SPIRE

SUBJECT:	**Cold vibration test plan CQM**		
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Distribution

Change Record

ISSUE	DATE	
Draft	10/12/03	First draft
Draft 2	27/2/04	GRMS values added.
Draft 3	29/3/04	Section 14.2 Sine displacement changed to 2mm
1	4/6/04	Raised to issue 1 for formal issue, no changes from draft 3

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Glossary

SPIRE Spectral and Photometric Imaging REceiver

References

Applicable Documents

No	Document	Ref
AD1	Cryovibration facility Design Description Document	TN-CSL-CRYOV-01003. issue 4 rev 0
AD2	Instrument Interface Document, part A	IID-A, issue 3
AD3	Random Vibration SPIRE February 2003 issue 3.doc	Technote 9
AD4	Herschel/SPIRE Handling and integration procedure	
AD5	Instrument interface drawing	5264-300 sheet 1 to 7, issue 18

Reference Documents

RF1 Drawing describing the MGSE assemblies
RF2 Lifting the FPA from/in transport container
RF3 Lifting the FPA from/on base plate
RF4 Fax, SCI-PT/22891, dd 18th December 2003. Cryo-Qual approach.

1. SCOPE

This document describes the cold vibration testing on the FPU to be carried out at CSL, Liege.

2. INTRODUCTION

3. PRE TEST PREPARATIONS AT RAL

As part of the preparations at RAL, instrumentation will be fitted within the FPU.
To achieve this the following equipment will be loaned to SPIRE by CSL.

- 11 Accelerometers, consisting of three tri-ax configurations and two single axis configurations.
- 11 accelerometer cables of minimum length 1.5m. This is long enough to bring the cables to the outside of the SPIRE FPU, further extension is probably required to the cryostat wall.

This equipment is required at RAL, at least two weeks before the start of the test campaign.

4. DELIVERY

The following equipment will be delivered to CSL by the SPIRE project. It will be delivered by road in one shipment.

FPU, JFETS and JFET harness in a dedicated container
MGSE
Lifting equipment

5. PRE TEST CHECKOUT

It is not planned to do any function checks after delivery of the Instrument or before the start of the test. Only a visual inspection will be carried out..

6. INSTRUMENTATION

6.1 Accelerometers

All accelerometers will be pre-fitted before delivery, see section 3. The instrument will be delivered to CSL ready to test, no additional accelerometers on the instrument are required.

6.2 Temperature sensors

The SPIRE CQM FPU contains several sensors already fitted. These can be read out by the CSL facility.

These temperature sensor signals are available at connector J32 on the FPU. A cable to connect this to one of the CSL supplied 37 way 'D; type connectors will be supplied by SPIRE, with pin outs as listed in AD1

7. INTEGRATION AND HANDLING

The FPU and JFETS will be integrated onto the fixture following the SPIRE handling and integration procedure.
The salient points are extracted here for convenience.

7.1 Handling

7.1.1 General.

The FPU is a delicate optical instrument and should be handled with extreme care at all time.
For this vibration test, contamination of the optical surfaces within the instrument is prevented a plastic film cover tapped loosely in position. This should be left in position at all times. It will not prevent the FPU from depressurising of repressurising.
WARNING: The bipod legs on two corners of the instrument are very thin section and easily damaged. Care must be taken at all times not to put side loads into these items. These are at risk at all times when the FPU is not attached to a rigid plate.
See appendix A for detailed instructions for lifting the instrument.

7.1.2 Unpacking from dedicated experiment container.

The FPU is supplied in a dedicated container, attached to a baseplate together with the JFETS and the JFET harness already integrated. It is bagged in polythene or lumaloy film.
To remove the FPU and JFETS from its container, the following procedure should be followed: -
In an area with a cleanliness of class 100,000 minimum, undo the four latches that secure the container lid and remove the lid.
The protective bagging encloses the FPU, JFETS and harness and is taped to the baseplate.
Unscrew and remove the cap head screws that secure the baseplate to the anti vibration mounts.
Attach the lifting frame RF2 to a crane. Lower the lifting frame to the baseplate and attach to the eyebolts provided on the baseplate.

The FPU, JFETS and baseplate can now be lifted out of the container with a crane.
Transport to cleanroom, minimum class 10,000 and remove bagging material.
If a class 10,000 environment is not available, leave the assembly in the bagged condition.

7.1.3 Preparation for integration.

The FPU is supplied with the JFETS and associated harness already fitted.

