Fermilab
P.O. Box 500 Batavia, Illinois 60510

Beams Division Departmental Procedure
Mechanical Support Department
BDDP-ME-0130
MiniBooNE Target Station MI-12
Procedure for Removing, Handling, and Storing a Radioactive Target and Installing a New Target

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Mech. Engr. – B. D. Mech. Suppt. Dept.

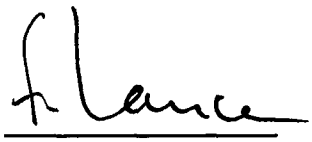
Approved by:  Date of Approval: 4-16-04
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Table of Contents

1.0 Purpose and Scope

The beryllium target module within the horn module in the MiniBooNe Target Station at the MI-12 service building is expected to become highly radioactive, up to 2 Rad/hr at 2 ft., and eventually expected to fail. Repairs are not expected to be feasible due to the radiation exposure, so the plan is for the target module to be changed in the event that the entire horn module does not have to be changed as well. If the entire horn module is to be changed, refer to BDDP-ME-0129.

The old target module will be pulled directly into a steel coffin, which will be stored in the Target Service Building TSB in the old Proton line. A new target module will be installed by placing it carefully on a rail system, which is lined up carefully with the rails within the horn module, then pushing it from the alignment rails directly into the horn module within the MI-12 target shielding pile. This procedure describes all the steps required to do this.

This procedure is only intended to cover those activities which are performed by BDMS technicians. Although certain work listed in the steps of this procedure is performed by EE support techs, alignment, instrumentation and riggers, this document is not intended to delineate how to perform that work, nor to identify safety requirements specific to that work. Those groups are responsible for performing their work according to their own procedures and safety requirements.

2.0 Instructions

2.1 Preliminary preparations

2.1.1. LOTO requirements

The Beams Division Radiation Safety Officer will determine the LOTO requirements for a target change. Devices to be locked out and/or tagged out include:

a. Horn power supplies
b. Radio Active Water (RAW) system power
c. Target Air Cooling (TAC) system power

2.1.2. Training requirements

All personnel participating in a target change shall have current Radiological Worker CR training. Personnel disposing of radioactive waste shall have current Radioactive Waste Disposal Training. The crane operator shall have current Crane Operator training. Verification may be obtained by the FNAL TRAIN database. The Beams Division Radiation Safety Officer may specify additional training prior to the target change.

2.1.3. Hardware certification

The lifting spreader beam used for handling target coffins has been certified by the manufacturer, and reviewed by Fermilab in Engineering Note 1323-ES-296332.

2.1.4. Radiation safety and work permits

Prior to initiating any work associated with a target change, a Radiation Work Permit shall be completed per the requirements of the Beams Division Radiation Safety Officer. Because of the high level of residual radioactivity in and around the horn, BD/Radiation Safety personnel will monitor and supervise target change activities relevant to personnel radiation safety, and may specify additional precautions as deemed necessary on site during the target change activities. All radioactive waste leaving the vault enclosure, other than the spent target itself, shall be disposed of in accordance with Beams Division Radioactive Waste Disposal Procedure BDSP-10-0201. All personnel, tools and equipment leaving the enclosure shall follow the standard frisking procedures specified in Rad Worker Training. The securing and disposition of the spent target shall be monitored and supervised by BD/RS personnel. Additional responsibilities of Radiation Safety include monitoring vault access, specifying clothing requirements, unlocking and re-securing appropriate radiation safety padlocks (e.g., Pad 118 locks controlled by the Radiation Safety Section), specifying special dosimetry requirements, and performing radiation surveys and contamination checks.

2.1.5. Special tools required

Long handled hooks are used to remove certain stripline parts. Long extensions and u-joints are used on socket wrench handles to raise and lower the horn on its 3-point support system.

2.1.6. Planning a target change

Prior to performing a target change, all Mechanical Support Department personnel involved in the activity and the BD/RSO or designee shall have a pre-job planning meeting to examine the steps required for the target change. Goals of the meeting include:

a. Estimating the integrated exposure that workers will receive during the activity, and ensuring that it is as low as reasonably achievable (ALARA).
b. Establishing dosage points at which the job would be stopped.
c. Identifying additional radiation monitoring required for specific steps or during specific phases of the change activity (e.g., use of digital dosimeters, monitoring radiation levels with special detectors, checking surface contamination, etc.)
d. Establishing clothing, time, distance and shielding requirements for personnel during critical phases of the change.
e. Discussing previous target changes.
f. Discussing any proposed deviations from the normal target change procedure outlined herein. Such activities shall comply with applicable Fermilab Safety Standards.

