4. THERMAL INTERFACE DESIGN

TBC

SECTION 4 CONTENTS

4.1 THERMAL DESIGN DESCRIPTION

4.1.1 Thermal Design Requirements

unit	Temperature limits (°C)		
	operating	non operating (1)	switch on
WEC 1-4 EFW mechanisms	-10 +45	-30 +55	-20 +40
WEC 1-4 EFW spheres	-45 +70	-55 +100	-30 +40
WEC 5 EFW electr unit	-10 +45	-30 +55	-20 +40
WEC 6 STAFF search coils	-90 +70	-100 +80	N.A.
WEC 7 STAFF	-10 +45	-30 +55	-20 +40
WEC 8 STAFF stack	-10 +45	-30 +55	-20 +40
WEC 9/2 DWP	-10 +45	-30 +55	-20 +40
WEC 9/1 WHISPER	-10 +45	-30 +55	-20 +40
WEC 10 WBD	-10 +45	-30 +55	-20 +40
WEC 11 PWR	-10 +45	-30 +55	-30 +40

Tab 4.1/1 Unit design temperature range

(1) range to be kept for avoiding destruction or damage of components or processes.

4.1.2 Thermal Design Description

a) WEC 1 to 4 (spheres):

The EFW spherical sensors are thermally isolated from the spacecraft environment due to the 50 meters of wire between them. The spheres absorbability and emissivity are close to 1, with low thermal mass. Then, their temperature are dictated by the environment. In sunlight, the sphere shells should reach temperatures between +25 and +50°C, with excursions to +70°C when

the spacecraft is at a very low altitude (due to the earth's albedo). In shadow, the sphere temperature will fall rapidly because of the low thermal mass. For reference, the sphere thermal considerations for the GEOS sensors are described in ESA Working Paper 879. The opened sensor clamshell retainers (shown the Interface Drawing, Fig 4.3/1) have very little thermal impact, however may pose a spacecraft skin shadowing problem. The thermal exchange and equilibrium of the deployment units will be studied and later one defined during the development phase, in both configurations of the canister, opened and closed.

b) WEC 6 (SEARCH COIL) :

The search coil unit is thermally decoupled from the spacecraft boom by its structure made of epoxy. The unit is covered by a surrounding thermal blanket with cutouts especially designed for avoiding induced currents in front of the sensors which could reduce the magnetic sensitivity of the experiment. The sensors themselves are coated with a TBD conductive material which ensures two functions:

i) - to insure the thermal decoupling with the inner foil of the thermal blanket,

ii) - to protect the sensors against the electrostatic discharges.

There is no heater. The temperature of the search coils is monitored by one thermistor for a scientific purpose, namely to correct the transfer function versus the search coil temperature.

The thermal exchange between the search coils and the boom must be reduced as far as possible to obtain a long thermal time constant between the unit and the structure. For this reason, the boom and the boom-wiring should be coated with a low emissivity material as aluminized tape, providing electrical shielding of the cable.

c) Other units

Since the other electronic units and stacks are mounted inside the spacecraft, the thermal concept will simply be based on a good contact via a conductive surface properly coupled to the spacecraft structure.

4.2 TEMPERATURE AND THERMAL CONTROL BUDGETS

4.2.1 Temperatures

4.2.1.1 Unit Temperature Reference Point

The Temperature Reference Point of the WEC units will be the adjacent point of one of the attachment point to the spacecraft mounting plane;
The TRP (Temperature Reference Point) is located at the interface between unit and S/C on the unit side.
They are defined on the thermal interface drawing.

4.2.1.2 TRP Temperature Range

The WEC units will comply with the interface (TRP) temperatures guarantied by the Thermal Control Subsystem listed in tables 4.2/1.1 and 4.2/1.2.
No specific prefered temperature ranges.

4.2.1.3 Radiative Temperature Range

with the radiative environment temperatures listed in table 4.2/2

4.2.1.4 Qualification and Acceptance Temperature

with the qualification and acceptance temperature listed in table 4.2/4.

	Temperature Limits			
Experiment Unit	operating (°C)	non operating (°C)	switch on (°C)	rate of change
WEC 1 to 4 WEC 5, WEC 7, WEC 8 WEC 9, WEC10, WEC11	-10 +40	-30 +50	-20 +40	N/A
WEC 6	-10 +60	-100 +60	N/A	N/A

Table 4.2/1.1 Temperature Ranges - at Temperature Reference Point - Ground Environment

Experiment Unit	Temperature Limits			
	operating (°C)	non operating (°C)	switch on (°C)	rate of change
WEC 1 to 4 WEC 5, WEC 7, WEC 8 WEC 9, WEC10, WEC11	-10 +40	-30 +50	-20 +40	TBD
WEC 6	-10 +60	-100 +60	N/A	TBD

Table 4.2/1.2 Temperature Ranges - at Temperature Reference Point - Space Environment

Experiment Unit	P/L bay heat sink Temperature Limits	
	sunlight range (°C)	eclipse in 4 h (°C)
WEC 1 to 4 WEC 7, WEC 8 WEC 9, WEC10	-10 +30	-10 to -30
WEC 5, WEC 11	-10 +30	-10 to -30

(TBC end of phase B)

Table 4.2/2 radiative payload bay interface Space Environment

Experiment Unit	Temperature Limits qualification		acceptance	
	operating (°C)	non operating (°C)	operating (°C)	non operating (°C)
WEC 1 to 4	-20 +50 (*)	-30 +60 (*)	-10 +40 (*)	-20 +50 (*)
WEC 5, WEC 7, WEC 8 WEC 9, WEC10, WEC11	-20 +50	-30 +60	-10 +40	-20 +50
WEC 6	-20 +70 (*)	-110 +70 (*)	-10 +60 (*)	-100 +60 (*)

Table 4.2/4 Temperature Ranges qualification/acceptance

Range established considering 10°C of qualification margin and 10°C of design margin.
(*) protruding and boom mounted units : the range will be redefined according to temperature predictions.

4.2.2 Budgets

Experiment Unit	In Sunlight [W]		In Eclipse [W]	
	nominal	tolerance	nominal	tolerance
WEC 1 TO 4	0.20	TBD	TBD	TBD
WEC 5	N/A		N/A	
WEC 6	TBD	TBD	TBD	TBD
WEC 7	N/A		N/A	
WEC 8	N/A		N/A	
WEC 9	N/A		N/A	
WEC 10	N/A		N/A	
WEC 11	N/A		N/A	

Table 4.2/5 Heat Exchange

(positive sign indicates a heat flow from the unit to the S/C)

Heat exchange will be updated later according to the EID A update.

4.3 INTERFACE

4.3.1 Conductive interface

All the units are mounted on the S/C with 1 mm clearance.
WEC 1/4 are mounted on the S/C using 2 reinforced ring mounted lugs and 4 standard mounting lugs.
WEC 8, WEC 9 and WEC 10 are mounted using 6 standard mounting lugs. All other units use 4 standard mounting lugs.
No insulation is required.
Ref to interface drawings fig. 4.3/1 to 4.3/8.

4.3.2 Radiative interface

Ref to I/F drawings fig. 4.3/1 to 4.3/8.

3.3.2.1 Internal

Exp unit	emissivity
WEC 1/4	$\leq$ 0.2
WEC 5	$\geq$ 0.8
WEC 7	$\leq$ 0.2
WEC 8	$\leq$ 0.2
WEC 9	$\leq$ 0.2
WEC 10	$\leq$ 0.2
WEC 11	$\geq$ 0.8

(TBC end of phase B by DOR)

Tab 4.3/1 Emisivity class

4.3.2.2 External

WEC 1/4 = Gold Alodine on all surface exposed to space
WEC 6 = MLI covering all surface

4.3.3 Heater power and heater control

None of the WEC units requires heater.

4.3.4 Coatings and finishes

a) WEC 1 TO 4 (SPHERES, LONG WIRE BOOMS and DEPLOYMENT UNITS):

spheres : Carbon deposit on aluminium
deployment units : Gold Allodine
wire booms : silver copper bread overlapping aluminium (with a 60% coverage)

b) WEC 6 (SEARCH COILS):

The search coil unit will be covered with a thermal multilayer having an external TBD conductive surface grounded to the spacecraft. A local connection to the adjacent boom structure by a grounding foil must be avoided to keep a good thermal decoupling between the search coils and the spacecraft.

c) WEC 8 and 10

They will be goldenised.

d) OTHER UNITS :

The units not exposed to the plasma environment will be either black anodysed or with Allodine 1200 according to the table 4.3/1.

4.3.5 **Experiment Thermal Interface Drawings**

a) WEC 1/4

They are the only protruding units, interface with PBS is TBD

b) Other units

Ref to Fig 4.3/2 to 4.3/8.

