APPENDIX B: KIT OF PARTS

Please check the FIRST web site for an updated Kit of Parts list, as changes are expected.

List of Components

Bearings

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Pillow Block	1/2"	Green Container - Bearing Bag	2	The Torrington Company
Radial Ball Bearing With Spherical O.D., RA008RRB	1/2" I.D., Self Locking Collar	Green Container - Bearing Bag	4	The Torrington Company
Single Row Radial Flanged Ball Bearing,	1/4" I.D.	Green Container - Bearing Bag	4	The Torrington Company
Single Row Radial Flanged Ball Bearing,	3/8" I.D.	Green Container - Bearing Bag	4	The Torrington Company
Two Bolt Self Aligning Flange, 40MST	Fits 1/2" Bearing	Green Container - Bearing Bag	8	The Torrington Company

Control System

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
15 Pin Solder Cup Connector	DB15 Female	Green Container - Electronics Bag	2	AMP Foundation
25 Pin Solder Cup Connector	DB25 Male	Green Container - Electronics Bag	2	AMP Foundation
Plastic Shield for 25 Pin Connector	fits DB25 Connector	Green Container - Electronics Bag	2	AMP Foundation
Optical Sensor		Green Container - Electronics Bag	4	Banner Engineering
Fuse Panel	ATC, 12 fuseable, 12 unfused	Green Container - Electronics Bag	2	Bussmann
LED, Panel Mount	Red, 12V	Green Container - Electronics Bag	2	Chicago Miniature
LED, Panel Mount	Green, 12V	Green Container - Electronics Bag	2	Chicago Miniature
LED, Panel Mount	Amber, 12V	Green Container - Electronics Bag	2	Chicago Miniature
Muffin Fan (Tiny)	12 Vdc	Green Container - Electronics Bag	5	EBM Industries
Servo	42 oz./in. peak torque, 0.19 sec./60°	Green Container - Electronics Bag	2	Hitec RCD, Inc.
Snap-Action Circuit Breaker	30 amp,12 volt, Auto-Resetting	Green Container - Electronics Bag	6	Snap-Action, Inc.
Snap-Action Circuit Breaker	20 amp,12 volt, Auto-Resetting	Green Container - Electronics Bag	6	Snap-Action, Inc.
Circuit Breaker	60 Amps, Ratings: 1-63A set at 77°F Tripping curve: magnetic operates	Green Container - Electronics Bag	1	SquareD
Anderson Power Products Catalog	Catalog	Green Container - Loose	1	Anderson Power Products
Quick-Disconnect Power Connector (with 1' leads)	#6 AWG Red/Black Wire, pair	Green Container - Loose	2	Anderson Power Products

List of Components

Flightstick Joystick	7” Cable with Male DB15	Green Container - Loose	2	CH Products
Muffin Fan	12 Vdc	Green Container - Loose	1	EBM Industries
Battery	12 volt	Green Container - Loose	2	Exide
9 Pin Cable	DB9 Male to Female, 6’, Shielded	Green Container - Loose	4	Innovation First
PWM/Relay Cable	Hitec/JR-style, 36” Long	Green Container - Loose	8	Innovation First
PWM/Relay Y Cable	Hitec/JR-style, 24” Long	Green Container - Loose	2	Innovation First
Revolving Light	w/ red and,blue lenses	Green Container - Loose	1	North American Signal
Yaw Rate Sensor		Red Container - Loose	1	BEI Systron Donner
2 Conductor Jacketed Wire	35’, #16 AWG	Red Container - Loose	1	BICC General
2 Conductor Jacketed Wire	30’, #24 AWG	Red Container - Loose	1	BICC General
3 Conductor Shielded Wire	30’, #24 AWG	Red Container - Loose	1	BICC General
1 Conductor Wire	35’, #10 AWG, Red	Red Container - Loose	1	Delphi Connection
1 Conductor Wire	35’, #10 AWG, Black	Red Container - Loose	1	Delphi Connection
1 Conductor Wire	10’, #6 AWG, Black	Red Container - Loose	1	Delphi Packard Electric Systems
1 Conductor Wire	10’, #6 AWG, Red	Red Container - Loose	1	Delphi Packard Electric Systems
Connector for Seat Motor	2 pin, 16 AWG x 12" cable	Red Container - Loose	2	Delphi Packard Electric Systems
Connector for Yaw Rate Sensor	3 pin, 24 AWG x 12" cable	Red Container - Loose	1	Delphi Packard Electric Systems
Battery Charger	Sealed Lead Acid Battery, 4 amp	Red Container - Loose	1	Exide
15 Pin Molded Cable	DB15 pin M-M, 6 feet	Red Container - Loose	2	Innovation First
Operator Interface		Red Container - Loose	1	Innovation First
Power Supply for Operator Interface	9 Vdc	Red Container - Loose	1	Innovation First
Radio Modem for Operator Interface	RS-422, 9 pin F, metal antenna	Red Container - Loose	1	Innovation First

List of Components

Radio Modem for Robot Controller	RS-422, 9 pin F, rubber antenna	Red Container - Loose	1	Innovation First
Relay Module (Spike)	12V, 20A Max	Red Container - Loose	4	Innovation First
Robot Controller		Red Container - Loose	1	Innovation First
Speed Controller (Victor 883)		Red Container - Loose	4	Innovation First

Documentation

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
FedEx Airbills		Red Container - Loose	4	FedEx
Kee Klamp Pipe Fitting Brochure		Red Container - Loose	1	Kee Industrial Products
Kee Lite Pipe Fitting Brochure		Red Container - Loose	1	Kee Industrial Products

Fasteners

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Velcro grip tie (2 in a pack)	6"x 1"	Green Container - Velcro Bag	1	Tyton Hellermann
Velcro Grip Ties	8" x 1.75"	Green Container - Velcro Bag	2	Tyton Hellermann
Velcro 1” Hook & Loop Tape	36" Length, Adhesive Backing	Green Container - Velcro Bag	1	Velcro USA, Inc.
Velcro 1” One Wrap Tape	24” Lengths, Black	Green Container - Velcro Bag	1	Velcro USA, Inc.
Velcro 18" One Wrap grip tie	1”x18" grip tie	Green Container - Velcro Bag	2	Velcro USA, Inc.
Velcro 5/8” One Wrap Tape	24" Lengths, Black	Green Container - Velcro Bag	1	Velcro USA, Inc.
Velcro 8" One Wrap grip tie	1”x8" grip tie	Green Container - Velcro Bag	10	Velcro USA, Inc.
Velcro Sticky Back Coins	5/8” Ø x 36" (48 sets)	Green Container - Velcro Bag	1	Velcro USA, Inc.
Drill Housing Screws	#4 x 3/4, Pan Head - Phillips	Red Container - Miscellaneous Bag	10	Fastenal Company
Drill Motor / Gearbox Screw	M4 x 6mm, Button Head 19	Red Container - Miscellaneous Bag	4	Fastenal Company
Helical Plastic Wire Wrap	1/4” Ø x 24”	Red Container - Miscellaneous Bag	1	Tyton Hellermann
Helical Plastic Wire Wrap	1/2" Ø x 24”	Red Container - Miscellaneous Bag	1	Tyton Hellermann
Polyethylene grommet	3/16" x 24”	Red Container - Miscellaneous Bag	1	Tyton Hellermann

List of Components

Polyethylene grommet	3/8" x 24”	Red Container - Miscellaneous Bag	1	Tyton Hellermann

Misc Hardware

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Drill Housing Cover		Green Container - Drill Bag	2	S-B Power Tool Company
Flexible Shaft Coupling	Black	Red Container - Seat / Window Bag	2	DEKA

Motors & Pumps

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Drill Drive Assembly	225 in-lb max, 3/8-24 UNF outer, M5 X 0.8 left-hand inner	Green Container - Drill Bag	3	S-B Power Tool Company
Drill Motor	12 Vdc	Green Container - Drill Bag	3	S-B Power Tool Company
Johnson Electric Motor	40.55W max @ 27.59 m-Nm, 14043 Rpm	Green Container - Electronics Bag	1	Johnson Electric North America,
Fisher-Price 10 Web Jeep Driver	Black	Green Container - Loose	2	Fisher-Price, Inc.
Fisher-Price Axle	7/16" ∅ x 26"	Green Container - Loose	1	Fisher-Price, Inc.
Fisher-Price Motor/Gearbox	12 Vdc stall torque (mNm) 532.19+/-10%	Green Container - Loose	2	Fisher-Price, Inc.
Globe Motor with Drive Assembly	12Vdc	Green Container - Loose	2	Globe Motors
Drill Housing Kit w/ Shift Lever	T-Handle Style Grip, Left/Right	Green Container - Loose	2	S-B Power Tool Company
Van Door Motor - Bosch	12 Vdc, 75 RPM	Red Container - Loose	1	Bosch Automotive
Motor, Chiaphua		Red Container - Loose	1	Chiaphua
Seat Motor, Keyang	12 Vdc	Red Container - Loose	2	Delphi Automotive
Window Motor, Left, Jideco		Red Container - Loose	1	Jideco
Window Motor, Right, Jideco		Red Container - Loose	1	Jideco
Motor, Mabuchi		Red Container - Miscellaneous Bag	1	Mabuchi Motor America
Gear, for Chiaphua Motor		Red Container - Seat / Window Bag	1	Chiaphua

Other

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
PUMA Size 5 Soccer Ball, Yellow	Size 5, Yellow	Red Container - Loose	1	PUMA

List of Components

Worm Gear Actuator-Left Hand	2 inch linear movement	Red Container - Seat / Window Bag	1	Excellence Manufacturing,
Worm Gear Actuator-Right Hand	2 inch linear movement	Red Container - Seat / Window Bag	1	Excellence Manufacturing,

Pulleys

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Bushing (for CMT pulleys)	fits 0.375"+0-.0005 (h6 tolerance) shafts, pulley hub to shaft up to	Green Container - Pulley Bag	2	Custom Machine & Tool
Bushing (for CMT pulleys)	fits 0.500"+0-.0005 (h6 tolerance) shafts, pulley hub-shaft up to 65Nm	Green Container - Pulley Bag	2	Custom Machine & Tool
Pulley, aluminum timing (use CMT 1216 bushing)	20 teeth,5mm HTD pitch,to 15mm belt,use CMT 1216 bushing,flanged	Green Container - Pulley Bag	2	Custom Machine & Tool
Pulley, plastic timing (use CMT 1216 bushing)	30 teeth,5mm HTD pitch,to 15mm belt,use CMT 1216 bushing,flanged	Green Container - Pulley Bag	1	Custom Machine & Tool
Pulley, plastic timing (use CMT 1216 bushing)	60 teeth,5mm HTD pitch,to 15mm belt, use CMT 1216 bushing,flanged	Green Container - Pulley Bag	1	Custom Machine & Tool

Rods & Shafts

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Flexible Motor Shaft	13.5” Long, Fits Seat Motor	Red Container - Seat / Window Bag	2	Grand Rapids Controls
Aluminum Rod	1/2” Ø x 24”	Red Container - Tube	1	Northstar Steel and Aluminum,
Shaft, TGP (turned, ground, polished)	1/4” Ø x 18” TGP	Red Container - Tube	1	Northstar Steel and Aluminum,
Shaft, TGP (turned, ground, polished)	3/8” Ø x 18” TGP	Red Container - Tube	1	Northstar Steel and Aluminum,
Shaft, TGP (turned, ground, polished)	5/16” Ø x 18” TGP	Red Container - Tube	1	Northstar Steel and Aluminum,
Shaft, TGP (turned, ground, polished)	1/2” Ø x 18” TGP	Red Container - Tube	1	Northstar Steel and Aluminum,

Springs

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Compression Spring	0.600” O.D. x 2.25 ” Long x 0.067” Wire Diameter	Red Container - Miscellaneous Bag	2	Associated Spring
Constant Force Spring, Extra Small	0.34” I.D.	Red Container - Miscellaneous Bag	2	Associated Spring
Constant Force Spring, Large	1.02” I.D.	Red Container - Miscellaneous Bag	2	Associated Spring
Constant Force Spring, Medium	0.59” I.D.	Red Container - Miscellaneous Bag	2	Associated Spring
Constant Force Spring, Small	0.51” I.D.	Red Container - Miscellaneous Bag	2	Associated Spring
Extension Spring	0.650” O.D. x 2.000” Long x 0.055” Wire Diameter	Red Container - Miscellaneous Bag	2	Associated Spring

List of Components

Torsion Spring, Left Hand	180 Degrees, 0.404” Dia , 0.048” Wire Diameter	Red Container - Miscellaneous Bag	2	Associated Spring
Torsion Spring, Right Hand	180 Degrees, 0.404” Dia , 0.048” Wire Diameter	Red Container - Miscellaneous Bag	2	Associated Spring
Latex Tubing	1/4” I.D., 3/8” O.D., 5’	Red Container - Miscellaneous Bag	1	Kent Elastomer

Tool

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Crimping Tool for Spade/Ring Connectors	Orange/Black Color	Green Container - Loose	1	Thomas & Betts Corp.

