4.8 CONTROLS, INTERLOCKS AND CABLE INSTALLATION (WBS 1.1.8)

4.8.1 Controls

4.8.1.1 Introduction

Controls for NuMI are comprised of generally standard interface and networking components. These include a combination of VME, IRM, CAMAC and PLC hardware with necessary and appropriate modules to afford monitor and control of technical equipment through ACNET, the Accelerator Controls Network. Specific choices of interface are based on cost, availability, reliability and ease of interface. Connection of these interfaces to ACNET central services is accomplished by extension of existing single and multi mode fiber cable networks.

Installation of ACNET services for NuMI includes connectivity to accelerator time (TCLK) and beam synchronous (MIBS) clocks and to the NuMI Beam Permit System.

ACNET consoles enable the monitor and control of accelerator operations, including the NuMI beamline and associated technical components. While operations are generally concentrated in the Main Control Room with the use of these consoles, remote consoles may be connected to the extended network. In particular, remote consoles are to be made available at select locations to facilitate commissioning and operations as appropriate.

4.8.1.2 System Description: Controlled Equipment and Systems and Their Locations

Controls for NuMI are or will be installed at eight distinct geographical locations. Three of these locations are already outfitted with basic Controls infrastructure. Major items of equipment or systems to be controlled and monitored are listed for each of the locations in **Table 4.8-1**.

	MI-60 Service Building South 60S	MI-60 Service Building North 60N	MI-62 Service Building 62SB	MI-65 Service Building 65SB	Target Hall PS Support Room THSR	MINOS Service Building MSB	MINOS Near Detector Hall MND	Absorber Access Tunnel AAT
Power Supplies								
Single Turn Extraction Kicker	X							
Lambertsons		X						
Dipole Magnets - Ramped		X	X	X				
Quadrupole Magnets - Ramped		X	X	X				
Trim Correction Elements		X		X				
Focusing Horns Including Stripline					X			
Loss and Profile Monitor High Voltage		X	X	X	X			
Near Detector Analysis Magnet							X	
Vacuum								
Primary Beam Transport - Including Isolation Valves, Gauges & Ion Pumps		X	X					
Decay Pipe (PLC)								X
Fluid Systems								
Flourinert Cooling for Extraction Kickers	X							
MI-62 LCW and Pond Water Systems (PLC)			X					
Target & Baffle RAW System (PLC)					X			
Horn 1 RAW System (PLC)					X			
Horn 2 RAW System (PLC)					X			
Target Pile Air Cooling System (PLC)					X			
MINOS LCW System (PLC)							X	
MINOS Sump Pumps						X	X	
Decay Pipe Cooling RAW System (PLC)					X			X
Intermediate Water Cooling for Absorber RAW System (PLC)								X
Absorber Cooling RAW System (PLC)								X
Instrumentation								
Primary Transport Beam Position Monitors		X		X				
Beam Profile Monitors		X		X				
Loss Monitors		X	X		X			
Total Loss Monitors			X					
Beam Intensity Toroids			X		X			

Baffle and Target Instrumentation (PLC)					X			
Target Budal Monitors					X			
Positioning Systems for Target and Horn 1					X			
Horn 1 and 2 Module and Stripline Instrumentation (PLC)					X			
Horn Bdot Magnetic Field Probes					X			
Absorber Instrumentation (PLC)								X
Hadron Monitor at Downstream End of Decay Pipe								X
Muon Monitors at Muon Alcoves #1, #2 and #3								X
Beam Permit System - Process Channel Interface (7 Total)	X	XX	X	X	XX			
ACNET Connectivity								
Ethernet	X	X	X	X	X	X	X	X
VME	X	X	X	X	X			X
Internet Rack Monitor - IRM					X			
Programmable Logic Controller - PLC		X	X	X	X		X	X
CAMAC	X	X	X	X	X	X	X	X

Table 4.8-1 Technical Equipment Interfaced to the Control System versus Location

4.8.1.3 System Description: Accelerator Clocks and NuMI Operations

The present accelerator complex uses a number of clock systems to control devices and to time beam transfers. Of particular interest to NuMI operations are the following:

TCLK The primary accelerator time clock is a 10 MHz clock known as TCLK. A TCLK event is realized by the transmission of 8 bits of data enveloped by a start and parity bit in the serial clock stream. TCLK events are designated by a two-character hexadecimal number preceded by a dollar sign and range from $00 through $FF. Six new or redefined TCLK events have been assigned to accommodate NuMI operations. These are $23, $A5, $19, $A9, $A6 and $A8. NuMI operations are planned to occur in a new Main Injector reset cycle signed by **TCLK $23**. This reset cycle is unique in that it can simultaneously support P-Bar production and NuMI operations. In the dual mode, one to five batches of Booster beam may be loaded into MI for NuMI. The total cycle time for the Main Injector running under the $23 reset is optimally established at 1.8 seconds.