2.2 General Instructions

In order to reduce the radiation exposure to under 100 mR/hr at 1 ft, the shielding requirement for the target coffin is a minimum of 9 cm (3.6") of steel on all sides. Surplus steel of 1", 2" and 4" is available free at Fermilab and can be used to make the coffin, so a 4" wall thickness has been selected. The interior dimensions of the coffin will be 14" wide x 7" high x 170" long. Outer dimensions of the coffin will be 22" wide x 178" long x 15" high, plus lifting eyes on top. A loaded coffin is expected to weigh approximately 12,200 lbs, which does not exceed the crane lifting capacity.

2.3 Removing an old target module

1. Rad Safety conducts a survey under Controlled Access, noting any spilled water, and cleaning it up per Rad Safety procedures. Time Estimate 1-3 hrs.
2. BDEES techs shut off any power supplies not already locked out by the Controlled Access (LOTO required). Time Est. 0.1 hrs
3. BDMS techs shut off the Radio Active Water (RAW) system upstairs at the control box on the East wall. Time Est. 0.1 hrs
4. BDMS techs shut off the Target Air Cooling (TAC) system (LOTO required). Time Est. 0.1 hrs
5. Supervised Access permit with Personal Protection Equipment and radiation monitoring as specified by Rad Safety.
6. BDMS techs shutoff the Low Conductivity Water system valves for the hoses to the magnets Q873, Q874, and Q875 and the TAC system. Time Est. 0.1 hrs

7. BDMS techs let up vacuum in the beamline, disconnect flanges between magnets HT872, Q873, Q874, and Q875, and remove bellows spool pieces. Rolling ladders will be needed for this and some subsequent operations. Time Est. 0.5 hrs
8. BDMS techs remove water hoses from magnets Q873, Q874, and Q875, and secure them out of the way. Time Est. 0.5 hrs
9. BDMS techs loosen two quick-disconnect flanges and remove the copper ring collimator CuCOLL875 and drop it into a steel shielding box for disposal. It is expected to be Class 3 or higher. Time Est. 0.2 hrs
10. BDEES and BD Instrumentation techs remove cables from magnets, multiwire, BPM's, toroid, loss monitors and other beamline components, and secure them out of the way. Time Est. 0.5 hrs
11. Rad Safety removes padlocks on target vault shielding. Time Est. 0.1 hrs
12. Riggers remove 93 "H" concrete shielding blocks from the pit, weight 11'550# each, 5 heavy "H" blocks weighing 18'000# each, and some steel filler plates, which are loaded on a flatbed or moved with a forklift and taken out to be stored on the hardstand. Depending on the radiation levels of the blocks, fencing around the hardstand may be required. The blocks and steel filler plates are numbered for position. Between layers 5 and 4 there is an air barrier of Herculite which must be removed, taking note of how it was done so it can be redone later. Time Est. 40 hrs
13. Riggers remove any small hand-stacked radiation shielding blocks (if present) that may be in the way and stack them in the enclosure on a pallet. Time Est. 2 hrs
14. Alignment crew takes as-found measurements of magnets Q873, Q874 and Q875 before removal. Time Est. 1.0 hrs
15. Riggers remove magnet Q874 first, then its stand, leaving the ACME adjuster parts on a dolley in the vault. (rigging equipment needed). Time Est. 0.5 hrs
16. Riggers push Q875 upstream so it clears the horn striplines, then remove it, then its stand with the multiwire, BPM's and toroid, leaving the adjuster parts in the vault. Time Est. 0.75 hrs
17. Riggers push Q873 downstream so it clears the cable tray, then remove it, then its stand, leaving the adjuster parts in the vault. Time Est. 0.75 hrs
18. BDMS techs disconnect the two target module air circulation tube fittings near the horn, disconnect the two fittings away from the horn, remove two lengths of tube going to the horn, disconnect two joints at the target cooling system racks, and put caps on all the fittings to seal in any possible contamination from beryllium dust. Time Est. 0.5 hrs
19. BDMS and BD Instrumentation techs disconnect signal and power cables and water hoses and move the target air cooling TAC system racks (ME-416109) upstream 100 ft. Time Est. 0.2 hrs
20. BDMS and BD Instrumentation techs disconnect 8 BPM cables and 4 RTD cables from the bulkhead connectors and secure the cables out of the way. Time Est. 0.1 hrs
21. BDMS techs bring the rail structure (MC-389443, weight 5100#) and install it on the floor, leveling it with shims, for the horn coffin support trolley. Time Est. 1.0 hrs
22. BDMS techs bring the coffin support trolley (MD-389447), set it up in the pit on rails, and set the side guide rollers so the trolley is centered on the rails. (weight approx. 3600 lbs) Time Est. 0.3 hrs

