INDUSTRIAL NEWSLETTER

MOOG

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Product Manufacturing at Moog: Custom-Built Solutions

Moog has been a leader in precision motion control products for over 50 years and a player in global manufacturing and supply chain management since the 1960s. We have continued to evolve our systems and processes over time to specialize in both hydraulic and electric products and to meet customer expectations for best-in-class product design. Our organization is focused now on effectively delivering customized products so that each becomes the exact solution that a customer needs to improve a machine's performance or solve a system problem.

This article describes Moog's new strategy for working with customers to build custom products to exacting specifications and how we work to continually improve our capabilities and service. We will use Servovalves and Servo-Proportional valves as examples but the concepts apply to all of Moog's core product lines. Many people in the industry think of valves as standard products and are surprised to find that nearly every product made by Moog today is custom-designed and built for an exact machine and application. Our operations today and in the future will focus on meeting our customers' needs for performance-based customized motion control solutions.

Moog's Strategic Plan

Moog's Industrial Organization has recently completed a new business strategy based on the needs and concerns of our customers. Our objective is to be a Global Organization that supplies and services customized motion control solutions to Global and Regional Markets. Think of this as an agile single virtual company with the benefits of local representation. To implement this focus our operations are now designated as either supply-side or demand-side to enable faster and better delivery of custom products. This will allow us to better serve our customer by focusing on some core competencies:

- Customer intimacy – Understanding customer needs and providing unique solutions.
- Ability to customize our core product and platforms close to the customer interface.
- Global Core Product Organization to leverage broad resources and concentrate on delivering best-in-class products, processes and service.

Customer Intimacy: Understanding Customer Needs

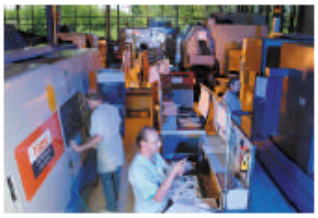
Customer intimacy has been the key to effective product development and application for the entire history of Moog. Our operations are organized as Centers of Excellence that specialize in the design and manufacture of products. For example, all of Moog's electrical feedback Servo-Proportional Valves for industrial applications are centralized in Europe. These valves are then sold and supported in over 20 locations around the world, where the customer can communicate with our engineering staff in his or her local language. Many of our locations have operations that provide testing, and customization on-site to provide the maximum flexibility in providing solutions. Consequently, Moog also maintains a sophisticated global supply chain including purchasing, manufacturing, and distribution in the Americas, Europe, and the Pacific.

Moog uses regular customer satisfaction research to understand what is fundamental to our customers' success and to ensure our operations meet current and future needs. In the hydraulics arena, new technologies such as microprocessor-based digital products offer not only additional features but also more software-based customization. The trend of transitioning machines from electro-hydraulic to electro-mechanical and hybrid control means that Moog's approach of providing "technology neutral solutions," will take on greater and greater importance. Moog is truly committed to providing customized solutions and working with customers to continually improve operations and the ability to act more quickly on needs.

Ability to Customize Our Core Product and Platform: Close to the Customer Interface

Some machine builders think of a servovalve, that has been around for 50 years, as a standard product that can be purchased off-the-shelf. Yet, Moog's value to our customer is to provide the optimum motion control solutions to improve machine performance. For many machine builders, servovalves and Servo-Proportional Valves are the key to making their machine the fastest, most accurate, safest, and most energy efficient in the marketplace. Moog ensures that the latest design changes and improvements are incorporated into all new products rather than selling a component off-the-shelf and making it fit. Thus, Moog can serve customers better as a solution provider rather than a standard component manufacturer.

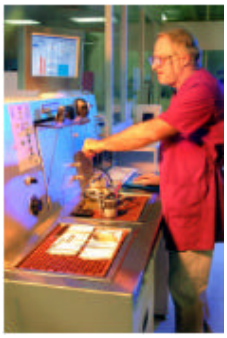
As you would expect, Moog uses the latest manufacturing techniques from Point of Use Inventory to Lean Manufacturing to Value Stream Mapping in order to ensure the quality of product and timeliness of delivery. Most of our operations use cell or team manufacturing to ensure that decision-making and quality stays with each technician. While empowerment is a buzzword for many businesses today, it is actually core to Moog's corporate culture and has been in practice since its inception in 1951. Moog's culture is stated succinctly as "promoting a workplace with mutual trust and individual responsibility." This philosophy is one of the reasons why the people of Moog have made it the quality leader in the industry.



