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SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1783

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(R) Ship Systems and Equipment—Selection of Hydraulic Directional Control Valves

1. ***Scope—***This SAE Recommended Practice provides the designer with guidance for the selection of directional control valves for use in the hydraulic systems of surface ships and submersibles. This guidance includes use of standard valves and interfaces, minimum envelopes that should be reserved to permit interchangeability, environmental considerations, and general technical requirements.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of all SAE specifications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001. www.sae.org.

ARP490—Electrohydraulic Flow-Control Valves
SAE J1777—General Environmental Considerations for Marine Vehicles
SAE J1778—Ship Systems and Equipment—Recommended Practice for Hydraulic Fluid Selection
SAE J1782—Ship Systems and Equipment—Hydraulic Systems—Noise Control
SAE J2280—Ship Systems and Equipment—Fasteners—Selection and Identification Requirements
SAE J2333—Ship Systems and Equipment—Hydraulic Systems—Filter Selection Parameters
SAE J2470—Hydraulic Fluid Power—Valves—Method for Assessing Sensitivity to Contaminants
SAE J24714—Fluid systems—Connector Tubes—General Specification and Part Standard

2.1.2 U.S. GOVERNMENT PUBLICATIONS—Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. web site: http://assist.daps.mil or http://stinet.dtic.mil/.

MIL-STD-461—Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-V-868—Valves, Hydraulic Directional Control, General Specification for (The three specification sheets for MIL-V-868 have been cancelled but are available from Global Engineering/IHS. web site: global.ihs.com)
MIL-S-901—Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-V-24722—Valve and Subplate, Servo Flow-Control, Electrohydraulic, General Specification for (The three specification sheets for MIL-V-24722 have been cancelled but are available from Global Engineering/IHS)
MIL-HDBK-2193—Hydraulic System Components, Ship

TO PLACE A DOCUMENT ORDER: +1 (724) 776-4970 FAX: +1 (724) 776-0790
SAE WEB ADDRESS http://www.sae.org

MIL-STD-167-1—Mechanical Vibration of Shipboard Equipment (Type I-Environmental and Type II–Internally Excited

2.1.3 NFPA PUBLICATIONS—Available from National Fluid Power Association, 3333 North Mayfair Road, Milwaukee WI 53222. web site: www.nfpa.com.

NFPA T3.5.1—Hydraulic Fluid Power—Valves—Mounting Surfaces
NFPA T3.5.27—A bibliography of hydraulic valve standards and test procedures
NFPA T3.5.49—Hydraulic fluid power – Application guidelines for hydraulic valves

2.1.4 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-0008. http://www.ansi.org

ISO 1219—Fluid power systems and components—Graphic symbols
ISO 4401—Hydraulic fluid power—Four-port directional control valves—Mounting surfaces
ISO 7790—Hydraulic fluid power—Four-port Modular stack valves and four-port directional control valves, Sizes 03 and 05—Clamping dimensions
ISO 10055—Mechanical vibration—Vibration testing requirements for shipboard equipment and machinery components
ISO 10372—Hydraulic fluid power – Four and five-port servovalves—Mounting surfaces
ISO 10770-1—Hydraulic fluid power—Electrically modulated control valves—Part 1: Test methods for four-way directional flow control valves
ISO 10770-2—Hydraulic fluid power—Electrically modulated control valves—Part 2: Test methods for three-way directional flow control valves

3. Definitions

3.1 H.I.-Shock—High impact shock loading produced by number of blows from specified height and direction of hammer drop on equipment as specified in MIL-S-901.

4. Technical Requirements

4.1 Valve Specifications—Depending upon the application, the designer may select valves to industry, military or specifically developed specifications. For many military applications, standard industry valves may be used provided they meet certain military requirements. (See 4.2.4.) Specifications, standards, and test procedures related to hydraulic directional control valves have been prepared by SAE, National Fluid Power Association, ISO, and some Department of Defense activities. Except for some military specifications, most of these documents are not suitable for procurement of valves but contain requirements that can be incorporated into procurement specifications. For example, the selection of a standardized design interface should be used in order to have a wide selection of manufacturers and to promote interchangeability. In this recommended practice, some of the most applicable government and industry specifications, recommended practices and test procedures are identified. For a more complete listing of valve standards and test procedures see NFPA T3.5.27. NFPA T3.5.49 provides basic guidance for the selection, installation, operation, and maintenance of hydraulic valves.

4.1.1 INDUSTRY STANDARDS—Most of the National Fluid Power Association valve standards have been adopted as American National Standards and many are technically equivalent to ISO documents.

