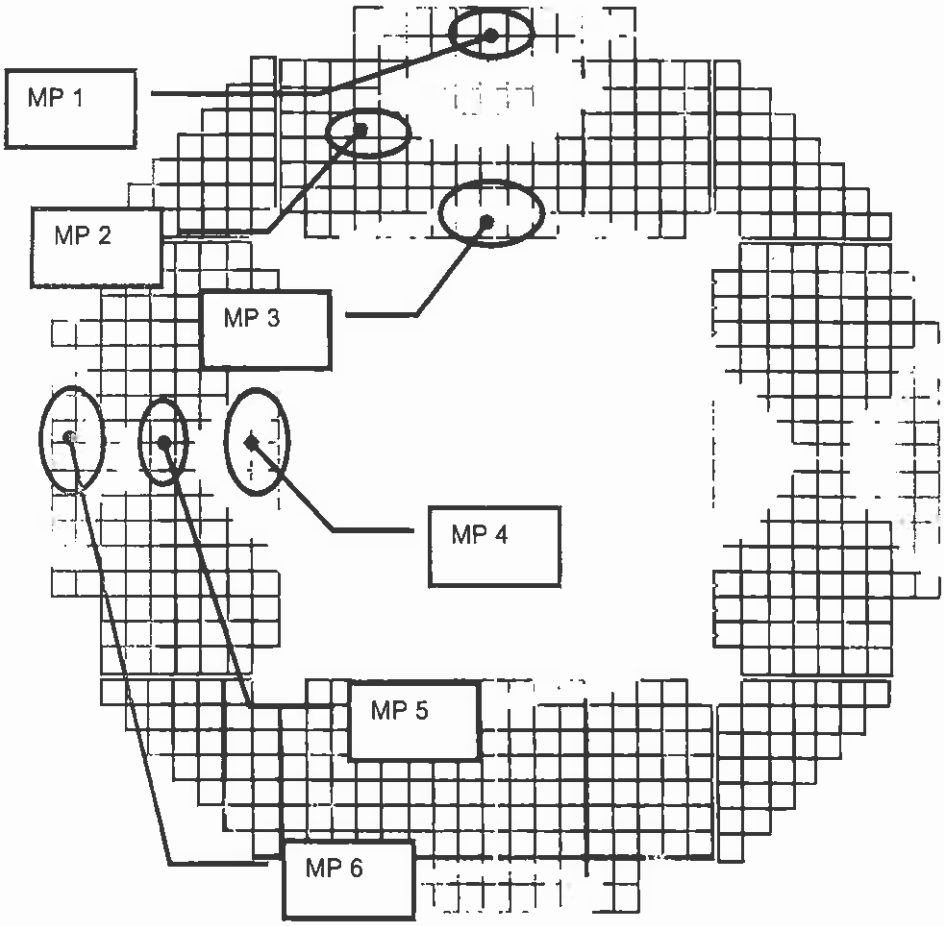


*Figure 20-4: Grids Accelerometers position*

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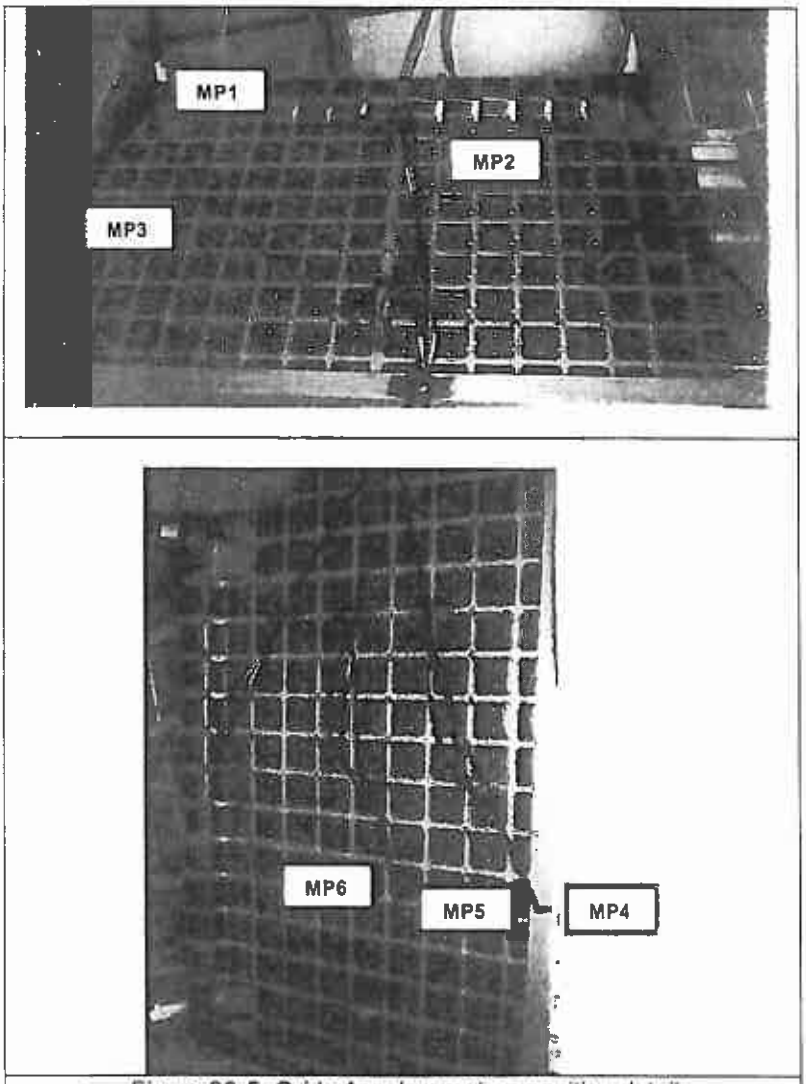


*Figure 20-5: Grids Accelerometers position detail*

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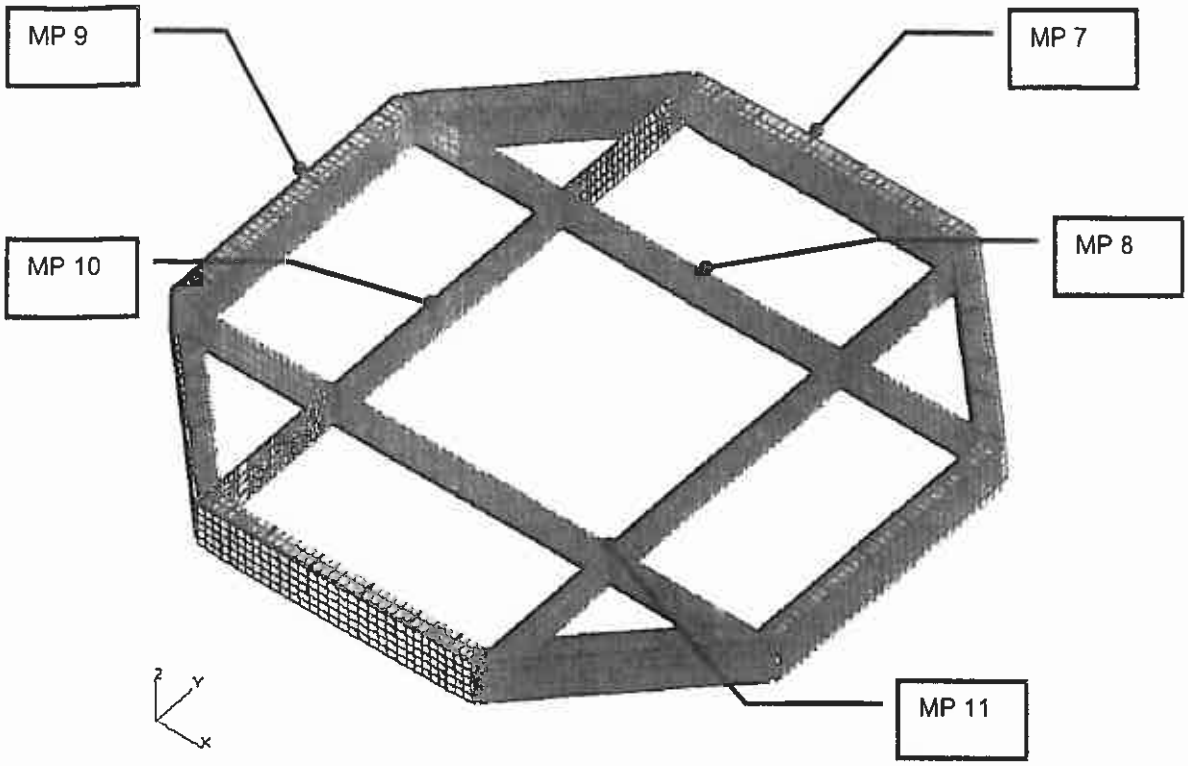
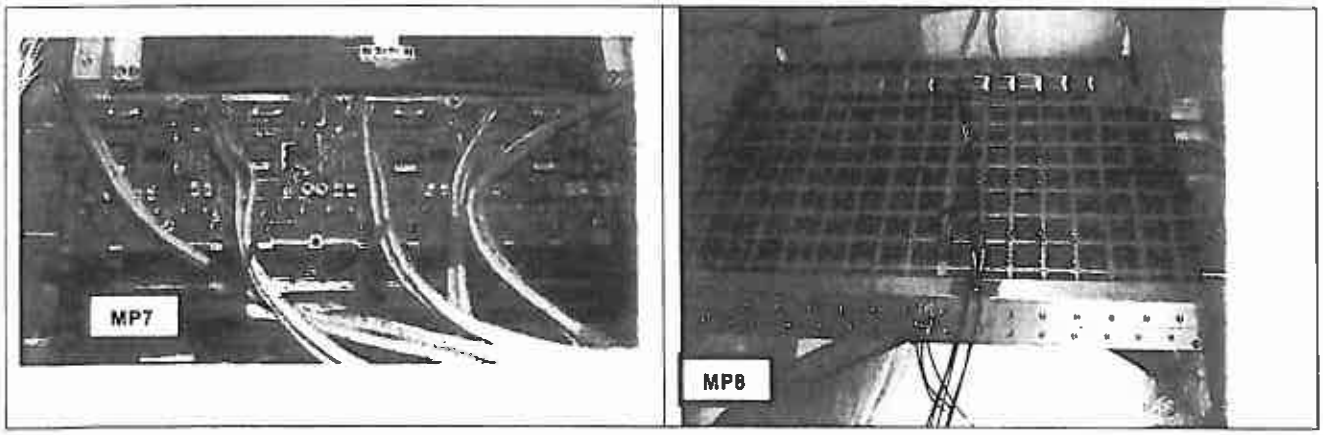