EXP UNIT	FUNCTION	DRAWING NUMBER
WEC 1	EFW deployment units	CL-DT-WEC-01
WEC 2	EFW deployment units	CL-DT-WEC-01
WEC 3	EFW deployment units	CL-DT-WEC-01
WEC 4	EFW deployment units	CL-DT-WEC-01
WEC 5	EFW electronic box	CL-DT-WEC-05
WEC 6	STAFF sensor	CL-DT-WEC-06
WEC 7	STAFF preamplifier	CL-DT-WEC-07
WEC 8	STAFF electronic	CL-DT-WEC-08
WEC 9	WHISPER unit DWP wec processing unit	CL-DT-WEC-09 CL-DT-WEC-09
WEC 10	WBD unit	CL-DT-WEC-10
WEC 11	PWR wec power unit	CL-DT-WEC-11

tab 4.3/3 Drawing number

4.3.6 **Installation Drawing**

ref to section 2.2.3

4.3.7 **Temperature monitoring**

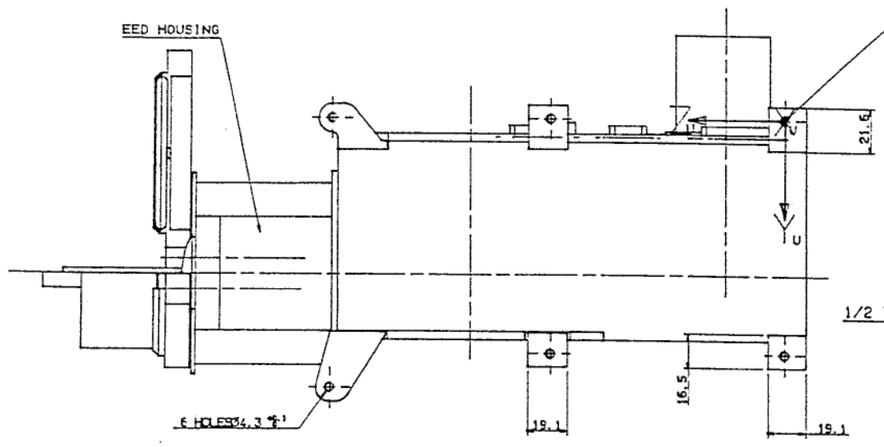
Experiment Unit	Powered		Temperature Range (° C)	Location within Unit
	S/C	Exp.*		
WEC 6 (search coils)		1	TBD	TBD
WEC 7 (magnetic preamplifier)		1		
WEC 8 (STAFF stack)		1		
WEC 9/1(WHISPER)		1	-55 +125	center
WEC 9/2 (DWP)		3		
WEC 10 (WBD)		1		

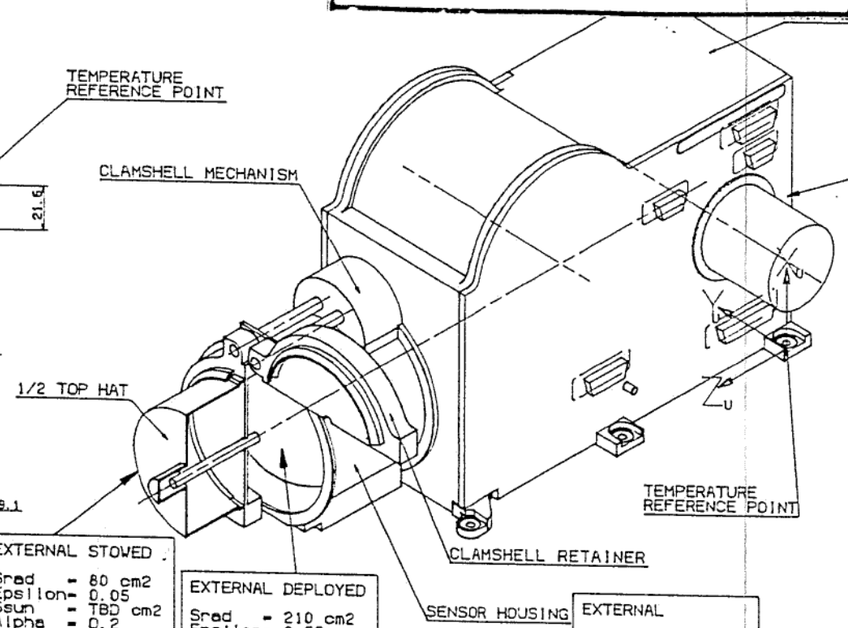
Table 4.3/4 Temperature Sensors

Fig. 4.3/1 WEC - Thermal ICD WEC 1 - 4 (EFW)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-01]		ORIGINATOR	
TITLE EFW deployment unit Thermal interface		WEC/EFW/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	Firts release of CL-DT-WEC-01	ESA	22/03/91

DRG NO.: C.O. CL.D.T. VEC.0.1 REV. A

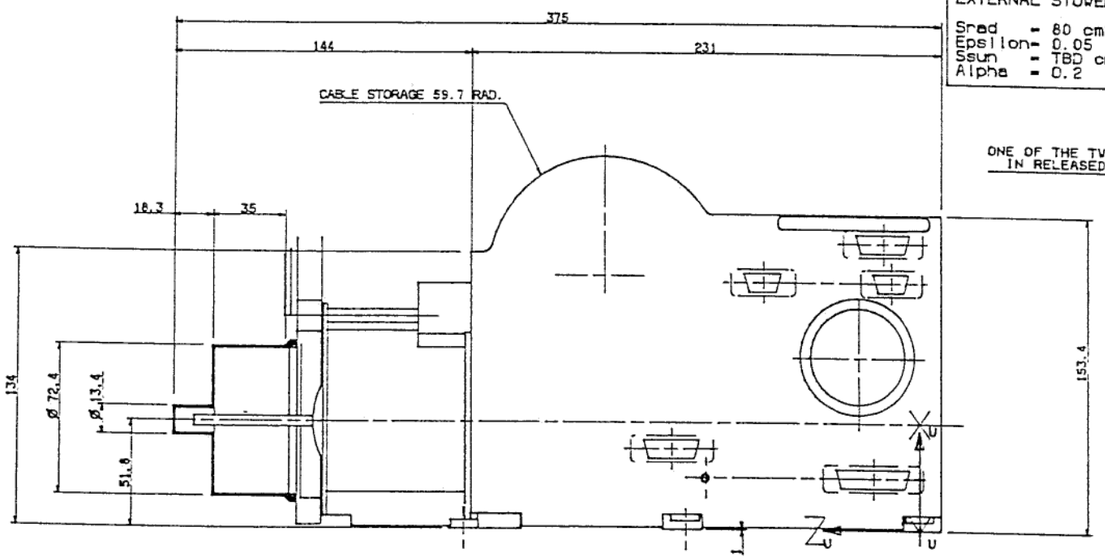


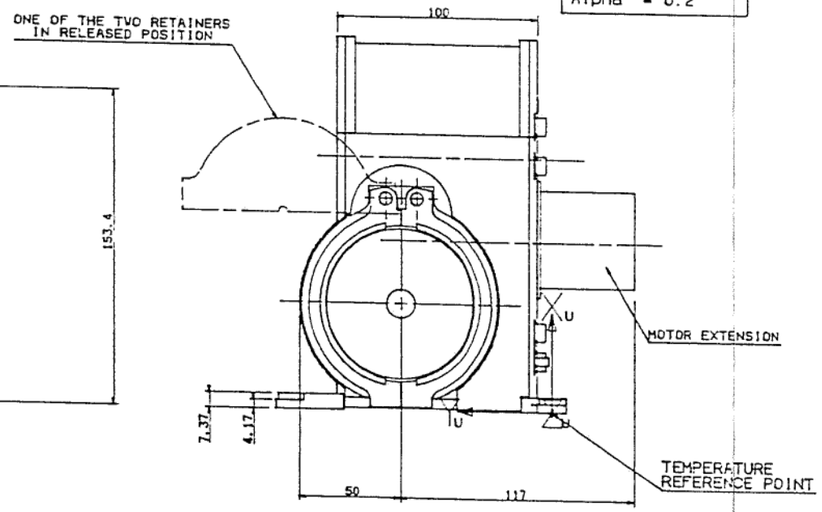


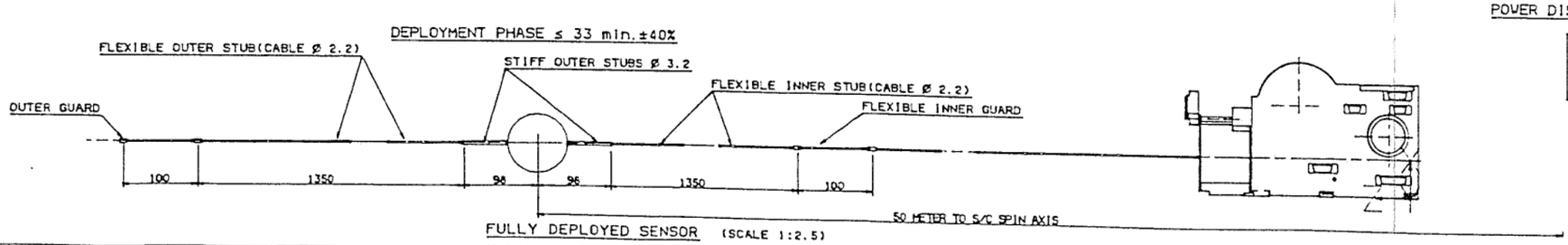
EXTERNAL STOWED
Srad = 80 cm2
Epsilon= 0.05
Ssun = TBD cm2
Alpha = 0.2

EXTERNAL DEPLOYED
Srad = 210 cm2
Epsilon= 0.55
Ssun = TBD cm2
Alpha = 0.8

EXTERNAL
Srad = 104 cm2
Epsilon= 0.05
Ssun = TBD cm2
Alpha = 0.2







THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: ELECTRICAL FIELDS DEPLOYMENT UNITS WEC 1,2,3 &4

EXPERIMENT DEVELOPER DRWG. NR.: REV./REV. DATE:

D-26306-ICD (P) A/0789
26306-ICD (T) A/0689

HEAT CAPACITY: SEE TABLE BELOW ±5% TBC

HOUSING MATERIALS:

STRUCTURAL ITEMS: ALUMINIUM 6061 T6
SCREWS ETC.: AUSTENITIC STAINLESS STEEL

WALL THICKNESS: TBD mm

SURFACE TREATMENT:

MECHANISM: ALODINED
FEET: GOLD ALODINED
SENSOR HOUSING: GOLD ALODINED
TOP HAT: ANODISED
CABLE: SILVER PLATED COPPER BRAID
SENSOR: CARBON BLACK COATING (DAG-213)

THERMAL INTERFACE HARDWARE: PAYLOAD BELT FLANGE TBD

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 26.3 cm2
FOOT THICKNESS: 7.37mm (RECESSED 3.2mm)
SURFACE ROUGHNESS: ≤ 1.6 µm
FOOT FLATNESS: ≤ 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11.2x 0.6 mm DEEP
THERMAL CONDUCTIVITY: 0.6 W/°C

INSTRUMENT GROUNDING: NOT SPECIFIC

OPTICAL PROPERTIES, HEAT CAPACITY:

	C (J/K)	ALPHA	EPSILON
TOP HAT	70	0.2	0.05
SPHERICAL SENSOR	150	0.9	0.9
BOOM CABLE	200	0.4	0.3
SENSOR HOUSING	200	0.2	0.05
MAIN MECHANISM	2400	0.2	0.2
TOTAL DEPLOYED	2600		
TOTAL STOWED	2870		