4.1.1.1 *Directional Control Valves*—There are no industry specifications that can be directly used to procure valves. There are ANSI and ISO standards for valve interfaces, electrical connectors and methods for determining metering characteristics. In specifying valves, standard mounting and electrical interface standards should be identified. In addition, the following information must be provided:

a. Maximum operating pressure, rated flow, and maximum differential pressure at rated flow
b. Fluid to be used (operating temperature range/viscosity)
c. Seal materials (particularly for military applications where specific materials are required)
d. Spool flow paths and types of operators (This can often best be conveyed by a symbol per ISO 1219.)
e. Leakage and other special requirements

4.1.1.2 *Electrohydraulic Servovalves*—There are several documents that are widely used to define electrohydraulic servovalve test requirements. SAE ARP490 is widely used in the aerospace industry. ISO 10770-1 and ISO 10770-2 provide test methods for electrically modulated hydraulic directional flow control valves. ISO 10372 provides recommended mounting configurations for four and five-port servovalves. The designer should identify the requirements per one or more of these documents, taking care not to specify conflicting requirements. In addition, the type of information identified in 4.1.1.1 for directional control valves should also be provided.

4.1.1.3 *Proportional Control Valves*—ISO 10770-1 and ISO 10770-2 cover both proportional control valves and servovalves.

4.1.2 MILITARY SPECIFICATIONS

4.1.2.1 *General Requirements*—The general requirements that have often been applied to all hydraulic components for Navy ships are identified in MIL-HDBK-2193. This document was originally a Military Standard whose requirements could be invoked by the military; as a Handbook the document is for guidance, Not all the requirements/recommendations in MIL-HDBK-2193 are applicable to each installation but guidance is provided as to when the requirements/recommendations are applicable.

4.1.2.2 *Directional Control Valves*—General requirements for hydraulic directional control valves, specifically developed for Navy submarines are contained in MIL-V-868. Specific configuration valves of different sizes with standardized interfaces are defined on MIL-V-868 specification sheets, now cancelled. While these documents may not reflect current Navy requirements, they are an excellent source for general requirements for directional control valves. These valves were sub-plate mounted with connector tubes between the valves and sub-plates. SAE J24714 has been developed to replace the military specification for the connector tubes. In addition, connector tube configurations are available into which restrictor, check and relief valves can be installed. Connector tubes in accordance with SAE J24714 should be used whenever suitable for applications requiring connector tubes.

4.1.2.3 *Electrohydraulic Servovalves*—General requirements for Navy ship electrohydraulic servocontrol valves are contained in MIL-V-24722. These general requirements are based to a large degree on SAE ARP490. Specific configuration valves of various sizes and flow rates with definitive interfaces are defined in MIL-V-24722 specification sheets, now cancelled. While these documents may not reflect current Navy requirements, they are an excellent source for general requirements and how to define interface requirements.

4.2 Environmental Requirements

4.2.1 GENERAL REQUIREMENTS—The general environmental considerations that apply to marine vehicle applications are identified in SAE J1777.

4.2.2 ABOVE DECK APPLICATIONS—Special precautions must be taken to ensure that the valve components will survive this environment. These components include electrical connectors and internal coils and wiring, fasteners, exposed shifting elements, nameplates, name plate drive screws and valve body and end cap material coatings. In many applications, corrosion resistant materials must be selected for satisfactory performance in this environment. In other cases, plating and paint may be used to provide adequate protection. See MIL-HDBK-2193 for further guidance.

4.2.3 BELOW DECK APPLICATIONS—Protection for below deck use is usually less restrictive. However, the salt air atmosphere still requires that external valve components and electrical connectors be protected against moisture and oxidation.

4.2.4 SPECIAL NAVY REQUIREMENTS—For many Navy and military ship applications, the components must meet requirements unique to military applications. While not all the requirements identified below apply to every application, they may be invoked for many applications.

4.2.4.1 Most hydraulic components, including valves must pass High-Impact Shock requirements. See MIL-HDBK-2193 for references to the applicable requirements. Test requirements and acceptance criteria are provided in MIL-S-901.

4.2.4.2 For most Navy ships, the equipment must be able to meet the environmental vibration requirements of MIL-STD-167-1. These requirements do not usually pose a problem for hydraulic valves and are similar to mechanical vibration requirements identified in 4.2.7 that are applicable to all ships.

4.2.4.3 Some military applications, such as submarines have very stringent acoustical or noise requirements that may be classified. Many directional control valves for use in submarine hydraulic systems utilize special quieting elements. For valves with acoustic requirements, consult with valve designer when specifying envelope and porting interface pattern requirements to ensure acoustic requirements can be met. Almost all applications will be subject to environmental noise as discussed in 4.4.1.

4.2.4.4 For military ships, electromagnetic interference (EMI) must be minimized to prevent adding to the ship's EMI signature (detectability). This in addition to standard EMI requirements as identified in 4.2.6. It is anticipated that the system will be tested per MIL-STD-461, which specifies requirements for the control of EMI emissions and susceptibility of equipment and systems installed on Navy ships and submarines. The valve control system should not become degraded or malfunction due to EMI susceptibility, and should not create significant radiated or conducted EMI emissions.

4.2.5 FLUID COMPATIBILITY—Hydraulic valves, including seals and electrical wiring must be compatible with the system fluid. SAE J1778 indicates the compatibility of various seal materials with fluids commonly used in marine vehicles. MIL-HDBK-2193 contains design guidance on material requirements and an immersion test for nonmetallic materials to determine compatibility with the various types of fluids.