23. BDMS techs bring the six-axis alignment rail structure (ME-389744) for installing the BPM and target modules and set it up on the main trolley. Time Est. 1.0 hrs
24. Alignment crew checks the alignment of the rail structure relative to the rails inside the horn, adjusts as necessary. Time Est. 1.0 hrs
25. BDMS techs attach a NW50 blankoff flange with an eyebolt to the BPM module beamtube, and pull the BPM module out onto the alignment rails using the boat winch attached to the bottom of the alignment rail structure. Time Est. 0.5 hrs.
26. BDMS techs remove the alignment rail structure with the BPM module on it. The BPM module is checked for radiation and isolated. Time Est. 0.5 hrs
27. BDMS techs attach a bar (MB-416072) with eyebolt and wheels to the threaded studs on the target module. Time Est. 0.2 hrs
28. BDMS techs bring the extension structure (MD-416062) for supporting the target coffin and set it up on the main trolley. Time Est. 1.0 hrs
29. Alignment crew checks alignment of coffin support points on trolley, adjusts as necessary. Time Est. 1.0 hrs
30. BDMS techs bring the hydraulic cylinders and control units for moving the trolley and set the cylinders up on the rails. Time Est. 0.5 hrs
31. The yoke adapter pieces, FNAL dwg. MA-389450, are attached to the trolley. Time Est. 0.1 hrs
32. Receiving Dept truck brings the target storage coffin (ME-416061).
33. BDMS techs remove the coffin door and install a wire rope cable with hook inside the coffin with the free end of the wire rope coming out the end opposite from the door. The extension shelf (MC-416067) is attached. The door is replaced so the coffin will be properly balanced. Time Est. 0.2 hrs
34. BDMS techs tie rope tag lines on small eyelets at the corners of the target coffin; these are for swinging the coffin remotely while it is hanging on the crane hook. Time Est. 0.1 hrs
35. BDMS techs remove coffin (weight approx. 6 tons) from the truck (MI-12 crane capacity is 30 tons), using a special spreader bar (FNAL dwg. MD-389371) with foundry hooks which can be hooked and unhooked remotely by the crane operator (not by an assistant climbing on the coffin), swing it 90 degrees, and set it on the support trolley in the target vault (the crane operator is standing above, guided by an assistant who is in the lower pre-vault area) Time Est. 0.2 hrs
36. Crane spreader bar is unhooked remotely from the coffin lifting eyes (not unhooked by someone on top of the coffin); the operator is above where he can see the hooks. Time Est. 0.1 hrs
37. Spreader bar is removed and replaced by a single foundry hook. Time Est. 0.1 hrs
38. Coffin door (150#) is hooked by the foundry hook on the crane, raised by the crane, and set down on top of the coffin. The foundry hook unhooks remotely (not by a person climbing on the coffin), and is raised out of the way. Time Est. 0.2 hrs
39. BDMS tech pulls the target module pulling cable out of the coffin at the downstream end and hooks to the eyebolt on the target module. Time Est. 0.2 hrs
40. BDMS techs roll the coffin towards the horn module using hydraulic cylinders. Time Est. 0.2 hrs
41. Alignment crew checks that the extension shelf (MC-416067) with guide rails on the coffin is aligned with the target support rails in the horn module. Time Est. 0.2 hrs

