Ford Tractor Air Conditioning System

Principles and Fundamentals

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FOREWORD

This manual contains basic fundamental principles for servicing Ford Tractor Air Conditioning Systems. It is intended to be used as a guide by service technicians in understanding and diagnosing the Air Conditioning Systems used in Ford tractors. Disassembly and assembly procedures of specific components are not given. As such, this manual should be used in conjunction with the repair manual for the specific tractor being serviced when it is necessary to repair or overhaul any of the air conditioning system components.

The text material is divided into the following parts:

- Basic Theory of Air Conditioning
- Description of the Design and Function of the Air Conditioner System Components
- Service and Maintenance Procedures
- Trouble Shooting Procedures

IMPORTANT

Because of the potential hazards involved in the handling of the special refrigerant used in air conditioner systems, it is important to carefully observe all the CAUTIONS and WARNINGS, cited in the Manual. Doing so will guard against the use of certain service methods that could not only damage a vehicle, but could also cause serious injury to personnel.

It is also important to use all the special service tools (and only these tools) recommended for each particular service operation, in order that both vehicle and personnel safety will be assured. Special tools for servicing the Air Conditioning System are listed on page 43.

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FORD TRACTOR AIR CONDITIONING SYSTEMS PRINCIPLES AND FUNDAMENTALS

Chapter 1

AIR CONDITIONING SYSTEMS

1. INTRODUCTION

Air Conditioning in a tractor, as in a building, is a means of improving the comfort and health of individuals by controlling the temperature, humidity, and circulation of air.

Sources of Heat In a Tractor

In a tractor cab, a normally enclosed area, there are numerous sources of heat that can increase the air temperatures well above the comfort zone of most individuals. These sources include:

- Heat from the sun, radiated through the roof and windows
- Engine heat, transmitted through the firewall
- Heat radiated from field or road
- Heat from warm air entering the vehicle
- Heat radiated by the operator

NOTE: The normal comfort zone of most individuals ranges from 67° F (20° C) (with a relative humidity of 70%) to as high as 91° F (32.7°C) (if the relative humidity is as low as 30%).

All these sources combine, in warm climates, to increase the air temperature in a tractor cab above the comfort zone maximum . . . . . hence, the need for air conditioning.

Functions of an Air Conditioning System

Effective air conditioning not only lowers the temperature of the air, but also improves humidity, cleanliness, and circulation.

Humidity refers to the moisture content of air. When air has absorbed all the moisture it can hold, the relative humidity is said to be 100 percent. Humidity is, to some extent, related to air temperature because warm air will hold more moisture than cold air. Summertime humidity in the 80° F (27° C) range is not uncommon, and it has been said that, "It's not the heat, it's the humidity!" This is only partly true because it's the combination of the two that makes an individual feel warm.

The ease and rapidity of evaporation when we perspire, determines our sense of coolness. When the air is dry, perspiration evaporates rapidly, and the heat leaving our body makes us feel cool; but when the moisture content of the air is high, perspiration will evaporate more slowly, and, with less body heat removed, we will feel warmer.

The effect of low humidity on comfort is illustrated by the fact that a person will feel just as cool when the temperature is 80° F (27° C) and the humidity is about 30 percent, as when the temperature is 72° F (22° C) but the humidity is near 90 percent. This demonstrates the relationship of temperature and humidity and the fact that an air conditioning system should reduce both the temperature of the air and its humidity.

In air conditioning, heat reduction is accomplished by circulating the air through a chilling unit called an "evaporator." This same unit serves to remove moisture in the same way as a refrigerator where the thick frost, which often collects in the freezer compartment, consists of moisture that has been removed from the air; however, because the evaporator temperature is kept above the freezing point, instead of frost, the moisture which collects on the evaporator remains fluid and drips off.

Air conditioning also makes the air cleaner because the wet surface of the evaporator collects dust and pollen particles which drain off along with the condensed moisture.

2. THEORY

There are numerous approaches to explaining the theory and operation of an air conditioning system. All are somewhat technical, and include a discussion of such subjects as: the nature, measurement, and movement of heat; the basic laws of refrigeration; changes in the state of a substance (evaporation and condensation); and air conditioning system components and operation.