MIBS The Main Injector has a separate beam synchronous clock system, MIBS, that is locked in frequency to the Main Injector rf system. This clock, that operates at approximately 7.5 MHz (rf/7), is used to coordinate Main Injector transfers and beam related diagnostics. A most significant event on the MIBS clock is $AA, the revolution marker. For the MI, the $AA event occurs approximately every 10 microseconds. MIBS event $74 has been assigned to initiate the extraction of 120 GeV beam for NuMI. When issued, this extraction event is always synchronous with respect to the MIBS $AA revolution marker event.

Timing observations for the Main Injector $29 cycle for P-Bar Production are listed in **Table 4.8-2**. Expected timing for the Main Injector $23 cycle for P-Bar Production and NuMI Operations are listed in **Table 4.8-3**. TCLK and MIBS events of interest to NuMI operations are listed in **Table 4.8-4**.

Timing Observations of MI $29 Cycle for P-Bar Production Cycle

Event	Description / Comment	Time in Milliseconds	Note
$80	3 x 15 Hz Ticks Before $29 MI Reset or -201 ms	-201.0	
$29	Main Injector Reset	0.0	1
$22	Start of Ramp	89.0	
$25	Start of Flattop	778.9	
MIBS $79	Initiate P-Bar Production Beam Transfer	838.9	
	MI-52 Kicker Fire Time MIBS $79 + 24.918 MR Rev	839.2	
$26	End of Beam Operations	848.9	
	Total $29 Cycle Time	1,466.7	2
	Flattop to Actual P-Bar Production Beam Extraction	60.3	

Note 1 The $29 to $22 Interval Accommodates One $14 Booster Batch to Main Injector.

Note 2 The Current $29 Cycle is Judged to be Twenty-Two 15 Hz Ticks Long or 1.467 Seconds

Table 4.8-2 Timing Observations for MI $29 Cycle for P-Bar Production

Expected Timing for MI $23 Cycle for P-Bar Production and NuMI Operations

Event	Description / Comment	Time in Milliseconds	Note
$80	Signature Event for P-Bar Production Cycle	?	**3**
$A5	Signature Event for NuMI Beam Cycle	-0.001	**4**
$23	Main Injector Reset	0.0	**5 & 6**
$22	Start of Ramp	422.3	
$25	Start of Flattop	1,112.2	
MIBS $79	Initiate P-Bar Production Beam Transfer	1,172.2	
	MI-52 Kicker Fire Time MIBS $79 + 24.918 MI Rev	1,172.5	
MIBS $74	Initiate NuMI Beam Extraction	1,173.3	**7**
	I:KPS6N Kicker Fire Time MIBS $74 + 20.xxx MI Rev	1,173.5	**8**
$26	End of Beam Operations	1,182.2	
	Total $23 Cycle Time	1,800.0	**9**
	Flattop to Actual P-Bar Production Beam Extraction	60.3	
	Flattop to Actual NuMI Beam Extraction	61.3	

Note 3 $80 May be Placed Before or After the $23, but Must be Before the $14.

Note 4 The $A5 Event is Now Expected to be Imediately Before the $23 MI Reset. That Stated, $A5 May be Placed Before or After the $23, but Must be Before the $19s.

Note 5 The $23 to $22 Interval Will Accommodate Six Booster Batches to Main Injector. Normally a Single $14 Batch for P-Bar Production and 5 x $19 Batches for NuMI.

Note 6 The $29 to $22 Interval of 89 ms is Extended by Five 15 Hz Ticks for the $23 Ramp Scenario. Subsequent Times Generally Advance by 333.3 ms.

Note 7 Exact Placement of MIBS Extraction Event is Subject to Observed Peak of Longitudinal Bunch Length and Number of Integral MI Turns of Beam After MIBS $74.

Note 8 Time is About 1 ms After P-Bar Production Beam Extraction When Longitudinal Bunch Length is Peaked. 20 MI Revolutions is the Suggested Integral Value of Delay After MIBS $74. ".xxx" Fractional Turn Delay to be Field Determined.

Note 9 The Expected $23 Cycle is Judged to be Twenty-Seven 15 Hz Ticks Long or 1.8 Seconds[1]

Table 4.8-3 Expected Timing for MI $23 Cycle for P-Bar Production and NuMI Operations

[1] The cycle time was discussed at the 4/12/04 installation/L3 Managers' meeting. Bruce Baller reiterated that the baseline cycle time is 1.87 seconds—not 1.8 seconds. The meaning of this is that project funds should not be expended to reduce the cycle time from 1.87 seconds to 1.8 seconds.

