



Bulletin HY08-1113-B1/NA

WaveScale

Effective: September, 2015

Supersedes: July, 2015

Linear Displacement Transducers



In line with our policy of continuing product improvement, specifications and information contained in this bulletin are subject to change.

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FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

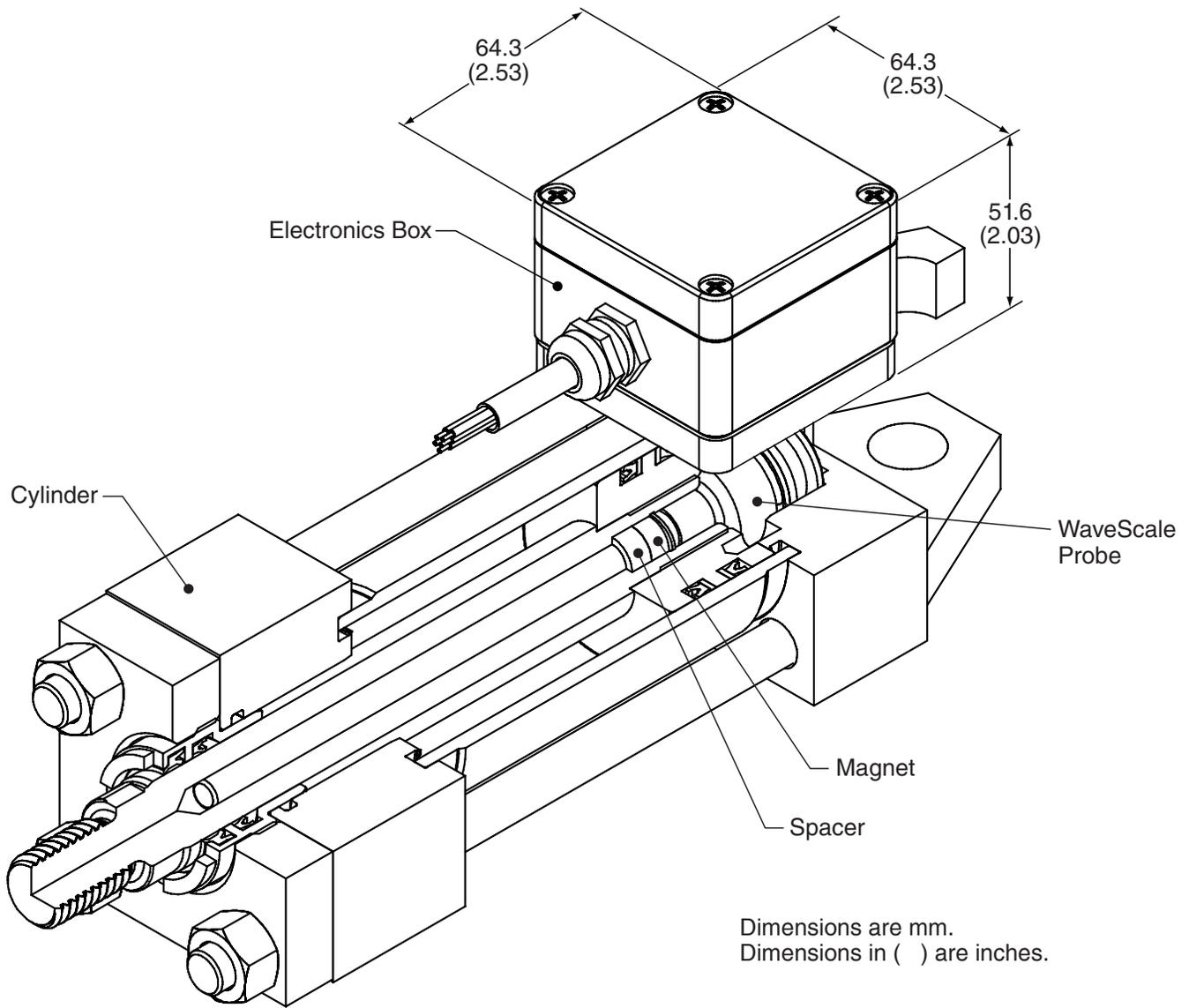
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Cutaway View

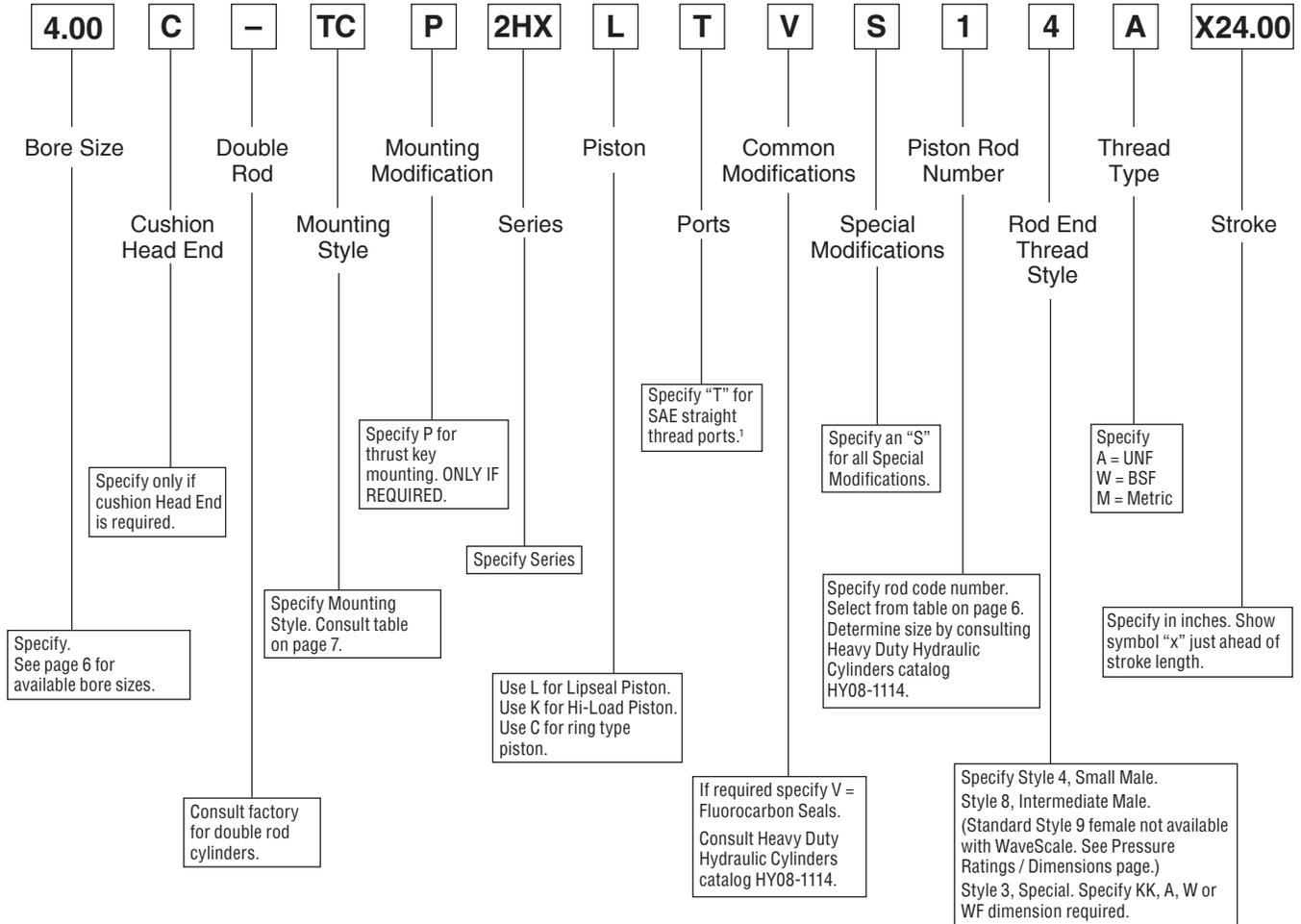
This cylinder meets standard NFPA heavy duty hydraulic cylinder dimensions, 2" to 6" bore with a male piston rod end. The main advantage is no false stage is required for cap mounts.