4.2.6 ELECTROMAGNETIC INTERFERENCE (EMI) SHIELDING—The design needs to isolate the electronic components to prevent system degradation or malfunction due to susceptibility to external EMI sources. The valve control system should not become degraded or malfunction due to EMI susceptibility, and should not create significant radiated or conducted EMI emissions.

4.2.7 MECHANICAL VIBRATION—Vibration testing requirements for shipboard equipment and machinery components are identified in ISO 10055. (Also see 4.2.4.2.)

4.3 Valve Interfaces and Envelopes

4.3.1 MILITARY SPECIFICATION VALVES—Most military specifications as noted in 4.1.2 for valves identify the interface configurations and the maximum valve envelope along with part identification numbers to identify a specific valve.

4.3.2 VALVES TO INDUSTRY SPECIFICATIONS AND STANDARDS—Most of the industry documents (NFPA T3.5.1 and ISO 4401) identify only the valve interfaces and not the maximum valve envelope. Not all manufacturers' valves are interchangeable with regard to envelope. This document identifies the minimum valve envelopes which the designer should specify.

4.3.2.1 *Valve Interfaces*—NFPA/ANSI B93.7M and ISO 4401 define standard valve interfaces. The major difference between these two standards is that the ANSI mounting surfaces usually include an orientation pin hole to prevent installation of a valve with the wrong rotation. The list below indicates the maximum port diameters for various sizes of valves covered by these standards.

a. 02: 4.0 mm
b. 03: 6.3 mm
c. 05: 11.2 mm
d. 07: 17.5 mm
e. 08: 23.4 mm
f. 10: 32.0 mm

Valves requiring ports larger than 32 mm do not have to meet standardized interfaces.

Standardized clamping dimensions which define the height of four port stack and four port directional control valves are identified in ISO 7790.

4.3.2.2 *Valve Envelopes*—Figures 1 through 6 provide dimensions within which most valves to the standard ISO 4401 and NFPA T3.5.1 interfaces should fit. Note that these figures indicate envelope dimensions in which most manufacturers' valves should fit. In specifying valves, a requirement should be included that valves are to fit within these envelope dimensions. Also, the designer must exercise care to leave sufficient space for removal of the valves and accessories as shown on the figures.

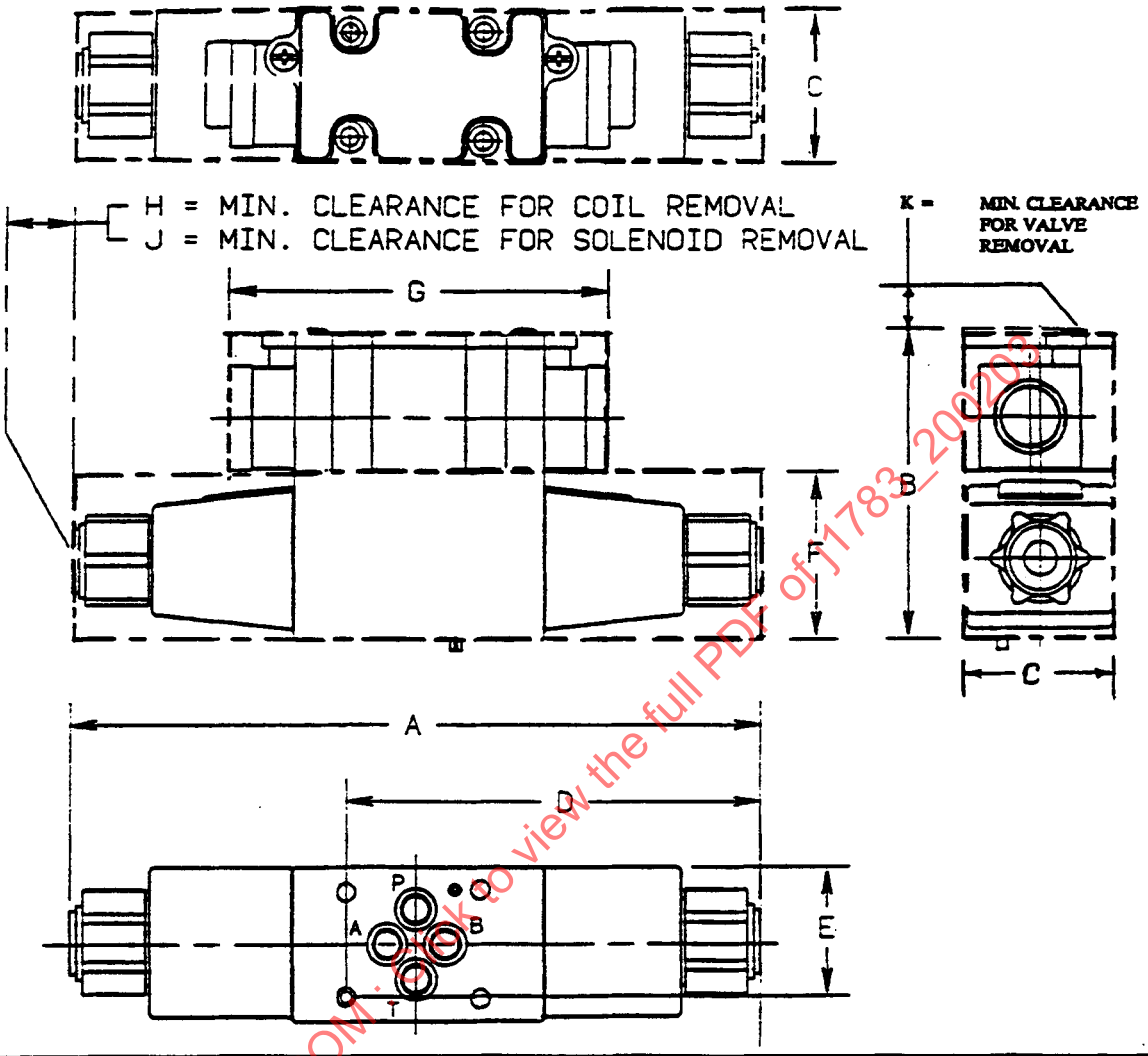
4.4 Additional Technical Requirements.