NuMI TCLK and MIBS EVENTS

TCLK	DEFINITION	COMMENT
$A5	NuMI Reset for Extracted Beam	Expected to be Closely Synchronous With and Well in Advance of NuMI Extracted Beam. Primary Reset for NuMI Ramped Devices.
$23	Main Injector Cycle Reset for P-Bar Production and NuMI Operations	Usually Has Beam for Both P-Bar Production and NuMI Operations. But Could Have Beam for Only One Destination.
$14	Booster Reset for P-Bar Production Beam	Normally One High Intensity Batch.
$19	Booster Reset for NuMI Operations Beam	Normally One to Five Batches for NuMI with Programmable Intensity.
$52	Beam for Previous Booster Reset Will Be Accelerated.	A Generic Event.
$53	Beam for Previous Booster Reset Will Not Be Accelerated.	A Generic Event.
$1F	Booster Beam About to be Transferred to Main Injector	A Generic Event.
$22	Main Injector Ramp Begins	A Generic Event.
$25	Main Injector Flattop	A Generic Event.
$81	Reflected MIBS Event $79	Expected to be Synchronous Within a Few Microseconds.
$A9	Reflected MIBS Event $74	Expected to be Synchronous Within a Few Microseconds.
$27	Detected Fall of the Main Injector Beam Permit	Fires the Main Injector Abort Kicker
$2F	Fire the Main Injector Abort	Happens Every Cycle.
$26	End of Beam Operations in the Main Injector	All Beam Should be Gone.
$A6	NuMI Beam Permit Has Fallen to Non-Permit State	Serves to Inhibit Accelerating Beam Associated With Booster $19 Reset. Also Will Inhibit Generation of MIBS $74.
$A8	NuMI Beam Permit System Reset	Issued by Operator Command. Rcvd by C200 and C201 Modules. Clears Latched Inputs of C200.
$FA	Reflected MIBS $ED	A Generic Event.

MIBS	DEFINITION	COMMENT
$AA	Main Injector Revolution Marker	Once Every 588 RF Cycles. Approximate 10 Microsecond Period.
$79	Initiate Transfer of 120 GeV P-Bar Prod Beam to P-Bar Tgt	Reflected as TCLK $81.
$74	Initiate Transfer of 120 GeV NuMI Beam to NuMI Primary Beamline	Reflected as TCLK $A9.
$ED	Request for a MIBS Transfer Event Has Been Denied	Reflected as TCLK $FA. This is a Generic Event. If One Expects to See $74 or $79 and Does Not, This $ED Event Should Be Generated.

Table 4.8-4 NuMI Significant TCLK and MIBS Clock Events

4.8.1.4 System Description: NuMI Beam Permit System

The fundamental design of the NuMI Beam Permit System (NBPS) takes advantage of already designed hardware and methodologies for Beam Permit/Abort that were instituted in the early days of the Tevatron. While not necessarily redundant in architecture, the NBPS is simple and fail-safe in design.

The NBPS is realized by a dedicated fiber optic line linking all of the distinct geographic locations of NuMI controls. Its operation closely resembles that of a simple flip-flop being in either a beam permit or inhibit state. Inputs for the beam inhibit conditions are many, with each being latched. Bringing the NBPS communication line to the beam permit state is singularly accomplished by operator initiation of a specific TCLK event, but only after beam inhibit conditions have been cleared. The state of the line is examined at two significant locations. The NBPS state is examined at MI-60 as a necessary condition to launch the MIBS $74 extraction event and to allow the firing of the NuMI single turn extraction kicker. The NBPS state is also examined at the Main Control Room as an input to the Beam Switch Sum Box (BSSB) as one of the necessary conditions to allow acceleration of beam in the Linac that is destined for NuMI.

The NBPS distinguishes itself from other installed permit systems in the number and type of inputs. Specifically it is intended to monitor as many technical components and sub-systems as practical that portend successful operation of the NuMI beamline and meaningful operations. The NBPS is especially unique in that it examines data for proper state and operation both closely before and immediately subsequent to NuMI beam extraction. Central to this unique capability is the development of the Process Channel Interface (PCI) and its companion ACNET interface, the CAMAC C204 module. The C204/PCI facility is capable of examining analog and digital inputs with respect to down loaded limit values. The decision process is localized, prompt and not centrally reliant on ACNET services for execution. ACNET services are required for set-up.

The following is a condensed list of significant inputs to the NuMI Beam Permit System:

- NuMI Radiation Safety System
- Main Injector Performance Parameters
- Single Turn Extraction Kicker Power Supply
- Dipole and Quadrupole Magnet Power Supplies

- Beam Loss Monitors
- Total Beam Loss Monitors
- Horn Power Supply
- Low Conductivity and Radioactive Water Systems
- Extraction Beamline Vacuum System Isolation Valves
- Temperature Monitors of Various Technical Components

4.8.2 Interlocks

4.8.2.1 Introduction

The Radiation Safety System (RSS) for NuMI encompasses the underground enclosure with the exception of the following areas. These areas are to be accessible during NuMI beam operations.

