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X-Ray NDE

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The X-Ray NDE program at MSFC is primarily performed in three separate x-ray cells located in buildings 4702, 4707, and 4711. The x-ray units range from backscatter systems, to standard x-ray systems, to a 2 MeV linear accelerator.



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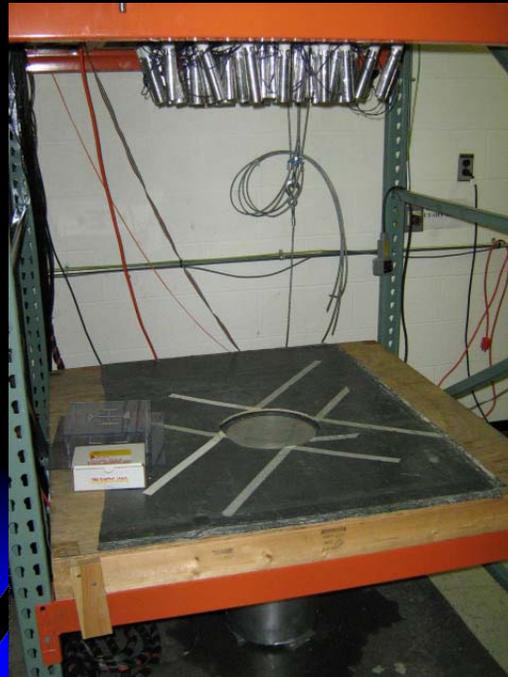
X-Ray Units

4702	Comet MXR-320/26	320keV, 4200W max	Industrial Radiography
4702	Pantak	100keV, 30mA max	Industrial Radiography
4707	Varian Linatron	2MeV linear accelerator	Computed Tomography (CT)
4707	Pantak	420keV, 5mA max	Computed Tomography (CT)
4707	Pantak	300 keV, 6 mA max	Portable Radiography Tube
4707	Tronix	150keV, 4mA max	Portable Radiography Tube
4711	Yxlon / Comet MXR 160/22	160 keV, 45 mA max	Backscatter X-Ray System
4711	Yxlon / Comet MXR 160/22	160 keV, 45 mA max	Backscatter X-Ray System
4711	Digiray	90 keV, 150 uA	Reverse X-ray System



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4711 Backscatter X-Ray Cell





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4702 Conventional X-ray Cell





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4707 Computed Tomography (CT)





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Radiological Conditions/Controls Per Cell

- ▼ Backscatter lowest rad levels, Linear accelerator highest rad levels
- ▼ Backscatter requires least shielding, linear accelerator requires most
- ▼ All three have essentially the same Engineering Controls
- ▼ All three have essentially the same Administrative Controls



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ENGINEERING CONTROLS:

- Cell itself, keyed console, door interlocks, emergency stops, lights/buzzers, area radiation monitors, alarming dosimetry, card readers

ADMINISTRATIVE CONTROLS:

- Site wide procedures and a specific Organizational Issuance (OI) for each cell.
- MSFC has committed to use State of Alabama Regs as a guideline