Another important element of customization is competency in precision manufacturing. For example, the fit and overlap of valve bodies and bushings and spools are manufactured to tolerances of microns (0.000050 – 0.000150 inches) using some of the most sophisticated honing, grinding, lapping and EDM machinery in the market. Even more important than machining is using state-of-the-art techniques to measure very small dimensions accurately and quickly. Moog developed this measuring technology in-house as the key to reliable and consistent machining processes.

In addition to precision machining, the ability to assemble a large variety of customized products in small batches is a critical competency of Moog operations. This encompasses not only the supply chain management of over 100,000 different parts, but also documentation of assembly processes and testing. To meet our customer expectations of consistent quality and short delivery times, Moog must be able to assemble and adjust valves to customer specifications. The complexity of customizing all of our 35,000 models of servo and proportional valves is enormous, but products must also be offered at reasonable cost and delivery times, even for one-piece lot sizes. The answer for Moog is to employ effective global sourcing systems and partnerships with long term suppliers.

Global Core Product Organization: To leverage broad resources and concentrate on delivering best-in-class products, processes and service.



The role of designing and building products at Moog is just one part of a wider Supply Chain Management process. With respect to core products and platforms, we manufacture or procure parts/materials from the most effective source, and consolidate like items to leverage volume and make best use of resources. Common processes are used around the Moog globe, which will enable rapid redeployment of tasks and resources on an "as required" basis.

One important new service that is being developed by Moog experts to complement our future strategy is the ability to quickly provide custom working models of products for our customer's prototype machines. This is increasingly critical to our customers as their new generation machine development time becomes compressed. Hence a rapid prototyping facility will be a collective cell of manufacturing, assembly, and testing capabilities supported by dedicated functions, that will enable the speedy transition from first design concept to first working model. Such an initiative will inevitably require streamlined processes to enable the vision to be realized.

Due to Moog's 50 years of experience, an important aspect of our global supply chain and customization competency is the ability to store and retrieve specification data on the 35,000+ models manufactured at sites all round the world. When a customer needs a replacement of Moog product they can be assured of the same performance as well as product upgrades and design improvements. This requires a sophisticated manufacturing and assembly process that is tied to an effective specification system to manage this complexity.

Future Success:

Moog's new strategy builds on the success of 50 years to help us continue to design and build products that are not only best-in-class but a unique solution for the customer. While this article used valves as an example, the concept also applies to our servomotor and drives, pumps, and controllers as well as innovative sub-systems that combine multiple products. Clearly, Moog will continue to invest in our core capabilities in product design, manufacturing and service. This requires continual investment in machining, assembly, and testing of products including acquisition of new machines and control systems to further reduce set-up and cycle times. This also requires an emphasis on lean processes and efficient supply chains as well as a highly flexible organization. Of course, the people who work at Moog remain the most important element and the real secret behind our innovation and excellence. Today, more than ever, Moog is a partner in providing one of the most important key differentiators for our customers, a unique motion control solution made specifically for their machine.

Author:

Colin Lewis was appointed as the Head of Global Core Products, Moog International in April 2004. His career started with Moog Controls Limited (MCL) in the United Kingdom as Director of Programs on Aerospace. He was subsequently named General Manger Aerospace. Prior to his most recent position, Colin jointly held the positions of Managing Director, MCL, and General Manager, Electric Products.

Special thanks to Gunter Kilgus, Dave Stocking, and Kim Marie McKernan who made significant contributions to this article.