- MI-65 Access Shaft Including Stairwell and Elevator
- MI-65 Below Ground Elevator and Shaft Landing Area
- Target Hall Power Supply and RAW Support Rooms
- MINOS Access Shaft Including Elevators
- MINOS Below Ground Elevator Landing Area
- MINOS Below Ground Shaft Landing Area
- Absorber Access Tunnel up to the Absorber Area
- MINOS Experimental Hall Access Tunnel
- MINOS Experimental Hall.

Areas of exclusion during NuMI beam operations are divided into eight separated areas with most being under the domain of the NuMI RSS. All areas are contiguous with the exception of three Muon Alcoves. **Table 4.8-5** indicates the NuMI interlocked areas and barriers.

Area #	Area Description	RSS	Associated Barrier
Area 1	Upstream Carrier Tunnel	Main Inj	G1 D2
Area 2	Downstream Carrier Tunnel, Pre-Target Enclosure and Target Hall, Including Entrance Labyrinth	NuMI	D2 G3 D4
Area 3	Decay Pipe Passageway (Mini-Loop)	NuMI	D4 G5
Area 4	Absorber Hall Including Upstream End of Absorber Access Tunnel, Entrance Labyrinth and Muon Alcove #1	NuMI	G5 D6
Area 5	Muon Alcove #2	NuMI	D7
Area 6	Muon Alcove #3	NuMI	D8
Area 7	Muon Alcove #4	NuMI	D9

Gate or Door#	Barrier Location	RSS	Area
Gate 1	Upstream End of Carrier Tunnel	MI	Area 1
Door 2	Fire Door and CMU Wall at Mid-Point of Carrier Tunnel	MI + NuMI	Areas 1 & 2
Gate 3	Beginning of Entrance Labyrinth to Pre-Target and Target Hall at Bottom of MI-65 Shaft Stairway	NuMI	Area 2
Door 4	Fire Door at Upstream End of Decay Pipe Passageway	NuMI	Areas 2 & 3
Gate 5	Gate at Downstream End of Decay Pipe Passageway	NuMI	Areas 3 & 4
Door 6	Fire Door Across Absorber Access Tunnel Between Absorber Hall and Muon Alcove #2	NuMI	Area 4
Door 7	Entrance to Muon Alcove #2	NuMI	Area 5
Door 8	Entrance to Muon Alcove #3	NuMI	Area 6
Door 9	Entrance to Muon Alcove #4 (This Door May Be Simply Locked Closed by RSO Lock)	NuMI	Area 7

Table 4.8-5 NuMI Interlocked Areas and Barriers

The NuMI RSS must be cleared for beam to be transmitted down the NuMI beamline. The state of the RSS is also an input to the NuMI Beam Permit System. While not integral to the NuMI RSS, radiation "stack" monitors sample and record levels of activated air from the Pre-Target, Target Hall and Absorber areas.

4.8.2.2 System Description: Critical Devices

The critical devices for the NuMI area have been established as the **Lambertson** and **HV101** magnet strings in the Main Injector enclosure Q608 to Q611 area. Power supplies for these devices are located at the North end of the MI-60 Service Building.

Lambertsons - There are two power supplies at the North end of the MI-60 equipment gallery for the three Lambertson magnets located in the MI enclosure by Main Injector quadrupole Q608. The first Lambertson supply, I:LAM60, powers the first Lambertson magnet immediately upstream of Q608. The second supply, I:LAM61, powers the two Lambertsons positioned immediately downstream of Q608. Both of these two supplies are considered as the first of two critical devices for NuMI. A single AC contactor for these supplies is located nearby on the East wall of the equipment gallery and is controlled by the first Critical Device Controller of the NuMI RSS.

HV101 - The second critical device is the HV101 string of six EPB magnets located between Q609 and Q612. The three power supplies for HV101 are located in the North power supply room of MI-60. An AC contactor for these supplies is located nearby on the South wall of the power supply room and is controlled by the second Critical Device Controller of the NuMI RSS.

4.8.2.3 System Description: Search and Secure Areas

The NuMI beamline spans two radiation safety systems, the first being the **existing Main Injector RSS** and then the new **NuMI RSS**. The boundary between the two systems is the (Hobbit) door located at the mid-point of the Carrier Tunnel. The upstream end of the Carrier Tunnel (Upper Hobbit) is to be guarded by a separately accessible mini-loop so as to avoid necessity of routine search and secure of this area. The downstream end of the Carrier Tunnel (Lower Hobbit) is associated with the NuMI RSS. In that the Carrier Tunnel is to be considered an alternate emergency exit for personnel, installed gates or doors must be capable of being opened without necessity of regular access keys.