The overall length of the cylinder is not increased.

How to Order:

1. Specify the complete Parker Cylinder Model Number from the Basic Model Number format below and from catalog HY08-1114.
2. Specify the 6 place Valve and Feedback code for 2HX cylinders.

Basic Model Number



Note: Cap end cushion not available.

Consult current Heavy Duty Hydraulic Cylinders catalog HY08-1114 for complete dimensions, specifications and model number information.

¹ 2" Bore WaveScale Cylinder has an undersized port (#8 SAE) on the cap end only.

Valve and Feedback Codes

(required for 2HX ordering)

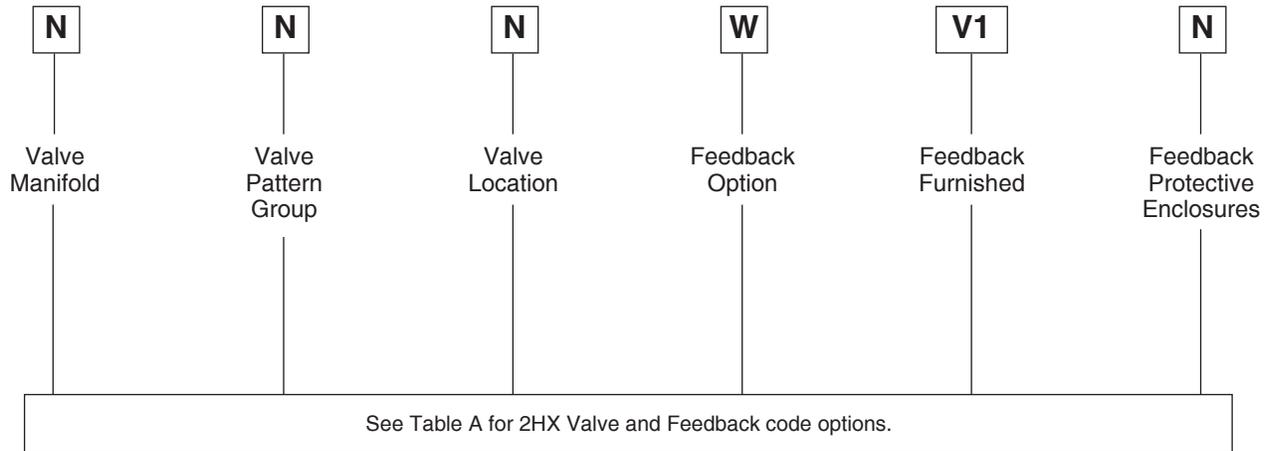
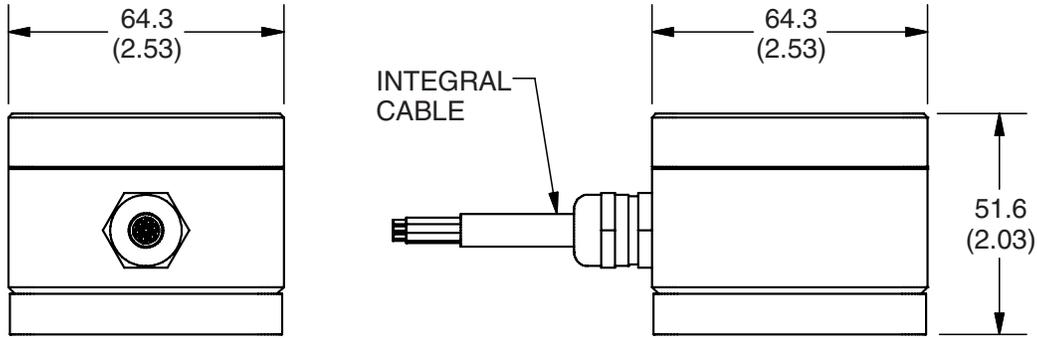


Table A

Valve Manifold	Valve Pattern Group	Valve Location	Feedback Option	Feedback Furnished	Feedback Protective Enclosures
N = None	N = Not Applicable	N = Not Applicable	N = None	NF = No Feedback	N = Not Applicable
B = Bolt-On	A = Servo (Group A)	H = Head	B = Balluff LDT	FR = LRT Installed	A = False Stage
I = Integral	D = Servo (Group D)	C = Cap	C = MTS LDT	1P = Prepare to Accept ¹	D = Light Duty
	G = D03 (Group G)		F = LRT	V0 = 0 Vdc to +10 Vdc	F = Medium Duty
	H = D05 (Group H)		W = Wavescale LDT	V1 = +10 Vdc to 0 Vdc	
	J = D06 (Group J)		X = Other (please specify)	A0 = 4 mA to 20 mA	
	K = D07 (Group K)			A1 = 20 mA to 4 mA	
	M = D08 (Group M)			A2 = 0 mA to 20 mA	
	X = Other (please specify)			A3 = 20 mA to 0 mA	
				A4 = Other Analog – Specify required output	
				DE = PWM, External Interrogation	
				DI = PWM, Internal Interrogation	
				SS = SSI Output	
				R0 = Start/Stop	
				D4 = Other Digital – Specify required output	

¹ Feedback Furnished code 1P and Protective Enclosure codes A=False Stage, D=Light Duty and F=Medium Duty are not available with Feedback Options F=LRT or W=WaveScale and are greyed out.