*Figure 20-6 External Structure accelerometer position*

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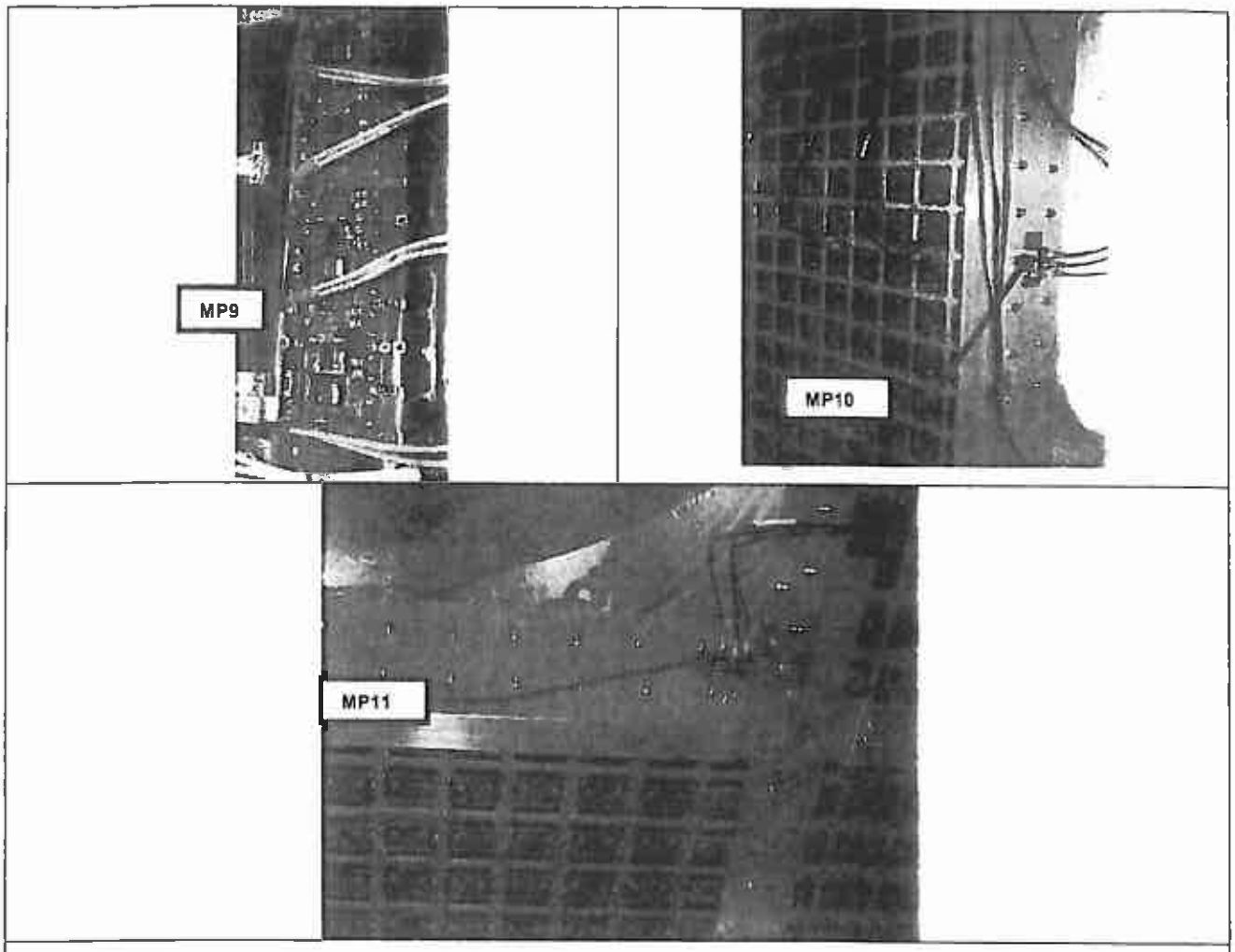


*Figure 20-7 External Structure accelerometer position detail*

The following figure shows the selected position for the reflector to monitor the interface acceleration and the amplification on reflector top.

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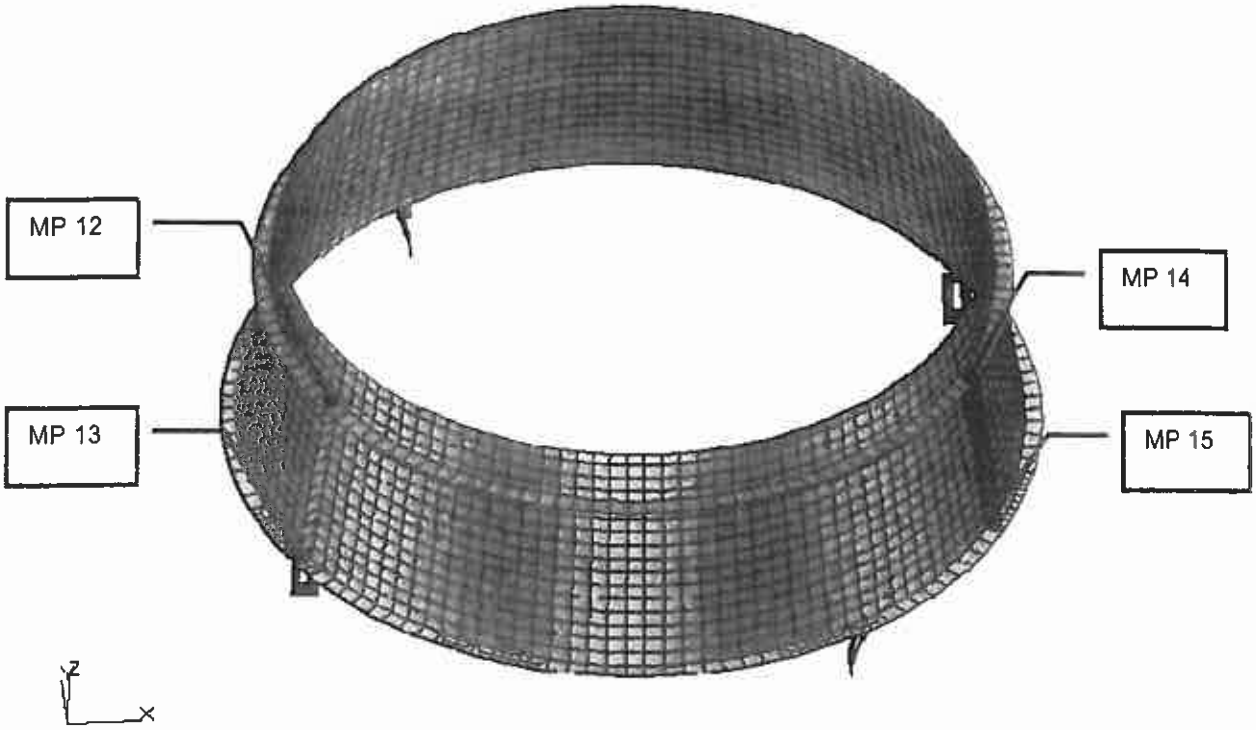
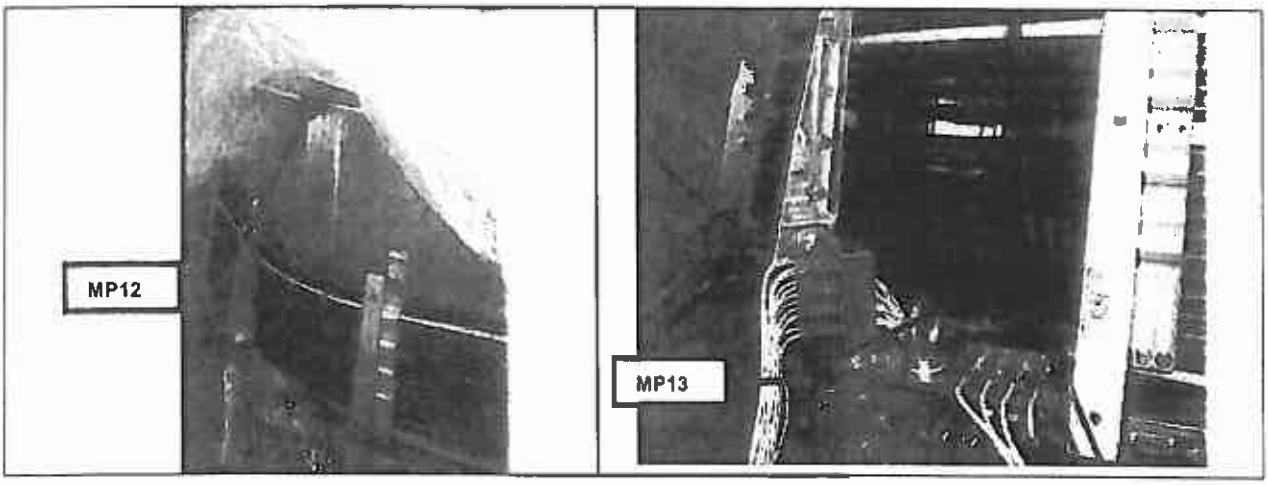