Wheels

Part Name/Description	Dimensions	Location	Qty/Kit	Product Supplier
Caster, W/ 1/2-13x1 1/2 stem	300 Pounds, swivel	Green Container - Loose	2	Fastenal
Wheelchair Wheel	6” Ø, 5/16” I.D. Bearings, 1-1/2” Wide Flange	Red Container - Loose	2	Skyway Recreation
Wheelchair Wheel	8” Ø, 5/16” I.D. Bearings, 1-1/2” Wide Flange	Red Container - Loose	2	Skyway Recreation

APPENDIX C: ADDITIONAL HARDWARE LIST

Bearings

Bearings	Any amount, Any size

Control System

DB15 M-M Cable	6' Length, Up to 2
Electrical Tape	Any amount when used as an insulator
Insulated Electrical Connectors	Any amount/size, off-the-shelf, proper gauge/current rating
Permanent Magnet	Any amount
Wire	Proper gauge, color & insulated
Wire Nuts	Any amount
Joystick, Steering Wheel, or Pedals	15 pin (not USB) PC interface, up to 6
Plastic Enclosure for Custom Circuit	BUD Industries, P/N: PN-1324-C, qty 1
Electronic Components	Up to $100 worth from Future FAI or Digi-Key
PWM/Relay Cable	Hitec/JR-style, 36" Long, Any Amount
Snap-Action Circuit Breaker	30 amp,12 volt, Auto-Resetting, Any Amount - when used with Speed Controller
Snap-Action Circuit Breaker	20 amp,12 volt, Auto-Resetting, Any Amount
Project Box	Black , Almond or Gray
Custom Circuit Board	must fit inside Plastic Enclosure for Custom Circuit Board (see below), qty 1
Diode for Double Solenoid Valves	P/N: 1N4001, 1A Max, up to 4
Heat Shrink Tubing	Any amount, Any Ø
Hood for 15 pin connector	Thermoplastic, Up to 12

Potentiometer	Any amount, 100k Ohms, linear taper
PWM/Relay Y Cable	Hitec/JR-style, Any Amount
Relay Module (Spike)	Any amount - when used per rules
Speed Controller (Victor 883)	Any amount - when used with motor
Switches	Any amount, off-the-shelf, non-powered
Terminal Blocks	Any amount, off-the-shelf, proper gauge/current rating

Fasteners

Fasteners, Washers, Nuts, Adhesives	Any amount/size
Joining Plates for Extrusions	Any amount, Any size
5 Minute Epoxy Gel	
Rubber Band, Large	3-1/2” x 1/4” wide, Up to 5
Hose Clamps	Any Ø, Any amount
Pipe fittings (tees, reducers, elbows, angles)	Any amount - to join sections of pipe
Rubber Band, Small	3-1/2” x 1/8” wide, Up to 5
Pipe Endcaps	Any amount - if used to cap pipes
Pipe flanges	Any amount - if used to attach pipes

Rods & Shafts

Pins - linkage or hinge	Any amount
Shaft Couplings	any amount, any size
Threaded Rod	1/4” Ø x 20”, 20 Pitch Coarse Thread

Copper Water Pipe	Any length, 1/2” Ø
Electrical Conduit Pipe (EMT)	Any length, 1/2” - 3/4" Ø
Flexible Conduit (ENT)	Any length, 1/2” Ø PVC
Metal Shaft	any amount, up to 1" Ø
Schedule 40 PVC Pipe	Any length, 1/2” - 1 1/2" Ø
Wooden Closet Rod	Any length, up to 1 1/4” Ø

Rope, Belts, & Chain

Steel Cable	Any length, up to 1/8"Ø
Chain/Belt	Any length
Nylon Braided Rope	Any length, up to 5/16” Ø
Timing Belt	Up to 20', single or double sided

Sheets & Boards

HDPE Block	1 Piece 1" x 12” x 12"
Wood	Any length, 3/4” x 3-1/2”
1/2” Plywood	1 sheet 4'x8'
1/4” Plywood	1 sheet 4'x8'
Aluminum Plate	Any length, Up to 1/4” thick
Polycarbonate Sheet	Any amount, Up to 3/8” thick
Steel Plate	Any amount, Up to 1/4” thick

Springs

Snugger	Spring With Plastic Guide

Sprockets & Pulleys

Sprockets, Gears and Pulleys	Any size, Any amount, with or without internal bearings

Structural

Aluminum Angle	Any length, Up to 2"x2"x 1/4" thick
Extruded Aluminum	Any length, Up to 2"x3" cross-section
Extruded Fiberglass	Any length, Up to 3"x3" cross-section
Steel Angle	Any length, Up to 2"x2"x 1/4" thick
Fiberglass	Any amount, Up to 1/8” thick
Resin + Hardener	As needed for fiberglass

Wheels

Caster, Swivel	Any amount, up to 3" Ø
Skyway Wheels	any amount, any size

APPENDIX D: SMALL PARTS INC ORDERING INFORMATION

SMALL PARTS INC.
Tel: 800-220-4242
Fax: 800-423-9009
Web Site: www.smallparts.com/first
E-mail: first@smallparts.com

ORDERING GUIDELINES

FIRST - Robotics Competition 2002

For the Robotics Competition 2002 Small Parts, Inc will give each team a 25% discount on all products in the SPI catalog or any special products SPI provides for the competition. There are only two exceptions to this discount, the Wheel Hub Kits and the Drill Motor Couplings.

This year also brings a change in the payment method required for orders placed with Small Parts, Inc. during the competition. All orders must be paid with a Credit Card at the time the order is placed.

Ordering
We encourage teams to place their order via the Internet. Current pricing is available at our competition website www.smallparts.com/first.

Orders may be faxed to 800-423-9009. Please make sure you have completed all parts of the fax form provided and have checked pricing at our website.

To receive your 25% discount you must include your team number with every order.

Please plan accordingly.
Placing orders late in the week may require additional charges to assure delivery by Friday or Saturday. Shipping to a school can create delivery delays. Most priority deliveries arrive by approx 10:00am the next day, however, standard deliveries may be delivered up until 5:00pm. If your school closes at 2 or 3pm there can be delivery delays.

Holiday Schedule
Small Parts, Inc. will be closed Monday February 18, 2002 for President's Day.

Shipping
Shipping charges apply to all orders and will be billed at the time of shipment. Shipping charges listed below refer to Continental US only. Shipments outside this area will be billed at carrier rates. Corporate shipping accounts may be used, please provide this information in the order instructions

Shipping UPS Ground (10lbs or less).....$5.95
Shipping 2-Day under 10lbs (excluding DIM weight).....add $5.00
Shipping weights in excess of 10lbs.....Carrier rate
Overnight Shipping (Priority).....Carrier rate
Saturday Delivery.....Overnight shipping +$10.00

Returns
During the FIRST Robotics Competition we request that all returns be made within three weeks of the Invoice date. Items returned after that time will be subject to a 50% restocking fee. Prior to returning any materials teams must receive a Return Materials Authorization number from Small Parts, Inc. Returns must be in their original packaging.

FAX ORDER FORM

SMALL PARTS INC.

Toll-Free Fax: 800-423-9009

Tel: 1-800-220-4242
Web Site: www.smallparts.com/first
E-mail: first@smallparts.com

FIRST – Robotics Competition 2002

Team No. _____

Team Name _____

Corporate Sponsor _____

Date: _____ Ref. No.: _____

Your Name: _____ 1

E-mail: _____

Phone: _____ Fax: _____

CREDIT CARD INFORMATION

❑ AMEX ❑ VISA ❑ MASTERCARD Expiration Date: _____

Card No.: _____

Cardholder Name: _____ 2

Billing Address: _____

_____

City: _____ State: _____ ZIP: _____

USE THIS ALTERNATE SHIPPING ADDRESS

Attention: _____

Address: _____

_____ 3

City: _____ State: _____ ZIP: _____

Phone: _____ Fax: _____

Other Instructions: _____

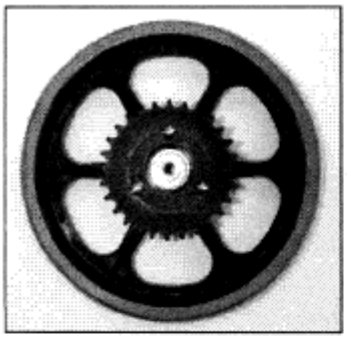
SHIPPING METHOD

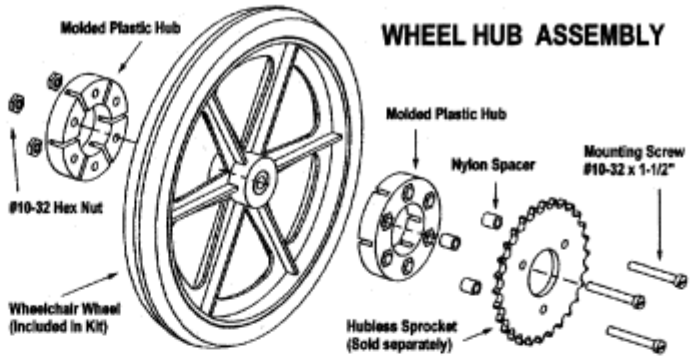
❑ UPS Ground ❑ 2-Day ❑ Priority ❑ Saturday Delivery (Priority Only) **FEDEX** or **UPS** Account No. *(If needed)* _____ 4

ITEM	QTY.	PART No.	DESCRIPTION	UNIT PRICE	TOTAL
1					
2					
3					
4					
5					
6					
7					
8					
9					
10			5		
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

TOTAL

Wheel Hub Kit





This wheel hub kit provides a fast, secure and inexpensive way to mount a sprocket to the wheelchair wheels provided in your kit of parts. When assembly is completed, the sprocket is mounted directly to the wheel and cannot slip.

Wheel hub kit contains parts to mount sprockets to two wheels, but does not include sprockets or pulleys.

Qty	Description	SPI Replacement Part #
4	Plastic Hubs	Only available in kit
6	#10-32 x 1" Fillister Hd Screws	MX-032-16FL
6	#10-32 x 1-1/2" Fillister Hd Screws	MX-032-24FL
12	#10-32 Hex Nuts	HNX-032
12	#10 Lock Washers	LWXA-190
15	#10 x 3/8" Nylon Standoffs	RSN-10/6

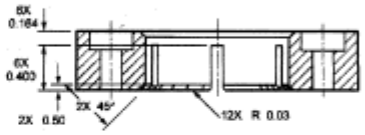
Part No.	Description	Price Each
FIR-DC01*	Wheel Hub Kit (for two wheels)	20.00

**This item is exempt from discounts*

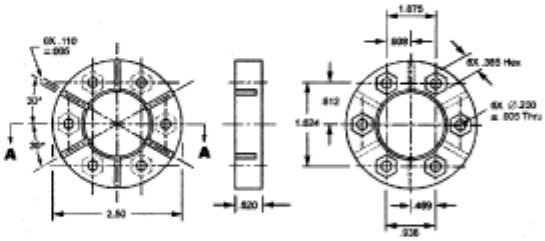
***Note:** Sprockets are sold separately.*
A selection of hubless sprockets is provided below.

