# Electrical Depth

Electrical service for the Maryland Transportation Authority Police Training Facility is fed from an existing BG&E 13.8 kv primary overhead 3-phase lines. A 1600 amp, 480 volt, 3phase, 4-wire switchboard will be provided at the service entrance. The main switchboard will serve panels rated at 480Y/277, which will power mechanical equipment, luminaires, and stepdown transformers to feed appliance and special lighting panels serving 120 volt loads, including receptacles. A dedicated panel will provide power to the exit signs, the exit or night lights, the elevator cab and machine room lights, and the security and fire alarm systems. Emergency power is supplied by a 480 kW generator at 480/277 volts during power failures.

Based on the lighting redesign of Classroom 'A', the physical training facility, the front façade and entrance canopy, and the firing range, the electrical system was re-examined and changes were made to panelboard schedules and feeder sizes as appropriate. The new lighting loads were used to update panelboard schedules and balance the loads on the three phases. Voltage drop also was calculated to ensure that no more than 3% voltage drop was experience for the branch circuits. The resulting panelboards and calculations are included in this electrical depth.

Similarly, the electrical system required updating to meet the changes established in the mechanical breadth. The air-handling units servicing the firing range were resized as part of the mechanical breadth. The new loads were applied to the panelboards. Updated panelboards and appropriate calculations are shown in this section.

A cost analysis of energy-efficient transformers versus standard transformers that were designated in the original design was performed. The analysis examines both initial costs and long-term operating costs and a resulting payback period was established. Also included is a description of the differences between energy-effficient and standard transformers and the advantages of one over the other.

Overcurrent protection device coordination and short circuit current were examined through a protection device analysis. A single path through the electrical distribution system was analyzed to determine its effectiveness.

# Classroom 'A'

Classroom 'A' is the largest classroom space in the Maryland Transportation Authority Police Training Facility. Classroom 'A' has dimensions of 30'-8" by 40'-7". The intended use of this space is for instructional lectures, training classes, and large meetings. Each classroom is equipped with a 16' whiteboard, an 8' tack board with continuous display rail, a wall-mounted 27" TV, an 8' wide projection screen, and a 16' long countertop with base cabinets and wall shelving above.

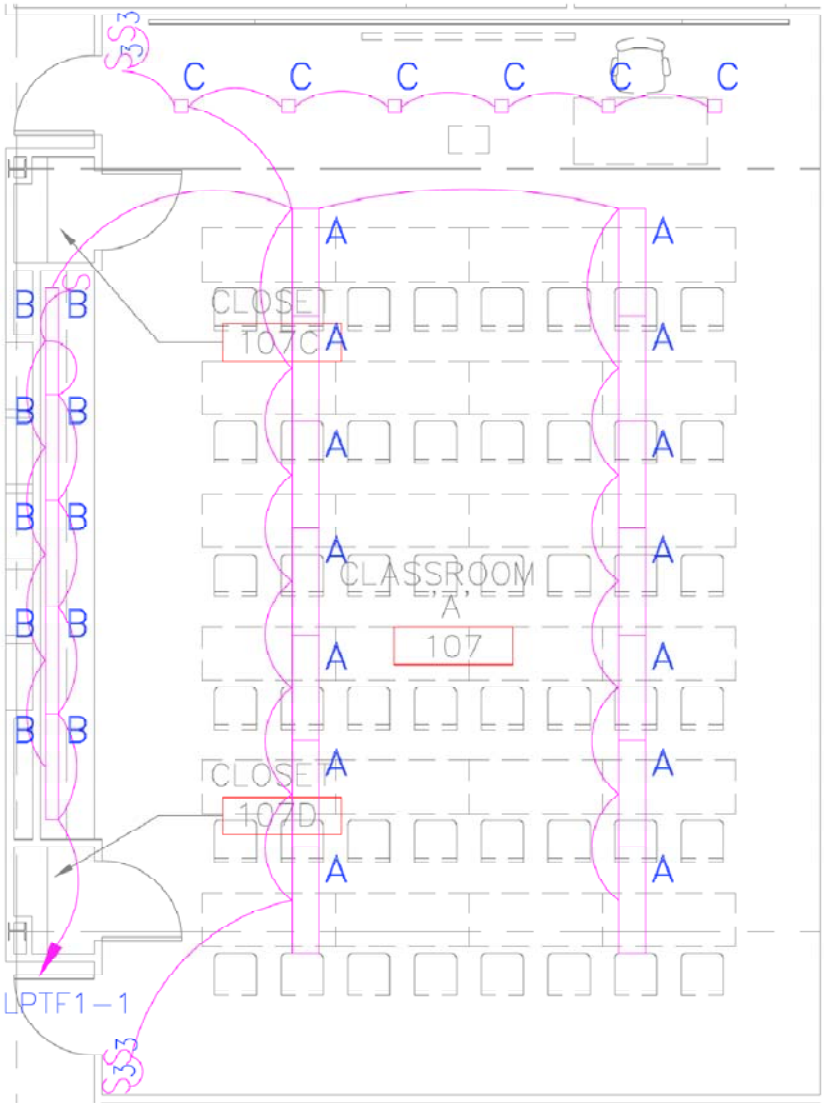
The lighting redesign consists of three different elements: general ambient lighting, cabinet-mounted fixtures, and square downlights across the front of the room. General ambient lighting is provided by suspended by semi-indirect fixtures oriented from lengthwise so as not to interfere with the projector and screen system. Cabinet-mounted fixtures provide a peripheral emphasis, with fixtures under the upper cabinet units providing task lighting for the counter surface and fixtures above the upper cabinet units heightening the space.

Lutron's Radio Touch Wireless Lighting Controls system fits the control needs of the lighting redesign. The control system provides flexibility and energy savings through the use of wireless radio signals communicating with and dimming the luminaries to create scenes. The following three preset scenes will be programmed into the Radio Touch system:

1) Audio/Visual Presentation Scene
2) Lecturing Scene
3) Examination Scene

Projection screen and equipment can be integrated into the controls system. Occupancy sensors will also need to be included and integrated in the system to meet the automated shutoff requirements.

## Layout of Fixtures




## Fixture Schedule

| LUMINAIRE SCHEDULE - CLASSROOM 'A' | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TAG | MANUFACTURER | CATALOG NUMBER | DESCRIPTION | LAMP TYPE | WATTS | # OF LAMPS | OPERATING VOLTAGE | FIXTURE INPUT WATTS |
| A | PEERLESS | PRM4-1 54HO R12 277 | SUSPENDED SEMI-INDIRECT | T5 | 54 | 1 | 277 | 88.5 |
| B | LITHONIA | UC 42K 277 | UNDERCABINET FIXTURE | T5 | 13 | 2 | 277 | 28 |
| C | GOTHAM LIGHTING | SQF 1/32TRT 6AR 277 | SQUARE DOWNLIGHT | CFL - TR | 32 | 1 | 277 | 38 |

## Original Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | TYPE PANEL | LTG | | |
| MOUNTING | SURFACE | | LPTF1 | | | | | | MIN AIC | 30K | | |
| SIZE/TYPE BUS | 100A | | LOCATION | | | | | | REMARKS | | | |
| SIZE/TYPE MAINS | 100A | | ELEC RM | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| LTG | 103, 104, 105, 106 | 770.0 | 20 | 1 | * | | | 2 | 20 | 1240.0 | 217, 216, 215, 214 | LTG |
| LTG | 107, 111 | 2500.0 | 20 | 3 | | * | | 4 | 20 | 900.0 | 221, 220 | LTG |
| LTG | CORR, LOBBY | 1900.0 | 20 | 5 | | | * | 6 | 20 | 2700.0 | 218, 219, 211, 213 | LTG |
| LTG | ELEV RM | 70.0 | 20 | 7 | * | | | 8 | 20 | 900.0 | CORR | LTG |
| LTG | 113, 109, 110, 108 | 1900.0 | 20 | 9 | | * | | 10 | 20 | 1400.0 | 212, 210, 209, 201, 202, 203 | LTG |
| LTG | 114, 115, 116 | 2400.0 | 20 | 11 | | | * | 12 | 20 | 2400.0 | 207, 208 | LTG |
| LTG | 117, 118, 119, 120 | 720.0 | 20 | 13 | * | | | 14 | 20 | 800.0 | 204, 205, 206 | LTG |
| LTG | STAIR & CORR NIGHT | 1000.0 | 20 | 15 | | * | | 16 | 20 | 2240.0 | GYM | LTG |
| LTG | WEAPONS CLEANING COUNTER | 1000.0 | 20 | 17 | | | * | 18 | 20 | 750.0 | 130 | LTG |
| LTG | EXTERIOR | 890.0 | 20 | 19 | * | | | 20 | 20 | 500.0 | 131 | LTG |
| LTG | ELEV PIT | 100.0 | 20 | 21 | | * | | 22 | 20 | 390.0 | CORR C-4 | LTG |
| SPARE | | | 20 | 23 | | | * | 24 | 20 | | | SPARE |
| SPARE | | | 20 | 25 | * | | | 26 | 20 | | | SPARE |
| SPARE | | | 20 | 27 | | * | | 28 | 20 | | | SPARE |
| SPARE | | | 20 | 29 | | | * | 30 | 20 | | | SPARE |
| SUB-TOTAL | A PHASE | 5890.0 | | B PHASE | | | | | | 10430.0 | C PHASE | 11150.0 |
| TOTAL CONNECTED LOAD (WATTS) | | 27470.0 | | DEMAND LOAD | | | | | | 34337.5 | REQUIRED AMPACITY | 41.3 |