*Figure 20-8 Reflector accelerometer position*

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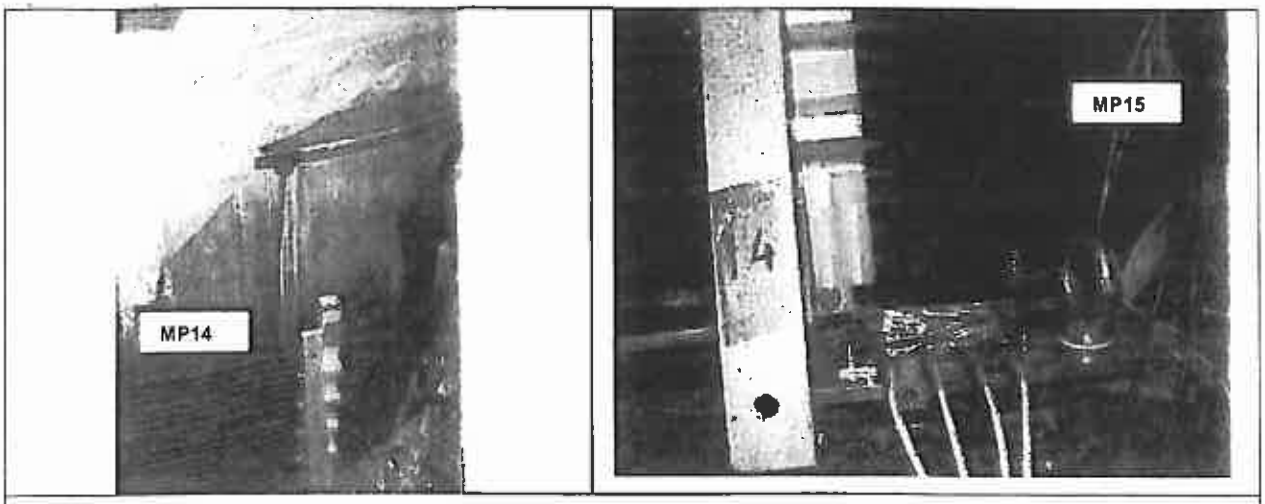


*Figure 20-9 Reflector accelerometer position detail*

The following figure shows the Debris Shield measurement point positions used during the test (PVS 1)

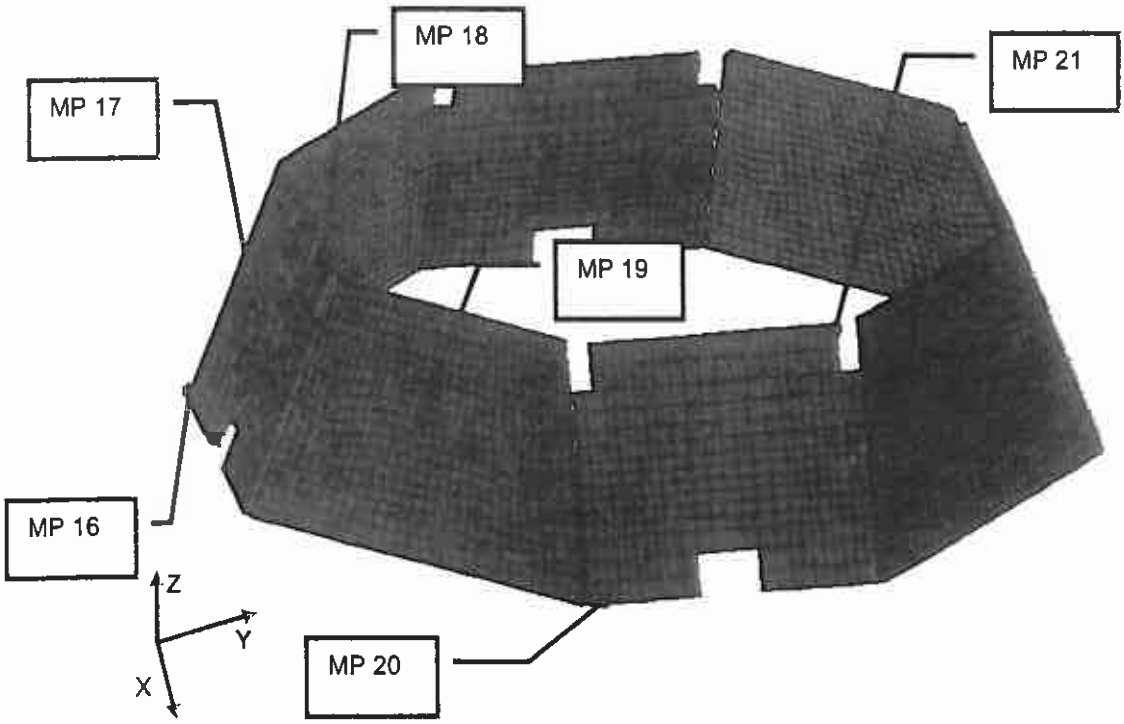


*Figure 20-10 Debris shield accelerometer position*

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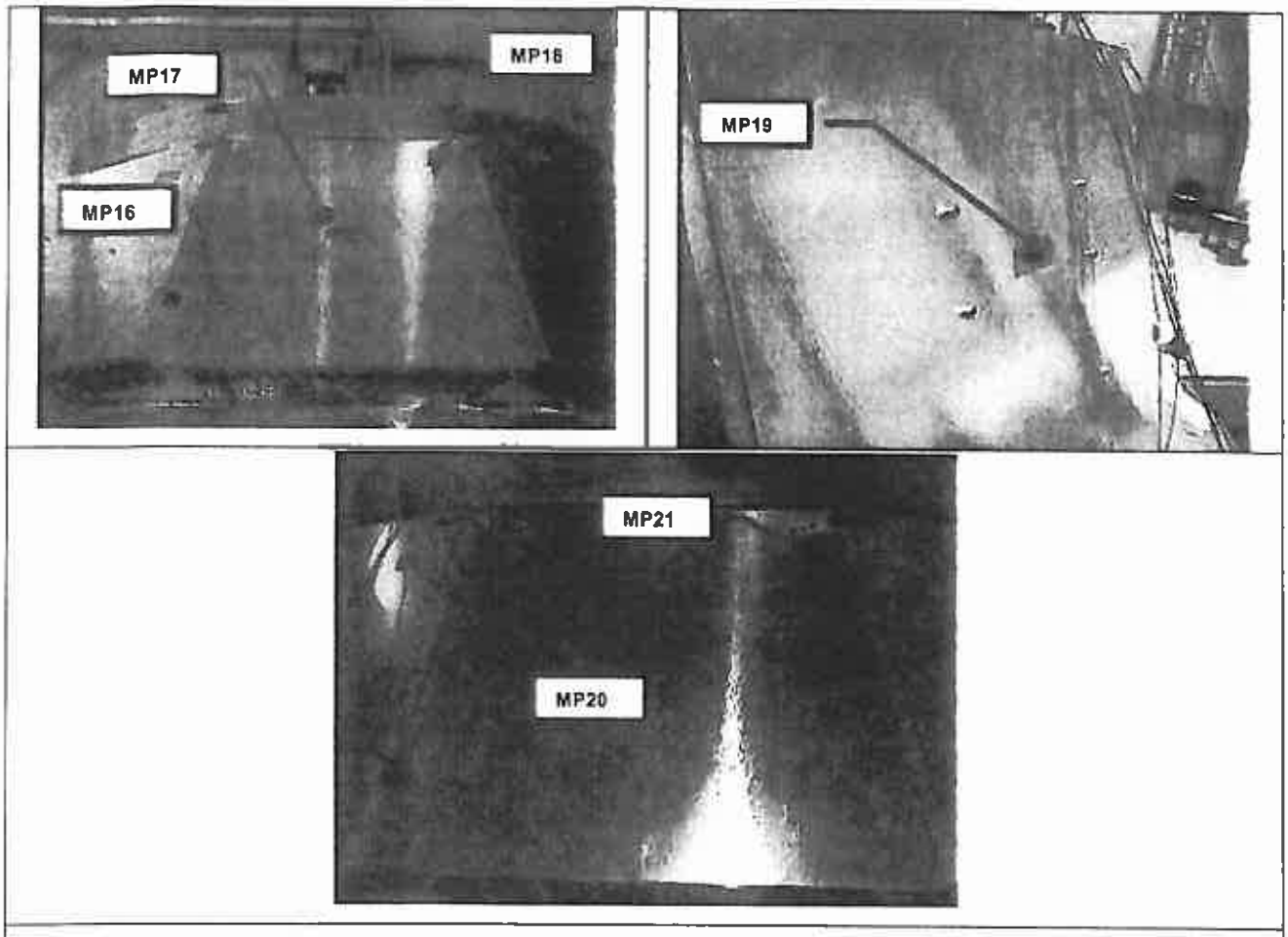


*Figure 20-Debris Shield accelerometer position detail*

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# 21.TEST RESULTS

In the following chapters a resume of the test results is provided for each objective:

## 21.1 FREQUENCY IDENTIFICATION FOR X, Y AND Z AXIS

The following first modes have been identified:

- *RICH First Mode hard mounted is* $F_1$ = 110 Hz , *for X direction*
- *RICH First Mode hard mounted is* $F_1$ = 105 Hz, *for Y direction*
- *RICH First Mode hard mounted is* $F_1$ = 100 Hz , *for Z direction*

The main plots showing the modes during the resonance searches (before and after vibration test for each axis) are displayed hereafter with a assessment of the mode shape based on the measures of MP7 (X direction RICH CoG representative) MP9 (Y direction RICH CoG representative) and MP8 (Z direction RICH CoG representative).
The plots are very well superimposed in all the frequency range demonstrating that the structure and all the delector components are unaffected by the qualification random vibration.