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Appendix A.:Valve Customization

In the example of servovalves and Servo-Proportional Valves, the amount and level of customization available is surprising to customers. To illustrate the level of customization Moog can provide in this example a list of some of the valve components that can be customized is listed below

- Torque Motors/Spool Actuators (Linear Motor, Solenoid, Pilot Valve)
- Valve Size/Rated and Maximum Flows
- Operating Pressure
- Valve Function (Q, P, Pq Control,.....)
- Nozzle size
- Coil assembly
- Feedback wire spring rate
- Hydraulic amplifier set up
- Spool-in-Body/Bushing and Spool Assembly
- Null cuts (see the attached article **Did You Know)**

Fail-safe options (Electric/Hydraulic)

Did You Know? Customized Null Cutting and Optimized Performance

One of the most important services Moog offers is the ability to customize its products to improve machine performance and provide solutions to motion control problems that our customers are facing. This requires an advanced knowledge of system design and machine applications, as well as experience in designing and building precision products. One example of this capability is the process of customizing the spool null cut in Moog's Servovalves and Servo-Proportional Valves. It is a critical process for customers as this customization provides for the highest performance and precision of motion control. While many engineers are aware of the importance of the precision of the spool cut they may not be aware of the process Moog application engineers use to define a null cut configuration to solve system or machine problems.

There are many options for customizing a spool null cut to optimize machine performance for a specific application. This article discusses some of the following typical configurations: critical center spool (axis cut), open center spool (underlap), closed center spool (overlap) and dual gain valves.

Critical Center Spool Valves

Critical center spool valves, also called "Axis cut or Zero overlap valves," are the most popular valve configuration for high performance Moog Servovalves. This describes a product where the spool lands align with the edge of the ports so that the control flow is zero at null and there is no dead band in the null region. Axis cut valves are suitable for position control servo systems because they deliver seamless control flow to an actuator and give higher pressure gain, leading to increased actuation stiffness.

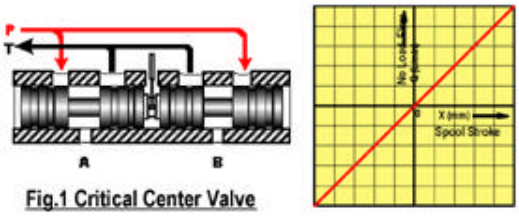


Fig.1 Critical Center Valve

The axis cut valve may not be suitable for some applications. One example is a servo system that is not stable due to poor damping. Another involves situations where there is a strong requirement to save energy and the null leakage of the axis cut valve is unacceptable. In these situations, other null cut customization options are available.

Open Center Spool Valves

Open center spool valves also named "Underlapped valves" describes a product where each edge of the spool does not fully cover the corresponding control port in the null position. When the valve is at null this arrangement results in a flow from the supply port, across each control port to the return port.

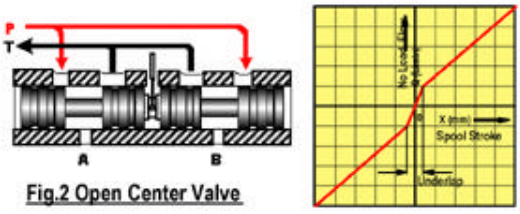


Fig.2 Open Center Valve

Underlapped valves may be suitable in the following cases:

- Machines that lack adequate damping. Underlap can be helpful because the increased flow versus port pressure characteristic in the null region gives a natural damping effect. The typical underlap to improve system damping is normally 2 ~ 3% of rated control flow.
- Machines where the pressure gain of the axis cut valve is too high to give a reasonable gain distribution in the closed loop. Underlap may used to achieve a suitable pressure gain.
- Machines with a hydraulic servo-drive where there is a need to compensate for motor leakage by maintaining high strut port pressures to achieve better stability and higher stiffness at null. In this case, the metering edges of the two control ports to the return port are overlapped so that at null the strut port pressure is increased.
- Machines that require the actuator to be manually overridden in case of power loss. An underlapped valve permits flow between two control ports of the open center valve. In this case safety, not performance, may be first priority.

On the negative side, this null cut configuration increases the null leakage with a resulting energy loss. This can be minimized by using so-called load sense systems, which unload the supply pressure during the no-load condition when the valve is at null.