Molded Plastic Hub

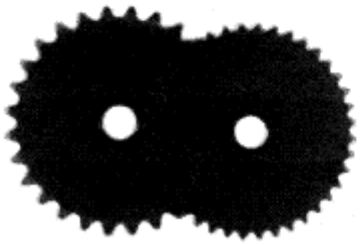
ALL DIMENSIONS IN INCHES

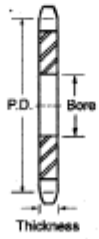


SECTION A-A



Hubless Sprockets





These Hubless sprockets have been selected to use with the wheel hub kit above. They offer a wide range of drive ratios.

Hubless Sprockets — Steel

1/4" Pitch No. 25 — Nominal Thickness: 0.110"

All Dimensions in Inches

Part No.	No. of Teeth	O.D.	Bore	Weight (approx.)	Price
RCHS-2532	32	2.888	3/8	0.14 lbs	15.84
RCHS-2540	40	3.327	1/2	0.20 lbs	16.89
RCHS-2548	48	3.964	1/2	0.32 lbs	17.64
RCHS-2560	60	4.920	1/2	0.54 lbs	18.84

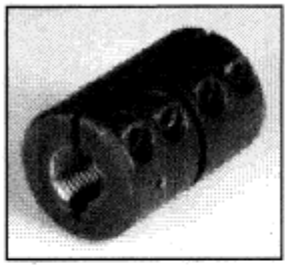
Hubless Sprockets — Steel

3/8" Pitch No. 35 — Nominal Thickness: 0.168"

RCHS-3528	28	3.55	1/2	0.34 lbs	15.06
RCHS-3532	32	4.03	5/8	0.46 lbs	15.78
RCHS-3536	36	4.51	5/8	0.62 lbs	16.53
RCHS-3542	42	5.23	19/32	0.78 lbs	18.33

SMALL PARTS INC. **www.smallparts.com/first**

Drill Motor Coupling Kit



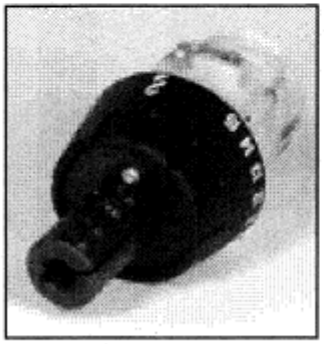
This clamp type coupling made of steel has been modified to provide a means of coupling the drill motor/gear assembly of the Skill Bosch drill to a 3/8" diameter shaft.

One end of the coupling has been threaded to match the 3/8-24 thread on the gear assembly. Included on this end is a 1/16" hole for a spring roll pin. This pin when inserted through the coupling and the gear assembly shaft will lock the coupling and prevent unscrewing when the gear motor is reversed.

The other end of the coupling has a smooth 3/8" ID for coupling to a 3/8" shaft. This coupling end also has a 1/8" keyway to lock the coupling to the shaft.

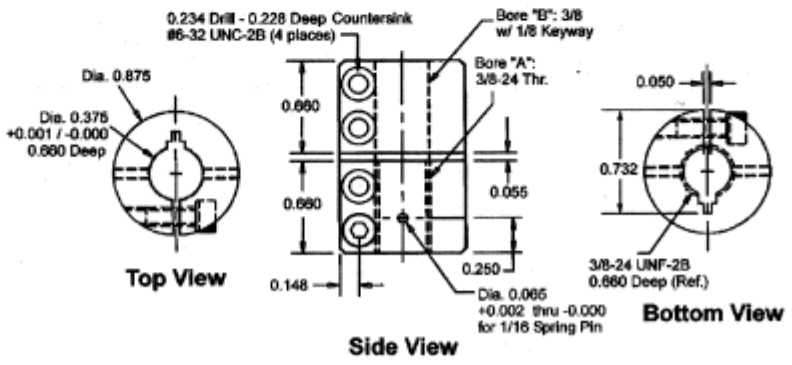
PART NO.	DESCRIPTION	PRICE EACH
FIR-DC02*	One Coupling, Two Pins & One Hex Key	25.00

* *This item is exempt from discounts*



Drill Motor Coupling mounted on gear assembly

ALL DIMENSIONS IN INCHES



APPENDIX E: KEE KLAMP ORDERING INFORMATION

PURCHASE ORDER FORM – FIRST Competitors – SPECIAL PRICING
Kee Industrial Products, Inc
100 Stradtman Street, Buffalo, NY 14206 Fax: (716) 896-5696

Kee Klamp® Pipe Fittings

Team #		Corporate Sponsor:							
Phone:		Fax:		Ship To Address:					
PAYMENT METHOD: Master Card / Visa (CIRCLE ONE)				City:		State		Zip	
CARD NO.		Exp. Date		Attn:					
Card Holder Name:				Phone :					
Signature:				SHIPPING METHOD:					
PLEASE FAX COMPLETED FORM TO (716) 896-5696				RPS/UPS Ground		UPS Next Day		Two Day	

Any questions, please call (800) 851-5181

PLEASE NOTE—NO RETURNS OR REFUNDS

Description

All Kee Klamp fittings required for the complete border and driver stations. Please review carefully as some items are to hold the colored lights, event controllers under the driver station shelf, the break out box at each end of the field, and the Plexiglas.

Bill of Materials
Kee Klamp Fittings

	Field Border and Driver Station Frame	Qty	Unit $	Total $
KK 10-7	Kee Klamp Tee	4	5.04	20.16
KK 14-7	Kee Klamp Straight Coupling	4	5.75	23.50
KK 15-7	Kee Klamp Elbow	4	6.16	24.64
KK-19-7	Kee Klamp Variable Angle 90°-180° Joint	4	13.81	55.24
KK-25-7	Kee Klamp Tee	2	8.91	17.82
KK 26-7	Kee Klamp Two Socket Cross	12	6.86	82.32
KK C50-77	Kee Klamp Single Socket Swivel	6	8.65	51.90
KK C58-7	Kee Klamp Swivel Flange	6	9.45	56.70
KK 61-7	Kee Klamp Flange	20	5.61	112.20
KK 70-7	Kee Klamp Rail Support	20	6.72	134.40
KK 77-7	Kee Klamp Plastic Plug	10	.91	9.10
			Total	587.98
	Light Holders			
KK-45-7	Kee Klamp 90° Offset Crossover	8	6.62	52.96
	Event Controller Hangers			
KK-M50-7	Kee Klamp Combo Fitting for Flat to Tubular	16	4.10	65.60
	Breakout Box Fittings			
KK-A10-7	Kee Klamp Clamp	2	7.28	14.56
	Plexiglas Holders			
KK-70-7	Kee Klamp Rail Support	16	6.72	107.52
				$828.62

Effective: January 1, 2002 Terms: Only Master Card/Visa Accepted F.O.B. Buffalo, NY Warehouse

*** SPECIAL PRICING FOR FIRST ROBOTICS COMPETITION ONLY**
ALL ORDERS MUST BE TAGGED OR IDENTIFIED AS: "FIRST COMPETITION"

APPENDIX F -SUPPLIER CONTACT INFORMATION

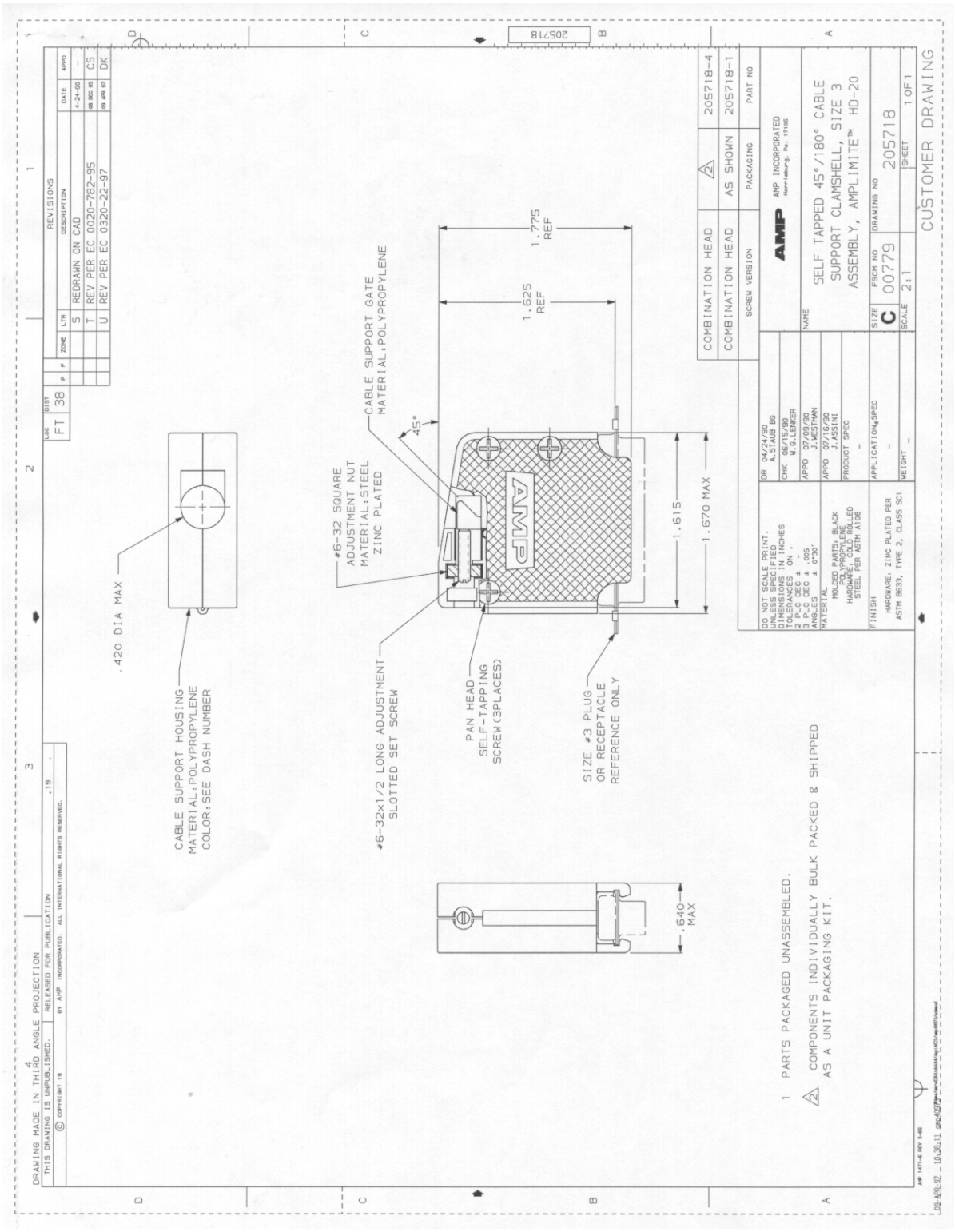
Associated Spring Raymond Customer Service P.O. Box 586 1705 Indianwood Circle Maumee, OH 43537-0586 Phone: 1-800-458-0867	**AutoDesk, Inc**. 111 McInnis Parkway San Rafael, CA 94903 Ph: 415-507-5000
EBM Industries, Inc. 100 Hyde Road Farmington, CT 06034 Phone: 860-674-1515 Fax: 860-674-8536 Email: sales@ebm.com Web: www.ebm.com	**Exide Corporation** 13000 Deerfield Parkway Bldg 200 Alpharetta, GA 30004
Fisher Price Motor and Gearbox purchase from any authorized Power Wheels Service Center. P/N - Mabuchi RS550PF-6534 Gearbox # 7	**Future Electronics, Inc.** Pete Rosati 41 Main Street Bolton, MA. 01740 Ph: 800-444-1521(listen to menu choices carefully) Web: www.futureelectrnics.com
All Pneumatics questions or problems HPE Automation PH: 954-429-9560 Fax: 954-429-9515 (primary) Fax: 954-429-0858 (back up) E-mail: fhord@hpeco.com	**Hitec RCD Servos** 12115 Paine St. Poway CA 92064 Phone: 858-748-6948 Web: www.hitecrcd.com
Hellermann Tyton 7930 N. Faulkner Rd. P.O. Box 245017 Milwaukee, WI 53224 Phone: 800-537-1512 Fax: 800-848-9866 Web: www.hellermanntyton.com	**Innovation First, Inc.** 8910 F. Wesley St. Greenville, TX 75401 Phone: 903-454-1978 Web: www.innovationfirst.com/firstrobotics/ *NO PHONE ORDERS WILL BE TAKEN* **Purchase of CH Joysticks and Snap Action Circuit breakers available**
Kee Industrial Products, Inc. 100 Stradtman Street Buffalo, NY 14206 Ph: 800-851-5181 Fax: 716-896-5696 Web: www.keeklamp.com	**McMaster-Carr Supply Co.** 473 Ridge Rd. P.O. Box 317 Dayton, NJ 08810 Phone: 732-329-3200 Fax: 732-329-3772 Web: www.mcmaster.com
Parallax, Inc. 3805 Atherton Road Suite 102 Rocklin, CA 957657 Phone: 888-512-1024 Fax: 916-624-8003 Web: www.parallaxinc.com	**S-B Power Tool Company** 121 Corporate Blvd South Plainfield, NJ 07080 Phone: 908-769-8208

