ENGINEERING REPORT

COMPARISON OF GARRETT PRODUCTION NUCLEAR VALVES WITH THE VALVE USED IN THE EPRI/PWR SAFETY AND RELIEF VALVE TEST PROGRAM

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COMPARISON OF GARRETT PRODUCTION NUCLEAR VALVES WITH THE VALVE USED IN THE EPRI/PWR SAFETY AND RELIEF VALVE TEST PROGRAM

1. INTRODUCTION AND SUMMARY

1.1 Introduction

This report, prepared by Garrett Pneumatic Systems Division of The Garrett Corporation, is intended for use by the Electric Power Research Institute (EPRI) in support of the EPRI/PWR Safety and Relief Valve Test Program. Included are descriptions of Garrett's power-operated relief valves presently in production, and a comparison of these designs with the Garrett PORV presently being utilized in the EPRI/PWR (pressurized water reactor) test program.

As background information, it is noted that Garrett Pneumatic Systems Division was created in January, 1981, in a corporate re-organization of AiResearch Manufacturing Company of Arizona, a Division of The Garrett Corporation. The Pneumatic Systems Product Line (of which the Nuclear/Industrial Valve Project is a part) was given full divisional status at that time.

1.2 Summary

Garrett Pneumatic Systems Division (GPSD) is currently under contract to both Combustion Engineering and Westinghouse to provide power-operated relief valves for installation in the steam supply systems of nuclear power plants. The valves are mounted on top of the reactor coolant system pressurizer in pressurized water reactors.

At the present time, Combustion Engineering of Windsor, Connecticut, has ordered two solenoid-operated relief valves (SORV) for the St. Lucie No. 2 reactor being built for the Florida Power and Light Company. The CE valves (Garrett Part 3750010) are right-angle designs equipped with flanged pipe connections with a 3-inch nominal diameter inlet and an 8-inch nominal diameter outlet. The valves are capable of venting saturated steam, a two-phase mixture of water and steam, saturated water, or subcooled water.

Westinghouse Electric Corporation of Pittsburgh, Pennsylvania, has ordered thirty power-operated relief valves (PORV) (Garrett Part 3750014) for various Westinghouse nuclear installations around the world. The Westinghouse valves are straight-through, welded-connection designs equipped with 3-inch inlet and 6-inch outlet ports. These valves are also capable of venting saturated steam, a two-phase mixture of water and steam, saturated water, or subcooled water.

Both the CE and Westinghouse valves contain a high percentage of common parts. Both units are also very similar to the valve used in the EPRI/PWR test program. The terms "solenoid-operated" and "power-operated" correspond to the nomenclature used by the respective customers, Combustion Engineering and Westinghouse. The valves are identical in basic function and operation and differ primarily in the configuration of the flow housings as subsequently discussed herein.

Table I presents a list of the utilities and power plants which use the Garrett PORVs and SORVs. The following sections of this report present detailed descriptions of these valves, together with a discussion of the similarity of these units to the EPRI test valves tested at the Marshall Steam Station and Wyle Laboratories.

The first Garrett test PORV was identified as Part 3224718-1. This valve incorporated a single-piece cage and seat assembly which were held in position by a Flexitallic gasket used as a compression spring. At the time of the Marshall test, Garrett intended this design to be utilized in the production SORVs and PORVs to be delivered to Combustion Engineering and Westinghouse. Although the Marshall Test of the Garrett PORV was successful, the test valve developed a small leak (0.01 gallon per minute) under the valve seat. Upon reviewing this test result, Garrett concluded that an improved design was possible and changed both the test and production valve designs to incorporate these design improvements. Test valve 3224718-1 was returned to Garrett and modified to the 3224718-2 configuration which incorporated all the design features of the improved Combustion Engineering and Westinghouse valve designs. A more detailed discussion of the design features used in the Marshall Test Valve, Part 3224718-1, is given in Appendix A.

The Garrett test PORV, Part 3224718-2, was subsequently tested at Wyle Laboratories.

2. DESCRIPTION OF GARRETT PRODUCTION NUCLEAR VALVE DESIGNS

2.1 Typical Functional Schematic

Figure 1 shows the functional schematic typical for all current Garrett power-operated relief valves. The mode of operation of these valves is described in the following paragraphs.

TABLE I

LIST OF DOMESTIC PRESSURIZED WATER REACTORS
USING GARRETT RELIEF VALVES

Utility	Plant	Valve Port Size inches	Valve Configuration	Garrett Part Number
Florida Power and Light	St. Lucie No. 2	3 x 8	Right angle	3750010
Georgia Power Company	Arvin W. Vogtle No. 1	3 x 6	Straight-through	3750014
	Arvin W. Vogtle No. 2	3 x 6	Straight-through	3750014
Kansas Gas and Electric	Wolf Creek No. 1	3 x 6	Straight-through	3750014
Northeast Utilities	Millstone No. 3	3 x 6	Straight-through	3750014
Union Electric Company	Callaway No. 1	3 x 6	Straight-through	3750014
	Callaway No. 2	3 x 6	Straight-through	3750014

