Fermilab

Particle Physics Division

Mechanical Department Engineering Note

Number: MD-ENG- Date: 8/25/2020

Project: Test Intensity Area

Project Internal Reference:

Title: ITA Cave and Target rail Engineering Note

Author(s): Jim Kilmer

Reviewer(s):

Key Words:

Abstract/Summary:

This note has calculations for the construction of the ITA shield cave made from shielding blocks and a rail system for holding samples that can be moved in and out of the cave.

Applicable Codes:

AISC, Manual of Steel Construction, Ninth Edition

Hilti product data

Irradiation Test facility Shield cave and Target Rail System
Jim Kilmer
10-15-2019

The Irradiation test facility needs a new target cave to insert objects for exposure to large doses of beam. A first pass cave used B blocks for construction. We have redesigned the cave to use only C blocks to make the weights more manageable. As part of the redesign it was necessary to support one end of the blocks using an angle iron bolted to blocks making up the opposite wall. This note shows the design basis for that angle iron support. The drawing is F10104402.

Fermilab shielding blocks are all made to a specific drawing (2961-ME-30369). That specifies that the concrete in the blocks must reach 5000 psi compressive strength in 23 days.

Use side view in drawing F10132355. Ignor the load of the half of the C block on the left side being supported fully by the lower block. Choose the edge of the lower block as a fulcrum. The weight of the right side of the block is resisted from falling by the shear force of the angle iron support. Note that in the perfect situation all of the weight of the block is balanced on the fulcrum and there is no load on the angle at all. Calculate instead the worst possible case. The center of mass of the block is at 18 inches from the fulcrum and the shear force of the angle iron is at 36 inches from the fulcrum. Add 250 pounds, 200 pounds for the target system and 50 pounds for the rails. One half of a C block weighs 4050 pounds. The center of mass of the target is at the same distance from the fulcrum as the CM of the block.

$$F_{shear} := \frac{18\cdot in\cdot(4050 + 250)\cdot lbf}{36\cdot in} = 2.15 \times 10^{3}\cdot lbf$$ Held up by two bolts

This is the shear force that must be supplied by the angle iron or rather the bolts holding the angle up. There are two 1/2" - 13, A325 bolts under each section of the angle below a block (6 total). Total shear load on each bolt is 1075 pounds. Use the AISC Manual of Steel Construction, Ninth Edition, Table J3.2 on page 5-73. The table shows that the allowable stresss on A325 fasteners whether or not the threads are in the shear plane is 17 KSI. This number is for the nominal area of the fastener.

$$A := \frac{\pi}{4}\cdot(.5\cdot in)^{2} = 0.196\cdot in^{2}$$ Nominal area of bolt

$$Fboltshear := 17000\cdot\frac{lbf}{in^{2}}\cdot A = 3.338 \times 10^{3}\cdot lbf$$ Maximum Allowable Shear load for each bolt

Since the bolt shear force allowed is greater than the shear force on the bolt, the bolts are OK.

The bolts are screwed into Hilti Drop-in Anchors made from Carbon steel installed in greater than 4000 psi concrete for 1/2-13 threads. Data from Hilti data sheets show that these anchors have an allowable shear load of 1560 pounds each. With two bolts per C block holding up the angle iron they support a load of 3120 pounds, larger than Fshear and thus the anchors are OK.

The rail system for the targets is shown in drawing F10132355. Each rail is rated to support 250 pounds of load. Data sheets for the rail system are attached. Because the rails are each rated for 250 pounds limit the load of the target platform to 200 pounds including the platform weight. Then each rail supports only a weight of 100 pounds. The rails are supported by Hilti drop-in anchors sized at 1/2" - 13 and the concrete strength is 4000 psi. All of these anchors are in tension. The Hilti data sheets show that these anchors are good for 1690 pounds load.

