SPIRE Filters

Failure Modes Effects & Criticality Analysis (FMECA) Report

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Date	Version	Remarks
31/08/01	1.0	First Issue for DDR
25/01/02	2.0	First configuration controlled issue

List of Acronyms

Term	Meaning	Term	Meaning
AD	Applicable Document	IR	Infrared
ADC	Analogue to Digital Converter	IRD	Instrument Requirements Document
AIV	Assembly, Integration and Verification	IRTS	Infrared Telescope in Space
AME	Absolute Measurement Error	ISM	Interstellar Medium
AOCS	Attitude and Orbit Control System	JFET	Junction Field Effect Transistor
APART	Arizona's Program for the Analysis of Radiation Transfer	ISO	Infrared Space Observatory
APE	Absolute Pointing Error	LCL	Latching Current Limiter
ASAP	Advanced Systems Analysis Program	LIA	Lock-In Amplifier
ATC	Astronomy Technology Centre, Edinburgh	LVDT	Linear Variable Differential Transformer
AVM	Avionics Model	LWS	Long Wave Spectrometer (an instrument used on ISO)
BDA	Bolometer Detector Array	MAC	Multi Axis Controller
BFL	Back Focal Length	MAIV	Manufacturing, Assembly, Integration and Verification
BRO	Breault Research Organization	MCU	Mechanism Control Unit = HSMCU
BSM	Beam Steering Mirror	MGSE	Mechanical Ground Support Equipment
CBB	Cryogenic Black Body	M-P	Martin- Puplett
CDF	Cardiff, Department of Physics & Astronomy	NEP	Noise Equivalent Power
CDMS	Command and Data Management System	NTD	Neutron Transmutation Doped
CDMU	Command and Data Management Unit	OBS	On-Board Software
CDR	Critical Design Review	OGSE	Optical Ground Support Equipment
CEA	Commissariat a l'Energie Atomique	OMD	Observing Modes Document
CMOS	Complimentary Metal Oxide Silicon	OPD	Optical Path Difference
CoG	Centre of Gravity	PACS	Photodetector Array Camera and Spectrometer
CPU	Central Processing Unit	PCAL	Photometer Calibration source
CQM	Cryogenic Qualification Model	PFM	Proto-Flight Model
CVV	Cryostat Vacuum Vessel	PID	Proportional, Integral and Differential (used in the context of feedback control loop architecture)
DAC	Digital to Analogue Converter	PLW	Photometer, Long Wavelength
DAQ	Data Acquisition	PMW	Photometer, Medium Wavelength
DCU	Detector Control Unit = HSDCU	POF	Photometer Observatory Function
DDR	Detailed Design Review	PROM	Programmable Read Only Memory
DM	Development Model	PSW	Photometer, Short Wavelength
DPU	Digital Processing Unit = HSDPU	PUS	Packet Utilisation Standard
DSP	Digital Signal Processor	RAL	Rutherford Appleton Laboratory,
DQE	Detective Quantum Efficiency	RD	Reference Document
EDAC	Error Detection and Correction	RMS	Root Mean Squared
EGSE	Electrical Ground Support Equipment	SCAL	Spectrometer Calibration Source
EM	Engineering Model	SCUBA	Submillimetre Common User Bolometer Array
EMC	Electro-magnetic Compatibility	SED	Spectral Energy Distribution
EMI	Electro-magnetic Interference	SMEC	Spectrometer Mechanics
ESA	European Space Agency	SMPS	Switch Mode Power Supply
FCU	FCU Control Unit = HSFCU	SOB	SPIRE Optical Bench
FIR	Far Infrared	SOF	Spectrometer Observatory Function
FIRST	Far Infra-Red and Submillimetre Telescope	SPIRE	Spectral and Photometric Imaging Receiver
FOV	Field of View	SRAM	Static Random Access Memory
F-P	Fabry-Perot	SSSD	SubSystem Specification Document
FPGA	Field Programmable Gate Array	STP	Standard Temperature and Pressure
FPU	Focal Plane Unit	SVM	Service Module
FS	Flight Spare	TBC	To Be Confirmed
FTS	Fourier Transform Spectrometer	TBD	To Be Determined
FWHM	Full Width Half maximum	TC	Telecommand
GSFC	Goddard Space Flight Center	URD	User Requirements Document
HK	House Keeping	UV	Ultra Violet
HOB	Herschel Optical Bench	WE	Warm Electronics
HPDU	Herschel Power Distribution Unit	ZPD	Zero Path Difference
HSDCU	Herschel-SPIRE Detector Control Unit		
HSDPU	Herschel-SPIRE Digital Processing Unit		
HSFCU	Herschel-SPIRE FPU Control Unit		
HSO	Herschel Space Observatory		
IF	Interface		
IID-A	Instrument Interface Document - Part A		
IID-B	Instrument Interface Document - Part B		
IMF	Initial Mass Function		

Table of Contents

1. Scope

This document presents the results of the FMECA carried out on the SPIRE filters.

