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COOLING SYSTEM: VARIABLE DISPLACEMENT A/C COMPRESSOR

By **JACQUES GORDON**, Technical Editor

THE VARIABLE DISPLACEMENT AIR CONDITIONER COMPRESSOR has been in use for about 20 years. It is usually an axial compressor, with the pistons arranged around and parallel to the driveshaft. One-way reed valves in the cylinder head control refrigerant flow into and out of each cylinder.

Depending on the design, the pistons are driven by a wobble plate or a swash plate. In a wobble plate compressor, the pistons are connected to the plate with short push rods. An angled yoke on the driveshaft causes the plate to wobble when the shaft rotates, driving the pistons back and forth in their bores.

In a swash plate compressor, the plate itself rotates with the driveshaft. A bearing in the bottom of each pis-

ton “clamps” around the edge and rides on either face of the swash plate. The plate is set at an angle to the shaft, so as it rotates, the pistons are forced back and forth in their bores.

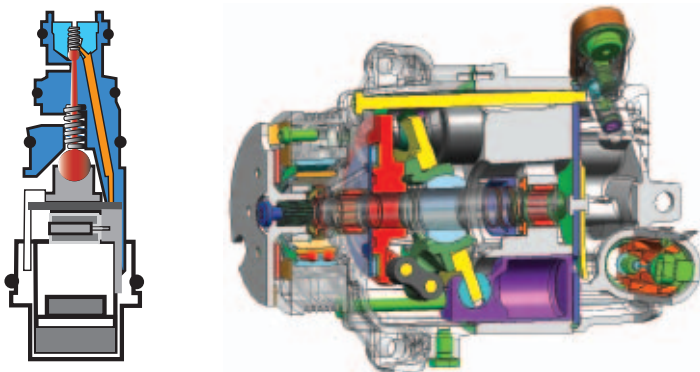
The angle of the wobble plate or the swash plate determines the length of the piston stroke. In a variable displacement compressor, that angle can be changed, which changes the length of the pistons’ stroke and, therefore, the amount of

refrigerant displaced on each stroke. The angle is adjusted using springs and linkage that move lengthwise along the driveshaft, and it’s controlled with refrigerant pressure in the compressor housing.

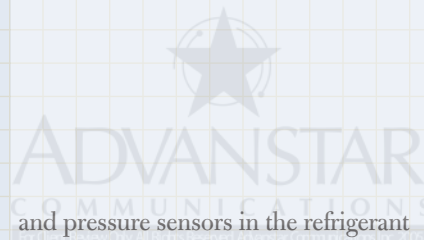
When housing pressure is increased, the pressure exerted on the back side of the pistons keeps them “higher” in their bores and closer to the cylinder head. This shortens the stroke, reducing displacement. When housing pressure is reduced, a spring pushes the adjusting linkage away from the cylinder head, increasing plate angle and lengthening the piston stroke to increase displacement.

Housing pressure is adjusted using a control valve with ports and passages that connect it to the suction (low-side) and discharge (high-side) chambers of the compressor head. Two different types of control valves are used. The traditional mechanical valve has a precision pressure-sensitive diaphragm that senses low-side pressure. When the cabin temperature is warm, evaporator temperature increases, which increases low-side pressure. This pushes on the diaphragm, opening a port that vents a little bit of housing pressure to the suction side. Reducing housing pressure increases piston stroke, which increases refrigerant flow volume through the system. As evaporator

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This electric control valve (left) includes the pressure sensor in the valve assembly, but the sensor could be mounted anywhere in the system. The Delphi compressor (right) uses an adjustable swash plate to change piston displacement.



temperature decreases, so does low-side pressure. The diaphragm “re-bounds” to close the low-side vent port and at the same time open a port that admits high-side pressure into the housing. This reduces piston stroke

and, therefore, refrigerant flow volume. Remember, changing flow volume doesn’t necessarily change pressure.

Around 2001, DENSO was first to replace the diaphragm valve with a solenoid valve and add temperature

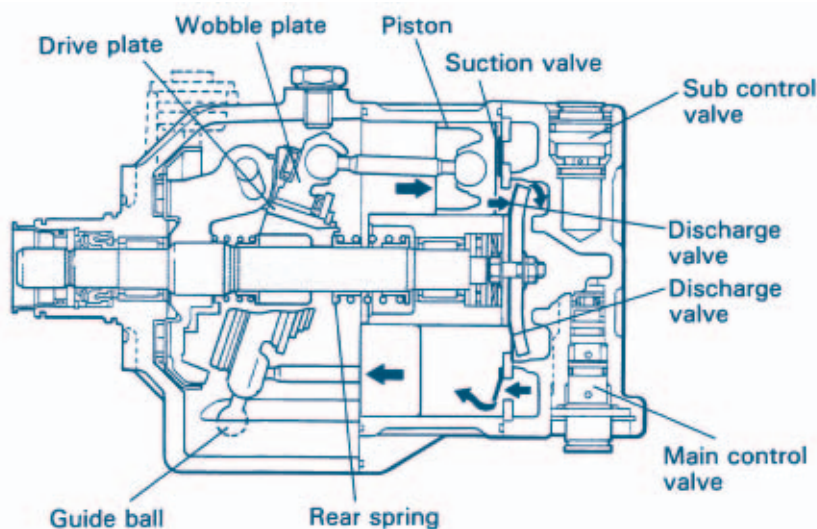
and pressure sensors in the refrigerant system. This allows a computer to control the valve and adjust compressor displacement to control evaporator temperature, rather than using evaporator temperature to control displacement. Today almost all manufacturers offer electronically controlled variable displacement compressors, and some applications have no clutch, meaning the compressor runs whenever the engine is running.

Most vehicles already operate the compressor any time the windshield defogger is turned on, even in winter. The electronic displacement control valve makes it easier to run the compressor continuously because displacement can be reduced closer to zero than with a mechanical valve. Continuous operation keeps seals lubricated, minimizes oil pooling and prevents other kinds of damage that result from long periods of inactivity.

Also, with the A/C system controlled according to cabin temperature demand as opposed to evaporator temperature demand, the need to reheat air that’s been cooled below the requested temperature is eliminated. Ultimately the electronically controlled variable displacement compressor puts less load on the engine, improving fuel economy by as much as one-half mile per gallon. And of course, the driver will never feel the A/C clutch cycling or the idle speed surge that sometimes accompanies it.

The mechanical control valve is inexpensive and reliable, but it doesn’t provide the same control as the electronic valve. Eventually most A/C systems will use an electronically controlled variable displacement compressor.

6-CA COMPRESSOR



A cut-away of a Nippondenso 6-CA compressor. When housing pressure is low, the rear spring increases drive plate/wobble plate angle, thus increasing displacement.