The parts of the rails inside the cave are anchored to the upper block directly. Outside the cave the rails are supported by 1/2" - 13 threaded rods into anchors in the ceiling of the enclosure. The supports are adjustable by turnbuckles that are rated at 2200 pound load each. The threaded rod is a B7 specification with steel with an ultimate tensile strength of 120 KSI. Use a safety factor of four so limit the stress of the threaded rod at 30 Ksi

$D := 0.4084 \cdot in$ -Minor Diameter of 1/2" - 13 threaded rod

$A := \frac{\pi}{4} \cdot D^2 = 0.131 \cdot in^2$ Tensile stress area of rod

$Allowableload := A \cdot 30000 \cdot \frac{lb}{in^2} = 3.93 \times 10^3 \cdot lb$

The load on the rods from these rails is much less than the allowable load calculated.

All of these parts were bought from McMaster-Carr. The load ratings of the parts are in the data in their catalog. Here are the catalog numbers:

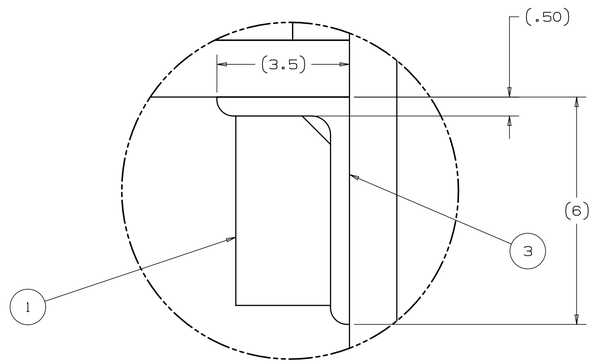
Rails and related parts	5927K11, 5927K12, 5927K14
Turnbuckles	2996T524
Threaded rod	98957A033