2. Documents

2.1. Applicable documents

All applicable documents are listed in the AD chapter of the CIDL (HSO-CDF-LI-029).

2.2. Reference documents

3. Details of the analysis

A failure modes effects and criticality analysis has been performed on all functional elements of the filters which can cause failure effects within the experiment or cause damage to, or interfere with, the proper functioning of the SPIRE instrument or Herschel spacecraft.

Each failure effect identified has been given a criticality category according to the definition below:

- Category 1**:** The failure effect is not confined to the subsystem. When this failure results also in loss or degradation of the instruments function this shall be stated.

- Category 2: The failure results in loss or degradation of the subsystems function but the effect is confined to the subsystem.

- Category 3: Minor internal subsystem failures.

The following attributes have been added to the criticality category as appropriate:

- "R", if the design contains a redundant item which can perform the same function
- "SH", if the failure effect causes a safety hazard
- "SPF" if the failure is caused by a single point failure.

The following failure modes have been considered: -

Failure during operation
Degradation or out of tolerance operation
Mechanical failure

Design specifications, descriptions functional diagrams etc. used in the preparation of the FMECA shall be attached or referenced.

Table 1 Results of FMECA of the filters subsystem.

FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS (FMECA)

Product: SPIRE Instrument
Project/Phase: Herschel
System/Subsystem/Equipment: Filters, beam splitters & dichroics
Mission phase/Operational Mode: Space Flight
Prepared by: P.Hargrave
Approved by:
Date: 25/08/01
Document reference:
Issue:

Id number	Item/ block	Function	Failure mode	Failure cause	Failure effects a. Local effects b. End effects	Severity	Failure detection method/ observable symptoms	Compensation provisions	Correction actions	Remarks
000.001	CFIL1	Common input filter. Attenuates out-of-band radiation	Delamination	Manufacturing error	a. Loss in transmission. Additional in-band fringing. b. Decreased instrument sensitivity	1	Detected as loss in transmission in the photometer. Any fringing could be observed in the spectrometer.	None	None	Very unlikely – delamination would occur in first few thermal cycles of qualification tests.
000.002			Cracking	Differential thermal contraction	a. Negligible impact on performance b. Negligible impact on performance	3	None	None	None	Never observed before, but possible.
000.003			Slippage in clamp / warping	Incorrect mounting	a. None b. None	3				
000.004			Falls from clamp	Incorrect mounting, cracking.	a. Reduction in blocking. b. Increased background on all detectors. Possibility of damage to other Herschel Instruments and SPIRE subsystems.	1	Increased background loading on all detectors	None	None	Highly unlikely. Never observed before. This filter and mount will undergo rigorous qualification tests.
001.001	4K blockers	Attenuates out-of-band radiation	Delamination	Manufacturing error	a. Loss in transmission. Additional in-band fringing. b. Decreased instrument sensitivity	1	Detected as loss in transmission in the photometer. Any fringing could be observed in the spectrometer.	None	None	Very unlikely – delamination would occur in first few thermal cycles of qualification tests.
001.002			Cracking	Differential thermal contraction	a. Negligible impact on performance b. Negligible impact on performance	3	None	None	None	Never observed before, but possible.

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001.003			Slippage in clamp / warping	Incorrect mounting	a. None b. None	3				
001.004			Falls from clamp	Incorrect mounting, cracking.	a. Reduction in blocking. b. Increased background on detectors. Possibility of damage to other SPIRE subsystems.	1	Increased background loading on photometer or spectrometer detectors (depending on which filter is lost)	None	None	Highly unlikely. Never observed before. Filters and mounts will undergo rigorous qualification tests.
002.001	2K Blockers	Attenuates out-of-band radiation	Delamination	Manufacturing error	a. Loss in transmission. Additional in-band fringing. b. Decreased instrument sensitivity	1	Detected as loss in transmission in the photometer. Any fringing could be observed in the spectrometer.	None	None	Very unlikely – delamination would occur in first few thermal cycles of qualification tests.
002.002			Cracking	Differential thermal contraction	a. Negligible impact on performance b. Negligible impact on performance	3	None	None	None	Never observed before, but possible.
002.003			Slippage in clamp / warping	Incorrect mounting	a. None b. None	3				
002.004			Falls from clamp	Incorrect mounting, cracking.	a. Reduction in blocking. b. Increased background on detectors. Possibility of damage to other SPIRE subsystems.	1	Increased background loading on photometer or spectrometer detectors (depending on which filter is lost)	None	None	Highly unlikely. Never observed before. Filters and mounts will undergo rigorous qualification tests.

