End Item Data Package (EIDP)

SPIRE - Photometer Calibration Source (PCal) - CQM

SPIRE Ref.: SPIRE-UCF-DOC-002096
Cardiff Ref.: HSO-CDF-EIDP-053 Issue 1.0
13 July 2004

Prepared by: Peter Hargrave
Cardiff SPIRE Technical Manager

Approved by: Ian Walker
Cardiff AIG Programme Manager

Distribution list

RAL	Eric Sawyer	ATC	Phil Parr-Burman
	Eric Clark		
	Judy Long		
	Bruce Swinyard		
	Doug Griffin		
Cardiff	Peter Ade		
	Matt Griffin		
	Ian Walker		

Change Record

Issue	Section	Date	Changes
1.0		13/07/04	First issue

Table of contents

SECTION 01 - Shipping Documents

PCal CQM was hand carried to RAL by P. Hargrave on 29th September 2003.
Incoming inspection was carried out by P. Hargrave and E. Clark (RAL).

SECTION 02 - Transportation, Packing, Handling & Integration Procedures

Handling

- Full ESD precautions to be observed when handling PCal.
- Inspection may be carried out in class-100 clean air cabinet.
- The rear cover must not be removed unless an authorised member of Cardiff personnel is present.
- Outer surface may be cleaned using a clean-room wipe impregnated with iso-propyl alcohol, with a piece of Kapton tape covering the aperture.
- PCal must be stored in the shipping container provided.
- Installation of PCal will be carried out by an ESA-approved soldering technician at RAL, according to the PCal ICD.

SECTION 03 - Certificate of Conformance

Cardiff University Astronomy Instrumentation Group hereby certifies that the following equipment,	
Spacecraft / Project:	**Herschel**
Instrument:	**SPIRE**
Model:	**CQM**
Subsystem:	**Photometer Calibration Source**
Serial No:	**PCAL-CQM-000**
As described in this End Item Data Package: **HSO-CDF-EIDP-053**	
Complies with the requirements set out in: **SPIRE-RAL-PRJ-000034**	

Responsible Authority		***Signature***
Cardiff Product Assurance	Dr I.Walker	
Cardiff SPIRE Management	Dr P.Hargrave	

SECTION 04 - Qualification Status List / Compliance Matrix

Test	Status	Applicable document / Test reference	Test Institute
Dimension and tolerances to specification	Compliant	HSO-CDF-ICD-013 issue 3.0	UWC
Visual inspection (internal & external)	Passed		UWC
Mass	Compliant	HSO-CDF-ICD-013 issue 3.0	UWC
Thermal / vacuum cycles	Passed. Prior to delivery, PCal-CQM underwent a total of four thermal / vacuum cycles to <15-K, in addition to two performance test cool-downs		UWC
Power consumption	Compliant	SPIRE-RAL-PRJ-000034 Issue 1.2	UWC
Vibrations 300K	Passed	AIV-2003-008-VIB	RAL
Vibrations 4K	Passed	AIV-2003-008-VIB	RAL
Environmental condition - Vacuum $3x10^{-1}$mBar	Complete		UWC
Differential pressure (a pumping-out rate of 10mB/sec)	Compliant	Routine lab tests and thermal cycling exceed this pump-out rate (initial pump-out rate is usually ~50mB/sec)	RAL
Pre-bake out (not exceeding 80°C)	Performed & compliant		UWC
Outgassing	Not tested. All materials & parts used are on ESA / NASA approved list.		UWC
Cleanliness checks, by visual inspection.	Passed		UWC
Degradation due to high energy radiation.	Not tested. All materials & parts used are on ESA / NASA approved list.		UWC

Compliance with IRD

Requirement ID	Description	Value	Compliant?
IRD-CALP-R01	Nominal operating output	The area:surface brightness product of the calibrator aperture shall be =1% of the area:surface brightness product of the telescope image at the position of M4 (with an assumed telescope temperature of 80 K and emissivity of 4%) for 200 < λ < 700µm.	Yes – see test data
IRD-CALP-R02	Operating range	Commandable in 256 steps, with at least 124 steps covering the range from zero output to 2% of the power from the telescope	Yes – 12-bit DAC current drive in range 0-7mA. Nominal output achieved at 2.4mA
IRD-CALP-R03	Equivalent obscuration of aperture through BSM mirror	The outside envelope of the calibrator housing shall not foul on any part of the BSM for any operational angular position of the BSM	This is the same as IRD-CALP-R09! The old requirement referred to equivalent obscuration of the telescope primary at the BSM pupil…….
IRD-CALP-R04	Speed of response	Response to step change in applied power, 90% settling time of radiant power output <350ms (70ms)	Compliant with requirement, but goal not met. See test data.
IRD-CALP-R05	Repeatability	RMS of output signal better than 1% over 20 cycles on to off during a calibration operation of less than 2 minutes. Drift less than10% over lifetime of the mission. Repeatability of signal 1% for 12 calibration operations equi-spaced over a period of 12 hours, with uniform base temperature and drive current.	Yes. See life test report.
IRD-CALP-R06	Operation	Nominally once per hour for no more than 10 seconds.	Yes
IRD-CALP-R07	Frequency	Continuously or pseudo continuously variable between 0 and 2 Hz.	Yes
IRD-CALP-R08	Interface	The calibrator will be integrated into the beam steering mechanism.	Yes – see PCAL ICD. HSO-CDF-ICD-013-3.0
IRD-CALP-R09	Volume envelope	This shall be compatible with the space available within the BSM enclosure as described in the BSM specification document.	Yes
IRD-CALP-R10	Thermal isolation	The thermal conductance between the calibrator body and the SPIRE optical bench shall be > 2 mW/K.	TBD. Determined by BSM structure.

IRD-CALP-R11	Operating temperature	<6K	Yes
IRD-CALP-R12	Cold power dissipation	Shall be within the specification given in RD8	?
IRD-CALP-R13	Warm power dissipation	*Requirement removed*	
IRD-CALP-R14	Operating voltage	Less than 28V at input power level of 5mW	Yes - see PCAL ICD. HSO-CDF-ICD-013-3.0
IRD-CALP-R15	Redundancy	Cold redundancy for the thermal source	Yes
IRD-CALP-R16	Lifetime	The calibration source shall be capable of up to 250,000 operational cycles at the nominal electrical power.	Yes. See life test report.

SECTION 05 - Top Level Drawings (Inc. Family Tree)

Hardware tree

The hardware tree for PCal is shown in Figure 1. Note that the part numbers are given by the general form “PCAL-XXX-nnn”, where “XXX” is the model designation (CQM, PFM etc) and “nnn” is the number given in the hardware tree. For instance, the part number for the PCal flight model rear cover would be “PCAL-PFM-205”.

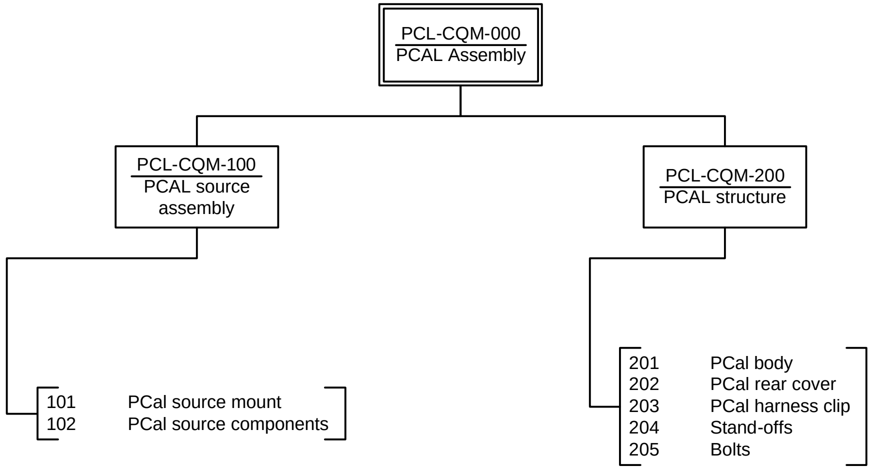


Figure 1 Hardware tree for PCal components.