DESCRIPTION: KILMER CONCRETE BLOCK LAYOUT 2

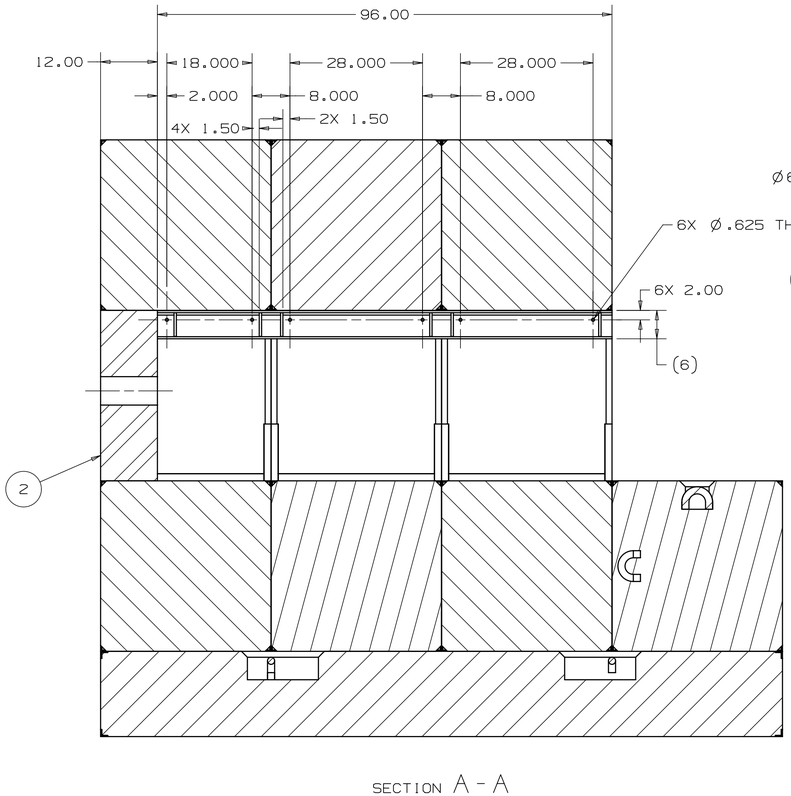
PROJECT: Mech-BeamlineEquipment

CATEGORY: LAYOUT

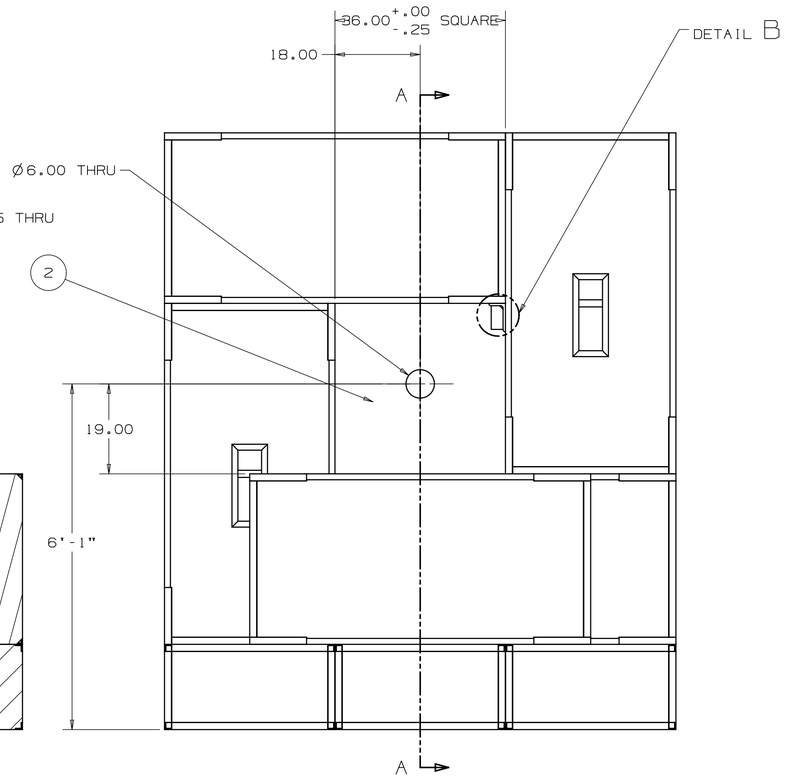
REV	REVISION CONTROL DOCUMENT	DATES	SIGNATURES
-	F10104402---RCD		DRAWN
			APPROVED