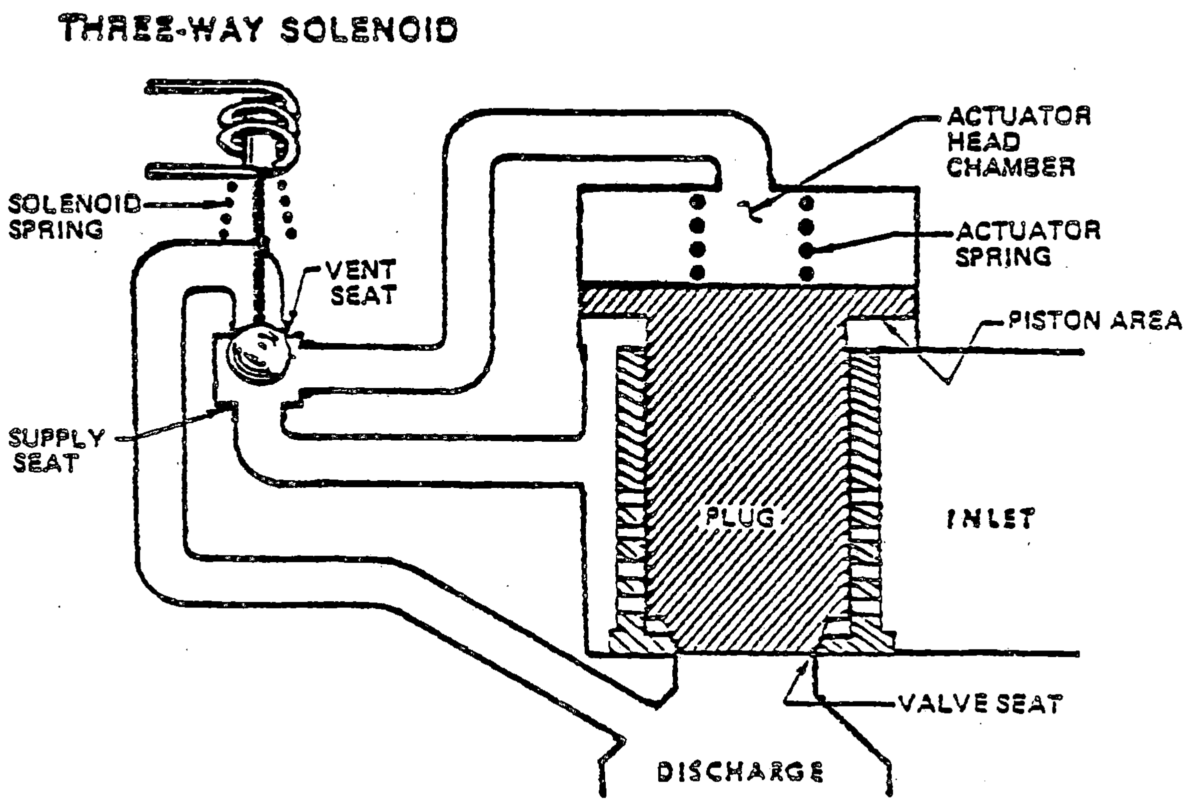


FIGURE 1

FUNCTIONAL SCHEMATIC DIAGRAM OF
GARRETT POWER-OPERATED
RELIEF VALVES

The Garrett power-operated relief valve is a line pressure actuated, solenoid-controlled, relief valve of the caged-plug type. The schematic diagram of Figure 1 shows the unit with the solenoid de-energized and the valve closed. Inlet pressure (either vapor or water) flows into the valve inlet connection and is ported through the solenoid seat to the actuator head chamber of the valve. Inlet pressure is also ported underneath the piston and through the cage holes to surround the plug. The forces tending to hold the valve closed include the pressure in the actuator head chamber acting on the entire piston area and the actuator spring load. Inlet pressure also acts on the annular area beneath the piston (and outside the seat diameter) in a direction to open the valve. Since the annular area is less than the total piston area, the closing force predominates and the plug is held down against the seat with a force equal to the value of inlet pressure multiplied by the seat area.

When the solenoid is energized, the magnetic force acts on the solenoid armature to move the ball from the vent seat (as shown) to the opposite seat, thus sealing off inlet pressure from the actuator head chamber. At the same time, the actuator head pressure is vented to discharge through the vent seat of the solenoid. With the actuator head chamber now at discharge pressure, inlet pressure acting on the annular area is sufficient to overcome the actuator spring load. The plug moves away from the seat in the direction to open the valve.

As the valve opens, pressure inside the cage builds up underneath that portion of the plug exposed to discharge pressure. Because of the pressure drop through the cage flow holes, this pressure is less than inlet pressure but higher than the discharge pressure. The large seating force that exists when the valve is closed is thus turned into an opening force, causing the plug to move to the full-lift position.

When the solenoid is de-energized, the ball moves back to the seat as shown, sealing off the path to discharge and repressurizing the actuator head chamber with inlet pressure. With the plug in the full-lift position, the opening force consists of inlet pressure acting on the annular area and cage pressure acting on the base of the plug. The closing forces (consisting of inlet pressure in the actuator head chamber and the actuator spring load) overcome the opening forces and cause the plug to move toward the seat. Discharge pressure drops to a minimum as the valve reseats, and the valve is once more held in the closed position by a force that is equal to inlet pressure multiplied by the seat area.

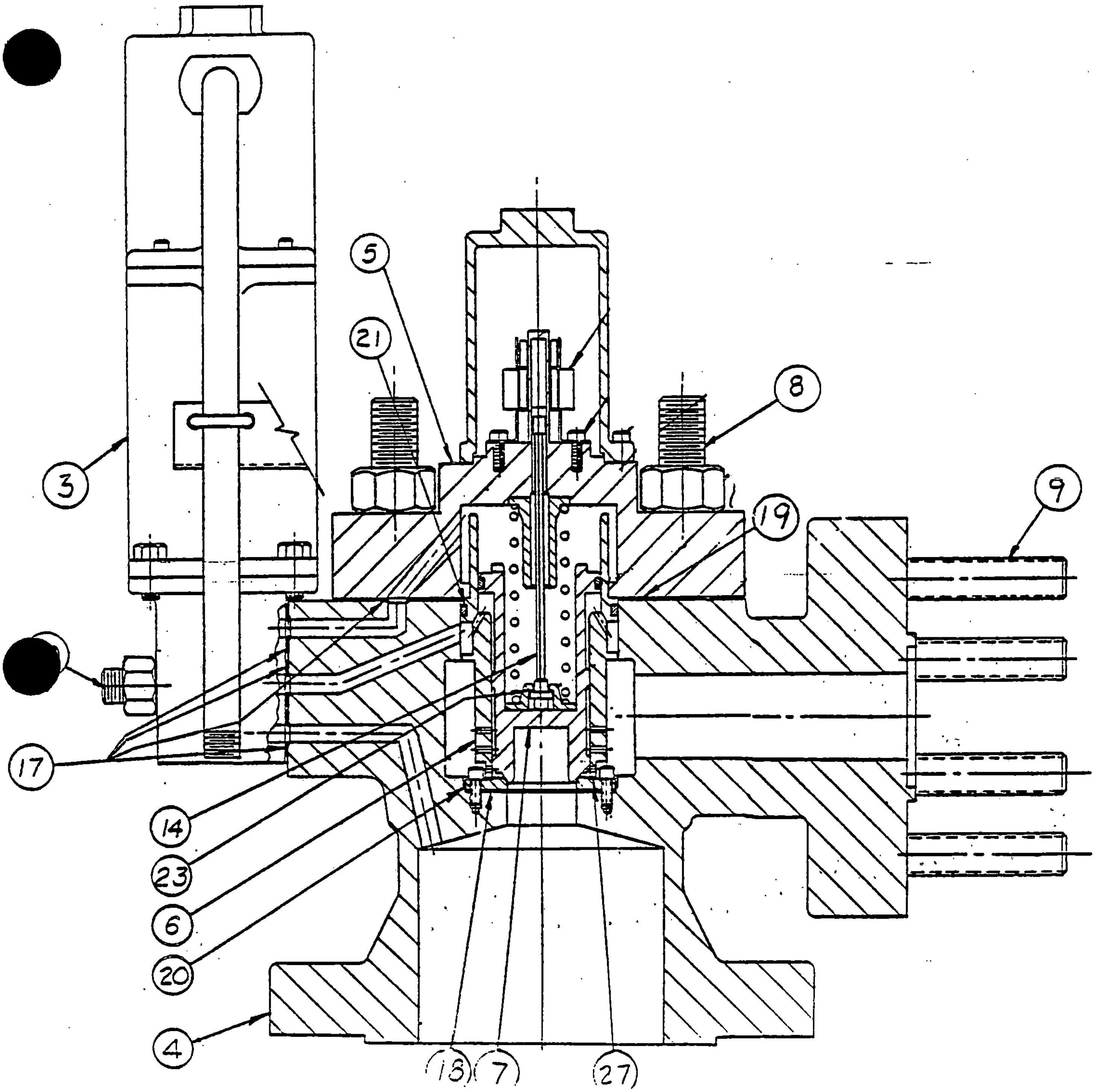
2.2 Combustion Engineering Solenoid-Operated Relief Valve

2.2.1 Major Components - The major components which comprise the Garrett 3-inch X 3-inch right angle solenoid-operated relief valve (SORV) (Garrett Part 3750010) are illustrated in Figure 2 and are described in the following tabulation.

