Chapter 9: Types of HydraForce Solenoid Valves

Objectives

The objectives for this chapter are as follows:

• Become familiar with the model coding system used by HydraForce.

• Recognize what each portion of the model code designates as well as the options available.

• Review a brief description each type of Solenoid valve as well as the corresponding hydraulic symbol.

• Learn what a reverse flow check valve is and which valves use it.

• Become familiar with the manual override option, how it works and the types available for the various valves.

• Learn what the screen, waterproofing, body, seal and termination options are and why they are available.

Introduction

In this chapter, we will learn about the standard solenoid valves available from HydraForce. This will be done by discussing the model coding system used to describe each valve. Following this, the valve symbol for each type of valve will be shown as well as a cross section of the corresponding valve.
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Model Coding

HydraForce uses a model coding method which is specific to its product line. Each part of the model number represents an aspect of the valve which differentiates it from other solenoid valves. The following section breaks down the model number and describes the information which can be obtained from each portion of the number.

MM

As shown in the chart above, MM indicates the type of valve. The designation for a solenoid valve is SV. Other designations exist for the various types of valves. For example, PD would indicate a pilot operated directional valve and RV would indicate a relief valve.

CC

This portion of the model number indicates the size of the cavity, the coil size and the pressure rating of the valve.

HydraForce cavities are considered to be common industry cavities. The designations shown in the model code are based on the SAE (Society of Automotive Engineers) port sizes. For example, this means that the thread and top o-ring of an 08 size cavity is the same as one used in an SAE 08 port. An example of the cavities used on the 2-way cartridges is shown on the following pages. The dimensions in bold are the same as those used in an SAE port.
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Size 8, 2-Way

1.188 Dia. Spotface x .031 Deep
- 0.502/0.500 Dia. x 1.156 Deep
- 0.690/0.686 Dia. x 0.750 Deep
- 3/4–16UNF–2B x 0.500 Deep

Size 10, 2-Way

1.188 Dia. Spotface x .031 Deep
- 0.627/0.625 Dia. x 1.312 Deep
- 0.814/0.810 Dia. x 0.932 Deep
- 7/8–14UNF–2B x 0.625 Deep

Size 12, 2-Way

1.500 Dia. Spotface x .031 Deep
- 0.877/0.875 Dia. x 1.920 Deep
- 0.978/0.975 Dia. x 1.400 Deep
- 1-1/16–12UN–2B x 0.810 Deep

Size 16, 2-Way

1.750 Dia. Spotface x .031 Deep
- 1.128/1.126 Dia. x 1.844 Deep
- 1.236/1.232 Dia. x 1.344 Deep
- 1-5/16–12UN–2B x 0.750 Deep
The cavity sizes as well as the coil size and pressure ratings available are listed in the following table:

<table>
<thead>
<tr>
<th>Model Code</th>
<th>Cavity Size</th>
<th>Coil Size</th>
<th>Pressure Rating</th>
</tr>
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<tbody>
<tr>
<td>08</td>
<td>08</td>
<td>08</td>
<td>3000 psi</td>
</tr>
<tr>
<td>98</td>
<td>Special (Typically Metric)</td>
<td>08</td>
<td>Determined by Application</td>
</tr>
<tr>
<td>80</td>
<td>10</td>
<td>08</td>
<td>Determined by Application</td>
</tr>
<tr>
<td>82</td>
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<td>38</td>
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<td>10</td>
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</tr>
<tr>
<td>12</td>
<td>12</td>
<td>10</td>
<td>3500 psi</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>10</td>
<td>3000 psi</td>
</tr>
</tbody>
</table>

**P SS**

The P in this portion of the model code indicates the number of ports present on the valve. There are either two, three or four ports available. The first and second S indicate the flow paths as well as the number of positions in the actuator. If the third S is left blank, this indicates a two-position actuator, otherwise a three-position actuator is indicated (except in the case of the SV12-40R which is a two-way actuator). The discussion has been focused on the two-position actuator throughout this manual. The three-position actuator will be presented in the following sections.