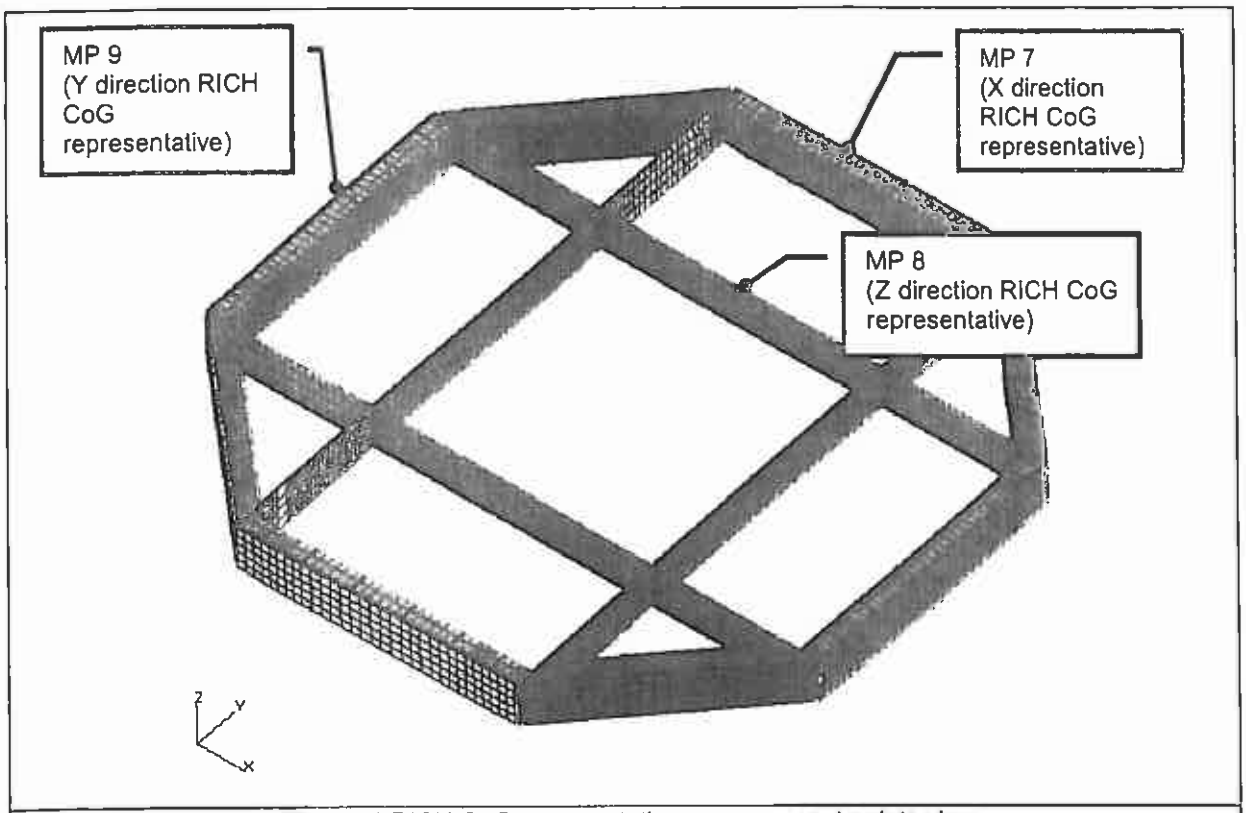


Fig. 21-1 RICH CoG representative measurement points view

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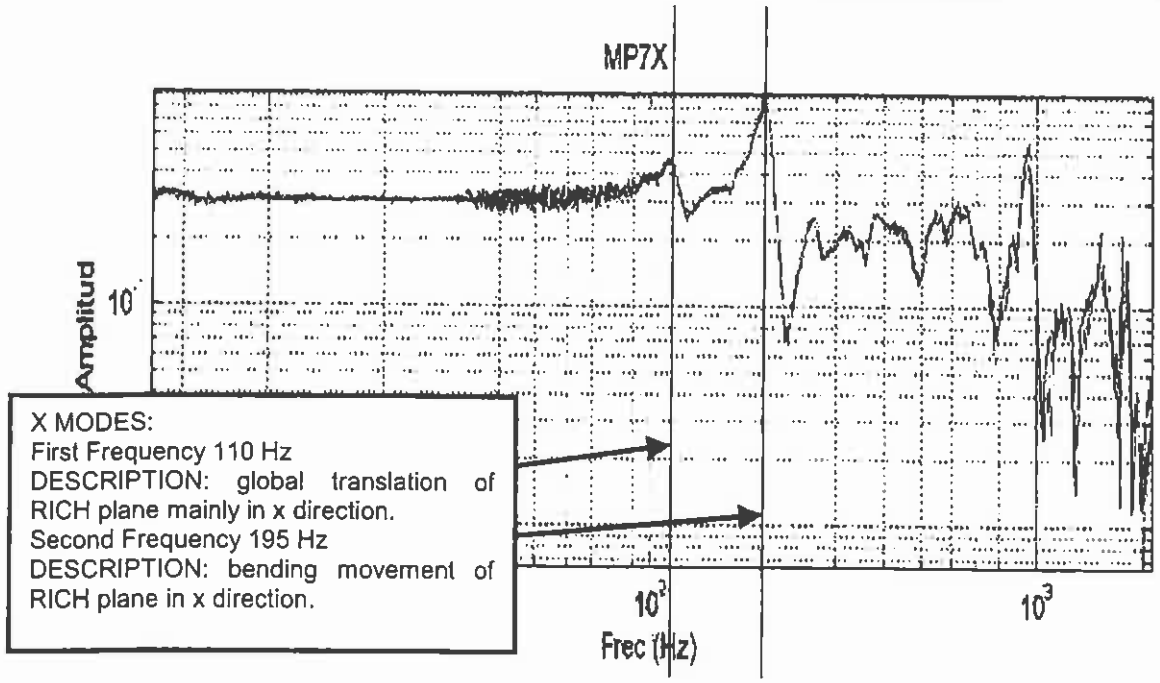