LDT Technical Section

The WaveScale Actuator is the most versatile actuator that we offer. Utilizing the Temposonics G Series feedback device, there are three distinct outputs available to suit most applications. Velocity is limited primarily by the limits of mechanical components outside of the

actuator, although position update time can affect the system ramp-down. The WaveScale Actuator is the industry favorite in tough, rugged machinery applications. A key advantage is the absolute position output which is not lost if there is a power failure.

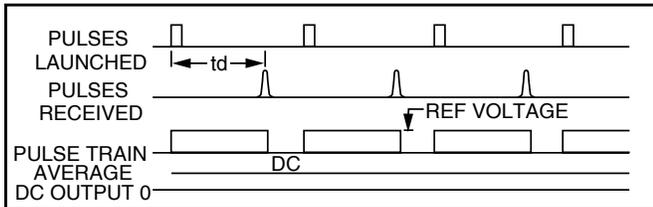
Magnetostriction

In a WaveScale position sensor, a pulse is induced in a specially-designed magnetostrictive waveguide by the momentary interaction of two magnetic fields. One field comes from a movable magnet which passes along the outside of the sensor tube, the other field comes from a current pulse or interrogation pulse launched along the waveguide. The interaction between the two magnetic fields produces a strain pulse, which travels at sonic speed along the waveguide until the pulse is detected at the head of the sensor. The position of the magnet is determined with high precision by measuring the elapsed time between the launching of the electronic interrogation pulse and the arrival of the strain pulse. As a result, accurate non-contact position sensing is achieved with absolutely no wear to the sensing components.

An average of 200 ultrasonic strain pulses are launched for every reading. With so many readings taken for each position, vibration and shock have negligible effect on the readings. The transducer assembly is shielded to eliminate interference caused by electromagnetic fields in the radio frequency range. In addition, static magnetic fields of several hundred gauss must get as close as 3/16" from the protective tube before any interference in transducer operation occurs.

Features

- High immunity to shock and vibration
- Single voltage input +24Vdc
- 3000 psi operating pressure
- Standard strokes up to 100"
- Multiple outputs
 - 0 to 10 VDC forward and reverse acting, grounded (forward acting standard)
 - 4-20 mA forward and reverse acting, grounded
 - 0-20 mA forward and reverse acting, grounded
 - Digital Start/Stop
 - Digital pulse-width modulation



Feedback Accuracy

The accuracy of a given feedback device is a composite of a number of factors, the most important of which are:

Resolution – The smallest movement of the device that will produce a measurable output.

Non-Linearity – The deviation of the signal from a straight line output.

Repeatability – The maximum deviation of output signal for repeated positioning to a fixed point.

Hysteresis – The deviation of the signal when approaching a fixed point from opposite directions.

Temperature Coefficient – The shift in output due to temperature change. This is a combination of the effect

of temperature on the cylinder, the transducer and the electronics.

These factors which are normally additive refer to the feedback device itself. The performance achieved by a given system depends on the various factors such as system stiffness, valve performance, friction, temperature variation, and backlash in mechanical linkages to the cylinder.

In the case of front flange mounted cylinders, the stretch of the cylinder due to hydraulic pressure changes may affect position repeatability and system performance.

Standard Specifications

Parameter	Specification
Resolution:	<i>Analog:</i> Infinite ¹ <i>Digital:</i> 1 ÷ [gradient x crystal freq. (mHz) x circulation]
Non-Linearity:	±0.02% or ±0.10 mm (±0.004 in.), whichever is greater Minimum absolute linearity and varies with sensor model. Non-linearity increases with multiple circulations.
Repeatability:	Equal to resolution
Hysteresis:	<0.02 mm (0.0008 in.)
Outputs:	<i>Analog:</i> Voltage or Current <i>Digital:</i> Start/Stop or PWM
Measuring Range:	<i>Analog:</i> 25 to 2540 mm (1 to 100 in.) <i>Digital:</i> 25 to 2540 mm (1 to 100 in.)
Operating Voltage:	+24 Vdc (±10%)
Power Consumption:	100 mA Typical
Operating Temperature:	-40 to 85°C (-40 to 185°F)

EMC Test:	DIN IEC 801-4, Type 4, CE Qualified; DIN EN 50081-1 (Emissions), DIN EN 50082-2 (Immunity)
Shock Rating:	100 g (single hit)/IEC standard 68-2-27 (survivability)
Vibration Rating:	5 g/10-150 Hz/IEC standard 68-2-6
Adjustability: <i>(for analog sensors only)</i>	Field adjustable zero and span to 5% of active stroke length
Update Time:	<i>Analog:</i> ≤1 ms (Typical) <i>Digital:</i> Minimum = [Stroke (specified in inches) + 3] x 9.1 μs
Operating Pressure:	210 bar (3000 psi) static

¹ The above specifications for analog sensors are assuming that output ripple is averaged by the measuring device as with any typical analog device. Specifications are subject to change without notice. Consult the factory for specifications critical to your needs.

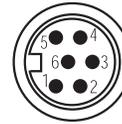
Connection Types:

Integral Connector D6
Integral Cable with Hanging D6 Connector
Integral Cable with Pigtail Termination

Analog Output:
(Voltage or Current)

Pin No.	Wire Color	Function
1	Gray	0 to +10, -10 to +10 Vdc or 4 to 20 mA, 0 to 20 mA or reverse acting: +10 to 0, +10 to -10 Vdc or 20 to 4 mA, 20 to 0 mA.
2	Pink	Return for Pin 1
3	Yellow	Not used.
4	Green	Not used.
5	Red or Brown	Customer Supplied Power (+24 Vdc)
6	White	DC Ground

Integral or Hanging Connector (D6 Male)
(As viewed from end of sensor)



Digital Output:
(PWM or Start/Stop)

Pin No.	Wire Color	Function
1	Gray	(-) Gate for PWM, (-) Stop for Start/Stop
2	Pink	(+) Gate for PWM, (+) Stop for Start/Stop
3	Yellow	(+) Interrogation for PWM, (+) Start for Start/Stop
4	Green	(-) Interrogation for PWM, (-) Start for Start/Stop
5	Red or Brown	Customer Supplied Power (+24 Vdc)
6	White	DC Ground