## New Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | TYPE PANEL | LTG | | |
| MOUNTING | SURFACE | | LPTF1 | | | | | | MIN AIC | 30K | | |
| SIZE/TYPE BUS | 100A | | LOCATION | | | | | | REMARKS | | | |
| SIZE/TYPE MAINS | 100A | | ELEC RM | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| LTG | 107 | 2953.0 | 20 | 1 | * | | | 2 | 20 | 1240.0 | 217, 216, 215, 214 | LTG |
| LTG | 103, 104, 105, 106 | 770.0 | 20 | 3 | | * | | 4 | 20 | 900.0 | 221, 220 | LTG |
| LTG | CORR, LOBBY | 1900.0 | 20 | 5 | | | * | 6 | 20 | 2700.0 | 218, 219, 211, 213 | LTG |
| LTG | ELEV RM | 70.0 | 20 | 7 | * | | | 8 | 20 | 900.0 | CORR | LTG |
| LTG | 114, 115, 116 | 2400.0 | 20 | 9 | | * | | 10 | 20 | 1400.0 | 212, 210, 209, 201, 202, 203 | LTG |
| LTG | 113, 109, 110, 108 | 1900.0 | 20 | 11 | | | * | 12 | 20 | 2400.0 | 207, 208 | LTG |
| LTG | 117, 118, 119, 120 | 720.0 | 20 | 13 | * | | | 14 | 20 | 800.0 | 204, 205, 206 | LTG |
| LTG | STAIR & CORR NIGHT | 1000.0 | 20 | 15 | | * | | 16 | 20 | 2393.0 | GYM | LTG |
| LTG | WEAPONS CLEANING COUNTER | 1000.0 | 20 | 17 | | | * | 18 | 20 | 750.0 | 130 | LTG |
| LTG | EXTERIOR | 3468.0 | 20 | 19 | * | | | 20 | 20 | 500.0 | 131 | LTG |
| LTG | ELEV PIT | 100.0 | 20 | 21 | | * | | 22 | 20 | 390.0 | CORR C-4 | LTG |
| SPARE | | | 20 | 23 | | | * | 24 | 20 | | | SPARE |
| SPARE | | | 20 | 25 | * | | | 26 | 20 | | | SPARE |
| LTG | 111 | 1612.0 | 20 | 27 | | * | | 28 | 20 | | | SPARE |
| SPARE | | | 20 | 29 | | | * | 30 | 20 | | | SPARE |
| SUB-TOTAL | A PHASE | 10651.0 | | B PHASE | | | | | | 10965.0 | C PHASE | 10650.0 |
| TOTAL CONNECTED LOAD (WATTS) | | 32266.0 | | DEMAND LOAD | | | | | | 40332.5 | REQUIRED AMPACITY | 48.5 |

| PANEL LPTF1 - CKT 3 | | | |
|---|---|---|---|
| TAG | QUANTITY | AMPS / FIXTURE | AMPS |
| A | 14 | 0.53 | 7.42 |
| B | 10 | 0.24 | 2.4 |
| C | 6 | 0.14 | 0.84 |
| VOLTAGE | 277 | TOTAL AMPS | 10.66 |
| VA | | | 2953 |

| PANEL LPTF1 - CKT 27 | | | |
|---|---|---|---|
| TAG | QUANTITY | AMPS / FIXTURE | AMPS |
| A | 6 | 0.53 | 3.18 |
| B | 4 | 0.24 | 0.96 |
| C | 12 | 0.14 | 1.68 |
| VOLTAGE | 277 | TOTAL AMPS | 5.82 |
| VA | | | 1612 |

## New Feeder Size

Panelboard LPTF1 is fed with (4) #8 AWG & (1) #8 AWG ground in 3/4" conduit.

## Voltage Drop

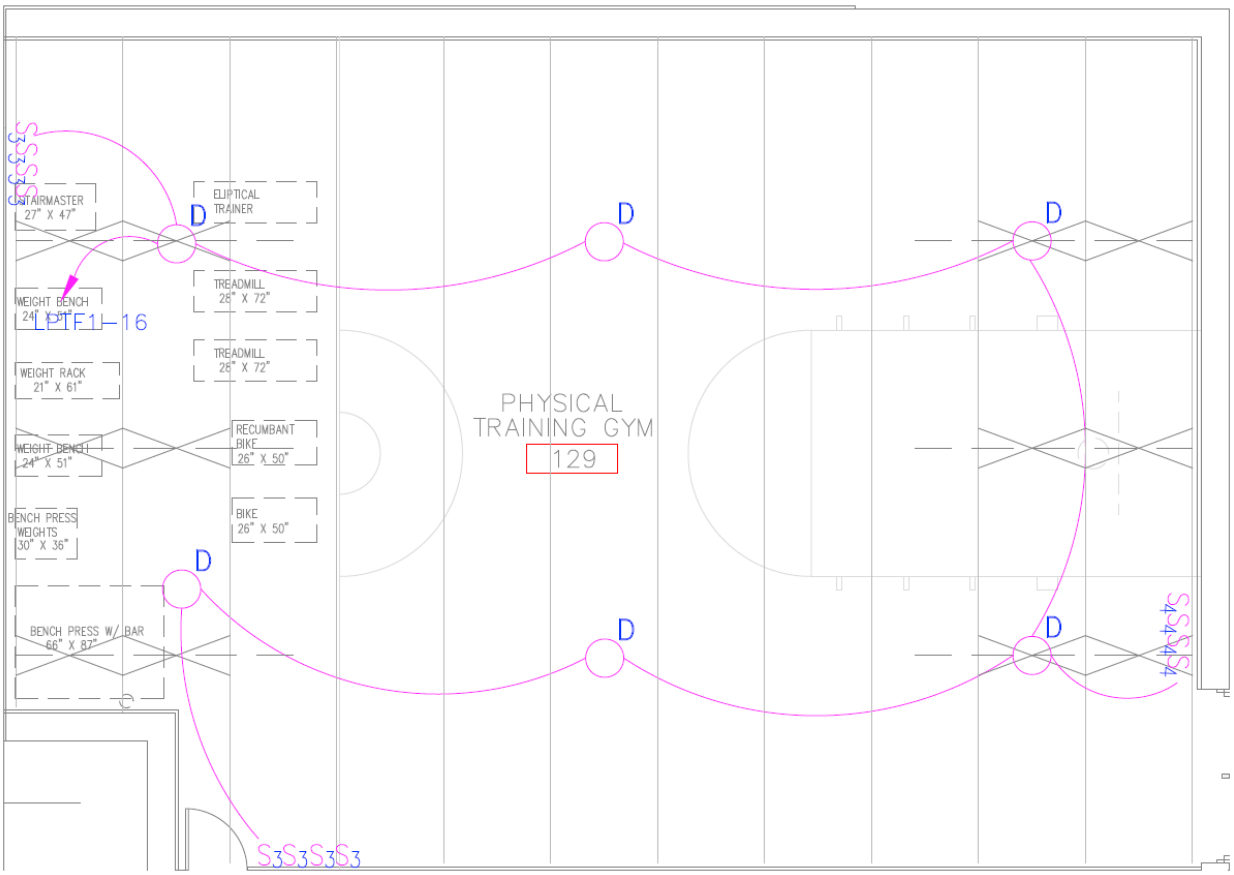
| PANEL LPTF1 - CKT 1 | |
|---|---|
| Voltage | 277 |
| PF | 0.98 |
| Length | 160 |
| Wire Size | #12 |
| $V_{drop/(1000A*ft)}$ | 1.9 |
| Current (A) | 10.66 |
| Single Phase Mult. | 2 |
| $V_{drop/(L-N)}$ | 6.481 |
| % $V_{drop}$ | 2.34 |

# Physical Training Gymnasium

The gymnasium will be used for scheduled classes in self-defense as well as personal training with exercise and weight-lifting equipment. A small half-court basketball set-up is included for pick-up games in the evenings and weekends. Measuring approximately 41' by 59', the gymnasium is the only space in the facility will exposed structural trusses. The space also has wall padding covering CMU walls for safety.