The following tasks need to be carried out before integration onto the spacecraft.

a) Fitting of JFET supports.

The JFETS will be fitted to the spacecraft together with the FPU. They will need supporting during this activity.
A support beam is supplied for this purpose.
Position the support beam on the top of the FPU as shown in fig…………… Connect the wire support straps to the JFET boxes as shown.

b) **Fitting of Lifting attachment**

Fit the lifting attachment to the FPU as shown in fig…….

c) **Alignment cube.**

The FPU is supplied with the alignment cube fitted, and should be left in place until all alignment activities are complete.

d) **Removal from baseplate**

WARNING: The bipod legs on two corners of the instrument are very thin section and easily damaged. Care must be taken at all times not to put side loads into these items. These are at risk at all times when the FPU is not attached to a rigid plate.
Undo the five M4 fasteners which secure the Photometer JFET rack (HSJP) (8 JFETS) to the baseplate.
Undo the four M4 fasteners that secure the Spectrometer JFET rack (HSJS) (2 JFETS) to the baseplate. Note that two of these fasteners are studs with nuts on the top, the nuts should be removed and the studs left in place.
The three L0 straps and one L1 strap are also secured to the baseplate. To release these, undo the 4 off M4 fasteners on each strap and remove. NOTE. The underside of the L0 straps form the thermal interface to the spacecraft helium tank pods. Their surfaces are flat and soft gold plated, these surfaces can easily be damaged and the thermal performance of the instrument may suffer as a result.
Undo and remove the 8 fasteners that attach the bipods to the base plate, remove the M8 nut at the top of the support cone. Lift the instrument using the MGSE supports. Instrument needs to be lifted horizontally, therefore use the 4 stand offs to lift it by rotating them one by one such the instrument is slowly lifted and kept horizontal. In this way unnecessary stressing of the bipods is prevented. When instrument is disengaged from the cone, the instrument can be lifted further using the crane. After that is done the cone can be removed from the base plate and moved to the shaker, bolted down and the instrument can be lowered on top of it. See Handling and Integration procedure attached in appendix A to this document for more details.
The FPU and JFETS can now be lifted from the baseplate.

The FPU and JFETS are now ready for integration.

7.1.4 Required tools/MGSE

SPIRE supplied tools/MGSE:-	FPU handling frame.	
	JFET support beam	
	FPU/JFET/baseplate lifting gear	
	Fixation bolts,	
	FPU	M6 12 off

	L0 straps	M4 16 off
	JFET	special screws
	L1 strap	M4 4 off
	L3 strap	Not required
	Thermal strap interface plate and bolts	
	Torque wrench	
	Allan key, spanners etc	
Supplied by facility	Crane, with slow speed capability	

7.2 Integration on to fixture

FPU and JFETS
Fit the thermal strap interface plate (SPIRE supplied) to the fixture with the 8 off M6 bolts supplied.
Assuming activities described unpacking and preparation sections have been carried out, and the FPU and JFETS are supported on a crane.
Remove the cone mount from the transit plate by removing the four M6 fasteners.
Fix the cone to the vibration fixture using the four M6x21 cap head screws. Note: there are special washers (part number A3/5264/302-3) under the head of each screw and also Vespel insulating bushes (A3/5264/302-2) either side of the mounting flange.
Torque the screws to 8.1 Nm.
Fix the Spectrometer JFET studs (2 off) as indicated on interface drawing 0-KE-0104-360. Note these should be screwed into the fixture until 37mm of stud are protruding from the surface.
Lift the FPU and JFETS using the lifting gear as described in section 6.
Very gently lower the assembly onto the fixture, ensuring that the JFET studs engage on the JFETS and the cone mount engages in its location on the FPU. . See appendix A for more details.
The flexible ends of the L0 straps are unsupported at this stage and will need to be guided into place as the FPU is lowered.
NOTE: the cone is very thin walled section and large moments can be applied if the unit is not lowered with its interface plane parallel to the fixture
When all units are resting on the fixture, fit the attachment screws (M6X21) to the bipod feet as for the cone mount.
Fit the two Bellville washers and the M8 Kaylock nut to the cone mount. Torque to 8.25Nm.
Remove the lifting/handling fixture.

L0 straps
The L0 straps should be fitted to the interface plate which has been previously fitted to the fixture, using 4 off M4 bolts per strap.