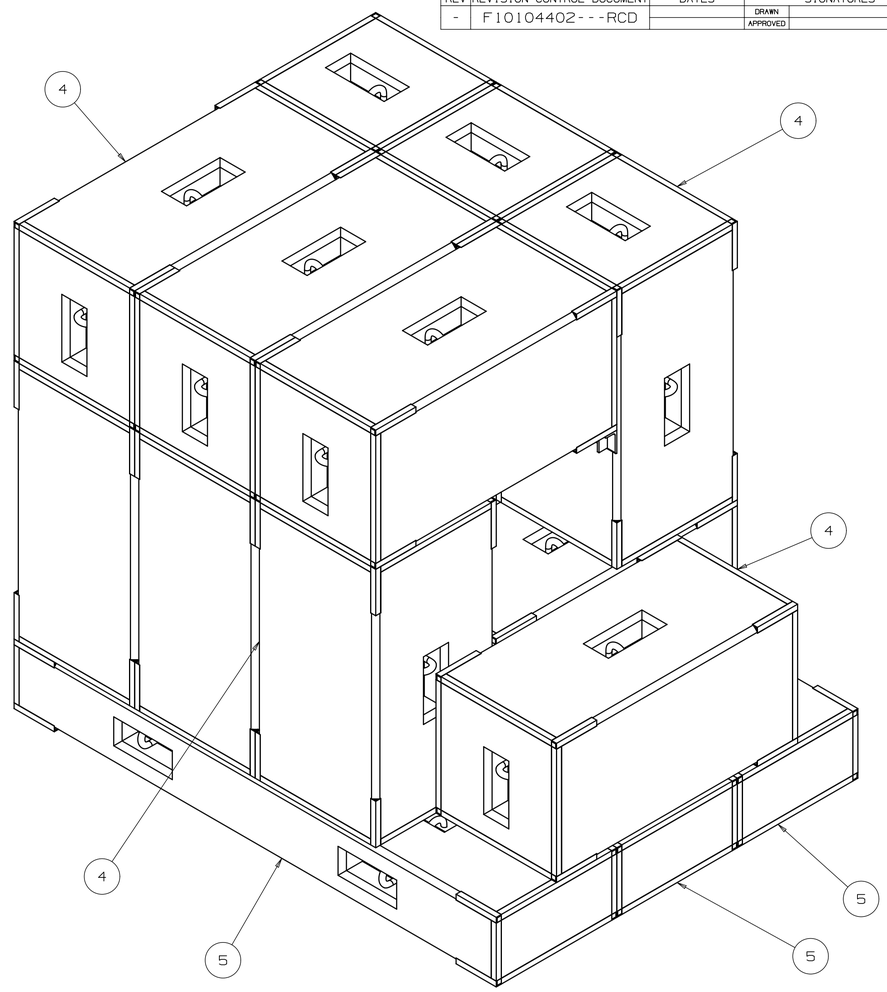


DETAIL B
SCALE 1:2



SECTION A - A





ITEM	VENDOR \ NO	FERMI NO	PART NAME	QTY
5		FC0022826	CONCRETE SHIELDING-J 8100#	3
4		FC0022822	CONCRETE SHIELDING-C 8100#	13
3		F10128330	ANGLE, 6X3.5X.50X96LG MATL. A36	1
2		F10128332	SHIELD - 36IN-SQ X 12IN THICK WITH 6IN HOLE, LOW CARBON STEEL	1
1		F10128336	BAR - .5 X 2.5 X 5, MATL. LOW CARBON STEEL	6

UNLESS OTHERWISE SPECIFIED

±.X	±.XX	±.XXX	±X/X	±X°
.1	.06	.031	1/8	1°

BREAK ALL SHARP EDGES, MAX: .03
DO NOT SCALE DRAWING
DIMENSIONS BASED ON: ASME Y14.5-2009
MAX MACHINE ALL SURFACES: 500
DRAWING UNITS: INCHES