Basic Air Conditioning

As a means of better understanding the relationship of these subjects to the over-all concept of air conditioning, let us consider the following simple description of how air conditioning is achieved.

As illustrated in Figure 1, a typical, basic air conditioning system has two radiator-type tanks and a pump connected by tubing. One tank (evaporator) is located inside the operator compartment, the other tank (condenser) is located outside the tractor. A special refrigerant, which can be easily heated or cooled, is circulated between the two tanks by the pump (compressor).

Now, with the use of a well-known law of refrigeration that heat will flow from any object to one that has less heat, this is how a tractor cab is air conditioned:

- With a low-temperature refrigerant in the evaporator, heat from the hotter operator compartment air will

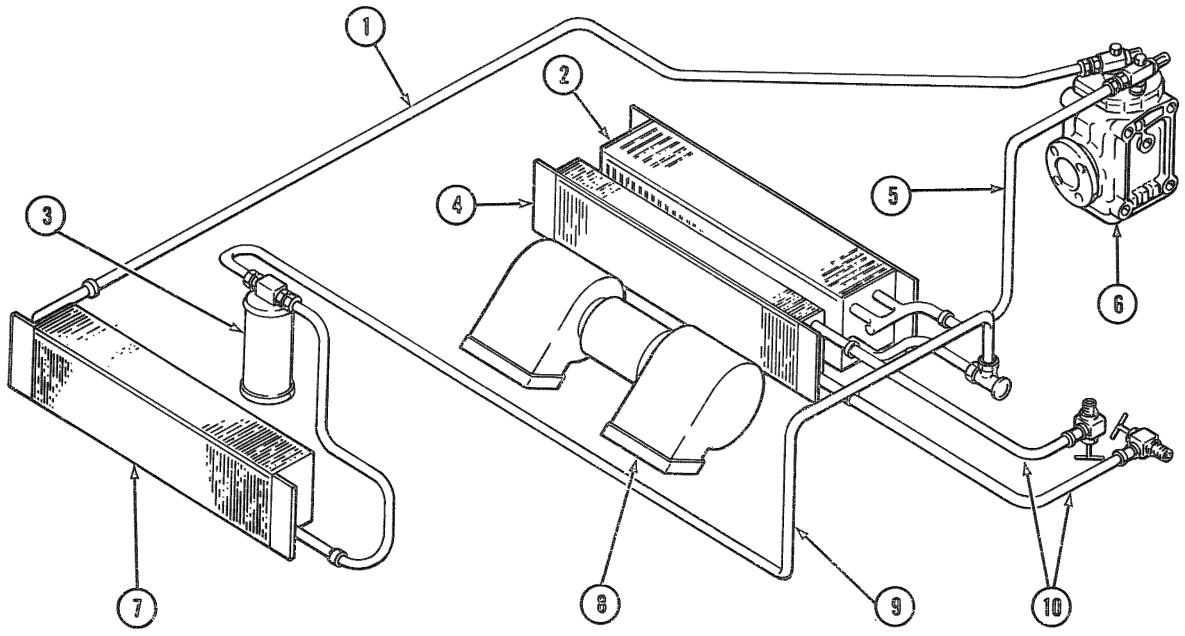

Figure 1
Basic Air Conditioning Components

1. High Pressure Vapor Hose
2. Evaporator
3. Dehydrator and Receiver
4. Heater
5. Low Pressure Vapor Hose
6. Compressor
7. Condenser
8. Blower Assembly
9. High Pressure Liquid Hose
10. Heater Hose Connections

flow to and be absorbed by the refrigerant, thus cooling the air.

- As the now warmer refrigerant passes to the condenser, its temperature will be further increased mechanically, so that it will be hotter than the outside air. Under this condition, the flow will be reversed, and the heat in the refrigerant will flow to and be absorbed by the outside air.