Closed Center Spool Valves

Closed center spool valves, also named “Overlapped Valves”, describes a valve in which the spool land overlaps the edge of the port and completely block the ports in the bushing, when the valve is centered. This is not commonly used in critical servo systems because of the negative effect of the resulting dead band, but the following are some conditions where there are advantages to using this form of customization:

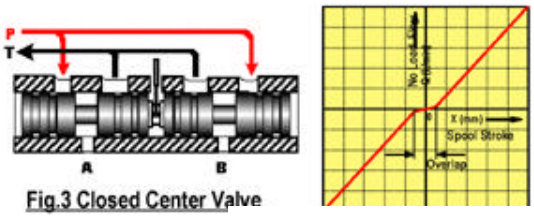


Fig.3 Closed Center Valve

- In systems where axis cut valves do not work well due to high leakage through the diametral clearance between the spool and sleeve. Here a very small overlap may be required.
- For larger servovalves the null leakage of an axis cut can represent an unacceptable energy loss. To reduce this, a 3% overlap valve is frequently used.
- When operator and machine safety is critical. In the event of power loss or no hydraulic pressure, the load can be held by an overlap valve, blocking the control ports.

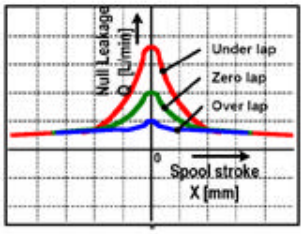


Fig.4 Null Leakage Comparison

In Servo-Proportional valves without a bushing where rapid erosion of the critical flow control edges in the body can occur. Overlap is used together with electronic

Dual Flow Gain Valves

A Dual Flow Gain Valve is another kind of customization where the valve has a non-linear characteristic curve. Typically, this valve has lower flow gain in the null region permitting higher system gain, but beyond a certain flow the higher flow gain permits high speed traverse. Typical examples of the application are electric discharging machines and material handling robots.

Author:

Nobuhiro Ohtaguro, Adviser, Products Engineering, has worked for Moog in the Pacific for over 30 years. He started his career as an application engineer and progressed to Engineering Manager in Moog Japan. He also worked in Australia and Singapore as a Special Project Manager for 3.5 years. Today he provides technical advice and training to the engineers in the Pacific Moog subsidiaries.

Hot Websites:

Search Engine Showdown and U.S. Copyright Office

Search Engine Showdown (**http://www.searchengineshowdown.com/**) and U.S. Copyright Office (**http://www.copyright.gov/**)

Search Engine Showdown is an excellent source of information on the major spidered search engines. It includes a "Features Chart" of the major engines, ordered by database size, with at-a-glance links to reviews. The site is prepared by Greg Notess, a librarian at Montana State University and well-known writer and speaker on various aspects of Web searching. Notess is considered to be one of the true experts on the search capabilities and behaviors of spidered search engines.

U.S. Copyright Office homepage has been created with the desire to serve the copyright community of creators and users, as well as the general public. Here you will find all key publications, news, frequently asked questions, links to the copyright law, and much more.

Product Spotlight

Digital Interface Valve with an Integrated Microprocessor and Fieldbus Communications

Moog Inc. has developed a new hydraulic valve platform, Digital Interface Valves, with microprocessor based electronics and a CANOpen fieldbus. These new valves can replace analog technology and offer configurable functions that enable customers to define the dynamic behavior of the valve and adapt its characteristics to particular application requirements, while providing high-precision digital flow and pressure control. These valves are central to implementing a distributed control concept in a machine because tasks can be assigned to local devices rather than the main control device, providing our customer's machines with increased flexibility and functionality.

The Direct Drive Servo-Proportional Valve of the Digital Interface Valve (D638 Series) is operating in multiple applications around the world. Prototypes are being tested for other models including the Digital pQ Servo-Proportional Valves (D941 S eries) for pressure control and pressure limiting applications. This new product development platform is part of Moog's ongoing initiative to extend digital intelligence to its most advanced hydraulic and electric motion control products.