THIRD ANGLE PROJECTION

DRAWN	G.SMITH	DATE	31-May-2018
CHECKED	J.KILMER	DATE	20-Dec-2019
APPROVED		DATE	

USED ON

MATERIAL: SEE PARTS LIST

GROUP: Particle Physics Mechanical Support | CAGE CODE: 0USR6

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

NAME: KILMER CONCRETE BLOCK LAYOUT 2

SCALE	SIZE	DRAWING NUMBER	SHEET	REV
1:16 OR NOTED	D	F10104402	1 of 1	-

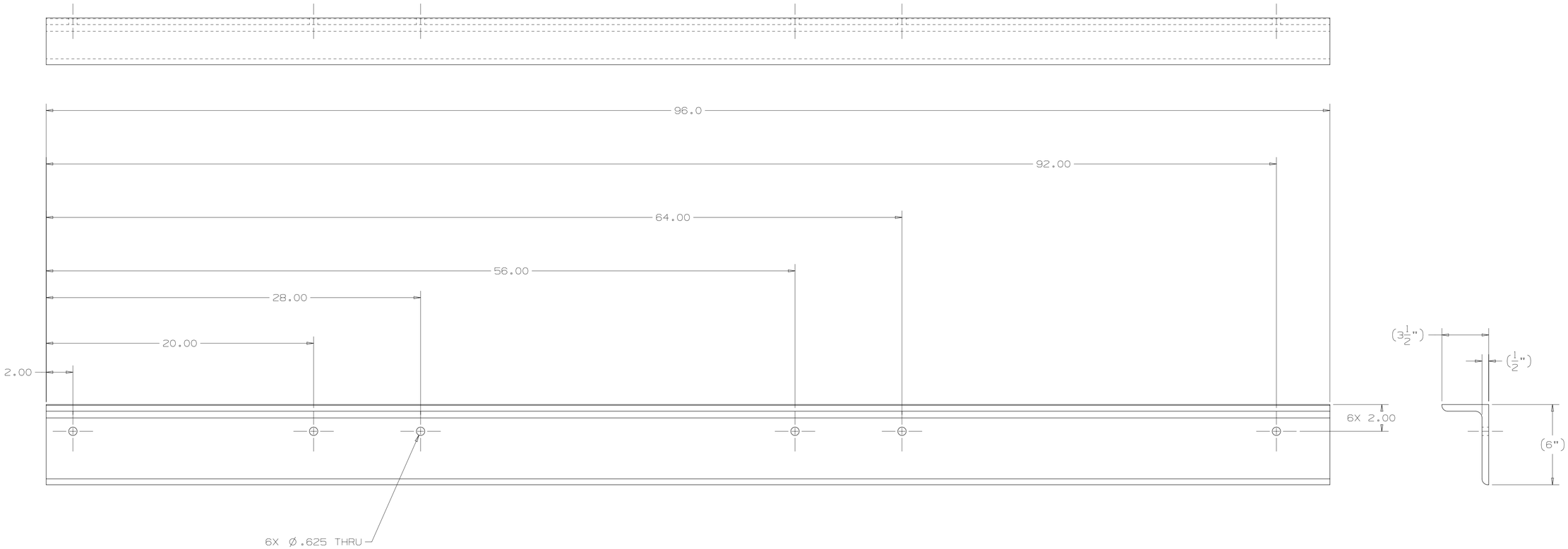
TEMPLATE VERSION: 2018.12.03

DESCRIPTION: ANGLE, 6X3.5X.50X96LG

PROJECT: Mech-Shielding

CATEGORY: ANGLE

REV	REVISION CONTROL DOCUMENT	DATES	SIGNATURES
-	F10128330---RCD		DRAWN
			APPROVED



UNLESS OTHERWISE SPECIFIED				
±.X	±.XX	±.XXX	±X/X	±X°
.1	.02	.005	1/16	1°

BREAK ALL SHARP EDGES, MAX: .015
DO NOT SCALE DRAWING
DIMENSIONS BASED ON: ASME Y14.5-2009
MAX MACHINE ALL SURFACES: 125
DRAWING UNITS: INCHES

THIRD ANGLE PROJECTION

DRAWN	J.RAUCH	DATE	17-Oct-2019
CHECKED	J.KILMER	DATE	20-Dec-2019
APPROVED		DATE	

USED ON: F10104402

MATERIAL: ASTM A36 STEEL, UNS K02600

GROUP: Particle Physics Mechanical Support | CAGE CODE: 0U5R6

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

NAME: ANGLE, 6X3.5X.50X96LG

SCALE	SIZE	DRAWING NUMBER	SHEET	REV
1:4	D	F10128330	1 OF 1	-

TEMPLATE VERSION: 2018.12.03

DESCRIPTION: MTA TRACK ASSEMBLY
PROJECT: Mech-BeamlineEquipment
CATEGORY: SHIELDING