L1 straps.
For this test a non flight representative strap will be supplied to thermally short the FPU optical bench to the test fixture. This short strap fits between the interface plate and the 4 off M4 tapped hols in the lower corner edge of the FPU, close to the interface plate.

L3 straps.

Fit the two L3 straps to the JFETS using two M4 screws in each JFET. Torque to 2.5 Nm.
Attach the other end to a convenient tapped hole in the fixture, one of the unused harness support bracket holes would be ideal.

7.3 Removal from fixture

WARNING: The bipod legs on two corners of the instrument are very thin section and easily damaged. Care must be taken at all times not to put side loads into these items. These are at risk at all times when the FPU is not attached to a rigid plate.
Remove all electrical connections,
Attach the FPU and JFET lifting devices as detailed in section 'preparation for integration'
Undo the five M4 fasteners which secure the Photometer JFET rack (HSJFP) to the fixture
Undo the four M4 fasteners that secure the Spectrometer JFET rack (HSJFS)to the fixture. Note that two of these fasteners are studs with nuts on the top.
Undo the 4 off M4 fasteners on each L0 strap and remove, separate the cold strap from the interface plate. NOTE. The underside of these straps form the thermal interface to the spacecraft helium tank pods. Their surfaces are flat and soft gold plated, these surfaces can easily be damaged and the thermal performance of the instrument may suffer as a result.
Undo and remove the 4 off M4 screws which secure L1 cold strap to the interface plate, separate the cold strap from the interface plate
Undo and remove the M4 screws that secure the L3 straps to the fixture.
Undo and remove the 8 fasteners that attach the FPU bipods to the baseplate.
Undo and remove the M8 nut that secures the FPU to the cone mount.
NOTE: the cone is very thin walled section and large moments can be applied if the unit is not raised with its interface plane parallel to the fixture.

The FPU and JFETS can now be lifted from the HOB

7.3.1 Preparation for packing

All units should be wrapped in clean film and replaced in their transit containers. The FPU should be refitted to its baseplate using the following procedure:

Assuming activities described in section above have been carried out, and the FPU and JFETS are supported on a crane.
Fix the cone to the SPIRE baseplate using the four M6x21 cap head screws. Note: there are special washers (part number A3/5264/302-3) under the head of each screw and also Vespel insulating bushes (A3/5264/302-2) either side of the mounting flange.
Torque the screws to 8.1 Nm.
The Spectrometer JFET studs (2 off) as indicated on interface drawing 0-KE-0104-360. Should still be fitted to the baseplate
Lift the FPU and JFETS using the lifting gear as described in section 6.
Very gently lower the assembly onto the baseplate, ensuring that the JFET studs engage on the JFETS and the cone mount engages in its location on the FPU. See appendix A for more details.

NOTE: the cone is very thin walled section and large moments can be applied if the unit is not lowered with its interface plane parallel to the baseplate
When all units are resting on the baseplate, fit the attachment screws (M6X21) to the bipod feet as for the cone mount, torque the screws to 8.1 Nm.
Remove the lifting/handling fixture.
Fit the two long bolts and two nuts to secure the spectrometer JFET. Torque the screws to 2.1 Nm.
Fit the 5 long bolts to secure the photometer JFET. Torque the screws to 2.1 Nm.
Secure the L0 straps to the baseplate using M4X20 socket head cap screws. Torque the screws to 1.5 Nm.
Cover the FPU and JFETS with a double layer of clean polythene or lumaloy film and secure each one with tape to the baseplate.
Fit the lifting frame RF2 to the four eyebolts in the plate.

7.3.2 Packing in containers.

Lift the plate into the container.
Remove lifting frame.
Secure baseplate to the anti-vibrations mounts in the floor of the transit container.
Fit container lid.

8. BUILD STANDARD

The STM of the SPIRE instrument is identical to the PFM with the following exceptions:-

Mass thermal dummies of the following subsystem are fitted in place of the Flight units:-

- Beam Steering Mirror (and support)
- Spectrometer Mechanism (full structure but no electronics and dummy flex-pivots)
- Four of the five detectors are mass dummies (mass representative and internally suspended mass representative of the flight hardware with thermal interface for thermal busbar). One detector (PLW) is to full flight standard.

The interface to the spacecraft is identical to the flight unit. The mass of the CQM model of the SPIRE instrument is 42.2Kg including the JFETS and JFET harness.

