|  |  |
| --- | --- |
| Delivery Ring Abort System General AIP  **BASIS of ESTIMATE FORM (BoE)** | **Document Number:** Mu2e-doc-1494  **Date of Estimate:** 5/16/12  **Prepared by:** Brian Drendel |

|  |
| --- |
| WBS Category Number: MuAIP.03.04.01  WBS Category Name: Abort System General  Control Account (number and name): |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |
| External Supporting Documents:   1. B. Drendel, et.el. “Using the Existing AP2 Shielding Stack for the Mu2e Abort,” Mu2e Document Database #1971, January 2012. 2. B. Drendel, R. Schultz “BoE Costing for Debuncher and Accumulator Beam Abort” Mu2e Document Database #1494, May 2011. 3. D. Augustine, “Mu2e Storage Rings Mechanical Schedule,” Mu2e Document Database #1571 4. J. Morgan, “MP0x Cost Estimate,” Mu2e Document Database #1628, May 2012. 5. J. Morgan, “Septum Magnet Cost,” Mu2e Document Database #1628, May 2012. |

Modifications to the AP2 beam line between IQ24 and the Delivery Ring Septum to create an abort beam line for the Delivery Ring to be used in g-2 and Mu2e operations. Improvements will be made to tunnel components, other devices within the tunnel enclosures and in the service buildings.

**Preliminary Design:**

|  |
| --- |
| WBS Category Name: Preliminary Design of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

The preliminary design will continue to develop requirements and specifications for improvements and upgrades to components/hardware and provide data for completing the design effort. The information will also establish data for use by project management to determine a high confidence level in the specifications. Effort will focus on providing documentation to determine if the proposed design meets project requirements.

**Preliminary Design Labor:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.?? | Engineering Oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 100 | 30% | 130 |
| MuAIP.?? | Engineering Oversight | FNAD.  (Engineer) | 185 | 30% | 241 |
| MuAIP.?? | Drawings | FNAD.  (Drafter) | 30 | 30% | 39 |
| MuAIP.?? |  | FNAD.  (Technician) | 85 | 30% | 111 |

(labor estimates assume 85% efficiency)

**Final Design Labor:**

|  |
| --- |
| WBS Category Name: Final Design of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

The final design will provide the drawings and documents necessary to build or purchase components/hardware. Effort will focus on finalization of drawings and other documentation for building or purchasing components/hardware.

**Final Design Labor:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.?? | Engineering Oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 100 | 30% | 130 |
| MuAIP.?? | Engineering Oversight | FNAD.  (Engineer) | 185 | 30% | 241 |
| MuAIP.?? | Drawings | FNAD.  (Drafter) | 30 | 30% | 39 |
| MuAIP.?? |  | FNAD.  (Technician) | 85 | 30% | 111 |

(labor estimates assume 85% efficiency)

**Implementation:**

|  |
| --- |
| WBS Category Name: Implementation of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

Implementation will include the purchase/or build of components and hardware necessary to support a fully functioning system. Effort will involve the purchase of vendor items or build/modification of components to meet project requirements. Included will be the installation and testing of items to ensure functionality.

**Implementation M&S and Labor:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.?? | M&S Total | FN.M&S.STND | $391K | 40% | $547K |
| MuAIP.?? | Engineering Oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 200 | 30% | 260 |
| MuAIP.?? | Engineering Oversight | FNAD.  (Engineer) | 730 | 30% | 949 |
| MuAIP.?? | Drawings | FNAD.  (Drafter) | 1870 | 30% | 2431 |
| MuAIP.?? |  | FNAD.  (Technician) | 60 | 30% | 78 |

(labor estimates assume 85% efficiency)

**Additional Background Information**

Line items are as follows:

1. Abort Line Installation: Tunnel installation efforts for all abort line elements from the kicker to the abort. Numbers are taken from the project schedule2
2. Abort Line Power Supplies: Beam line element power supplies in the abort line. Most power supplies will be repurposed from the existing AP2 line. The V730 power supply, which currently powers IBV1, will power both IBV1 and ABV1 in series.
3. Abort Line Magnets: Beam line element magnets in the abort line. Most magnets will be repurposed from the existing AP2 line, and all elements from the abort septum to IQ29 will go unchanged. ABV1 will be repurposed from the spare pool or IBH1 which is not needed for Mu2e operations. The base cost estimate assumes ABV1 magnet will need to be refurbished.
4. Abort Line trims/shunts: Beam line element trim magnets and shunts in the abort line. Beam line trims will be repurposed from the existing AP2 line. Two new trims may be added to the abort line between ABV1 and the dump, and/or a shunt may be put on the ABV1 magnet. The base cost estimate assumes that we repurpose two trim magnets from the AP2 line or Accumulator and that both trims will need to be refurbished.
5. Septa magnet: The septa magnets planned for Mu2e are identical to the “MP0x” style magnets built for Booster. They are designed to operate at 15 Hz and match the magnet field requirements needed for Accumulator extraction. Two magnets will be required, much like the Accumulator injection septa configuration that was used for pbar production. The estimate was provided by Technical Division5, who built the Booster septa magnets.
6. Septum power supply: Since the two septa magnets can be run at the same current, a single power supply can run them in series. The power supply cost estimate was provided by the EE Support Department4, who built the Booster power supplies. They have used the cost to build the Booster supplies and adjusted M&S costs for inflation. Electrician labor costs for the installation are considered as part of the M&S.
7. Septa Load cables: Both the load cables and most of the effort involved with pulling the cables between the power supply and magnet is considered M&S. Electricians are expected to do the majority of the work, most of the labor effort provided by others involves oversight of cable routing and cable termination.
8. Mechanical and vacuum: New magnet stands will be required for the septum magnets, the stands will likely be modified stochastic cooling stands. Vacuum reassembly and pump down, as well as installation of some new components is also covered.
9. Electrician: As mentioned above, RG 220 and signal cables will be pulled by electricians and treated as M&S. The electricians will also install equipment to provide primary power to the power supplies.

Below is a breakdown of the most likely manpower needed for each category.

**Conceptual Design Labor**:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Conceptual Design | | | | | | |
|  | Engineering Physicist (hours) | | | Engineeer (hours) | | |
| Abort line installation |  | 20 |  |  | 15 |  |
| Abort line power supplies |  | 4 |  |  | 4 |  |
| Abort line magnets |  | 4 |  |  | 4 |  |
| Abort line trims/shunts |  | 4 |  |  | 4 |  |
| Septa Magnet |  | 4 |  |  | 10 |  |
| Septa Power Supply |  | 4 |  |  | 10 |  |
| Septa Load Cables |  | 2 |  |  | 5 |  |
| Septa Mechanical |  | 6 |  |  | 10 |  |
| Total |  | 48 |  |  | 62 |  |

**Preliminary and Final Design Labor:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Preliminary and Final Design | | | | | | |
|  | Engineering Physicist (hours) | | | Engineeer (hours) | | |
| Abort line installation |  | 20 |  |  | 10 |  |
| Abort line power supplies |  | 10 |  |  | 10 |  |
| Abort line magnets |  | 10 |  |  | 10 |  |
| Abort line trims/shunts |  | 10 |  |  | 10 |  |
| Septa Magnet |  | 40 |  |  | 40 |  |
| Septa Power Supply |  | 20 |  |  | 240 |  |
| Septa Load Cables |  | 10 |  |  | 20 |  |
| Septa Mechanical |  | 80 |  |  | 30 |  |
| Total |  | 200 |  |  | 370 |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Preliminary and Final Design | | | | | | |
|  | Drafter (hours) | | | Technician (hours) | | |
| Abort line installation |  | 20 |  |  | 10 |  |
| Abort line power supplies |  | 0 |  |  | 10 |  |
| Abort line magnets |  | 0 |  |  | 10 |  |
| Abort line trims/shunts |  | 0 |  |  | 10 |  |
| Septa Magnet |  | 0 |  |  | 20 |  |
| Septa Power Supply |  | 20 |  |  | 50 |  |
| Septa Load Cables |  | 0 |  |  | 20 |  |
| Septa Mechanical |  | 20 |  |  | 40 |  |
| Total |  | 60 |  |  | 170 |  |