From the MI-65 Service Building, the main area of the NuMI RSS includes the downstream Carrier Tunnel, Pre-Target enclosure, Target Hall and the labyrinth access to these areas. These are the areas subject to a normal search and secure procedure. From the Target Hall, there is also access to the Decay Pipe passageway. This passageway is approximately 2,200 feet in length on the East side of the concrete embedded Decay Pipe. There is a fire door at its mid-point that serves as a boundary between the MI-65 and MINOS fire protection systems. (The mid-point door also serves to isolate the MI-65 and MINOS air circulation systems.) The downstream end of this passageway terminates at the Absorber Hall. The Decay Pipe passageway is guarded as a separately accessible area so as to avoid necessity of routine search and secure of this area. As is the case for the Carrier Tunnel, the Decay Pipe passageway is considered an alternate emergency exit for personnel. The associated doors and gates are capable of being opened without necessity of regular access keys.

One or more radiation monitoring scarecrows will be placed in the Carrier Tunnel and or Pre-Target regions and connected to the NuMI RSS. Scarecrow placement here will preclude repetitive higher loss operation of the NuMI beamline in these areas.

The MI-65 shaft, its stairwell, the elevator landing area, the shaft landing area and Target Hall support rooms may be occupied during NuMI operations. Though not part of the NuMI RSS, the RAW support room is expected to have some level of access control due to expected activation at the de-ionization bottles associated with the RAW systems.

From the MINOS Service Building, the main areas of the NuMI RSS include the Muon Alcoves, the very upstream end of the Absorber Access Tunnel and the Absorber Hall itself. The Absorber Hall enclosure area accommodates entry to the Decay Pipe passageway. The MINOS shaft, its elevator landing area, the shaft landing area, most of the Absorber Access Tunnel and all downstream areas, including the MINOS Near Detector Experimental Hall and its access tunnel, may be occupied during NuMI operations.

There are four entry points to the NuMI radiation area from the Absorber Access Tunnel. The first three are at entrances to the Muon Alcoves (No. 4, No. 3 and No. 2), each being a dead end for access to muon detectors positioned in the beam flux path. The two most upstream of the three alcoves (No. 2 and No. 3) house arrays of muon detectors. Beyond the alcoves and moving upstream toward the Absorber, there is a fire door that is the fourth entry point. Immediately South of this interlocked door is the access labyrinth to the Absorber Hall. Passing through the Absorber Hall area (an area that includes Muon Alcove No. 1), there is an access gate to the downstream end of the Decay Pipe passageway. Access to the Decay Pipe passageway is to be supported by a separate mini-loop to preclude necessity of routine search and secure. The most upstream end of the Absorber Access Tunnel houses Decay Pipe vacuum equipment, RAW skids for the Absorber and Decay Pipe Cooling water systems and electrical equipment.

The Absorber Access Tunnel, Absorber Hall and the Decay Pipe passageway are considered as an alternate emergency exit for personnel in the downstream MINOS areas. The associated doors and gates are capable of being opened without necessity of regular access keys.

It is expected that no more than two personnel will be required to satisfactorily search and secure areas in the domain of the NuMI Radiation Safety System.

4.8.2.4 System Description: Electrical Safety System for NuMI

Electrical hazards from exposed conductors and connections exist in the NuMI beamline from point of extraction to the magnetic focusing horns. These hazards are typically associated with the beamline magnetic elements such as dipole and quadrupole magnets. Such hazards are also associated with the extraction kicker, Lambertsons, and horns. **The Electrical Safety System (ESS)** extensions of both the Main Injector and NuMI RSS provide permitting inputs to associated power supplies to partially mitigate the hazard of exposed conductors that are not otherwise guarded. The MI ESS connects to supplies in MI-60 and MI-62, while the NuMI ESS connects to supplies at the MI-65 area, both above and below ground. Trim element conductors and connections are guarded and connection of their associated power supplies to either ESS is not necessary.

Accommodating access into the Main Injector and NuMI stub is further provided by connection of selected supplies to the "Beamline" Feeder 96/97. This feeder is de-energized during MI access. Technical power supplies at the MI-65 location are powered from conventional power feeders through a single 2000 kVA pulsed power transformer. Opening of a single point disconnect of 13.8 kV power to this transformer facilitates access to the downstream end of the Carrier Tunnel, Pre-Target enclosure and Target Hall. For purposes of Electrical Safety, this disconnect need not be opened for access to the Muon Alcoves, Absorber Hall or Decay Pipe passageway.