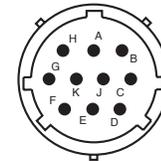
Connection Type:

Integral Cable with Hanging MS Connector

Analog Output:
(Voltage or Current)

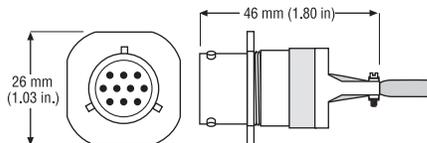
Pin No.	Wire Color	Function
A	White	DC Ground
B	Drain	Case Ground
C	Gray	Return for Pin D
D	Pink	0 to 10 Vdc, 4 to 20 mA, or 0 to 20 mA
E	Red or Brown	Customer Supplied Power (+24 Vdc)
F	-	No Connection
G	Yellow	10 to 0 Vdc, 20 to 4 mA, or 20 to 0 mA
H	Green	Return for Pin G
J	-	No Connection
K	-	No Connection

Hanging Connector (MS Male)



Digital Output:
(PWM or Start/Stop)

Pin No.	Wire Color	Function
A	White	DC Ground
B	Drain	Case Ground
C	Gray	(-) Gate for PWM, (-) Stop for Start/Stop
D	Pink	(+) Gate for PWM, (+) Stop for Start/Stop
E	Red or Brown	Customer Supplied Power (+24 Vdc)
F	-	No Connection
G	-	No Connection
H	-	No Connection
J	Yellow	(+) Interrogation for PWM (+) Start for Start/Stop
K	Green	(-) Interrogation for PWM



Hanging Connector (MS male)

CAUTION!

- 1) When wiring Tempsonics L Series sensors, **do not connect DC ground to the cable shield or drain wire.**
- 2) For single-ended interrogation, the unused interrogation lead must be connected to DC ground (single-ended interrogation is not recommended).
- 3) When using PWM with internal interrogation, both interrogation leads must be connected to DC ground.
- 4) Minimum load impedance for voltage outputs is 5KΩ.

The pressure rating is reduced on some bores and rod codes. Due to the gun drill depth required in the piston rod for WaveScale, standard "W" dimensions for Style 9 female thread cannot be supplied. Special Style 3 female thread with "KK" and minimum "W" dimensions shown in the table below can be supplied. Style 4 and 8 cannot be studded rod ends to have the "W" dimension as standard.

Envelope and Rod Dimensions

Bore	Rod Code	Rod Dia. MM	A	Style 4 KK	Style 8 CC	Add Stroke	4 to 1 Design Factor (PSI) ¹
						LB	
2	1	1	1 1/8	3/4-16	7/8-12	5 1/4	2300
	2	1 3/8	1 5/8	1-14	1 1/4-12	5 1/4	3000
2 1/2	1	1	1 1/8	3/4-16	7/8-12	5 3/8	1400
	2	1 3/4	2	1 1/4-12	1 1/2-12	5 3/8	3000
	3	1 3/8	1 5/8	1-14	1 1/4-12	5 3/8	3000
3 1/4	1	1 3/8	1 5/8	1-14	1 1/4-12	6 1/4	3000
	2	2	2 1/4	1 1/2-12	1 3/4-12	6 1/4	3000
	3	1 3/4	2	1 1/4-12	1 1/2-12	6 1/4	3000
4	1	1 3/4	2	1 1/4-12	1 1/2-12	6 5/8	3000
	2	2 1/2	3	1 7/8-12	2 1/4-12	6 5/8	3000
	3	2	2 1/4	1 1/2-12	1 3/4-12	6 5/8	3000
5	1	2	2 1/4	1 1/2-12	1 3/4-12	7 1/8	3000
	2	3 1/2	3 1/2	2 1/2-12	3 1/4-12	7 1/8	3000
	3	2 1/2	3	1 7/8-12	2 1/4-12	7 1/8	3000
	4	3	3 1/2	2 1/4-12	2 3/4-12	7 1/8	3000
6	1	2 1/2	3	1 7/8-12	2 1/4-12	8 3/8	3000
	2	4	4	3-12	3 3/4-12	8 3/8	3000
	3	3	3 1/2	2 1/4-12	2 3/4-12	8 3/8	3000
	4	3 1/2	3 1/2	2 1/2-12	3 1/4-12	8 3/8	3000

Bore	Rod Code	Rod Dia. MM	A	Special Female Thread Style 3 KK	Special Female Thread Style 3 W	Add Stroke	4 to 1 Design Factor (PSI) ¹
						LB	
2	1	1	1 1/8	3/4-16	1 7/8	5 1/4	2300
	2	1 3/8	1 5/8	1-14	2 9/16	5 1/4	3000
2 1/2	1	1	1 1/8	3/4-16	1 3/4	5 3/8	1400
	2	1 3/4	2	1 1/4-12	2 7/8	5 3/8	3000
	3	1 3/8	1 5/8	1-14	2 3/8	5 3/8	3000
3 1/4	1	1 3/8	1 5/8	1-14	1 3/4	6 1/4	3000
	2	2	2 1/4	1 1/2-12	2 5/8	6 1/4	3000
	3	1 3/4	2	1 1/4-12	3 1/4	6 1/4	3000
4	1	1 3/4	2	1 1/4-12	1 7/8	6 5/8	3000
	2	2 1/2	3	1 7/8-12	3 1/8	6 5/8	3000
	3	2	2 1/4	1 1/2-12	2 1/4	6 5/8	3000
5	1	2	2 1/4	1 1/2-12	1 3/4	7 1/8	3000
	2	3 1/2	3 1/2	2 1/2-12	3 1/8	7 1/8	3000
	3	2 1/2	3	1 7/8-12	2 5/8	7 1/8	3000
	4	3	3 1/2	2 1/4-12	3 1/8	7 1/8	3000
6	1	2 1/2	3	1 7/8-12	1 7/8	8 3/8	3000
	2	4	4	3-12	3 1/16	8 3/8	3000
	3	3	3 1/2	2 1/4-12	2 3/8	8 3/8	3000
	4	3 1/2	3 1/2	2 1/2-12	2 3/8	8 3/8	3000

All dimensions in the above tables are in inches.

¹ The 4:1 design factor is based on the tensile strength of the piston to rod connection.