The luminaire selected for the physical training gymnasium makes use of eight compact fluorescent lamps. The luminaries provide the traditional look of gymnasium low-bay HID fixtures with the instant-start advantage of fluorescents. Various light output levels can be achieved by allowing for individual lamp switching. This type of switching can be executed with multiple wall switches and does not require a complicated control system.

## Layout of Fixtures




## Luminaire Schedule

| LUMINAIRE SCHEDULE - GYMNASIUM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TAG | MANUFACTURER | CATALOG NUMBER | DESCRIPTION | LAMP TYPE | WATTS | # OF LAMPS | OPERATING VOLTAGE | FIXTURE INPUT WATTS |
| D | SPORTLITE | LX800 T42 22LEXCP 277 | CFL HIGH BAY | CFL -TR | 42 | 8 | 277 | 392 |

## Original Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | TYPE PANEL | LTG | | |
| MOUNTING | SURFACE | | LPTF1 | | | | | | MIN AIC | 30K | | |
| SIZE/TYPE BUS | 100A | | LOCATION | | | | | | REMARKS | | | |
| SIZE/TYPE MAINS | 100A | | ELEC RM | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| LTG | 103, 104, 105, 106 | 770.0 | 20 | 1 | * | | | 2 | 20 | 1240.0 | 217, 216, 215, 214 | LTG |
| LTG | 107, 111 | 2500.0 | 20 | 3 | | * | | 4 | 20 | 900.0 | 221, 220 | LTG |
| LTG | CORR, LOBBY | 1900.0 | 20 | 5 | | | * | 6 | 20 | 2700.0 | 218, 219, 211, 213 | LTG |
| LTG | ELEV RM | 70.0 | 20 | 7 | * | | | 8 | 20 | 900.0 | CORR | LTG |
| LTG | 113, 109, 110, 108 | 1900.0 | 20 | 9 | | * | | 10 | 20 | 1400.0 | 212, 210, 209, 201, 202, 203 | LTG |
| LTG | 114, 115, 116 | 2400.0 | 20 | 11 | | | * | 12 | 20 | 2400.0 | 207, 208 | LTG |
| LTG | 117, 118, 119, 120 | 720.0 | 20 | 13 | * | | | 14 | 20 | 800.0 | 204, 205, 206 | LTG |
| LTG | STAIR & CORR NIGHT | 1000.0 | 20 | 15 | | * | | 16 | 20 | 2240.0 | GYM | LTG |
| LTG | WEAPONS CLEANING COUNTER | 1000.0 | 20 | 17 | | | * | 18 | 20 | 750.0 | 130 | LTG |
| LTG | EXTERIOR | 890.0 | 20 | 19 | * | | | 20 | 20 | 500.0 | 131 | LTG |
| LTG | ELEV PIT | 100.0 | 20 | 21 | | * | | 22 | 20 | 390.0 | CORR C-4 | LTG |
| SPARE | | | 20 | 23 | | | * | 24 | 20 | | | SPARE |
| SPARE | | | 20 | 25 | * | | | 26 | 20 | | | SPARE |
| SPARE | | | 20 | 27 | | * | | 28 | 20 | | | SPARE |
| SPARE | | | 20 | 29 | | | * | 30 | 20 | | | SPARE |
| SUB-TOTAL | A PHASE | 5890.0 | | B PHASE | | | | | | 10430.0 | C PHASE | 11150.0 |
| TOTAL CONNECTED LOAD (WATTS) | | 27470.0 | | DEMAND LOAD | | | | | | 34337.5 | REQUIRED AMPACITY | 41.3 |

## New Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | TYPE PANEL | LTG | | |
| MOUNTING | SURFACE | | LPTF1 | | | | | | MIN AIC | 30K | | |
| SIZE/TYPE BUS | 100A | | LOCATION | | | | | | REMARKS | | | |
| SIZE/TYPE MAINS | 100A | | ELEC RM | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| LTG | 107 | 2953.0 | 20 | 1 | * | | | 2 | 20 | 1240.0 | 217, 216, 215, 214 | LTG |
| LTG | 103, 104, 105, 106 | 770.0 | 20 | 3 | | * | | 4 | 20 | 900.0 | 221, 220 | LTG |
| LTG | CORR, LOBBY | 1900.0 | 20 | 5 | | | * | 6 | 20 | 2700.0 | 218, 219, 211, 213 | LTG |
| LTG | ELEV RM | 70.0 | 20 | 7 | * | | | 8 | 20 | 900.0 | CORR | LTG |
| LTG | 114, 115, 116 | 2400.0 | 20 | 9 | | * | | 10 | 20 | 1400.0 | 212, 210, 209, 201, 202, 203 | LTG |
| LTG | 113, 109, 110, 108 | 1900.0 | 20 | 11 | | | * | 12 | 20 | 2400.0 | 207, 208 | LTG |
| LTG | 117, 118, 119, 120 | 720.0 | 20 | 13 | * | | | 14 | 20 | 800.0 | 204, 205, 206 | LTG |
| LTG | STAIR & CORR NIGHT | 1000.0 | 20 | 15 | | * | | 16 | 20 | 2393.0 | GYM | LTG |
| LTG | WEAPONS CLEANING COUNTER | 1000.0 | 20 | 17 | | | * | 18 | 20 | 750.0 | 130 | LTG |
| LTG | EXTERIOR | 890.0 | 20 | 19 | * | | | 20 | 20 | 500.0 | 131 | LTG |
| LTG | ELEV PIT | 100.0 | 20 | 21 | | * | | 22 | 20 | 390.0 | CORR C-4 | LTG |
| SPARE | | | 20 | 23 | | | * | 24 | 20 | | | SPARE |
| SPARE | | | 20 | 25 | * | | | 26 | 20 | | | SPARE |
| LTG | 111 | 1612.0 | 20 | 27 | | * | | 28 | 20 | | | SPARE |
| SPARE | | | 20 | 29 | | | * | 30 | 20 | | | SPARE |
| SUB-TOTAL | A PHASE | 8073.0 | | B PHASE | | | | | | 10965.0 | C PHASE | 10650.0 |
| TOTAL CONNECTED LOAD (WATTS) | | 29688.0 | | DEMAND LOAD | | | | | | 37110.0 | REQUIRED AMPACITY | 44.7 |

| PANEL LPTF1 - CKT 16 | | | |
|---|---|---|---|
| TAG | QUANTITY | AMPS / FIXTURE | TOTAL AMPS |
| D | 6 | 1.44 | 8.64 |
| VOLTAGE | 277 | TOTAL AMPS | 8.64 |
| VA | | | 2393 |

## New Feeder Size

Panelboard LPTF1 is fed with (4) #8 AWG & (1) #8 AWG ground in 3/4" conduit.

## Voltage Drop

| PANEL LPTF1 - CKT 16 | |
|---|---|
| Voltage | 277 |
| PF | 0.98 |
| Length | 215 |
| Wire Size | #12 |
| $V_{drop/(1000A*ft)}$ | 1.9 |
| Current (A) | 9.64 |
| Single Phase Mult. | 2 |
| $V_{drop/(L-N)}$ | 7.876 |
| % $V_{drop}$ | 2.84 |

# Firing Range Area

The firing range is approximately 100' by 110'. Training is the main theme and so lighting systems that simulate realistic scenerios designed. Three major cases exist: (1) an exterior night condition with too little light, (2) a glare condition with too much light, and (3) a condition to simulate normal interior conditions. A DALI system was selected to control the lighting for the range.