4.8.3 Cables

Cables associated with the NuMI Project are generally quite conventional in nature. The uniqueness of the NuMI underground enclosure, however, requires utilization of fire retardant cable insulation or jacketing unless the cables are installed in conduit. Certain cables in the high radiation environment of the target chase and absorber have suitably radiation tolerant insulation.

Cabling between MI-65 and MINOS areas is accomplished via buried communication duct pathways. All cables are labeled in accord with Accelerator Division standards.

4.8.3.1 System Description: General Cable Plant

The general cable plant of the NuMI Project has two fundamental aspects. The first aspect involves connectivity of both MI-65 and MINOS Service Buildings to established Laboratory infrastructure. An additional attribute here is the connection of certain services between these two service buildings. The second aspect of the cable plant involves connectivity between MI-60, MI-62 and MI-65 and MINOS Service Buildings and technical and experimental equipment in the accelerator and beamline enclosures.

The established Laboratory infrastructure required at the MI-65 and MINOS Service Buildings includes the following. These elements of infrastructure are already available at the MI-60 and MI-62 Service Buildings.

- Accelerator Radiation Safety System
- Accelerator Controls Network (ACNET)
- Wide Area Network Connectivity including access to Fermilab Central Analysis and Data Storage Facilities
- CATV
- Fire & Utility Monitoring System (FIRUS)
- Telephone Communications (POTS)
- MI-62, MI-65 and MINOS Fire Detection System Connectivity

The second aspect of the cable plant includes the following.

- Extension of above infrastructure (excluding Fire Detection System) to the new underground areas as appropriate
- Connections between various Power Supplies and enclosure Beamline Elements (Kickers, Lambertsons, Dipole and Quadrupole Magnets, Trim Elements)
- Connections between MI-62 based Vacuum System Electronics and Ion Pump Power Supplies and Beamline Vacuum Equipment (Ion pumps, Gauges, Isolation Valves)
- Connections between service building based electronics and beamline instrumentation (Beam Position Detectors, Beam Toroids, Profile Monitors, Regular and Total Loss Monitors)

- Localized connections in and between technical, scientific components and infrastructure hardware

4.8.3.2 System Description: MI-65 and MINOS Access Shaft Cables

At the MI-65 access shaft, cables are generally installed in cable tray. At the MINOS access shaft, all cables are installed in conduit. The depth of the MINOS shaft, approximately 350 feet, demands that cables have several points of support so as not to exceed cable tensile strength. Advantage is being taken of the "Outfitting" civil construction work activities. These involve similar installations in the shafts for the AC power distribution system, fire detection and utility infrastructure. Adding the installation of technical and infrastructure cabling to the Outfitting scope of work is simplifying installation. **Table 4.8-6** and **Table 4.8-7** summarize the various cables installed under the Service Building and Outfitting subcontract for the MI-65 and MINOS Access Shafts respectively.

MI-65 Service Building Shaft Wire and Cable - Installed Under SB&O Subcontract

Quantity	Avg Length	Type of Cable	Start	Finish	Route	Utilization	Provided & Used By
14	491	Insulated Copper Building Wire 500 MCM THHN Black	Electrical Room	Two Locations in Pre-Target	Power Tray	E:V118 String of Four B2 Dipoles	Subcontractor WBS 1.1.3
20	583	Insulated Copper Building Wire 1/0 THHN Black	Electrical Room	Varied Locations in Carrier Tunnel & Pre-Target	Power Tray	Q113-Q121 Quads and H117 Dipole	Subcontractor WBS 1.1.3
9	585	Shielded Twisted Pair 10 AWG	Electronics Room	Varied Locations in Carrier Tunnel & Pre-Target	Power Tray	Trim Elements	Fermilab WBS 1.1.3
24	536	3/8" Low Loss Heliax Coax Andrew LDF2RN-50	Electronics Room	Varied Locations in Carrier Tunnel & Pre-Target	Signal Tray	Beam Position Monitors & Calibration Signals	Fermilab WBS 1.1.1
12	555	Amphenol Spectra Strip Round 'n' Flat #843-159-2801-050	Electronics Room	Varied Locations in Carrier Tunnel & Pre-Target	Signal Tray	Profile Monitor Signal	Fermilab WBS 1.1.1
2	500	Multiconductor, 19 Conductor, 18 AWG, Alpha 1898/19C	Electronics Room	Pre-Target	Power Tray	Profile Monitor Motors Trunk	Fermilab WBS 1.1.1
4	500	Multiconductor, 9 Shielded Twisted Pairs, 18 AWG, Alpha 6025C	Electronics Room	Pre-Target	Signal Tray	Profile Monitor LVDTs Trunk	Fermilab WBS 1.1.1
1	500	Multiconductor, 15 Shielded Twisted Pairs, 22 AWG, Alpha 6018C	Electronics Room	Pre-Target	Signal Tray	Profile Monitor Limit Switches Trunk	Fermilab WBS 1.1.1