Electronic Enclosure Positions

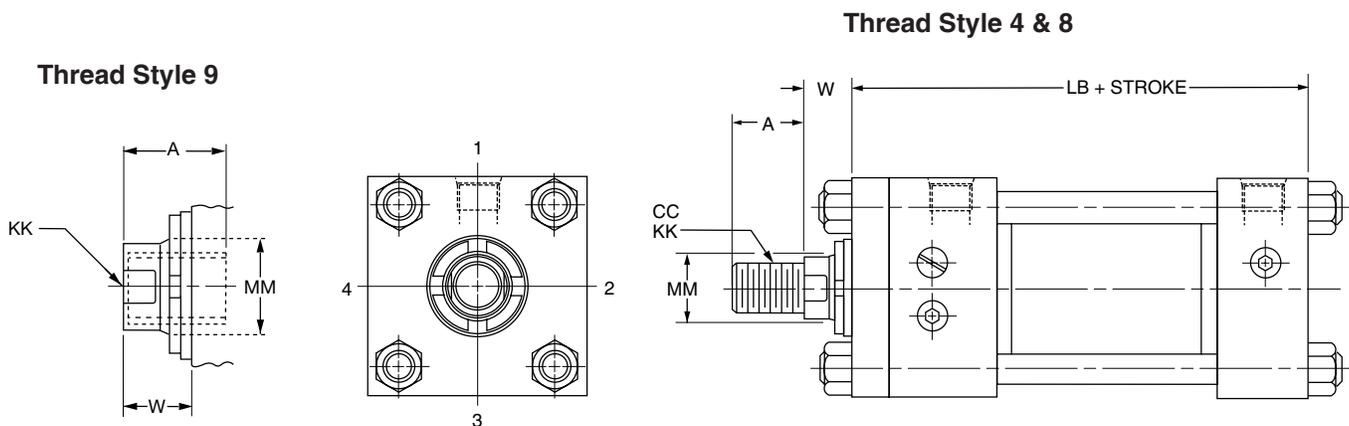
The standard location for the electronic enclosure is position #2. Reference the table below for locations that are not occupied by a mount or port.

Available Mounting and Electronic Enclosure Position

MOUNTING STYLE	DESCRIPTION	ELECTRONIC ENCLOSURE POSITION
TB	Head Tie Rods Extended	1,2,3,4
TC	Cap Tie Rods Extended	1,2,3,4
TD	Both Ends Tie Rods Extended	1,2,3,4
J	Head Rectangular Flange	1,2,3,4
JB	Head Square Flange	1,2,3,4
JJ	Head Rectangular	1,2,3,4
H	Cap Rectangular Flange	1,3 CF
HB	Cap Square Flange	CF
HH	Cap Rectangular	1,3 CF
C	Side Lug	1 CF
E	Centerline Lug	N/A
F	Side Tapped	1,2&4
CB	Side End Angles	1,2&4
G	Side End Lugs	1,2&4
BB	Cap Fixed Clevis	1,2,3,4
D	Head Trunnion	1,2,3,4
DB	Cap Trunnion	1,3 CF
DD	Intermediate Fixed Trunnion	1,3 CF
SB	Spherical Bearing	1,2,3,4

N/A = Not Available
 CF = Consult Factory

Envelope and Rod Dimensions



Safety Guide for Selecting and Using Hydraulic, Pneumatic Cylinders and Their Accessories

WARNING: ⚠ FAILURE OF THE CYLINDER, ITS PARTS, ITS MOUNTING, ITS CONNECTIONS TO OTHER OBJECTS, OR ITS CONTROLS CAN RESULT IN:

- Unanticipated or uncontrolled movement of the cylinder or objects connected to it.
- Falling of the cylinder or objects held up by it.
- Fluid escaping from the cylinder, potentially at high velocity.

THESE EVENTS COULD CAUSE DEATH OR PERSONAL INJURY BY, FOR EXAMPLE, PERSONS FALLING FROM HIGH LOCATIONS, BEING CRUSHED OR STRUCK BY HEAVY OR FAST MOVING OBJECTS, BEING PUSHED INTO DANGEROUS EQUIPMENT OR SITUATIONS, OR SLIPPING ON ESCAPED FLUID.

Before selecting or using Parker Hannifin Corporation (the Company) cylinders or related accessories, it is important that you read, understand and follow the following safety information. Training is advised before selecting and using the Company's products.

1.0 General Instructions

1.1 Scope – This safety guide provides instructions for selecting and using (including assembling, installing, and maintaining) cylinder products. This safety guide is a supplement to and is to be used with the specific Company publications for the specific cylinder products that are being considered for use.

1.2 Fail Safe – Cylinder products can and do fail without warning for many reasons. All systems and equipment should be designed in a fail-safe mode so that if the failure of a cylinder product occurs people and property won't be endangered.

1.3 Distribution – Provide a free copy of this safety guide to each person responsible for selecting or using cylinder products. Do not select or use the Company's cylinders without thoroughly reading and understanding this safety guide as well as the specific Company publications for the products considered or selected.

1.4 User Responsibility – Due to very wide variety of cylinder applications and cylinder operating conditions, the Company does not warrant that any particular cylinder is suitable for any specific application. This safety guide does not analyze all technical parameters that must be considered in selecting a product. The hydraulic and pneumatic cylinders outlined in this catalog are designed to the Company's design guidelines and do not necessarily meet the design guideline of other agencies such as American Bureau of Shipping, ASME Pressure Vessel Code etc. The user, through its own analysis and testing, is solely responsible for:

- Making the final selection of the cylinders and related accessories.
- Determining if the cylinders are required to meet specific design requirements as required by the Agency(s) or industry standards covering the design of the user's equipment.
- Assuring that the user's requirements are met, OSHA requirements are met, and safety guidelines from the applicable agencies such as but not limited to ANSI are followed and that the use presents no health or safety hazards.
- Providing all appropriate health and safety warnings on the equipment on which the cylinders are used.

1.5 Additional Questions – Call the appropriate Company technical service department if you have any questions or require any additional information. See the Company publication for the product being considered or used, or call 1-847-298-2400, or go to www.parker.com, for telephone numbers of the appropriate technical service department.

2.0 Cylinder and Accessories Selection

2.1 Seals – Part of the process of selecting a cylinder is the selection of seal compounds. Before making this selection, consult the "seal information page(s)" of the publication for the series of cylinders of interest.

The application of cylinders may allow fluids such as cutting fluids, wash down fluids etc. to come in contact with the external area of the cylinder. These fluids may attack the piston rod wiper and or the primary seal and must be taken into account when selecting and specifying seal compounds.

Dynamic seals will wear. The rate of wear will depend on many operating factors. Wear can be rapid if a cylinder is mis-aligned or if the cylinder has been improperly serviced. The user must take seal wear into consideration in the application of cylinders.