9. TEST OBJECTIVES

- To Qualify the design of the SPIRE instrument and its critical subsystems, at a temperature typical of the launch environment.
- To monitor the dynamic behaviour of the instrument at cold temperature so that it can be compared with the results of the warm vibration test.

10. TESTING

10.1 General

The SPIRE FPU and JFETS will be subjected to the following vibration tests.

Note the detectors within SPIRE are supported on highly tensioned Kevlar fibres. These fibres are at a higher tension when at room temperature that they are when cold. Consequently no vibration tests shall be carried out when the FPU is above 100K, with the exception of low level resonance searches.

In each axis:
- Low level resonance search
- Sine test
- Low level resonance search
- Random test
- Low level resonance search

The order of axis is not important.

NOTE. Due to the low natural frequency of the fixture, high levels may be encountered within the FPU at modest input levels.
Accelerometers mounted on the detector boxes will be monitored and used to limit the vibration levels applied to the FPU.

11. PUMP DOWN RATE

SPIRE has thin filters in various locations within the FPU. These can be damaged if the cryostat is pumped down too quickly.

Max pump down or re-pressurisation rate is 50mb/min

12. COOL DOWN RATE

To avoid damage to the FPU cool down/warm up rate should not exceed 20K/hour, between room temperature and 100K, below 100K the rate should not exceed 50K/hour.

13. CONTROL PHILOSOPHY

The accelerometers mounted inside the instrument on the SOB and the detector boxes should not exceed the response measured during the warm vibration test at RAL in April 2002. Furthermore the responses should be limited to 10 g-rms maximum for sensitive subsystems, following RF4. A SPIRE mechanical engineer will be present during the cold vibration tests to specify the notches. The instrument is not allowed to exceed the equivalent quasi-static interface force for each axis in any direction. Readings from accelerometers mounted near the CoG can be used to monitor the overall interface force at frequencies below the first instrument or fixture resonance.

14. TEST SPECIFICATION

14.1 Resonance search

A resonance search shall be conducted at approximately 0.5 g input between 5 and 2000 Hz to identify any changes in the primary resonance's. The will serve as the structure's health check.
The sweep rate shall be 1 Oct/min The monitor accelerometers shall be located on the SPIRE vibration fixture near the mounting locations of the instrument. The resonance search will be performed prior and after a qualification run. No nuts or bolts should be tightened or loosened between these verification runs.

14.2 Sine vibration test

As stated in IID-A, AD (1) the qualification levels are:

X axis

Frequency Range Hz	Qualification level
5 - 20.1	+/- 2mm
20.1 - 100	18 g

Test sweep rate 2 Oct/min, the input will be limited to equivalent quasi static interface force.

Y and Z axis

Frequency Range Hz	Qualification level
5 - 13.5	+/- 2mm
13.5 - 100	8 g

Test sweep rate 2 Oct/min, the input will be limited to equivalent quasi static interface force.

14.3 Random vibration test

As stated in IID-A, AD (1) the qualification levels are:

Y and Z axis

Frequency Range Hz	Qualification level
20-100	+3dB/Oct

100-150	0.02 g^2/Hz
150-300	0.0125g^2/Hz
300-2000	-7 dB/Oct
Global	2.54 gRMS

Test duration 2 minutes in each axis

X axis

Frequency Range Hz	Qualification level
20-100	+3dB/Oct
100-150	0.05 g^2/Hz
150-300	0.02g^2/Hz
300-2000	-7 dB/Oct
Global	3.47 gRMS

Test duration 2 minutes

14.4 Test Sequence

The test sequence can be adjusted to suit the planning of the facility

15. REJECTION AND RETEST

If a failure, malfunction or out of tolerance performance occurs during or after test as appropriate the test shall be discontinued. This also includes test equipment qualification. the deficiency, including any design defect, shall be corrected and the applicable procedures repeated until successfully completed. If the corrective action subsequently affects the significance of results of previously completed test in the sequence, such test shall be repeated.

16. DOCUMENTATION

A test report shall be produced logging all events and the results of the visual inspections. Also all main resonances shall be reported and the worst case responses at the subsystem interfaces. The rest report shall also contain the environmental measurement data (taken during the test) and the calibration/qualification certificates of the test facility.

17. PRODUCT ASSURANCE

Before a test can proceed a Test Readiness Review (TRR) shall be convened by the SPIRE project manager. All the relevant test and facility documentation will be made available. The TRR must give approval before the test can commence. The TRB will convene between each reconfiguration of the test set-up. The test set up can be dismantled after the TRB convened and agrees.