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ENGINEERING CONTROLS

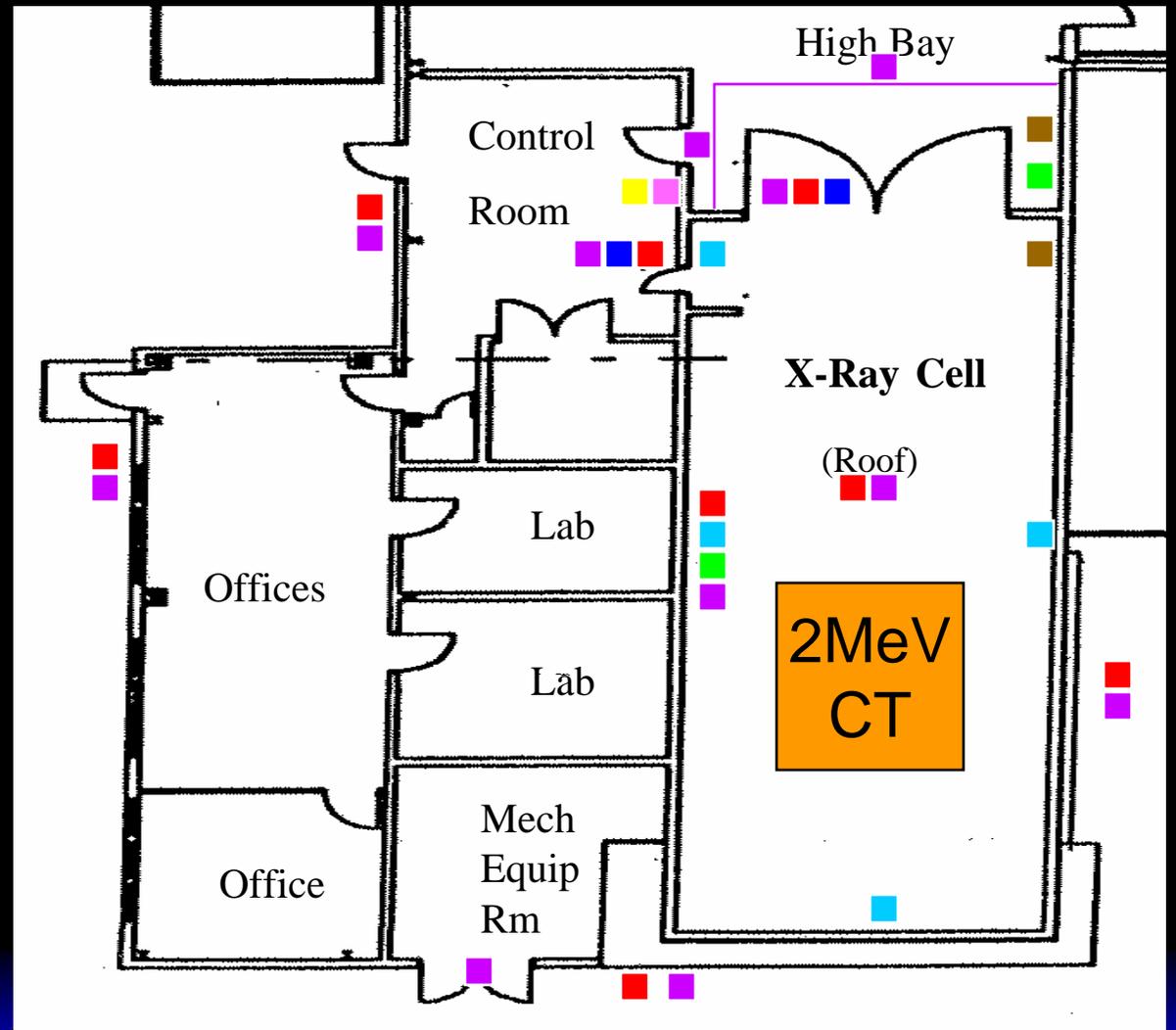
4707 CT Cell - Typical



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4707 X-Ray Cell

- Warning Light ■
- Warning Sign ■
- Interlock ■
- Cutoff ■
- Console ■
- Area Rad Monitor ■
- Audible Alarm ■
- Camera ■





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4707 Exterior Signs/Lights





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4707 X-Ray Cell Doors





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4707 X-Ray Cell Interior





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ADMINISTRATIVE CONTROLS

4707 X-Ray Cell - Typical



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Site Wide Procedures:

MPD 1860.2, Radiation Safety Program

**MPR 1860.1, MSFC Radiation Safety
Procedural Requirements**



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MPR 1860.1

- ▼ **Training – initial and annual, computer based**
- ▼ **Dosimetry – TLDs provide by Army at Redstone Arsenal**
- ▼ **Steps for purchase and use approval, RSO/RSC approval of cell**
- ▼ **Specific engineering controls**
- ▼ **Requires user procedure that is approved by RSO**
- ▼ **Requires annual survey and periodic inspections by RSO**



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Organizational Issuances (OI)

- **Separate OI For Each Cell**
- **Very Specific Instructions To Implement
The requirements of MPR 1860.1**
- **Must Be Approved/Signed By RSO**
- **Also By Industrial Safety**



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4707 OI

5.3 OPERATING PROCEDURE

WARNING: At least one interlock-control door shall remain open at all times when personnel are in the x-ray cell. **Additionally, the x-ray control panel key shall be removed from the control panel and secured by a certified operator prior to entering the x-ray cell. The operator shall confirm that the x-ray cell is unoccupied prior to inserting the control panel key.** Operator shall wear a TLD badge on upper torso of body at all times when operating x-ray system. At the end of the day the TLD badge shall be placed in a designated location. A certified operator shall be present at all times when the x-ray system is in the energize mode.

5.3.1 Check logbook to verify that audible and visible radiological warning system check has been performed for the current day.

5.3.2 Check logbook to verify that the safety Interlock system has been checked for the current month.

5.3.3 Check logbook to verify that emergency shutdown system has been checked for the current month.

5.3.4 Rope off corridor area near north (bay) doors.

5.3.5 Operator shall make sure x-ray beam is directed toward primary (south) wall.

5.3.6 Close north (bay) doors to the x-ray cell. Mechanical clicking shall occur to signal that interlocks have been reset.

5.3.7 Verify that vertical slide bolt is engaged on Bay doors.

5.3.8 Visibly inspect x-ray cell to make sure that no one is inside.

5.3.9 Close west door to the x-ray cell. Mechanical clicking shall occur to signal that interlocks have been reset, and an audible buzzer shall alarm. The red light to the left of the cell door shall illuminate.