Find Number	Component Description	Material
3	Solenoid	Garrett designed
4	Body	CRES SA182, GR F316
5	Bonnet	CRES SA182, GR F316
6	Cage	CRES SA479, Type 21800
7	Plug	CRES SA479, Type 316 (RCoCr-A hardfacing)
8,9,10	Studs	SA540, GRB21, CL2 (Electroless-nickel plated)
17,18,19	Seals	347 and Graphoil
20	Seat	SA479, Type 316L (RCoCr-A hardfacing)

2.2.2 Design Features and Operation - As shown in Figure 2, the Garrett right-angle SORV utilizes a "cartridge" closure element approach which isolates the internal operating mechanism from the outer pressure vessel components. The valve body, bonnet, and solenoid, and their respective studs and nuts, retain system pressure as required by the ASME Boiler and Pressure Vessel Code, Section III, Class I. The body also transmits and reacts external loads applied to the valve.

Valve operation and closure are performed by the cage, plug, and seat assembly, which are mechanically isolated from the pressure-retaining parts. The valve seat is sealed with a sheet metal/Graphoil-type Selco seal and is bolted into the body with ten high-strength A286 CRES bolts. The seat, thus anchored, becomes the guide for the cage and plug assembly. Once installed, the cage captures the seat bolts. The cage ID is guided on a raised ring on the seat and sealed by means of a carbon piston ring bore seal in the body just below the bonnet. The plug OD is sealed by means of a carbon piston ring bore seal on the cage ID to form a closed volume over the plug. This closed volume is the actuator head chamber shown in Figure 1 and discussed in paragraph 2.1 above.



COMPONENTS OF 3 X 8 RIGHT-ANGLE
SOLENOID-OPERATED RELIEF VALVE
GARRETT PART 3750010

FIGURE 2

The caged plug design has a number of inherent advantages over an uncaged plug-type valve. When the plug is actuated to the open position, the plug sealing surface is retracted out of the flow stream, thus reducing or eliminating the possibility of erosion of the sealing surface by either high-pressure steam or contaminants in the flow stream. In addition, the annular arangement of the cage flow holes focuses the flow stream in the center of the cage, thus reducing flow velocities over the valve seat and thereby also reducing the possibility of erosion.

In addition, the cage/seat assembly acts as a dual orifice system with a two-stage pressure drop. The reason for the differences in cage and seat flow areas in the various valves is 1) the need to vent the specified quantity of steam and/or water through the valve, and 2) to eliminate the possibility of saturated water flashing to steam upstream of the seat.

Compensation for thermal growth caused by differential heating rates between the valve cage and body is provided by a gap which is maintained between the bottom of the cage and the top of the seat. When the valve is closed, the cage is held up against the bonnet by a light spring (Find Number 27). When the valve opens, pressure forces the cage up into the bonnet with a high load, thus maintaining the gap between the base of the cage and the seat. Even under worst-case thermal growth conditions, the seat-cage-bonnet stack is never such that the thermal compensator gap is reduced to zero. Thus, the "floating" cage remains axially unloaded at all times, and thermal growth has no effect on operability of the valve.

Compensation for end load-induced deformation of the valve body is provided in much the same manner. The diametral clearance between the cage and body in the area of the piston ring is an order of magnitude larger than the worst possible deformation of the body in this region. Even when maximum end loads are applied to the base of the valve, the body never contacts the cage OD and no forces are transmitted between the two components.

The Garrett SORV incorporates redundant position switches. Two of the switches are actuated when the valve is in the closed position and two are actuated when the valve is in the open position. During the time that the valve is stroking between the open and closed positions, all four switches maintain continuity. The switches are actuated by means of a samarium/cobalt magnet which moves up and down with the plug inside the bonnet. Thus, position indication is obtained without penetration of the pressure boundary or the use of packings.

The Garrett SORV is controlled by a Garrett-designed solenoid. The solenoid is a direct-acting, three-way valve. In this concept, electromagnetic force is transmitted directly onto a ball, switching it between two seats. The solenoid contains no delicate pilot mechanisms or other devices which might stick or jam. The electromagnetic force developed by the solenoid during actuation is on the order of several hundred pounds. Paragraph 2.4 presents a description of the design features of the solenoid.

2.3 Westinghouse Power-Operated Relief Valve

2.3.1 Major Components - The major parts which comprise the Garrett 3-inch x 6-inch straight-through power-operated relief valve (PORV) (Garrett Part 3750014), are illustrated in Figure 3 and are described in the following tabulation.

Find Number	Component Description	Material
1	Body	CRES SA182, GR F316
2	Bonnet	CRES SA182, GR F316
3	Seat	SA479, Type 316L (RCoCr-A hardfacing)
4	Solenoid	Garrett designed
6,27	Studs	SA453, GR 660
14,15,16	Seals	347 and Graphoil
24	Cage	CRES A276, Type 21800
29	Plug	CRES SA479, Type 316 (RCoCr-A hardfacing)

2.3.2 Design Features and Operation - As shown in Figure 3, the Garrett straight-through PORV utilizes a "cartridge" closure element approach similar to that of the right-angle SORV discussed in paragraph 2.2.2. The valve body, bonnet, and solenoid, and their respective studs and nuts, retain system pressure as required by the ASME Boiler and Pressure Vessel Code, Section III, Class I. The body also transmits and reacts external loads applied to the valve.

Valve operation and closure are performed by the cage, plug, and seat assembly, which are mechanically isolated from the pressure-retaining parts. The valve seat is sealed with a sheet metal/Graphoil type Selco seal and is bolted into the body with ten high-strength A286 CRES bolts. the seat, thus anchored, becomes the guide for the cage and plug assembly. Once installed, the cage captures the seat bolts. The cage ID is guided on a raised ring on the seat and sealed by means of a carbon piston ring bore seal in the body just below the bonnet. The plug OD is sealed by means of a carbon piston ring bore seal on the cage ID to form a closed volume over the plug. This closed volume is the actuator head chamber shown in Figure 1 and discussed in paragraph 2.1 above.