2.2 Piston Rods – Possible consequences of piston rod failure or separation of the piston rod from the piston include, but are not limited to are:

- Piston rod and or attached load thrown off at high speed.
- High velocity fluid discharge.
- Piston rod extending when pressure is applied in the piston retract mode.

Piston rods or machine members attached to the piston rod may move suddenly and without warning as a consequence of other conditions occurring to the machine such as, but not limited to:

- Unexpected detachment of the machine member from the piston rod.

- Failure of the pressurized fluid delivery system (hoses, fittings, valves, pumps, compressors) which maintain cylinder position.
- Catastrophic cylinder seal failure leading to sudden loss of pressurized fluid.
- Failure of the machine control system.

Follow the recommendations of the "Piston Rod Selection Chart and Data" in the publication for the series of cylinders of interest. The suggested piston rod diameter in these charts must be followed in order to avoid piston rod buckling.

Piston rods are not normally designed to absorb bending moments or loads which are perpendicular to the axis of piston rod motion. These additional loads can cause the piston rod to fail. If these types of additional loads are expected to be imposed on the piston rod, their magnitude should be made known to our engineering department.

The cylinder user should always make sure that the piston rod is securely attached to the machine member.

On occasion cylinders are ordered with double rods (a piston rod extended from both ends of the cylinder). In some cases a stop is threaded on to one of the piston rods and used as an external stroke adjuster. On occasions spacers are attached to the machine member connected to the piston rod and also used as a stroke adjuster. In both cases the stops will create a pinch point and the user should consider appropriate use of guards. If these external stops are not perpendicular to the mating contact surface, or if debris is trapped between the contact surfaces, a bending moment will be placed on the piston rod, which can lead to piston rod failure. An external stop will also negate the effect of cushioning and will subject the piston rod to impact loading. Those two (2) conditions can cause piston rod failure. Internal stroke adjusters are available with and without cushions. The use of external stroke adjusters should be reviewed with our engineering department.

The piston rod to piston and the stud to piston rod threaded connections are secured with an anaerobic adhesive. The strength of the adhesive decreases with increasing temperature. Cylinders which can be exposed to temperatures above +250°F (+121°C) are to be ordered with a non studded piston rod and a pinned piston to rod joint.

2.3 Cushions – Cushions should be considered for cylinder applications when the piston velocity is expected to be over 4 inches/second.

Cylinder cushions are normally designed to absorb the energy of a linear applied load. A rotating mass has considerably more energy than the same mass moving in a linear mode. Cushioning for a rotating mass application should be reviewed by our engineering department.

2.4 Cylinder Mountings – Some cylinder mounting configurations may have certain limitations such as but not limited to minimum stroke for side or foot mounting cylinders or pressure de-ratings for certain mounts. Carefully review the catalog for these types of restrictions.

Always mount cylinders using the largest possible high tensile alloy steel socket head cap screws that can fit in the cylinder mounting holes and torque them to the manufacturer's recommendations for their size.

2.5 Port Fittings – Hydraulic cylinders applied with meter out or deceleration circuits are subject to intensified pressure at piston rod end.

The rod end pressure is approximately equal to:

$$\frac{\text{operating pressure} \times \text{effective cap end area}}{\text{effective rod end piston area}}$$

Contact your connector supplier for the pressure rating of individual connectors.

3.0 Cylinder and Accessories Installation and Mounting

3.1 Installation

3.1.1 – Cleanliness is an important consideration, and cylinders are shipped with the ports plugged to protect them from contaminants entering the ports. These plugs should not be removed until the piping is to be installed. Before making the connection to the cylinder ports, piping should be thoroughly cleaned to remove all chips or burrs which might have resulted from threading or flaring operations.

3.1.2 – Cylinders operating in an environment where air drying materials are present such as fast-drying chemicals, paint, or weld splatter, or other hazardous conditions such as excessive heat, should have shields installed to prevent damage to the piston rod and piston rod seals.

3.1.3 – Proper alignment of the cylinder piston rod and its mating component on the machine should be checked in both the extended and retracted positions. Improper alignment will result in excessive rod gland and/or cylinder bore wear. On fixed mounting cylinders attaching the piston rod while the rod is retracted will help in achieving proper alignment.

3.1.4 – Sometimes it may be necessary to rotate the piston rod in order to thread the piston rod into the machine member. This operation must always be done with zero pressure being applied to either side of the piston. Failure to follow this procedure may result in loosening the piston to rod-threaded connection. In some rare cases the turning of the piston rod may rotate a threaded piston rod gland and loosen it from the cylinder head. Confirm that this condition is not occurring. If it does, re-tighten the piston rod gland firmly against the cylinder head.

For double rod cylinders it is also important that when attaching or detaching the piston rod from the machine member that the torque be applied to the piston rod end of the cylinder that is directly attaching to the machine member with the opposite end unrestrained. If the design of the machine is such that only the rod end of the cylinder opposite to where the rod attaches to the machine member can be rotated, consult the factory for further instructions.

3.2 Mounting Recommendations

3.2.1 – Always mount cylinders using the largest possible high tensile alloy steel socket head screws that can fit in the cylinder mounting holes and torque them to the manufacturer's recommendations for their size.

3.2.2 – Side-Mounted Cylinders – In addition to the mounting bolts, cylinders of this type should be equipped with thrust keys or dowel pins located so as to resist the major load.

3.2.3 – Tie Rod Mounting – Cylinders with tie rod mountings are recommended for applications where mounting space is limited. The standard tie rod extension is shown as BB in dimension tables. Longer or shorter extensions can be supplied. Nuts used for this mounting style should be torqued to the same value as the tie rods for that bore size.

3.2.4 – Flange Mount Cylinders – The controlled diameter of the rod gland extension on head end flange mount cylinders can be used as a pilot to locate the cylinders in relation to the machine. After alignment has been obtained, the flanges may be drilled for pins or dowels to prevent shifting.

3.2.5 – Trunnion Mountings – Cylinders require lubricated bearing blocks with minimum bearing clearances. Bearing blocks should be carefully aligned and rigidly mounted so the trunnions will not be subjected to bending moments. The rod end should also be pivoted with the pivot pin in line and parallel to axis of the trunnion pins.

3.2.6 – Clevis Mountings – Cylinders should be pivoted at both ends with centerline of pins parallel to each other. After cylinder is mounted, be sure to check to assure that the cylinder is free to swing through its working arc without interference from other machine parts.