NOTE: IN THE EVENT THAT THE BUZZER DOES NOT SOUND OR THE RED LIGHT DOES NOT ILLUMINATE OPERATIONS SHALL BE IMMEDIATELY SUSPENDED AND THE RSO AND NDE TEAM OR BRANCH CHIEF SHALL BE NOTIFIED.

5.3.10 Verify that no unauthorized personnel are in the control room.

5.3.11 Perform computed tomography inspection Per operator instructions in the ACTIS 2000 or Hytec FlashCT operator's manual.



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6.1 OPERATIONS

6.1.1 Two Certified Operators are required for operation of the linear accelerator; one Certified Operator is required for operation of the x-ray tube.

6.1.2 Prior to operation of the facility, tests of the safety interlock switches, manual emergency shutdown switches and audible and visible radiological warning signals, as outlined in Section 7, shall be performed.

6.1.3 Checks of the audible and visible radiological warning signals shall be performed and logged daily, prior to the first operation of the day.

6.1.4 Checks of the interlock switches and manual emergency shutdown switches shall be performed and logged monthly.

6.1.5 Additional safety checks may be performed at the discretion of the certified operator or as directed by the Team Lead or Branch Chief or the Radiation Safety Officer.

6.1.6 Safety checks are not required on days when the system is not operated.



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7.2.5 RADIATION MONITORING DEVICES - Survey meters are used to monitor the control room, the inside hallway of building 4707, and the adjacent office area during inspection operations. Meters shall be calibrated every six months. **Area surveys of the facility, including the control room, adjacent office areas, and surrounding areas including the area outside the large double doors and outside the CT facility, shall be conducted by EM20 every three months.** Radiation monitoring records shall be maintained for a period of three years to assure that proper shielding has been provided.

7.2.6 SURVEILLANCE SYSTEMS - **Video surveillance units are used to monitor the exposure bay and the inside hallway of building 4707.** The surveillance systems are also used to verify that no unauthorized personnel are in the exposure area prior to operation of the x-ray unit. Surveillance, in the form of a walk through and visual inspection of the x-ray cell shall be used to verify that no personnel are in the exposure area prior to operation of the x-ray unit. If the operator observes any person entering the exposure bay during operation of the x-ray unit, he shall immediately cease operation of the x-ray system and notify the RSO and the NDE Team Lead or Branch Chief.



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7.3 PERSONNEL MONITORING

7.3.1 DOSIMETRY - The monitoring of personnel exposure to radiation shall be accomplished by employing thermoluminescent dosimeter (TLD) badges. The TLD badges are checked quarterly to monitor x-ray dosage.

7.3.2 TLDs shall be carried by the operators only while in the computed tomography facility.

7.3.3 Personal alarming dosimeters shall also be worn by operators.

7.5 PERSONNEL CONTROL

7.5.1 At least two certified operators shall be present at all times during linear accelerator operations; at least one certified operator shall be present at all times during x-ray tube operations.

7.5.2 Access control is achieved through the use of an electronic badge reader with a restricted access list. **Entrance to the south mechanical equipment room is controlled by storage of the key to that room in the computed tomography facility.**

7.5.3 All other NDE operations not requiring x-rays shall be performed outside the computed tomography facility.



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Appendix C: Procedure for Functional Check of Safety Interlock System

1. Perform walkthrough of x-ray cell to ensure that no personnel are inside.
2. Close north x-ray cell doors (bay).
3. Close west x-ray cell door as completely as possible without contacting the interlock safety switch.
4. Independently, attempt to energize each x-ray unit.
5. **The x-ray unit should not energize. If the x-ray unit does energize, immediately turn the x-ray unit off, suspend operations of the x-ray unit, notify the RSO and NDE Team Lead or Branch Chief and submit a work order to have the interlock system repaired. Operation of the system shall be suspended until approval is obtained from the RSO and Team Lead.**
6. Perform walkthrough of x-ray cell to ensure that no personnel are inside.
7. Close one of the north x-ray cell doors (bay) as completely as possible without contacting the interlock safety switch. The other door shall be closed completely.
8. Post a monitor at the north x-ray cell doors to prevent inadvertent entry into the x-ray cell.
9. Close the west x-ray cell door.
10. Independently, attempt to energize each x-ray unit.
11. **The x-ray unit shall not energize. If the x-ray unit does energize, immediately turn the x-ray unit off, suspend operations of the x-ray unit, notify the RSO and NDE Team Lead or Branch Chief and submit a work order to have the interlock system repaired. Operation of the system shall be suspended until approval is obtained from the RSO and Team Lead.**
12. Repeat steps 6 through 11 for the other bay door.
13. Record interlock tests in the Interlock Test Logbook.