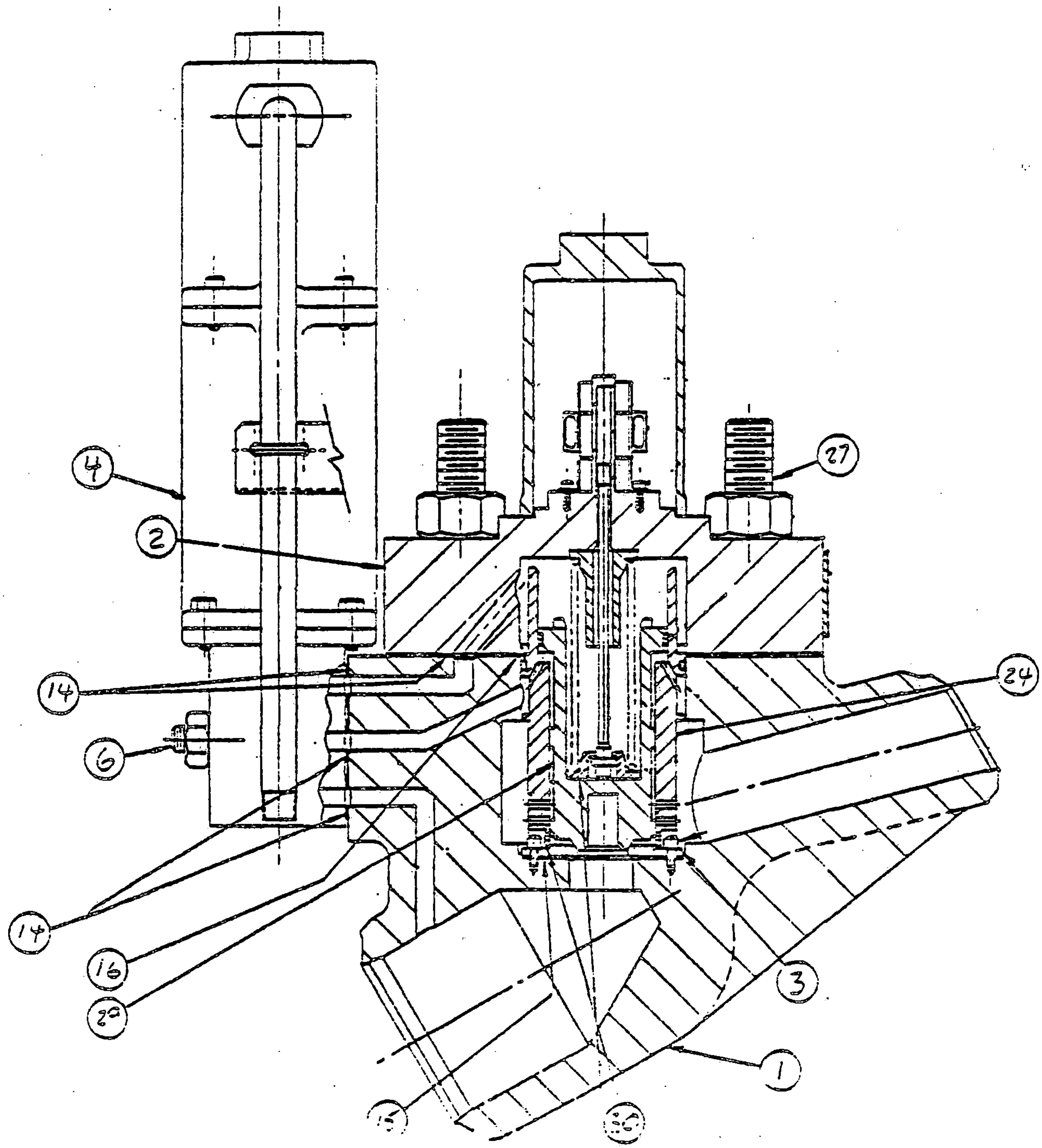


FIGURE 3

COMPONENTS OF 3 X 6 STRAIGHT-THROUGH
POWER-OPERATED RELIEF VALVE
GARRETT PART 3750014

The caged plug design has a number of inherent advantages over an uncaged plug-type valve. When the plug is actuated to the open position, the plug sealing surface is retracted out of the flow stream, thus reducing or eliminating the possibility of erosion of the sealing surface by either high pressure steam or contaminants in the flow stream. In addition, the annular arrangement of the cage flow holes focuses the flow stream in the center of the cage, thus reducing flow velocities over the valve seat and thereby also reducing the possibility of erosion.

In addition, the cage/seat assembly acts as a dual orifice system with a two-stage pressure drop. The reason for the differences in cage and seat flow areas in the various valves is 1) the need to vent the specified quantity of steam and/or water through the valve, and 2) to eliminate the possibility of saturated water flashing to steam upstream of the seat.

Compensation for thermal growth caused by differential heating rates between the valve cage and body is provided by a gap which is maintained between the bottom of the cage and the top of the seat. When the valve is closed, the cage is held up against the bonnet by a light spring (Find Number 30). When the valve opens, pressure forces the cage up into the bonnet with a high load, thus maintaining the gap between the base of the cage and the seat. Even under worst-case thermal growth conditions, the seat-cage-bonnet stack is never such that the thermal compensator gap is reduced to zero. Thus, the "floating" cage remains axially unloaded at all times, and thermal growth has no effect on operability of the valve.

Compensation for end load-induced deformation of the valve body is provided in much the same manner. The diametral clearance between the cage and body in the area of the piston ring is an order of magnitude larger than the worst possible deformation of the body in this region. Even when maximum end loads are applied to the valve, the body never contacts the cage OD and no forces are transmitted between the two components.

The Garrett PORV incorporates redundant position switches. Two of the switches are actuated when the valve is in the closed position and two are actuated when the valve is in the open position. During the time that the valve is stroking between the open and closed positions, all four switches maintain continuity. The switches are actuated by means of a samarium/cobalt magnet which moves up and down with the plug inside the bonnet. Thus, position indication is obtained without penetration of the pressure boundary or the use of packings.

The Garrett PORV is controlled by a Garrett-designed solenoid. The solenoid is a direct-acting, three-way valve. In this concept, electromagnetic force is transmitted directly onto a ball, switching it between two seats. The solenoid contains no delicate pilot mechanisms or other devices which might stick or jam. The electromagnetic force developed by the solenoid during actuation is on the order of several hundred pounds. Paragraph 2.4 presents a description of the design features of the solenoid.

2.4 Direct Acting, Three-Way Solenoid

2.4.1 Major Components - The major parts which comprise the Garrett solenoids for nuclear applications (Garrett Parts 3750020 and 3750028) are illustrated in Figure 4 and are described in the following tabulation. The only difference between the two designs is that Part 3750028 is not equipped with position indicator switches, although it does include the magnet rod used for actuating the position switches. Part 3750028 is used on SORV 3750010 (Combustion Engineering), while Part 3750020 is used on PORV 3750014 (Westinghouse).