Before continuing with the model coding designations, let’s take a moment to define what normally open and normally closed actually means.

**Normally Closed**

The term normally closed is used on valves which control flow between two ports. As shown in the symbol, the flow from port two to one is blocked in the neutral or de-energized state. The flow is blocked when no power is applied to the solenoid. Hence the name normally closed.

**Normally Opened**

The term normally opened is used to describe valves which control the flow between two ports. As shown in the symbol, flow or oil passes between ports two and one, in the neutral or de-energized position. Oil flows between the two ports when no power is applied to the solenoid. Hence the name normally opened.
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The following diagrams, and those on the next several pages, are cross sectional views of some of the standard valves available from HydraForce. The views include the corresponding hydraulic symbol.

2-Way 2 Port

0
Normally Closed

1
Normally Open

2
Normally Closed

3
Normally Open

SV08-20

SV08-21

SV08-22

SV08-23

The SV08-20 is a two position pull style valve. The armature has two working positions; de-energized, and energized. The hydraulic portion consists of a normally closed, pilot operated poppet valve. This means that the pilot pin controls the opening and closing of the poppet.

The 21 type valve shown above, is a normally open, pilot operated poppet valve using a two position push style actuator. When de-energized, oil flows between ports 2 and 1. When energized, the pilot pin pushes down on the poppet, closing off the flow of oil.

The 22 type is a normally closed pilot operated poppet valve using a two position pull style actuator. This valve allows unrestricted flow from port 1 to port 2 when the valve is de-energized. This is the main difference between the SV08-20 and SV08-22. (See the following page for further explanation.)

The valve shown above is a 2-way normally open, pilot operated poppet valve. When the coil is not powered, oil can flow from 2 to 1 or from 1 to 2. When energized, the poppet blocks the oil from flowing from port 2 to 1. The actuator used is a two position, push style.
Reverse Flow Check Valve Function

The illustration to the right is a cage, poppet and pilot pin from the SV08-20. The oil is shown trying to flow from port 1 to port 2. As shown, the oil also flows into the area around the pilot pin. Since the bleeder side hole of the poppet is smaller than the pilot pin seat, oil fills behind the poppet and pilot pin. Eventually, these two parts move closer to the cage seat, until the flow is restricted to approximately the flow passing through the bleeder hole.

The diagram below shows the cage, poppet and pilot pin from the SV08-22 along with two additional parts which make up the check valve. A check valve is a valve which allows flow in one direction. Two parts which make up a portion of this valve are the ball and roll pin. (A roll pin is a piece of flat metal rolled into a cylindrical shape or a pin.) The check valve shown below is known as a free reverse check valve when inside a solenoid valve. It is given this name because it allows oil to flow freely in the opposite direction as indicated in the symbol shown with the SV08-22 valve.

In this valve, when oil goes from port one to two, it also pushes on the ball. The ball blocks the oil from getting around the pilot pin. Oil does not fill this area, it instead pushes on the poppet until it has fully opened. In other words, the flow is not restricted by the poppet.
The 24 type is a normally closed, direct acting spool valve. When de-energized, flow is blocked. In the energized position, oil can flow from ports 2 to 1 or 1 to 2. The actuator used by HydraForce in this valve has two positions and can be either a push or a pull style. Both the 08 and the 10 size are pull style and the 12 size is a push style.

