Mechanical Breadth

Lead exposure and the potential for lead poisoning is a major concern in the firing range. There are many sources of lead dust and fumes in a firing range, including the bullet primer, vaporization and fragmentation of the bullet, and "side blast," dust and fumes blown at a 90^0 angle from the gun due to extreme temperature and pressure. Health and safety are obviously of high importance, and, therefore, minimizing the risk of lead exposure and poisoning is worth striving for.

Occupational Health and Safety Administration (OSHA) standards require airborne lead containment levels to be below 0.20 mg/m^3. The following suggestions for minimizing lead exposure have been made by the National Institute for Occupational Safety and Health (NIOSH).

- High Efficiency Particulate (HEPA) filters should be used to filter all air being exhausted from the firing range.
- High efficiency heating and cooling coils lower the interference with air flow balance.
- A minimum of 50 fpm should be maintained at the firing line.
- Optimum ventilation rate is 75 fpm at the firing line.
- Air should be distributed at least 15 feet behind the shooter with the supply air inlets place on the back wall.
- The range should have a dedicated ventilation system so as not to contaminate other spaces in the building.
- Supply and return air systems should be electrically interlocked so that one can not be in use without the other.

Existing (Conventional) System

The original design for the MdTA was designed but never built. Mechanically, the system has a conventional approach to ventilating the space. Supply diffusers were specified to be installed in the ceiling sporadically down the length of the range. However, the entry of air in these down range locations would cause turbulence and swirling of the air, which would kick up more dust and lead particles. It could even cause the air to flow toward the shooters instead of away from them toward the exhaust system, carrying the harmful particles into closer proximity with the occupants.

Proposed Solution

The proposed solution is to install a diffusing wall on the rear wall behind where the shooters stand. The wall would consist of a wide wall with sealed CMU, a 2' gap for air to be supplied to the wall, and stacked 2'x4' louvers creating a wall system that would supply air to the range area. By supplying air at a low velocity, low turbulence air is able to move down the lanes, away from the shooters, carrying the harmful dust and lead particles with it. Another advantage of this type of system is that not as much cooling of the air will be necessary. The air is supplied just behind where the occupants of the space will be. Even though this is a large room, the air only needs to be conditioned for the area where occupants will be. The air will heat up from the occupant latent load, the firing of the guns, luminaires, and target equipment as it moves down the range, but if only needs to be cooled to meet the load within the first 30' of the space (not the whole 110'). This will save energy on cooling energy and associated costs.

Required Cubic Feet per Minute

The goal is to have 75 fpm of air moving along the space. The cfm required by this system can be determined with this velocity and the cross-sectional area of the space.

$$Q = vA = (75\ ft/min)*(100ft)*(11ft) = 82{,}500\ ft^3/min$$

To create the diffusing wall system, 2'x4' louvers will be stacked the length and height of the wall. The bulkhead on the rear wall will be removed to allow for full wall area to be used as a diffusing wall.

Air-Changes per Hour

To ensure that enough air is being circulated to promote a healthy environment, the number of air changes per hour (ACH) was computed. ACH represents the number of times in an hour that the total volume of the space is exchanged with fresh or filtered air (www.energyvortex.com).

$$ACH = Q * V = (82{,}000\ cfm)*(60min/hr)/(121{,}000\ ft^3) = 40.7\ ACH$$

40.7 ACH is more than enough to adequately ventilate the space and will definitely meet the ASHRAE requirements.

Sizing of the Motor

If I were performing a true mechanical design, a mechanical equipment sales representative would be contacted at this point to assist in the selection of air-handling unit equipment. However, for the purpose of this simplified design, the affinity laws were used to determine the required motor power. The equations below show the affinity law calculations for motor sizing.

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

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

$$HP_2 = 103\ hp$$

The motor should then be sized up to the next standard size. Therefore, a 125 hp motor was selected. This motor size can now be used to determine what changes must be made to the electrical design. Please refer to the electrical depth portion of this report to view the continued effect of the proposed mechanical solution on other systems of the building.