The test review board will consist of the designated SPIRE representative and the test facility manager or their representatives.

APPENDIX A

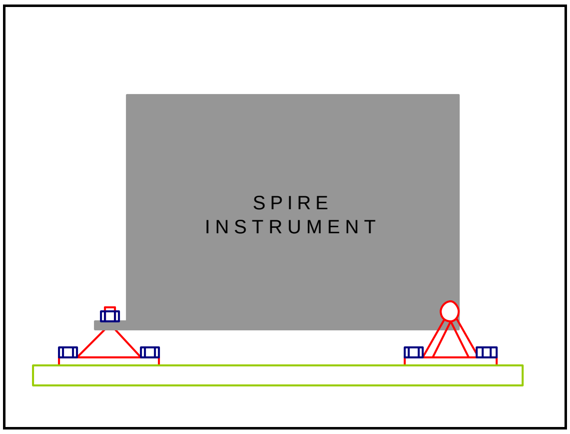
Handling and integration – Lifting the instrument

Nominal – bolted down on a base.

The bolts that keep the cone support fixed on its interface with the base cannot all be reached easily. The cone itself is a (very) thin walled structure and should not be dented. The fit between the cone and the instrument (its internal optical bench) is a very close fit. The top of the cone is a threaded (at the top) stud protruding through a lug extending from the SPIRE optical bench. It is locked with an M8 self locking nut and pretensioned with a Bellville washer. At the bottom of the cone there is a ring with 4 holes in it. These mounting holes have on each side (top and bottom) a Vespel top-hat washer to provide electrical insulation. Through each pair of these washers an M6 bolt with a plain shank is used to bolt the cone on the baseplate. Each bolt has a custom made washer to spread the load on the Vespel washer.

The two bipods that support the instrument at the other side are fragile in one direction. Their weak direction is perpendicular to the plane through their feet. At the top these bipods are fitted inside a lug protruding from the instrument side. At the bottom the bipods are mounted on the base the same way as the cone.The following is MANDATORY for lifting the instrument off its supports at any time.

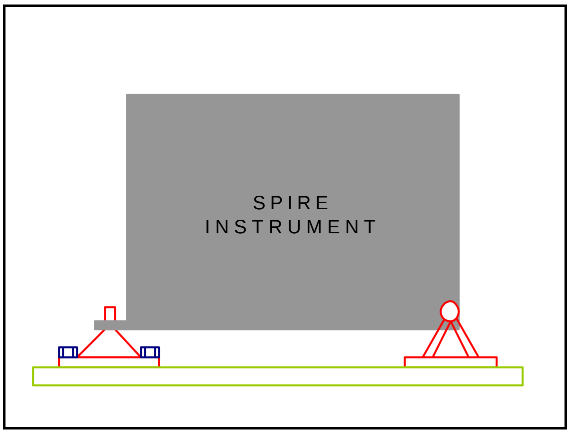
Some of the bolts holding down the cone on the base are not accessible hence, they should not be removed before the instrument is lifted. In order to lift the instrument the M8 nut at the top of the cone and the four M6 bolts that fix each bipod to the base shall be removed. Since the fit between the cone and the instrument optical bench is a very close one it is vital that the instrument is lifted while keeping it as horizontal as possible. Lifting it without any provision to keep the instrument level will certainly damage both the cone and the instrument optical bench.



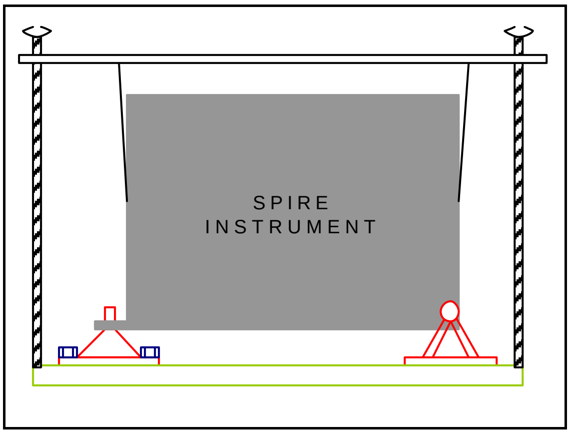
Schematic layout of the mounted instrument.

In the above figure (and following) the mounting cone or bipods are red, fixings blue. MGSE is black. Mounting base is green. The instrument is grey.