TOP LEVEL DRAWING LIST

Drawing No.	Title

SECTION 06 - Interface Drawings

INTERFACE DRAWING LIST

Drawing No.	Title	Notes
PCAL-ICD-000-B	PCal Interface Control Drawing	

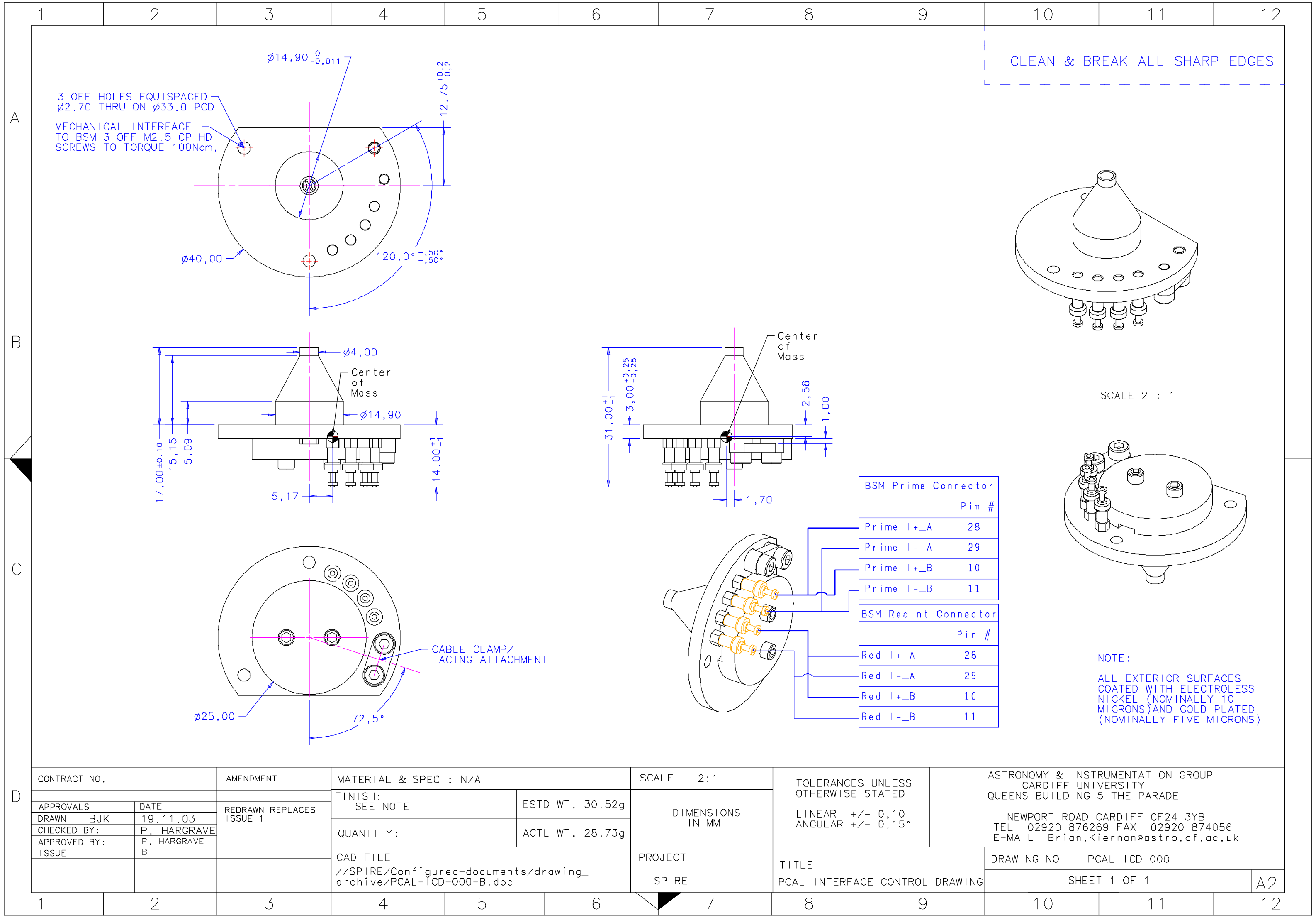


Figure 2 Interface drawing for PCal-CQM

SECTION 07 - Functional, Block & Mechanical Drawings

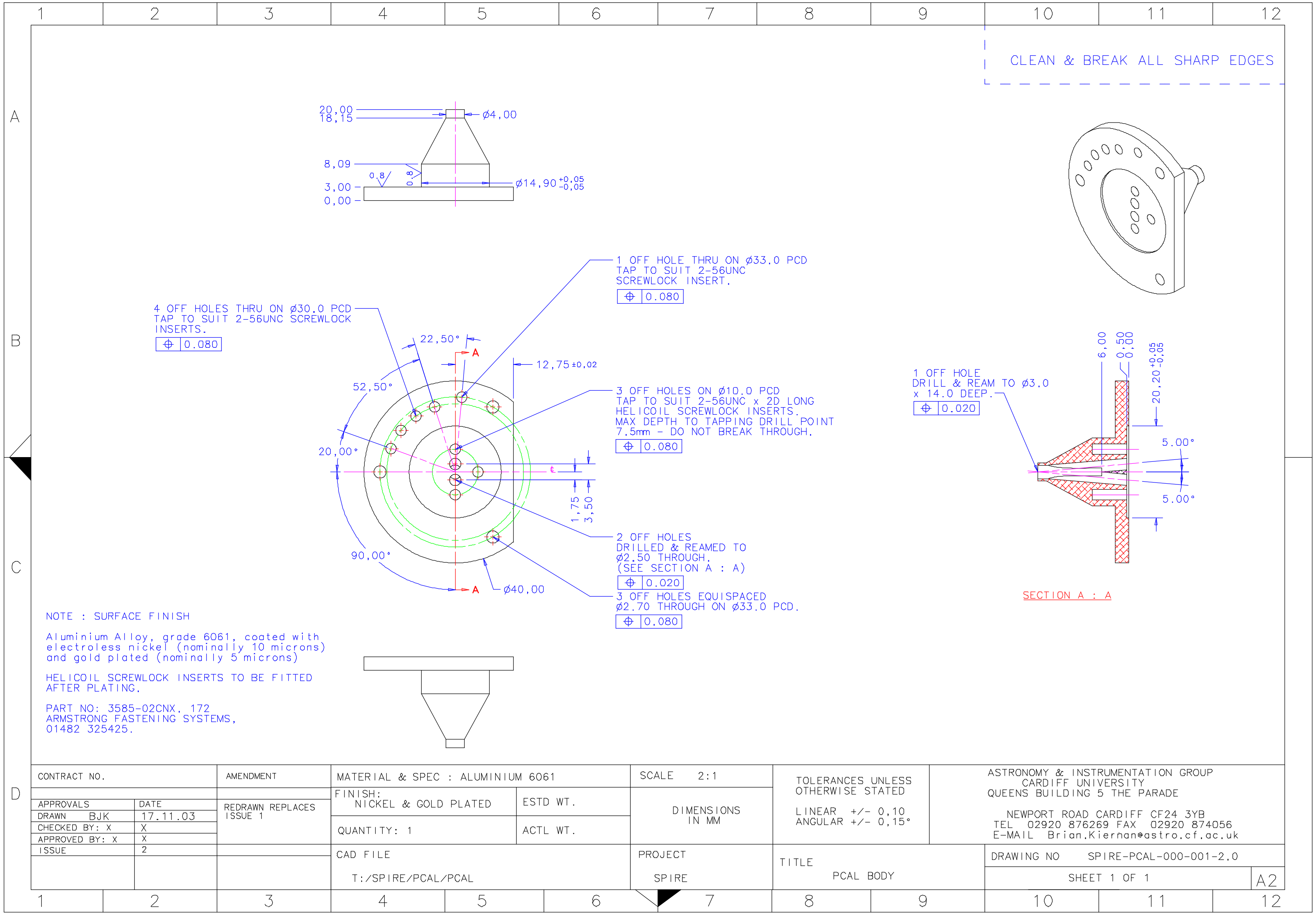
Component drawings are given in this section.