Find Number	Component Descripton	Material
1	Body	SA182, GR F316
2	Pressure Vessel	SA479, Type 347
3	Coil Assembly	Nickel clad copper with "E" glass insulation
4	Cover	1020 nickel plated steel
5	Armature	Carpenter 430
6	Stop	Carpenter 430
7	Stem	ASTM A276, Type UNS S21800
8	Ball and Seat Assembly	Stellite 6B ball and RCoCr-A hard-faced seats

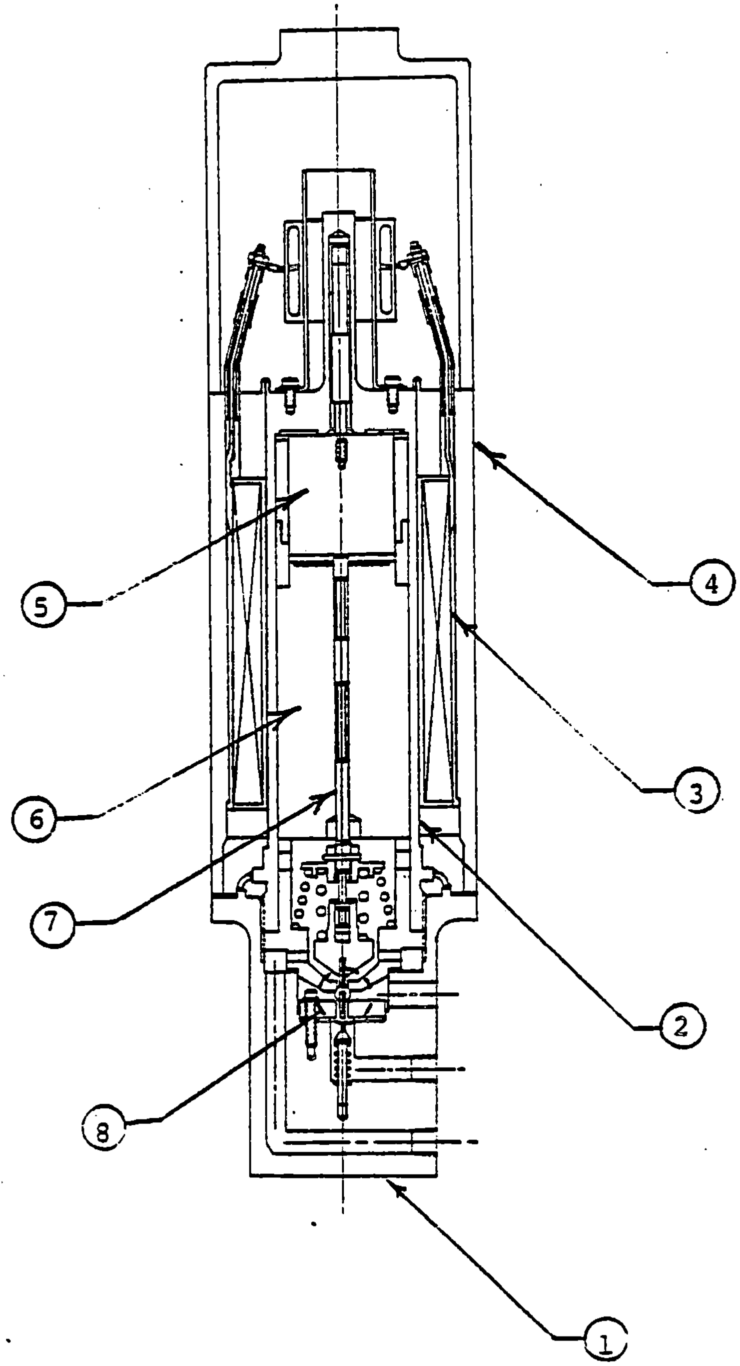


FIGURE 4

COMPONENTS OF THREE-WAY SOLENOID VALVES
GARRETT PARTS 3750020 AND 3750028

2.4.2 <u>Design Features and Operation</u> - As shown in Figure 4, the Garrett solenoid is a direct-acting, three-way electromagnetic switcher valve. When power is applied to the solenoid coil, the resulting electromagnetic field forces the armature down against the stop assembly with a large force margin. The armature pushes the solenoid stem down against the ball, moving it from the upper seat to the lower seat. The solenoid stem includes an override mechanism which limits the total force applied to the solenoid ball when it reaches the lower seat, thus protecting both the ball and the seat from damage. When the solenoid is de-energized, a return spring pushes the solenoid stem and armature back to the position shown. A small return spring, plus the inlet pressure force causes the valve to return to the upper seat.

Design features of the Garrett solenoid include the use of Carpenter 430 corrosion-resistant magnetic material in the armature and stop assembly, together with a hermetically sealed pressure vessel and body assembly. All of the materials used in the construction of the solenoid are inorganic. The solenoid coil is wrapped with nickel-clad copper wire with "E" glass insulation. The coil is also bifilar wound to limit voltage spikes when the solenoid is de-energized.

The solenoid incorporates provisions for orifices in both the inlet pressure and discharge vent lines. These orifices can be sized to provide independent control of the opening and closing times of the valve on which the solenoid is installed according to the requirements of each individual customer.

3. DESCRIPTION OF EPRI/PWR TEST VALVE, PART 3224718-2

The valve selected for the EPRI/PWR Safety and Relief Valve Test Program is Garrett Part 3224718-2. The unit is a hogged out, flanged model of a straight-through power-operated relief valve similar to the Westinghouse valve. Figures 5 and 6 present, respectively, external and cross-sectional views of the test valve. Figure 7 is a cross-sectional view of the Garrett development model three-way solenoid used to control the test valve.

4. COMPARISON OF EPRI/PWR TEST VALVE WITH PRODUCTION CONFIGURATIONS

This section of the report presents a discussion of similarities and differences between the EPRI/PWR test valve and the valves presently in production by Garrett for use in nuclear applications.