The 25 type is a 2-way, normally closed, direct acting spool valve. In the neutral position, oil can flow from port 2 to 1 or 1 to 2. When energized, oil is blocked from flowing. The actuator is a two position type. It is a pull style in the 08 and 10 size and a push style in the 12 size.
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2 Way (2 Port) 2 Position

<table>
<thead>
<tr>
<th>6 Normally Closed</th>
</tr>
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<tbody>
<tr>
<td><img src="image1.png" alt="2 Way Valve Diagram" /></td>
</tr>
</tbody>
</table>

3 Way (3 Port) 2 Position

<table>
<thead>
<tr>
<th>8 Normally Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2.png" alt="3 Way Valve Diagram" /></td>
</tr>
</tbody>
</table>

The 26 type is a 2-way, normally closed, direct acting poppet valve. The actuator is a two position pull type. Notice that this valve is made from the pilot section of the 20 style valve. This means that the hydraulic parts are made up of the pilot pin and the pilot pin seat, which is in the cage. There is no poppet in this valve. This valve is called a double blocking valve because either port can be used as used as the inlet and still block flow.

The SV38-28 is a normally closed, direct acting poppet valve. It blocks oil from passing between ports 2 to 1 or from ports 1 to 2 when de-energized. When energized oil flows between the two ports. The actuator in this valve is a two position push style. This valve is called a double blocking valve because either port can be used as used as the inlet and still block flow.

This valve is a direct acting, spool valve. In the de-energized or neutral position, flow can pass from port 2 to 1. When energized, oil can flow from port 3 to 2 or 2 to 3 and is blocked from flowing from port 1. The 34 style spool can allow bidirectional flow from ports 2 to 1 or 1 to 2. The 30 style spool generally only allows flow from 2 to 1. The 30 style (only available in the 08 size) is unique because it extends out of the bottom of the cage. In the 34 style (available in the 10 and 12 size), the spool stays within the length of the cage. The actuators are 2 position types and are pull style in the 08 and 10 size, and push style in the 12 size. The 08 and 10 size valves are both closed in transition and the 12 size is open.
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3-Way (3 Port) 2 Position

The 31 type valve is a direct acting, spool type. It allows flow from ports 2 to 1 or 1 to 2. It also blocks oil at port 3 in the de-energized position. In the energized position, oil can flow from port 1 to 3 or 3 to 1 and is blocked at port 2. The actuator has 2 positions and is either a push or pull type. The 08 and 10 size use a pull style actuator and the 12 size uses a push style actuator. In addition, the 08 and 10 size valves are both closed in transition and the 12 size is open.

The 33 type valve is a 2 position direct acting, spool valve. In the de-energized position, oil can flow between ports 3 to 1 or 1 to 3 and is blocked at port 2. When the spool is in the energized position, oil can flow from ports 1 to 2 or 2 to 1 and is blocked at port 3. The actuator has 2 positions and is either a push or pull type. The 08 and 10 size use a pull style actuator and the 12 size uses a push style actuator. In addition, the 08 and 10 size valves are both closed in transition and the 12 size is open.

The SV38-38 valve is a 2 position direct acting, poppet valve. In the de-energized position, the poppet is seated, blocking flow at port 3 and allowing flow from 1 to 2 or 2 to 1. When energized, the poppet sits on a second seat, blocking oil at port 1 and allowing it to flow from 2 to 3 or 3 to 2. The actuator is a 2 position, push style. This valve is only available as an SV38-38, which means that it is in an 08 size cavity, a 10 size coil and is only rated to 3000 psi. This valve is open in transition.
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The 40 type valve is a 2 position, direct acting, spool type. In the de-energized position, it allows oil to flow from ports 3 to 2 and 4 to 1. When the spool is in the energized position, oil flows from port 3 to 4 and 2 to 1. The actuator has 2 positions and is a pull style. This spool type is open in transition.

The 40R is a 2 position direct acting, spool valve. The model code indicates that the flow paths are the same as the 40 spool, but the logic is reversed, as indicated by the R. In the de-energized position, flow passes from port 3 to 4 and 2 to 1. When energized, oil passes from 3 to 2 and 4 to 1. The actuator is a 2 position push style. The 08 and 10 size are pull types and the 12 is a push type. This valve is only available in a 12 size and is open in transition.