- In summary, a tractor air conditioning system serves to create a temperature differential inside the cab so that the heat will move from the warmer air to the cooler refrigerant in the evaporator. Outside the cab, a temperature differential is created to move heat from the warmer refrigerant in the condenser to the cooler outside air.

How this is accomplished . . . . . the theory, operation, system components, and maintenance, as well as trouble shooting and repair procedures . . . . . will be explained in subsequent sections of this manual.

Nature of Heat

To help understand air conditioning, it is important that we know something about the nature of heat. Heat has been defined as a form of radiant energy. In common usage the term "heat" has several different meanings:

- Sensation of heat — experienced when sitting in the sun or near a fire or other hot object. Different from sense of touch in that it is not dependent on actual contact.

- Degree of heat, or temperature — position of a substance in the scale of heat. Absolute cold is believed to be -459.6° F (-275.3° C). Since this temperature has never been attained by man, every substance above this temperature is said to contain heat, and has a position in the heat scale. (See Figure 2.)

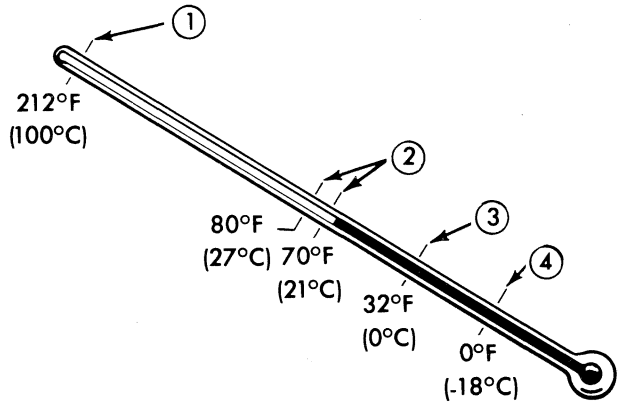

Figure 2
Position of Substances in the Heat Scale

1. Water Boils
2. Man's Comfort Zone
3. Water Freezes
4. Very Cold to Man

- Quantity of heat in an object — depends on its size, temperature, and the material of which the object is made.

  NOTE: The temperature of an object, however, does not depend on its size, but rather upon the quantity of heat in each unit of its mass.

- Radiant heat — When an object is exposed to the rays of the sun or to a fire, it is warmed. It must not be assumed, however, that heat has traveled across the space between them. What has traveled is radiant energy in the form of a wave motion that is liberated as heat when it strikes a colder or absorbing object.

Sources of Heat

There are numerous sources of heat: combustion or fire from burning wood, coal, gas, or oil; friction from the meshing of gears, striking a match, or from any two objects being rubbed together; chemical action, as when lime is slaked by uniting it with water, or when food is oxidized in the body to produce what is known as "animal" heat; and, most of all, the sun which radiates heat to the earth, and which is considered our main source of heat.

Measurement of Heat

Heat is measured in two ways: intensity and quantity. The intensity or "temperature" of a substance is measured by a thermometer.

NOTE: All temperatures referred to in this manual are in both "degrees Fahrenheit" (° F) and "degrees Centigrade" (° C).

Even though heat is intangible, it can be measured by quantity or"amount" as well as by intensity. The amount of heat in a substance is measured by what is known as a British Thermal Unit (BTU). One BTU is the amount of heat required to make one pound of water one degree warmer at sea level. This ability to measure the amount of heat will be found to be most important in understanding the movement of heat in an air conditioning system, particularly during changes in the state or form of a substance (solid, liquid, gas).

Movement or Transfer of Heat

One of several natural laws used in the air conditioning process is that heat always moves from a warmer to a colder substance. Heat movement can be caused by creating a difference in the temperature between two substances. For example, a pan of water that is heated above room temperature and set aside, will eventually "cool" to room temperature. Heat in the warmer water will move to the cooler air until the water temperature is the same as the temperature of the surrounding air, Figure 3.