Key benefits of Digital Interface Valve products for customers are:

- CANBus Communication: Diagnostic capabilities, integrated monitoring of key environmental and internal characteristics, and valve parameter modifications can be accessed on-site or remotely.
- Flexibility: The ability to download parameters via the fieldbus connection or directly from the upper PLC program enables optimum tuning of valve parame ters during the machine cycle, even while the machine is operating. The Windows®-based graphical user interface is easy to learn and convenient
- Cost Savings: Since the pressure control loop is tunable via software, rather than passive electronic components , it is now possible to stock a single valve for multiple applications reducing the need to stock several valve models.
- Lower Installation Costs: A serial wiring scheme reduces the amount of wiring and improves noise immunity.

Some special benefits of the design of the pQ Servo-Proportional Valve (D941 Series) include:

- Superior Control: The improved frequency response of the design allow high spool position loop gain, providing excellent static and dynamic response and superior control system performance The improved valve dynamic performance is due to the extremely high natural frequency of the ServoJet® pilot stage (500 Hz) and the implementation of advanced current control algorithms, which is only possible via digital electronics.
- Energy Savings: Considerably improved flow recovery (more than 90% of the pilot stage internal leakage flow) contributes to energy savings, especially for machines with multiple valves.
- Reliability: The high pressure recovery of the ServoJet pilot stage (more than 80% delta p at 100% command signal) provides higher spool driving forces and ensures enhanced spool position repeatability.
- Safety: Fail-safe versions with defined safe spool position using a spring, a poppet valve or by external supply cut off ensure operator safety.

For more information, visit http://www.moog.com/noq/_capabilities__c918/.

Ask the Expert:

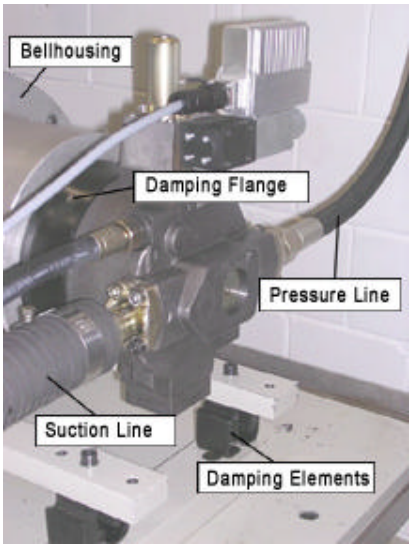
Fundamentals of Industrial Noise Control in Systems with RKP Pumps

Why would users experience noise from the Radial Piston Pump (RKP)?

The RKP pump has a reputation of being one of the quietest pumps in the marketplace, but occasionally users may experience a noise problem that is often due to installation issues.

There are two factors to be considered when looking at a noise problem. The first is intermittent internal forces caused by the reversing of a piston from the suction side to the high-pressure side of the RKP pump. This repeated loading results in a mechanical energy, which eventually radiates through the housing of the pump as air-borne noise. This intermittent internal force can cause some mechanically coupled system components to vibrate and subsequently produce structure-borne noise.

The other factor is the acoustic pressure wave produced by the compression of the hydraulic fluid. The resulting delivery flow from the RKP pistons will include a pulsation. This pressure ripple transfers fluid-borne noise into the hydraulic circuit and, if allowed to propagate, can stimulate other parts of the system to which eventually radiate the energy as noise.



Again, the end-user should establish if the problem is radiated noise through the housing or structural resonances of the system.

What can a user do to prevent structure-borne noise?

To prevent structure-borne noise in a machine, it is necessary to decouple the pump from the machine structure. Moog frequently recommends a damping or anti-vibration flange between the pump and the electric motor and a soft coupling between the pump-to-motor drive shaft interface. The power unit (pump and electric motor) should be mounted with rubber, grommetlike supports at a stable and solid part of the machine framework. The discharge pressure line from the pump should be a flexible hose mounted with a wide bend. The high-pressure lines from the manifolds to the actuators should be fixed to the system by means of rubber clamps.

What are some solutions for fluid-borne noise?

To prevent fluid-borne noise from affecting other parts of the machine, Moog again recommends rubber damping elements (e.g. elastomeric isolation mounts or resilient pads) under any manifold at a stable part of the framework.

