PAYLOAD FLIGHT HAZARD REPORT				a. NO:	AMS-02-F09
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)			c. PHASE:	II
d. SUBSYSTEM:	Radiation	e. HAZARD GROUP:	Radiation, Injury/Illness	f. DATE:	May 22, 2006
g. HAZARD TITLE:	Exposure of the Crew to Excessive Ionizing Radiation			i. HAZARD CATEGORY:	CATASTROPHIC **X** CRITICAL
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B and ISS Addendum, paragraphs: 200.2, 212.1				
j. DESCRIPTION OF HAZARD:	Crewmember injury/illness due to exposure to ionizing radiation sources. AMS-02 utilizes radioactive materials within the TRD's four chambered calibration tube, each chamber utilizing 0.2 μCi of Fe^{55}. The AMS-02 does not contain any ionizing radiation generators. While the AMS-02 does interact with the natural background radiation of the space environment, it does not adversely modify that environment.				
k. CAUSES *(list)*	1. Presence of ionizing radiation within crew accessible environments.				

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

PAYLOAD FLIGHT HAZARD REPORT		a. NO:	AMS-02-F09
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE:	II
l. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)			OPS CONTROL
1. CAUSE: Presence of ionizing radiation within crew accessible environments.			
1.1 CONTROL: AMS-02 has selected Fe^{55} in the form of Iron Citrate to provide the requisite ionizing radiation within the TRD calibration chambers. The significant radiation of Fe^{55} consists of x-rays in the 5.89 keV range. The half-life of Fe^{55} is approximately 2.73 years. The calibration tube of the TRD will be confirmed to utilize only Fe^{55} as the radiation source. 1.1.1 SVM: Confirmation that manufacturer of the TRD calibration tube utilized Fe^{55} as the ionizing radiation source material. 1.1.1 STATUS: Open.			
1.2 CONTROL: The quantity of Fe^{55} to be used for each calibration tube chamber will be such that the radioactive source will be limited to not more than 0.3 μCi for a total Fe^{55} (Iron Citrate) radioactivity level of 1.2 μCi (See Attached JSC Form 44) 1.2.1 SVM: Radioactive material deposition procedure. 1.2.2 SVM: Radiological Survey after procedure. 1.2.3 SVM: Approval of AMS-02 Form 44. 1.2.1 STATUS: Open 1.2.2 STATUS: Open 1.2.3 STATUS: Closed. SRAG Ionizing Radiation Source Review Response ID 2005-002, "Assessment of Crew Risk from Exposure to Radioactive Material/Radiation Producing Equipment," dated 02/22/2006. JSC Radiation Constraint Panel/Radioactive Payloads Working Group (RCP/RPWG).			
1.3 CONTROL: The calibration tubes are designed as pressurized components (see HR AMS-02-F05 for qualification of pressurize component characteristics) and the Iron Citrate (solid, Fe^{55}) is attached to the stainless steel cavity within the Monitor Tube structure. Iron citrate is introduced to the interior of the calibration tubes as a solution and the iron is deposited to the walls, forming a thin, well secured layer of iron bonded to the steel. 1.3.1 SVM: Review of processing procedures. 1.3.2 SVM: Inspection of flight calibration tubes/wipe test to verify retention of radioactive iron within tubes.			

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F09
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

1.3.1 STATUS: Open 1.3.2 STATUS: Open	
1.4 CONTROL: The thickness of the calibration tube attenuates the radioactivity to undetectable levels. The stainless steel construction is sufficiently thick to preclude the penetration of the 5.89keV x-ray radiation from the Fe^{55} source. 1.4.1 SVM: Direct measurement of radiation emissions of TRD calibration tube will confirm no emissions. 1.4.1 STATUS: Open	
Note: The AMS-02 will be tested and calibrated by use of particle beams directed at the science instruments. These beams can not leave a residual radioactivity in the materials of construction of the AMS-02.	

ACRONYMS	
AMS-02 – Alpha Magnetic Spectrometer 02	mCi – milli Curies
TRD – Transition Radiation Detector	est – estimate
μCi – micro Curies	CERN – (originally - Conseil Européen pour la Recherche Nucléaire) Officially European Organization for Nuclear Research
Fe^{55}, Fe-55 – Iron 55 isotope	MPPF –
keV – kilo electron Volts	ETH Zurich –
SVM – Safety Verification Method	

IONIZING RADIATION SOURCE DATA SHEET
SPACE FLIGHT HARDWARE AND APPLICATIONS
Lyndon B. Johnson Space Center

Complete Items 1 through 10 and Part A for radioisotope sources and Part B for ionizing radiation-producing equipment.