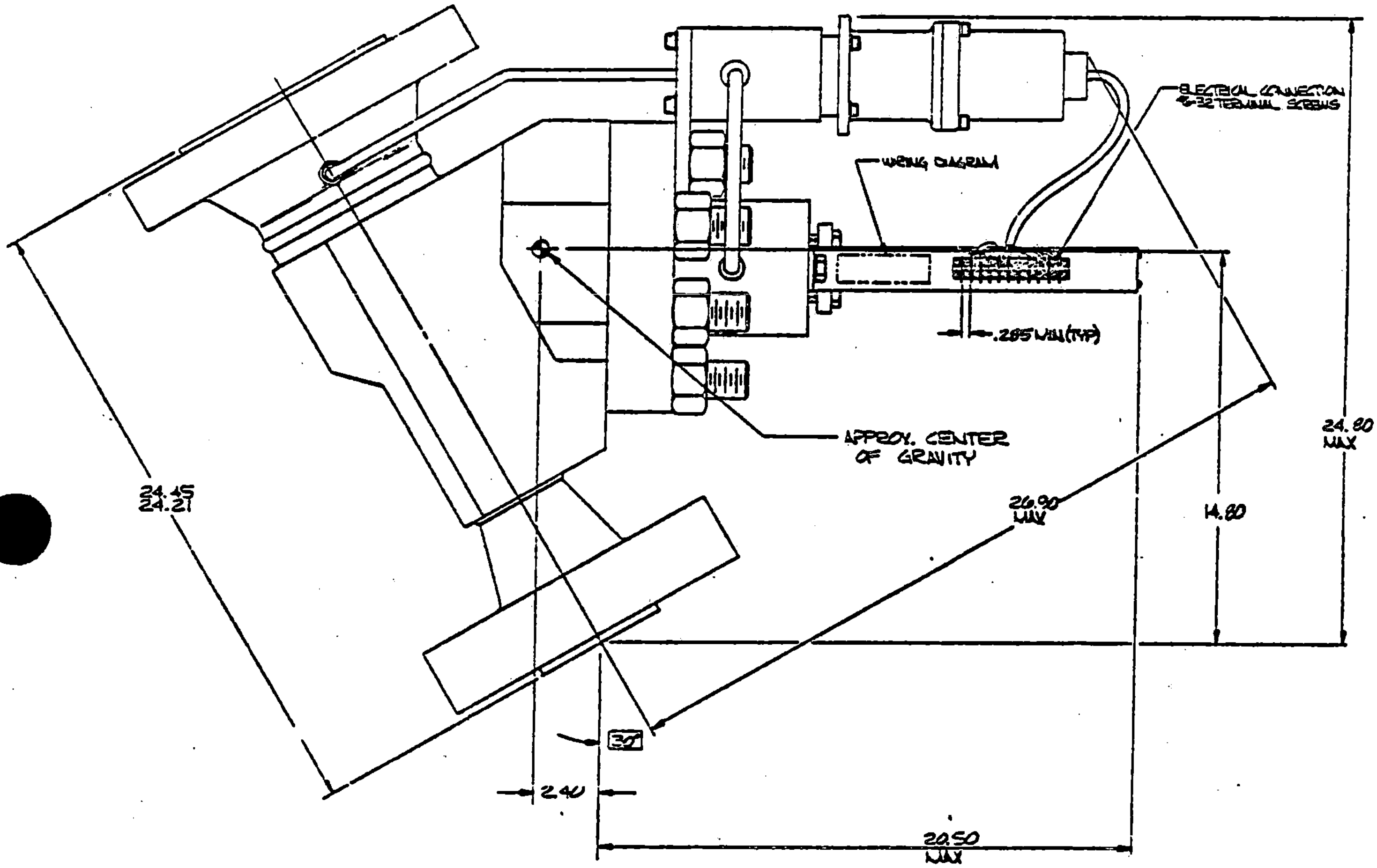


FIGURE 5

EPRI/PWR TEST VALVE
GARRETT PART 3224718-2

MODIFIED DUKE/WYLE PORV PART 3224718-2

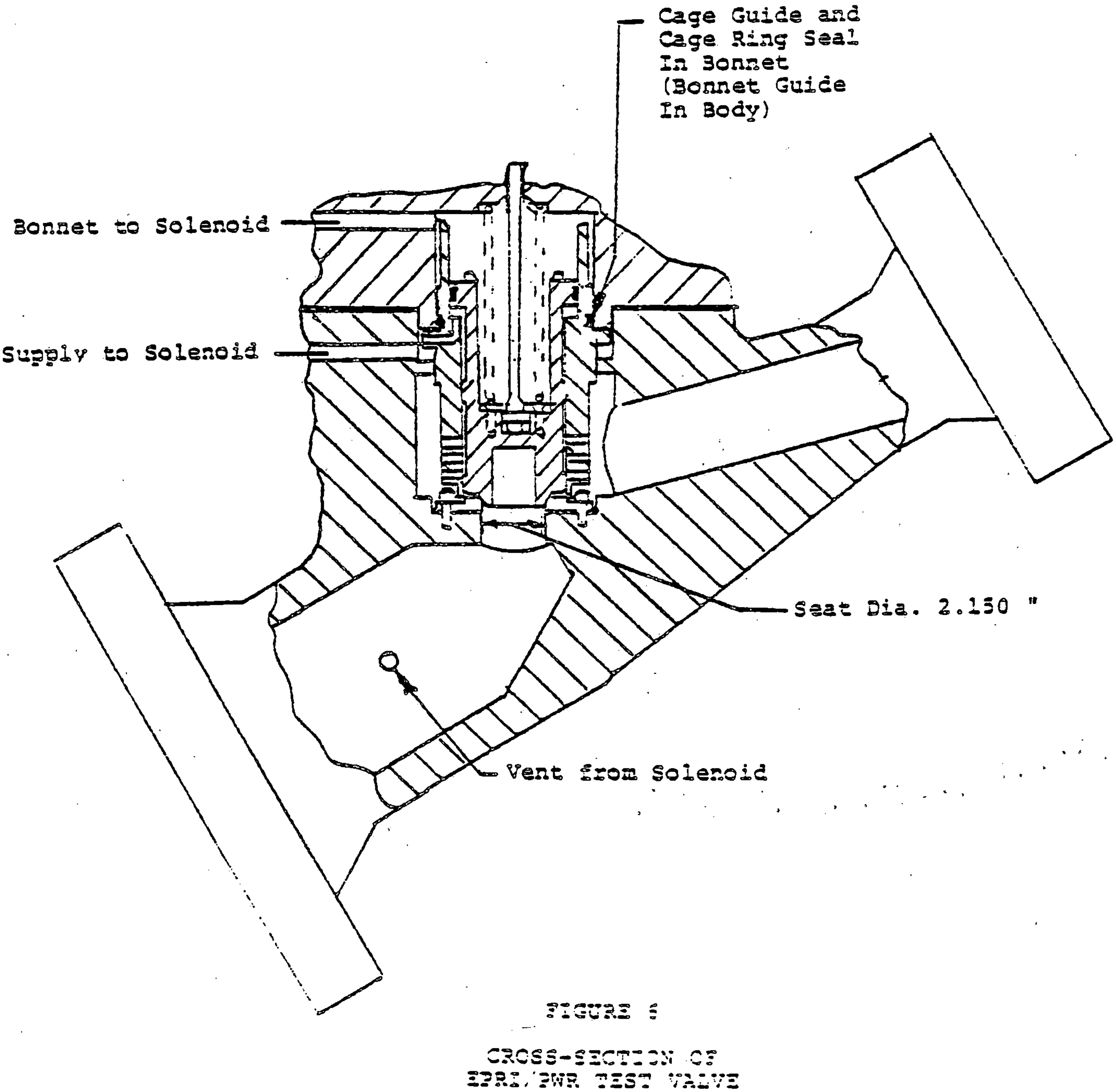


FIGURE 6

CROSS-SECTION OF
EPRI/PWR TEST VALVE

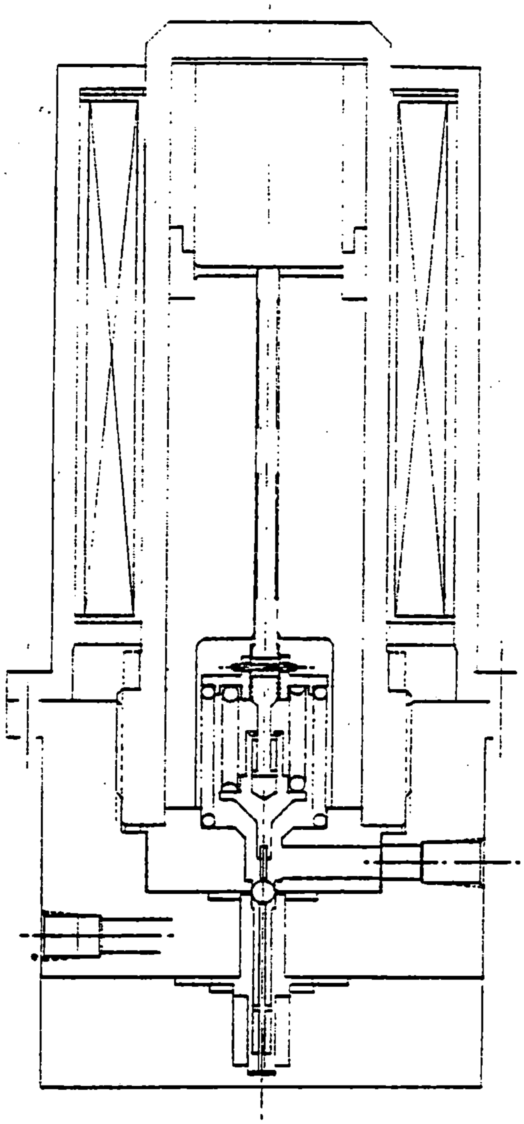


FIGURE 7

CROSS-SECTION OF
GARRETT DEVELOPMENT SOLENOID

4.1 Main Valve Assembly

As previously noted, Garrett Part 3224718-2 was created specifically for the EPRI/PWR Safety and Relief Valve Test Program. Therefore, great care has been taken to make the unit representative of the production models currently being furnished to Westinghouse and Combustion Engineering. The only differences are in the cage and seat flow areas, and in the housing configuration. Part 3750010 is a right-angle design. These points are discussed in greater detail in the following paragraphs.

4.1.1 Inlet Pipe Area - The inlet flange connection on production units of Part 3750010 has an area of 5.309 square inches (2.600 inch nominal diameter). The welded inlet connection on Part 3750014 has an area of 5.103 square inches (2.549 inch nominal diameter). The inlet area of the test valve, Part 3224718, is 4.909 square inches (2.500 inch nominal diameter). These variations are not significant with respect to the basic performance or operation of the valves.

4.1.2 Discharge Pipe Area - The discharge flange connection on Part 3750010 has an area of 43.59 square inches (7.45 inch nominal diameter) while Part 3750014 has a welded discharge connection with 22.28 square inches (5.326 inch nominal diameter). The test valve discharge area is 28.27 square inches (6.00 inch nominal diameter). Similarly, these variations are not significant with respect to the basic performance or operation of the valves.

4.1.3 Seat Area - The seat flow details of the valves are as follows:

Part Number	Seat Diameter inches	Flow Area square inches
3750010	2.135	3.580
3750014	1.420	1.584
3224718-2	2.150	3.631

The variation in seat diameters and flow areas noted above is a function of the desired pressure-relieving capacity and whether the valve size has been optimized for water or steam flow. However, the variation in flow areas has no effect on valve function or operability.

4.1.4 Cage Configuration - The ID of the cages at the flow holes on the production valves is 3.00 inches, whereas the test valve has a 2.500-inch diameter cage. The pattern and details of the flow holes in each cage are described below.

Part Number	Hole Diameter inch	Hole Pattern	Flow Area square inches
3750010	0.146	7 rows of 48	5.625
3750014	0.230	5 rows of 32	6.648
3224718-2	0.142	7 rows of 38	4.213

The diameter of the cage and the pattern of flow holes depends on the desired pressure-relieving capacity and whether the valve has been optimized for water or steam flow. As with the seat areas, the variation in flow areas has no effect on valve function or operability.

4.2 General Similarities

As shown in Figure 6, the EPRI/PWR test valve, Garrett Part 3224718-2, is generally representative of both of the production valves discussed in Section 2 above. The test valve incorporates the following items which are also included in the production valves.

1. A bolt-down seat
2. A "floating" cage with a thermal compensation gap between the cage and seat
3. Piloting of the cage on a register land of the seat
4. Selco seals
5. Hardfaced seat and plug
6. Carbon piston ring seal on plug
7. Carbon piston ring seal on cage