Some additional broadband noise may be present due to mechanisms such as cavitation, turbulence, and unstable pump compensators. Elimination of these problems will further minimize a secondary noise source. The suction line should be a short hose of sufficiently large diameter without any filters, check valves, and/or sharp edges.

For more information, visit http://www.moog.com/industrial/pumps/.

Upcoming Events

Please visit the Moog booth at:

- 23 BIEMH - Bienal Española de la Máquina Herramienta in Bilbao, Spain (June 7 - 12, 2004)
- Motion and Control (formerly IFPEX), - NEC, Birmingham, UK (September 28-30, 2004; Stand No. 274)
- K International Exhibition for Plastic and Rubber in Düsseldorf, Germany (October 20 - 27, 2004)
- Japan International Machine Tool Fair in Tokyo, Japan (November 1 - 8, 2004)

For more information, click on http://www.moog.com/noq/_general__c916/.

Other Moog News

- **Technical Bulletin for DINRail Mounted Modules - May 2004** (http://www.moog.com/media/1/DINBulletin4.pdf)
- Technical Paper on **"M3000- A Motion-Control Toolbox for Hydraulic Axes"- March 2004.** (http://www.moog.com/Media/1/M3000AMotionControlToolboxTechpaper.pdf)
- Published article on **Motion Cueing Essentials** in Military Training and Simulation News - January 2004 (http://www.moog.com/Media/1/motioncueingessentials-mtsnarticle.pdf)

Contact Us

To find the location or distributor nearest you visit http://www.moog.com/noq/_contact__c494/.

CONTACT INFORMATION

Argentina	tel: +54 (11) 4326 5916	fax: +54 (11) 4326 5916	sales.argentina@moog.com
Australia	tel: +61 3 9561 6044	fax: +61 3 9562 0246	sales.australia@moog.com
Austria	tel: +43 1 688 1384	fax: +43 1 688 1384	rlange@moog.de
Brazil	tel: +55 11 5523 80 11	fax: +55 11 5524 21 86	sales@br.moog.com
China	tel: +86 21 5854 1411	fax: +86 21-5854 1417	sales@moog.com.cn
Finland	tel: +358 9 2517 2730	fax: +358 9 2517 2739	sales.finland@moog.com
France	tel: +33 (0)1 45 60 70 00	fax: +33 (0)1 45 60 70 01	sales.france@moog.com
Germany	tel: +49 07031-622-0	fax: +49 07031-622-100	Sales@Moog.de
India	tel: +91 80 2668 9947	fax: +91 80 2668 9963	sales.india@moog.com
Ireland	tel: +353 21 4519000	fax: +353 21 4519001	sales.ireland@moog.com
Italy	tel: +39 0332 421111	fax: +39 0332 429233	sales.italy@moog.com
Japan	tel: +81 463 55 3615	fax: +81 463 54 4709	sales@moog.co.jp
Korea	tel: +82 031 764 6711	fax: +82 031 764 0929	sales@moogkorea.co.kr
Luxembourg	tel: +352 40 46 40-1	fax: +352 40 46 40 909	sales.luxembourg@moog.com
Norway	tel: +47 22 43 29 27	fax: +47 22 43 29 01	contact@moog.no
Russia	tel: +007 83171 31811	fax: +007 83171 31813	sales.russia@moog.com
Singapore	tel: +65 6773 6238	fax: +65 6777 7627	sales@moog.com.sg
South Africa	tel: +27 11 655 7030	fax: +27 11 655 7131	southafrica@moog.de
Spain	tel: +34 902 133 240	fax: +34 902 133 180	ventas@moog.es
Sweden	tel: +46 31 680060	fax: +46 31 287532	contact@moog.se
United Kingdom	tel: +44 1684 296600	fax: +44 1684 296760	sales@moog.co.uk
USA	tel: +1 716 652 2000	fax: +1 716 687 7910	sales.icd_hyd@moog.com sales.icd_elec@moog.com

MOOG

Moog Inc., Industrial Controls
USA: +1-716-652-2000
Germany: +49-7031-622-0
Japan: +81-463-55-3615
For the location nearest you, contact www.moog.com/worldwide.