

Fig. 11 Air Distribution for a Subway Car

and liquid line piping is approximately fifty feet on a typical coach. Since the compressor and condenser are usually close together, the hot gas line is generally not over 15 ft in length. Flexible tube connections are used on all piping to units that are resiliently mounted. It is common practice to run the liquid and suction line together even though a heat exchanger is used. Good design calls for using an oversized filter-drier in the liquid line. The problems of servicing in most railroad yards makes it difficult to prevent dirt and moisture from getting into the system when making minor repairs.

Where water is used such as on the steam jet system and on evaporative condensers, special precautions must be taken to prevent freezing. In this case thermostatic dump valves drain the units when the temperature drops below 42 F. The water supply piping, fittings and valves are usually located in a steam heated enclosure at one end of the car water storage tank.

Fig. 12 shows a schematic piping diagram of a typical direct expansion 8 ton component air-conditioning system for a railroad passenger car. The system shown uses an evaporative condenser but an air-cooled condenser would be piped the same except for the water lines and tank.

CONTROL REQUIREMENTS

The temperature control presently used generally consists of two mercury type thermostats in the body of the car or in the return air stream. The thermostats are connected to the air conditioning control panel. This panel contains the necessary

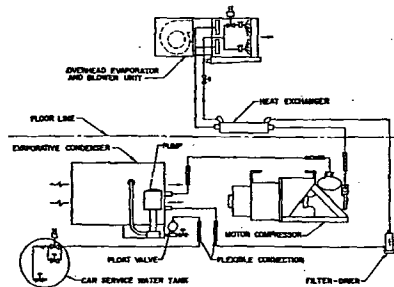


Fig. 12 Piping Diagram for Typical 8-ton Direct Expansion System

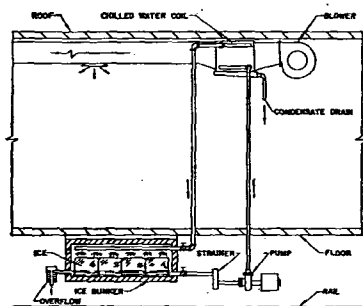


Fig. 13 Ice Activated System

switches, relays and fuses to actuate the motors and valves on the systems. Once the system is turned on, it automatically maintains the car temperature at the settings of the thermostats. Usually a 78 F and a 76 F thermostat are used in conjunction with a 50 percent split evaporator coil and an unloading compressor or a two-speed compressor. On pull-down and during heavy loading the full capacity of the system is in operation. When the inside temperature reaches 78 F the thermostat operates a liquid line solenoid valve and cuts out 50 percent of the evaporator coil. On a two-speed compressor it drops the compressor speed to approximately half speed. The system continues to operate at half capacity until the lower thermostat is satisfied and then the system with the exception of the blower fan cycles on and off to maintain the 76 F temperature. The electrical control circuit is generally d.c. voltage; however, a.c. voltage is also used where a 220/440 volt system is in use.

The control of an ice activated cooling system is done simply by starting and stopping the cold water pump by means of a thermostat and relay.

On a steam jet system, control is obtained by a single thermostat actuating a motorized steam valve in the main steam supply line to the ejector nozzle. The cold water pump runs continually.

When an engine driven compressor is used, control is obtained by modulating the engine speed in response to the thermostats.

Over the years many variations of the above control have been used. However, tests indicate that acceptable conditions of temperature and humidity are obtained by using the split evaporator and balancing the load with an unloading compressor or two-speed compressor motor.

TYPES OF SYSTEMS

Several hundred ice cooled systems are still in service on American railroads. They are used primarily during peak passenger loads such as on summer holidays and special excursion trains.

In the ice cooled system water is sprayed over the ice located in large ice bunkers beneath the car. The chilled water is pumped up to the cooling coil in the ceiling where the blower fans are also located. Control is obtained by starting and stopping the circulating pump. Fig. 13 shows a schematic diagram of this system. It is important that the pump be protected by a large strainer because of the dirt that is introduced into the system by the loading of the ice bunkers. The power

for the direct current pump and blower motors is usually obtained from the car lighting generator.

The *axle driven system* also known as the mechanical drive system, is still in use on some railroads, but no new installations are being made. Briefly, the system consists of a drive from the axle to an electric torque converter or constant speed control which in turn drives the compressor and condenser fans. The direct current power for the torque converter, blower fans and controls is obtained from the car lighting generator. The disadvantage of this system is that no cooling is available until the car speed reaches 20 mph. For pre-cooling the cars in the yard an alternating current motor is used to run the compressor and condenser fan. The d.c. power for the blower is provided by the car batteries when the car is not moving.