4.0 Cylinder and Accessories Maintenance, Troubleshooting and Replacement

4.1 Storage – At times cylinders are delivered before a customer is ready to install them and must be stored for a period of time. When storage is required the following procedures are recommended.

4.1.1 – Store the cylinders in an indoor area which has a dry, clean and noncorrosive atmosphere. Take care to protect the cylinder from both internal corrosion and external damage.

4.1.2 – Whenever possible cylinders should be stored in a vertical position (piston rod up). This will minimize corrosion due to possible condensation which could occur inside the cylinder. This will also minimize seal damage.

4.1.3 – Port protector plugs should be left in the cylinder until the time of installation.

4.1.4 – If a cylinder is stored full of hydraulic fluid, expansion of the fluid due to temperature changes must be considered. Installing a check valve with free flow out of the cylinder is one method.

4.1.5 – When cylinders are mounted on equipment that is stored outside for extended periods, exposed unpainted surfaces, e.g. piston rod, must be coated with a rust-inhibiting compound to prevent corrosion.

4.2 Cylinder Trouble Shooting

4.2.1 – External Leakage

4.2.1.1 – Rod seal leakage can generally be traced to worn or damaged seals. Examine the piston rod for dents, gouges or score marks, and replace piston rod if surface is rough.

Rod seal leakage could also be traced to gland wear. If clearance is excessive, replace rod bushing and seal. Rod seal leakage can also be traced to seal deterioration. If seals are soft or gummy or brittle, check compatibility of seal material with lubricant used if air cylinder, or operating fluid if hydraulic cylinder. Replace with seal material, which is compatible with these fluids. If the seals are hard or have lost elasticity, it is usually due to exposure to temperatures in excess of 165°F. (+74°C). Shield the cylinder from the heat source to limit temperature to 350°F. (+177°C.) and replace with fluorocarbon seals.

4.2.1.2 – Cylinder body seal leak can generally be traced to loose tie rods. Torque the tie rods to manufacturer's recommendation for that bore size.

Excessive pressure can also result in cylinder body seal leak. Determine maximum pressure to rated limits. Replace seals and retorque tie rods as in paragraph above. Excessive pressure can also result in cylinder body seal leak. Determine if the pressure rating of the cylinder has been exceeded. If so, bring the operating pressure down to the rating of the cylinder and have the tie rods replaced.

Pinched or extruded cylinder body seal will also result in a leak. Replace cylinder body seal and retorque as in paragraph above.

Cylinder body seal leakage due to loss of radial squeeze which shows up in the form of flat spots or due to wear on the O.D. or I.D. – Either of these are symptoms of normal wear due to high cycle rate or length of service. Replace seals as per paragraph above.

4.2.2 – Internal Leakage

4.2.2.1 – Piston seal leak (by-pass) 1 to 3 cubic inches per minute leakage is considered normal for piston ring construction. Virtually no static leak with lipseal type seals on piston should be expected. Piston seal wear is a usual cause of piston seal leakage. Replace seals as required.

4.2.2.2 – With lipseal type piston seals excessive back pressure due to over-adjustment of speed control valves could be a direct cause of rapid seal wear. Contamination in a hydraulic system can result in a scored cylinder bore, resulting in rapid seal wear. In either case, replace piston seals as required.

4.2.2.3 – What appears to be piston seal leak, evidenced by the fact that the cylinder drifts, is not always traceable to the piston. To make sure, it is suggested that one side of the cylinder piston be pressurized and the fluid line at the opposite port be disconnected. Observe leakage. If none is evident, seek the cause of cylinder drift in other component parts in the circuit.

4.2.3 – Cylinder Fails to Move the Load

4.2.3.1 – Pneumatic or hydraulic pressure is too low. Check the pressure at the cylinder to make sure it is to circuit requirements.

4.2.3.2 – Piston Seal Leak – Operate the valve to cycle the cylinder and observe fluid flow at valve exhaust ports at end of cylinder stroke. Replace piston seals if flow is excessive.

4.2.3.3 – Cylinder is undersized for the load – Replace cylinder with one of a larger bore size.

4.3 Erratic or Chatter Operation

4.3.1 – Excessive friction at rod gland or piston bearing due to load misalignment – Correct cylinder-to-load alignment.

4.3.2 – Cylinder sized too close to load requirements – Reduce load or install larger cylinder.

4.3.3 – Erratic operation could be traced to the difference between static and kinetic friction. Install speed control valves to provide a back pressure to control the stroke.

4.4 Cylinder Modifications, Repairs, or Failed Component – Cylinders as shipped from the factory are not to be disassembled and or modified. If cylinders require modifications, these modifications must be done at company locations or by the Company's certified facilities. The Industrial Cylinder Division Engineering Department must be notified in the event of a mechanical fracture or permanent deformation of any cylinder component (excluding seals). This includes a broken piston rod, tie rod, mounting accessory or any other cylinder component. The notification should include all operation and application details. This information will be used to provide an engineered repair that will prevent recurrence of the failure.

It is allowed to disassemble cylinders for the purpose of replacing seals or seal assemblies. However, this work must be done by strictly following all the instructions provided with the seal kits.

Notes

Notes

Manufacturing Locations

Regional Plants

California

221 Helicopter Circle
Corona, CA 92880
Tel.: (951) 280-3800
Fax: (951) 280-3808
Fax: (800) 869-9886

Connecticut

80 Shaker Road
Enfield, CT 06082
Tel.: (860) 749-2215
Fax: (800) 323-0105

Georgia

1300 Six Flags Road
Lithia Springs, GA 30122
Tel.: (770) 819-3400
Fax: (800) 437-3498

Indiana

Goodland Plant
715 South Iroquois Street
Goodland, IN 47948
Tel.: (219) 297-3182
Fax: (800) 328-8120

Michigan

900 Plymouth Road
Plymouth, MI 48170
Tel.: (734) 455-1700
Fax: (734) 455-1007

Oregon

29289 Airport Road
Eugene, OR 97402-0079
Tel.: (541) 689-9111
Fax: (541) 688-6771
Fax: (800) 624-7996

Offer of Sale

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4. Warranty. Seller warrants that the Products sold hereunder shall be free from defects in material or workmanship for a period of eighteen months from the date of delivery to Buyer. The prices charged for Seller's products are based upon the exclusive limited warranty stated above, and upon the following disclaimer: **DISCLAIMER OF WARRANTY: THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO PRODUCTS PROVIDED HEREUNDER. SELLER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS AND IMPLIED, INCLUDING DESIGN, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

5. Claims; Commencement of Actions. Buyer shall promptly inspect all Products upon delivery. No claims for shortages will be allowed unless reported to the Seller within 10 days of delivery. No other claims against Seller will be allowed unless asserted in writing within 30 days after delivery. Buyer shall notify Seller of any alleged breach of warranty within 30 days after the date the defect is or should have been discovered by Buyer. Any action based upon breach of this agreement or upon any other claim arising out of this sale (other than an action by Seller for an amount due on any invoice) must be commenced within 12 months from the date of the breach without regard to the date breach is discovered.