FUNCTIONAL & BLOCK DRAWING LIST

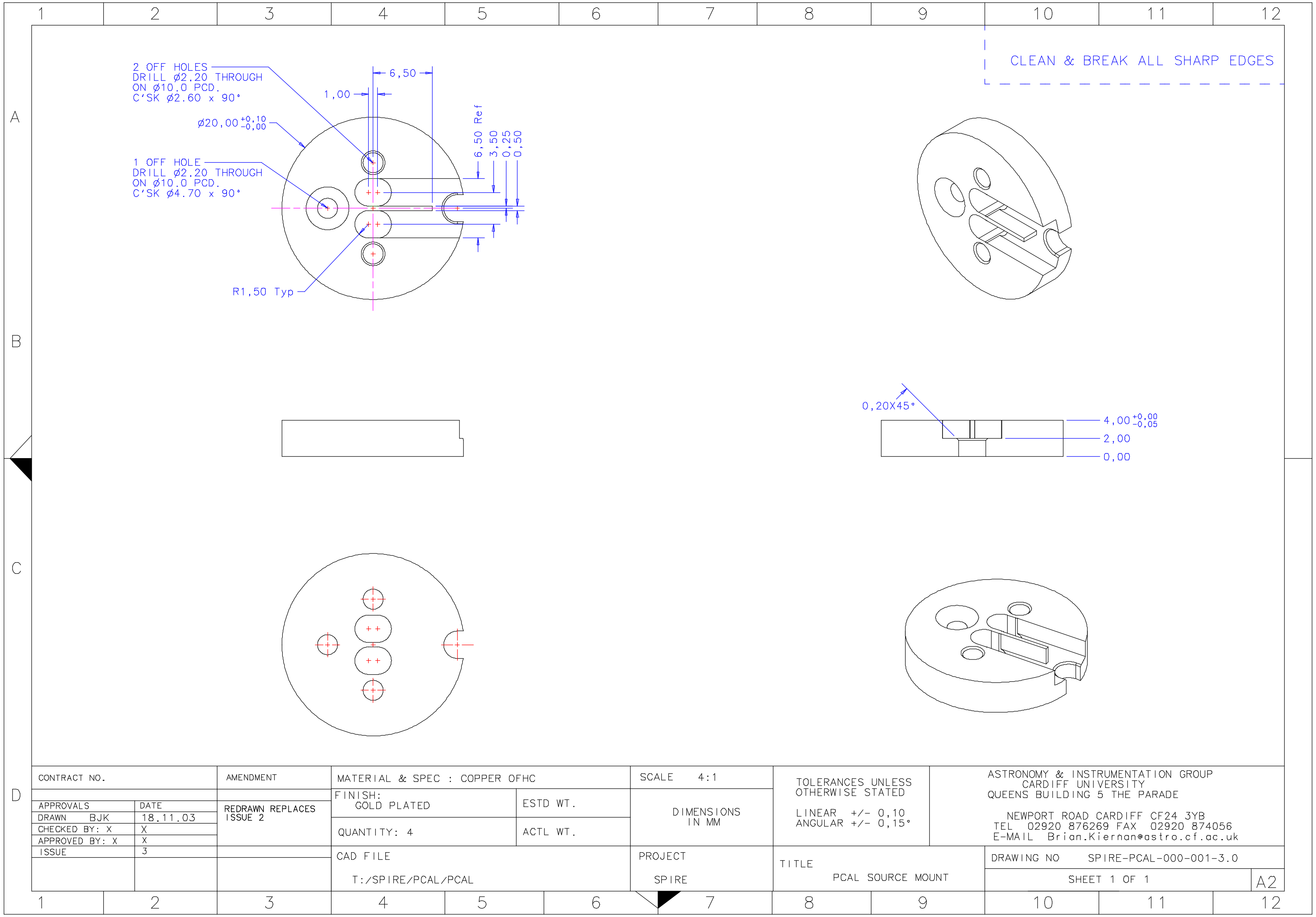
Drawing No.	Title

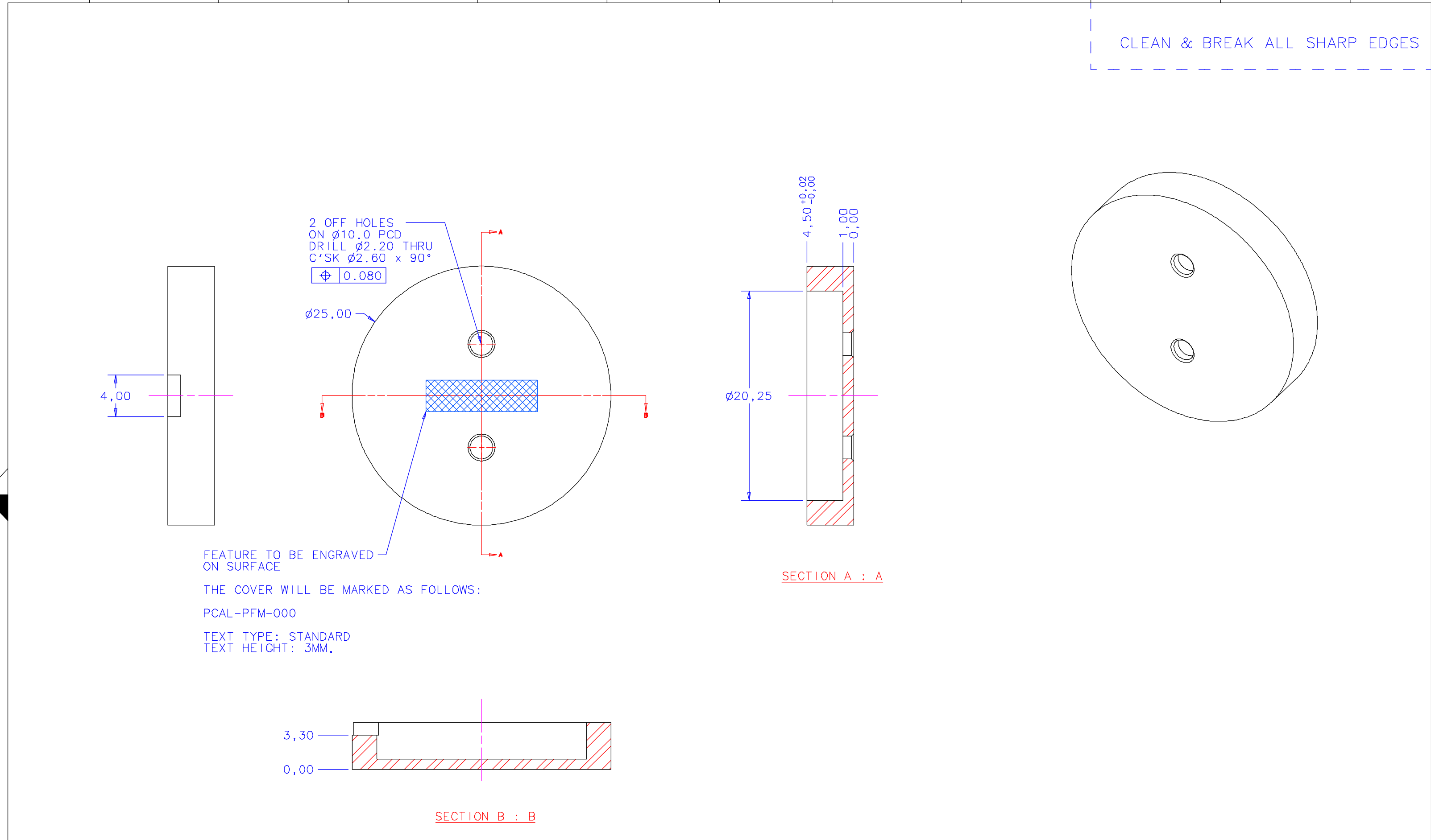
MECHANICAL COMPONENT DRAWING LIST

Drawing No.	Title	Notes
SPIRE-PCAL-000-001-2.0	PCAL BODY	
SPIRE-PCAL-000-001-3.0	PCAL SOURCE MOUNT	
SPIRE-PCAL-000-001-4.0	PCAL REAR COVER	
SPIRE-PCAL-000-001-5.0	PCAL SOURCE HOLDER	
SPIRE-PCAL-000-001-6.0	PCAL HARNESS CLAMP	