The differences between the production and test valves are primarily due to the fact that the test valve was designed and produced before completion of the production designs. These differences include use of external solenoid tubing on the test valve rather than internal as on the production versions. Also, the cage in the test model is piloted on the bonnet which, in turn, is piloted on the body. In the production configuration, the cage pilots directly into the body. Finally, the test valve has a packing system to seal a rod that is connected to an LVDT for a readout of valve position. This instrumentation is for test purposes only and the production valves use the magnetic reed switch system previously described.

4.3 Straight-Through versus Right-Angle Flow Housing

Both the EPRI/PWR test valve and the Westinghouse production valve are straight-through, 3 in. x 6 in. power-operated relief valves. The Combustion Engineering valve is a 3 in. x 8 in. right angle design. Although a right-angle valve is somewhat different from a straight-through design from the standpoint of hydrodynamic efficiency and external loading, the test results from the Garrett/EPRI test valve are considered fully applicable to the Combustion Engineering valve, Part 3750010.

The variation in pressure relieving capacity of a right angle versus straight-through valve is easily calculated once the discharge geometry is known. All steam and water flows obtained during the EPRI test program can be applied to the right-angle CE valve design with a high degree of confidence.

The "cartridge" closure design of the Garrett valve eliminates the possibility of valve binding due to end load-induced deflections. The worst case load possible for the Garrett 3 in. x 8 in. right angle SORV is 33,100 pounds of thrust against the discharge flange. This is reacted to the associated structure as a 384,878 in.-lb moment through the inlet flange. An analysis was performed in which it was assumed that this moment would "ovalize" the flow body in the region of the cage carbon piston ring seal. The result of this analysis was that the body diameter would deform by minus 0.00116 inch in this region. Since the minimum cage clearance with the body is 0.012 inch, or ten times as much, no external load-induced binding can occur.

4.4 Solenoid

The Garrett development solenoid shown in Figure 7 is being used to control the EPRI/PWR test valve, Part 3224718-2. As shown, the development model solenoid includes an electromagnetic coil of the same size as the production model, a three-way switching mechanism with a ball-type plug, a mechanical override on the solenoid stem to limit the total force applied to the ball during actuation, and a similar style body and pressure vessel to retain system pressure.

Since the basic intent of the EPRI/PWR safety and relief valve test was primarily to demonstrate valve operability under all conditions of flow and pressure likely to be attained in an operating pressurized water reactor, and not to impose the environment of a Design Basis Event on the equipment, the Garrett development solenoid utilizes materials differing from those found in the production solenoids. The development solenoid is functionally representative of the production design.

5. CONCLUSIONS

As discussed in the previous paragraphs, the Garrett/EPRI Test Valve, Part 3224718-2, is representative of both Garrett PORV designs presently in production. Therefore, the results of the EPRI/PWR Safety and Relief Valve Test are considered fully applicable to both the Combustion Engineering Solenoid-Operated Relief Valve, Part 3750010 (3 in. x 8 in. right-angle valve) and the Westinghouse Power-Operated Relief Valve, Part 3750014 (3 in. x 6 in. straight-through valve).