1	500	Multiconductor, 15 Shielded Twisted Pairs, 22 AWG, Alpha 6018C	Electronics Room	Pre-Target	Signal Tray	Magnet Klixons Trunk	Fermilab WBS 1.1.3
1	300	Fiber Optic Trunk Cable 24 Fiber Singlemode	Electronics Room	Target Hall PS Support Room	Signal Tray	Networking	Fermilab WBS 1.1.8
1	300	Fiber Optic Trunk Cable 36 Fiber Multimode	Electronics Room	Target Hall PS Support Room	Signal Tray	Controls	Fermilab WBS 1.1.8
2	300	Multiconductor, 20 Conductor, 18 AWG, Custom, Blue Jkt	Electronics Room	Target Hall PS Support Room	Signal Tray	Radiation Safety System	Fermilab WBS 1.1.8
2	300	Multiconductor, 4 Shielded Twisted Pairs, 18 AWG, Custom, Blue Jkt	Electronics Room	Target Hall PS Support Room	Signal Tray	RSS Data Links & Audio Warning	Fermilab WBS 1.1.8
1	300	Multiconductor, 15 Shielded Twisted Pairs, 22 AWG, Alpha 6018C	Electrical Room	Target Hall PS Support Room	Signal Tray	FIRUS Utility Monitors & Spare Utility	Fermilab WBS 1.1.8
2	300	RG213/U 50 Ohm Coax Red Jkt, Stk #1170-044500	Electronics Room	Target Hall PS Support Room	Signal Tray	EAV-2 and EAV-3 Stack Rad Monitors	Fermilab WBS 1.1.8
1	300	Multicoax, 16 x RG58C/U, 50 Ohm, Custom, Orange Jacket	Electronics Room	Target Hall PS Support Room	Signal Tray	Profile Monitor Clearing HV & Spare Utility	Fermilab WBS 1.1.1
2	300	CAC-6 75 Ohm Coax	Electronics Room	Target Hall PS Support Room	Signal Tray	CATV Monitors	Fermilab WBS 1.1.8
4	300	RG59/U 75 Ohm Coax	Electronics Room	Target Hall PS Support Room	Signal Tray	CATV Cameras	Fermilab WBS 1.1.8
1	300	Multiconductor, 25 Twisted Pairs, 24 AWG, Teflon Jacket	Electrical Room Inside Terminal	Target Hall PS Support Room	Signal Tray	Telecom POTS	Fermilab WBS 1.1.8

Table 4.8-6 MI-65 Access Shaft Cables Installed Under SB&O Subcontract

MINOS Service Building Shaft Wire and Cable - Installed Under SB&O Subcontract

Quantity	Length Each	Type of Cable	Start	Finish	Route	Utilization	Provided & Used By
1	725	Fiber Optic Trunk Cable 24 Fiber Singlemode	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	Network Fiber	Fermilab WBS 1.1.8
1	725	Fiber Optic Trunk Cable 36 Fiber Multimode	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	Controls Fiber	Fermilab WBS 1.1.8
1	725	Multiconductor, 15 Shielded Twisted Pairs, 22 AWG, Alpha 6018C	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	FIRUS Utility Monitors & Spare Utility	Fermilab WBS 1.1.8
4	725	CAC-6 75 Ohm Coax	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	CATV Monitors	Fermilab WBS 1.1.8
6	725	RG59/U 75 Ohm Coax	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	CATV Cameras	Fermilab WBS 1.1.8
3	725	RG213/U 50 Ohm Coax Red Jkt, Stk #1170-044500	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	Spare Utility	Fermilab WBS 1.1.8
1	725	Multicoax, 16 x RG58C/U, 50 Ohm, Custom, Orange Jacket	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	Spare Utility	Fermilab WBS 1.1.8
1	725	Multiconductor, 25 Twisted Pairs, 24 AWG, Teflon Jacket	Mechanical - Electrical Area	MINOS Hall	Signal Conduit	Telecom POTS	Fermilab WBS 1.1.8
2	1100	Multiconductor, 20 Conductor 18 AWG, Custom, Blue Jkt	Mechanical - Electrical Area	Upstream End of Absorber Access Tunnel	Signal Conduit and Tray	Radiation Safety System	Fermilab WBS 1.1.8
2	1100	Multiconductor, 4 Shielded Twisted Pairs, 18 AWG, Custom, Blue Jkt	Mechanical - Electrical Area	Upstream End of Absorber Access Tunnel	Signal Conduit and Tray	Radiation Safety System Data Links	Fermilab WBS 1.1.8

Table 4.8-7 MINOS Access Shaft Cables Installed Under SB&O Subcontract

4.8.3.3 System Description: Communication Ducts

The MI-65 Service Building connects directly to the Main Injector communication duct system that generally follows Indian and Kautz Road pathways at communications manhole CMH-CUB-1. This system also affords connection to the Accelerator Cross Gallery and the new MI-12 MiniBooNE Target Building. While the MI system has connections to MI-8 and MI-62, more direct communication duct paths have been installed that connect MI-65 to both MI-62 and MI-

8. Infrastructure requirements at the MI-65 Service Building are primarily supported by installation of cables between MI-62 and MI-65. **Table 4.8-8** lists the cables to be found in the MI-62 to MI-65 communications ducts.