4.4.1 NOISE—In many ship applications, hydraulic system noise is an important consideration. SAE J1782 addresses noise requirements which may apply to the hydraulic systems of ships and submersibles and identifies techniques which may be used to reduce system noise.

4.4.2 FASTENERS—The proper selection of fasteners is important for valves used in the marine environment. SAE J2280 provides guidance for the selection and identification of fasteners for use in ship systems.

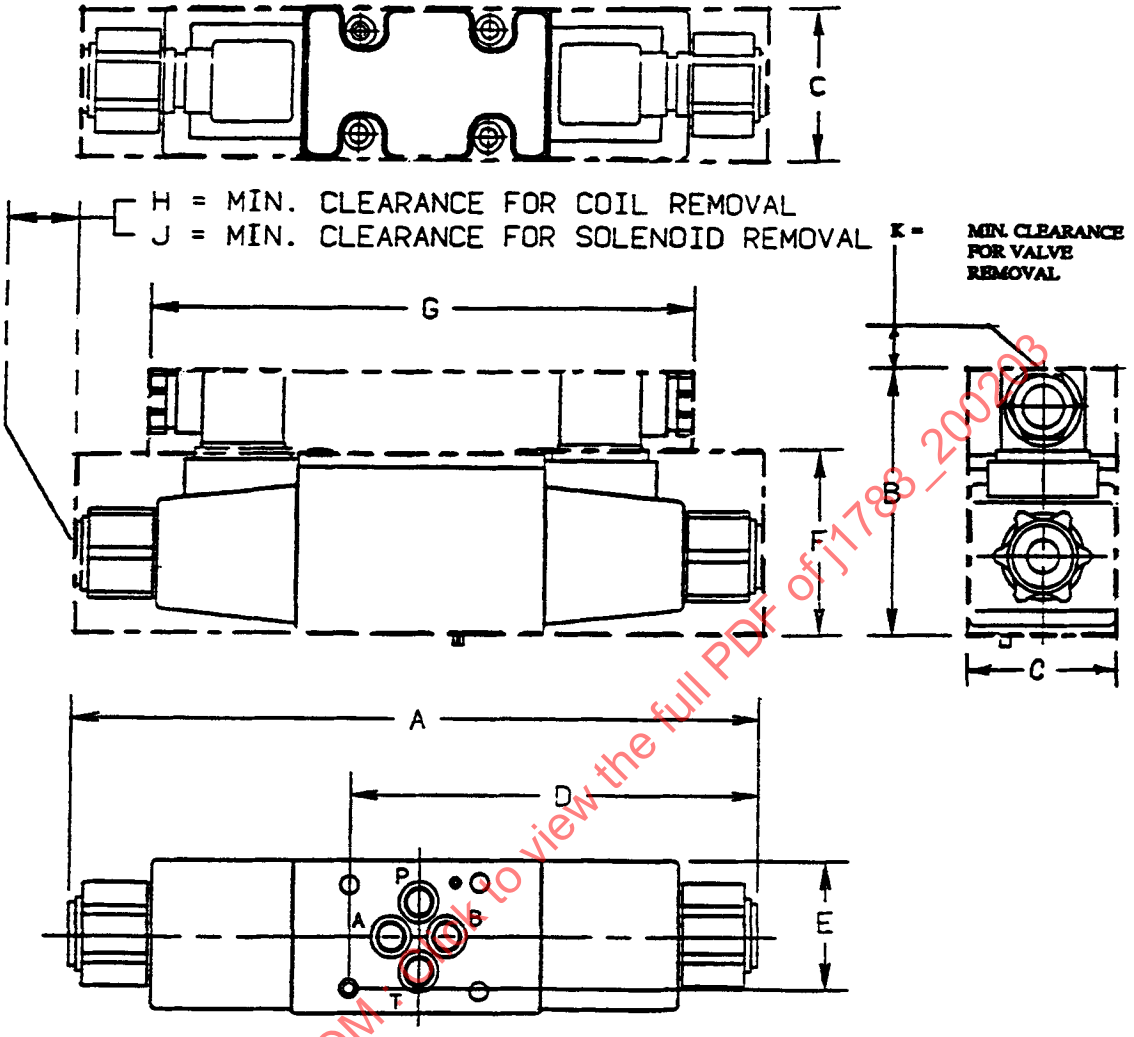
4.4.3 FLUID CLEANLINESS REQUIREMENTS FOR VALVES—General cleanliness recommendations for different types of hydraulic valves are identified in SAE J2333.