IDENTIFICATION

1. PAYLOAD DESIGNATION/EXPERIMENT Alpha Magnetic Spectrometer (AMS)-02	2. STS NUMBER AND/OR LAUNCH DATE UF 4/June 2008
3. SOURCE USING ORGANIZATION Massachusetts Institute of Technology (MIT)	4. ADDRESS 77 Massachusetts Ave., Cambridge MA 02139
5. CONTACT Dr. Martina Green	6. TELEPHONE 617 252 1684
7. PAYLOAD SPONSOR/MANAGER JSC/EA/AMS-02 Project Office	8. ADDRESS M/C EA, 2101 Nasa Rd 1, Houston, TX 77058
9. CONTACT EA1/Stephen Porter	10. TELEPHONE 281 244 7149

PART A. RADIOISOTOPE SOURCES

I. SOURCE DESCRIPTION

ISOTOPE	TOTAL QUANTITY *(MILLICURIE)* *(Include determination date)*	NUMBER OF SOURCES *(List individual source quantity)*
Fe^{55}	0.0012 mCi Total	4 sources of 0.0003 mCi

CHEMICAL FORM Solid Iron Citrate	PHYSICAL STATE Solid encapsulated
SOURCE SEALED [X] YES [ ] NO	IDENTIFICATION NUMBERS
MANUFACTURER MIT Radiation Lab or Isotope Production Laboratories	ADDRESS 77 Massachusetts Ave., Cambridge MA 02138-4307 or

II. SOURCE USE DATA

PURPOSE

[ ] EXTERNAL CALIBRATION [X] INFLIGHT CALIBRATION
[ ] OTHER *(Describe)*
[ ] CREW INVOLVEMENT/REQUIREMENTS *(Include nominal and contingent situations)*

III. SOURCE DIAGRAM

DETAILS ON SEALING, TECHNIQUES, AND DIMENSIONS

The source will be bonded to the inner stainless steel surface of the monitor tubes by evaporation. Adhesion will be ensured by wipe testing. The monitor tube end caps will then be welded on. The steel tube containing the Fe-55 will be part of the TRD gas circuit which itself will remain sealed after construction. Additional description and diagrams follow.

IV. TEST DATA

DATA SOURCE LEAK TESTED	RESULTS (MICROCURIE)
Manufacturer testing and certification	TBS Expected to be 0.

THERMO-VACUUM QUALIFIED TO:	DATE
_____ MM Hg _____ DEGREE C.	

V. PRE-FLIGHT TRANSFERS

LOCATIONS WHERE SOURCE IS TO BE USED OR STORED AND APPROXIMATE DATES

LOCATIONS	DATED FROM:	TO:
CERN	July 2005	L-7 Months
MPPF	L-7 Months	L-1
STS/ISS Exterior Payload Attach Site	L-1 Months	L + 3 years (2 year contingency)

SOURCE CUSTODIAN/RADIATION SAFETY OFFICER	TELEPHONE
Dr. Martina Green	617-252-1684

VI. POST-FLIGHT DISPOSITION

OUTLINE REQUIREMENTS

The source will remain undisturbed internal to AMS-02 TRD system through shipment from KSC back to ETH Zurich. Upon return from the ISS in late 2011 (est) the monitor tube assembly containing the Fe-55 will be removed and disposed of in as low activity waste.

PART B. IONIZING RADIATION PRODUCING EQUIPMENT

I. EQUIPMENT CHARACTERISTICS

TYPE OF RADIATION PRODUCED

MAXIMUM ENERGY LEVEL	OPERATING ENERGY LEVEL

DURATION OF OPERATION	NO. OF UNITS	PULSED UNIT DUTY CYCLE
_____ HOURS TOTAL, ALL UNITS		

II. RADIATION CHARACTERISTICS

RADIATION INTENSITY OF FLIGHT CONFIGURED UNIT	SECONDARY RADIATIONS PRODUCED	
	ENERGY LEVEL	TYPE
_____ RAD/HR @ _____ METERS	_____ KeV	