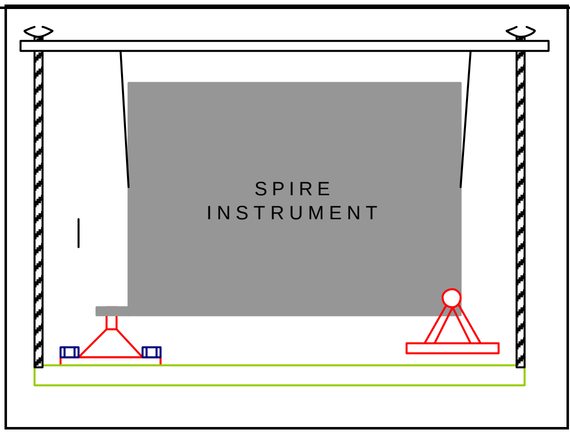
The JFETs need to be lifted together with the instrument and MGSE will be provided for that. It consists of a yoke resting on the top of the instrument holding both JFET boxes at either end of the instrument.



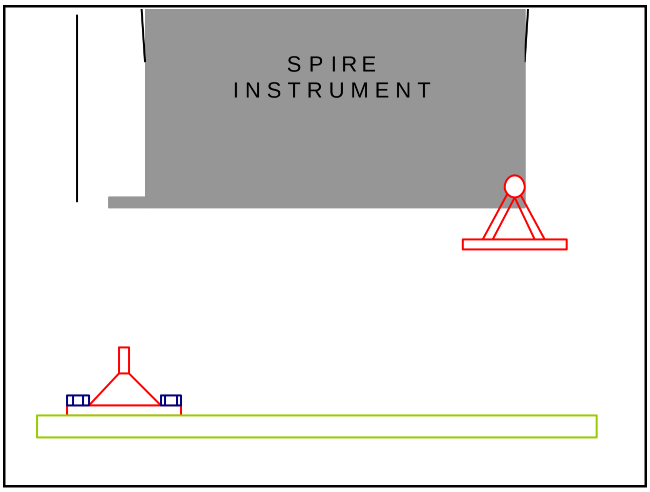
First step – remove one M8 nut from cone and four M6 bolts from A-frames



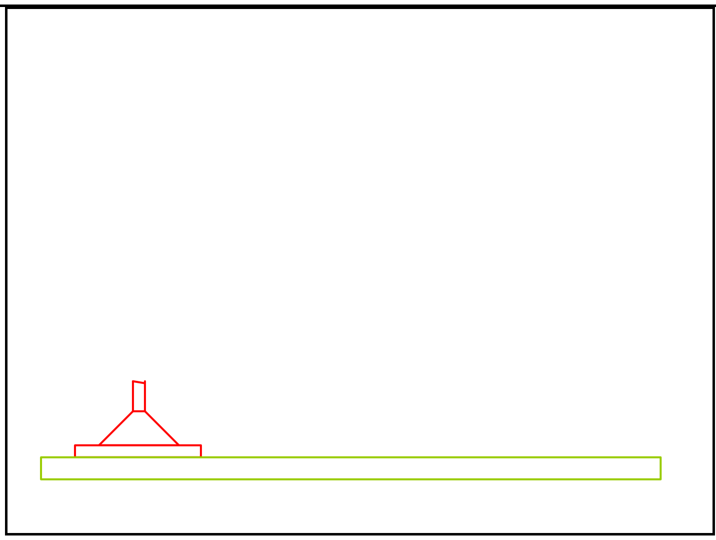
Attach lifting equipment and carefully start lifting the instrument whilst keeping it absolutely horizontal



Keep lifting it until the cone disengages



After the cone is completely free, the instrument can be lifted with a standard hoist



Remove the four M6 bolts fixing the cone to the base

After this the instrument is still hanging in its slings. The cone is then moved to the location where the instrument is mounted next. The cone is bolted down using the 4 M6 and the reverse procedure is followed. The instrument is slowly lowered until the stud on the top is close to the hole in the lug of the SPIRE optical bench. Then lower it slowly keeping the instrument horizontal. When the bipods touch the base bolt them down. Screw the M8 Kaylock nut on the stud of the cone. Remove the lifting MGSE. See for the applicable torques the interface drawing AD5. The M6x21 cap head interface bolts should be torqued to 8.1 Nm and the M8 Kaylock nut for the cone at 8.25 Nm. Unless the interface drawing states otherwise, the quoted torques are from issue 18, sheet 4.