4.4.4 SENSITIVITY TO CONTAMINANTS—SAE J2470 provides test methods to determine the contaminant sensitivity of hydraulic control valves.



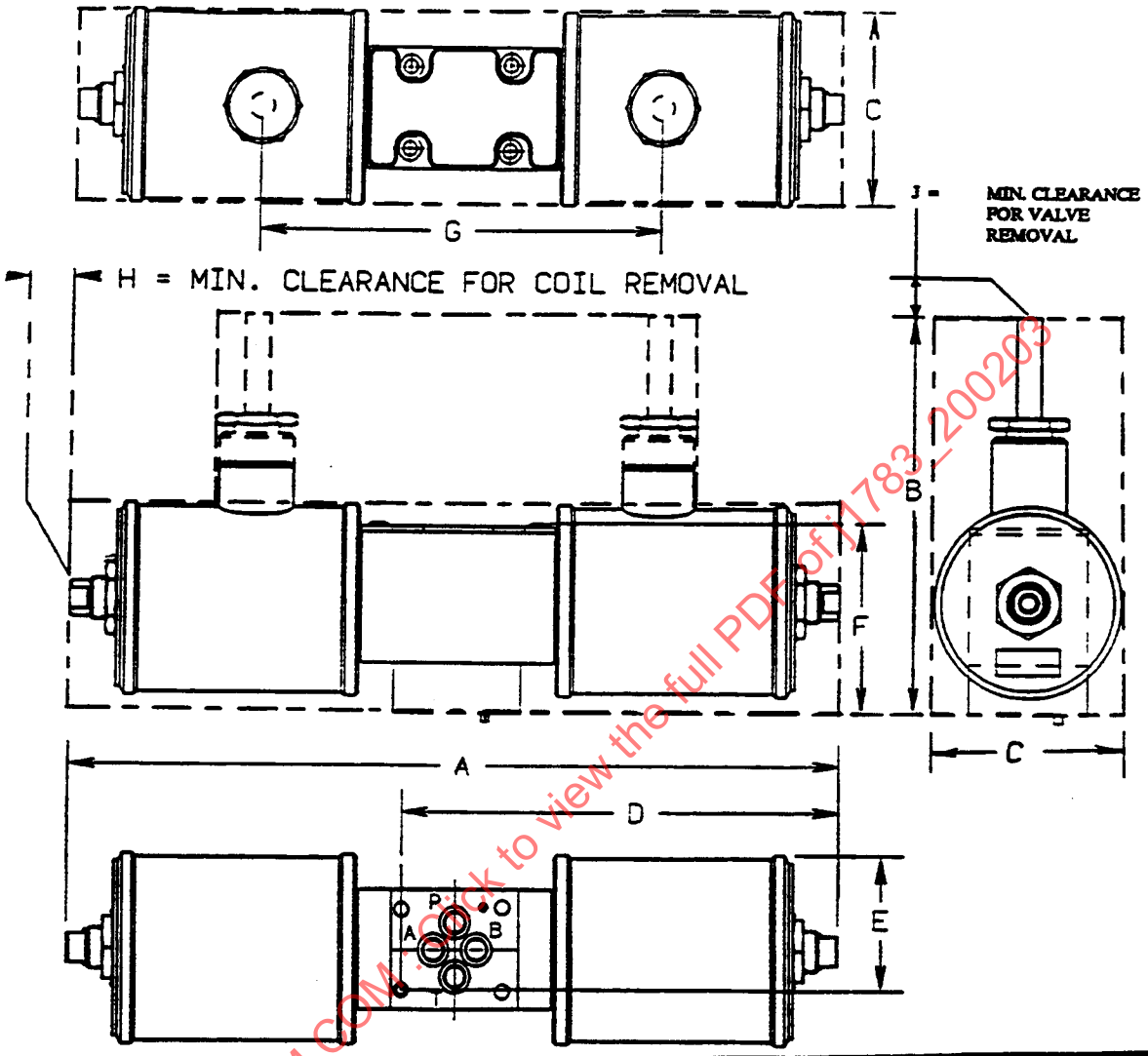
A. C. & D. C. (ELECTRICAL POWER SUPPLY) DIMENSIONAL CHART											
mm (Inch)	A	B	C	D	E	F	G	H	J	K	
A.C. Supply	219.7 (8.65)	92.5 (3.64)	48.0 (1.89)	131.6 (5.18)	38.5 (1.52)	50.0 (1.97)	117.9 (4.64)	43.4 (1.71)	42.9 (1.69)	25.4 (1.00)	
D.C. Supply	250.7 (9.87)	92.5 (3.64)	48.0 (1.89)	146.8 (5.78)	38.5 (1.52)	50.0 (1.97)	117.9 (4.64)	57.9 (2.28)	57.9 (2.28)	25.4 (1.00)	