## Luminaire Schedule

| LUMINAIRE SCHEDULE - FAÇADE AND ENTRANCE CANOPY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TAG | MANUFACTURER | CATALOG NUMBER | DESCRIPTION | LAMP TYPE | WATTS | # OF LAMPS | OPERATING VOLTAGE | FIXTURE INPUT WATTS |
| I | ERCO | 73753.023 | DOWNLIGHT | HALOGEN | 50 | 1 | 12 | 50 |
| E | WINDIRECT | P2 - SSW - 148T5 - 277V - SCK1 - SGW - | WALLWASH | T5 | 28 | 1 | 277 | 33 |
| J | LIGHTOLIER | DPB2S18DS340 | TROFFER | T8 | 32 | 3 | 277 | 91 |
| K | ERCO | 34115.023 | FLOODLIGHT | T5 | 28 | 1 | 277 | 33 |

## Original Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | TYPE PANEL | LTG | | |
| MOUNTING | SURFACE | | LPFR1 | | | | | | MIN AIC | 65K | | |
| SIZE/TYPE BUS | 250A | | LOCATION | | | | | | REMARKS | | | |
| SIZE/TYPE MAINS | 150A | | ELEC RM - 124A | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| SPARE | | | 20 | 1 | * | | | 2 | 20 | 360.0 | BULLET TRAP PIT | LTG |
| LTG | 124, 124A | 440.0 | 20 | 3 | | * | | 4 | 20 | 4155.0 | RANGE | BULLET TRAP MOTOR 3 HP |
| BULLET TRAP MOTOR 3 HP | RANGE | 4155.0 | 20 | 5 | | | * | 6 | | | | |
| | | | | 7 | * | | | 8 | | | | |
| | | | | 9 | | * | | 10 | 20 | 915.0 | RANGE | BULLET TRAP MOTOR 1/2 HP |
| BULLET TRAP MOTOR 1/2 HP | RANGE | 915.0 | 20 | 11 | | | * | 12 | | | | |
| | | | | 13 | * | | | 14 | | | | |
| | | | | 15 | | * | | 16 | 20 | 760.0 | 126, 127, 128 | LTG |
| LTG | MECH RM 123 | 3380.0 | 20 | 17 | | | * | 18 | | | | SPARE |
| UH 5 & 5A | 124, 124A | 15000 | 20 | 19 | * | | | 20 | | | | SPARE |
| | | | | 21 | | * | | 22 | | | | SPARE |
| | | | | 23 | | | * | 24 | 20 | 10000.0 | 127, 128 | UH 8 & 9 |
| UH 6 & 7 | 125, 126 | 15000.0 | 20 | 25 | * | | | 26 | | | | |
| | | | | 27 | | * | | 28 | | | | |
| | | | | 29 | | | * | 30 | 50 | 24000.0 | RANGE | LTG CONTACTOR PANEL CP |
| SEPTIC SYSTEM CONTROL PANEL | 123 | 4000.0 | 20 | 31 | * | | | 32 | | | | |
| | | | | 33 | | * | | 34 | | | | |
| | | | | 35 | | | * | 36 | | | | SPACE |
| SPARE | | | 20 | 37 | * | | | 38 | | | | SPACE |
| | | | | 39 | | * | | 40 | | | | SPACE |
| | | | | 41 | | | * | 42 | | | | SPACE |
| SUB-TOTAL | A PHASE | 26406.7 | | B PHASE | | | | | | 27246.7 | C PHASE | 29426.7 |
| TOTAL CONNECTED LOAD (WATTS) | | 83080.0 | | DEMAND LOAD | | | | | | 103850.0 | REQUIRED AMPACITY | 125.0 |

## New Panelboard Schedule

| PANEL LPFR1 - CKT 30,32,34 | | | |
|---|---|---|---|
| **TAG** | **QUANTITY** | **AMPS / FIXTURE** | **TOTAL AMPS** |
| I | 12 | 0.4 | 4.8 |
| E | 4 | 0.12 | 0.48 |
| J | 4 | 0.34 | 1.36 |
| K | 4 | 0.12 | 0.48 |
| VOLTAGE | 277 | TOTAL AMPS | 7.12 |
| VA | | | 1972 |

## New Feeder Size

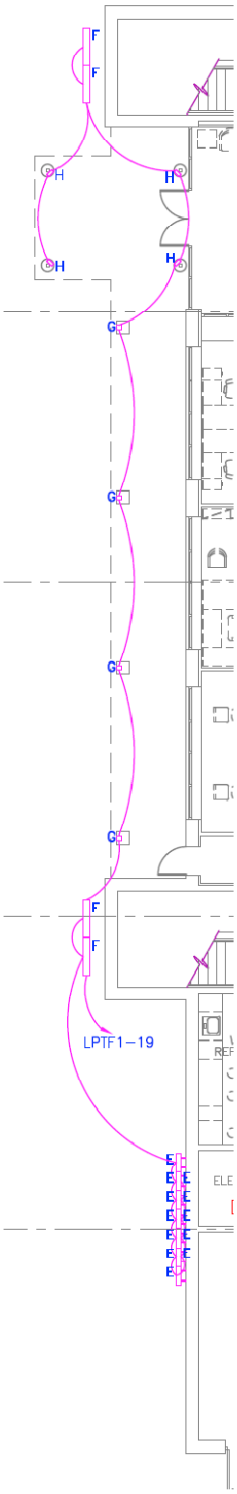
Panelboard LPTF1 is fed with (4) #8 AWG & (1) #8 AWG ground in 3/4" conduit.

# Front Façade and Entry Canopy

Stretching 153'-0" in length and 30'-0" in height, the façade has several different materials and architectural elements. The basic façade is comprised of sections of ground face CMU and split face CMU. There is a roof cover at the first floor level which is made of standing seam metal. Window trim and finishes are pre-finished aluminum and there are two pre-cast concrete logos, one at either end of the façade. Primary occupancy will occur during the day, however, for security and surveillance purposes and for the low amounts of evening traffic that will occur, an adequately lighted exterior is important.

One of the major elements of the façade is the building name. The letters of the building name are put in silhouette by washing the wall behind the letters with light. The wall outsets that are adorned with architectural precast panels displaying the Maryland Transportation Authority and the MdTA Police logos are illuminated using Color Kinetics Color Blaze LED fixtures. Recessed step lights are housed within the columns that support the entrance canopy and floodlights illuminate the arched canopy over the entrance. All exterior lighting will be controlled by photocells.

# Layout of Fixtures



## Luminaire Schedule

| LUMINAIRE SCHEDULE - FAÇADE AND ENTRANCE CANOPY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TAG | MANUFACTURER | CATALOG NUMBER | DESCRIPTION | LAMP TYPE | WATTS | # OF LAMPS | OPERATING VOLTAGE | FIXTURE INPUT WATTS |
| E | WINDIRECT | P2 - SSW - 148T5 - 277V - SCK1 - SGW - | WALLWASH | T5 | 28 | 1 | 277 | 33 |
| F | COLOR KINETICS | 116-000016-00 | COLOR BLAZE | LED | 240 | --- | 277 | 240 |
| G | ERCO | 44553.023 | STEP LIGHT | CFL-TR | 9 | 1 | 277 | 12 |
| H | COLOR KINETICS | 123-000005-00 | CANOPY | LED | 50 | --- | 277 | 50 |

## Original Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | TYPE PANEL | LTG | | |
| MOUNTING | SURFACE | | LPTF1 | | | | | | MIN AIC | 30K | | |
| SIZE/TYPE BUS | 100A | | LOCATION | | | | | | REMARKS | | | |
| SIZE/TYPE MAINS | 100A | | ELEC RM | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| LTG | 103, 104, 105, 106 | 770.0 | 20 | 1 | * | | | 2 | 20 | 1240.0 | 217, 216, 215, 214 | LTG |
| LTG | 107, 111 | 2500.0 | 20 | 3 | | * | | 4 | 20 | 900.0 | 221, 220 | LTG |
| LTG | CORR, LOBBY | 1900.0 | 20 | 5 | | | * | 6 | 20 | 2700.0 | 218, 219, 211, 213 | LTG |
| LTG | ELEV RM | 70.0 | 20 | 7 | * | | | 8 | 20 | 900.0 | CORR | LTG |
| LTG | 113, 109, 110, 108 | 1900.0 | 20 | 9 | | * | | 10 | 20 | 1400.0 | 212, 210, 209, 201, 202, 203 | LTG |
| LTG | 114, 115, 116 | 2400.0 | 20 | 11 | | | * | 12 | 20 | 2400.0 | 207, 208 | LTG |
| LTG | 117, 118, 119, 120 | 720.0 | 20 | 13 | * | | | 14 | 20 | 800.0 | 204, 205, 206 | LTG |
| LTG | STAIR & CORR NIGHT | 1000.0 | 20 | 15 | | * | | 16 | 20 | 2240.0 | GYM | LTG |
| LTG | WEAPONS CLEANING COUNTER | 1000.0 | 20 | 17 | | | * | 18 | 20 | 750.0 | 130 | LTG |
| LTG | EXTERIOR | 890 | 20.0 | 19 | * | | | 20 | 20 | 500.0 | 131 | LTG |
| LTG | ELEV PIT | 100.0 | 20 | 21 | | * | | 22 | 20 | 390.0 | CORR C-4 | LTG |
| SPARE | | | 20 | 23 | | | * | 24 | 20 | | | SPARE |
| SPARE | | | 20 | 25 | * | | | 26 | 20 | | | SPARE |
| SPARE | | | 20 | 27 | | * | | 28 | 20 | | | SPARE |
| SPARE | | | 20 | 29 | | | * | 30 | 20 | | | SPARE |
| SUB-TOTAL | A PHASE | 5890.0 | | B PHASE | | | | | | 10430.0 | C PHASE | 11150.0 |
| TOTAL CONNECTED LOAD (WATTS) | | 27470.0 | | DEMAND LOAD | | | | | | 34337.5 | REQUIRED AMPACITY | 41.3 |