REV	REVISION CONTROL DOCUMENT	DATES	SIGNATURES
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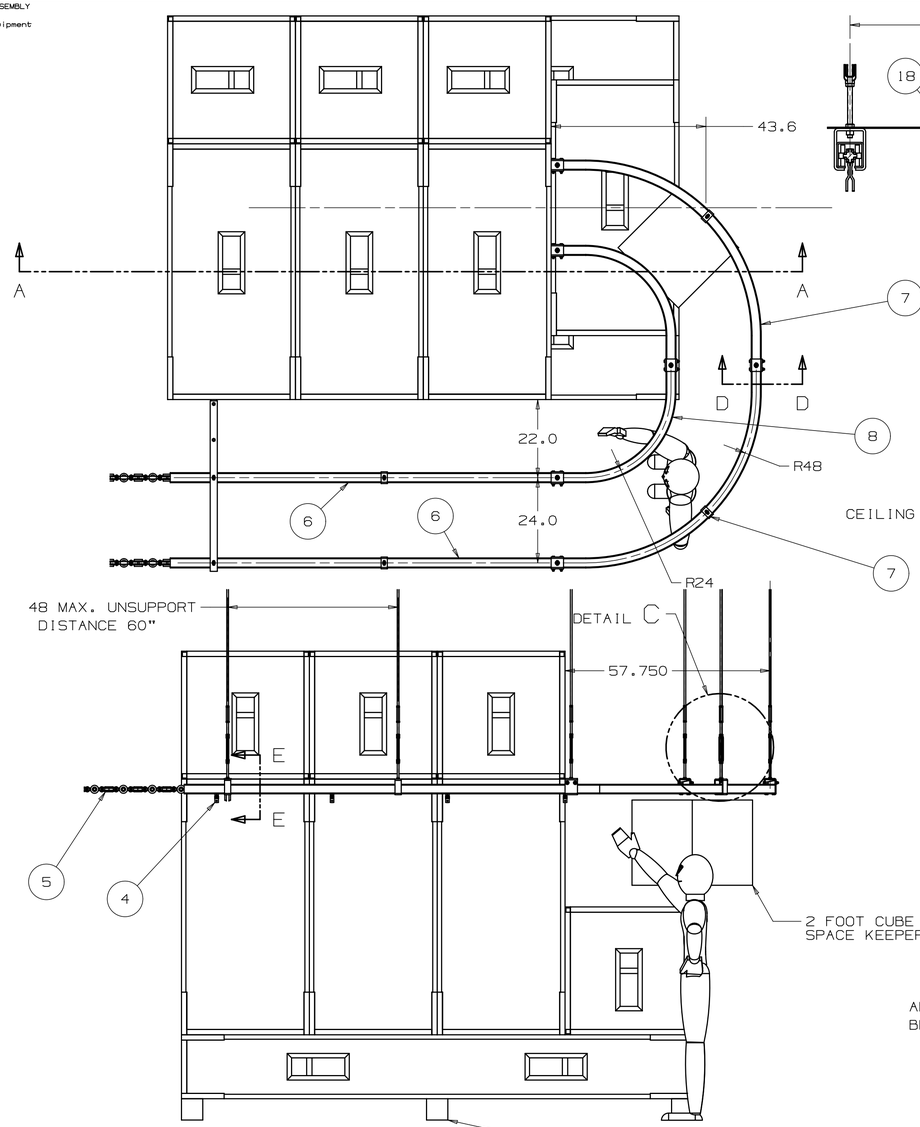