GARRETT PNEUMATIC SYSTEMS DIVISION
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APPENDIX 1

GARRETT STRAIGHT-THROUGH TEST VALVE
PERFORMANCE AT MARSHALL STEAM STATION
JANUARY 23, 1981

41-3088B
Appendix 1

GARRETT STRAIGHT-THROUGH TEST VALVE PERFORMANCE AT MARSHALL STEAM STATION JANUARY 23, 1981

Garrett straight-through power-operated relief valve, Part 3224718-1, was tested in the EPRI/PWR Safety and Relief Valve Test Program at Marshall Steam Station on January 23, 1981. The valve configuration at that time was similar to that of the right angle valve shown in the attached Figure 1, except that Part 3224718-1 has a straight-through body and utilizes a linear potentiometer system for measuring plug position. The valve internal design included a single-piece cage and seat assembly held down by means of a Flexitallic spring gasket, and an orificed plug controlled by a two way, piloted Valcor solenoid.

The valve was subjected to eleven cycles of operation at 2440 psig with dry, saturated steam. The valve operated normally, with no tendency to fail to operate. Internal leakage, which was zero at the beginning of the test, was 0.006 gpm at 2440 psig after two cycles, and 0.01 gpm at the end of eleven cycles. Following the conclusion of the official EPRI test, Garrett requested that a number of additional cycles be run on the valve. After 66 unofficial cycles, the valve leakage continued at the 0.01 gpm value. Steam flow rates for all tests were 295,000 lb per hr.

Following this test, the valve was disassembled and inspected. All parts were in good condition following the 77 cycles of operation, except for the Flexitallic gaskets beneath the valve seat and at the body/bonnet interface. The seat gasket was completely washed out and the body/bonnet gasket was showing signs of distress. The washed-out seat gasket was considered to be the cause of the 0.01 gpm internal leakage rate.

Post-test analysis showed that the problem was caused by differential thermal growth during the first opening cycle. A Flexitallic gasket between the cage and bonnet had the dual function of holding the cage down against the seat gasket and compressing sufficiently to compensate for differential thermal growth. The spring gasket proved unable to withstand the applied load and took a permanent set, thus allowing the cage to become unloaded and lift up off the seat gasket. The seat gasket was therefore exposed to the scouring action of the steam and all of the asbestos washed out during the first cycle of operation. The valve then experienced the 0.01 gpm leakage beneath the seat.

Since the Marshall steam test proved that the original method of compensating for thermal growth was inadequate, a number of design changes were made to Part 3224718-1 and to the Combustion Engineering and Westinghouse production power-operated relief valves. These included:

1. Designing a separate, bolted down seat.

2. Allowing the valve cage to float for thermal compensation.

3. Replacing the seat and body/bonnet Flexitallics with Selco seals.

4. Changing the cage-to-bonnet seal from a Flexitallic to a carbon piston ring bore-seal.

In addition, at the time of the Marshall test, Garrett was in the process of changing the production PORVs from a Valcor, piloted, two-way solenoid to a Garrett designed and manufactured, direct-acting, three-way solenoid. The three-way solenoid design was judged to give better control of valve operation. Therefore, Part 3224718-1 was modified to accept the Garrett three-way solenoid.

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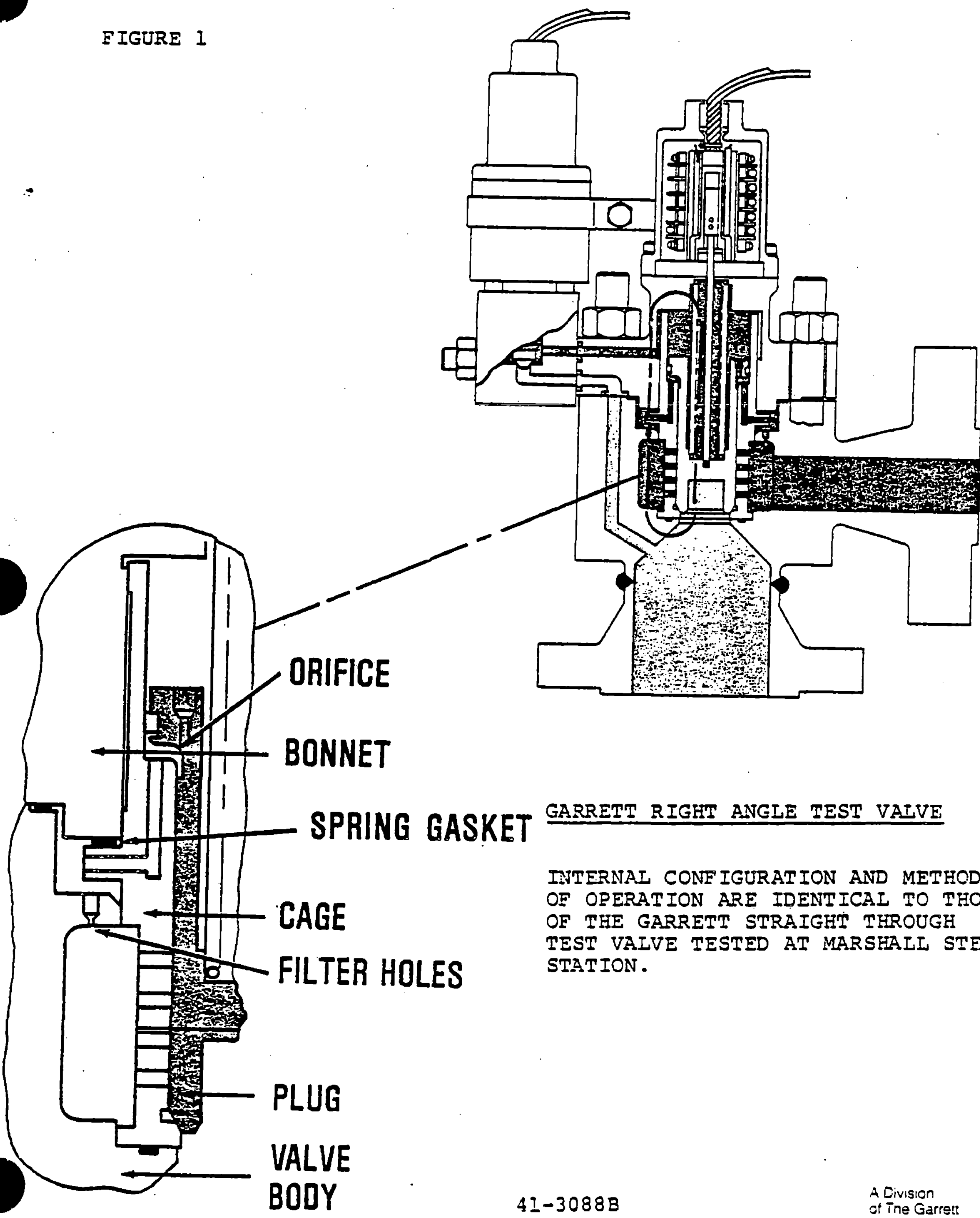
FIGURE 1



GARRETT RIGHT ANGLE TEST VALVE

INTERNAL CONFIGURATION AND METHOD OF OPERATION ARE IDENTICAL TO THOSE OF THE GARRETT STRAIGHT THROUGH TEST VALVE TESTED AT MARSHALL STEAM STATION.

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