The 41 type valve is a 2 position, direct acting, spool valve. In the de-energized position, oil is blocked from flowing through any of the ports. When shifted, the spool allows oil to flow from ports 3 to 4 and 2 to 1. The actuator is a two position pull or push type. The 08 and 10 size are pull types and the 12 is a push type. This valve is closed in transition.

The 4-Way (4 Port) 2 Position

The symbol and valve above represent a 2 position / 4 way direct acting spool valve. In the de-energized position, ports 3 and 4 are connected. When the coil is energized, the spool shifts, blocking the flow of oil through any of the ports. The actuator is a 2 position type. It is a pull style in the 08 and 10 size valves and a push style in the 12 size. This valve is closed in transition.
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This valve is a direct acting spool type. In the de-energized or neutral position, port 4 is connected to port 1 and oil is blocked at both ports 2 and 3. When in the energized position, port 3 is connected to 4 and 2 is connected to 1. The actuator is a 2 position pull type. The actuator is a 2 position pull type in both the 08 and 10 size. This valve is open in transition.

This is a direct acting 4 way spool type valve. When the valve is energized, ports 3 and 1 are connected and oil is blocked at ports 2 and 4. When the valve is de-energized, ports 3 and 2 are connected as well as ports 4 and 1. The actuator is a 2 position pull type in both the 08 and 10 size. This valve is open in transition.

This valve is a direct acting 2 position / 4 way spool valve. In the de-energized position, all ports are blocked. When energized, oil can flow between ports 3 to 2 and 4 to 1. The actuator is a 2 position pull type. This valve is only available as an 08 size, and is closed in transition.

The 46 valve is a 2 position / 4 way direct acting spool type. In the de-energized position, oil is allowed to flow from ports 3 to 4 and 2 to 1. When the coil is energized, the spool connects ports 4 and 2 to 1 and blocks oil at port 3. The actuator is a 2 position pull type. This valve is only available in an 08 size, and is open in transition.
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The 47A shown to the left is a 3 position / direct acting spool valve. The spool type is known as a tandem center spool. This means that several valves can be connected in tandem (or one following the other as shown in the schematic below). This valve is available in the 08 and 10 size cavities. The actuator has 3 positions, 2 energized and 1 neutral. In the neutral position, flow occurs between ports 3 and 1 and oil is blocked at ports 2 and 4. When the top coil (referred to as solenoid 1 or S1) is energized, ports 3 and 2 are connected as well as ports 4 and 1. When S2 (the bottom coil) is energized, oil can flow between ports 3 to 4 and 2 to 1. This spool type valve is open in transition.
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4-Way (4 Port) 3 Position

The 47B is a 3 position / 4 way direct acting spool valve. The valve is termed the open center spool valve because in the neutral (or central) position all ports are connected. When the top coil is energized, port 3 is connected to port 4 and port 2 is connected to port 1. Energizing S2 (bottom coil) allows oil to flow between ports 3 to 2 and 4 to 1. This valve is only available in a 10 size. The actuator is a 3 position type. When S1 is energized, the actuator acts as a pull style. When S2 is energized, the actuator acts as a push style. This valve is open in transition.

The 47C is a 3 position / 4 way direct acting spool valve. When both coils are de-energized, the armature and spool are in the neutral (central) position. All ports are blocked in this position. For this reason, this spool type is called a closed center spool. When in the center position, oil is closed off and no flow passes through any of the 4 ports. If S1 is energized, oil can flow from ports 3 to 4 and from 2 to 1. When power is applied to S2, port 3 is connected to 2 and port 4 is connected to 1. The actuator is a 3 position type. Energizing S1 pulls the armature and energizing S2 causes the armature to push down on the spool. This valve is available in the 08 and 10 size cavities. This valve is closed in transition.
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4-Way (4 Port) 3 Position

The 47D is a 3 position / 4 way direct acting spool valve, and is open in transition. In the neutral position, ports 2 and 4 are connected to port 1. When energizing S1, oil flows from port 3 to 4 and from port 2 to 1. When S2 is energized, port 3 is connected to 2 and 4 is connected to 1. This type of spool is known as a motor spool. It is often used to control the direction of rotation of a hydraulic motor. The diagram below shows a simple circuit of this application.