III. EQUIPMENT USE DATA

CREW INVOLVEMENT/PROCEDURES

RADIATION PRODUCTION WARNING SYSTEM	SAFETY INTERLOCK SYSTEM
☐ YES *(Describe)* ☐ NO	☐ YES *(Describe)* ☐ NO

Gas Monitoring Tubes

Mounted in TRD Box C is a single Monitor tube structure that contains 4 calibration tubes (proportional tubes, monitor tubes), which monitor the gas gain changes for locally different temperatures. The individual calibration tubes have an inner diameter of 6 mm, like the straw tubes, but are milled within the single Monitor Tube structure. On the inner wall of each of the calibration tubes is a 0.3 µCi deposit of Fe^{55}/iron citrate. The 1 mm (minimum) wall of the calibration tube attenuates the 5.9 keV radiation from the source to below detectable levels. Figure 2 indicates the mounting location of the four calibration tubes on the TRD structure of the AMS-02, these are represented by the older design in this graphic, and this is provided for context with relationship to the TRD Gas System Elements. Figure 3 represented the correct design of the Monitor Tube with Figure 4 a close up of the mounting of the Monitor Tube. The final attachment is a derivation of required quantity of Fe^{55} that the TRD Gas System requires to complete its mission.

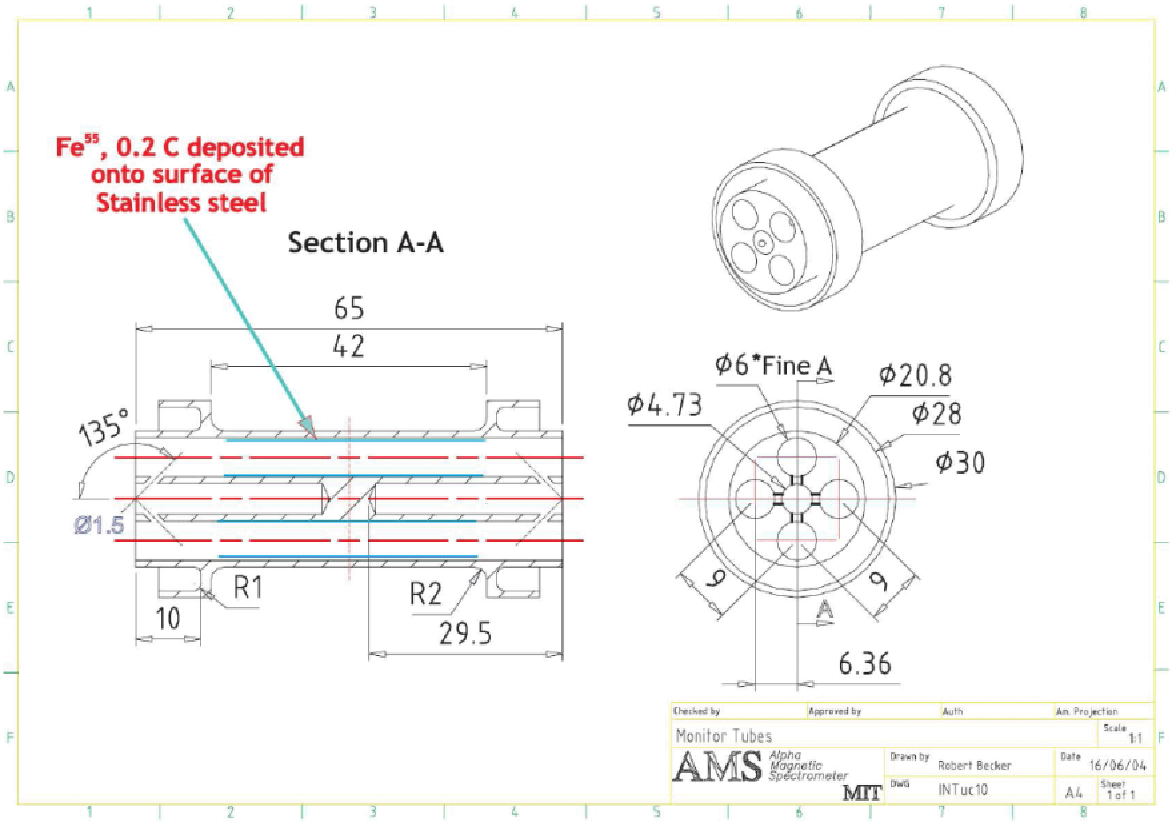


Figure 1: AMS-02 TRD Calibration Tube

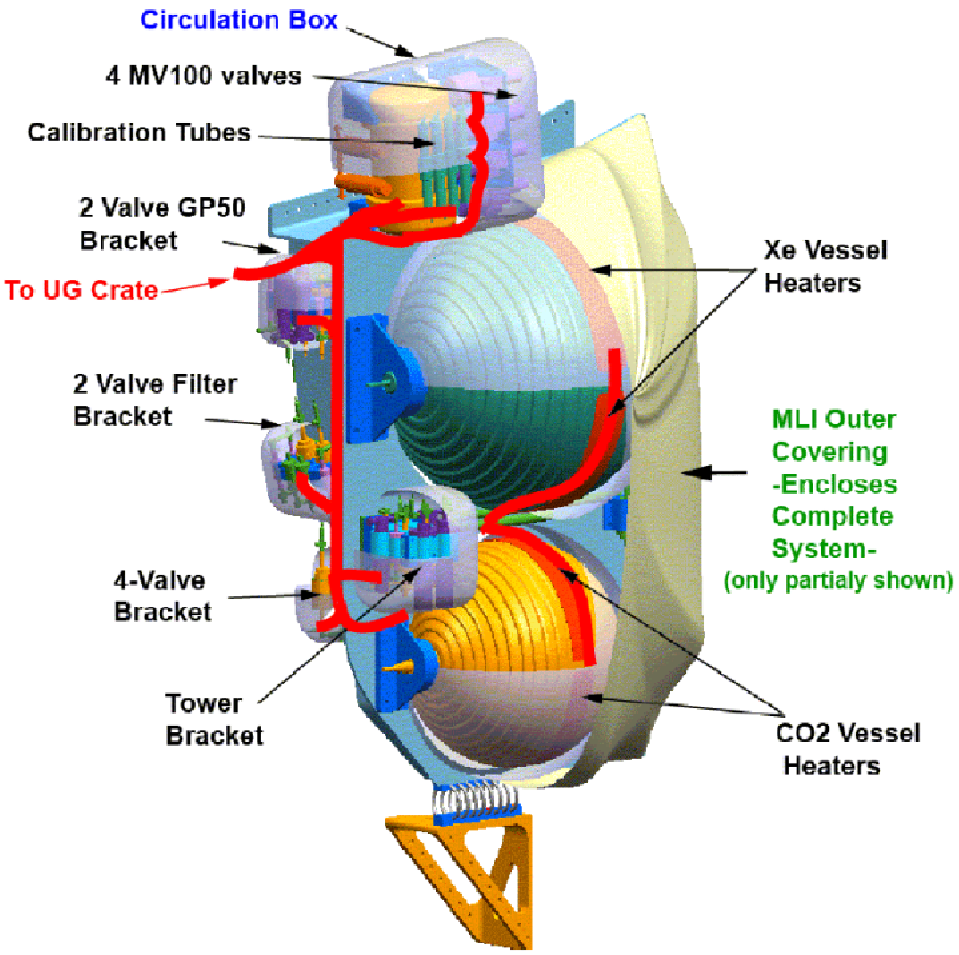


Figure 2: Location of Calibration (Monitor) Tube

Note: This graphic indicates location, but the tubes are now manufactured within a common structure and not individual tubes. New Design Follows.