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Appendix D: Procedure for Functional Check of Manual Emergency Shutdown Safety Switches

1. Perform walkthrough of x-ray cell to ensure that no personnel are inside.
2. Close north x-ray cell doors (bay).
3. Depress a single emergency shut down switch.
4. Exit bay and close west x-ray cell door completely.
5. Independently, attempt to energize each x-ray unit.
6. The x-ray unit shall not energize. If the x-ray unit does energize, immediately turn the x-ray unit off, suspend operations of the x-ray unit, notify the RSO and the NDE Team Lead or Branch Chief and submit a work order to have the emergency safety switch repaired. Operation of the system shall be suspended until approval is obtained from the RSO and Team Lead.
7. Manually reset emergency shutdown switch.
8. Repeat steps 1 through 7 until each of the emergency shut down switches has been independently tested.
9. Record emergency shutdown switch test in the Manual Emergency Shutdown System Test Logbook.



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Appendix E: Procedure for Check of Audible and Visible Radiological Warning Systems

1. Verify that the Pantak interlock bypass plug is secured in the lockbox on the west wall of room 136.
2. Verify visible radiological hazard warning signs are in place as follows:
Interior x-ray control room east wall, adjacent to x-ray cell door.
Exterior x-ray cell bay doors (one sign on each door).
Exterior west wall (two signs, one at each entry).
Exterior east wall.
Exterior south wall.

Roof.

2. Verify that no personnel are inside mechanical control room and that mechanical control room is locked.
3. Verify that no one is on the roof of the x-ray cell.
4. Perform walkthrough of x-ray cell to ensure that no personnel are inside.
5. Close north x-ray cell door.
6. Close west x-ray cell door.
7. Verify that audible buzzer is operational.
8. Verify that red light in control room is on.
9. Verify that red strobe lights are functioning as follows:
Exterior east wall.
Exterior north x-ray cell door (bay).
Exterior south wall mechanical control room above door.
Exterior south wall.

Roof.

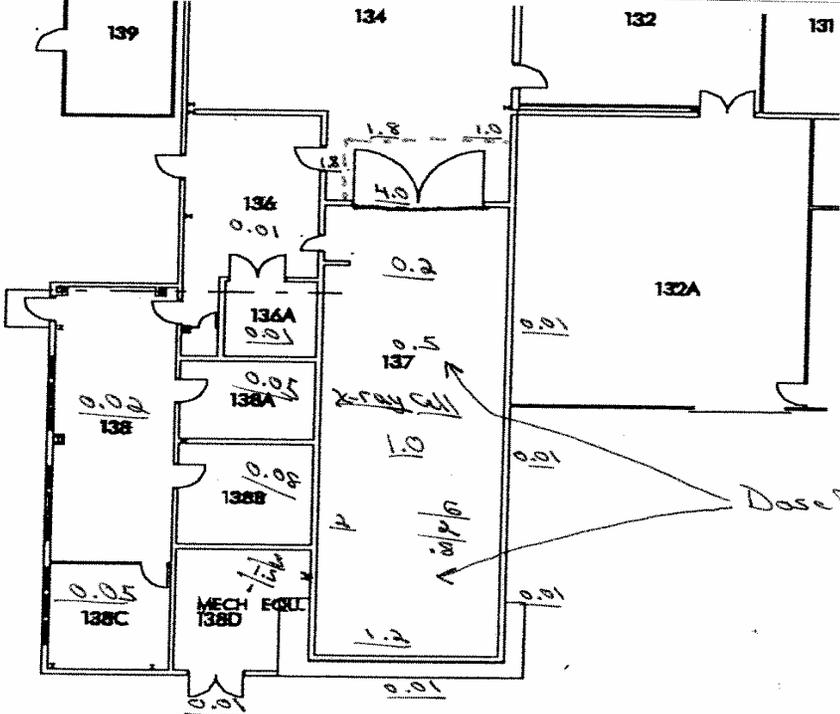
9. In the event that any of the audible and visible warning signals are not in place or are not operating properly the x-ray unit shall not be placed in operation. The NDE Team Lead shall be notified immediately and a work request shall be initiated to repair the system. Operation of the system shall be suspended until approval is obtained from the NDE Team Lead and RSO.

10. Record audible and visible radiological warning sign check in Audible and Visible Radiological Warning System Check Logbook.



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4707 CT X-Ray Cell Survey

 National Aeronautics and Space Administration George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812		Radiological Survey Map	
Date: 8.6.07	Time: 1400	Performed by: (Print/Sign) <i>Phil Brown</i>	Description: Survey of 4707 x-ray cell during operation of 2 MeV Linear Accelerator
			
Dose Rate Instrument Serial Number Micro Ram R01E 1883		Contamination Instrument Type <i>N</i> Serial Number <i>A</i>	
		Comments: All dose rates in mrem/hr Annual Survey	



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Effects of Prolonged exposure to Low Level Radiation