POWER DISSIPATION: IN THE MAIN MECHANISM AT TBD LOCATION

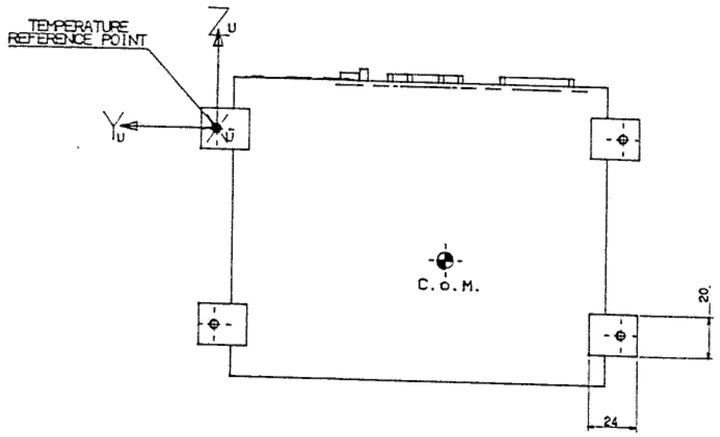
MEAN	0.12 W
MIN.	0.10 W
MAX.	0.20 W
DEPLOYMENT	4.20 W

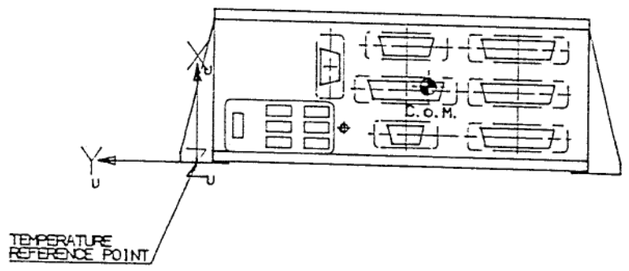
NAME	DATE	VISA
	881129	
	890131	
	910101	

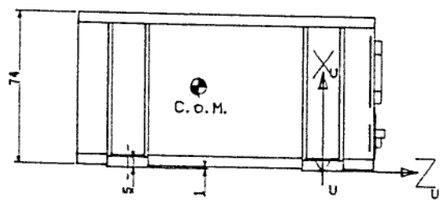
MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
ESA-ESTEC
CLUSTER
SCALE: 1:1
TITLE: EXP.: WEC 1-4 THERMAL I/F DRG.
DRG NO.: C.O. CL.D.T. VEC.0.1 REV: A

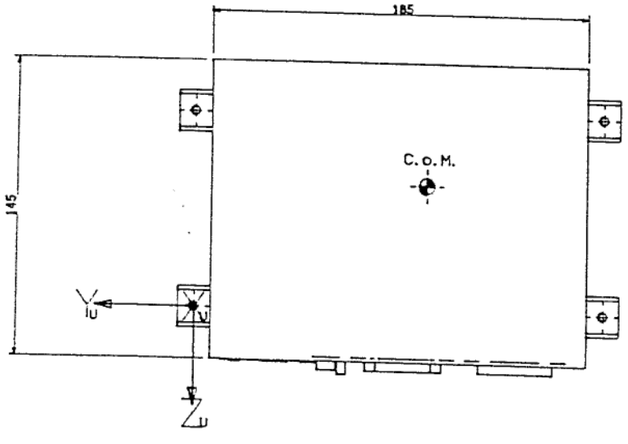
Fig. 4.3/2 WEC - Thermal ICD WEC 5 (EFW Electr.)

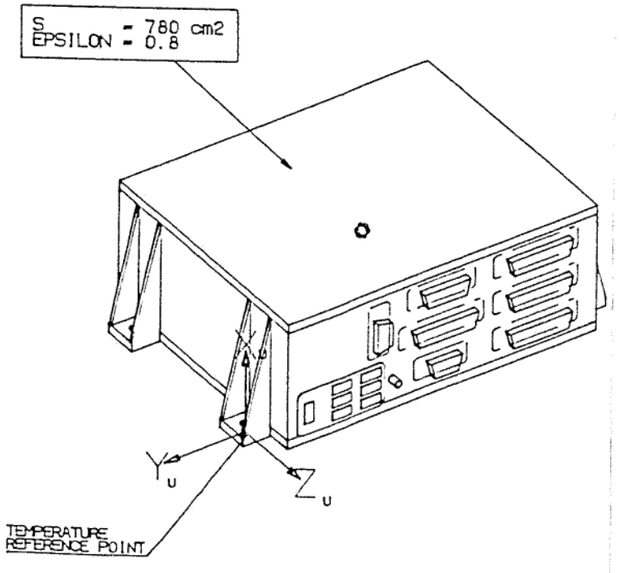
DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-05]		ORIGINATOR	
TITLE EFW electronic box Thermal interface		WEC/EFW/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DT-WEC-05	ESA	22/03/91











THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 5 EFW ELECTRONIC BOX

EXPERIMENT DEVELOPER DRWG.NR.: DM288-002

REV./REV.DATE: 04/051290

HEAT CAPACITY: 1710 J/K ± 5% (TBC)

HOUSING MATERIALS:
STRUCTURAL ITEMS: ALUMINIUM 6061-T651
SCREWS,ETC.: STAINLESS STEEL AISI 304
OTHERS: ACETATE RESIN, PTFE
WALL THICKNESS: TBD

SURFACE TREATMENT:
FEET: IRIDITE 14.2
BODY: BLACK ANODISED ACC. ESA PSS-01-0703 ISS. 1

THERMAL INTERFACE HARDWARE: NO SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 17.8 cm2
FOOT THICKNESS: 5 mm
SURFACE ROUGHNESS: < 1.6 µm
FOOT FLATNESS: ≤ 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: TBD mm2
THERMAL CONDUCTIVITY: 0.53 W/K (TBC)

OPTICAL PROPERTIES: N/A

POWER DISSIPATED AT C.o.M.:

MEAN = 1.95 W
MAX = 2.4 W
MIN = 1.8 W

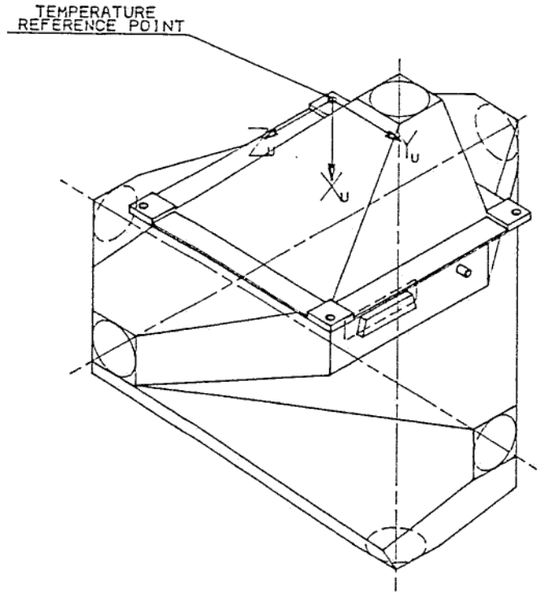
	NAME	DATE	VISA
DRAWN	FERRIER	911119	
CHECKED	J.L HUTCHESON	180191	
APPROVED	SCHMUTTERLE	180191	

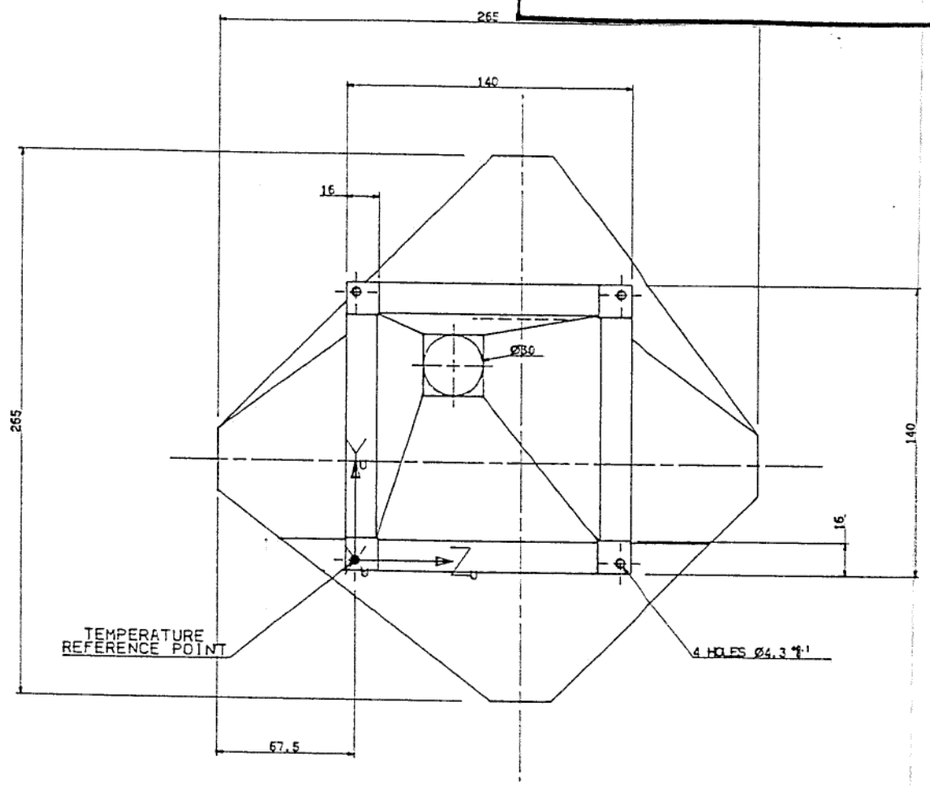
MATERIAL:
SPECIFICATION:
FINISH: SEE ABOVE
ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP: WEC 5 ELEC. BOX THERMAL I/F DRG