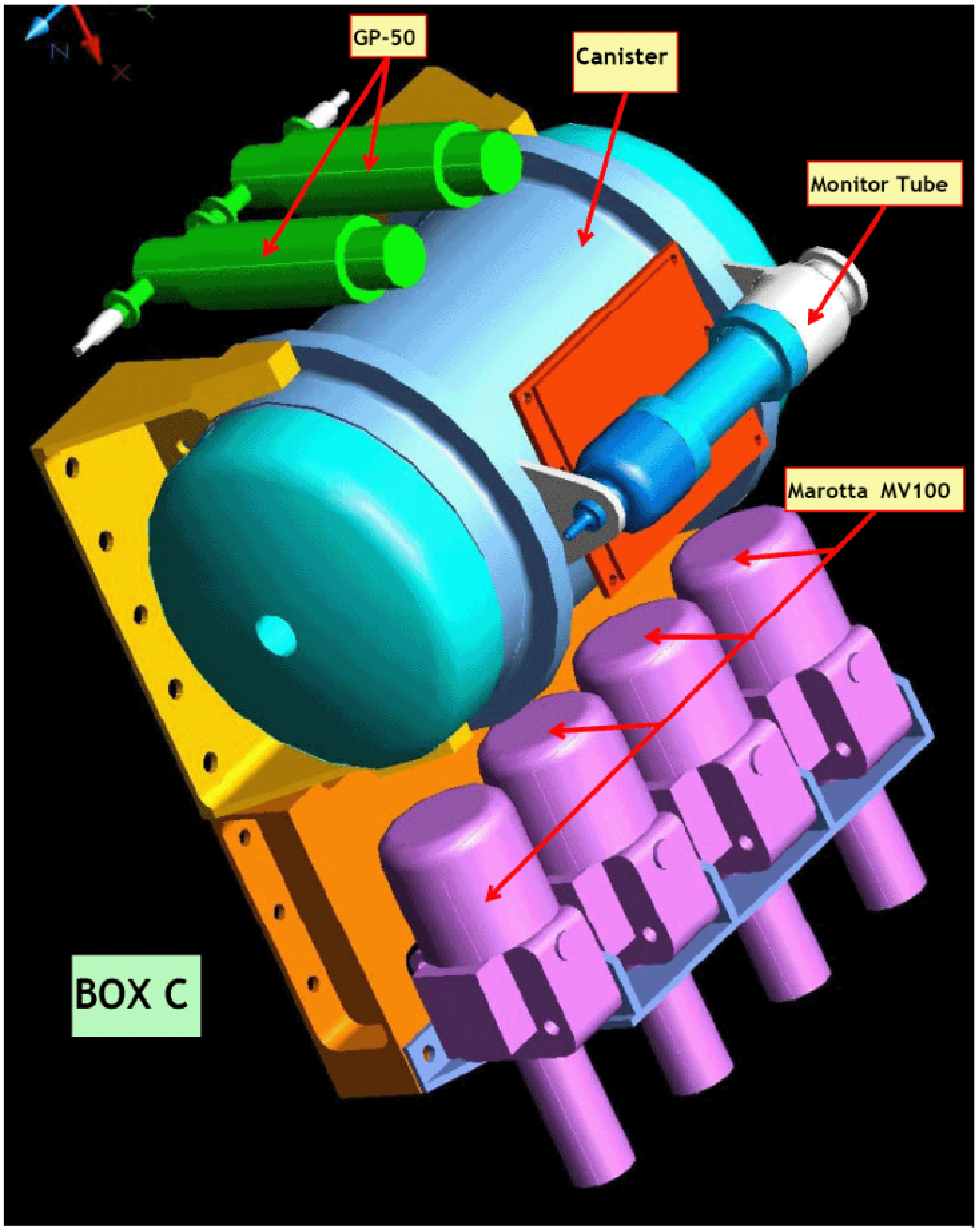


Figure 3: Monitor Tube (Location of Fe55) shown on TRD Gas System Box C Monitor Tube is a closed, welded component.