## New Panelboard Schedule

**PANELBOARD SCHEDULE**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | | TAG | | | | | | | TYPE PANEL | LTG | |
| MOUNTING | SURFACE | | LPTF1 | | | | | | | MIN AIC | 30K | |
| SIZE/TYPE BUS | 100A | | LOCATION | | | | | | | REMARKS | | |
| SIZE/TYPE MAINS | 100A | | ELEC RM | | | | | | | | | |
| LOAD DESCRIPTION | LOCATION | LOAD WATTS | C/B SIZE | POS NO | A PH | B PH | C PH | POS NO | C/B SIZE | LOAD WATTS | LOCATION | LOAD DESCRIPTION |
| LTG | 107 | 2953.0 | 20 | 1 | * | | | 2 | 20 | 1240.0 | 217, 216, 215, 214 | LTG |
| LTG | 103, 104, 105, 106 | 770.0 | 20 | 3 | | * | | 4 | 20 | 900.0 | 221, 220 | LTG |
| LTG | CORR, LOBBY | 1900.0 | 20 | 5 | | | * | 6 | 20 | 2700.0 | 218, 219, 211, 213 | LTG |
| LTG | ELEV RM | 70.0 | 20 | 7 | * | | | 8 | 20 | 900.0 | CORR | LTG |
| LTG | 114, 115, 116 | 2400.0 | 20 | 9 | | * | | 10 | 20 | 1400.0 | 212, 210, 209, 201, 202, 203 | LTG |
| LTG | 113, 109, 110, 108 | 1900.0 | 20 | 11 | | | * | 12 | 20 | 2400.0 | 207, 208 | LTG |
| LTG | 117, 118, 119, 120 | 720.0 | 20 | 13 | * | | | 14 | 20 | 800.0 | 204, 205, 206 | LTG |
| LTG | STAIR & CORR NIGHT | 1000.0 | 20 | 15 | | * | | 16 | 20 | 2393.0 | GYM | LTG |
| LTG | WEAPONS CLEANING COUNTER | 1000.0 | 20 | 17 | | | * | 18 | 20 | 750.0 | 130 | LTG |
| LTG | EXTERIOR | 3468.0 | 20 | 19 | * | | | 20 | 20 | 500.0 | 131 | LTG |
| LTG | ELEV PIT | 100.0 | 20 | 21 | | * | | 22 | 20 | 390.0 | CORR C-4 | LTG |
| SPARE | | | 20 | 23 | | | * | 24 | 20 | | | SPARE |
| SPARE | | | 20 | 25 | * | | | 26 | 20 | | | SPARE |
| LTG | 111 | 1621.0 | 20 | 27 | | * | | 28 | 20 | | | SPARE |
| SPARE | | | 20 | 29 | | | * | 30 | 20 | | | SPARE |
| SUB-TOTAL | A PHASE | 10651.0 | | B PHASE | | | | | | 10974.0 | C PHASE | 10650.0 |
| TOTAL CONNECTED LOAD (WATTS) | | 32275.0 | | DEMAND LOAD | | | | | | 40343.8 | REQUIRED AMPACITY | 48.5 |

| PANEL LPTF1 - CKT 16 | | | |
|---|---|---|---|
| **TAG** | **QUANTITY** | **AMPS / FIXTURE** | **TOTAL AMPS** |
| E | 12 | 0.12 | 1.44 |
| F | 4 | 2.4 | 9.6 |
| G | 4 | 0.18 | 0.72 |
| H | 4 | 0.19 | 0.76 |
| VOLTAGE | 277 | TOTAL AMPS | 12.52 |
| VA | | | 3468 |

## New Feeder Size

Panelboard LPTF1 is fed with (4) #8 AWG & (1) #8 AWG ground in 3/4" conduit.

# Branch Circuit Voltage Drop

| PANEL LPTF1 - CKT 19 | |
|---|---|
| Voltage | 277 |
| PF | 0.95 |
| Length | 150 |
| Wire Size | #12 |
| $V_{drop/(1000A*ft)}$ | 1.833 |
| Current (A) | 12.52 |
| Single Phase Mult. | 2 |
| $V_{drop/(L-N)}$ | 6.885 |
| % $V_{drop}$ | 2.49 |

# Resizing for Mechanical Breadth

The mechanical breadth portion of this report examined and redesigned the mechanical system for the firing range. The initial design utilized two air-handling units each supplying 33,000 cfm and powered by 50 hp motors. Ceiling diffusers placed at various locations down the range, supplied air to the range. In the interest of limiting swirling of air, which increases the likelihood of ingesting harmful lead particles that can cause lead poisoning, a mechanical redesign for the range was suggested. A diffusing wall located behind the shooting line, which supplies air from two air-handling units, was the basis of the proposed redesign. Calculations in the mechanical breadth section show that the system requires two air-handling units each supplying 42,000 cfm. The affinity laws were then applied to determine the appropriate hp of the motors powering the units.

$$\frac{HP1}{HP2}=\left(\frac{cfm_1}{cfm_2}\right)^3$$

$$\frac{50}{HP2}=\left(\frac{33{,}000}{42{,}000}\right)^3$$

$$HP_2 = 103\ hp$$

The motor should then be sized up to the next standard size. Therefore, a 125 hp motor was selected.

Full-load current (FLC) for each 125 hp motor powering AHU-1 and AHU-2 servicing the range was found in NEC Table 430.250. The two motors require 156A FLC each. Minimum circuit amps (MCA) were determined as 125% of FLC.

MCA = FLC * 125% = 156A * 1.25 = 195A

Wire sizing for the branch circuits was determined based on MCA using NEC Table 310.16. Each branch circuit will be served by (4) 3/0 AWG and (1) #3 AWG ground in 2" conduit.

Next, NEC Table 430.52 was used to determine the maximum overcurrent protective device (MOPD) rating based on the maximum percentage of full-load current for an inverse time circuit breaker.

MOPD = 156A * 250% = 156A * 2.50 = 390A (max)

The next smaller circuit breaker was selected. Circuits 7 and 8 serving AHU-1 and AHU-2 are protected by 350A 3-pole circuit breakers.

The new panelboard feeder size is determined using the required ampacity for the new panelboard schedule. Wire sizes are found from NEC Table 310.16. Panelboard MDP is now fed with 5 sets of (4) 400 MCM and (1) 4/0 AWG ground in 3" conduit.

Below are the original and updated schedules for Panelboard MDP. The highlighted portions of the panel are the circuits that have been adjusted to meet the mechanical breadth redesign.

## Original Panelboard Schedule

| PANELBOARD SCHEDULE | | | | | | |
|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | TAG | | | | |
| MOUNTING | SURFACE | MDP | | | | |
| SIZE/TYPE BUS | 1200A | LOCATION | | | | |
| SIZE/TYPE MAINS | 1200A | ELEC RM | | | | |
| TYPE PANEL | LTG | REMARKS | | | | |
| MIN AIC | 65K | | | | | |
| LOAD DESCRIPTION | LOAD KVA | C/B SIZE | POS NO | A PH | B PH | C PH |
| CU-5 | 97.27 | 125 | 1 | * | * | * |
| CU-4 | 97.27 | 125 | 2 | * | * | * |
| AHU-5 SUPPLY | 17.45 | 40 | 3 | * | * | * |
| AHU-5 RETURN | 9.15 | 20 | 4 | * | * | * |
| AHU-4 SUPPLY | 17.45 | 50 | 5 | * | * | * |
| AHU-4 RETURN | 9.15 | 20 | 6 | * | * | * |
| AHU-1 | 54 | 100 | 7 | * | * | * |
| AHU-2 | 54 | 100 | 8 | * | * | * |
| AHU-1 ELEC. HEAT | 60 | 125 | 9 | * | * | * |
| AHU-2 ELEC. HEAT | 60 | 125 | 10 | * | * | * |
| WATER HEATER DWH-1 | 54 | 90 | 11 | * | * | * |
| SPARE | | 100 | 12 | * | * | * |
| SPARE | | 50 | 13 | * | * | * |
| SPARE | | 20 | 14 | * | * | * |
| ATS TO DPTF (NORMAL) | 301.59 | 400 | 15 | * | * | * |
| ATS TO SBDP (NORMAL) | 237.72 | 400 | 16 | * | * | * |
| SPARE | | | 17 | * | * | * |
| SPARE | | | 18 | * | * | * |
| A PHASE | 356.4 | TOTAL CONNECTED LOAD (KW) | | | | 1069.1 |
| B PHASE | 356.4 | DEMAND LOAD | | | | 748.3 |
| C PHASE | 356.4 | REQUIRED AMPACITY | | | | 900.5 |