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003.001	300mK Blockers	Attenuates out-of-band radiation	Delamination	Manufacturing error	a. Loss in transmission. Additional in-band fringing. b. Decreased instrument sensitivity	1	Detected as loss in transmission in the photometer. Fringing could be observed in the spectrometer if it were either of the spectrometer edge definers which failed in this mode.	None	None	Very unlikely – delamination would occur in first few thermal cycles of qualification tests.
003.002			Cracking	Differential thermal contraction	a. Negligible impact on performance b. Negligible impact on performance	3	None	None	None	Never observed before, but possible.
003.003			Slippage in clamp / warping	Incorrect mounting	a. None b. None	3	None	None	None	
003.004			Falls from clamp	Incorrect mounting, cracking.	a. Reduction in blocking. b. Increased background on detectors. Possibility of damage to other SPIRE subsystems.	1	Increased background loading on photometer or spectrometer detectors (depending on which filter is lost)	None	None	Highly unlikely. Never observed before. Filters and mounts will undergo rigorous qualification tests.

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004.001	300mK Edge definers	Defines low pass edge of band.	Delamination	Manufacturing error	a. Loss in transmission. Additional in-band fringing. Loss of edge definition. b. Decreased instrument sensitivity. Poorly defined detector channels.	1	Detected as loss in transmission in the photometer. Fringing could be observed in the spectrometer if it were either of the spectrometer edge definers which failed in this mode.	None	None	Very unlikely – delamination would occur in first few thermal cycles of qualification tests.
004.002			Cracking	Differential thermal contraction	a. Negligible impact on performance b. Negligible impact on performance	3	None	None	None	Never observed before, but possible.
004.003			Slippage in clamp / warping	Incorrect mounting	a. Warping b. Possibility of degradation of BDA performance	1	None	None	None	Highly unlikely. All 300mK filters are qualified through many thermal cycles using an Invar BDA interface replica. Any warping is very unlikely to damage the BDA.
004.004			Falls from clamp	Incorrect mounting, cracking.	a. Reduction in blocking. b. Increased background on detectors. Possibility of damage to other SPIRE subsystems.	1	Increased background loading on photometer or spectrometer detectors (depending on which filter is lost)	None	None	Highly unlikely. Never observed before. Filters and mounts will undergo rigorous qualification tests.

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005.001	Dichroics	Splits photometric bands. Acts as mirror for wavelengths below edge, transmits longer wavelengths	Delamination	Manufacturing error	a. Loss in transmission. Additional in-band fringing. Loss of edge definition. b. Decreased instrument sensitivity for transmitted channels. Poorly defined detector channels.	1	Detected as loss in transmission in the photometer MW or LW channels.	None	None	Very unlikely – delamination would occur in first few thermal cycles of qualification tests.
005.002			Cracking	Differential thermal contraction	a. Negligible impact on performance b. Negligible impact on performance	3	None	None	None	Never observed before, but possible.
005.003			Warping	Incorrect mounting. Differential thermal contraction.	a. Warping b. Loss of spatial purity for reflected channel. No loss of performance for transmitted channel.	1	Spatial comparison of photometer channel images	None	None	Highly unlikely. The dichroics are mounted in substantial rings to maintain flatness.
005.004			Falls from clamp	Incorrect mounting.	a. b. Reduction of blocking and possible partial obscuration for transmitted channels. Loss of reflected channel.	1		None	None	Highly unlikely. Never observed before. Filters and mounts will undergo rigorous qualification tests.

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006.001	Beam dividers	Transmits 50%, and reflects 50% of incident energy, independent of frequency (in SPIRE band)	Splitting of Mylar substrate	Manufacturing error	a. Loss of performance over part of element. b. Degraded performance for beam dividers – ripples introduced to transmission/reflection curve	1		None	None	This failure mode would appear after the first few thermal cycles and therefore would be eliminated by qualification
006.002			Warping	Incorrect mounting	a. Beam divider loses flatness b. Loss of frequencies according to degree of warp. Higher frequencies affected first. High degree of warp – lose whole spectrometer. Smaller degree of warp – lose ability to perform high-resolution scan.	1		None	None	The beam dividers are mounted in substantial rings to maintain flatness.