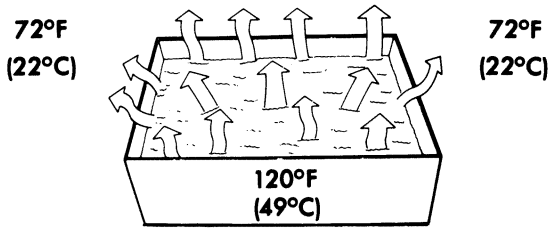

Figure 3
Movement of Heat From Hot to Cold

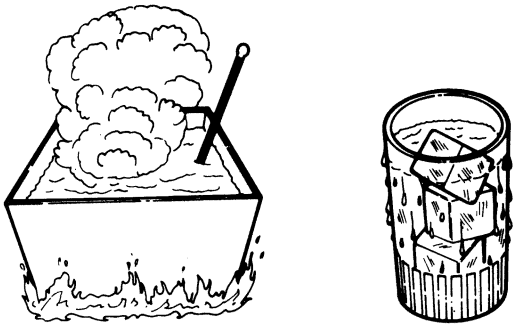

Figure 4
Evaporation and Condensation

At this point, it may seem strange that although our subject is Air Conditioning, we have talked mainly about heat; but actually, that's what air conditioning is all about — the handling and reduction of heat. Air conditioning in a tractor cab is simply taking heat away from the air inside the vehicle and transferring it to air outside the vehicle.

Change of State — Evaporation and Condensation

Thus far, we have learned that "cold" is nothing more than a reduction of heat, and that heat moves only from hot to cold. Also, we have some idea about how heat is measured. Now let's consider heat measurement and transfer in relation to changes in the state or form (solid, liquid, gas) of a substance which is an essential process in every air conditioning system.

Most substances can be found in any one of three states or forms — solid, liquid, or gas; and they can be changed from one state to another by changing their temperature. Water, for example, changes from a solid (ice) to a liquid at 32° F (0° C), and from a liquid to a gas (steam or vapor) at 212° F (100° C).

In air conditioning, we are primarily concerned with just two changes of state: Evaporation — the change of state of a substance from a liquid to a vapor (gas), and with Condensation — the change of state of a substance from a vapor to a liquid. When we understand the effect of these changes on heat transfer, we will know more about how an air conditioning system functions.

Evaporation

When a pan of water is placed over a fire, a thermometer will show that as the temperature of the water is raised, vapor will begin to raise from the water; and when the temperature reaches the boiling point, 212° F (100° C) the water will quickly change to vapor. This change of state from liquid to vapor, resulting from adding heat to water, is called evaporation, Figure 4.

Condensation

When the condition is reversed and the fire is removed, the vapor will lose its heat to surrounding cooler objects and will become water again. A common example of this is seen when vapor from boiling water collects on a cooler window pane, a cold glass of water, or on a mirror. This change of state from a vapor (gas) to a liquid is called condensation.

These two changes of state — evaporation and condensation — occur in every air conditioning cycle. Heat absorbed inside the cab changes the liquid refrigerant into a vapor, and heat released outside the cab changes the vapor back to a liquid.

Latent Heat

Latent heat, or "hidden heat" as it is sometimes called, refers to the enormous amount of heat (BTU's) that a liquid will absorb without getting any warmer when it changes state from a liquid to a gas (vapor). For example, a thermometer in boiling water at 212° F (100° C) will not show any increase in temperature above 212° F (100° C) regardless of how hot the fire becomes, Figure 5.

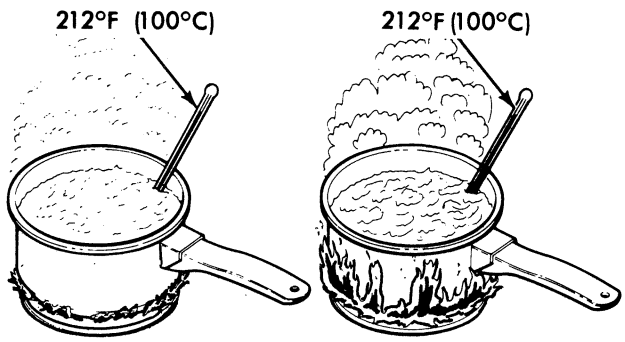

Figure 5
Heat of Boiling Water Never Exceeds 212° F (100° C)

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