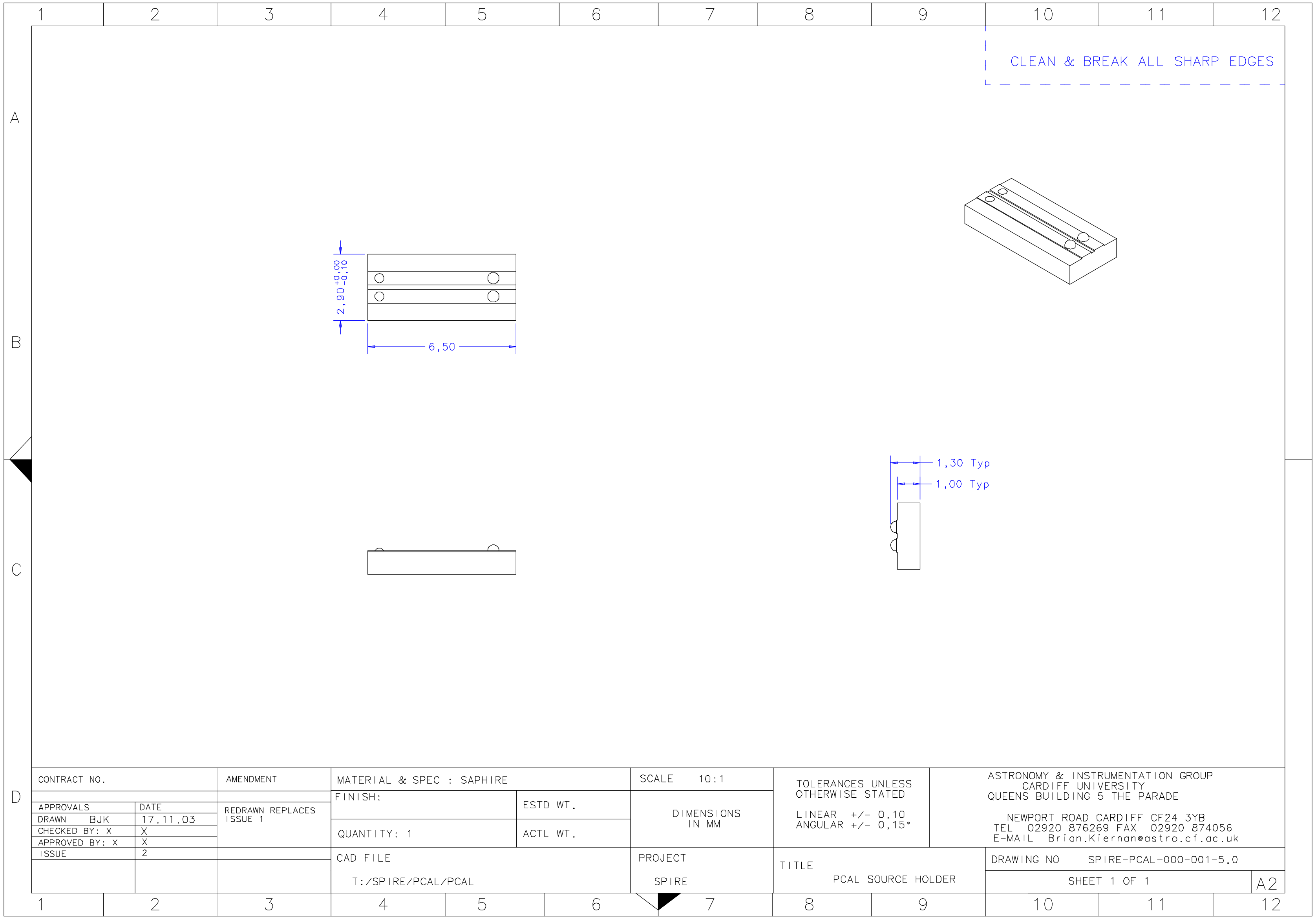


CLEAN & BREAK ALL SHARP EDGES
20,00
18,15
ø4,00
8,09
0,8
3,00
0,00
ø14,90 +0,05 -0,05
1 OFF HOLE THRU ON ø33,0 PCD
TAP TO SUIT 2-56UNC
SCREWLOCK INSERT.
0.080
4 OFF HOLES THRU ON ø30,0 PCD
TAP TO SUIT 2-56UNC SCREWLOCK
INSERTS.
0.080
22,50°
12,75 ±0,02
52,50°
20,00°
90,00°
ø40,00
1,75
3,50
3 OFF HOLES ON ø10,0 PCD
TAP TO SUIT 2-56UNC x 2D LONG
HELICOIL SCREWLOCK INSERTS.
MAX DEPTH TO TAPPING DRILL POINT
7,5mm - DO NOT BREAK THROUGH.
0.080
2 OFF HOLES
DRILLED & REAMED TO
ø2,50 THROUGH.
(SEE SECTION A : A)
0.020
3 OFF HOLES EQUISPACED
ø2,70 THROUGH ON ø33,0 PCD.
0.080
1 OFF HOLE
DRILL & REAM TO ø3,0
x 14,0 DEEP.
0.020
6,00
0,50
0,00
20,20 +0,05 -0,05
5,00°
5,00°
SECTION A : A
NOTE : SURFACE FINISH
Aluminium Alloy, grade 6061, coated with
electroless nickel (nominally 10 microns)
and gold plated (nominally 5 microns)
HELICOIL SCREWLOCK INSERTS TO BE FITTED
AFTER PLATING.
PART NO: 3585-02CNX. 172
ARMSTRONG FASTENING SYSTEMS,
01482 325425.
CONTRACT NO.
AMENDMENT
MATERIAL & SPEC : ALUMINIUM 6061
SCALE 2:1
TOLERANCES UNLESS OTHERWISE STATED
ASTRONOMY & INSTRUMENTATION GROUP
CARDIFF UNIVERSITY
QUEENS BUILDING 5 THE PARADE
APPROVALS DATE
DRAWN BJK 17.11.03
CHECKED BY: X X
APPROVED BY: X X
ISSUE 2
REDRAWN REPLACES ISSUE 1
FINISH: NICKEL & GOLD PLATED
ESTD WT.
DIMENSIONS IN MM
LINEAR +/- 0,10
ANGULAR +/- 0,15°
NEWPORT ROAD CARDIFF CF24 3YB
TEL 02920 876269 FAX 02920 874056
E-MAIL Brian.Kiernan@astro.cf.ac.uk
QUANTITY: 1
ACTL WT.
CAD FILE
T:/SPIRE/PCAL/PCAL
PROJECT
SPIRE
TITLE
PCAL BODY
DRAWING NO SPIRE-PCAL-000-001-2.0
SHEET 1 OF 1
A2

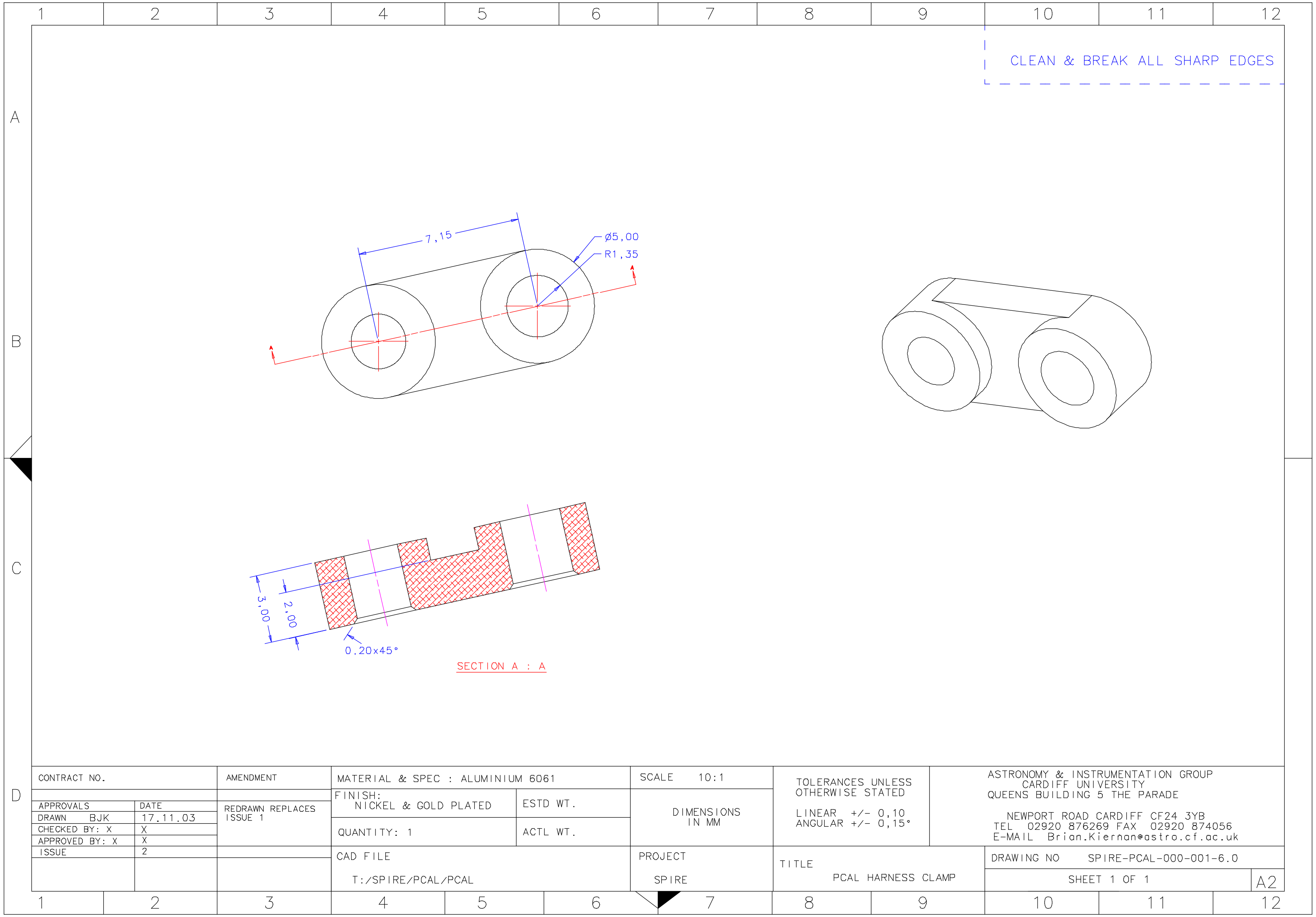

2 OFF HOLES
DRILL ø2.20 THROUGH
ON ø10.0 PCD.
C'SK ø2.60 x 90°
ø20,00 +0,10 -0,00
1 OFF HOLE
DRILL ø2.20 THROUGH
ON ø10.0 PCD.
C'SK ø4.70 x 90°
R1,50 Typ
6,50
1,00
6,50 Ref
3,50
0,25
0,50
CLEAN & BREAK ALL SHARP EDGES
0,20X45°
4,00 +0,00 -0,05
2,00
0,00
CONTRACT NO.
AMENDMENT
REDRAWN REPLACES ISSUE 2
APPROVALS
DATE
DRAWN BJK
18.11.03
CHECKED BY: X
X
APPROVED BY: X
X
ISSUE
3
MATERIAL & SPEC : COPPER OFHC
FINISH: GOLD PLATED
ESTD WT.
QUANTITY: 4
ACTL WT.
CAD FILE
T:/SPIRE/PCAL/PCAL
SCALE 4:1
DIMENSIONS IN MM
PROJECT
SPIRE
TOLERANCES UNLESS OTHERWISE STATED
LINEAR +/- 0,10
ANGULAR +/- 0,15°
TITLE
PCAL SOURCE MOUNT
ASTRONOMY & INSTRUMENTATION GROUP
CARDIFF UNIVERSITY
QUEENS BUILDING 5 THE PARADE
NEWPORT ROAD CARDIFF CF24 3YB
TEL 02920 876269 FAX 02920 874056
E-MAIL Brian.Kiernan@astro.cf.ac.uk
DRAWING NO SPIRE-PCAL-000-001-3.0
SHEET 1 OF 1
A2



CONTRACT NO.	AMENDMENT	MATERIAL & SPEC : ALUMINIUM 6061	SCALE 4:1	TOLERANCES UNLESS OTHERWISE STATED	ASTRONOMY & INSTRUMENTATION GROUP CARDIFF UNIVERSITY QUEENS BUILDING 5 THE PARADE NEWPORT ROAD CARDIFF CF24 3YB TEL 02920 876269 FAX 02920 874056 E-MAIL Brian.Kiernan@astro.cf.ac.uk
APPROVALS / DATE DRAWN BJK 17.11.03 CHECKED BY: X X APPROVED BY: X X ISSUE 3	REDRAWN REPLACES ISSUE 1	FINISH: NICKEL & GOLD PLATED / ESTD WT. QUANTITY: 1 / ACTL WT.	DIMENSIONS IN MM	LINEAR +/- 0,10 ANGULAR +/- 0,15°	
		CAD FILE T:/SPIRE/PCAL/PCAL	PROJECT SPIRE	TITLE PCAL REAR COVER	DRAWING NO SPIRE-PCAL-000-001-4.0 SHEET 1 OF 1 A2