SMALL PARTS, INC. 13980 NW 58th Court Miami Lakes, FL 33014 Phone: 305-820-9371 Fax: 800-423-9009 Web: www.smallparts.com	**Skyway Recreation Products** 4451 Caterpillar Road Redding, CA 96003 Phone: 800-332-3357 Fax: 530-243-5104 Email: sales@skywaywheels.com Web: www.skywaytuffwheels.com
S.S. Mills, Inc. P.O. Box 1568 Customer Service Dalton, GA 30722 Phone: 800-241-4013 Fax: 706-277-3677	**Thomas & Betts** Electrical Components Division 8155 T & B Blvd. Memphis, TN 38125 Phone: 901-682-8221 or 800-888-0211 Fax: 800-888-0790
Torrington Bearings For additional bearings call Motion Industries, Inc. P.O. Box 1097 Earth City, MO 63043-0097 Phone: 314-770-2600 Fax: 314-770-2272	**Velcro USA, Inc.** 406 Brown Avenue #1 P.O. Box 5218 Manchester, NH 03103 Phone: 603-669-4892 Fax: 603-669-899

APPENDIX G - MANUFACTURER PART SPECIFICATIONS

The following pages are manufacturers' specifications for parts provided in the Official Kit of Parts.
Additional booklets are in the Kit.
Be sure to read these spec sheets in order to properly allocate and use components.
Specification sheets in this section are in the order listed below for the following suppliers:

Supplier	Kit Part
AMP Incorporated	Connector Housing
Associated Spring Raymond	Springs
Banner Engineering	Sensors
BEI Systron Donner Inertial Division	Yaw Rate Sensor
Delphi Interior and Lightning Systems	Van Door Motor
Fisher-Price	Motor
Globe Motor	Motor and Drive Assembly
EBM Industries, Inc.	Muffin Fans
Innovation FIRST	Speed Controller
Keyang	Seat Motor
Mabuchi	Motor
Pioneer Packard	Connectors
S-B Power Tool Company	Drill Motors
Skyway Recreation Products	Wheel Chair Wheels
Snap-Action, Inc.	Circuit Breakers
Square D	Main Circuit Breaker
The Torrington Company	Ball Bearings
Tyton Hellermann Corporation	Wire Wrap, Grommet, and Grip Ties
VELCRO USA, Inc.	Velcoin®, One Wrap®, and Hoop and Loop
Yuasa Exide, Inc.	Battery



Subminiature D Connectors (AMPLIMITE)
Cable Clamps

205718-1 -- *1 of 1 products* ✔ Active

Y2K - OK

ASSEMBLY SUBCONTRACTORS | STEP SEARCH | DRAWINGS SPECIFICATIONS | SALES INFO | GENERAL INFO

Please use the customer drawing for all design activity.

- **Customer Drawing: 205718**, Rev. U
  Document Title: SELF TAPPED 45@27/180@27 CABLE SUPPORT CLAMSHELL, SIZE 3 ASSEMBLY, AMPLIMITE@PZTM HD-20

  167350.pdf (49K)

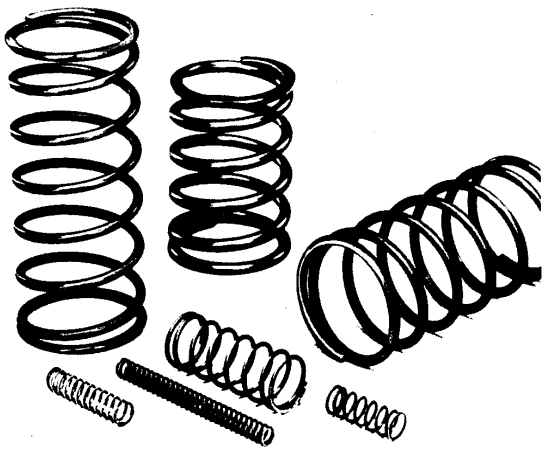
Line art and other pictures below are general representations of product dimensions, please use the customer drawing for all design activity.

Product Photo

Searchable Features:	
Product Type:	Cable Clamp
Cable Clamp Type:	Clam Shell
Cable Exit Angle:	Straight(180°)/45°
Cable Outer Diameter (mm [in]):	10.67 [.420] Max.
Shell Size:	3
Shielded:	No
Screws and Retainer Clips:	Without
Packaging Method:	Individual Kit

Other Properties:	
Product Series:	HD-20 (Solder Cup)
Clam Shell Length:	Standard
Body Material:	Thermoplastic
Body Finish:	Textured
Cable Support Gate Material:	Thermoplastic
Cable Clamp Material:	Thermoplastic
Square Nut Material:	Steel
Square Nut Plating:	Zinc
Screw Material:	Steel
Screw Plating:	Zinc
Screw Size:	6-32

Compression Springs



Stock sizes in music wire and stainless steel

Associated Spring offers a broad variety of helical compression springs in the SPEC selection. They are reliable, inexpensive and efficient — the right combination for general-purpose use throughout industry.

Material

Music wire
ASTM-A228 or AMS 5112

Stainless steel
Commercial Type 302, ASTM-A313 or
AMS 5688 spring temper. (chemical & physical only)

No charge for certificate of compliance when requested; certificate of chemical analysis available, see price book.

Music wire will be furnished unless stainless steel is specified. When inquiring or ordering, use letter "M" or letter "S" as suffix on catalog numbers to designate music wire or stainless steel wire, respectively.

Music wire springs are not recommended for applications where the temperature exceeds 250 deg F (121 deg C). Stainless steel springs are not recommended for applications where the temperature exceeds 500 deg F (260 deg C).

Direction of Helix

Right hand.

Ends

Squared and ground. Ends to be square within 3° with axis O.D. sizes 0.057-0.088 in (1.45-2.24 mm) squared ends not ground.

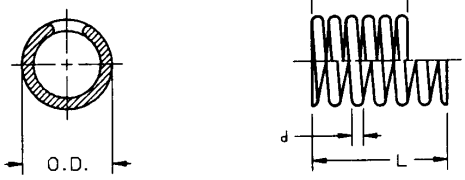
Free length L is for reference use only. Load P is attained at length L_1. For stainless steel multiply P by 0.833.

Load values shown are for music wire.

For normal service, springs should not be compressed below L_1.

To determine load P at any length other than L_1, multiply the proposed deflection by the rate R. *[P + (L-Lx) x R]

When stainless steel is used the value for rate R must be corrected by multiplying R by 0.833.



Finishes

Standard finish is that of the normal wire. Shot-peened and plated finishes furnished on request. Allow sufficient additional time for special finishes.

Tolerances

O.D. (English)	O.D. (Metric)
0.057 to 0.119 in ± 0.003 in	1.45 to 3.02 mm ± 0.08 mm
0.120 to 0.240 in ± 0.005 in	3.05 to 6.10 mm ± 0.13 mm
0.241 to 0.500 in ± 0.008 in	6.12 to 12.70 mm ± 0.20 mm
0.501 to 1.000 in ± 0.015 in	12.73 to 25.40 mm ± 0.38 mm
1.001 to 1.225 in ± 0.020 in	25.43 to 31.12 mm ± 0.51 mm
1.226 to 1.460 in ± 0.030 in	31.14 to 37.08 mm ± 0.76 mm
1.461 to 2.000 in ± 0.040 in	37.11 to 50.80 mm ± 1.02 mm

Load, P ± 10%
Spring Rate, R ± 10%
*Lx = Desired Load Length

STOCK COMPRESSION SPRINGS
Music Wire and Stainless Steel

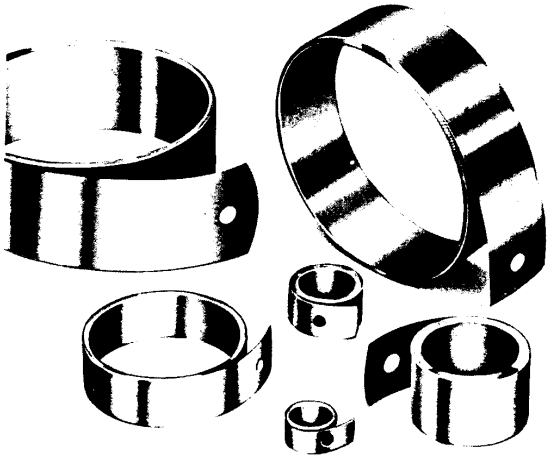
SPEC Associated Spring Raymond BARNES GROUP INC