With the spool in the center position, the motor can spin freely in either direction. When S1 is energized, the oil flows into the motor, causing it to rotate in a given direction. If S2 is energized, the motor spins in the opposite direction.

The actuator is a 3 position type with 2 energized positions acting opposite each other (a push & pull). The neutral position is between the 2 energized positions. This valve is available in both an 08 and 10 size cavity.
Manual Override

Manual override is used occasionally, when the power fails. This feature allows the user to manually actuate the valve and allow the object which the valve controls, to be moved. As stated, this is used only occasionally or in emergency situations.

There are five types of override which include; \( P \), \( K \), \( M \), \( J \), and \( Y \). The \( P \) style override is used on the 21, 23, 28 and 38 size valves. To operate this override, the override button is pressed down. See the following illustration. The \( K \) style is similar to the \( P \) style, but has a plastic knob added to the top which makes the override button easier to push down.

The following illustration shows both the \( P \) and \( K \) style overrides.
The \( M \) style manual override is available for valves with a two position pull type actuator, as well as valves with a three position push/pull type actuator. The following valves are included in these types:

<p>| | | | |</p>
<table>
<thead>
<tr>
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<tr>
<td>20</td>
<td>30</td>
<td>40</td>
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</tr>
<tr>
<td>22</td>
<td>31</td>
<td>41</td>
<td>46</td>
</tr>
<tr>
<td>24</td>
<td>33</td>
<td>42</td>
<td>47A,B,C,D</td>
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<tr>
<td>25</td>
<td>34</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>26</td>
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</table>

The following steps describe the use of the \( M \) style override with the 2 position pull type actuator (see diagram below):

1. Push down on the button to move it from the detent lock position.
2. While holding down the button, rotate it clockwise 90\(^\circ\) until it can’t be turned any further.
3. Release the button and a spring will push it out. This spring also pulls up the plunger to move the spool or pilot pin into the energized position.
4. To disengage the override (move it back to the de-energized position), push down on the button until it stops, rotate counter clockwise until it stops. Release the button and it will pop back into the detent position.

As stated, the \( M \) style override also works with the 3 position push / pull actuators. With this style valve, the override works by simply pushing or pulling on it. Pushing on it moves the spool and plunger into the S2 energized position. Pulling on it moves it into the S1 energized position. To move the armature and spool back to the de-energized position, simply release the button and springs will move these parts to this position. (Note: to pull up on the button requires 10 to 13 lbs of force.)
The \( Y \) style override is available on any of the 10 size, 2 position, pull style actuated valves listed for the \( M \) style override. To actuate this override, the small red button is pulled up. When the button is released, springs inside the valve return it to the de-energized position.

The \( J \) style is similar to the \( Y \) style, but uses a screw in place of the button. This screw can be used for connecting cables to the valve. In this manner, the override can be actuated remotely (at the other end of the cables). The diagram below shows a cross section of both a \( J \) style and a \( Y \) style override. (Note: Both the \( J \) and \( Y \) overrides require 10-13 lbs of force to pull up on the button.)

**Screens**

A screen is another option for the valve. It is used to protect the valve from large contaminants floating through the system. These are not intended to replace the system filter, but merely add additional filtering for the valve. This option is designated by an \( S \) in the model code and is only available for the 08 and 10 size valves.

The standard screen available stops particles which are 0.006 in size. These screens can be used on spool or poppet valves and can be used on any port, with the exception of port 1. Since port 1 is connected to the tank, oil flows out rather than in, carrying any contamination away from the valve.
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**Waterproof**

An additional option available is the waterproof option, and is designated in the model code with a W. This option available for HydraForce Solenoid valves, allows the coils to meet the IP67 weather rating. This rating means that the coil and cartridge can be immersed in 1 meter of water for 30 minutes with no water penetration. During this test, the coil and water remain at a constant temperature. The W option typically includes a special nut and two to three o-rings. Some 08 and 10 size cartridges require a different hex size to hold the o-ring in place.