**Implementation and Closeout Labor:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Implementation & Close-out | | | | | | |
|  | Engineering Physicist (hours) | | | Engineeer (hours) | | |
| Abort line installation |  | 20 |  |  | 20 |  |
| Abort line power supplies |  | 10 |  |  | 20 |  |
| Abort line magnets |  | 10 |  |  | 20 |  |
| Abort line trims/shunts |  | 10 |  |  | 50 |  |
| Septa Magnet |  | 40 |  |  | 100 |  |
| Septa Power Supply |  | 50 |  |  | 450 |  |
| Septa Load Cables |  | 10 |  |  | 50 |  |
| Septa Mechanical |  | 50 |  |  | 20 |  |
| Total |  | 200 |  |  | 730 |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Implementation & Close-out | | | | | | |
|  | Technician (hours) | | | Survey (hours) | | |
| Abort line installation |  | 100 |  |  | 10 |  |
| Abort line power supplies |  | 40 |  |  | 10 |  |
| Abort line magnets |  | 70 |  |  | 10 |  |
| Abort line trims/shunts |  | 100 |  |  | 10 |  |
| Septa Magnet |  | 20 |  |  | 20 |  |
| Septa Power Supply |  | 1,400 |  |  | 0 |  |
| Septa Load Cables |  | 40 |  |  | 0 |  |
| Septa Mechanical |  | 100 |  |  | 0 |  |
|  |  | 1870 |  |  | 60 |  |

\*Covered in another category below.

M&S numbers for the implementation stage will involve the cost of materials used to construct the abort line and dump as well as the cost of contracting out iron workers. From our project schedule2, here is the labor and M&S cost associated with installation of the beam line elements for the Debuncher abort located in the existing AP2 line. This includes surveying the beam line, installing a new vertical dipole magnet, installing trims and instrumentation, moving the beam line, and connecting water, vacuum and electrical.

**Debuncher Abort Beam Line Installation Labor:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Labor Hours | | |
| Survey Crew |  | 42 |  |
| Mechanical Technician |  | 84 |  |
| Electrical Technician |  | 32 |  |
| Welder |  | 4 |  |
| Total |  | 162 |  |

**Debuncher Abort Beam Line Installation M&S:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | M&S Cost | | |
| Iron Workers |  | $10.4K |  |
| Rigging TM |  | $1.82K |  |
| Electricians |  | $1.68K |  |
| Totals |  | $13.9K |  |

From our project schedule2,and engineering costing estimate1, here are the labor and M&S costs of installing the Debuncher Dump. The engineering costing estimate had larger cost numbers for iron workers. This is set as the maximum estimate. The project schedule has a smaller cost estimate for the iron workers. This is set as the minimum and most likely estimates.

**Abort Septa M&S**: Costs for abort septum magnet and power supply.

|  |  |  |  |
| --- | --- | --- | --- |
| M&S 475.02.04.07.03 Post CD-3 Implementation & Closeout | | | |
|  |  | | |
| Septa magnet |  | $60K |  |
| Septa power supply\* |  | $144K |  |
| Septa Load cables |  | $27K |  |
| Septa Mechanical and vacuum |  | $17K |  |
| Electrician |  | $17K |  |
| Totals |  | $325K |  |

\*2/13/12: Increased by $10K after Dan Wolff’s analysis.

**Abort Line Power Supply and Magnet M&S**: Costs for abort line power supplies and magnets.

|  |  |  |  |
| --- | --- | --- | --- |
| M&S 475.02.04.07.03 Post CD-3 Implementation & Closeout | | | |
|  |  | | |
| ABV1 magnet |  | $20K |  |
| ABV1 power supply |  | $20K |  |
| Trims and/or Shunts |  | $8K |  |
| Electrician |  | $5K |  |
| Totals |  | $53K |  |

References:

1. B. Drendel, et.el B. Drendel, et.el. “Using the Existing AP2 Shielding Stack for the Mu2e Abort,” Mu2e Document Database #1971, January 2012.
2. B. Drendel, R. Schultz “BoE Costing for Debuncher and Accumulator Beam Abort” Mu2e Document Database #1494, May 2011.
3. D. Augustine, “Mu2e Storage Rings Mechanical Schedule,” Mu2e Document Database #1571
4. J. Morgan, “MP0x Cost Estimate,” Mu2e Document Database #1628, May 2012.
5. J. Morgan, “Septum Magnet Cost,” Mu2e Document Database #1628, May 2012.. “Using the Existing AP2 Shielding Stack for the Mu2e Abort,” Mu2e Document Database #1971, January 2012.