CATALOG NUMBER*	Outside Diameter		Wire Diameter		Free Length L, Approx.		Load, P at L_1		Length, L_1		Solid Height, Approx.		Spring Rate, R	
	in	*mm*	in	*mm*	in	*mm*	lb†	*N*†	in	*mm*	in	*mm*	lb/in†	*N/mm*†
C0600-063-2000					2.00	*50.80*			1.059	*26.90*	0.700	*17.78*	18.0	*3.15*
C0600-063-2250					2.25	*57.15*			1.184	*30.07*	0.768	*19.51*	15.9	*2.78*
C0600-063-2500			0.063	*1.60*	2.50	*63.50*	18.00	*80.07*	1.308	*33.22*	0.836	*21.23*	14.2	*2.49*
C0600-063-2750					2.75	*69.85*			1.433	*36.40*	0.863	*21.92*	13.7	*2.40*
C0600-063-3000					3.00	*76.20*			1.558	*39.57*	0.927	*23.55*	12.5	*2.19*
C0600-063-3500					3.50	*88.90*			1.807	*45.90*	1.055	*26.80*	10.6	*1.856*
C0600-067-0625					0.62	*15.75*			0.360	*9.14*	0.300	*7.62*	80.0	*14.01*
C0600-067-0750					0.75	*19.05*			0.430	*10.92*	0.336	*8.53*	66.0	*11.56*
C0600-067-0880					0.88	*22.35*			0.455	*11.56*	0.401	*10.19*	50.0	*8.76*
C0600-067-1000					1.00	*25.40*			0.530	*13.46*	0.430	*10.92*	45.0	*7.88*
C0600-067-1250					1.25	*31.75*			0.665	*16.89*	0.505	*12.83*	36.0	*6.30*
C0600-067-1500			0.067	*1.70*	1.50	*38.10*	21.00	*93.41*	0.780	*19.81*	0.594	*15.09*	29.0	*5.08*
C0600-067-1750					1.75	*44.45*			0.830	*21.08*	0.715	*18.16*	23.0	*4.03*
C0600-067-2000					2.00	*50.80*			1.106	*28.09*	0.771	*19.58*	22.5	*3.94*
C0600-067-2250					2.25	*57.15*			1.236	*31.39*	0.847	*21.51*	19.8	*3.47*
C0600-067-2500					2.50	*63.50*			1.366	*34.70*	0.923	*23.44*	17.7	*3.10*
C0600-067-2750					2.75	*69.85*			1.496	*38.00*	0.966	*24.54*	16.7	*2.92*
C0600-067-3000					3.00	*76.20*			1.626	*41.30*	1.040	*26.42*	15.3	*2.68*
C0600-072-0620					0.62	*15.75*			0.405	*10.29*	0.381	*9.68*	114.5	*20.05*
C0600-072-0750					0.75	*19.05*			0.445	*11.30*	0.396	*10.06*	78.0	*13.66*
C0600-072-0880					0.88	*22.35*			0.520	*13.21*	0.433	*11.00*	68.0	*11.91*
C0600-072-1000					1.00	*25.40*			0.565	*14.35*	0.502	*12.75*	55.0	*9.63*
C0600-072-1250					1.25	*31.75*			0.710	*18.03*	0.581	*14.76*	45.0	*7.88*
C0600-072-1500			0.072	*1.83*	1.50	*38.10*	24.00	*106.76*	0.830	*21.08*	0.691	*17.55*	36.0	*6.30*
C0600-072-1750					1.75	*44.45*			0.950	*24.13*	0.801	*20.35*	30.0	*5.25*
C0600-072-2000					2.00	*50.80*			1.140	*28.96*	0.848	*21.54*	28.0	*4.90*
C0600-072-2250					2.25	*57.15*			1.301	*33.05*	0.946	*24.03*	25.9	*4.54*
C0600-072-2500					2.50	*63.50*			1.438	*36.53*	1.033	*26.24*	23.1	*4.05*
C0600-072-2750					2.75	*69.85*			1.601	*40.67*	1.119	*28.42*	20.9	*3.66*
C0600-072-3000	0.600	*15.24*			3.00	*76.20*			1.742	*44.25*	1.206	*30.63*	19.1	*3.34*
C0600-081-0620					0.62	*15.75*			0.466	*11.84*	0.412	*10.46*	212.6	*37.23*
C0600-081-0750					0.75	*19.05*			0.553	*14.05*	0.459	*11.66*	165.6	*29.00*
C0600-081-0880					0.88	*22.35*			0.639	*16.23*	0.507	*12.88*	135.6	*23.74*
C0600-081-1000					1.00	*25.40*			0.719	*18.26*	0.552	*14.02*	116.2	*20.35*
C0600-081-1250					1.25	*31.75*			0.885	*22.48*	0.644	*16.36*	89.5	*15.67*
C0600-081-1500					1.50	*38.10*			1.051	*26.70*	0.736	*18.69*	72.8	*12.75*
C0600-081-1750					1.75	*44.45*			1.217	*30.91*	0.828	*21.03*	61.3	*10.73*
C0600-081-2000					2.00	*50.80*			1.383	*35.13*	0.920	*23.37*	53.0	*9.28*
C0600-081-2250			0.081	*2.06*	2.25	*57.15*	32.69	*145.41*	1.549	*39.34*	1.012	*25.70*	46.6	*8.16*
C0600-081-2500					2.50	*63.50*			1.715	*43.56*	1.104	*28.04*	41.7	*7.30*
C0600-081-2750					2.75	*69.85*			1.881	*47.78*	1.196	*30.38*	37.6	*6.58*
C0600-081-3000					3.00	*76.20*			2.047	*51.99*	1.288	*32.72*	34.3	*6.01*
C0600-081-3250					3.25	*82.55*			2.213	*56.21*	1.380	*35.05*	31.5	*5.52*
C0600-081-3500					3.50	*88.90*			2.379	*60.43*	1.472	*37.39*	29.2	*5.11*
C0600-081-3750					3.75	*95.25*			2.545	*64.64*	1.564	*39.73*	27.1	*4.75*
C0600-081-4000					4.00	*101.60*			2.711	*68.86*	1.656	*42.06*	25.4	*4.45*
C0600-085-0620					0.62	*15.75*			0.477	*12.12*	0.433	*11.00*	262.5	*45.96*
C0600-085-0750					0.75	*19.05*			0.565	*14.35*	0.484	*12.29*	203.6	*35.65*
C0600-085-0880					0.88	*22.35*			0.654	*16.61*	0.536	*13.61*	166.4	*29.14*
C0600-085-1000					1.00	*25.40*			0.736	*18.69*	0.583	*14.81*	142.3	*24.92*
C0600-085-1250					1.25	*31.75*			0.906	*23.01*	0.682	*17.32*	109.4	*19.16*
C0600-085-1500					1.50	*38.10*			1.076	*27.33*	0.781	*19.84*	88.8	*15.55*
C0600-085-1750					1.75	*44.45*			1.247	*31.67*	0.880	*22.35*	74.8	*13.10*
C0600-085-2000					2.00	*50.80*			1.417	*35.99*	0.978	*24.84*	64.5	*11.29*
C0600-085-2250			0.085	*2.16*	2.25	*57.15*	37.62	*167.33*	1.588	*40.34*	1.077	*27.36*	56.8	*9.95*
C0600-085-2500					2.50	*63.50*			1.758	*44.65*	1.176	*29.87*	50.7	*8.88*
C0600-085-2750					2.75	*69.85*			1.928	*48.97*	1.275	*32.39*	45.8	*8.02*
C0600-085-3000					3.00	*76.20*			2.099	*53.31*	1.374	*34.90*	41.7	*7.30*
C0600-085-3250					3.25	*82.55*			2.269	*57.63*	1.473	*37.41*	38.3	*6.71*
C0600-085-3500					3.50	*88.90*			2.439	*61.95*	1.572	*39.93*	35.5	*6.22*
C0600-085-3750					3.75	*95.25*			2.610	*66.29*	1.670	*42.42*	33.0	*5.78*
C0600-085-4000					4.00	*101.60*			2.780	*70.61*	1.769	*44.93*	30.8	*5.39*
C0600-092-0750					0.75	*19.05*			0.591	*15.01*	0.524	*13.31*	291.5	*51.04*
C0600-092-0880			0.092	*2.34*	0.88	*22.35*	46.46	*206.65*	0.684	*17.37*	0.581	*14.76*	237.0	*41.50*
C0600-092-1000					1.00	*25.40*			0.770	*19.56*	0.633	*16.08*	202.2	*35.41*

†For stainless steel, multiply values by 0.833.

****When inquiring or ordering, use letter "M" or letter "S" as suffix on catalog numbers to designate music wire or stainless-steel wire, respectively.***

Constant-force Springs



Stock sizes in stainless steel

Constant-force springs are a special variety of extension spring. They consist of a spiral of strip material with built-in curvature so that each turn of the strip wraps tightly on its inner neighbor. When the strip is extended (deflected) the inherent stress resists the loading force, just as in a common extension spring, but at a nearly constant (zero) rate. The accompanying load/deflection curves illustrate this.

The constant-force spring is well suited to long extensions with no load build-up. In use, the spring is usually mounted with the ID tightly wrapped on a drum and the free end attached to the loading force, such as in a counterbalance application. This relationship can be reversed, however, with the free end mounted stationary and the spring itself providing the working force, as with carbon brushes in electrical apparatus.

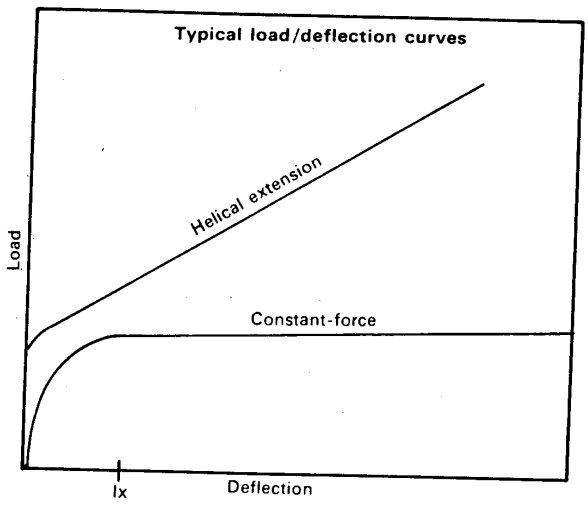
Considerable flexibility is possible with constant-force springs because the load capacity can be multiplied by using two or more strips in tandem, back-to-back, or laminated, as illustrated.

Material

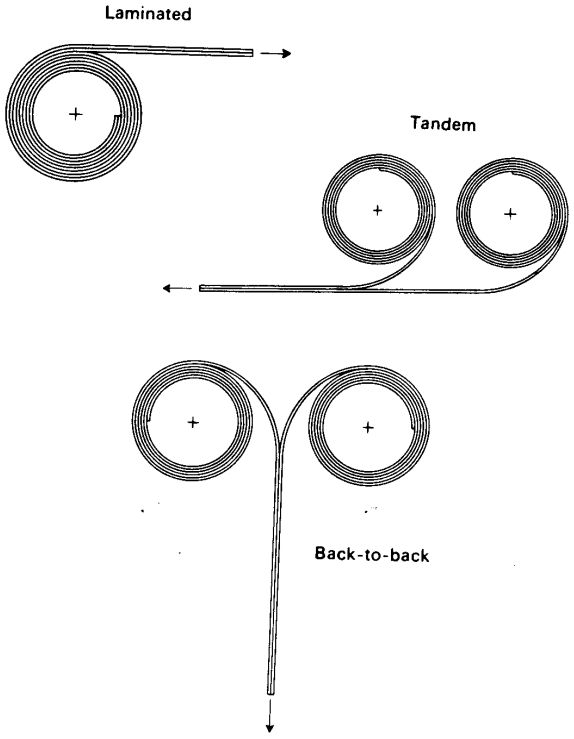
Type 301 stainless steel.

Note

Be sure to allow at least 1½ coils of material on the drum at full extension. The spring ID will wrap tightly on the drum so that in most applications no fastening method on the drum is required.



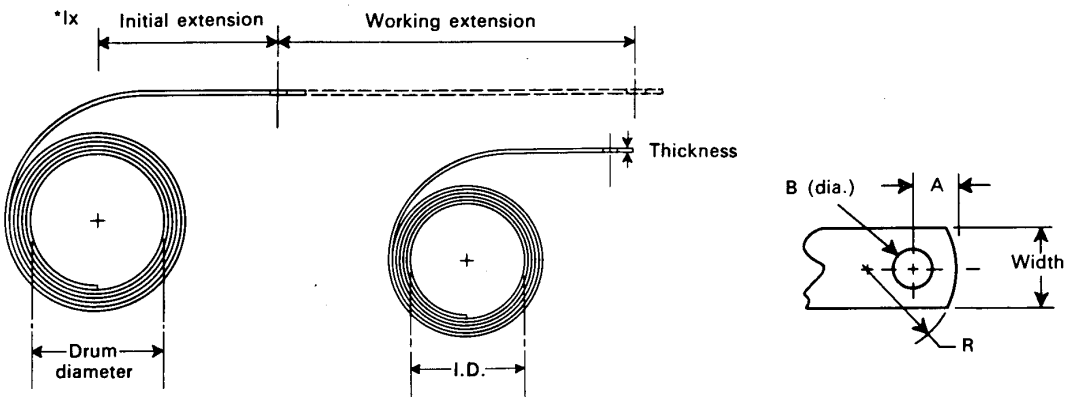
How to multiply constant-force spring load