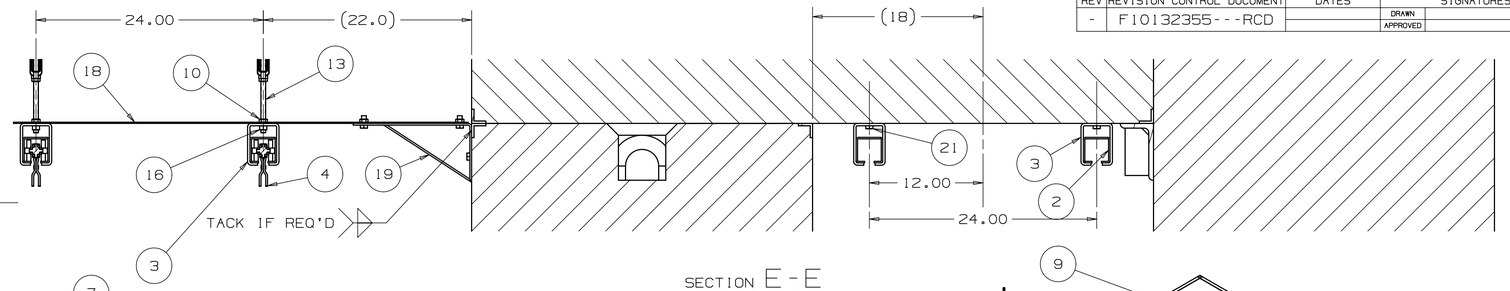
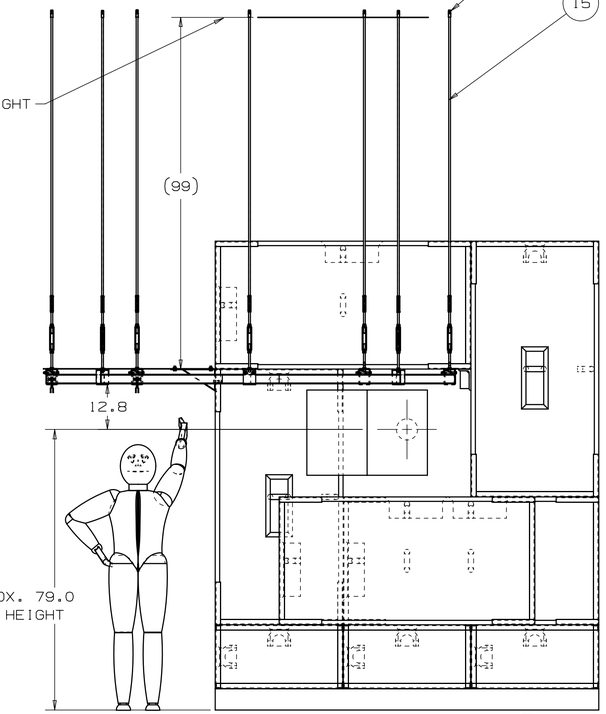
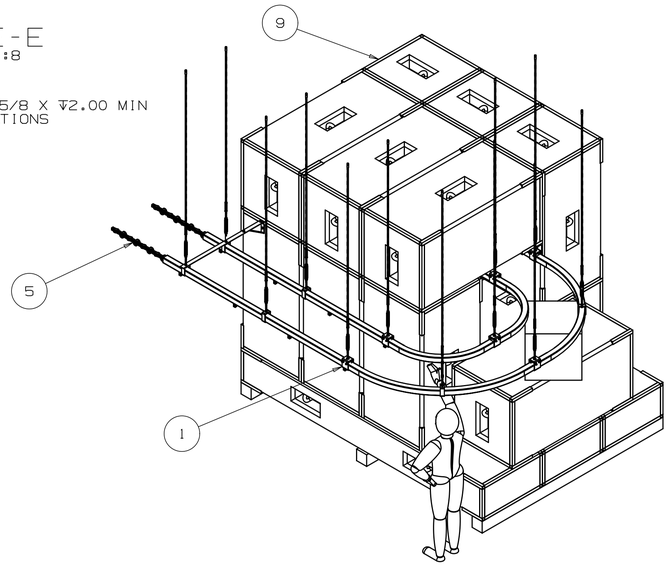
			APPROVED