CLEAN & BREAK ALL SHARP EDGES
2,90 +0,00 -0,10
6,50
1,30 Typ
1,00 Typ
CONTRACT NO.
AMENDMENT
APPROVALS
DATE
DRAWN BJK
17.11.03
CHECKED BY: X
X
APPROVED BY: X
X
ISSUE
2
REDRAWN REPLACES ISSUE 1
MATERIAL & SPEC : SAPHIRE
FINISH:
ESTD WT.
QUANTITY: 1
ACTL WT.
CAD FILE
T:/SPIRE/PCAL/PCAL
SCALE 10:1
DIMENSIONS IN MM
PROJECT
SPIRE
TOLERANCES UNLESS OTHERWISE STATED
LINEAR +/- 0,10
ANGULAR +/- 0,15°
TITLE
PCAL SOURCE HOLDER
ASTRONOMY & INSTRUMENTATION GROUP
CARDIFF UNIVERSITY
QUEENS BUILDING 5 THE PARADE
NEWPORT ROAD CARDIFF CF24 3YB
TEL 02920 876269 FAX 02920 874056
E-MAIL Brian.Kiernan@astro.cf.ac.uk
DRAWING NO SPIRE-PCAL-000-001-5.0
SHEET 1 OF 1
A2



CLEAN & BREAK ALL SHARP EDGES
7,15
ø5,00
R1,35
3,00
2,00
0.20x45°
SECTION A : A
CONTRACT NO.
AMENDMENT
MATERIAL & SPEC : ALUMINIUM 6061
SCALE 10:1
TOLERANCES UNLESS OTHERWISE STATED
ASTRONOMY & INSTRUMENTATION GROUP
CARDIFF UNIVERSITY
QUEENS BUILDING 5 THE PARADE
NEWPORT ROAD CARDIFF CF24 3YB
TEL 02920 876269 FAX 02920 874056
E-MAIL Brian.Kiernan@astro.cf.ac.uk
APPROVALS
DATE
DRAWN BJK
17.11.03
CHECKED BY: X
X
APPROVED BY: X
X
ISSUE
2
REDRAWN REPLACES ISSUE 1
FINISH: NICKEL & GOLD PLATED
ESTD WT.
DIMENSIONS IN MM
LINEAR +/- 0,10
ANGULAR +/- 0,15°
QUANTITY: 1
ACTL WT.
CAD FILE
T:/SPIRE/PCAL/PCAL
PROJECT
SPIRE
TITLE
PCAL HARNESS CLAMP
DRAWING NO SPIRE-PCAL-000-001-6.0
SHEET 1 OF 1
A2

SECTION 08 – Electrical Circuit Diagrams

The four prime PCAL wires (part of the BSM/PCal prime harness) are terminated on the two prime solder terminals. This harness is duplicated for the redundant systems. The PCAL wiring will consist of an insulated, screened, twisted quad sub-harness. The maximum harness impedance requested for PCAL is 10 Ohms per wire. A schematic of the BSM prime connector wiring is shown in Figure 3. The redundant wiring will be an exact copy of this harness.

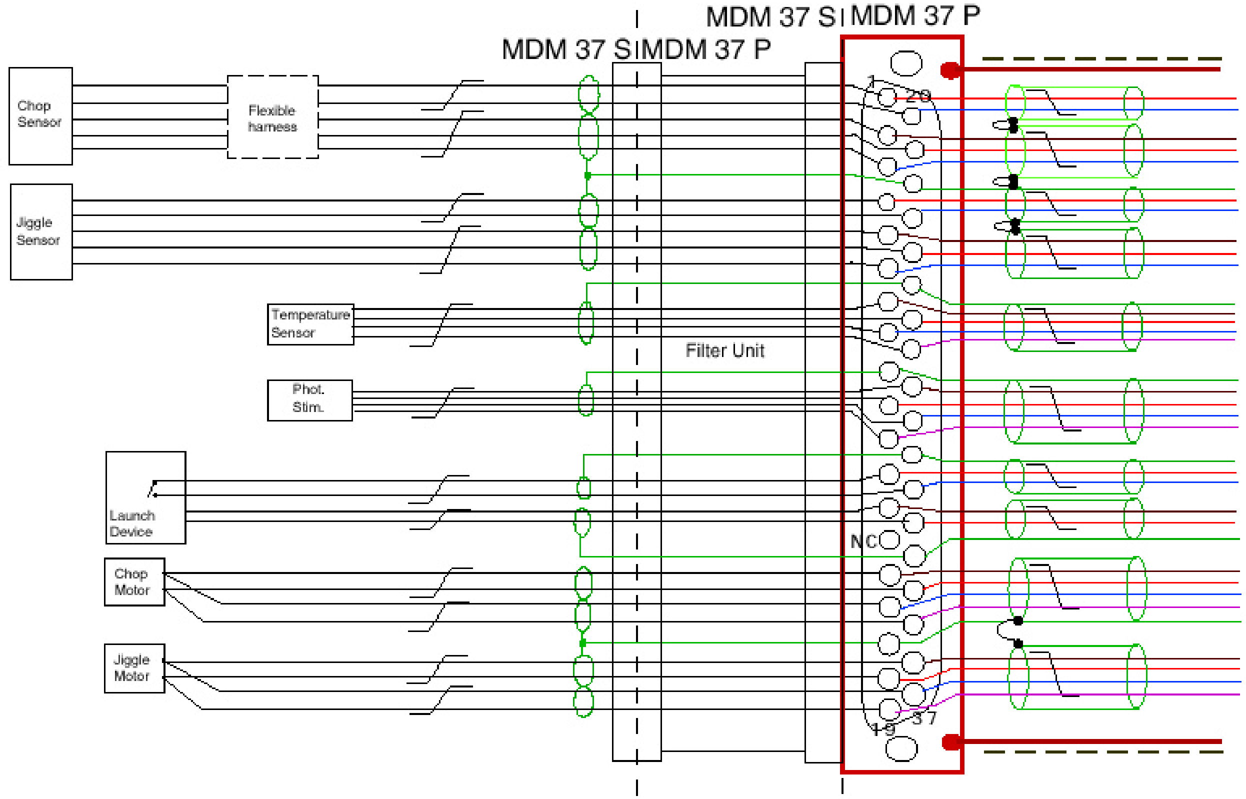


Figure 3 Schematic of pin allocations for PCal/BSM prime and redundant connectors. Both prime and redundant connectors are MDM-37 way socket connectors, with jackposts.

Table 1 Pin allocations for PCal-CQM electrical connectors (refer also to ICD).

BSM Prime connector Pin#	Label (in accordance with Harness Definition Document)	Function
28	Prime I+_A	Current drive
29	Prime I-_A	Current return
10	Prime I+_B	Voltage sense +
11	Prime I-_B	Voltage sense -
BSM Redundant connector Pin#	**Label (in accordance with Harness Definition Document)**	**Function**
28	Red I+_A	Current drive
29	Red I-_A	Current return
10	Red I+_B	Voltage sense +
11	Red I-_B	Voltage sense -

SECTION 09 - As Built Configuration Items Status List

Item	Reference	Location	Notes
PCal drawings and manufacturing files		\\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\drawing_archive\PCal	
Material certificates of conformance		Available at Cardiff for inspection	
Calibration data files		\\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\deliverables\shipped\PCAL\CQM\Data	
Test data		\\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\deliverables\shipped\PCAL\CQM\Data	
Test reports		\\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\deliverables\shipped\PCAL\CQM\Test_reports	
Calibration analysis worksheet		\\SPIRE\Cardiff_workpackages\Deliverables\Shipped\PCal\CQM\CQM-PCal-Analysis\CQM-PCal-calib-pch.mcd	

Part number	Description	Details
PCAL-CQM-100	HB8 – PCal CQM source assembly	Mounting ring manufactured and gold-plated at Cardiff. Source assembled by Haller-Beeman Associates
PCAL-CQM-201	PCAL BODY	Manufactured by Electromec
PCAL-CQM-202	PCal rear cover	Manufactured by Electromec
PCAL-CQM-203	PCal harness clip	Manufactured by Electromec
PCAL-CQM-204	Stand offs	Wearnes-Cambion
PCAL-CQM-205	Bolts	PTC

SECTION 10 – Serialised Components List

SECTION 11 - List of Waivers

No waivers.

SECTION 12 - Copies of Waivers

SECTION 13 - Operations Manual

13.1 PCal Overview

Refer to Appendix B – PCal Subsystem Design Description – HSO-CDF-DD-034.

13.2 PCal CQM Specifications as delivered

Specification	Related Requirement	Value	Comments
Thermal source ID		HB8	Mica substrate, 25 μm brass wires, silver epoxy
Thermal source redundancy	IRD-CALP-R15	Prime and redundant sources are provided	
Prime source impedance – 300K		252.7 Ω	
Prime source impedance – 77K		253.0 Ω	
Prime source impedance – 4K		253.0 Ω	
Redundant source impedance – 300K		241.8 Ω	
Redundant source impedance – 77K		241.7 Ω	
Redundant source impedance – 4K		243.2 Ω	
Prime source 90% rise time	IRD-CALP-R04	140 ms	Value for 2mW applied power. Time constant varies as a function of applied power.
Prime source 90% fall time	IRD-CALP-R04	60ms	Value for 2mW applied power. Time constant varies as a function of applied power.
Redundant source 90% rise time	IRD-CALP-R04	122ms	Value for 2mW applied power. Time constant varies as a function of applied power.
Redundant source 90% fall time	IRD-CALP-R04	49ms	Value for 2mW applied power. Time constant varies as a function of applied power.
Power dissipation at nominal operating output	IRD-CALP-R01, IRD-CALP-R12	1.45mW	
Current drive for nominal operating output		2.4mA	
Nominal (safe) current range	IRD-CALP-R02	0 – 4.5mA	This current range is for a maximum power dissipation of 5mW
Absolute maximum current rating	IRD-CALP-R02	7mA	This current level will dissipate 12.3mW in the PCal emitter.