STOCK CONSTANT-FORCE SPRINGS
Stainless Steel

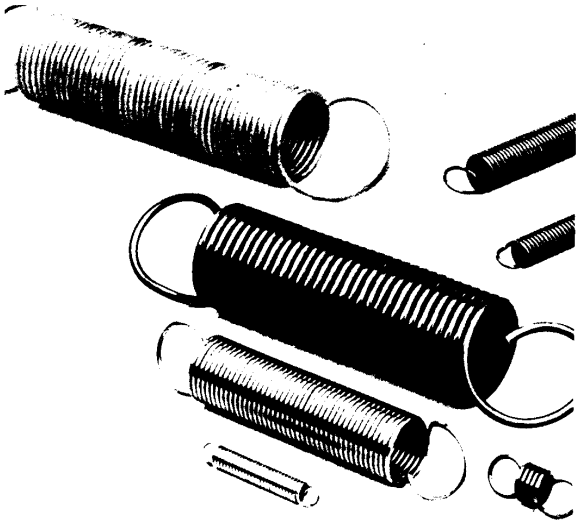
SPEC — Associated Spring Raymond / BARNES GROUP INC

CATALOG NUMBER	Thickness		Width		Length		Initial Extension		Working Ext.		I.D. (Reference)		Drum Diameter		Load ±10%		End Configuration A			B			R	
	in	*mm*	in	*mm*	in	*mm*	in	*mm*	in	*mm*	in	*mm*	in	*mm*	lb	*N*	in	*mm*	in	*mm*	in	*mm*
Fatigue Life 4,000 Cycles																						
CF015-0050	0.004	*0.10*	0.25	*6.35*	15	*381*	0.61	*15.49*	12	*305*	0.34	*8.64*	0.40	*10.16*	0.50	*2.22*	3/8	*9.5*	0.131	*3.3*	1/2	*12.7*
CF018-0075	0.005	*0.13*	0.31	*7.87*	18	*457*	0.75	*19.05*	15	*381*	0.42	*10.67*	0.50	*12.70*	0.75	*3.34*	3/8	*9.5*	0.131	*3.3*	1/2	*12.7*
CF022-0112	0.006	*0.15*	0.37	*9.40*	22	*559*	0.92	*23.37*	18	*457*	0.51	*12.95*	0.62	*15.75*	1.12	*4.98*	3/8	*9.5*	0.131	*3.3*	1/2	*12.7*
CF026-0162	0.007	*0.18*	0.50	*12.70*	26	*660*	1.06	*26.92*	21	*533*	0.59	*14.99*	0.75	*19.05*	1.62	*7.21*	3/8	*9.5*	0.131	*3.3*	1/2	*12.7*
CF030-0237	0.008	*0.20*	0.59	*14.99*	30	*762*	1.22	*30.99*	24	*610*	0.68	*17.27*	0.87	*22.10*	2.37	*10.54*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
CF034-0350	0.010	*0.25*	0.68	*17.27*	34	*864*	1.53	*38.86*	27	*686*	0.85	*21.59*	1.00	*25.40*	3.50	*15.57*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
CF038-0500	0.012	*0.30*	0.81	*20.57*	38	*965*	1.84	*46.74*	30	*762*	1.02	*25.91*	1.25	*31.75*	5.00	*22.24*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
CF043-0700	0.014	*0.36*	1.00	*25.40*	43	*1092*	2.14	*54.36*	33	*838*	1.19	*30.23*	1.50	*38.10*	7.00	*31.14*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
Fatigue Life 40,000 Cycles																						
CF021-0025	0.006	*0.15*	0.37	*9.40*	21	*533*	2.03	*51.56*	12	*305*	1.13	*28.70*	1.36	*34.54*	0.25	*1.11*	3/8	*9.5*	0.131	*3.3*	1/2	*12.7*
CF025-0037	0.007	*0.18*	0.50	*12.70*	25	*635*	2.36	*59.94*	15	*381*	1.31	*33.27*	1.58	*40.13*	0.37	*1.65*	3/8	*9.5*	0.131	*3.3*	1/2	*12.7*
CF030-0050	0.008	*0.20*	0.59	*14.99*	30	*762*	2.72	*69.09*	18	*457*	1.51	*38.35*	1.81	*45.97*	0.50	*2.22*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
CF036-0075	0.010	*0.25*	0.68	*17.27*	36	*914*	3.38	*85.85*	21	*533*	1.88	*47.75*	2.26	*57.40*	0.75	*3.34*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
CF042-0112	0.012	*0.30*	0.81	*20.57*	42	*1067*	4.07	*103.40*	24	*610*	2.26	*57.40*	2.71	*68.83*	1.12	*4.98*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*
CF048-0162	0.014	*0.36*	1.00	*25.40*	48	*1219*	4.74	*120.40*	27	*686*	2.63	*66.80*	3.16	*80.26*	1.62	*7.21*	3/8	*9.5*	0.187	*4.7*	7/8	*22.2*



*Initial extension is the minimum amount of extension needed to operate the spring and achieve a linear rate. (see chart page 77)

Extension Springs



Stock sizes in music wire and stainless steel

All SPEC stock helical extension springs have uniform body diameter and are produced with full twist loops the same diameter as the body. They are wound with initial tension; some force is required before the coils are initially separated. As with other Associated Spring stock components, they are capable of wide application for experimental, development, prototype and maintenance work.

Material

Music wire
ASTM-A228 or AMS 5112

Stainless steel
Commercial Type 302, ASTM-A313 or
AMS 5688 spring temper. (chemical & physical only)

No charge for certificate of compliance when requested; certificate of chemical analysis available, see price book.

Music wire will be furnished unless stainless steel is specified. When inquiring or ordering, use letter "M" or letter "S" as suffix on catalog numbers to designate music wire or stainless steel wire, respectively.

Music wire springs are not recommended for applications where the temperature exceeds 250 deg F (121 deg C). Stainless steel springs are not recommended for applications where the temperature exceeds 500 deg F (260 deg C).

Direction of Helix

Right or left according to machine set-up at time of run.

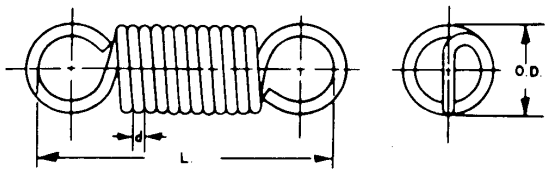
Ends

Full twist loop. Special ends on request.

Initial tension T is for reference only; free length dimension L is approximate.

Maximum load P is attained at extended length L_1.

To determine load P, rate R or initial tension T, for stainless steel, multiply the values given by 0.833. To determine load P*at any extension other than L_1, multiply the distance in inches that the spring will be extended from the free length L, by the spring rate R and add the initial tension T.



Finishes

Standard finish is that of the normal wire. Shot-peened and plated finishes furnished on request. Allow additional time for special finishes.

Tolerances

O.D. (English)	O.D. (Metric)
0.063 to 0.119 in ± 0.003 in	1.60 to 3.02 mm ± 0.08 mm
0.120 to 0.240 in ± 0.005 in	3.05 to 6.10 mm ± 0.13 mm
0.241 to 0.500 in ± 0.008 in	6.12 to 12.70 mm ± 0.20 mm
0.501 to 1.000 in ± 0.015 in	12.73 to 25.40 mm ± 0.38 mm
1.001 to 1.225 in ± 0.020 in	25.43 to 31.12 mm ± 0.51 mm
1.226 to 1.460 in ± 0.030 in	31.14 to 37.08 mm ± 0.76 mm
1.461 to 2.000 in ± 0.040 in	37.11 to 50.80 mm ± 1.02 mm

Load, P ± 10%
Spring Rate, R ± 10%
Position of Ends ± 22 deg

*P =(Lx-L) x R + T
Lx = Desired Load Length

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STOCK EXTENSION SPRINGS
Music Wire and Stainless Steel

Associated Spring Raymond / BARNES GROUP INC

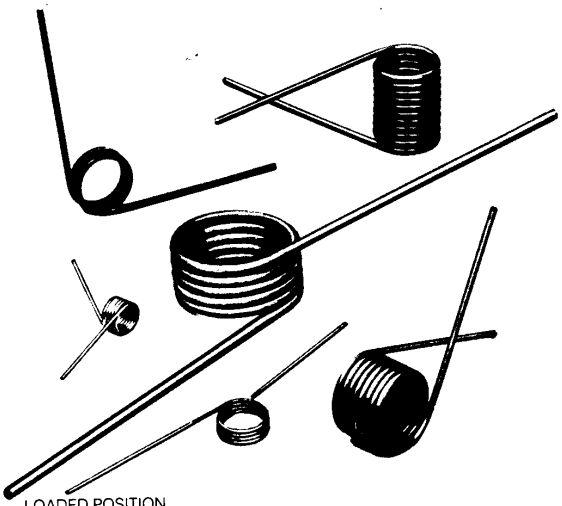
CATALOG NUMBER*	Outside Diameter		Wire Diameter		Free Length L, Approx.		Load, P at L_1		Initial Tension, T**		Ext. L_1		Spring Rate, R	
	in	*mm*	in	*mm*	in	*mm*	lb†	*N*†	lb†	*N*†	in	*mm*	lb/in†	*N/mm*†
E0500-055-1250					1.25	*31.75*					1.75	*44.45*	24.4	*4.27*
E0500-055-1370					1.37	*34.80*					2.14	*54.36*	15.6	*2.73*
E0500-055-1500					1.50	*38.10*					2.41	*61.21*	13.0	*2.28*
E0500-055-1750					1.75	*44.45*					3.01	*76.45*	9.0	*1.576*
E0500-055-2000					2.00	*50.80*					3.60	*91.44*	7.4	*1.296*
E0500-055-2250					2.25	*57.15*					4.29	*108.97*	6.1	*1.068*
E0500-055-2500			0.055	*1.40*	2.50	*63.50*	13.10	*58.27*	1.20	*5.34*	4.82	*122.43*	5.1	*0.893*
E0500-055-2750					2.75	*69.85*					5.41	*137.41*	4.4	*0.771*
E0500-055-3000					3.00	*76.20*					6.01	*152.65*	3.9	*0.683*
E0500-055-3500					3.50	*88.90*					7.19	*182.63*	3.2	*0.560*
E0500-055-4000					4.00	*101.60*					8.38	*212.85*	2.7	*0.473*
E0500-055-4500					4.50	*114.30*					9.56	*242.82*	2.3	*0.403*
E0500-055-5000					5.00	*127.00*					11.10	*281.94*	2.0	*0.350*
E0500-063-1250					1.25	*31.75*					1.63	*41.40*	46.9	*8.21*
E0500-063-1370					1.37	*34.80*					1.92	*48.77*	31.2	*5.46*
E0500-063-1500					1.50	*38.10*					2.17	*55.12*	25.5	*4.47*
E0500-063-1750					1.75	*44.45*					2.66	*67.56*	18.7	*3.27*
E0500-063-2000					2.00	*50.80*					3.16	*80.26*	14.8	*2.59*
E0500-063-2250					2.25	*57.15*					3.65	*92.71*	12.2	*2.14*
E0500-063-2500			0.063	*1.60*	2.50	*63.50*	18.80	*83.63*	1.70	*7.56*	4.12	*104.65*	10.4	*1.821*
E0500-063-2750					2.75	*69.85*					4.60	*116.84*	9.2	*1.611*
E0500-063-3000					3.00	*76.20*					5.10	*129.54*	8.1	*1.419*
E0500-063-3500					3.50	*88.90*					6.08	*154.43*	6.6	*1.156*
E0500-063-4000					4.00	*101.60*					7.07	*179.58*	5.5	*0.963*
E0500-063-4500					4.50	*114.30*					8.06	*204.72*	4.8	*0.841*
E0500-063-5000	0.500	*12.70*			5.00	*127.00*					9.04	*229.62*	4.2	*0.736*
E0500-069-1250					1.25	*31.75*					1.55	*39.37*	74.0	*12.96*
E0500-069-1370					1.37	*34.80*					1.78	*45.21*	54.3	*9.51*
E0500-069-1500					1.50	*38.10*					1.99	*50.55*	45.2	*7.92*
E0500-069-1750					1.75	*44.45*					2.45	*62.23*	31.3	*5.48*
E0500-069-2000					2.00	*50.80*					2.89	*73.41*	24.7	*4.33*
E0500-069-2250					2.25	*57.15*					3.33	*84.58*	20.3	*3.56*
E0500-069-2500			0.069	*1.75*	2.50	*63.50*	24.21	*107.69*	2.18	*9.70*	3.77	*95.76*	17.3	*3.03*
E0500-069-2750					2.75	*69.85*					4.24	*107.70*	14.8	*2.59*
E0500-069-3000					3.00	*76.20*					4.68	*118.87*	13.1	*2.29*
E0500-069-3500					3.50	*88.90*					5.56	*141.22*	10.7	*1.874*
E0500-069-4000					4.00	*101.60*					6.46	*164.08*	8.9	*1.559*
E0500-069-4500					4.50	*114.30*					7.34	*186.44*	7.8	*1.366*
E0500-069-5000					5.00	*127.00*					8.25	*209.55*	6.8	*1.191*
E0500-075-1250					1.25	*31.75*					1.51	*38.35*	107.7	*18.86*
E0500-075-1370					1.37	*34.80*					1.70	*43.18*	84.6	*14.81*
E0500-075-1500					1.50	*38.10*					1.90	*48.26*	69.7	*12.20*
E0500-075-1750					1.75	*44.45*					2.31	*58.67*	49.4	*8.65*
E0500-075-2000					2.00	*50.80*					2.73	*69.34*	38.2	*6.69*
E0500-075-2250					2.25	*57.15*					3.12	*79.25*	32.0	*5.60*
E0500-075-2500			0.075	*1.91*	2.50	*63.50*	30.51	*135.71*	2.75	*12.23*	3.53	*89.66*	26.9	*4.71*
E0500-075-2750					2.75	*69.85*					3.95	*100.33*	23.2	*4.06*
E0500-075-3000					3.00	*76.20*					4.34	*110.24*	20.8	*3.64*
E0500-075-3500					3.50	*88.90*					5.16	*131.06*	16.7	*2.92*
E0500-075-4000					4.00	*101.60*					5.97	*151.64*	14.1	*2.47*
E0500-075-4500					4.50	*114.30*					6.77	*171.96*	12.2	*2.14*
E0500-075-5000					5.00	*127.00*					7.60	*193.04*	10.7	*1.874*
E0650-055-1500					1.50	*38.10*					2.21	*56.13*	13.4	*2.35*
E0650-055-1750					1.75	*44.45*					3.16	*80.26*	6.8	*1.191*
E0650-055-2000					2.00	*50.80*					4.20	*106.68*	4.1	*0.718*
E0650-055-2250					2.25	*57.15*					5.13	*130.30*	3.2	*0.560*
E0650-055-2500	0.650	*16.51*	0.055	*1.40*	2.50	*63.50*	10.10	*44.93*	0.90	*4.00*	5.98	*151.89*	2.6	*0.455*
E0650-055-2750					2.75	*69.85*					6.94	*176.28*	2.2	*0.385*
E0650-055-3000					3.00	*76.20*					7.83	*198.88*	1.9	*0.333*
E0650-055-3500					3.50	*88.90*					9.61	*244.09*	1.5	*0.263*
E0650-055-4000					4.00	*101.60*					11.38	*289.05*	1.2	*0.210*
E0650-063-1500					1.50	*38.10*					2.06	*52.32*	24.8	*4.34*
E0650-063-1750			0.063	*1.60*	1.75	*44.45*	14.80	*65.83*	1.40	*6.23*	2.81	*71.37*	13.2	*2.31*
E0650-063-2000					2.00	*50.80*					3.61	*91.69*	8.3	*1.454*