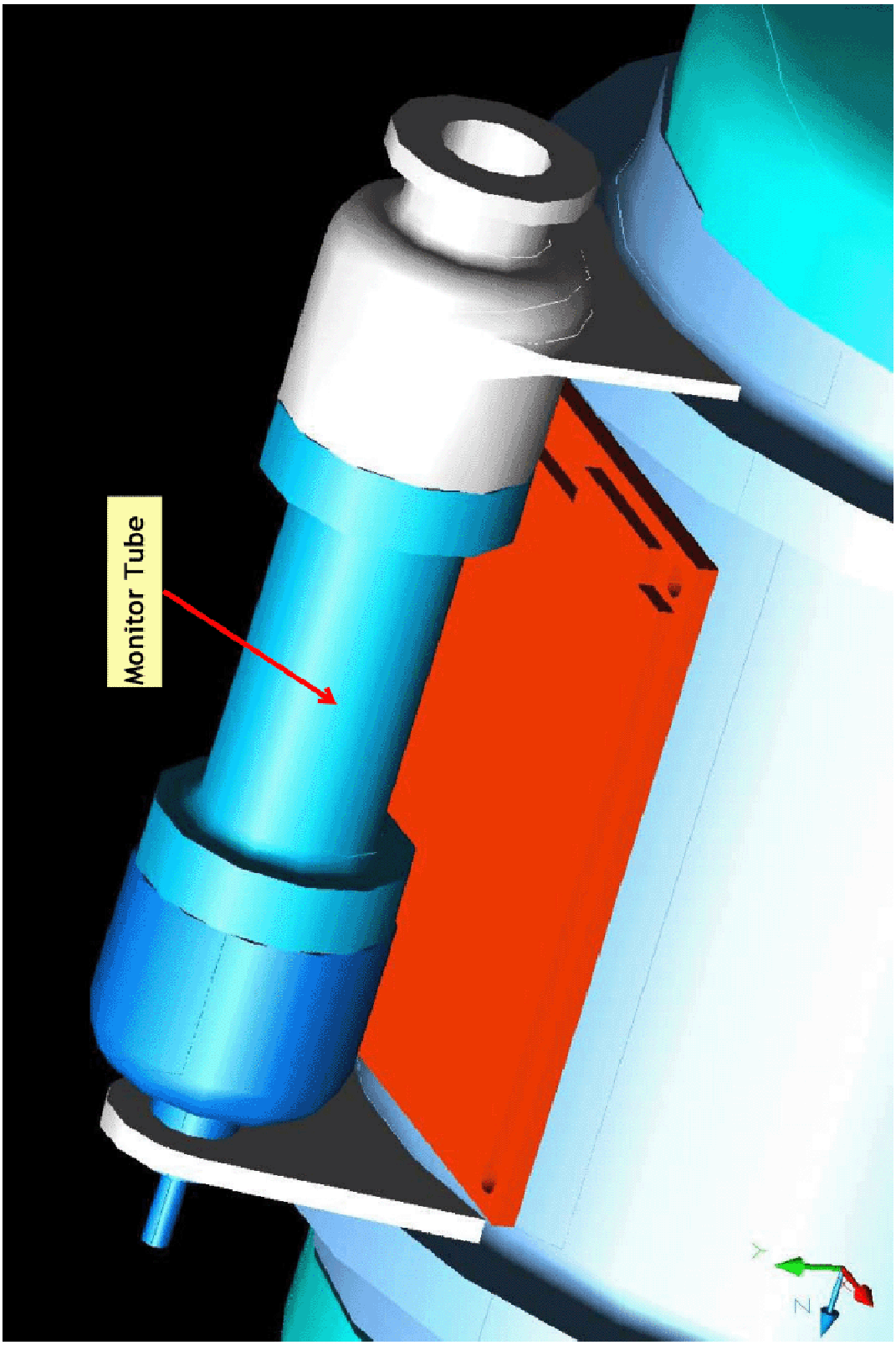


Figure 4: TRD Monitor Tube Mounting Methodology
Plumbing and Electrical Interfaces Not Shown

Fe^{55} Loading in Monitor Tube

(M. Green 07/18/2005)

1) **Measurement Requirement**

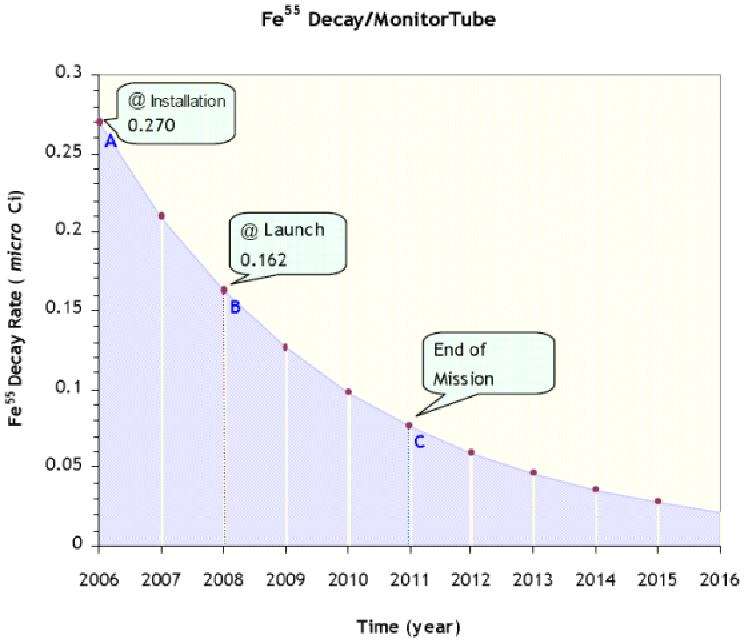
A good quality measurement of gain requires each monitor tube to have an Fe^{55} radioactivity on the order of 0.075 *micro* Ci (1 *micro* Ci = 3.7 x 10^4 disintegration/s). We would like to maintain this value at the end of the three-year mission (2011).