*Fig. 21-2: MP7 X direction mode identification*

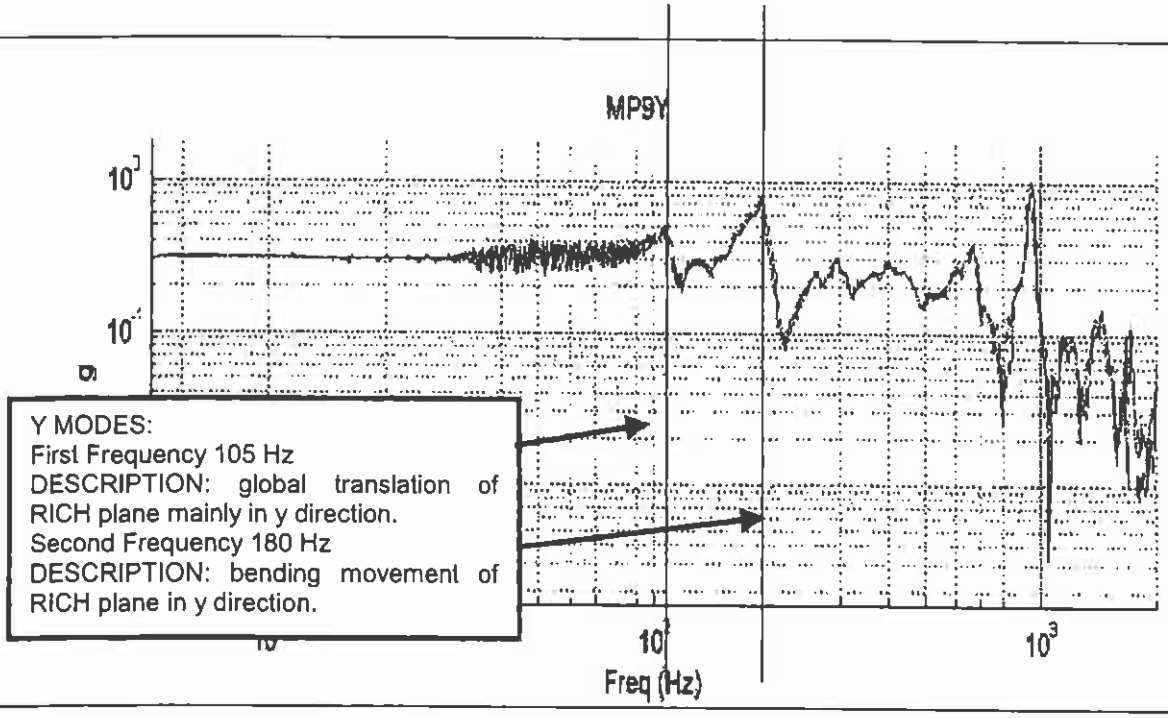


*Fig. 21-3: MP9 Y direction mode identification*

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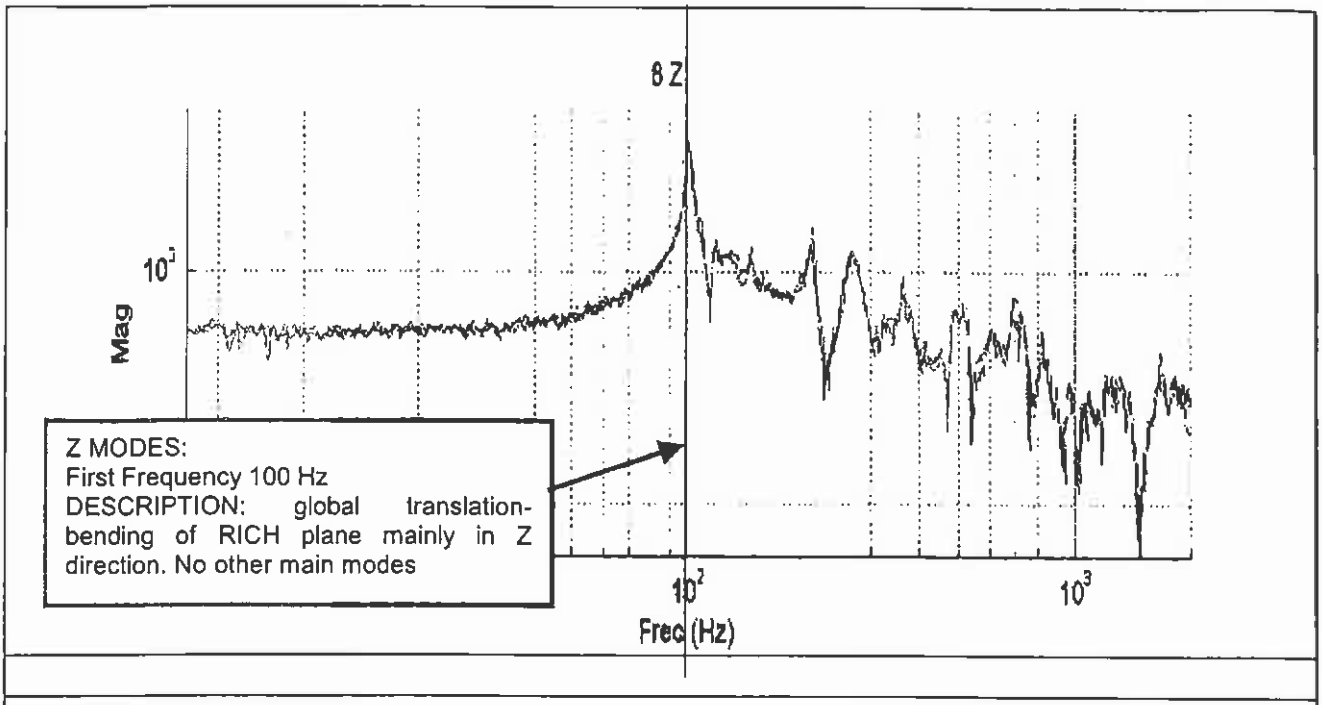


*Fig. 21-4: MP8 Z direction mode identification*

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## 21.2 RANDOM VIBRATION ENVIRONMENT VERIFICATION

The testing of the structure was successfully performed using flight representative vibration levels notching the MEFL for X-Y-Z directions:

- *RICH Verification for Random Vibration successfully performed. No discrepancies between Resonance search plots before and after each random vibration were detected, moreover no deformation, damage or loose parts were detected during visual inspections.*
- *Maximum recorded level to the external structure was: Z direction MP7 6.98 $g_{RMS}$*
- *Maximum recorded levels to the PMTs monitored was: Z direction MP3 6.63 $g_{RMS}$*
- *Maximum recorded levels to the Reflector monitored was: Z direction MP13 6.31 $g_{RMS}$*

The following plots show the RICH structure response (CoG representative) and the grids highest dynamic response.

X-DIRECTION

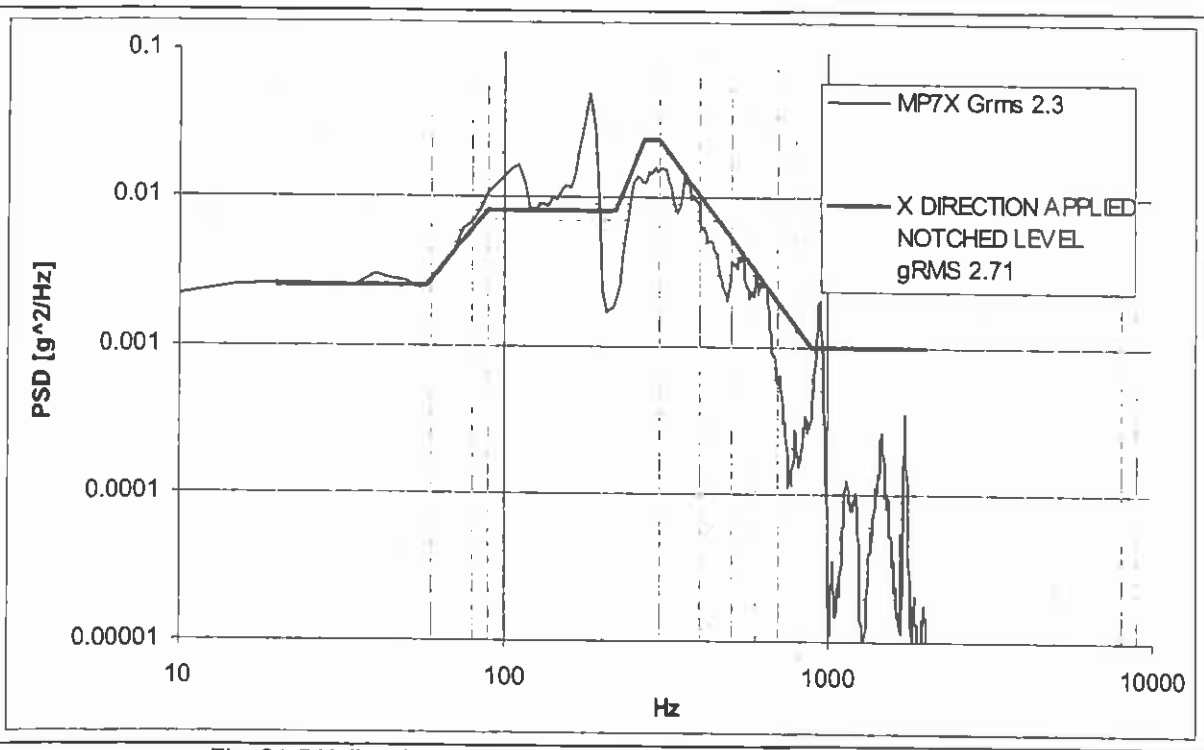


Fig. 21-5 X direction MP7 response (RICH CoG representative output)

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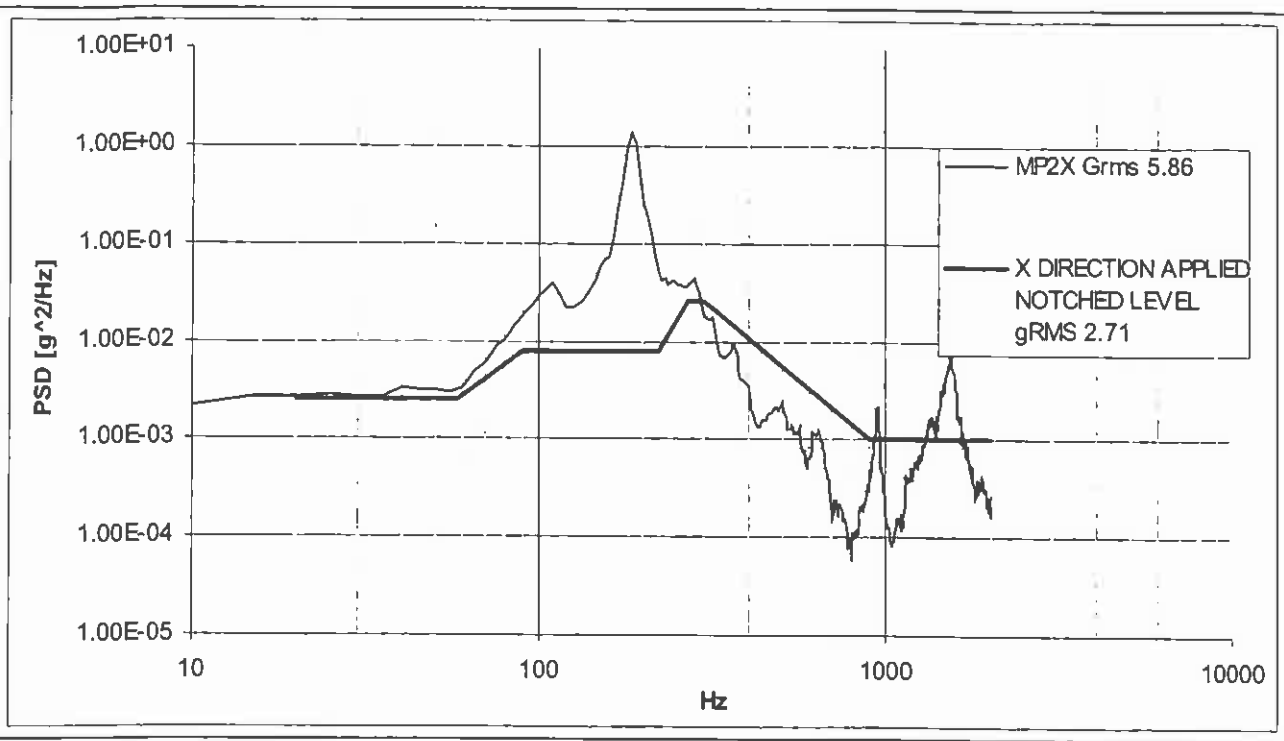