†For stainless steel, multiply values by 0.833.

**When inquiring or ordering, use letter "M" or letter "S" as suffix on catalog numbers to designate music wire or stainless-steel wire, respectively.*

***Initial tension is for reference only and may vary.*

Torsion Springs



Material

Stainless steel
Commercial Type 302 ASTM-A313 or
AMS 5688 (chemical & physical only)

No charge for certificate of compliance when requested; certificate of chemical analysis available, see price book.
See Page 77 for music wire torsion springs.

Direction of Helix

Must be specified by suffix to catalog number. Use L for left-hand wound, R for right-hand wound.

Ends

Straight torsion ends are standard.

Finish

Plain finish is standard. Allow additional time for special finishes.

Tolerances

Torque	±10%
O.D.	± 5%

Stock sizes in stainless steel

Associated Spring torsion springs are widely used to store and release energy of rotation or to maintain a pressure over a short distance. Our stock selection includes torsion springs with four end positions, as shown in the drawings on this page.

SPEC torsion springs are normally used over a supporting mandrel or arbor. Suggested mandrel sizes allow about 10% clearance at the deflections listed. If greater deflections are used, the arbor size should be reduced. Sufficient room (minimum axial space) must be provided in the assembly for the spring to function properly. The minimum axial space does not refer to the length of the coils.

SPEC torsion springs should be used in the direction that winds the coils. In the unwinding direction the maximum load is lower because of residual stresses.

Torque values listed are recommended maximum torques. These values can be increased about 20% for static conditions with only slight setting.

For inspection purposes the load should be applied at ½ leg length (E). Using other lengths appreciably alter the active length of wire and affect the test results.

The torque values listed can be translated to direct load by use of the formula $P = \frac{M}{E_n}$ where P is the load applied at the new leg length E_n. Example: For part T012-090-055, what is the load when $E_n = 0.187$? $P = \frac{M}{E_n} = \frac{0.047}{0.187} = 0.25$ lb.

The torque values listed will be attained at the deflections listed. Torque values at intermediate deflections can be computed by direct proration. Example: For part T030-180-250, the torque at 90 deg deflection is 0.312 in-lb.

Figures show springs wound left-hand

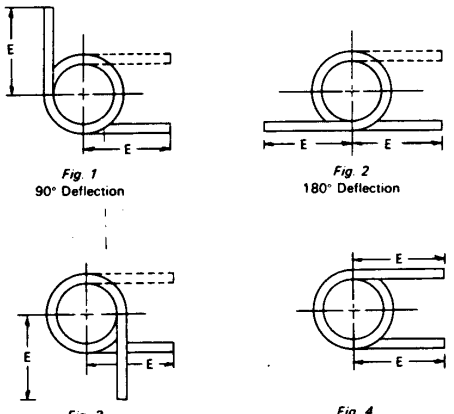


Fig. 1 90° Deflection
Fig. 2 180° Deflection
Fig. 3 270° Deflection
Fig. 4 360° Deflection

Dotted lines represent final loaded position.