**Body (Line Housing)**

The body or line housing is the part which the valve screws into. This part connects the solenoid valve to the rest of the system. The bodies can be made of plated steel or anodized aluminum. Both of these processes protect the bodies from oxidizing. Applications up to 3000 psi typically only require an aluminum body. If the application is operating above this pressure, steel is recommended. Also, if the system is expected to see a high number of cycles or pressure spikes above 3500 psi, steel is recommended. (Note: a pressure spike is a momentary peak in pressure. This is usually only a concern when the application is above the pressure rating of the valve, body or system.)
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Seals

The type of seal on the outside of the cartridge valve is known as an o-ring. The material used in this seal is dependant on the application. There are four materials offered as options; N, V, P & E.

The N option designates a seal made from a material known as Buna N. This seal is used in general applications up to 3500 psi and can be used (is compatible) with a wide variety of fluids. The temperature range it can be used in is -40° to 120° C. This is the standard material used for HydraForce valves.

The V option is a seal made from a fluorocarbon material named Viton™. This seal is also used in general applications and is compatible with more fluids than the Buna N. Like Buna N, this seal is used in applications where the pressure is lower than 3500 psi. The major difference between this material and Buna N is the temperature range the material can withstand. Viton is rated for -30° to 205° C (-20° to 400° F). It is recommended that Viton is used when the oil temperature is expected to be above 100° C continuously or 120° C intermittently.

P designates a seal made from Polyurethane, which is a more durable material than Viton or Buna N. It is typically used in applications where the pressure is at or above 3500 psi. This material can work between -50° to 100° C.

E designates a seal made from a material known as EPDM (ethylene propylene di monomer). This material is specifically for brake fluid and similar fluids made from phosphate esters. It can be used in applications which have a temperature range of -55° to 135° C and pressures up to 3500 psi.

Each of the seals discussed is available in two different grades. The grade refers to the hardness of the material which is known as the durometer of the material. The two grades available are 70 durometer and 90 durometer.

Seals with a 70 durometer hardness are used in applications up to 3500 psi. For higher pressures 90 durometer material should be used. HydraForce standard o-rings are 70 durometer Buna N, Viton or EPDM. For applications above 3500 psi the standard is a 90 durometer polyurethane. If the application requires a 90 durometer seal other than the polyurethane, it can be ordered in a special cartridge.
Coil Voltages and Terminations

Each coil is available with different windings which enables the coil to be used in various applications. The coil is stamped with the rated nominal voltage and the appropriate winding for that voltage is housed within the coil. Several terminations are available for various application. These are listed in chapter 5.
Summary

In this chapter the following concepts were presented:

• The model coding structure.

• Options available when ordering a valve and how these options are designated in the model coding structure.

• Normally open and normally closed valves and symbols for each.

• A symbol, cross section and brief description was given of the standard HydraForce valves.

• Explanation of the reverse flow check valve.

• Detailed explanation of the override options, how the work and which overrides are used on the various valves.

• Detailed explanation of the seal types and the materials used in each option.
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Review Questions

Use the following review questions as a measure of your understanding of the chapter material. Answers are provided in the appendix.

1. Describe the type of actuator used in the SV08-47A ______________________
2. What does the SV portion of the model code designate? ______________________
3. True or False. In a normally opened valve, oil flows between the two ports when no power is applied to the solenoid. ______________________
4. Which side of the hydraulic symbol designates the energized position, left or right? ______________________
5. A check valve allows flow in how many directions? ______________________
6. Why is the SV08-47D known as the motor spool? ______________________
8. What is the screen option used for? ______________________
9. What is the standard seal type HydraForce uses? ______________________
10. What is the term used when referring to the hardness of the seal? ______________________