Fig. 21-6 X direclion RICH lower skin highest response MP2

Y-DIRECTION

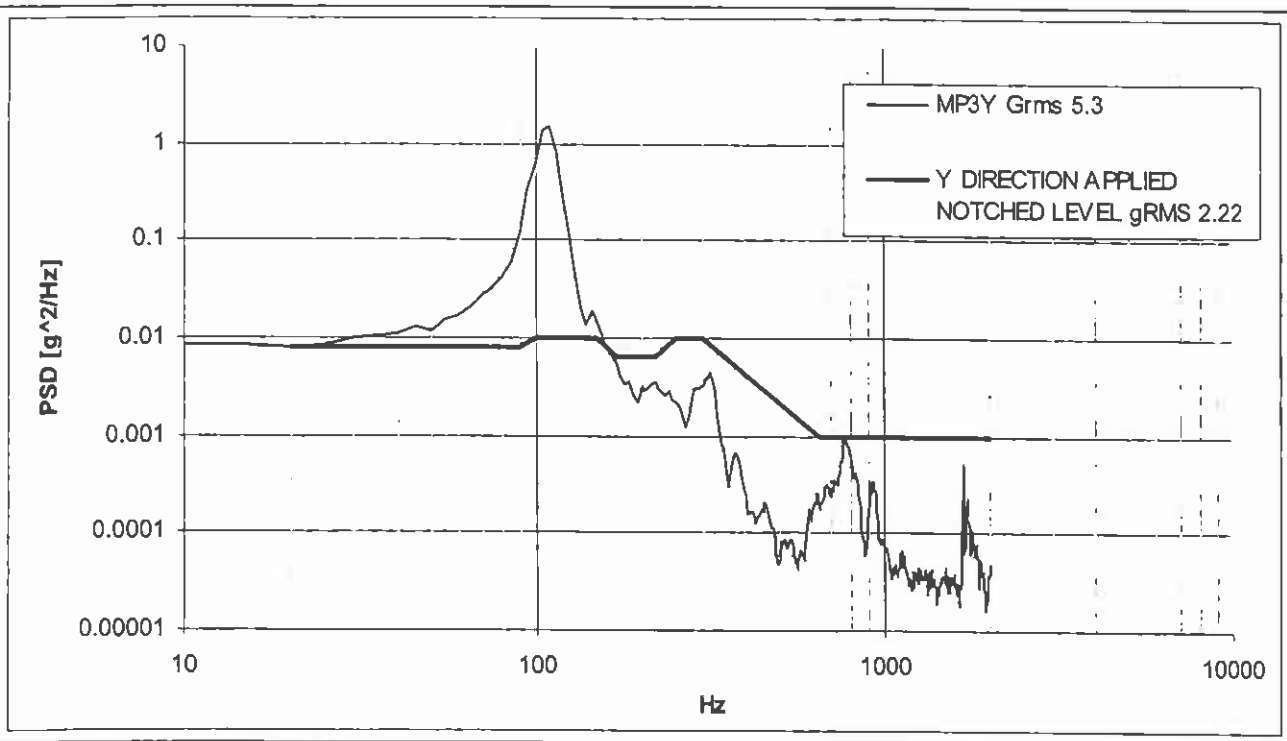


Fig. 21-7 Y direction MP9 response (RICH CoG representative output)

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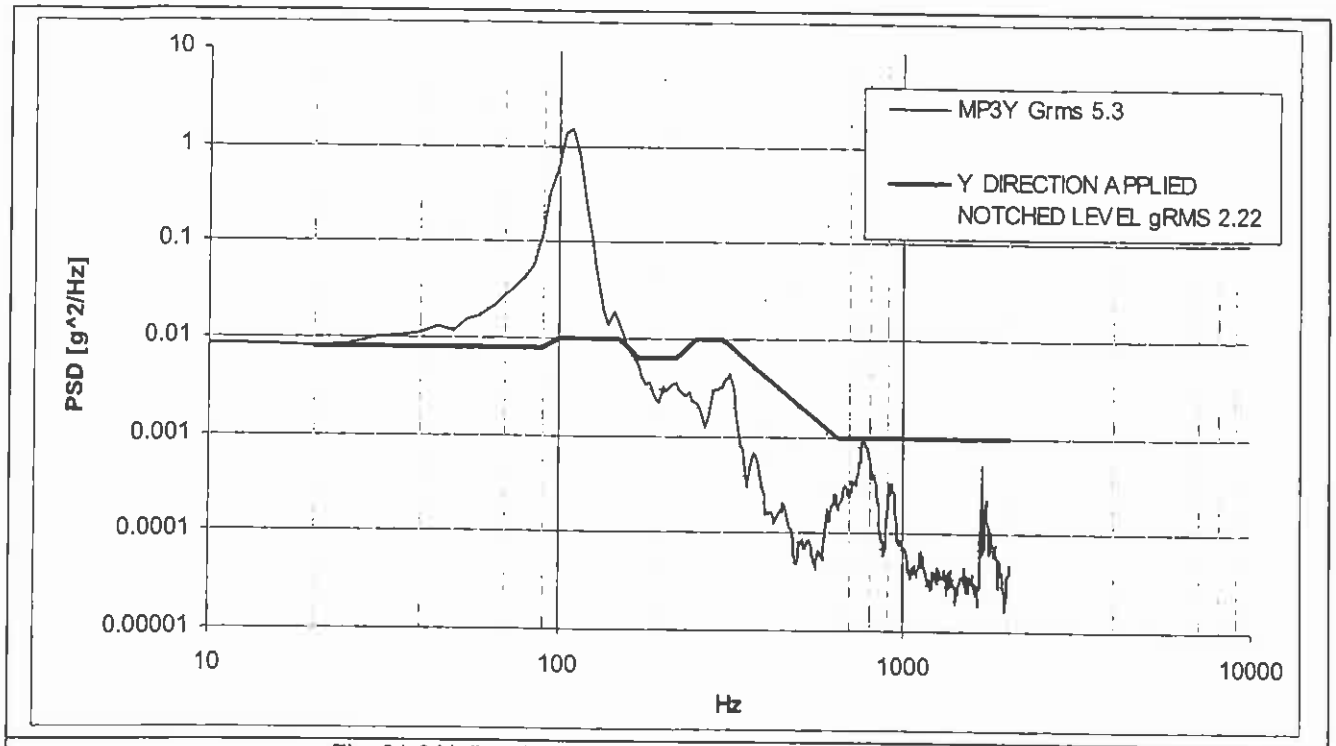