Nominal operating voltage	IRD-CALP-R14	0.6V	
Nominal (safe) voltage range		0 – 1.25V	This voltage range is for a maximum power dissipation of 5mW
Stability & repeatability	IRD-CALP-R05	RMS better than 1% over lifetime. Cycle-to-cycle repeatability better than 1%.	Two identical sources (four emitters) have undergone 375,000 cycles each (5mW applied) without any degradation or variation in the performance of the devices.
Frequency	IRD-CALP-R07	Maximum frequency before modulation – 1.8Hz @ 1mW, 0.5Hz @ 5mW	Time constant varies as a function of applied power from 85ms to 300ms (1mW to 5mW)
Operating temperature	IRD-CALP-R11	<10K	PCal must not be operated above 10K ambient.
Lifetime	IRD-CALP-R16	>375,000 cycles	At 5mW power dissipation per cycle
Mass		28.9g	
Volume	IRD-CALP-R09		

13.3 PCal Operation

13.3.1 Drive current

- The PCal drive electronics are specified to provide current drive in the range 0 - 7mA.
- Nominal output from the PCal aperture is achieved with an applied current of 2.4mA.
- PCal may be safely operated routinely in the current drive range 0 – 4.5mA.
- If required for diagnostic purposes, PCal may be driven with up to 7mA for **brief** periods, with an excitation frequency no lower than 0.5Hz. The number of cycles carried out at currents above 4.5mA should be explicitly recorded.

13.3.2 Drive frequency

- When operated in the nominal current drive range (0 – 2.4mA), the frequency of the excitation pulses should be in the range 0.1 – 2Hz. PCal may be operated at higher frequencies, but the output will be modulated due to the devices time-constant.
- When operated at drive currents above 4.5mA, the excitation frequency should be no lower than 0.5Hz.

SECTION 14 - Historical Record

The following table contains *brief* historical details of the manufacture, assembly and testing of PCal-CQM
A *full* historical record of every stage of manufacture for each component is traceable at UWC, in both hard copy log-book format and on a Microsoft Access database.

Date	Event	Notes
20/01/03	STM components accepted	
27/01/03	HB7 STM source photometrically tested in STM/CQM structure	
03/02/03	Ship STM to RAL for vibration qualification	
03/02/03	Installation to RAL vibration facility	
04/02/03	Warm & cryogenic vibration tests at RAL	
05/02/03	De-installation from RAL test facility & ship back to Cardiff	
10/02/03	Post-vibration inspections	
24/02/03	Installation to photometric test dewar	
26/02/03	Photometric tests	
03/03/03	De-installation from photometric test dewar	
	PCal-STM upgraded to PCal-CQM	***PCal-CQM assembled using STM structure, but new emitter (HB8)***
21/07/03	PCal CQM components received	
29/04/03	Stand-offs accepted (Wearnes-Cambion)	
04/08/03	PCal emitter received & accepted (Haller-Beeman)	
11/08/03	PCal CQM assembly	
01/09/03	PCal CQM installation in photometric test dewar	
03/09/03	PCal CQM photometric tests	
04/09/03	De-installation from test dewar	
15/09/03	Pre-delivery inspections	
16/09/03	Cleaning & bakeout	
29/09/2003	Delivery to RAL	

SECTION 15 - Logbook / Diary of Events

Not provided – available from subsystem provider upon request.

SECTION 16 - Operating Time / Cycle Record

- 02/09/2003 – First photometric characterisation.
- One thermal cycle 300K – 4K – 300K. Cooling rate of ~40K/Hr. Warming rate of ~15K/Hr.
- Prime and redundant sources underwent around 20 on-off cycles in accordance with the PCal photometric test procedure (\\Darkstar\Astroworld\Projects\Spire\Cardiff_workpackages\PCAL\Assembly&test\PFM\Experimental Set-up.doc, \\Darkstar\Astroworld\Projects\Spire\Cardiff_workpackages\PCAL\Assembly&test\PFM\pcaltestplan.pdf)

SECTION 17 – Connector Mating Record

SECTION 18 – Age Sensitive Items Record

SECTION 19 – Pressure Vessel History / Test Record

SECTION 20 - Calibration Data Record

The calibration data in this section are presented in terms of the requirement on photometric output, and plotted as Figure 4. The photometric output in this plot is expressed in terms of the area:surface-brightness product of the PCal aperture, as a fraction of the area:surface-brightness product of the telescope image at the position of M4. The required output (>1% of telescope image) is achieved with a power dissipation of 1.7mW (2.59mA).

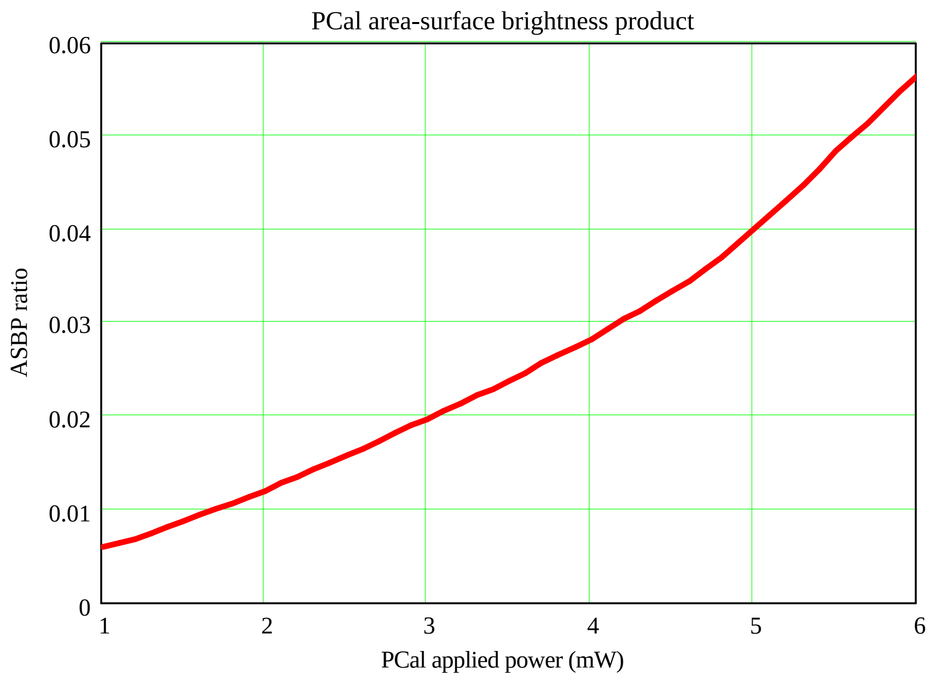


Figure 4 Area:surface-brightness product (ASBP) of PCal aperture as a fraction of the ASBP of the telescope image at M4, plotted as a function of applied power.

SECTION 21 - Temporary Installation Record

SECTION 22 - Open Work / Deferred Work / Open Tests

SECTION 23 - List of Non-Conformance Reports

SECTION 24 - Copies of Non-Conformance Reports

SECTION 25 - Test Reports

25.1 Calibration test report

PCal CQM was calibrated in a three-stage process. Initial calibration of our primary calibration reference, designated HB1, was carried out in a low-background ^{3}He bolometer test facility (BACUS)[1], using a well-characterised cryogenic black-body (CBB) source. A smaller, faster turnaround photodetector test dewar was then calibrated against HB1, and this was then used for calibration of prototype devices against HB1.

25.1.1 Stage one – Primary calibration of HB1 against CBB

^{3}He Bolometer test facility

A ^{3}He bolometer is enclosed by a shield and filter stack, also at ~300-mK, and the whole assembly is then surrounded by a radiation shield at 4.2-K. A filter stack covers an aperture in the 4.2-K shield, and the aperture is closed with the CBB source. The CBB can have a 1-mm or 3-mm diameter aperture. Load curves are then taken as a function of CBB temperature in order to obtain a photometric power calibration for the bolometer system. The CBB is then replaced by the source to be tested, which is placed in a mount with a 1-mm diameter aperture at the same position in space as the CBB aperture. Bolometer load curves are then taken as a function of applied source power. Analysis of the load curves gives the radiant power absorbed by the detector in each case, and comparison of the absorbed power for the CBB and the test source gives us an effective blackbody temperature for the test source.

Calibration of HB1 (Figure 5)

Illuminator HB-1 and the cryogenic black body (CBB) were measured using the same aperture (1 mm diameter) and detector distance in BACUS using a ^{3}He bolometer.
The CBB was also measured using a 3mm diameter aperture, and this was used to cross-check the 1mm data. There is good agreement for the 3mm data, both with the 1mm data, and with published data for a similar HB source. Therefore the 3mm data is used (greater S/N) to finally calibrate the HB-1 electrical power vs. effective black-body temperature. Calculations are shown below :-
(extract from MathCad file \\SPIRE\Cardiff_workpackages\Deliverables\Shipped\PCal\CQM\CQM-PCal-Analysis\CQM-PCal-calib-pch.mcd)

See also HB1-3mmcbb-1mmHB1_cross-check-30-01-04.mcd

Calibration using 3mm CBB aperture data

Number of data points for CBB $i := 0..4$

CBB Data (pW) CBB Temperature (K)

$P_{CBB_i} :=$ $T_{CBB_i} :=$

P_{CBB_i}	T_{CBB_i}
0.125	22.81
0.371	41.66
0.527	63.08
0.704	78.00
0.881	100.3

$$A_{HB1} := \pi \cdot \left(\frac{1.018}{2}\right)^2$$

$$A_{CBB} := \pi \cdot \left(\frac{2.98}{2}\right)^2$$

Measured diameters for HB1 and CBB apertures

$$A_{ratio} := \frac{A_{CBB}}{A_{HB1}} \qquad A_{ratio} = 8.569$$

Area correction - divide CBB power by factor of ~8.5 to account for area difference:-

$$P_{CBB_i} := \frac{P_{CBB_i}}{A_{ratio}}$$

Number of data points for Beeman Illuminator $j := 0..5$

Data from file "1x1 Load VIs Analysis (28-11-00).mcd" - taken from first line of constant resistance.....