42. The free end of the wire rope cable is attached to the boat winch and the target module is pulled by the boat winch from the horn module into the coffin. Time Est. 0.6 hrs
43. The pulling cable is cut and the stub pushed inside the target coffin. Time Est. 0.1 hrs
44. The cable hole is plugged with a bolt. Time Est. 0.1 hrs
45. The coffin door is hooked by the foundry hook on the crane, lifted and guided into place by guide lugs on the coffin, then the door is lowered into the closed position by the crane. All this is remotely, not with a person climbing on the coffin. Time Est. 0.3 hrs
46. Crane unhooks remotely. Time Est. 0.1 hrs
47. BDMS techs roll the coffin support structure away from the horn module by hydraulic cylinders. Time Est. 0.2 hrs
48. Foundry hook is removed and replaced by the spreader bar. Time Est. 0.1 hrs
49. Crane operator remotely hooks the crane spreader bar onto the coffin lifting eyes (same lifting eyes because the center of gravity has not moved appreciably with the addition of the target module). Time Est. 0.1 hrs
50. Crane operator lifts the target coffin containing the target module (total weight approx. 7 tons).Radiation is expected to be about 100 mR/hr @ 1 ft during this move, so appropriate ALARA measures are to be used. Time Est. 0.1 hrs
51. Target coffin must be turned 90 degrees by BDMS techs pulling on tag lines from a distance. Time Est. 0.1 hrs
52. BDMS techs place the target coffin on the trailer of 10 tons capacity. The spreader bar and its cart are also loaded on the trailer. Time Est. 0.1 hrs
53. BDMS techs remove the hydraulic cylinders from the rails and remove them and their control units from the pit. Time Est. 0.4 hrs
54. Receiving truck with the loaded coffin on the 10 ton trailer starts on its way to the Target Service Building TSB, at low speed. Radiation is now less than 100 mR/hr @1'. Time Est. 1.0 hrs
55. Receiving Dept. takes the coffin and the spreader bar to the Target Service Building storage enclosure (crane capacity in TSB is 20 tons). Time Est. 0.5 hrs
56. BDMS techs, using the crane and spreader bar, hook the coffin lifting eyes remotely, lift the coffin with the spreader bar, and offload it onto a long railcar (railcar capacity is 40 tons, see dwg. 1210-ME-30673). Time Est. 0.2 hrs
57. Unhook remotely. Time Est. 0.1 hrs
58. BDMS techs use the TSB electric locomotive to push the railcar and coffin into the storage tunnel. Radiation is under 100 mR/hr @ 1'. Time Est. 0.1 hrs

2.4 Installing a new target module

59. BDMS techs remove the BPM module from the alignment rails structure (ME-389744) and store the module in isolation. Time Est. 0.1 hrs
60. BDMS techs bring a new target module, and install it on the target installation rail structure, with a third set of temporary bearings at the upstream end to support and push against the C-channels. Time Est. 0.5 hrs
61. BDMS techs lift the target installation rails alignment structure with the target on it, and set it up on the support trolley in the vault. Time Est. 0.5 hrs