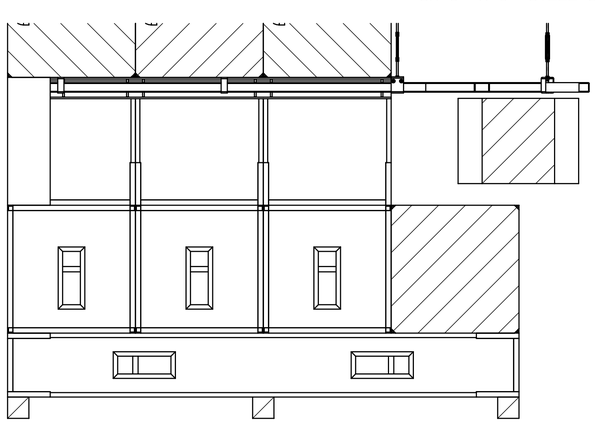


SECTION E-E
SCALE 1:8

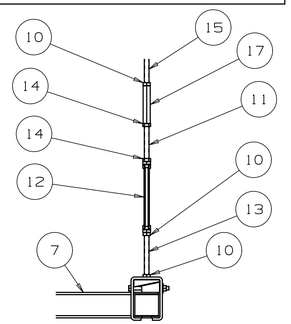




VIEW B
SCALE 1:32



DETAIL C
SCALE 1:8



SECTION D-D
SCALE 1:8

SECTION A-A

ITEM	FERMI NO	PART NAME	QTY
21	FC0011271	HHCS,1/2-13x1LGxFT,G5S,Z	7
20	FC0067482	HILTI KB .500-13 DROP IN ANCHOR	17
19	FC0072654	"L" BRACKET, 12"X6"	1
18	F10133656	BAR - 1/8 X 2 X 48 LOW CARBON STEEL	1
17	FC0067706	LH-RH FEMALE HEX THREAD ADAPTER	12
16	FC0014329	NUT-HEX, 1/2-13x0.4375,G2S	6
15	F10133647	THREADED ROD 1/2-13 x 8 FT LG, CUT TO 6'-10"	12
14	F09000480	NUT - JAM - 1/2-13LHX5/16 SST	24
13	FC0053857	ROD, THREADED - 1/2"-13 THREAD, 8" LONG, GRADE 8 STEEL	12
12	FC0067206	TURNBUCKLE BODY; 1/2-13 X 6.00" ADJ	12
11	F10133652	THREADED ROD LH 1/2-13 UNC,CUT TO 8 INCHES LG	12
10	FC0015223	NUT-JAM,1/2-13x0.3125,G2S,Z	38
9	F10104402	KILMER CONCRETE BLOCK LAYOUT 2	1
8	FC0074838	90 DEGREE CURVED TRACK WITH 2 FEET RADIUS FOR OVERHEAD ENCLOSED-TRACK CONVEYOR	2
7	FC0074839	90 DEGREE CURVED TRACK WITH 4 FEET RADIUS FOR OVERHEAD ENCLOSED-TRACK CONVEYOR	2
6	F10133608	CUT TO 9 FEET 1 INCH LONG STRAIGHT TRACK FOR OVERHEAD ENCLOSED-TRACK CONVEYOR McMASTER-CARR P/N 5927K11	2
5	FC0074835	TROLLEY CHAIN FOR TRACK CONVEYOR	2
4	FC0074836	4-1/2" HIGH CARRIER FOR OVERHEAD ENCLOSED-TRACK CONVEYOR	8
3	FC0074840	SUPPORT BRACKET FOR OVERHEAD ENCLOSED-TRACK CONVEYOR	10
2	F10132352	CUT TO 8 FEET 2 INCHES LONG STRAIGHT TRACK FOR OVERHEAD ENCLOSED-TRACK CONVEYOR McMASTER-CARR P/N 5927K11	2
1	FC0074841	JOINT BRACKET FOR OVERHEAD ENCLOSED-TRACK CONVEYOR McMASTER-CARR	6

UNLESS OTHERWISE SPECIFIED

±.X	±.XX	±.XXX	±X/X	±X°
.1	.02	.005	1/16	1°

BREAK ALL SHARP EDGES, MAX: .015
DO NOT SCALE DRAWING
DIMENSIONS BASED ON: ASME Y14.5-2009
MAX MACHINE ALL SURFACES: 125
DRAWING UNITS: INCHES
THIRD ANGLE PROJECTION

DRAWN	J.RAUCH	DATE	23-Jan-2020
CHECKED		DATE	
APPROVED		DATE	
USED ON			
MATERIAL	SEE PARTS LIST		
GROUP: Particle Physics Mechanical Support	CAGE CODE: 0USR6		

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

NAME: MTA TRACK ASSEMBLY

SCALE	SIZE	DRAWING NUMBER	SHEET	REV
1:1/64 OR NOTED	D	F10132355	1 of 1	-

TEMPLATE VERSION: 2018.12.03