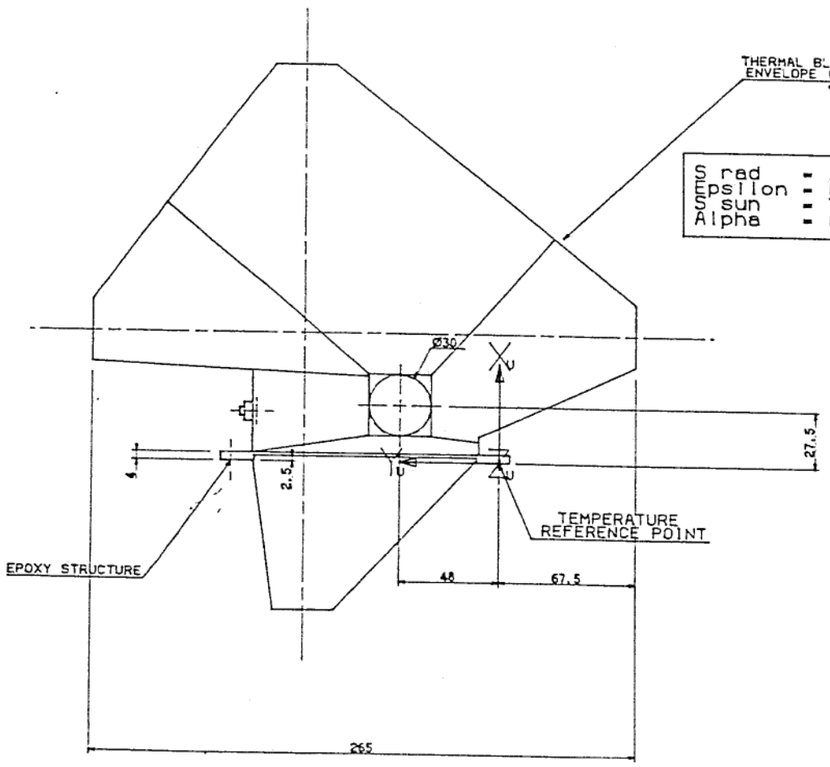
Fig. 4.3/3 WEC - Thermal ICD WEC 6 (STAFF sensor)

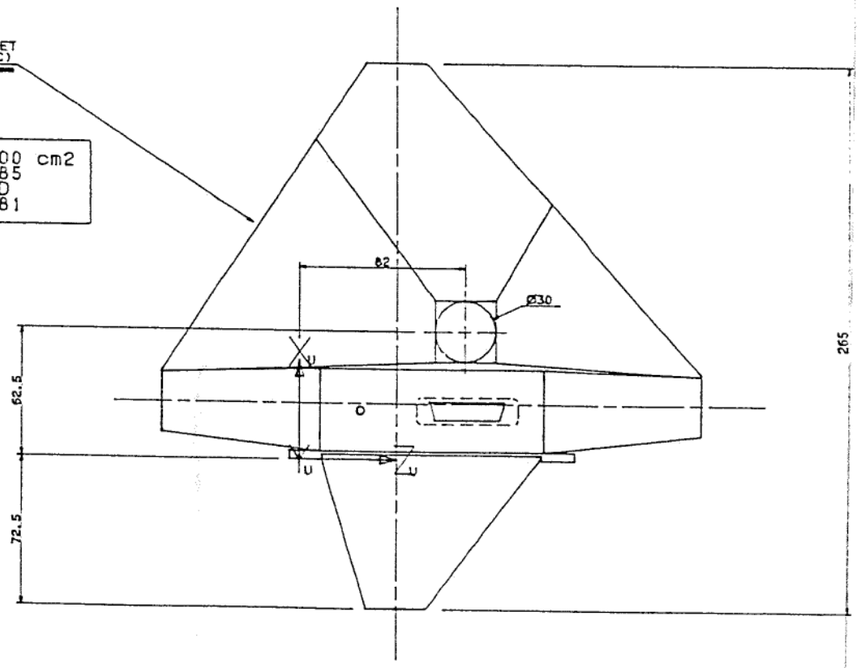
DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-06]		ORIGINATOR	
TITLE STAFF search coil thermal interface		WEC/STAFF/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	First release of CL-DT-WEC-06	ESA	22/03/91

DRG. NO.: CO. CLDT. WEC06 REV. A









THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: STAFF SENSOR WEC 6

EXPERIMENT DEVELOPER DRWG.NR.: A.M.

REV./REV.DATE: **/201190

HEAT CAPACITY: 450 J/K ±15%

HOUSING MATERIALS:

STRUCTURAL ITEMS: GLASS FIBER EPOXY
SCREWS, ETC.: TBD
THERMAL BLANKET: SHELDAHL G143700

WALL THICKNESS: TBD

SURFACE TREATMENT: N/A

FEET SURFACE FINISHING: GLAZED EPOXY FIBER

THERMAL INTERFACE HARDWARE: MLI

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 10.24 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: < TBD µm
FOOT FLATNESS : < 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: N/A
THERMAL CONDUCTIVITY: 3.2W/K

INSTRUMENT GROUNDING:

OPTICAL PROPERTIES: TBC MLI

THERMAL PROPERTIES: TBD

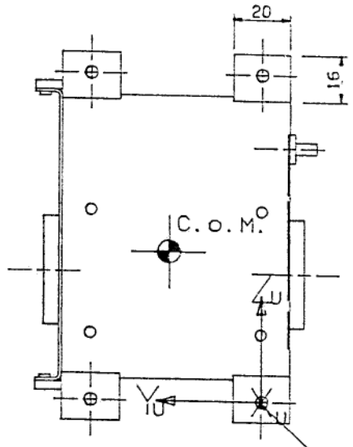
POWER: 0 W

	NAME	DATE	VISA
	FARNEST	011190	
	R. ETTLIX	180191	
	GEOMETROPLE	210191	

MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP.: WEC 6

Fig. 4.3/4 WEC - Thermal ICD WEC 7 (STAFF preamplifier)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-07]		ORIGINATOR	
TITLE STAFF preamplifier thermal interface		WEC/STAFF/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DT-WEC-07	ESA	22/03/91



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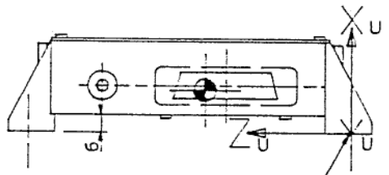

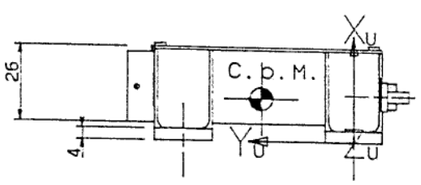

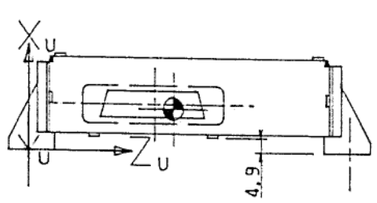

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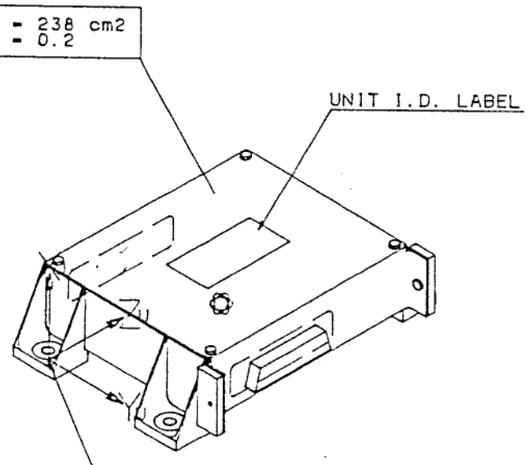
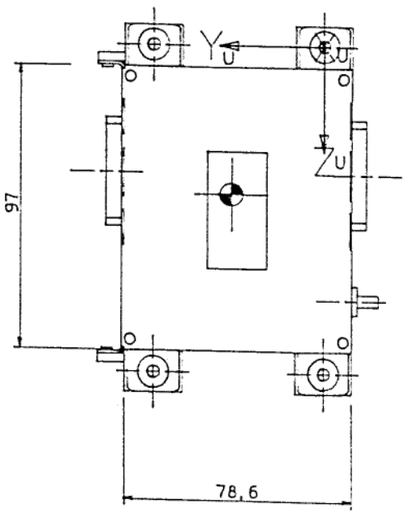
S = 238 cm2
EPSILON = 0.2

UNIT I.D. LABEL



TEMPERATURE REFERENCE POINT



THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: MODULE WEC7
STAFF EXPERIMENT

EXPERIMENT DEVELOPER DRWG.NR.: 39718568 900

REV./REV. DATE: 0/100191

HEAT CAPACITY: 270 J/K ± 10%

HOUSING MATERIALS:
STRUCTURAL ITEMS: A2618A
SCREWS, ETC.: 26CN1809
WALL THICKNESS: TBD

SURFACE TREATMENT:
BOX CUVERTIN 306
FEET SILVER PLATED

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 12.8 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
SURFACE FLATNESS: ≤ 0.05 mm
SPOTFACED AREA: Ø 11 mm DEEP 0.1 mm
THERMAL CONDUCTIVITY: 1.4 W/K

OPTICAL PROPERTIES: N/A

THERMAL PROPERTIES:

TOTAL AREA OF BOX RADIATING TO ALL SURFACES INSIDE S/C 0.02 M2

POWER DISSIPATED AT C.o.M.:

MEAN = 0.070 W
MAX = 0.100 W
MIN = 0.070 W

	NAME	DATE	VISA
DRAW:	M. SUNTER	100191	
CHECKED:	R. STOLK	150191	
APPROVED:	SCHUETTERLE	170191	
ISSUED:			
RELEASED:			
PROJ. ASS:			

MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
MASS: 300 gr/TBC gr
SURFACE ROUGHNESS 3.2 √ (µm)
TOLERANCES
DIMENSIONS ± TBD
ANGLES ± TBD
Unless otherwise specified
DIMENSIONS: mm
SCALE: 1:1
NO. OFF:

PROJECT: CLUSTER

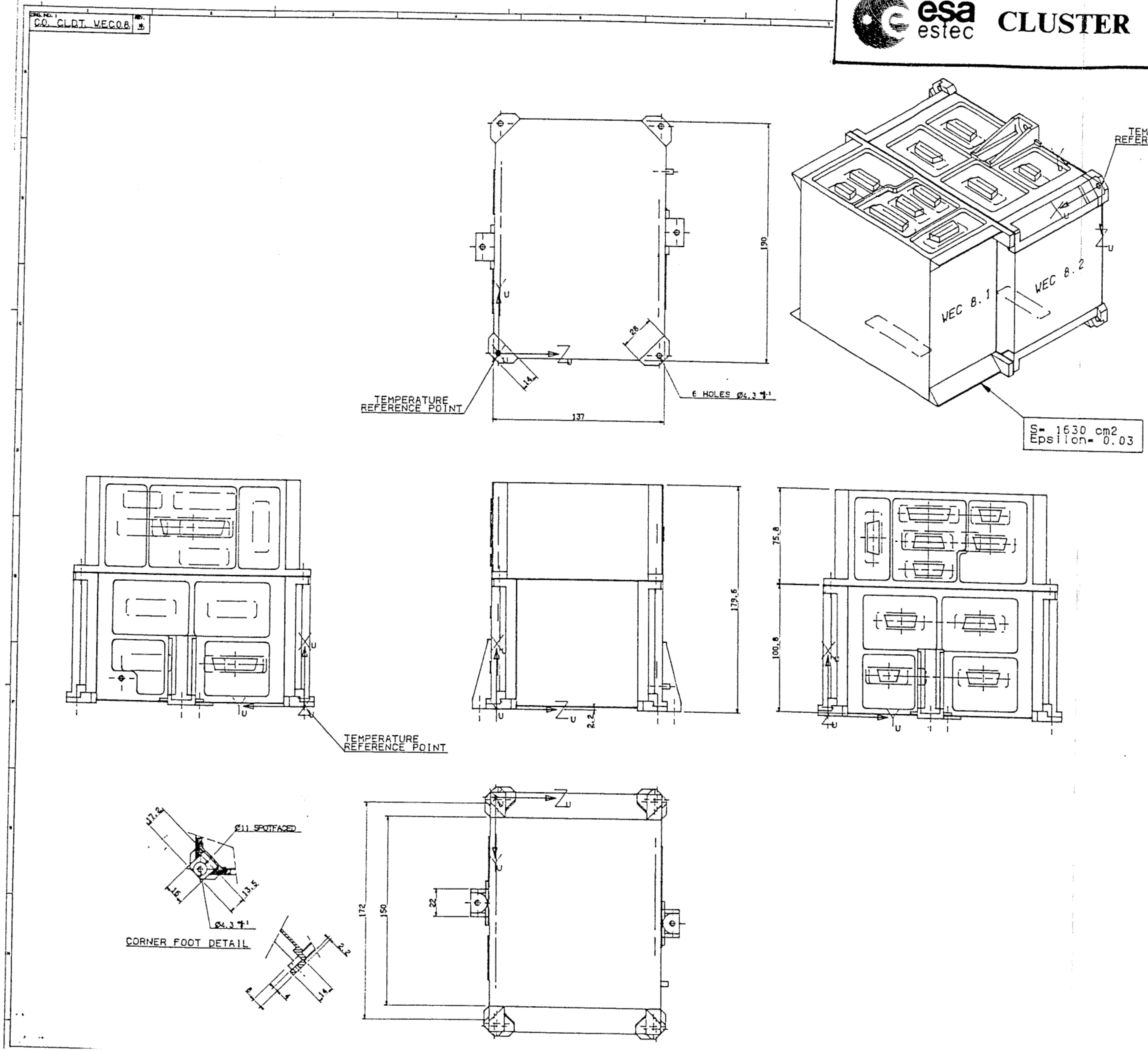
ESA-ESTEC
ENGINEERING SECTION
NOORDWIJK - HOLLAND

TITLE: EXP.: MODULE WEC 7 THERMAL I/F DRG.

NEXT ASSY:
DRG. NO.: C1_CLDT_WEC07 REV. A

Fig. 4.3/5 WEC - Thermal ICD WEC 8 (STAFF Electr. box)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-08]		ORIGINATOR	
TITLE STAFF main box thermal interface			
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DT-WEC-08	ESA	22/03/91



THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: STAFF WEC 8

EXPERIMENT DEVELOPER DRWG.NR.: 013.00.01

REV./REV.DATE: */181090

HEAT CAPACITY: 2700 J/K ±10%

HOUSING MATERIALS:

STRUCTURAL ITEMS: MAGNESIUM AZ31BF
STACK SCREWS: M4x18 Ns22s
WASHERS: Mu Ns22s
NUTS: Mu Ns22s
OTHERS: TBD

WALL THICKNESS: 0.8 mm

SURFACE TREATMENT: 2 µm GOLD PLATING

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 12 cm2
FOOT THICKNESS: 8 mm RECESSED 4 mm
SURFACE ROUGHNESS: ≤ 1.0 µm
FOOT FLATNESS: ≤ 0.01 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11 mm
THERMAL CONDUCTIVITY: 5W/K

OPTICAL PROPERTIES: N/A

THERMAL PROPERTIES:

TOTAL AREA OF BOX RADIATING TO ALL SURFACE INSIDE S/C 0.163 m2

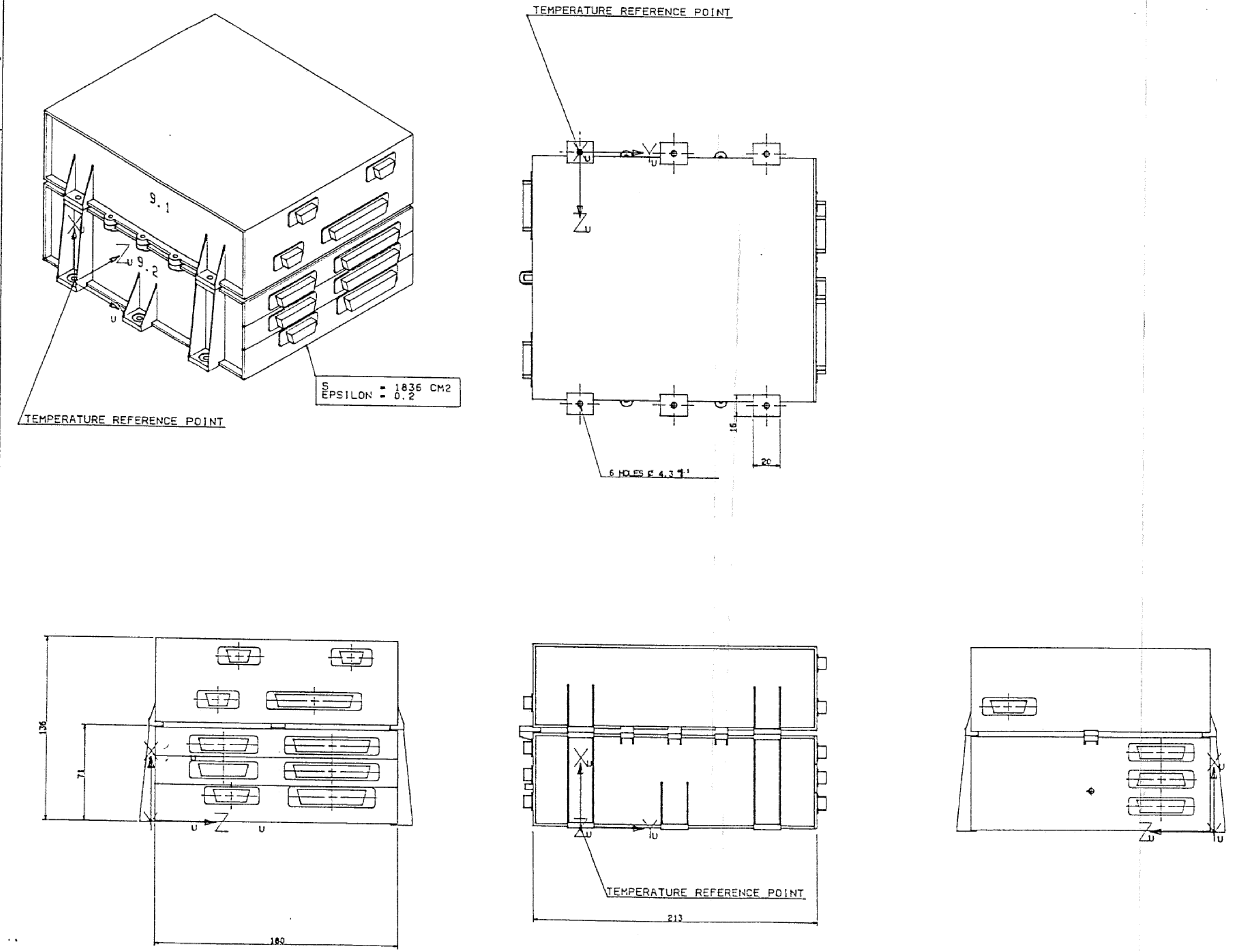
POWER DISSIPATED AT CENTERS OF GEOMETRY:

	WEC 8.1	WEC 8.2
MEAN	0.85W	1.75W
MIN.	0.85W	0 W
MAX.	0.87W	2.20W

Fig. 4.3/6 WEC - Thermal ICD WEC 9 (WHISPER/DWP)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-09]		ORIGINATOR WEC/WHISPER /DWP/ESA	
TITLE WHISPER/DWP unit thermal interface			
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DT-WEC-09	ESA	22/03/91

DRG. NO.: C.O. CLDT. WEC.O.9. REV. A



THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 9 WHISPER/DWP

EXPERIMENT DEVELOPER DRWG.NR.: N:WHI0010

REV./REV.DATE: TBD

HEAT CAPACITY: 3850 J/K ± 5% (TBC)

MATERIALS:
STRUCTURAL ITEMS:
HOUSING: WEC 9.1 AL.ALLOY 2618A
WEC 9.2 AL.ALLOY AA6082T6
SCREWS,ETC.: WEC 9.1 STAINLESS STEEL Z2CN1810
WEC 9.2 STAINLESS STEEL (TBD)
LABELS: SCOTCHCALL 8015, SCOTCHWELD 3900
OTHERS: TBD

SURFACE TREATMENT:
ALODINE 1200

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:
CONTACT AREA MOUNTING FEET: 19.2 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
SURFACE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11 mm
THERMAL CONDUCTIVITY: 0.64 W/K

THERMAL PROPERTIES: TBD

POWER DISSIPATED AT CENTER OF GEOMETRY:

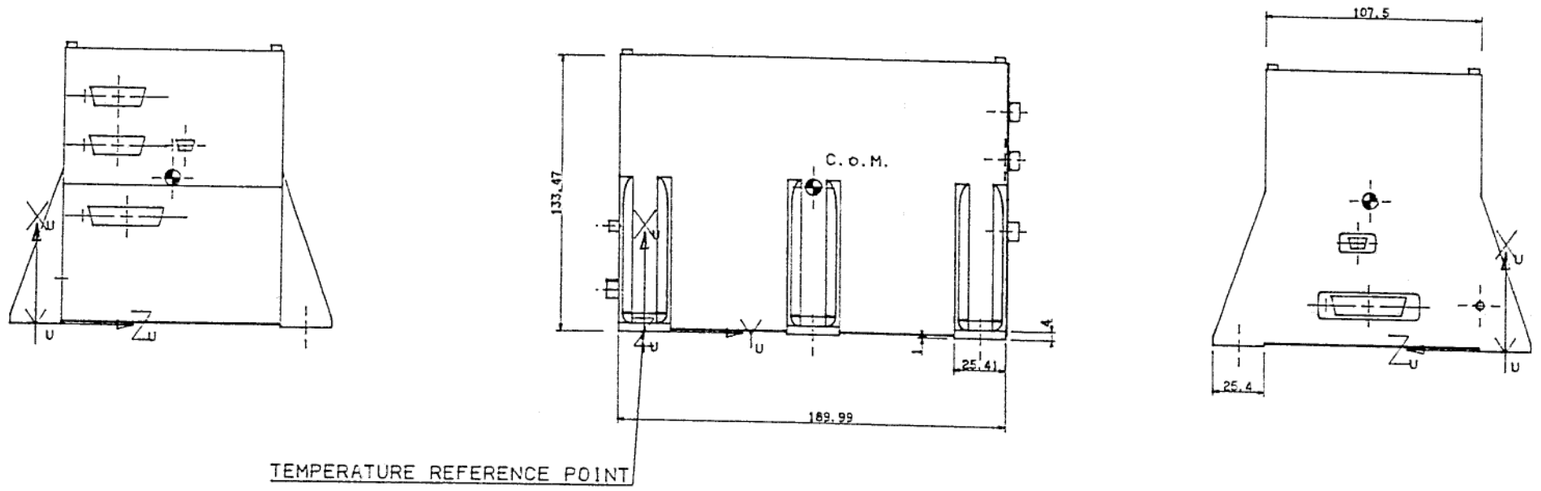
	WEC 9.1	WEC 9.2
MEAN	1.55 W	1.74 W
MIN	0 W	1.74 W
MAX	3.5 W	5.2 W

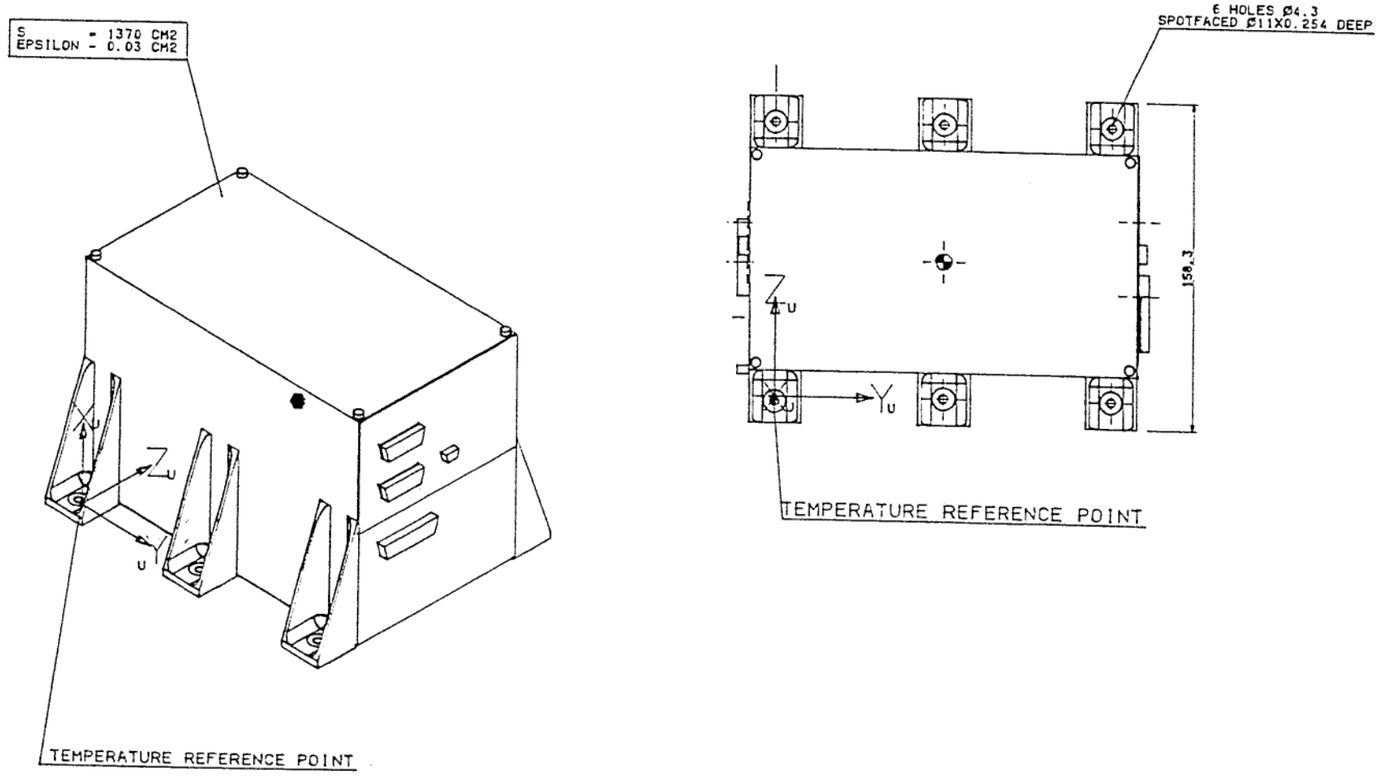
NAME	DATE	VISA
FARAGST	23.11.90	
R. STOLK	21.01.91	
SCHMETTERLE	21.01.91	

MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
SCALE: 1:1
ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP.: WEC 9 THERMAL I/F DRG.
DRG. NO.: C.O. CLDT. WEC.O.9. REV. A

Fig. 4.3/7 WEC - Thermal ICD WEC 10 (WBD)

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-10]		ORIGINATOR	
TITLE WBD unit thermal interface		WEC/WBD/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DT-WEC-10	ESA	22/03/91





THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 10 WIDEBAND RECEIVER

EXPERIMENT DEVELOPER DRWG.NR.:	REV./REV.DATE:
0542/93/D/50008	0/030190
02542/92/D/50008	A/030190

HEAT CAPACITY: 1470 J/K ± 5% (TBC)

HOUSING MATERIALS:

STRUCTURAL ITEMS: MAGNESIUM ALLOY A2310-M24
SCREWS ETC.: TBD
WALL THICKNESS: TBD

SURFACE TREATMENT:

COPPER UNDERPLATE
PER MIL-C-14508-CLASS II
SILVER UNDERPLATE
PER QQ-3-3850 TYPE H GRADE B
GOLD PLATE
PER MIL-G-43204C TYPE 1 GRADE C CLASS II

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 38.7 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 1.6 µm
SURFACE FLATNESS: ≤ 0.05 mm
SPOTFACED AREA: Ø 11 mm
THERMAL CONDUCTIVITY: 0.57 W/K (TBC)

OPTICAL PROPERTIES: N/A

THERMAL PROPERTIES:

TOTAL AREA OF BOX RADIATING TO ALLSURFACES INSIDE S/C 0.14 M2

POWER DISSIPATED AT C.o.M.:

MEAN = 2.13 W
MAX = 2.15 W
MIN = 2.13 W

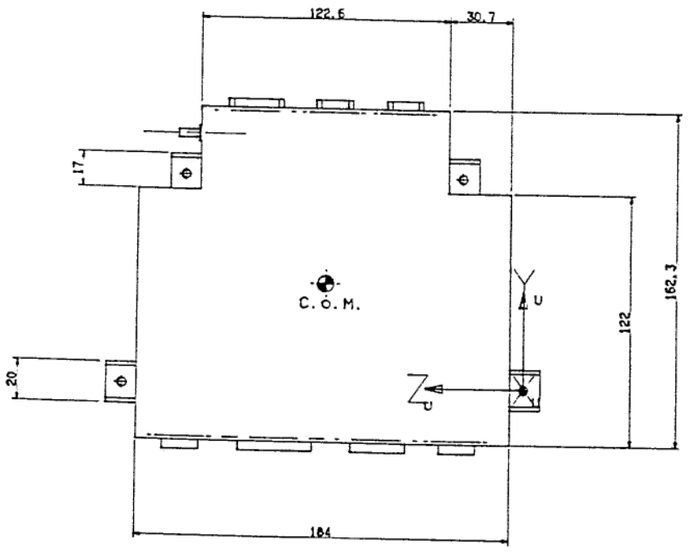
NAME	DATE	VISA
N. BUNTER	(DD/MM)	
M. STELLE	(DD/MM)	
SCHMUTTERLE	(DD/MM)	

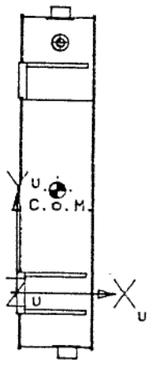
MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
ESA-ESTEC
CLUSTER
EXP.: WEC10

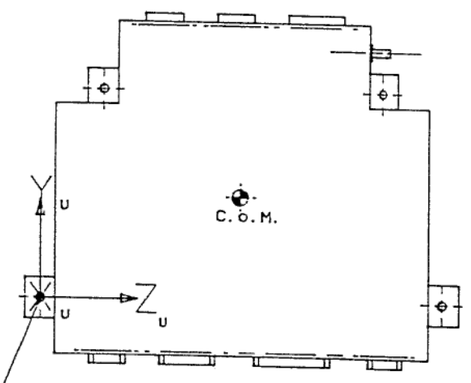
Fig. 4.3/8 WEC - Thermal ICD WEC 11 (Power Supply)