62. Alignment crew checks the alignment of the target rail supports on the trolley. Time Est. 1 hr
63. The trolley is rolled towards the horn until the installation rails just touch the rails inside the horn. Time Est. 0.2 hrs
64. Alignment crew checks that the target is aligned with the main rails within the horn module. Time Est. 0.2 hrs
65. Cable winch mechanism pulls on the third set of bearings, which push the new target module on its rails into the horn module. Time Est. 0.6 hrs
66. Pusher bearing is pulled away from the target module C-channels and withdrawn. Time Est. 0.2 hrs
67. BDMS techs install the BPM module onto the alignment rails structure. Time Est. 0.5 hrs
68. BDMS techs install the BPM module into the horn module. Time Est. 0.5 hrs
69. BDMS techs roll the trolley away from the horn. Time Est. 0.1 hrs
70. BDMS techs remove the alignment rails structure. Time Est. 0.5 hrs
71. BDMS techs remove the support trolley. Time Est. 0.5 hrs
72. BDMS techs remove the trolley rails. Time Est. 0.6 hrs
73. Alignment crew aligns the horn module. Time Est. 1.0 hrs
74. BDMS techs roll the target air cooling TAC system racks back into place and reinstall the connecting air tubes for it. Time Est. 0.6 hrs
75. BDMS techs reconnect water hoses to the TAC system. Time Est. 0.2 hrs
76. BDMS techs reconnect signal and power cables to the target air cooling TAC system. Time Est. 0.1 hrs
77. BDMS techs turn the RAW system on, check for leaks. Time Est. 1.0 hrs
78. BD Instrumentation techs connect cables to BPM module. Time Est. 0.2 hrs
79. BDEES techs perform electrical tests on horn power supplies. Time Est. 0.2 hrs
80. Riggers reset any additional small hand-stacked radiation shielding blocks (if needed). Time Est. 2 hrs
81. Riggers reinstall 3 magnet stands and 3 magnets. Time Est. 2 hrs
82. Riggers remove rigging equipment from the tunnel enclosure. Time Est. 0.5 hrs
83. Alignment crew aligns magnets. Time Est. 1.0 hrs
84. BDMS techs reconnect water hoses to 3 magnets. Time Est. 1.0 hrs
85. BDMS techs turn the LCW on, check for leaks. Time Est. 1.0 hrs
86. BDMS techs reinstall beam tube spool pieces, multiwire, BPM's, toroid, a new copper collimator, loss monitors and any other beamline components. Time Est. 2.0 hrs
87. BDMS techs make vacuum connections, pump down and leak check vacuum components. Time Est. 8 hrs
88. BDEES and BD Instrumentation techs reconnect cables to magnets, multiwire, toroid, BPM's, loss monitors and other beamline components. Time Est. 2 hrs
89. Riggers bring back the 5 heavy "H" shielding blocks, the 93 standard "H" blocks, the steel plates and any other special blocks, and install them in the target vault. The blocks are numbered for position. An air barrier of Herculite is installed between the 4^{th} and 5^{th} layers of blocks. Other gaps at the 5^{th} level are filled with foam packing. Time Est. 40 hrs
90. Rad Safety secures the shielding block and shutter door padlocks. Time Est. 0.2 hrs

91. BD Operations Group Search and Secure. Time Est. 1.0 hrs
92. BDEES turns power supplies on. Time Est. 0.5 hrs
93. Beam Permit – End of Procedure

3.0 Distribution

The controlled copy of this procedure shall be the current revision in electronic form, maintained by the BDMSD designee on the following web page:

http://www-bdnew.fnal.gov/MSDMain/BDDP/BDDP_log.htm

4.0 Responsibilities

Most steps in the procedure shall be performed by BDMS techs assigned to the Target Group.
Water hoses shall be removed and replaced by BDMS techs assigned to the Water Group.
Electrical power cables shall be removed and replaced by BDEES techs.
Electronic controls and instrumentation cables shall be removed and replaced by BD Instrumentation Dept. techs.
Concrete shielding blocks shall be removed and replaced by riggers subcontracted by FNAL.
Changes in the assignment of responsibilities may be made at the discretion of the leader of the Target Group.

5.0 Tools, Equipment and Materials

special lifting spreader bar (FNAL dwg. MD-389371)
rail structure (FNAL dwg. no. MC-389443, weight 5100#)
coffin support trolley (MD-389447)
yoke adapter piece (MA-389450)
bar (MB-416072)
extension structure (MD-416062)
target storage coffin (ME-416061)
extension shelf (MC-416067)
boat winch (McMaster-Carr 3644T53)
wire rope cable 30' with hook (McMaster-Carr 3308T53)
sheave for wire rope (McMaster-Carr 3434T119)
hydraulic cylinder carts (Miller Fluid Power units Model H82S2N, FNAL PO#432340, 10/22/85)
herculite and duct tape
long railcar (FNAL dwg. 1210-ME-30673) used only at TSB
six-axis target and BPM module alignment and installation structure (ME-389744)

6.0 References

Basic steps of this procedure are drawn on FNAL drawing 6755.170-ME-416060, which is stored with the Beams Division Mechanical Support Drafting Group, as are most tool and equipment drawings.

7.0 Records

The following photograph files of the procedure taken during the initial installation are filed with the FNAL Media Services Dept. Each file number contains 12 frames.
02-324
02-325
02-326
02-327
02-328
02-329
02-330
02-331
02-332
02-359
02-360
02-364
02-379

8.0 Supporting Documents

Prints and proof sheets of the abovementioned photographs are kept with the BDMS Target Group.

Videotapes of the initial installation are kept with the BDMS Target Group.

9.0 Revision Notes

If this document is revised, check BDDP-ME-0129 to see if the revisions also apply to it.