Fig. 21-8 Y direction RICH lower skin highest response MP3

Z-DIRECTION

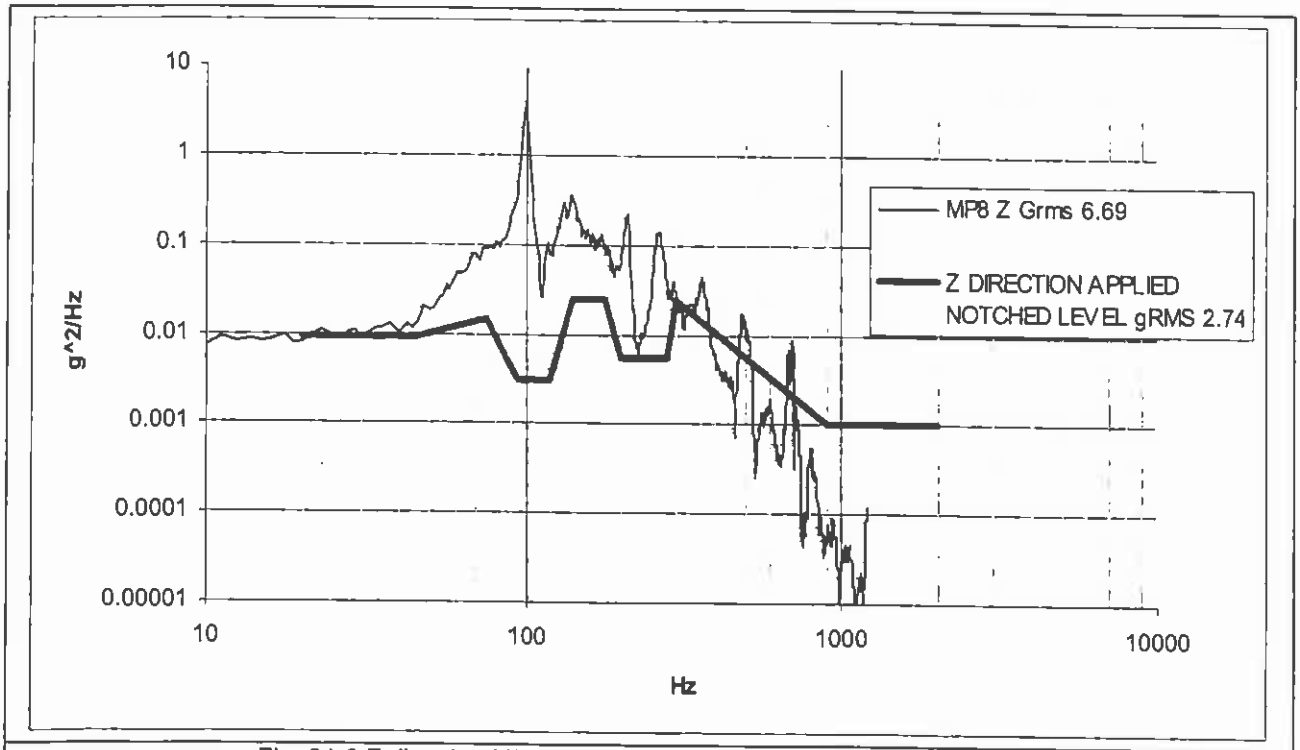


Fig. 21-9 Z direction MP8 response (RICH CoG representative output)

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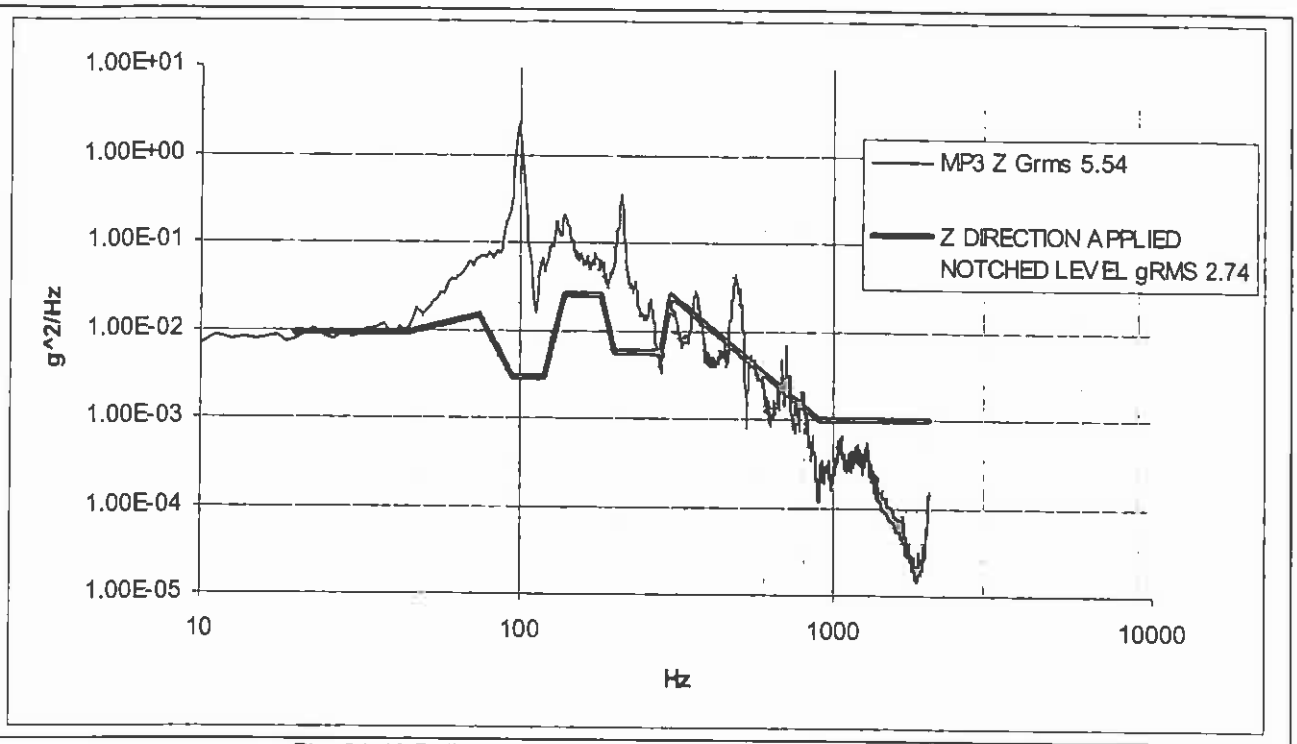


Fig. 21-10 Z direction RICH lower skin highest response MP3

## 22.TEST CONCLUSIONS AND COMMENTS

The test allowed to successfully verify the following test objectives:

- RICH minimum frequency hardmounted is F1=100 Hz, for Z direction. This confirms the test prediction results (RD2), therefore the first frequency requirement is satisfied (>50 Hz).
- RICH survived the vibration environment without degradation.
  - No discrepancies between Resonance search plots before and after each random vibration
  - No deformation of yelding
  - No damage or loose parts identified.
  - PMT functional performance succesfully verified by INFN before and after vibtration test.

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# 23.VIBRATION TEST PROCEDURE (STEP BY STEP)

This paragraph explains all the procedures that shall be performed on the models.
Each test activity is defined in sequence and task by task, including measurement recording to be made.

In the sequence procedure is also contained the statement that the test article shall be tested in accordance with the approved procedure to be signed and dated by Test Conductor, Quality Assurance Representative and Customer Representative (where applicable).

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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH - FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 1. | **FUNCTIONAL TEST REPORT CHECK** | | | |
| 1.1. | CHECK THE PRESENCE, IN THE DETECTOR DELIVERY DATA PACKAGE, OF THE FUNCTIONAL TEST REPORT (PERFORMED BY COLLABORATION PERSONNEL) STATING THAT THE HARDWARE IS READY FOR THE VIBRATION TEST | YES | YES | |
| 2. | **UUT QUALIFICATION VIBRATION TEST IN X DIRECTION** | | | |
| 2.1. | **RESONANCE SEARCH BEFORE RANDOM** | | | |
| 2.1.1. | SCREW THE FIXTURE TO THE SLIDING TABLE FOR VIBRATION IN X DIRECTION | OK | OK | |
| 2.1.2. | INSTALL UUT ON FIXTURE FOR X DIRECTION VIBRATION (NAS 1351-5 screw torque 35 Nm and DIN 912 M10 torque TBD NM) | OK | OK | |
| 2.1.3. | FIX CONTROL ACCELEROMETERS (CP) TO THE FIXTURE | OK | OK | |
| 2.1.4. | FIX ACCELEROMETERS TO UUT | OK | OK | |
| 2.1.5. | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO 19.2.1 )<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | |
| 2.1.6. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 2.1.7. | VERIFY FIXTURE TRASMISSIBILITY | OK | OK | |
| 2.1.8. | VERIFY PREDICTED FIRST FREQUENCY AND RESPONSE | OK | OK | The behaviour is similar to the predicted one.<br>**GRIDS:**<br>TWO PEAKS @ f1=110 Hz and f2=195 Hz<br>AMPLIFICATIONS RANGE FROM 6 TO 10.<br>**STRUCTURE:** TWO PEAKS @ f1=110 Hz and f2=195 Hz<br>AMPLIFICATIONS RANGE FROM 4 TO 13.<br>**REFLECTOR:** FIRST MODE IS @ f1=34 Hz<br>AMPLIFICATIONS RANGE FROM 4 AND 13.<br>**DEBRIS SHIELD:**<br>TWO PEAKS @ f1=85 Hz and f2=110 Hz |

| DATE: | TEST CONDUCTOR + QA DEPUTY | QA | CUSTOMER |
|---|---|---|---|
| 8-10 /10/ 07 | MASSIMILIANO OLIVIER M. Olivier | | |