At the present time some 2000 cars are still cooled by the *steam ejector type system*. This system uses water as the refrigerant. Steam is obtained from the high pressure steam heating boilers on the diesel engines. The high pressure train line steam is reduced to 45 lb and passed through the ejector nozzle connected to the evaporator tank. The low vacuum obtained (0.178 psia) cools the water in the evaporator tank to 50 F. This water is then pumped up to the cooling coil, similar to the ice activated system. Fig. 14 shows a complete schematic diagram of the steam jet system. To maintain the proper condensing pressure and to conserve water, an evaporative condenser is used. As can be seen from the diagram other auxiliaries are used such as the condenser purge ejector, steam traps, drain traps and check valves.

The *steam jet system* had certain advantages before the event of the diesel locomotive. The power required from the car axle was much less than for other systems, thus requiring less drawbar pull from the locomotive to pull the train. Plenty of steam was available at all times from the steam locomotive. From a maintenance and service standpoint the railroad people were already familiar with steam and water systems, whereas the direct expansion refrigerant system was all new to them. The primary disadvantage of the steam jet system is that steam is not available at all times.

The *engine-driven compressor system* has the decided advantage of not taking any power from the axle. The system is self-contained and the air conditioning can operate at any time or place. Normally the refrigeration compressor is driven either by a Diesel or propane gas internal combustion engine. The air-cooled condenser is usually part of the unit. Both the condenser fan and the compressor are belt driven from the main engine shaft. For a 7 ton system a 20 hp (net) engine is used. Some of the disadvantages of this system are the problem of refueling each car and the maintenance and service required on the engines.

The *electro-mechanical system* today is the most common and accepted system for air conditioning a railroad passenger car, when either d.c. or a.c. power is used. The d.c. power is ob-

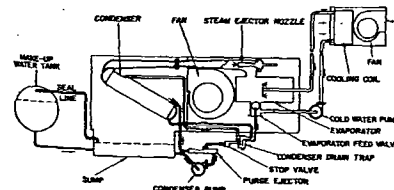


Fig. 14 Steam-jet System

tained from an axle driven generator on each car or in some cases from an engine driven generator. This same generator supplies power for the lights, controls and other auxiliaries on the car. For commuter cars the power is taken from the third rail or from the overhead power lines.

In practically all installations where d.c. power is used, the air conditioning system consists of a direct driven motor-compressor unit, an air-cooled condenser, and an overhead evaporator and blower unit. When more than eight or nine tons are required, multiple units are used. A single unit would be more economical but space does not permit the larger units.

Before the event of the modern V-type high speed compressor, most installations used a low speed (580 rpm) belt driven compressor. As a result, many of the belt driven compressors are still in use. The four cylinder compressor is usually provided with cylinder unloading and operates at 1750 rpm, depending on the design of the system.

Refrigerant 12 is standard on the American railroads, however, some Refrigerant 22 and Refrigerant 500 is used for special cases. The higher operating pressures of these refrigerants and the stocking and handling of more than one refrigerant at service points on the railroads create additional problems.

The trend today is to use an air-cooled condenser rather than an evaporative condenser. The air-cooled condenser results in high power consumption, but the advantages of getting rid of the water problems, spray pumps and extra weight more than offset the increased power. In some geographical areas where high ambient dry-bulb temperatures (120 F) are common, it is advisable to use the evaporative condenser. The space problem beneath the car has resulted in the use of an 8 row, 3/4 in. O.D. tube coil design. The severe dirt problem prevents the use of coils with a fin spacing of more than 8 fins per inch. Design saturated condensing temperatures at 100 F ambient are usually in the range of 130 F to 140 F with Refrigerant 12. When an evaporative condenser is used the corresponding condensing temperature would be around 115 F. Experience has shown that aluminum fins should not be used on condenser coils when located below the floor because of the corrosion problems. For an 8 ton air-cooled condenser, the fan horsepower is approximately 1.5 hp.

The overhead evaporator and blower unit because of the lack of space in the ceiling must be designed with a minimum of height. Usually two double inlet double width centrifugal fans mounted on a double shafted motor are used to deliver 2400 cfm at 1.5 in. static pressure for an 8 ton system. The evaporator coil is usually an 8 row coil with a face area designed to maintain a face velocity of approximately 550 fpm. Any water carry-over on the coil should be prevented. Two thermal expansion valves are normally used to provide modulation control with a solenoid controlling the upper half of the coil. The overhead heating coil is also a part of this unit and good practice calls for providing a condensate drain pan under both the evaporator coil and heating coil.

The motor starter panel for the compressor, condenser and blower fan motors is normally located in the car electrical locker.

Some d.c. self-contained units have been designed and are in service, but size and weight prevent their use on most cars. These units usually use the same or similar coils, compressor and auxiliaries except that aluminum fins are used on the condenser and evaporator coils.

When a.c. power is available from individual power plants on each car or from a head end power car, the air-conditioning unit is generally of the self-contained type. The a.c. power permits light weight hermetic compressors and lighter fan motors. The weight of an a.c. self-contained unit is ap-