



*This is one of a series of technical bulletins from your friends at Progress Supply
October, 2001*

SLUGGING

Here we are at the third article on “Compressor Mechanical Failures.” So far, we have discussed Liquid Refrigerant Floodback and Flooded Starts. Each of these conditions can and do cause compressors to fail. In some cases, they can cause the failure that we will discuss in this article.

Yes. This article will discuss **Slugging**. Slugging, an interesting word. I’m sure that each of you reading this may have your own thoughts of its meaning. To a baseball player it may mean hitting the ball very hard. To a boxer it may mean to hit someone very hard. To a Physics major it means a unit of mass, and to a shooter it means a bullet.

Every time I hear the word slug I am reminded of the time my partner, John, and I were asked to do the Copeland Compressor Operation & Service Seminar (COSS) to a group of engineers from China. We had three translators and as fast as John and I talked, they translated. All went well until we used the word slug. Everything came to a stop. In Chinese there is no word for slug. After a few minutes of Chinese conversation and after the translators defined what a slug is, the seminar went on.

What does Webster have to say about “SLUG?” My dictionary has at least eight definitions for this word. The closest definition to the way we use it in our industry is:

“A heavy blow, as with a fist or a baseball bat.” The piston or pistons are the “bat” that causes the heavy blow. The pistons are the blow that is exerted on a valve plate and/or the suction or discharge valves, the ball. And, yes, it happens when something gets in between the two. That something is generally liquid, liquid refrigerant or oil.

When the compressor experiences a severe slug, something is going to break. The something can be rods, pistons or wrist pins. Other parts that may be damaged or broken are suction or discharge valves and even a valve plate. In an extreme case, a crankshaft may break.

Liquid can be a friend or foe to a compressor. Liquid oil

in a cylinder is a foe. Oil is in circulation in all air conditioning and refrigeration systems. It leaves the compressor with the refrigerant and, if all is working properly within the system, the oil returns to the compressor in small measured quantities. When this occurs, there is no damage. All is well. Liquid refrigerant in a compressor is not a friend to the compressor. Refrigerant vapor can also be a friend or a foe (*refer to Flooded Starts*).

In the air-cooled compressors, refrigerant and oil return to the cylinder end of the compressor. Basically, it is returning to the cylinder piston area. The refrigerant should be in a vapor state and the oil should be in very small droplets. The oil will normally drop out at the entrance to the compressor and return to the crankcase through a small hole. The refrigerant vapor continues to the suction valves in the compressor valve plate. In normal operation, the

suction valves open during the suction stroke of the piston. The refrigerant vapor enters the cylinders and no damage occurs. If liquid refrigerant returns to the compressor it will continue to the suction valves and, during the suction stroke, the liquid refrigerant may cause the suction reed to be pushed beyond the reed stop. When this occurs, the tip of the suction valve will be broken off and may cause scoring of the cylinder walls, the top of the piston and/or valve plate.

In addition, the reed can now bend beyond the reed stop and “dig” into the top of the piston. This is not a slug as we may consider a slug but, in fact, is a liquid slug damaging the reed and the compressor’s capacity. The liquid refrigerant will not cause other types of “slug” damage in that the heat of compression vaporizes it during the compression stroke.

Large quantities of oil returning to the air-cooled compressor will cause slugging damage. All of the oil cannot return to the crankcase. A large portion of it will continue with the refrigerant to the suction reeds and into the cylinders during the suction stroke. It is during the compression stroke that damage occurs. The oil will not be vaporized during the compression stroke. The oil will get between the top of the piston and either the valve plate or reeds. Oil is not compressible. When this occurs, the sudden force of the piston through the oil will cause something to give. That something can be the reeds, the valve plate, the piston rod or potentially the crankshaft.

Slug damage in the refrigerant-cooled compressor occurs in a different way than in the air-cooled compressor.

Yes, liquid does get between the piston and the valve plate but in a different way.

The refrigerant and oil return directly to the motor compartment. Unlike in the air-cooled compressor, the oil and refrigerant returning cannot slug the refrigerant-cooled compressor during the normal run cycle. The returning oil drops down to the bottom of the motor compartment and returns to the crankcase under the motor. The refrigerant must work its way through or around the motor to the compressor's throat located in the top of the motor compartment. It is through the throat that the refrigerant moves to the cylinder piston area. Liquid refrigerant will not go up unless there is a means of "tossing" it up.

When the compressor is off and if refrigerant vapor continues to migrate back to the compressor (Flooded Start), the refrigerant moves into the oil (miscibility). The refrigerant will condense in the oil and sink to the bottom of the crankcase and motor compart-

ment. If enough refrigerant migrates to the compressor after a long shut down, there will be enough refrigerant under the oil that will cause the problem at the next start.

When the compressor starts, the suction pressure will be lowered, causing the refrigerant's boiling point to be lowered. This will cause the refrigerant in the motor compartment to boil vigorously. This boiling action will "explode" the oil above it. The liquid that has now been exploded up will be drawn through the throat of the compressor into the cylinder piston area. When the liquid oil moves into that area, a slug as described in the air-cooled section will occur. Pistons, piston rods, valve plate and reeds may be broken. Yes, even the crankshaft may be broken. Forces as high as 2000 to 3000 psi have been measured in the lab under slug conditions.

One word of caution when diagnosing broken rods. Rods break for one of two reasons, a liquid slug or from seizure of the rod to the crankshaft. The seizure of the rod to the crankshaft is the result of flooded starts, generally a number of flooded starts. When the seizure occurs, the rod will try to rotate with the crankshaft. This is a physical impossibility; the result is a broken rod. Liquid getting into the cylinder/piston area causes a slug break.

Isn't it interesting that the same system problem, flooded start, can cause two different types of rod breakage? Yes, it is important to open that compressor to determine the real cause of failure.

The next article will discuss **"Loss of Oil."**