Engine Room Ventilation Calculations

Ventilating Heat Exchanger cooled engines.

A heat exchanger (Figure 1) cooling system is typically selected because of because the air flow restriction through long ducts would be greater than that allowed for the engine-driven radiator fan.

Consider the following: Ventilating fans are not preferred for providing cooling and combustion air for the fire pump engine room. This is because electric ventilating fans could loose power in the event of a fire. This will require larger ventilation openings than would have normally been used for powered ventilation. See the following example calculation for a method of determining the airflow required for ventilation.

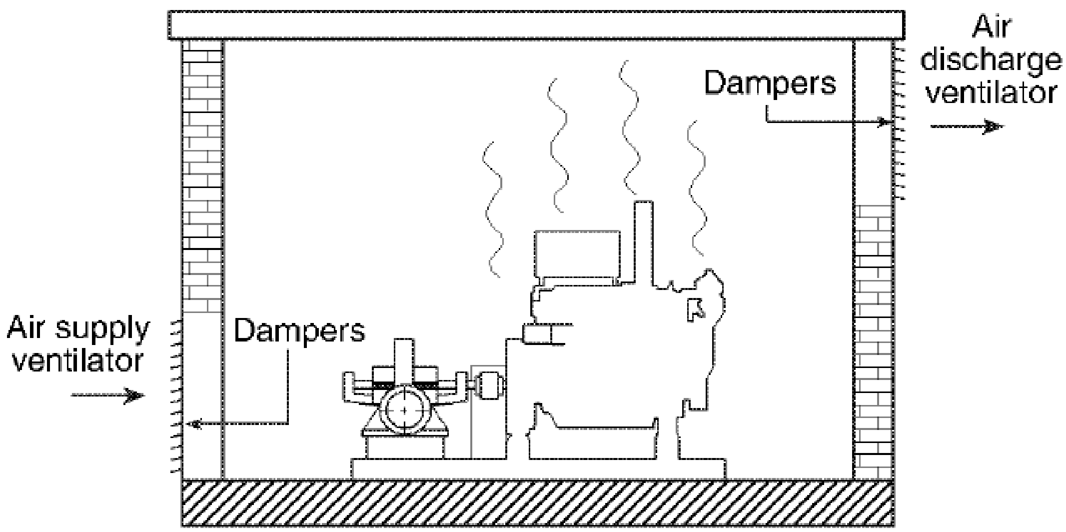

Figure 1. Typical Ventilation System for a Heat Exchanger-Cooled Diesel-Driven Pump.

Air Flow Calculations

The required air flow rate to maintain a specific temperature rise in the fire pump room is described by the formula: Where:
m = Mass flow rate of air into the room; ft3/min (m3/min)
Q = Heat rejection into the room from the engine and other heat sources; BTU/min (MJ/min).
cp = Specific heat at constant pressure; 0.241 BTU/lb- ^{O} F (1.01~10-~ MJ/kg-^{O} C).
ΔT = Temperature rise in the fire pump engine room over outdoor ambient; ^{O}F (^{O}C).
d = Density of air; 0.0754 lb/ft^3 (1.21 kg/m^3).
Which can be reduced to:

$$m = \frac{Q}{0.241 * 0.0754 * \Delta T} = \frac{55.0Q}{\Delta T} \text{ (ft}^3\text{/min)}$$

OR:

$$m = \frac{Q}{(1.01 * 10^3) * 1.21 * \Delta T} = \frac{818Q}{\Delta T} \text{ (m}^3\text{/min)}$$

The total airflow required in the room is the calculated value from this equation, plus the combustion air required for the engine.

In this calculation the major factors are obviously the heat radiated by the fire pump engine (and other equipment in the room) and the allowable maximum temperature rise. Since the heat rejection to the room is fundamentally related to the HP produced by the fire pump engine and that rating is controlled by building water flow demand, the major decision to be made by the designer regarding ventilation is what allowable temperature rise is acceptable in the room.

Example Ventilating Air Flow Calculation:
The recommended fire pump Specification Sheet indicates that the heat radiated to the room from the fire pump engine is 4,100 BTU\min. The muffler and 10 feet of 5-inch diameter exhaust pipe are also located inside the fire pump room. Determine the airflow required to limit the air temperature rise to 30° F.

1) Add the heat inputs to the room from all sources. Table-1 indicates that the heat loss from 5 inch exhaust pipe is 132 BTU/min per foot of pipe and 2,500 BTU/min from the muffler. Add the heat inputs to the room as follows:

   - Heat rejection from fire pump engine 4,100
   - Heat from Exhaust Pipe-10 x 132=1,320
   - Heat from Muffler 2.500
   - Total Heat to Fire Pump Room (BTU/Min) 7,920

2) The required airflow to account for heat rejection in the room is proportional to the total heat input divided by the allowable room air temperature rise.

$$m = \frac{55*7920}{30} = \mathbf{14,520\ ft^3/min}$$

Add the CFP calculation for heat rejection to the CFM the engine needs for combustion. This CFM calculation can be provided to the louver supplier so they can provide a size recommendation.

Pipe Diameter Inches (mm)		Heat From Pipe BTU/MIN-Foot (kJ/Min-Meter)		Heat From Muffler BTU/MIN (kJ/Min)	
10.5	(38)	47	(162)	297	(313)
2	(51)	57	(197)	490	(525)
2.5	(64)	70	(242)	785	(828)
3	(76)	84	(291)	1,100	(1,160)
3.5	(98)	96	(332)	1,408	(1,485)
4	(102)	108	(374)	1,767	(1,864)
5	(127)	132	(457)	2,500	(2,638)
6	(152)	156	(540)	3,550	(3,745)
8	(203)	200	(692)	5,467	(5,768)
10	(254)	249	(862)	8,500	(8,968)
12	(305)	293	(1,014)	10,083	(10,638)

Table 1. Heat Losses from Uninsulated Exhaust Pipes and Mufflers

Field Testing of Ventilation Systems
Since it is difficult to test for proper operation, one factor to view in system testing is the temperature rise in the room under actual operating conditions, vs. the design temperature rise. If the temperature rise at full load and lower ambient temperatures is as predicted, it is more probable that it will operate correctly at higher ambient and load levels.

The following procedure can be used for preliminary qualification of the ventilation system design:

1. Run the fire pump engine at full load long enough for the engine coolant temperature to stabilize. This will take approximately 1 hour.
2. With the fire pump engine set still running at rated load, measure the ambient air temperature of the fire pump room at the air cleaner inlet.
3. Measure the outdoor air temperature (in the shade).
4. Calculate the temperature difference between the outdoor temperature and the fire pump room.
5. Verify that the design temperature rise of the room is not exceeded, and that the maximum top tank temperature of the engine is not exceeded.

If either the design temperature rise or top tank temperature is exceeded, more detailed testing of the facility or corrections in the system design will be required to verify proper system design.