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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH - FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| | | | | |
| | | | | |

| DATE: | TEST CONDUCTOR | QA | CUSTOMER |
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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH-FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 2.2. | RANDOM VIBRATION IN X DIRECTION | | | |
| | | | | |
| 2.2.1. | PROGRAM SHAKER ACCORDING TO Table 19-1<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT MAXIMUM POINT STRATEGY | OK | OK | See PVS 2 |
| 2.2.2. | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-3dB) | OK | OK | |
| 2.2.3. | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 2.2.4. | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | Freq. OK gRMS OK | Freq. OK gRMS OK | The acceleration trend on PMTs observed at -9dB (STEP 2.2.1 B3) is confirmed. Notched full level is defined according to INFN. |
| 2.2.5. | PERFORM THE RANDOM VIBRATION TEST AT FULL LEVEL (-0dB) | OK | OK | See PVS 3 |
| 2.2.6. | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 2.2.7. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
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|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| **2.3.** | **RESONANCE SEARCH AFTER RANDOM VIBRATION** | | | |
| | | | | |
| 2.3.1. | PERFORM A RESONANCE SEARCH AFTER RANDOM | OK | OK | |
| 2.3.2. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 2.3.3. | VERIFY DISCREPANCIES WITH RESPECT TO PREVIOUS RESONANCE SEARCH | OK | OK | No discrepancies from the first resonance search (STEP 2.1.8) |
| 2.3.4. | REMOVE UUT MOUNTED ACCELEROMETERS IF REQUIRED | OK | OK | |
| 2.3.5. | CHECK FIXTURE BOLTS TORQUE | OK | OK | |
| 2.3.6. | REMOVE UUT FROM FIXTURE | OK | OK | |
| 2.3.7. | REMOVE FIXTURE | OK | OK | |

| DATE: | TEST CONDUCTOR + QA DEPUTY | QA | CUSTOMER |
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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH-FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 3. | **UUT QUALIFICATION VIBRATION TEST IN Y DIRECTION** | | | |
| 3.1. | **RESONANCE SEARCH BEFORE MEFL RANDOM** | | | |
| | | | | |
| 3.1.1. | SCREW THE FIXTURE TO THE SLIDING TABLE FOR VIBRATION IN Y DIRECTION | OK | OK | |
| 3.1.2. | INSTALL UUT ON FIXTURE FOR Y DIRECTION VIBRATION (NAS 1351-5 screw torque 35 Nm and DIN 912 M10 torque TBD NM)) | OK | OK | |
| 3.1.3. | FIX CONTROL ACCELEROMETERS (CP) TO THE FIXTURE | OK | OK | |
| 3.1.4. | FIX ACCELEROMETERS TO UUT | OK | OK | |
| 3.1.5. | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO 19.2.1 )<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | |
| 3.1.6. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 3.1.7. | VERIFY FIXTURE TRASMISSIBILITY | OK | OK | |
| 3.1.8. | VERIFY PREDICTED FIRST FREQUENCY AND RESPONSE | OK | OK | The behaviour is similar to the predicted one and it is symmetrical w.r.t. x direction:<br>**GRIDS:**<br>TWO PEAKS @ f1=105 Hz and f2=185 Hz<br>AMPLIFICATIONS RANGE FROM 6 TO 10.<br>**STRUCTURE:**<br>TWO PEAKS @ f1=105 Hz and f2=185 Hz<br>AMPLIFICATIONS RANGE FROM 4 TO 13.<br>**REFLECTOR:**<br>FIRST MODE IS @ f1=34 Hz<br>AMPLIFICATIONS RANGE FROM 4 AND 13.<br>**DEBRIS SHIELD:**<br>TWO PEAKS @ f1=80 Hz and f2=105 Hz |

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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH – FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 3.2. | **MEFL RANDOM VIBRATION IN Y DIRECTION** | | | |
| | | | | |
| 3.2.1. | PROGRAM SHAKER ACCORDING TO Table 19-2<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT MAXIMUM POINT STRATEGY | OK | OK | See PVS 2 |
| 3.2.2. | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-3dB) | OK | OK | |
| 3.2.3. | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 3.2.4. | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | OK | OK | The acceleration trend on PMTs observed at -9dB (STEP 3.2.1 B3) is confirmed. Notched full level is defined according to INFN. |
| 3.2.5. | PERFORM THE RANDOM VIBRATION TEST AT FULL LEVEL (-0dB) | OK | OK | See PVS 4 |
| 3.2.6. | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 3.2.7. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| | | | | |
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|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| **3.3.** | **RESONANCE SEARCH AFTER MEFL RANDOM VIBRATION** | | | |
| | | | | |
| 3.3.1. | PERFORM A RESONANCE SEARCH AFTER RANDOM (PROGRAM SHAKER ACCORDING TO 19.2.1 ) | OK | OK | |
| 3.3.2. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 3.3.3. | VERIFY DISCREPANCIES WITH RESPECT TO PREVIOUS RESONANCE SEARCH | OK | OK | No discrepancies from the first resonance search (STEP 3.1.8) |
| 3.3.4. | REMOVE UUT MOUNTED ACCELEROMETERS | OK | OK | |
| 3.3.5. | CHECK FIXTURE BOLTS TORQUE | OK | OK | |
| 3.3.6. | REMOVE UUT FROM FIXTURE | OK | OK | |
| 3.3.7. | REMOVE FIXTURE | OK | OK | |

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UUT DATA : Model FM Item RICH-SYSTEM C.I. RICH – FM01 S/N FM01

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4. | **UUT QUALIFICATION VIBRATION TEST IN Z DIRECTION** | | | |
| 4.1. | **RESONANCE SEARCH BEFORE MEFL RANDOM** | | | |
| 4.1.1. | SCREW THE FIXTURE TO THE SLIDING TABLE FOR VIBRATION IN Z DIRECTION | OK | | |
| 4.1.2. | INSTALL UUT ON FIXTURE FOR Z DIRECTION VIBRATION (NAS 1351-5 screw torque 35 Nm and DIN 912 M10 torque TBD NM) | OK | | |
| 4.1.3. | FIX CONTROL ACCELEROMETERS (CP) TO THE FIXTURE | OK | | |
| 4.1.4. | FIX ACCELEROMETERS TO UUT | OK | | |
| 4.1.5. | PERFORM A RESONANCE SEARCH (PROGRAM SHAKER ACCORDING TO 19.2.1 ) IF MULTIPOINT INPUT CONTROL IS USED SELECT HIGHEST POINT STRATEGY | OK | OK | The RS stopped at 1600 Hz, therefore an additional random RS is performed. See PVS 5-11 and PVS12-13 |
| 4.1.6. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | | |
| 4.1.7. | VERIFY FIXTURE TRASMISSIBILITY | OK | | |
| 4.1.8. | VERIFY PREDICTED FIRST FREQUENCY AND RESPONSE | OK | | The first mode shows an high amplification than the expectation, however this has low influence on the UUT random vibration behaviour from the $g_{RMS}$. point of view.<br>**GRIDS:**<br>TWO PEAKS @ f1=100 Hz and f2=211 Hz AMPLIFICATIONS RANGE FROM 3 TO 28 (ON FIRST PEAK).<br>**STRUCTURE:**<br>TWO PEAKS @ f1=100 Hz and f2=211 Hz AMPLIFICATIONS RANGE FROM 6 TO 36<br>**REFLECTOR:** FIRST MODE IS @ f1=105Hz AMPLIFICATIONS RANGE FROM 4 AND 13.<br>**DEBRIS SHIELD:** THREE PEAKS @ f1= 80 Hz, f2=110 Hz and f3=290 Hz |

| DATE: | TEST CONDUCTOR + QA DEPUTY | QA | CUSTOMER |
|---|---|---|---|
| 10-12/12/07 | ALESSANDRO BURSI | | |


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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH-FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| **4.2.** | **MEFL RANDOM VIBRATION IN Z DIRECTION** | | | |
| | | | | |
| 4.2.1. | PROGRAM SHAKER ACCORDING TO Table 19-3<br>IF MULTIPOINT INPUT CONTROL IS USED SELECT MAXIMUM POINT STRATEGY | OK | OK | See PVS 12 and 14 |
| 4.2.2. | PERFORM THE RANDOM VIBRATION TEST AT LOW LEVEL (-3dB) | OK | OK | |
| 4.2.3. | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 4.2.4. | VERIFY UUT RESPONSE AND NOTCHING IF REQUIRED | OK | OK | See PVS 12 and 14 |
| 4.2.5. | PERFORM THE RANDOM VIBRATION TEST AT FULL LEVEL (-0dB) | OK | OK | |
| 4.2.6. | VISUAL INSPECTION OF THE TEST ARTICLE | No visual damages detected | No visual damages detected | |
| 4.2.7. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
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| UUT DATA : | Model FM | Item RICH-SYSTEM | C.I. RICH-FM01 | S/N FM01 |
|---|---|---|---|---|

| STEP n° | TEST SEQUENCE | EXPECTED VALUE | MEASURED VALUE | REMARKS |
|---|---|---|---|---|
| 4.3. | **RESONANCE SEARCH AFTER MEFL RANDOM VIBRATION** | | | |
| | | | | |
| 4.3.1. | PERFORM A RESONANCE SEARCH AFTER RANDOM (PROGRAM SHAKER ACCORDING TO 19.2.1 ) | OK | OK | |
| 4.3.2. | ANNEX TO THE TEST REPORT THE RECORDING CHART AND SAVE FILE | OK | OK | |
| 4.3.3. | VERIFY DISCREPANCIES WITH RESPECT TO PREVIOUS RESONANCE SEARCH | OK | OK | No discrepancies from the first resonance search (STEP 4.1.8) |
| 4.3.4. | REMOVE UUT MOUNTED ACCELEROMETERS | OK | OK | |
| 4.3.5. | CHECK FIXTURE BOLTS TORQUE | OK | OK | |
| 4.3.6. | REMOVE UUT FROM FIXTURE | OK | OK | |
| 4.3.7. | REMOVE FIXTURE | OK | OK | |
| 4.3.8. | CHECK RICH I\F BOLTS TORQUE AFTER MIRROR DE-INTEGRATION | OK | OK | |
| | | | | |
| 5. | FINAL FUNCTIONAL TEST REPORT CHECK | | | |
| 5.1. | CHECK THE FINAL FUNCTIONAL TEST REPORT (PERFORMED BY COLLABORATION PERSONNEL) STATING THE STATUS OF THE PMTS AFTER THE VIBRATION TEST | OK | OK | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| DATE: | TEST CONDUCTOR + QA DEPUTY | QA | CUSTOMER |
|---|---|---|---|
| 13/12/07 | ALESSANDRO BURSI | | |


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