6. LIMITATION OF LIABILITY. UPON NOTIFICATION, SELLER WILL, AT ITS OPTION, REPAIR OR REPLACE A DEFECTIVE PRODUCT, OR REFUND THE PURCHASE PRICE. **IN NO EVENT SHALL SELLER BE LIABLE TO BUYER FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF, OR AS THE RESULT OF, THE SALE, DELIVERY, NON-DELIVERY, SERVICING, USE OR LOSS OF USE OF THE PRODUCTS OR ANY PART THEREOF, OR FOR ANY CHARGES OR EXPENSES OF ANY NATURE INCURRED WITHOUT SELLER'S WRITTEN CONSENT, EVEN IF SELLER HAS BEEN NEGLIGENT, WHETHER IN CONTRACT, TORT OR OTHER LEGAL THEORY. IN NO EVENT SHALL SELLER'S LIABILITY UNDER ANY CLAIM MADE BY BUYER EXCEED THE PURCHASE PRICE OF THE PRODUCTS.**

7. User Responsibility. The user, through its own analysis and testing, is solely responsible for making the final selection of the system and Product and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application and follow applicable industry standards and Product information. If Seller provides Product or system options, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the Products or systems.

8. Loss to Buyer's Property. Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer's property, will be considered obsolete and may be destroyed by Seller after two consecutive years have elapsed without Buyer ordering the items manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

9. Special Tooling. A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture Products. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the Products, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

10. Buyer's Obligation; Rights of Seller. To secure payment of all sums due or otherwise, Seller shall retain a security interest in the goods delivered and this agreement shall be deemed a Security Agreement under the Uniform Commercial Code. Buyer authorizes Seller as its attorney to execute and file on Buyer's behalf all documents Seller deems necessary to perfect its security interest.

11. Improper use and Indemnity. Buyer shall indemnify, defend, and hold Seller harmless from any claim, liability, damages, lawsuits, and costs (including attorney fees), whether for personal injury, property damage, patent, trademark or copyright

infringement or any other claim, brought by or incurred by Buyer, Buyer's employees, or any other person, arising out of: (a) improper selection, improper application or other misuse of Products purchased by Buyer from Seller; (b) any act or omission, negligent or otherwise, of Buyer; (c) Seller's use of patterns, plans, drawings, or specifications furnished by Buyer to manufacture Product; or (d) Buyer's failure to comply with these terms and conditions. Seller shall not indemnify Buyer under any circumstance except as otherwise provided.

12. Cancellations and Changes. Orders shall not be subject to cancellation or change by Buyer for any reason, except with Seller's written consent and upon terms that will indemnify, defend and hold Seller harmless against all direct, incidental and consequential loss or damage. Seller may change product features, specifications, designs and availability with notice to Buyer.

13. Limitation on Assignment. Buyer may not assign its rights or obligations under this agreement without the prior written consent of Seller.

14. Force Majeure. Seller does not assume the risk and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter "Events of Force Majeure"). Events of Force Majeure shall include without limitation: accidents, strikes or labor disputes, acts of any government or government agency, acts of nature, delays or failures in delivery from carriers or suppliers, shortages of materials, or any other cause beyond Seller's reasonable control.

15. Waiver and Severability. Failure to enforce any provision of this agreement will not waive that provision nor will any such failure prejudice Seller's right to enforce that provision in the future. Invalidation of any provision of this agreement by legislation or other rule of law shall not invalidate any other provision herein. The remaining provisions of this agreement will remain in full force and effect.

16. Termination. Seller may terminate this agreement for any reason and at any time by giving Buyer thirty (30) days written notice of termination. Seller may immediately terminate this agreement, in writing, if Buyer: (a) commits a breach of any provision of this agreement (b) appointments a trustee, receiver or custodian for all or any part of Buyer's property (c) files a petition for relief in bankruptcy on its own behalf, or by a third party (d) makes an assignment for the benefit of creditors, or (e) dissolves or liquidates all or a majority of its assets.

17. Governing Law. This agreement and the sale and delivery of all Products hereunder shall be deemed to have taken place in and shall be governed and construed in accordance with the laws of the State of Ohio, as applicable to contracts executed and wholly performed therein and without regard to conflicts of laws principles. Buyer irrevocably agrees and consents to the exclusive jurisdiction and venue of the courts of Cuyahoga County, Ohio with respect to any dispute, controversy or claim arising out of or relating to this agreement.

18. Indemnity for Infringement of Intellectual Property Rights. Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Section. Seller will defend and indemnify Buyer against allegations of infringement of U.S. patents, U.S. trademarks, copyrights, trade dress and trade secrets ("Intellectual Property Rights"). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that a Product sold pursuant to this Agreement infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If a Product is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using the Product, replace or modify the Product so as to make it noninfringing, or offer to accept return of the Product and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to Products delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any Product sold hereunder. The foregoing provisions of this Section shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.

19. Entire Agreement. This agreement contains the entire agreement between the Buyer and Seller and constitutes the final, complete and exclusive expression of the terms of sale. All prior or contemporaneous written or oral agreements or negotiations with respect to the subject matter are herein merged.

20. Compliance with Law, U. K. Bribery Act and U.S. Foreign Corrupt Practices Act. Buyer agrees to comply with all applicable laws and regulations, including both those of the United Kingdom and the United States of America, and of the country or countries of the Territory in which Buyer may operate, including without limitation the U. K. Bribery Act, the U.S. Foreign Corrupt Practices Act ("FCPA") and the U.S. Anti-Kickback Act (the "Anti-Kickback Act"), and agrees to indemnify and hold harmless Seller from the consequences of any violation of such provisions by Buyer, its employees or agents. Buyer acknowledges that they are familiar with the provisions of the U. K. Bribery Act, the FCPA and the Anti-Kickback Act, and certifies that Buyer will adhere to the requirements thereof. In particular, Buyer represents and agrees that Buyer shall not make any payment or give anything of value, directly or indirectly to any governmental official, any foreign political party or official thereof, any candidate for foreign political office, or any commercial entity or person, for the purpose of influencing such person to purchase products or otherwise benefit the business of Seller.





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