2) **Variation of Fe^{55} with time**

The monitor tubes are predicted to be mounted in Spring 2006, approximately two years prior to launch in 2008. Since the half-life of Fe^{55} is 2.73 years, in order to maintain a radioactivity of 0.075 *micro* Ci at the end of five years, the initial loading would need to be increased. According to the nuclear decay principle, the amount of Fe^{55} needed at the time of installation is calculated to be ~ 3.6 x 0.075 or 0.27 *micro* Ci /tube. The total initial loading for all four tubes would then be ~1 *micro* Ci (= 4 x .270). At the end of the three year mission, the total remaining loading is expected to be ~ 0.3 *micro* Ci. The graph below delineate the decline in Fe^{55} loading with time.

3) **Variation of Fe^{55} due to loading uncertainty**

Due to considerable uncertainty in the loading, the actual amount of Fe^{55} initially doped per tube could vary from the above figure. Since the decay rate does not change, the amount of Fe^{55} on the tubes during the entire course, from installation through the end of mission, would also differ from the above figures. Therefore, the exact amount of Fe^{55} on the tubes cannot be accurately assessed and the above numbers serve as ballpark figures only.



Ionizing Radiation Source Review Response

ID: 2005-002
Date: 02/22/2006

From: JSC Radiation Constraint Panel/Radioactive Payloads Working Group (RCP/RPWG)
To: SD4 / M. E. Coleman
NS2 / PSRP Executive Secretary
Subject: Assessment of Crew Risk from Exposure to Radioactive Material / Radiation Producing Equipment

I. General Information

A. Title

Alphamagnetic Spectrometer -02 (AMS-02) Transition Radiation Detector (TRD

B. Evaluation for Mission

STS-116 ☐ SubsequentFlights

C. Category

☐ Core System ☐ Operational Equipment ☑ Experiment ☐ Payload

D. Type of Radiation Source

Radioactive Material

Isotope	# Sources	Total Quantity (mCi)	Source Locations(s)	α	β/cm	γ/X-ray	$^1n_0$
FE-55	8	0.00012	CERN (Geneva, Switzerland)			X	

II. Review Response

A. Evaluation Criteria

	Yes	No	N/A	Waiver
1. The quantity of racioactive material is "exempt" under the requirements of 10 CFR 1960.	○	◉	○	○
2. Equipment design includes 3 levels on containment for radioactive materials.	○	◉	○	○
3. The maximum crew exposure for the equipment/material is within the limits extablished in 10 CFR 1960.	◉	○	○	○
4. Adequate crew training has been provided covering radiation exposure risks and techniques to minimize radiation exposure from the equipment/material.	○	○	◉	○
5. Adequate cleanup/disposal/decontamination procedures, material, crew time, and training are provided.	◉	○	○	○
6. Adequate contingency procedures are crew training are provided.	○	○	◉	○
7. Risk of exposure to non-participating crewmen is minimized.	◉	○	○	○
8. The experiment/equipment design and use conforms to the "ALARA" principal per 10 CFR 1060.	◉	○	○	○

B. Additional Comments

Please note that the value of the Fe-55 source given in Figure 1 is not correct. The true values per tube is ~0.03 microCi. Due to the small activity level, low energy, and no crew involvement, these sources pose no radiologic risk to the crew or vehicle.

III. RCP RPWG Recommendation

◉ Approve

○ Approve with the following modification(s):

○ Disapprove for the following reason(s):

This assessment has included considerations for cumulative exposures to the natural space radiation environment and other radioisotopes to be flown.

IV. Supercedance

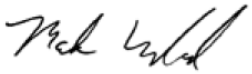
A. This RCP RPWG response supercedes response(s): .