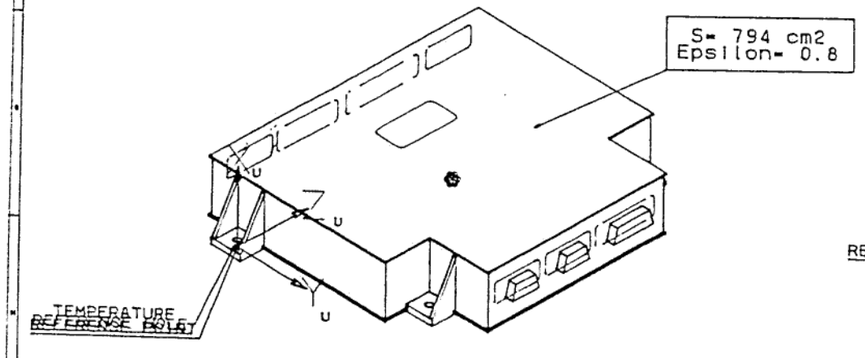
DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER [][CL-DT-WEC-11]		ORIGINATOR	
TITLE WEC power unit thermal interface		WEC/ESA	
ISSUE NO.	DESCRIPTION OF CHANGE	AUTHORITY	DATE
A	first release of CL-DT-WEC-11	ESA	22/03/91

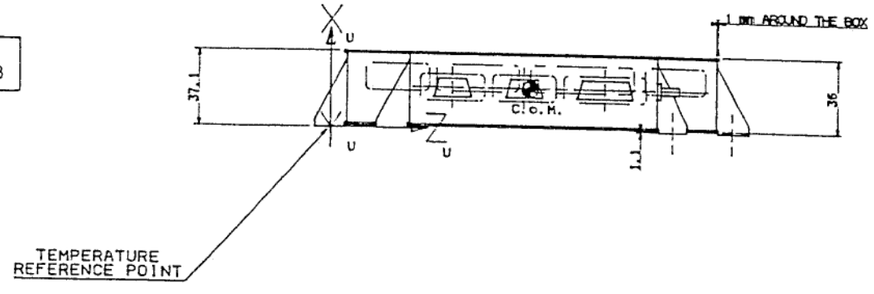
DWG. NO.: CO. CL.DT. WEC1.1 REV. A











THERMAL INTERFACE DRAWING

EXPERIMENT: WAVE EXPERIMENT CONSORTIUM

UNIT: WEC 11 POWER SUPPLY

EXPERIMENT DEVELOPER DRWG.NR.: 11 0085231

REV./REV.DATE: 4/910220

HEAT CAPACITY: 855 J/K ±10%

HOUSING MATERIALS:

STRUCTURAL ITEMS: HOUSING ALUMINIUM ALLOY 2618A
SCREWS: STAINLESS STEEL Z2CN1810
LABELS: SCOTCHCALL 8005
OTHERS: TBD
WALL THICKNESS: 0.8 mm

SURFACE TREATMENT:

BLACK ANODIZED

THERMAL INTERFACE HARDWARE: NOT SPECIFIC

EXPERIMENT MOUNTING:

CONTACT AREA MOUNTING FEET: 9.1 cm2
FOOT THICKNESS: 4 mm
SURFACE ROUGHNESS: ≤ 3.2 µm
FOOT FLATNESS: ≤ 0.05 mm
ATTACHMENT PLANE FLATNESS: ≤ 0.1 mm
SPOTFACED AREA: Ø 11 mm
THERMAL CONDUCTIVITY: 0.84 W/K

OPTICAL PROPERTIES: N/A

THERMAL PROPERTIES:

TOTAL AREA OF BOX RADIATING TO ALL SURFACE INSIDE S/C 0.08 m2

POWER DISSIPATED AT C.o.M.:

MEAN= 2.46 W
MIN.= 0.8 W
MAX.= 3.0 W

NAME	DATE	V/SA
J.J. HUTCHINSON	910118	
R. STOLK	910118	
SCHMITTBUHLE	910121	

MATERIAL: SEE ABOVE
SPECIFICATION:
FINISH: SEE ABOVE
ESA-ESTEC
PROJECT: CLUSTER
TITLE: EXP. WEC11

4.4 MATHEMATICAL MODEL

4.4.1 TMM

4.4.1.1 Thermal Analysis Software

ESATAN

4.4.1.2 Number of thermal nodes

one-node thermal models will be defined in terms of power dissipation in various modes, thermal conductance between the cases and the spacecraft, and the overall radiated conductivity of the boxes to the s/c for each unit or stack.

The spheres (WEC 1 to 4) and the wire booms are sufficiently far and isolated from the spacecraft to not require thermal models.

Two nodes thermal models will be delivered for WEC1/4 and WEC 9.

Three-nodes thermal models will be delivered for the search coil unit (WEC 6)

unit	No. of nodes for s/c design (interface)	No. of nodes for Exp design (internal)
WEC 1 to 4	2	3 (tbc)
WEC 5	1	2 (tbc)
WEC 6	3 (TBC)	4 (tbc)
WEC 7	1	3 (tbc)
WEC 8	1 (TBC)	5 (tbc)
WEC 9	2	3 (tbc)
WEC 10	1	2 (tbc)
WEC 11	1	2 (tbc)

Table 4.4/1 Thermal Analysis Data

4.4.1.3 S/C design TMM definition

Preliminary S/C design TMM are defined in tables 4.4/2.1 to 4.4/2.8 and figures 4.4/1 to 4.4/8.

4.4.2 **Thermal Analysis and Temperature Prediction**

a) WEC 1 to 4 (EFW spheres and deployment units)

Thermal studies and tests on actual models (in the HBF3,ESTEC) have been performed for the first time in early 1970 and these results have been confirmed during various flights. Confidence with respect to thermal design has been accumulated in the GEOS and ISEE projects for the sensors, and in the Viking project for sensors in combination with the boom deployment unit. The extrapolation of the available data to the 240 minutes of eclipse show that the temperature is expected to drop to -125 C for the sphere and -105 C for the substrate, which induce for both a 150 C drop of temperature (ref to Fig 4.4/1). A test has been carried out on a substrate with representative components, it was dipped 50 times between liquid nitrogen (-190 C) and air (20 C) without any damage.
Test cable have been subjected to temperature extremes from immersion in liquid nitrogen to +150 C.

b) WEC 1/4 (mechanism)

A thermal analysis will be performed for the deployment units which are thermally coupled to the spacecraft (conductive coupled through the attachment points, radiative coupled to the external spacecraft surface through the canisters surfaces and to the space through the canisters and the apertures, when the spheres are released).

c) WEC 6 (search coils)

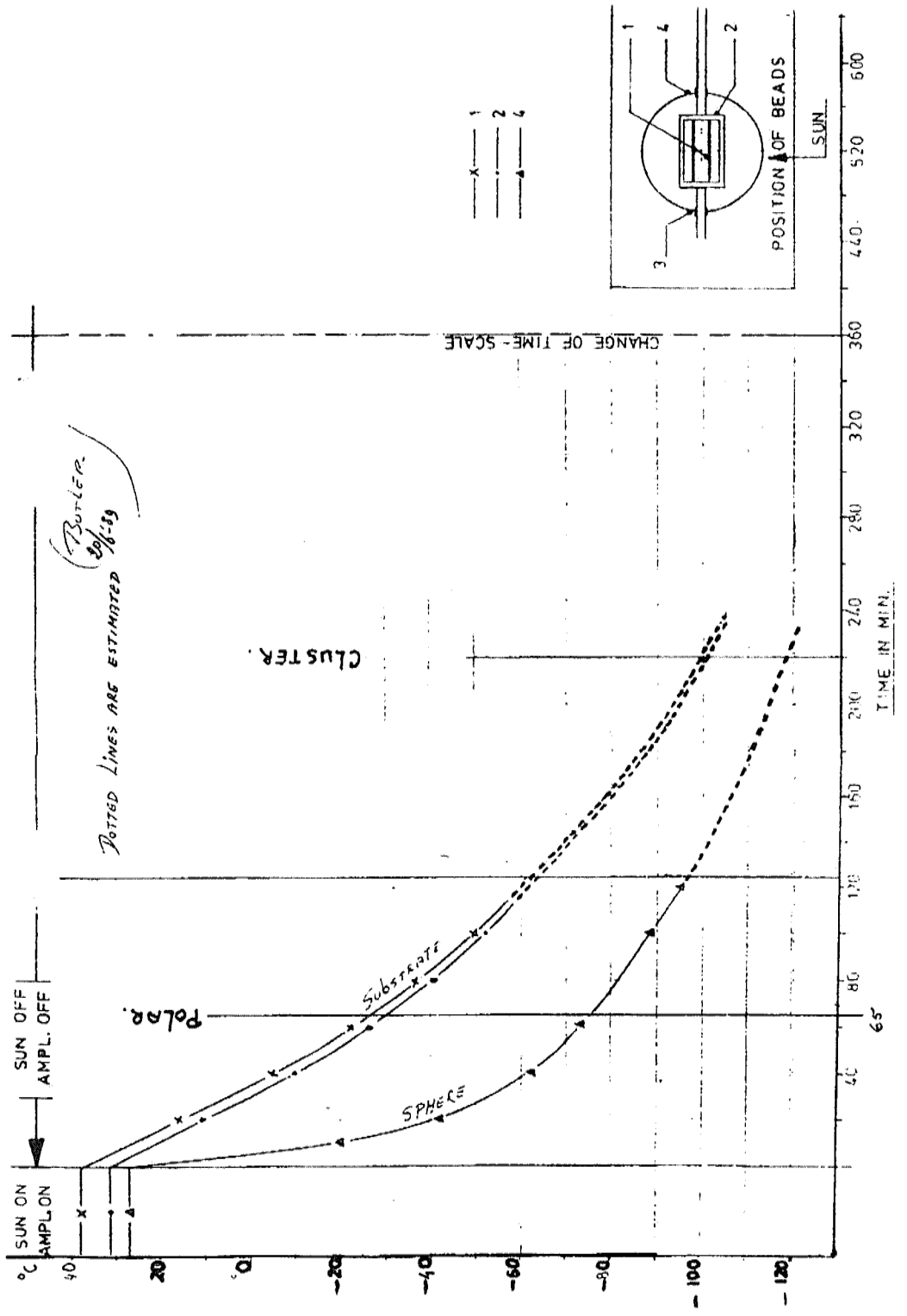
A preliminary thermal analysis will be undertaken by the CRPE at the beginning of the development phase in order to define the thermal concept and the materials.