## New Panelboard Schedule

| PANELBOARD SCHEDULE | | | | | | |
|---|---|---|---|---|---|---|
| VOLTAGE | 480/277 | TAG | | | | |
| MOUNTING | SURFACE | MDP | | | | |
| SIZE/TYPE BUS | 1600A | LOCATION | | | | |
| SIZE/TYPE MAINS | 1600A | ELEC RM | | | | |
| TYPE PANEL | LTG | REMARKS | | | | |
| MIN AIC | 65K | | | | | |
| LOAD DESCRIPTION | LOAD KVA | C/B SIZE | POS NO | A PH | B PH | C PH |
| CU-5 | 97.27 | 125 | 1 | * | | |
| | | | | | * | |
| | | | | | | * |
| CU-4 | 97.27 | 125 | 2 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-5 SUPPLY | 17.45 | 40 | 3 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-5 RETURN | 9.15 | 20 | 4 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-4 SUPPLY | 17.45 | 50 | 5 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-4 RETURN | 9.15 | 20 | 6 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-1 | 161.93 | 350 | 7 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-2 | 161.93 | 350 | 8 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-1 ELEC. HEAT | 60 | 125 | 9 | * | | |
| | | | | | * | |
| | | | | | | * |
| AHU-2 ELEC. HEAT | 60 | 125 | 10 | * | | |
| | | | | | * | |
| | | | | | | * |
| WATER HEATER DWH-1 | 54 | 90 | 11 | * | | |
| | | | | | * | |
| | | | | | | * |
| SPARE | | 100 | 12 | * | | |
| | | | | | * | |
| | | | | | | * |
| SPARE | | 50 | 13 | * | | |
| | | | | | * | |
| | | | | | | * |
| SPARE | | 20 | 14 | * | | |
| | | | | | * | |
| | | | | | | * |
| ATS TO DPTF (NORMAL) | 301.59 | 400 | 15 | * | | |
| | | | | | * | |
| | | | | | | * |
| ATS TO SBDP (NORMAL) | 237.72 | 400 | 16 | * | | |
| | | | | | * | |
| | | | | | | * |
| SPARE | | | 17 | * | | |
| | | | | | * | |
| | | | | | | * |
| SPARE | | | 18 | * | | |
| | | | | | * | |
| | | | | | | * |
| A PHASE | 428.3 | TOTAL CONNECTED LOAD (KW) | | | | 1284.9 |
| B PHASE | 428.3 | DEMAND LOAD | | | | 1325.4 |
| C PHASE | 428.3 | REQUIRED AMPACITY | | | | 1596.1 |

# Energy Efficient Transformer Analysis

The purpose of this analysis is to determine the cost effectiveness of energy-efficient transformers over the standard transformers designated for the project when it was designed in 2002. Today's energy conscious society has many products are making a push toward being green and energy efficient, and transformers are no exception. When first on the market, energy efficient transformers had an added initial cost, but used less energy, often making them more cost effective in the long run. In 2005, an energy act, called Public Law 109-58, 2005 Energy Act, was passed which stated that "the efficiency of a low voltage dry-type distribution transformer manufactured on or after January 1, 2007, shall be the Class I Efficiency Levels for distribution transformers specified in table 4-2 of the 'Guide for Determining Energy Efficiency for Distribution Transformers' published by the National Electrical Manufacturers Association (NEMA TP-1-2002)."

An energy savings payback calculator supplied by Powersmith, a manufacturer of energy efficient transformers was utilized in the analysis to determine cost effectiveness of energy efficient transformers versus their predecessing standard type transformers. A summary of the cost analysis is provided below.

Three transformer sizes exist in the MdTA Police Training Facility:

1) 45 kVA
2) 75 kVA
3) 112.5 kVA

The facility will be primarily used during normal working hours, so it has been estimated that the facility is operational 12 hours a day, 260 days of the year. The percent of the available full load kW that is used during normal operating hours and outside operating hours was estimated at 30% and 10% respectively.

Based on this analysis, installation of energy efficient transformers instead of standard transformers will result in a 4% reduction in the annual estimated electric bill. The annual operating cost savings would be $1,480. A 20 year life cycle cost analysis yields a savings of $53,451 and a 32 year life cycle cost analysis yields a savings of $121,934. The Powersmith calculator also shows that the system will pay for itself in 6.04 years.

Energy efficient transformers are an excellent addition to the building industry. The cost savings as displayed by this analysis can be substantial, and the total energy and resource savings has major benefits for the world in which we live.

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# The ESP Calculator™

*Energy Savings Payback Calculator*

| | |
|---|---|
| **Project Description** | **new project** |
| **Date** | **1-Mar-07** |

*Data Entry*

**Transformers on Project**

| QTY | kVA |
|---|---|
| | 15 |
| | 30 |
| 1 | 45 |
| 1 | 75 |
| 1 | 112.5 |
| | 150 |
| | 225 |
| | 300 |
| | 500 |
| | 750 |
| | 1000 |
| | 1500 |
| | 2000 |
| | 7.5 |

| | | | |
|---|---|---|---|
| **Available Full Load kW** | **232.5** | | |
| Average kVA (calc) | **78** | | |
| equipment operating hrs/ day | **12** | | |
| equipment operating days/yr | **260** | Calc Load kW | Calc Annual kWh |
| Load during normal operating hours | **30%** | 70 | 217,620 |
| Load outside operating hours | **10%** | 23 | 131,130 |
| | | **Total Annual Load kWh:** | **348,750** |

**Annual Cost to Operate Load Only**

| | | | | |
|---|---|---|---|---|
| kWh rate | $ 0.100 | Annual Consumption: | $ | 34,875 |
| demand rate ($/kW/mo) ex. $10.00 | $0.00 | Annual Demand: | $ | - |
| | | **Total Cost to run load** | **$** | **34,875** |

***Annual Cost of Status Quo Transformer Losses & Associated Air Conditioning (A/C) burden***

| | | |
|---|---|---|
| Status quo Efficiency (Normal Operation) | 97.0% | |
| Transformer kW Losses (Normal Operation) | 2.2 | kW |
| Status quo Efficiency (Outside op. hrs) | 92.0% | |
| Transformer kW Losses (Outside op. hrs) | 2.0 | kW |
| Annual addititional kWh from transformers | 18,133 | kWh |
| **Annual Cost of Transformer Losses** | $ 1,813 | |
| A/C System Performance (kW/ton) | 1.25 | |
| Additional Tons of Cooling (on peak) | 0.61 | tons |
| Annual addititional kWh from A/C | 6,439 | kWh |
| **Annual Cost of Associated A/C** | $ 644 | |

**Summary with Status Quo Transformer**

| | | |
|---|---|---|
| Annual Cost of feeding Building Load | $ | 34,875 |
| Annual Cost of Transformer Losses | $ | 1,813 |
| Annual Cost of Associated A/C | $ | 644 |
| **Electrical Bill (Status Quo Transformer)** | **$** | **37,332** |


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## The ESP Calculator™

*Energy Savings Payback Calculator*

### *Using Powersmiths instead of status quo transformers*

| | | |
|---|---|---|
| Powersmiths Efficiency (Normal Operation) | 98.2% | |
| Powersmiths kW Losses (Normal Operation) | 1.3 | kW |
| Powersmiths Efficiency (Outside op. hrs) | 97.6% | |
| Transformer kW Losses (Outside op. hrs) | 0.6 | kW |
| Annual addititional kWh from transformers | 7,213 | kWh |
| **Annual Cost of Powersmiths Losses** | $ 721 | |
| Additional Tons of Cooling (on peak) | 0.36 | tons |
| Annual addititional kWh from A/C | 2,562 | kWh |
| **Annual Cost of Associated A/C** | $ 256 | |

### *Comparing Status Quo & Powersmiths*

| | Status Quo | Powersmiths | |
|---|---|---|---|
| Annual Cost of feeding Building Load | $ 34,875 | $ 34,875 | |
| Annual Cost of Transformer Losses | $ 1,813 | $ 721 | |
| Annual Cost of Associated A/C | $ 644 | $ 256 | **Reduction** |
| **Annual estimated Electrical Bill** | $ 37,332 | $ 35,853 | **4%** |

| | | |
|---|---|---|
| **Peak kW reduction (normal op hours)** | **0.9** | **kW** |
| **Annual kWh reduction** | **14,797** | **kWh** |
| **Reduction in Air Conditioning Load (on peak)** | **0.25** | **tons** |

### *Cost Analysis (calc)*

| | |
|---|---|
| Energy Cost Escalation (above inflation) | 3.0% |
| Annual Power Quality Benefit | $ - |

| | Annual Operating Cost | Life Cycle Operating Cost & Savings | |
|---|---|---|---|
| | | 20 years | 32 years |
| Status Quo Transformers | $2,457 | $88,761 | $202,483 |
| Powersmiths Transformers | $978 | $35,310 | $80,549 |
| ***Savings with Powersmiths*** | **$1,480** | **$53,451** | **$121,934** |