B. Changes from the most recent RCP RPWG response:

V. References

**Attached Documents for STS-116: Alphamagnetic Spectrometer -02 (AMS-02)
Transition Radiation Detector (TRD)**

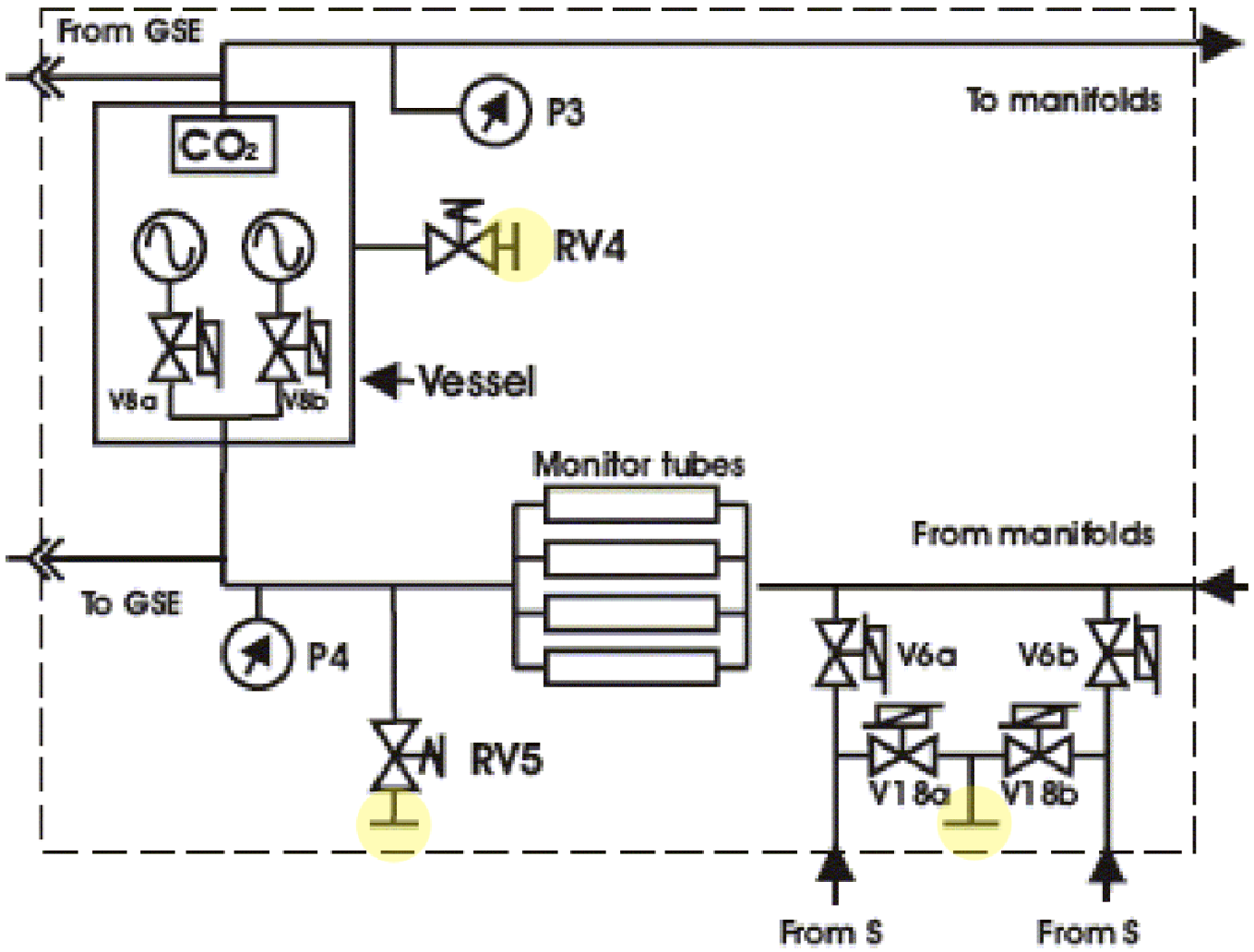
Uploaded File	Comments
AMS-02 Form 44$2005-002.doc	This is the original Form 44 we prepared with design information attached.



SF2/Mark Weyland / (281)483-6193
Chairman, JSC RCP RPWG

A copy of this form must be retained indefinitely by the NASA JSC Space Radiation Analysis Group.

NASA JSC Form 44 (Mar 00)



Location of Monitor Tubes in Box C of TRD Gas System Design