The CRPE has a long experience in this domain, proven by thermal designs of the GEOS, Ulysses and Galileo search coils. The final analysis will be made under contract in the industry. The model will be validated by a thermal balance test on the Engineering Model. The modelisation of the wiring, between the WEC units and to the spacecraft subsystems (power, telemetry, telecommand), will not be undertaken by the WEC as it will be made by, and under the responsibility of the prime spacecraft contractor.

Tab 4.4/3 Unit temperature prediction.

TBD

Fig 4.4/1 WEC 1/4 sphere temperature prediction.



Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with [cm²] sun	space	s/c	
1	Sensor housing	.20	.05	tbd	239	-	200
2	Mechanism box & TRP	-	.20	-	-	1470	2400

Nr	other Nodes
3	P/L bay
4	PBS
5	SAS
6	Space

Node Dissipation				
Nr	mean	min	max	Heater
1	0	0	0	-
2	0.12	0.10	0.20	-

Conductive Couplings		
Node	Node	Value [W/K]
1	2	0.10

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
2	3	294 tbc
1	4	tbd
1	5	tbd
1	6	tbd

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1 2	] ref to fig. 4.4/2.1]

Table 4.4/2.1.b WEC 1/4 deployed configuration S/C design TMM data sheet

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with [cm²] sun	space	s/c	
1	Sensor housing	.20	.05	tbd	339	-	420
2	Mechanism box & TRP	-	.20	-	-	1470	2450

Nr	other Nodes
3	P/L bay
4	PBS
5	SAS
6	Space

Node Dissipation				
Nr	mean	min	max	Heater
1	0	0	0	-
2	4.2	0	4.2	-

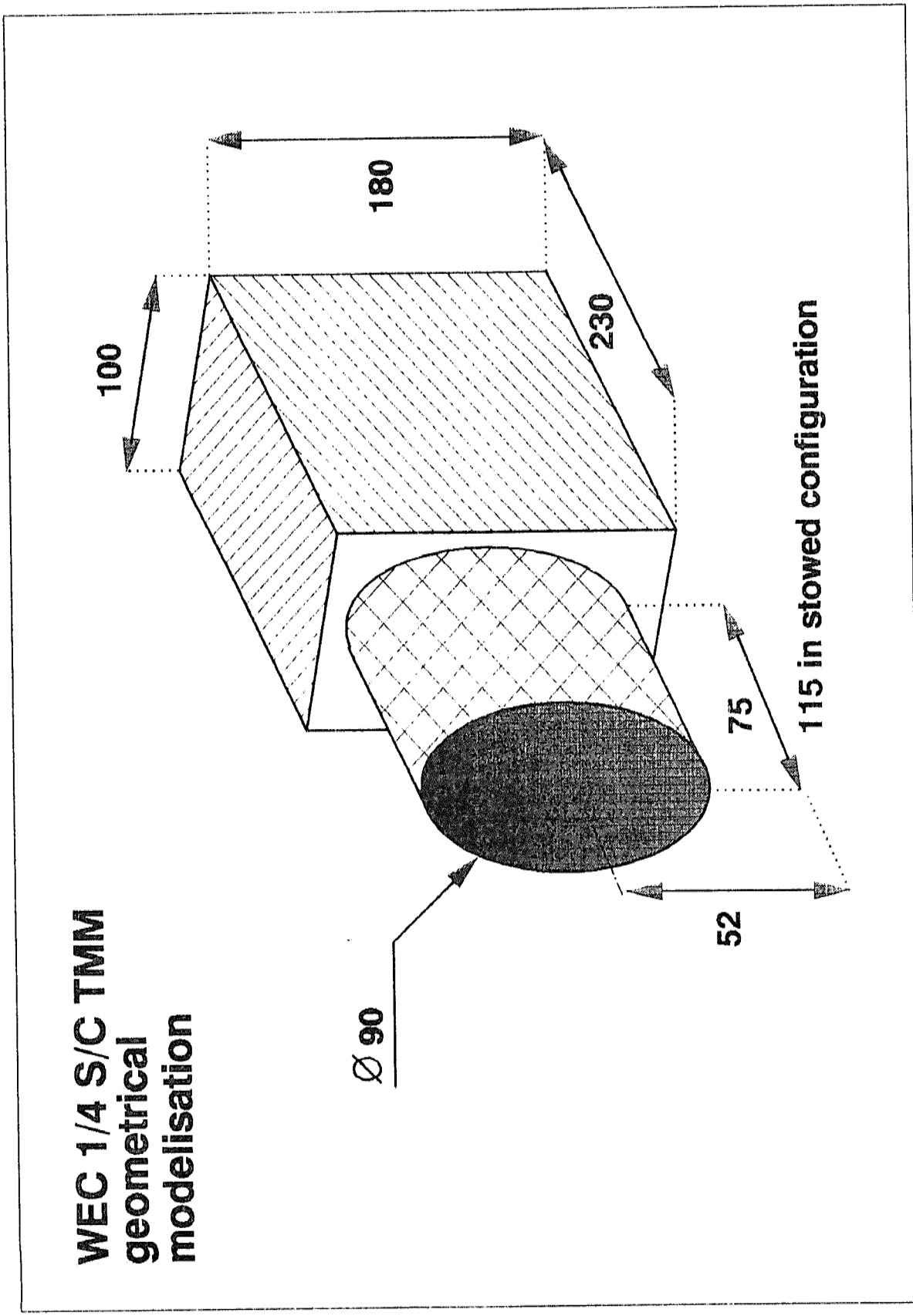
Conductive Couplings		
Node	Node	Value [W/K]
1	2	0.03

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
2	3	294 tbc
1	4	tbd
1	5	tbd
1	6	tbd

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1 2	] ref to fig. 4.4/2.1]

Table 4.4/2.1.a WEC 1/4 stowed configuration S/C design TMM data sheet

Fig 4.4/2.1 WEC 1/4 S/C design TMM geometrical modelisation



Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with sun [cm²]	space [cm²]	s/c [cm²]	
1	Box & TRP	-	.80	-	-	780	1710 tbc

Nr	other Nodes
3	P/L bay

Node Dissipation				
Nr	mean	min	max	Heater
1	1.95	1.80	2.40	-

Conductive Couplings		
Node	Node	Value [W/K]

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	3	624 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1	parallelepiped L = 185 W = 145 H = 74

Table 4.4/2.2 WEC 5 S/C design TMM data sheet

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with [cm²] sun	space	boom	
1	Antenna	-	.03	-	-	-	450
2	MLI	.81	.85	tbd	tbd	tbd	0
3	TRP	-	-	-	-	-	-

Nr	other Nodes
4	Boom
5	Space

Node Dissipation				
Nr	mean	min	max	Heater
1	0	0	0	-

Conductive Couplings		
Node	Node	Value [W/K]
1	3	0.005

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	2	23 tbc
2	4	tbd
2	5	tbd
		2975 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1 2	] ref to fig. 4.4/2.3]

Table 4.4/2.3 WEC 6 S/C design TMM data sheet

Fig 4.4/2.3 WEC 6 S/C design TMM geometrical modelisation

TBD

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with sun [cm²]	space [cm²]	s/c [cm²]	
1	Box & TRP	-	.20 tbc	-	-	238	270

Nr	other Nodes
3	P/L bay

Node Dissipation				
Nr	mean	min	max	Heater
1	0.07	0.10	0.70	-

Conductive Couplings		
Node	Node	Value [W/K]

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	3	54 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1	parallelepiped L = 96 W = 79 H = 26

Table 4.4/2.4 WEC 7 S/C design TMM data sheet

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with sun [cm²]	space [cm²]	s/c [cm²]	
1	Box & TRP	-	.03	-	-	1630	2700

Nr	other Nodes
3	P/L bay

Node Dissipation				
Nr	mean	min	max	Heater
1	2.60	1.45	3.17	-

Conductive Couplings		
Node	Node	Value [W/K]

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	3	49 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1	parallelepiped L = 190 W = 137 H = 176

Table 4.4/2.5 WEC 8 S/C design TMM data sheet

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with sun	space	s/c [cm²]	
1	Whisper	-	.20	-	-	886	1300
2	DWP & TRP	-	.20	-	-	950	1400
						tbc	tbc

Nr	other Nodes
3	P/L bay

Node Dissipation				
Nr	mean	min	max	Heater
1	1.99	0.00	3.50	-
2	1.74	1.74	5.20	-

Conductive Couplings		
Node	Node	Value [W/K]
1	2	0.42 tbc

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	3	174 tbc
2	3	190 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1 2	parallelepiped L = 213 W = 180 H = 65 H = 71

Table 4.4/2.6 WEC 9 S/C design TMM data sheet

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with sun	Surface exchange with space	Surface exchange with s/c [cm²]	
1	Box & TRP	-	.03	-	-	1370 tbc	1470 tbc

Nr	other Nodes
3	P/L bay

Node Dissipation				
Nr	mean	min	max	Heater
1	2.13	2.13	2.15	-

Conductive Couplings		
Node	Node	Value [W/K]

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	3	41 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1	parallelepiped L = 190 W = 107 H = 142

Table 4.4/2.7 WEC 10 S/C design TMM data sheet

Nr	Description of Node	Effective Values of					Heat Capacity [J/K]
		α	Σ	Surface exchange with sun	space	[cm²] s/c	
1	Box	-	.80	-	-	794	855
2	TRP	-	-	-	-	- tbc	- tbc

Nr	other Nodes
3	P/L bay

Node Dissipation				
Nr	mean	min	max	Heater
1	2.46	0.80	3.00	-

Conductive Couplings		
Node	Node	Value [W/K]
1	2	0.84 tbc

Radiative Couplings		
Node	Node	Value S*[mm²]*ReF*Σ
1	3	635 tbc

Geometrical Modelisation	
Node	Shape and dimensions [mm]
1	parallelepiped L = 182 W = 148 H = 37

Table 4.4/2.8 WEC 11 S/C design TMM data sheet