FIGURE 1—ANSI D03 SOLENOID OPERATED DIRECTIONAL CONTROL VALVE WITH CONDUIT BOX



A.C. & D.C. (ELECTRICAL POWER SUPPLY) DIMENSIONAL CHART											
mm (Inch)	A	B	C	D	E	F	G	H	J	K	
A.C. Supply	210.6 (8.29)	80.2 (3.16)	48.0 (1.89)	126.7 (4.99)	38.5 (1.52)	53.5 (2.11)	184.4 (7.26)	43.4 (1.71)	25.4 (1.00)	25.4 (1.00)	
D.C. Supply	240.8 (9.48)	85.6 (3.37)	48.0 (1.89)	141.8 (5.58)	38.5 (1.52)	53.5 (2.11)	177.6 (6.99)	57.2 (2.25)	25.4 (1.00)	25.4 (1.00)	

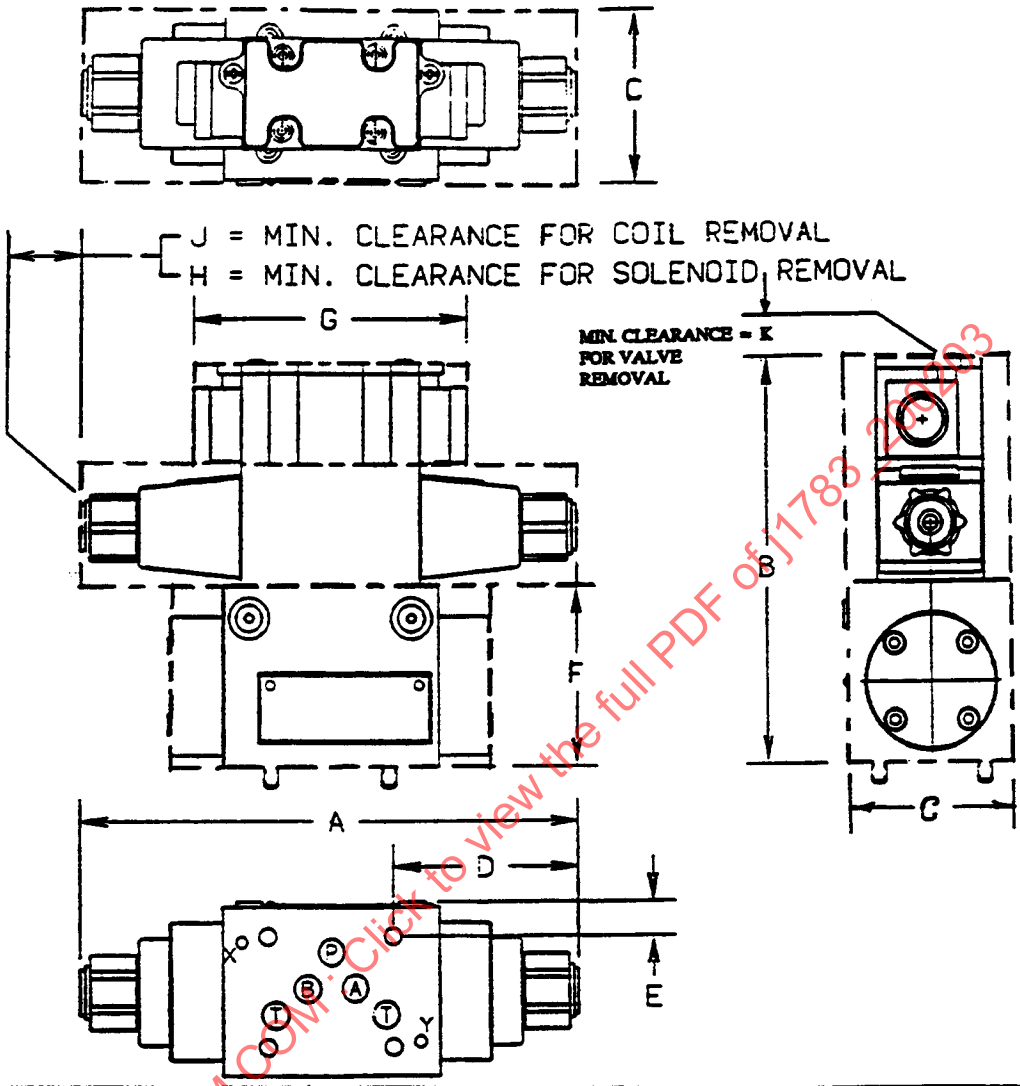
FIGURE 2—ANSI D03 SOLENOID OPERATED DIRECTIONAL CONTROL VALVE WITH SPADE CONNECTOR