Beeman Data (pW) $P_{Bmn_j} :=$ Applied power (mW) $eP_{Bmn_j} :=$

P_{Bmn_j}	eP_{Bmn_j}
0.0408	1.0224
0.0573	2.00129
0.0813	2.9863
0.1006	3.9333
0.1167	4.9968
0.1169	5.8975

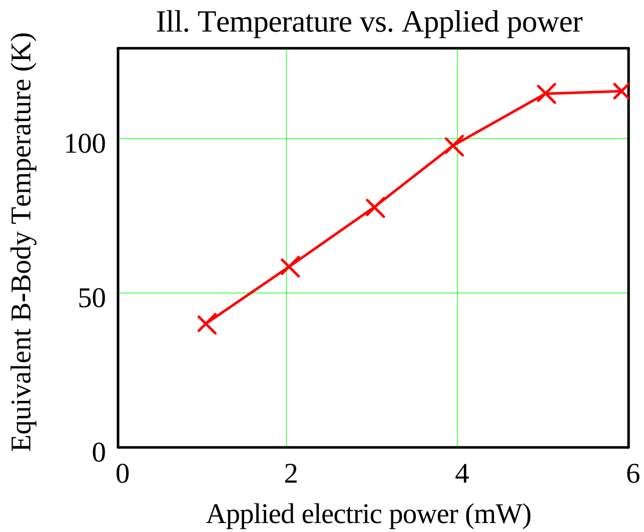
Use linterp to interpolate points

$$T(P) := \mathrm{linterp}(P_{CBB}, T_{CBB}, P)$$

Hence, the BBody equivalent temperature for the Beeman Illuminator is...

$$T_{Bmn} := T(P_{Bmn}) \quad \text{Kelvin}$$

$$T_{Bmn} = \begin{pmatrix} 40.022 \\ 58.138 \\ 77.382 \\ 97.913 \\ 115.295 \\ 115.511 \end{pmatrix} \quad \text{Kelvin}$$



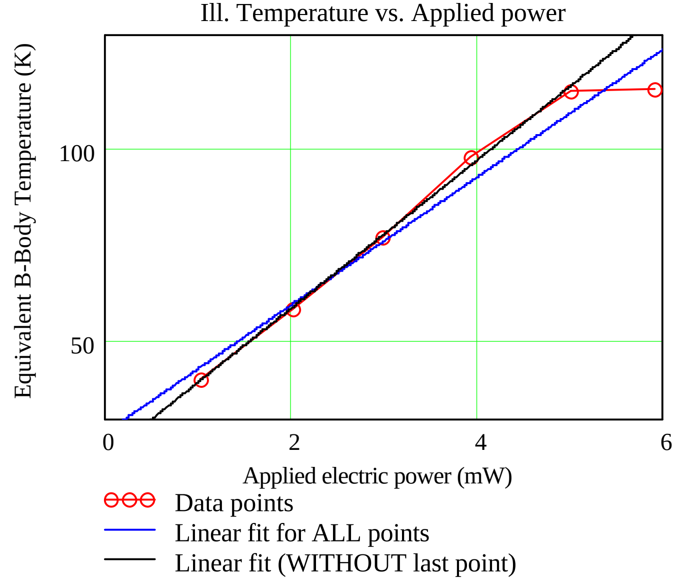


Figure 5 Extract from MathCad worksheet showing calculation of Blackbody equivalent temperature as a function of applied power for HB1.

25.1.2 Stage two – Calibration of photodetector dewar using HB1 (Figure 7)

The calibrated HB1 device was mounted behind a 1mm diameter aperture, in an HD-3 cryostat equipped with an unstressed Ge-Ga photoconductor detector. The experimental arrangement was as indicated in Figure 6.

For all experiments using this photoconductor detector, a detector bias of 250mV was used throughout, and extreme care was taken to ensure light-tightness of the assembly. The detector dark current was recorded at the start and end of each experiment to verify the stray-light background.

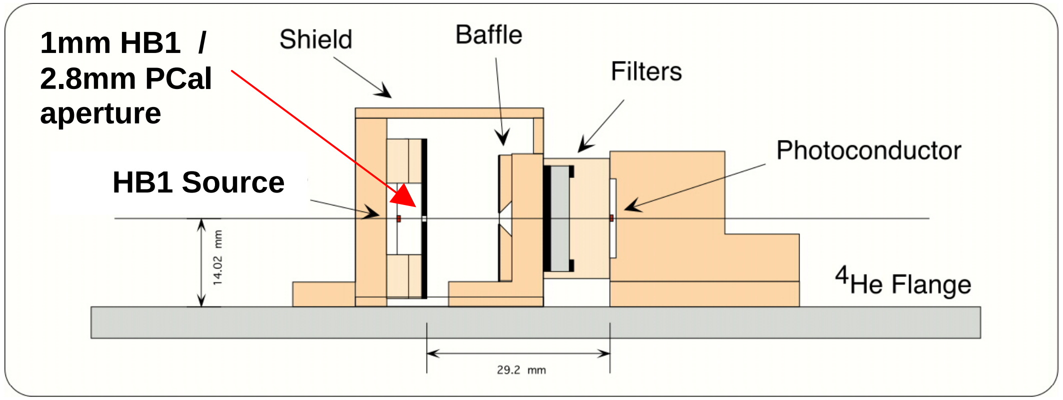


Figure 6 Photoconductor test cryostat set-up.

The photodetector voltage was recorded as a function of HB1 applied electrical power, and thus we could assign a black-body equivalent temperature at the aperture to the detector signal. Results are shown in Figure 7.

Stage 2: HB-1 illuminator power as a function of photodetector voltage

Data from IDL script hbtau.pro

Photodetector voltage as a function of HB-1 illuminator power (mW)

HB1photv :=

	0	1
0	0	0
1	1	2.98
2	2	5.79
3	3	8.1
4	4	10.07
5	5	11.8

(add in point at 0 0; not measured, but we should get 0 detector volts for 0 power (ignoring dark signal; small correction))

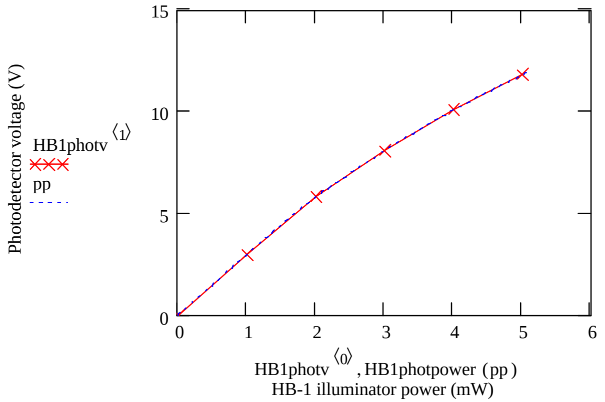
Spline fit

$$cvs := \mathrm{cspline}\left(HB1photv^{\langle 1 \rangle}, HB1photv^{\langle 0 \rangle}\right)$$

$$HB1photpower(P) := \mathrm{interp}\left(cvs, HB1photv^{\langle 1 \rangle}, HB1photv^{\langle 0 \rangle}, P\right)$$

$$i := 0 .. 120$$

$$pp_i := \frac{i}{10}$$



Detector voltage to temperature function, using electrical power to BB temp. conversion derived from 3mm data

$$HB1tfromv(V) := T(HB1photpower(V))$$

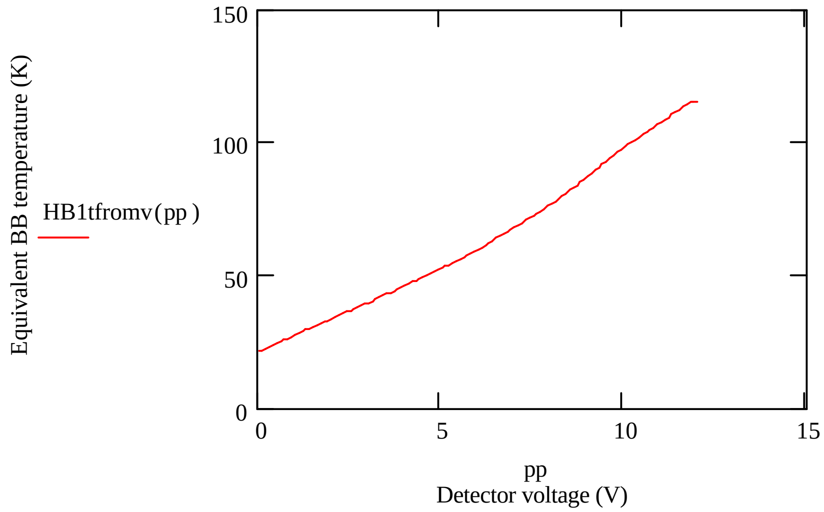


Figure 7 Extract from MathCad worksheet showing calibration of photodetector against HB1

25.1.3 Stage three – Calibration of PCal-CQM

PCal-CQM was then mounted in the photodetector test dewar, in a manner such that the 2.8mm diameter PCal aperture was placed at exactly the same position as the 1mm dia. HB1 aperture from the test described in section 25.1.2.