### *Cost*

| | Cost |
|---|---|
| Powersmiths Transformers | $34,491 |
| Status Quo Transformers | $25,549 |

### *Payback on total cost*

| | | | |
|---|---|---|---|
| | 6.04 | years | current kWh rate: |
| **Cost of Energy Savings** | $ 0.019 | /kWh | $0.100 |
| **Cost - Benefit Ratio** | 5.3 | times less to save a kWh than to buy a kWh | |

### *Leasing Option*

| | 60 Month Term | 48 Month Term | 36 Month Term |
|---|---|---|---|
| ***Total Annual Leasing Payments*** | **$6,460** | **$7,879** | **$10,025** |
| ***Net Annual Cost with savings*** | $4,980 | $6,400 | $8,546 |

### *Summary of Environmental Benefits*

| Annual Reduction in Greenhouse Gases (per EPA) | Equivalence |
|---|---|
| 11 tons of CO2 | 2 Acres trees planted |
| 35 tons of Coal | 1 Car Emissions |
| 86 kgs of SO2 | 1 homes heated |
| 37 kgs of NOx | |



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**The ESP Calculator™**
*Energy Savings Payback Calculator*

**Status Quo Transformer (Normal Operation)**

Enter the average efficiency of the transformers. This data is supplied by manufacturers and is based on linear load test.
Typical values for efficiency are in the 93-95% range for 15-45kVA, 95-97% range for 75-112.5kVA
and smaller, and 96-97.5% for 150 to 300kVA, and 97-98% for 300-500kVA transformers.

**Status Quo Transformer (Outside Op. hours)**

Transformer efficiency is typically lower than normal when lightly loaded (86-89% when 10-15% loaded for most sizes)

**A/C Performance (kW/ton)**

Varies widely depending on age and technology of cooling system. As low as 0.5 to over 2kW/ton (1.25-1.5 is often tp)
Unlike most substation transformers that are vented to the exterior, most building distribution transformers
are ventilated within the building, and their heat losses therefore add to the cooling load.

**Powersmiths Efficiency (Normal Operation) & (Outside Op. hours)**

Available on Powersmiths product data sheet

**Energy Cost escalation (above inflation)**

It is well recognized that energy rates are increasing much faster than inflation. Enter the % over inflation

**Annual Power Quality Benefit**

Savings attributable to reduced downtime, equipment locks & failures associated with poor power quality

**Cost of Energy Savings**

In its simplest form, the cost of energy savings represents the cost to save
a kWh as opposed to paying for it according to the prevailing kWh rate.

The equation is: Cost of Energy Savings = (Incremental Product Cost / Lifetime kWh saved)
This does not include any additional savings as energy rates go up over the installed product life

**Transformer Operating Losses**

Transformer Losses = kW load/net efficiency - kW load.

**% load left ON, outside of normal operating hours**

Typically 50-70% of normal load remains on during off-hours operation, also transformer remains energized 24hrs/day.

**Cost**

Cost of transformers. Enter dollar figure for transformers under consideration. If the interest is to look at the justification
for replacing existing transformers, enter $0 in the conventional transformer cost field.

**Energy Operating Cost**

Energy OPERATING COST (normal op) = (transformer + cooling) kW losses x kWh rate x hrs/day x days/yr + demand charge
Demand charge is not included in the calculation of losses outside normal hours to be conservative.

**Return on Investment (ROI)**

ROI on Incremental Cost is based on dividing the Incremental Investment in Powersmiths by the Annual Savings
ROI on Total Transformer Cost is based on dividing the Total Transformer Cost by the Annual Savings

**Leasing**

Powersmiths Leasing has many benefits, including avoiding the use of capital, offsetting monthly leasing payment with
the reduction in monthly energy bill from using Powersmiths

**Environmental Benefits**

Conversion rates from kWh to emission reduction and equivalent benefits are published by the EPA,
and reflect environmental benefits derived from reduced emissions associated with reduced power generation.

**TERMS OF USE**

Power Quality Institute has used its best efforts in developing the ESP Calculator ™ with the intent of providing an easy
to use and useful calculation tool. However, data entered and assumptions made may not accurately reflect all variables
that apply in a given facility. The results are therefore estimates only and may differ from actual measurements.
The user is responsible for evaluating the suitability and accuracy of the ESP Calculator ™. The Power Quality Institute
and Powersmiths International Corp. make no representations or warranties with respect to the accuracy or
completeness of the estimates generated by the ESP Calculator ™ and specifically disclaim any implied warranties of
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to special, incidental, consequential or other damages.

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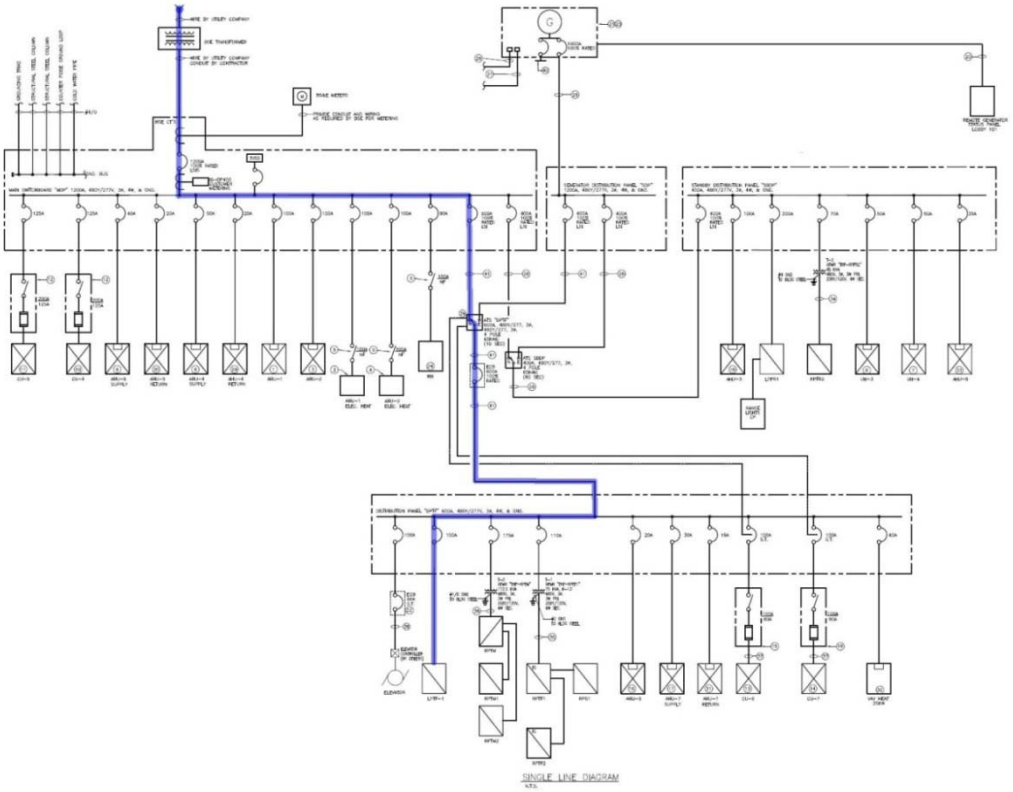
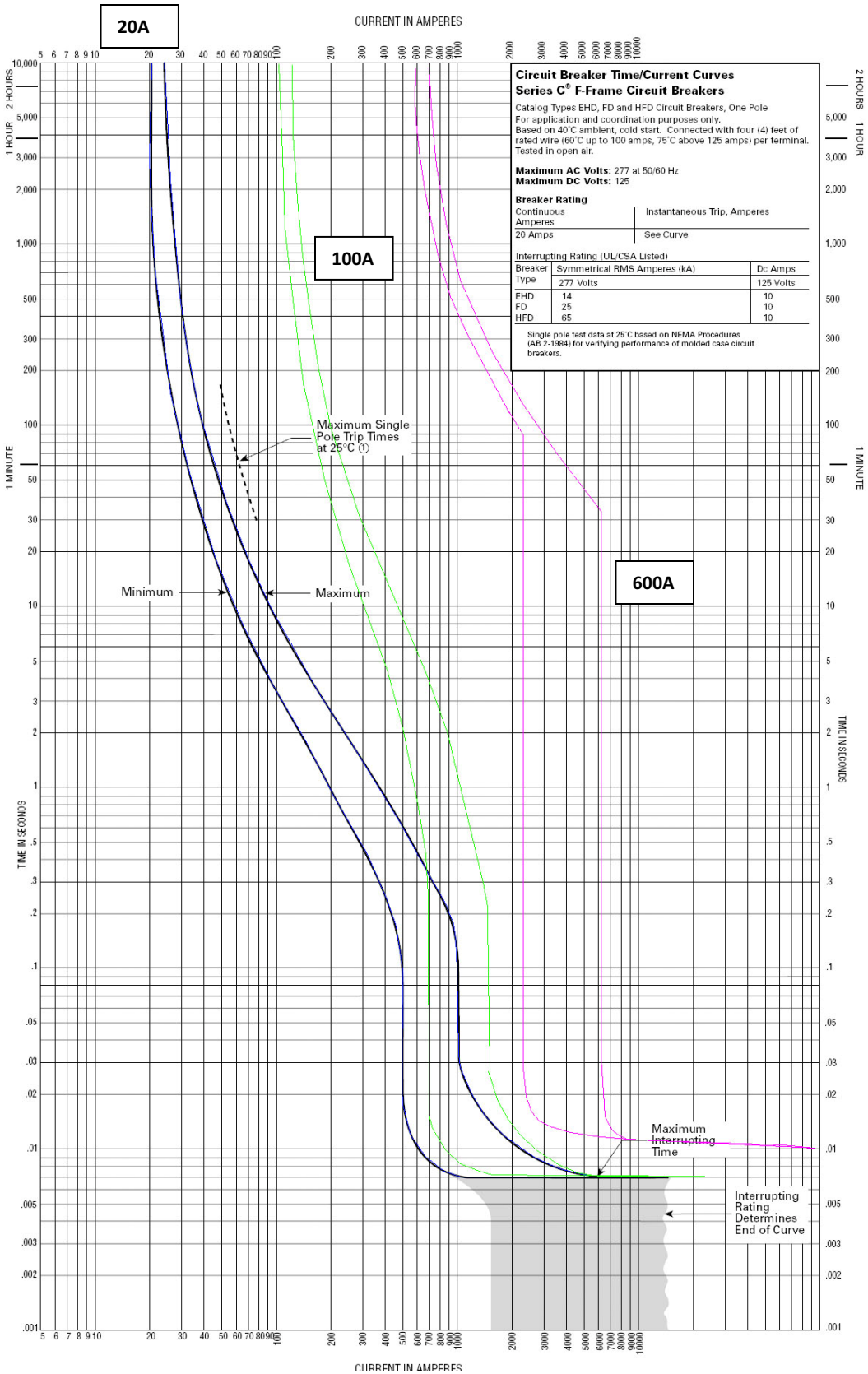
# Protective Device Coordination Study