A.C. & D.C. (ELECTRICAL POWER SUPPLY) DIMENSIONAL CHART

mm (Inch)	A	B	C	D	E	F	G	H	J		
A.C. Supply	303.8 (11.96)	151.1 (5.95)	73.0 (2.88)	172.5 (6.79)	52.1 (2.05)	72.4 (2.85)	165.1 (6.50)	95.25 (3.75)	25.4 (1.00)		
D.C. Supply	303.8 (11.96)	151.1 (5.95)	73.0 (2.88)	172.5 (6.79)	52.1 (2.05)	72.4 (2.85)	165.1 (6.50)	95.25 (3.75)	25.4 (1.00)		

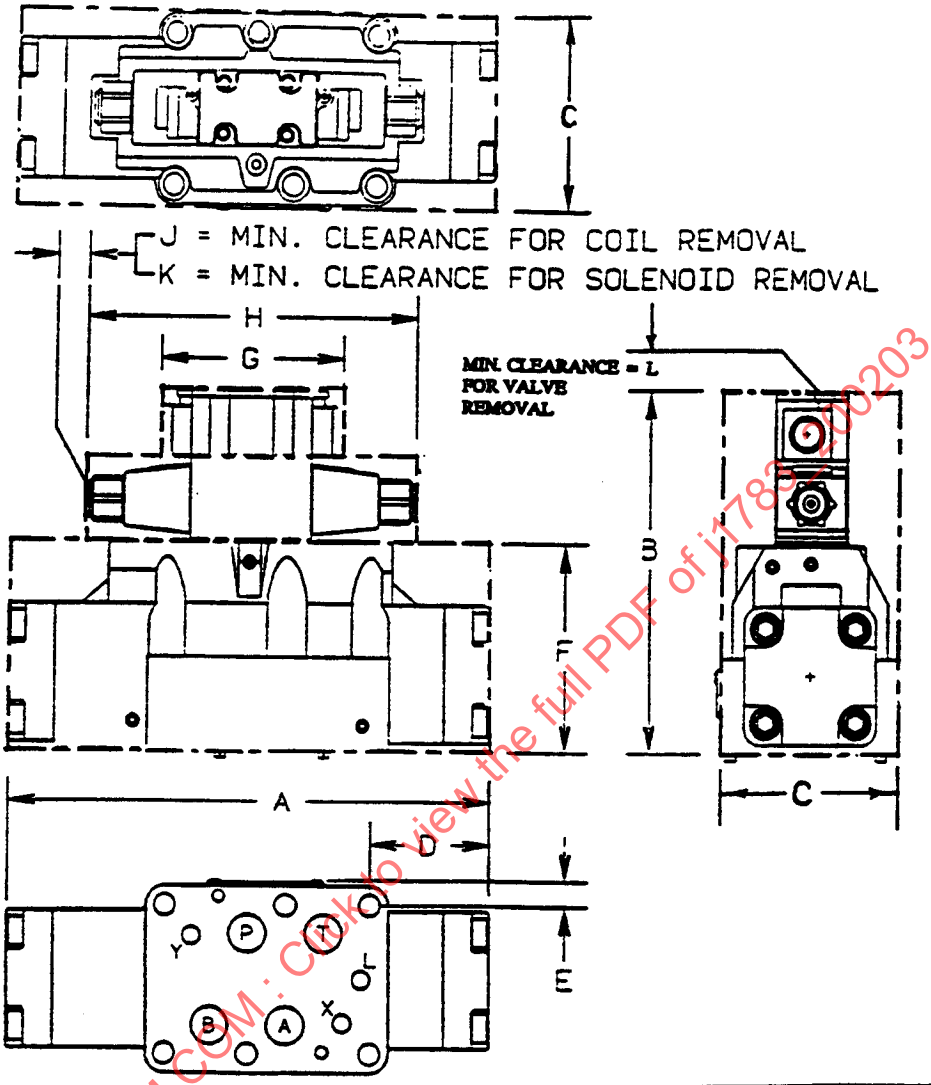
FIGURE 3—ANSI D03 SOLENOID OPERATED DIRECTIONAL CONTROL VALVE EXPLOSION PROOF



A.C. & D.C. (ELECTRICAL POWER SUPPLY) DIMENSIONAL CHART

mm (Inch)	A	B	C	D	E	F	G	H	J	K	
A.C. Supply	219.7 (8.65)	167.8 (6.61)	72.3 (2.85)	81.5 (3.21)	11.9 (0.47)	117.9 (4.64)	117.9 (4.64)	42.9 (1.69)	43.4 (1.71)	50.8 (2.00)	
D.C. Supply	240.8 (9.48)	167.8 (6.61)	72.3 (2.85)	96.7 (3.81)	11.9 (0.47)	117.9 (4.64)	117.9 (4.64)	57.9 (2.28)	57.9 (2.28)	50.8 (2.00)	