Power was applied to the prime and redundant sources in turn, and the detector signal was recorded for each power level as a function of time. In this way, we can extract the photometric output of the PCal source assembly and the time constant of each source.

The detector signal as a function of PCal power gives us the black-body temperature for a 1mm diameter aperture at the position of the PCal aperture. However, as the PCal aperture is in fact 2.8mm diameter, the requirement on PCal output is expressed in terms of an area:surface-brightness product as a percentage of the area:surface-brightness product of the telescope image at the position of M4 (BSM) (see section 04 – compliance with IRD).

The required surface brightness (1% of M4 telescope image) at the PCal aperture is achieved with an applied power of 1.7mW.

The requirement calls for a black-body temperature of 35.5K for a 1mm diameter aperture at the position of PCal in SPIRE, and this equates to an effective temperature of 15.2K filling the 2.8mm diameter PCal aperture. The true source temperature will, of course, be greater than this, of the order 60-70K for this photometric output.

Stage 3: PCAL temperature as a function of applied power

For HB8:

Data from IDL script hb8tau.pro originally - now from HB8-results.doc (zero power offset removed)

HB8 photodetector voltage as a function of illuminator power

HB8photv :=

	0	1
0	998.55	0.89992
1	1992	2.8015
2	3000.6	4.9013
3	3998.6	6.7699
4	4989.7	8.7329
5		

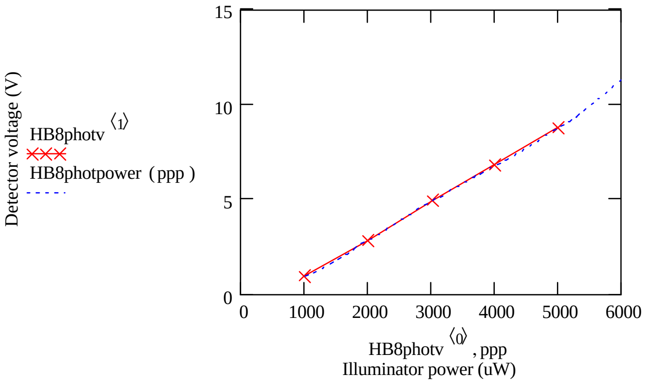
Spline fit

$$\mathrm{cvs} := \mathrm{cspline}\left(\mathrm{HB8photv}^{\langle 0\rangle}, \mathrm{HB8photv}^{\langle 1\rangle}\right)$$

$$\mathrm{HB8photpower}(P) := \mathrm{interp}\left(\mathrm{cvs}, \mathrm{HB8photv}^{\langle 0\rangle}, \mathrm{HB8photv}^{\langle 1\rangle}, P\right)$$

$i := 0..50$

$\mathrm{ppp}_i := (i + 10)\cdot 100$

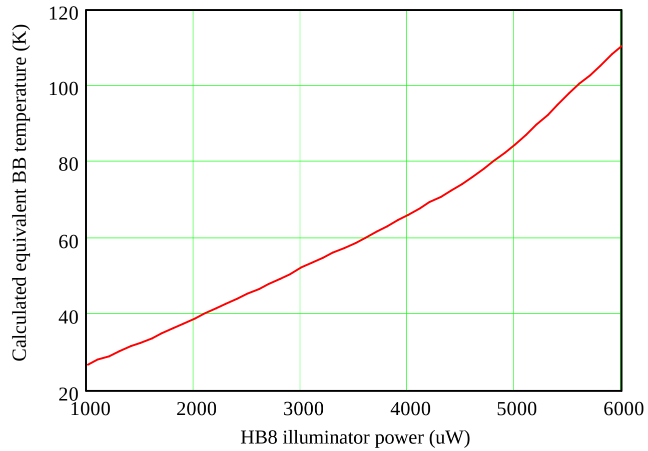


So we can calculate the equivalent BB temperature of the PCAL assembly using the results from stage 2

$$\mathrm{PCALt3mm}(p) := \mathrm{HB1tfromv}(\mathrm{HB8photpower}(p))$$

Summary

Calculated equivalent blackbody temperature for PCAL source HB8 as a function of power dissipated in the illuminator.



Note:

1) Results for the prime and redundant source are almost identical

2) These measurements on the PCAL sources are done with a 3 mm aperture, not the 1 mm used for the calibration sources. However, since the PCAL source is 1 mm square, it will not fill the 3 mm aperture. Therefore no aperture correction is made: these results tell us the equivalent source temperature for a source with a 1 mm aperture, and are an upper limit on the true temperature.

Figure 8 Calibration of HB8 – CQM source in PCal structure.

25.1.4 Summary

- Device number HB-1 was calibrated against a well characterised cryogenic black body in a ^{3}He bolometer test facility
- HB-1 was then used to transfer this calibration to a photoconductor detector test dewar, where the black body equivalent temperature at a 1mm diameter aperture was converted into detector signal
- The detector signal was then recorded as a function of power applied to the PCal assembly, which had a 2.8mm diameter aperture at the position of the HB-1 aperture
- The detector signal as a function of PCal power was then converted back to the equivalent black body temperature for a 1mm diameter aperture
- The requirements on PCal, in terms of area:surface brightness product, call for an effective temperature of 35.5K at a 1mm diameter aperture
- This effective temperature is reached with a power applied to PCal of 1.7mW
- This equates to an effective temperature of 15.2K filling the 2.8mm dia. PCal aperture.
- The PCal area-surface brightness product, expressed as a percentage of the telescope background, is plotted as a function of PCal applied power in Figure 9 below. The required PCal:telescope ratio (>1%) is achieved with an applied power of 1.7mW.

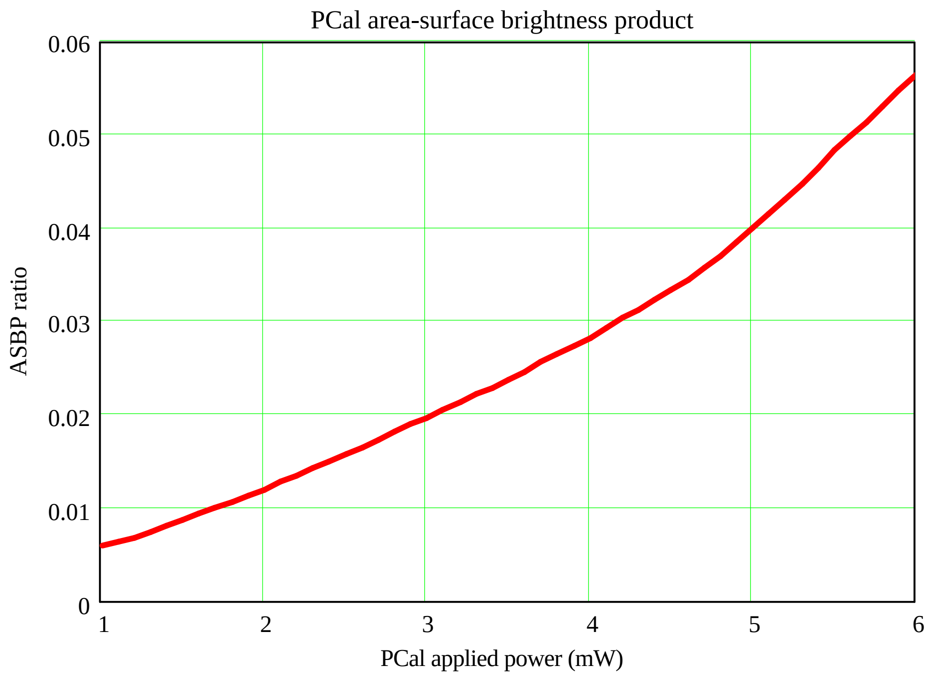


Figure 9 PCal area-surface brightness product expressed as a percentage of telescope background.

25.2 PCal CQM test report

Attached as Appendix A

25.3 PCAL lifetest report

Attached as Appendix B

SECTION 27 - Reference List of EIDP's

Associated

Title (Listed in alphabetical order)	ID (Serial No.)	Acronym	Document No.	Issue	Date

Lower Level

Title (Listed in alphabetical order)	ID (Serial No.)	Acronym	Document No.	Issue	Date

SECTION 28 - Mass Records

Assembly	Final measured mass
PCal CQM assembly	28.9g

SECTION 29 - Cleanliness Statement

SECTION 30 - Other Useful Information

SECTION 31 - DPL/DML etc

SECTION 32 – List of Appendices/Attachments

Appendix #	**Title** (Listed in alphabetical order)	**Document No.**	**Issue**	**Date**	**Notes**
A	PCal-CQM test report	HSO-CDF-RP-066			
B	PCal lifetest report	HSO-CDF-RP-067			

References

1. Hargrave, P.C., Maffei, B., Hermoso, R., Gannaway, G., Griffin, M.J., Ade, P.A.R., Haynes, C.V., Tucker, C.E., Moseley, S.H., Bock, J.J., Rodriguez, L., Nucl. Inst. Meth. Phys. Res. A 444 (2000) 427-431
2. Peter Hargrave, Jeffrey Beeman, Patrick Collins, Iris Didschuns, Matthew Griffin, Brian Kiernan, Giampaolo Pisano, "In-Flight Calibration Sources for Herschel-SPIRE", Proc. of *SPIE AS02 – Astronomical Telescopes & Instrumentation*, Waikoloa, Hawaii, 22-28 August 2002.

Appendix A

Appendix B