A single-path through the distribution system was selected to conduct a protective device coordination study. The path starts on the primary side of the utility transformer and continues through the main distribution panel all the way to a local lighting panel. The same path was used for both the overcurrent coordination study and the short circuit current analysis. The single-line diagram below shows the selected path.




Below are the circuit breaker trip curves for the 600A, 100A, and 20A circuit breakers on the path above. With the curves superimposed on the same graph, coordination among the breakers can be determined. As should occur, the further out on the path the circuit breaker is, the sooner it should trip if overcurrent is experienced, meaning the 20A circuit breaker will trip before the 100A circuit breaker which will trip before the 600A circuit breaker. At higher currents, there is some overlap between the 20A and 100A breakers. This will result in a race between the breakers as to which will trip first. However, it is unlikely that these high currents will be experienced, and normally the 20A breaker will trip first.


20A
100A
600A
CURRENT IN AMPERES
TIME IN SECONDS
2 HOURS
1 HOUR
1 MINUTE
Circuit Breaker Time/Current Curves
Series C® F-Frame Circuit Breakers
Catalog Types EHD, FD and HFD Circuit Breakers, One Pole
For application and coordination purposes only.
Based on 40°C ambient, cold start. Connected with four (4) feet of rated wire (60°C up to 100 amps, 75°C above 125 amps) per terminal.
Tested in open air.
Maximum AC Volts: 277 at 50/60 Hz
Maximum DC Volts: 125
Breaker Rating
Continuous Amperes | Instantaneous Trip, Amperes
20 Amps | See Curve
Interrupting Rating (UL/CSA Listed)
Breaker Type | Symmetrical RMS Amperes (kA) 277 Volts | Dc Amps 125 Volts
EHD | 14 | 10
FD | 25 | 10
HFD | 65 | 10
Single pole test data at 25°C based on NEMA Procedures (AB 2-1984) for verifying performance of molded case circuit breakers.
Maximum Single Pole Trip Times at 25°C ①
Minimum
Maximum
Maximum Interrupting Time
Interrupting Rating Determines End of Curve

# Short Circuit Analysis

The following short circuit analysis follows the path in the single-line diagram above. The short circuit current at each point was calculated using the spreadsheet shown below. Resulting short circuit current for each point being considered can be seen under the respective heading.

| Input Data | |
|---|---|
| Base KVA | 750 |
| System Votage | 480 |

**Utility Primary**

| Input Data | |
|---|---|
| Transformer KVA | 1000 |

| | |
|---|---|
| Utility S.C. KVA | 1000000 |
| Utility per unit Z | 0.00075 |

**Utility Transformer Secondary**

| | |
|---|---|
| Transformer X% | 5.347175 |
| Transformer R% | 2.246712 |

| | |
|---|---|
| Transformer per unit X | 0.040104 |
| Transformer per unit R | 0.01685 |
| Sub-total per unit X | 0.040854 |
| Sub-total per unit R | 0.01685 |
| Transformer per unit Z | 0.044192 |
| $I_{s.c.\ rms\ sym}$ | 20413.23 |

**MDP**

| Input Data | |
|---|---|
| Wire Size | 500 |
| Number of Sets | 1 |
| Length of Wire (ft) | 15 |

| | |
|---|---|
| Transformer X% | 0.000441 |
| Transformer R% | 0.000699 |

| | |
|---|---|
| Transformer per unit X | 0.001436 |
| Transformer per unit R | 0.002275 |
| Sub-total per unit X | 0.042289 |
| Sub-total per unit R | 0.019126 |
| Transformer per unit Z | 0.046413 |
| $I_{s.c.\ rms\ sym}$ | 19436.5 |

| DPTF | | | |
|---|---|---|---|
| Input Data | | | |
| Wire Size | 3/0 | | |
| Number of Sets | 1 | | |
| Length of Wire (ft) | 325 | | |
| Transformer X% | 0.026163 | Transformer per unit X | 0.085164 |
| Transformer R% | 0.016868 | Transformer per unit R | 0.054907 |
| | | Sub-total per unit X | 0.127454 |
| | | Sub-total per unit R | 0.074033 |
| | | Transformer per unit Z | 0.147395 |
| | | $I_{s.c.\ rms\ sym}$ | 6120.348 |

| LPTF-1 | | | |
|---|---|---|---|
| Input Data | | | |
| Wire Size | 1/0 | | |
| Number of Sets | 1 | | |
| Length of Wire (ft) | 30 | | |
| Transformer X% | 0.002415 | Transformer per unit X | 0.007861 |
| Transformer R% | 0 | Transformer per unit R | 0 |
| | | Sub-total per unit X | 0.135315 |
| | | Sub-total per unit R | 0.074033 |
| | | Transformer per unit Z | 0.154243 |
| | | $I_{s.c.\ rms\ sym}$ | 5848.609 |

Tables shown below were used in the calculation of short circuit current.

| General Purpose Transformer Standard Three-Phase | | |
|---|---|---|
| kVA | Avg % Z | Avg X/R |
| 15 | 3.6 | 1.94 |
| 30 | 6.4 | 0.92 |
| 45 | 6.6 | 1.13 |
| 75 | 5.7 | 1.38 |
| 112.5 | 6.1 | 1.51 |
| 150 | 5.5 | 1.53 |
| 225 | 6.6 | 2 |
| 300 | 3.6 | 1.81 |
| 500 | 5 | 2.89 |
| 750 | 5 | 1.98 |
| 1000 | 5.8 | 2.38 |

| Cable Impedance Data 600V and 5kv Non-shielded in Metal Duct | | | |
|---|---|---|---|
| Wire Size | X | R | Z |
| 8 | 0.811 | 0.0754 | 0.814 |
| 6 | 0.51 | 0.0685 | 0.515 |
| 4 | 0.321 | 0.0632 | 0.327 |
| 2 | 0.202 | 0.0585 | 0.21 |
| 1 | 0.16 | 0.057 | 0.17 |
| 1/0 | 0.128 | 0.054 | 0.139 |
| 2/0 | 0.102 | 0.0533 | 0.115 |
| 3/0 | 0.0805 | 0.0519 | 0.0958 |
| 4/0 | 0.064 | 0.0497 | 0.081 |
| 250 | 0.0552 | 0.0495 | 0.0742 |
| 300 | 0.0464 | 0.0493 | 0.0677 |
| 350 | 0.0378 | 0.0491 | 0.0617 |
| 400 | 0.0356 | 0.049 | 0.0606 |
| 450 | 0.0322 | 0.048 | 0.0578 |
| 500 | 0.0294 | 0.0466 | 0.0551 |