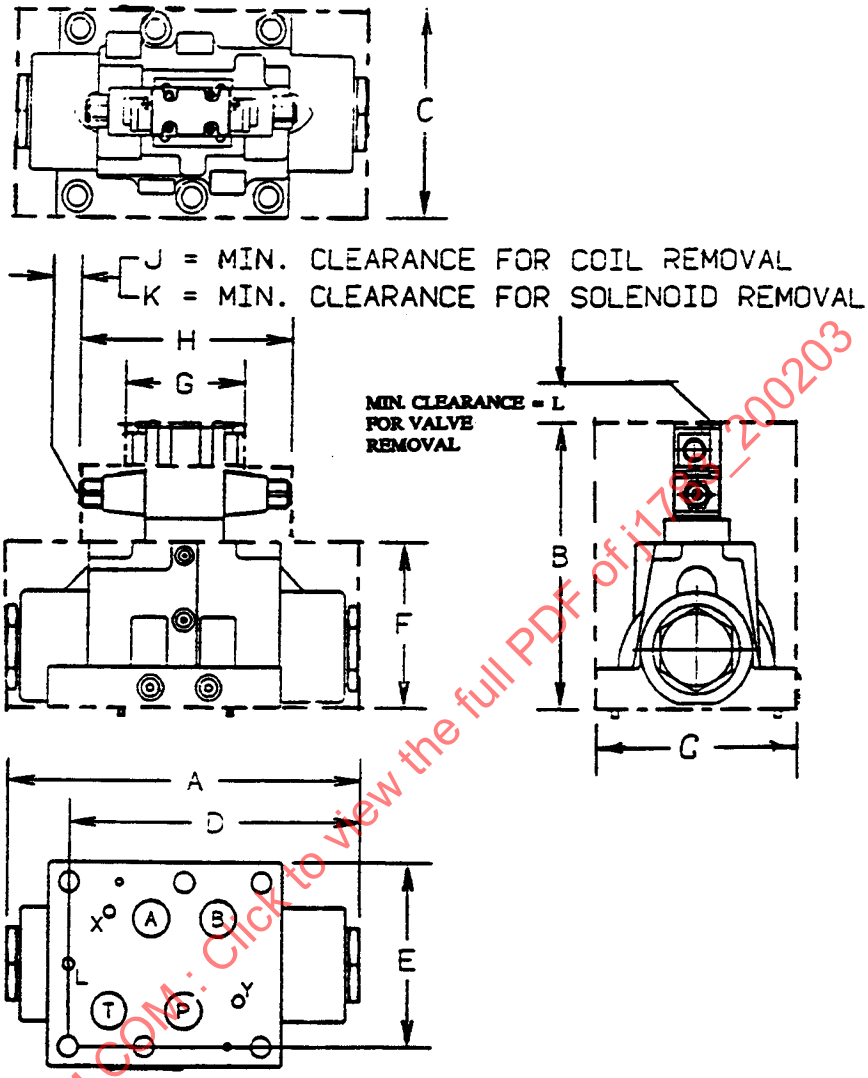
FIGURE 4—ANSI D05 PILOT OPERATED, SOLENOID CONTROLLED DIRECTIONAL CONTROL VALVE WITH CONDUIT BOX



A.C. & D.C. (ELECTRICAL POWER SUPPLY) DIMENSIONAL CHART

mm (Inch)	A	B	C	D	E	F	G	H	J	K	L
A.C. Supply	339.9 (13.38)	235.0 (9.25)	120.9 (4.76)	92.9 (3.66)	15.6 (0.62)	142.7 (5.62)	117.9 (4.64)	219.7 (8.65)	43.4 (1.71)	42.9 (1.69)	25.4 (1.00)
D.C. Supply	339.9 (13.38)	235.0 (9.25)	120.9 (4.76)	92.9 (3.66)	15.6 (0.62)	142.7 (5.62)	117.9 (4.64)	250.7 (9.87)	57.9 (2.28)	57.9 (2.28)	25.4 (1.00)

FIGURE 5—ANSI D08 PILOT OPERATED, SOLENOID CONTROLLED DIRECTIONAL CONTROL VALVE WITH CONDUIT BOX



A.C. &D.C. (ELECTRICAL POWER SUPPLY) DIMENSIONAL CHART

mm (Inch)	A	B	C	D	E	F	G	H	J	K	L
A.C. Supply	377.95 (14.88)	285.75 (11.25)	203.2 (8.00)	289.8 (11.41)	181.2 (7.1)	165.1 (6.50)	117.9 (4.64)	245.6 (9.67)	44.5 (1.75)	88.9 (3.5)	25.4 (1.00)
D.C. Supply	377.95 (14.88)	285.75 (11.25)	203.2 (8.00)	289.8 (11.41)	181.2 (7.1)	165.1 (6.50)	117.9 (4.64)	314.2 (12.4)	127.0 (5.0)	88.9 (3.5)	25.4 (1.00)

FIGURE 6—ANSI D10 PILOT OPERATED, SOLENOID CONTROLLED DIRECTIONAL CONTROL VALVE WITH CONDUIT BOX