Comm Duct Cables from MI-62 to MI-65 Service Building 900 Feet

Qty	Type of Cable	Utility
1	Fiber Optic Trunk 24 Singlemode Fibers	Accelerator Computer Network
3	Fiber Optic Trunks 12 Multimode Fibers Each	Accelerator Controls including: Main Injector CAMAC Link Tevatron Clock (TCLK) Main Inj Beam Sync (MIBS) Machine Data (MDAT) NuMI Beam Permit DDC Utility Monitor System
2	20 Conductor 18 AWG Cables	Safety Interlock
2	Four Twisted Pair Cables, 18 AWG	Safety Data Links and Audio Warning
1	Three Twisted Pair, 18 AWG	ES&H Radiation Mux Trunk
3	1/2" 75 Ohm Hardline Coax Cables	FIRUS
3	1/2" 75 Ohm Hardline Coax Cables	CATV
1	Four Twisted Pairs 16 AWG	NuMI Fire Protection Connectivity between MI-62 and MI-65 Bldgs
1	Telephone Trunk Cable 50 Pair 24 AWG	Telephone Communications (POTS)

Table 4.8-8 Communication Duct Cables Between MI-62 and MI-65

A single communications duct has been installed between MBD and MI-12. Multiple ducts have been installed between MI-12 and the Main Injector system proximate to MI-10. These ducts have installed cables for infrastructure, MiniBooNE specific applications, and NuMI specific applications. **Table 4.8-9** lists the NuMI related cables to be found in the communication duct system connecting MI-65 to MiniBooNE Detector Building (MBD).

MI-65 to MiniBooNE Detector Building 4,000 Feet

Qty	Type of Cable	Utility
2	20 Conductor 18 AWG Cables	Safety Interlock
2	Four Twisted Pair Cables 18 AWG	Safety Data Links and Audio Warning
1	Four Twisted Pairs 16 AWG	NuMI Fire Protection Connectivity between MI-65 and MINOS Bldgs

Table 4.8-9 Communication Duct Cables Between MI-65 and MBD

The MINOS Service Building is directly served by a communication duct system installed under the NuMI Site Preparation and Service Building and Outfitting civil subcontracts. This system has connection to the MiniBooNE Detector Building and the MiniBooNE communication duct system that connects MI-10, MI-12 and MBD. This system also has connection to the Lederman Science Education Center and the accelerator footprint area. The path to Science Center facilitates connection to telephone, FIRUS, CATV and computing network infrastructures. This basic infrastructure has already been installed at the MBD. Supporting MINOS infrastructure has been accomplished by extension of the MBD infrastructure. **Table 4.8-10** lists the cables to be found in the communications ducts between MBD and the MINOS Service Building.

MiniBooNE Detector Building to MINOS Service Building 1,600 Feet

Qty	Type of Cable	Utility
1	Fiber Optic Trunk 24 Singlemode Fibers	Accelerator Computer Network Including Wide Area Network Connectivity and Access to Fermilab Central Analysis and Data Storage Facilities
3	Fiber Optic Trunks 12 Multimode Fibers Each	Accelerator Controls including: Main Injector CAMAC Link Tevatron Clock (TCLK) Main Inj Beam Sync (MIBS) Machine Data (MDAT) NuMI Beam Permit DDC Utility Monitor System
2	20 Conductor 18 AWG Cables	Safety Interlock
2	Four Twisted Pair Cables, 18 AWG	Safety Data Links and Audio Warning
3	1/2" 75 Ohm Hardline Coax Cables	FIRUS (Sourced from Science Education Building and Accelerator Cross Gallery)
3	1/2" 75 Ohm Hardline Coax Cables	CATV (Sourced from Science Education Building and Accelerator Cross Gallery)
1	Telephone Trunk Cable 50 Pair 24 AWG	Telephone Communications (POTS) (Sourced from Science Education Building Area and Accelerator Cross Gallery)
1	Four Twisted Pairs 16 AWG	NuMI Fire Protection Connectivity between MI-65 and MINOS Bldgs

Table 4.8-10 Communication Duct Cables Between MBD and MINOS Service Building