STOCK TORSION SPRINGS

Stainless Steel

SPEC Associated Spring Raymond BARNES GROUP INC

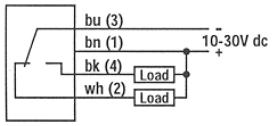
CATALOG NUMBER*	Wire Diameter		Outside Diameter		Pos. of Ends,	Def., Deg.	Torque M		Test Point ½ E		Suggested Mandrel Size		E		Min. Axial Space**	
	in	*mm*	in	*mm*	Fig.		in-lb	*N-mm*	in	*mm*	in	*mm*	in	*mm*	in	*mm*
T032-090-172			0.288	*7.32*	1	90			0.500	*12.70*	0.172	*4.36*	1.000	*25.40*	0.152	*3.86*
T032-180-156			0.270	*6.86*	2	180			0.500	*12.70*	0.156	*3.96*	1.000	*25.40*	0.272	*6.91*
T032-270-156	0.032	*0.81*	0.264	*6.71*	3	270	0.820	*92.7*	0.500	*12.70*	0.156	*3.96*	1.000	*25.40*	0.382	*9.70*
T032-180-218			0.366	*9.30*	2	180			0.500	*12.70*	0.218	*5.54*	1.000	*25.40*	0.208	*5.28*
T032-270-218			0.354	*8.99*	3	270			0.500	*12.70*	0.218	*5.54*	1.000	*25.40*	0.296	*7.52*
T032-360-234			0.382	*9.70*	4	360			0.500	*12.70*	0.234	*5.95*	1.000	*25.40*	0.352	*8.94*
T035-090-187			0.315	*8.00*	1	90			0.625	*15.88*	0.187	*4.75*	1.250	*31.75*	0.135	*3.43*
T035-180-187			0.303	*7.70*	2	180			0.625	*15.88*	0.187	*4.75*	1.250	*31.75*	0.290	*7.37*
T035-270-187	0.035	*0.89*	0.311	*7.90*	3	270	1.000	*113.0*	0.625	*15.88*	0.187	*4.75*	1.250	*31.75*	0.442	*11.23*
T035-180-281			0.450	*11.43*	2	180			0.625	*15.88*	0.281	*7.14*	1.250	*31.75*	0.212	*5.38*
T035-270-281			0.435	*11.05*	3	270			0.625	*15.88*	0.281	*7.14*	1.250	*31.75*	0.328	*8.33*
T035-360-312			0.471	*11.96*	4	360			0.625	*15.88*	0.312	*7.92*	1.250	*31.75*	0.405	*10.29*
T038-090-234			0.386	*9.80*	1	90			0.625	*15.88*	0.234	*5.94*	1.250	*31.75*	0.180	*4.57*
T038-180-218			0.368	*9.35*	2	180			0.625	*15.88*	0.218	*5.54*	1.250	*31.75*	0.323	*8.20*
T038-270-218	0.038	*0.97*	0.353	*8.97*	3	270	1.190	*134.5*	0.625	*15.88*	0.218	*5.54*	1.250	*31.75*	0.465	*11.81*
T038-180-312			0.487	*12.37*	2	180			0.625	*15.88*	0.318	*8.08*	1.250	*31.75*	0.247	*6.27*
T038-270-312			0.477	*12.12*	3	270			0.625	*15.88*	0.312	*7.92*	1.250	*31.75*	0.352	*8.94*
T038-360-328			0.514	*13.06*	4	360			0.625	*15.88*	0.328	*8.33*	1.250	*31.75*	0.418	*10.62*
T040-090-187			0.309	*7.85*	1	90			0.625	*15.88*	0.187	*4.75*	1.250	*31.75*	0.198	*5.03*
T040-180-218			0.348	*8.84*	2	180			0.625	*15.88*	0.218	*5.54*	1.250	*31.75*	0.374	*9.50*
T040-270-218	0.040	*1.02*	0.358	*9.09*	3	270	1.375	*155.4*	0.625	*15.88*	0.218	*5.54*	1.250	*31.75*	0.550	*13.97*
T040-180-343			0.518	*13.16*	2	180			1.000	*25.40*	0.343	*8.71*	2.000	*50.80*	0.242	*6.15*
T040-270-343			0.511	*12.98*	3	270			1.000	*25.40*	0.343	*8.71*	2.000	*50.80*	0.374	*9.50*
T040-360-343			0.507	*12.88*	4	360			1.000	*25.40*	0.343	*8.71*	2.000	*50.80*	0.508	*12.90*
T045-090-203			0.357	*9.07*	1	90			0.625	*15.88*	0.203	*5.16*	1.250	*31.75*	0.259	*6.58*
T045-180-218			0.377	*9.58*	2	180			0.625	*15.88*	0.218	*5.54*	1.250	*31.75*	0.427	*10.85*
T045-270-234	0.045	*1.14*	0.382	*9.70*	3	270	2.000	*226.*	0.625	*15.88*	0.234	*5.94*	1.250	*31.75*	0.595	*15.11*
T045-180-359			0.575	*14.61*	2	180			1.000	*25.40*	0.359	*9.12*	2.000	*50.80*	0.293	*7.44*
T045-270-359			0.556	*14.12*	3	270			1.000	*25.40*	0.359	*9.12*	2.000	*50.80*	0.415	*10.54*
T045-360-359			0.549	*13.94*	4	360			1.000	*25.40*	0.359	*9.12*	2.000	*50.80*	0.540	*13.72*
T048-090-218			0.375	*9.53*	1	90			0.625	*15.88*	0.218	*5.54*	1.250	*31.75*	0.238	*6.05*
T048-180-250			0.404	*10.26*	2	180			0.625	*15.88*	0.250	*6.35*	1.250	*31.75*	0.450	*11.43*
T048-270-250	0.048	*1.22*	0.416	*10.57*	3	270	2.500	*282.*	0.625	*15.88*	0.250	*6.35*	1.250	*31.75*	0.660	*16.76*
T048-180-406			0.618	*15.70*	2	180			1.000	*25.40*	0.406	*10.31*	2.000	*50.80*	0.292	*7.42*
T048-270-406			0.600	*15.24*	3	270			1.000	*25.40*	0.406	*10.31*	2.000	*50.80*	0.450	*11.43*
T048-360-406			0.594	*15.09*	4	360			1.000	*25.40*	0.406	*10.31*	2.000	*50.80*	0.610	*15.49*
T051-090-234			0.408	*10.36*	1	90			1.000	*25.40*	0.234	*5.94*	2.000	*50.80*	0.293	*7.44*
T051-180-250			0.430	*10.92*	2	180			1.000	*25.40*	0.250	*6.35*	2.000	*50.80*	0.485	*12.32*
T051-270-266	0.051	*1.30*	0.439	*11.15*	3	270	2.900	*328.*	1.000	*25.40*	0.266	*6.76*	2.000	*50.80*	0.675	*17.15*
T051-180-344			0.556	*14.12*	2	180			1.000	*25.40*	0.344	*8.74*	2.000	*50.80*	0.382	*9.70*
T051-270-359			0.571	*14.50*	3	270			1.000	*25.40*	0.359	*9.12*	2.000	*50.80*	0.522	*13.26*
T051-360-406			0.628	*15.95*	4	360			1.000	*25.40*	0.406	*10.31*	2.000	*50.80*	0.615	*15.62*
T054-090-296			0.484	*12.29*	1	90			1.000	*25.40*	0.296	*7.52*	2.000	*50.80*	0.310	*7.87*
T054-180-312			0.509	*12.93*	2	180			1.000	*25.40*	0.312	*7.92*	2.000	*50.80*	0.512	*13.00*
T054-270-312	0.054	*1.37*	0.514	*13.06*	3	270	3.275	*370.*	1.000	*25.40*	0.312	*7.92*	2.000	*50.80*	0.715	*18.16*
T054-180-421			0.654	*16.61*	2	180			1.000	*25.40*	0.421	*10.69*	2.000	*50.80*	0.405	*10.26*
T054-270-437			0.664	*16.61*	3	270			1.000	*25.40*	0.437	*11.10*	2.000	*50.80*	0.555	*14.10*
T054-360-453			0.694	*16.61*	4	360			1.000	*25.40*	0.453	*11.51*	2.000	*50.80*	0.705	*17.91*
T059-090-296			0.499	*12.67*	1	90			1.000	*25.40*	0.296	*7.52*	2.000	*50.80*	0.340	*8.64*
T059-180-328			0.526	*13.36*	2	180			1.000	*25.40*	0.328	*8.33*	2.000	*50.80*	0.560	*14.22*
T059-270-328	0.059	*1.50*	0.537	*13.64*	3	270	4.200	*475.*	1.000	*25.40*	0.328	*8.33*	2.000	*50.80*	0.785	*19.94*
T059-180-437			0.681	*17.30*	2	180			1.000	*25.40*	0.437	*11.10*	2.000	*50.80*	0.445	*11.30*
T059-270-453			0.699	*17.75*	3	270			1.000	*25.40*	0.453	*11.51*	2.000	*50.80*	0.605	*15.37*
T059-360-459			0.709	*18.01*	4	360			1.000	*25.40*	0.459	*11.66*	2.000	*50.80*	0.770	*19.56*
T063-090-343			0.560	*14.22*	1	90			1.000	*25.40*	0.343	*8.71*	2.000	*50.80*	0.362	*9.19*
T063-180-359			0.591	*15.01*	2	180			1.000	*25.40*	0.359	*9.12*	2.000	*50.80*	0.600	*15.24*
T063-270-375	0.063	*1.60*	0.600	*15.24*	3	270	5.150	*582.*	1.000	*25.40*	0.375	*9.53*	2.000	*50.80*	0.835	*21.21*
T063-180-500			0.767	*19.48*	2	180			1.000	*25.40*	0.500	*12.70*	2.000	*50.80*	0.475	*12.07*
T063-270-516			0.784	*19.91*	3	270			1.000	*25.40*	0.516	*13.11*	2.000	*50.80*	0.645	*16.38*
T063-360-516			0.798	*20.27*	4	360			1.000	*25.40*	0.516	*13.11*	2.000	*50.80*	0.820	*20.83*
T070-090-359			0.593	*15.06*	1	90			1.000	*25.40*	0.359	*9.12*	2.000	*50.80*	0.400	*10.16*
T070-180-390			0.625	*15.88*	2	180			1.000	*25.40*	0.390	*9.91*	2.000	*50.80*	0.665	*16.89*
T070-270-390	0.070	*1.78*	0.639	*16.23*	3	270	7.000	*791.*	1.000	*25.40*	0.390	*9.91*	2.000	*50.80*	0.930	*23.62*
T070-180-515			0.810	*20.57*	2	180			1.000	*25.40*	0.515	*13.08*	2.000	*50.80*	0.525	*13.34*
T070-270-531			0.826	*20.98*	3	270			1.000	*25.40*	0.531	*13.49*	2.000	*50.80*	0.717	*18.21*
T070-360-546			0.843	*21.41*	4	360			1.000	*25.40*	0.546	*13.87*	2.000	*50.80*	0.910	*23.11*

Indicate direction of helix desired by suffix to catalog number — L for left hand wound, R for right hand wound.

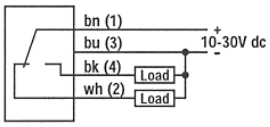
****Space needed on application to allow for operation of the spring. This dimension does not refer to the length of the coils.***

WORLD-BEAM Hookups

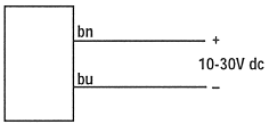
QS18 Sensors with NPN (Sinking) Outputs



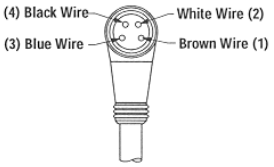
QS18 Sensors with PNP (Sourcing) Outputs



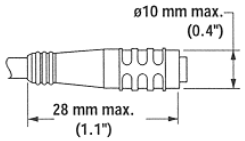
QS18 Emitters



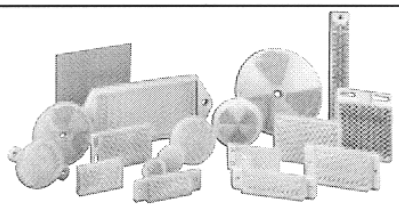
4-Pin Pico-Style Pin-out (Cable Connector Shown)



Pico-Style Quick-Disconnect Cables

Style	Model	Length	Dimensions
4-Pin Straight	PKG4-2	2 m (6.5')	

Retroreflective Targets



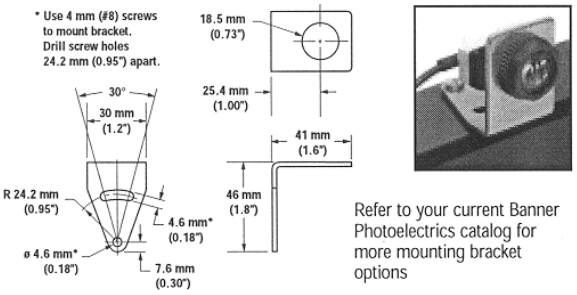
See the Accessories section of your current Banner Photoelectric Sensors catalog for complete information.

NOTE: Polarized sensors require corner cube type retroreflective targets only.

Mounting Brackets

SMB18A

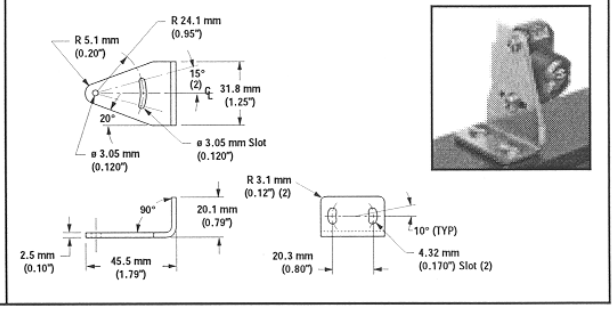
- 12-gauge, stainless steel
- Right-angle mounting bracket



Refer to your current Banner Photoelectrics catalog for more mounting bracket options

SMB312S

- Stainless steel 2-axis, side mounting bracket



WARRANTY: Banner Engineering Corp. warrants its products to be free from defects for one year. Banner Engineering Corp. will repair or replace, free of charge, any product of its manufacture found to be defective at the time it is returned to the factory during the warranty period. This warranty does not cover damage or liability for the improper application of Banner products. This warranty is in lieu of any other warranty either expressed or implied.

BANNER®
the photoelectric specialist

WARNING . . . Not To Be Used for Personnel Protection

Never use these products as sensing devices for personnel protection. Doing so could lead to serious injury or death.

These sensors do NOT include the self-checking redundant circuitry necessary to allow their use in personnel safety applications. A sensor failure or malfunction can cause either an energized or de-energized sensor output condition. Consult your current Banner Safety Products catalog for safety products which meet OSHA, ANSI and IEC standards for personnel protection.

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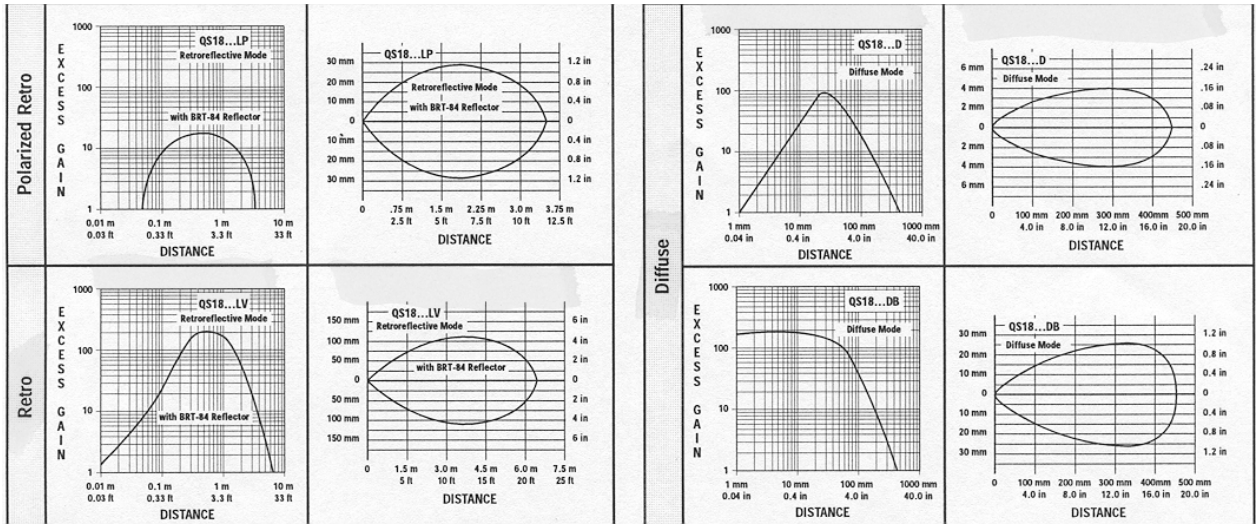

Polarized Retro
Retro
Diffuse
EXCESS GAIN
QS18...LP
Retroreflective Mode
with BRT-84 Reflector
QS18...LV
Retroreflective Mode
with BRT-84 Reflector
QS18...D
Diffuse Mode
QS18...DB
Diffuse Mode
DISTANCE

BEI SYSTRON DONNER INERTIAL DIVISION
SENSORS & SYSTEMS COMPANY

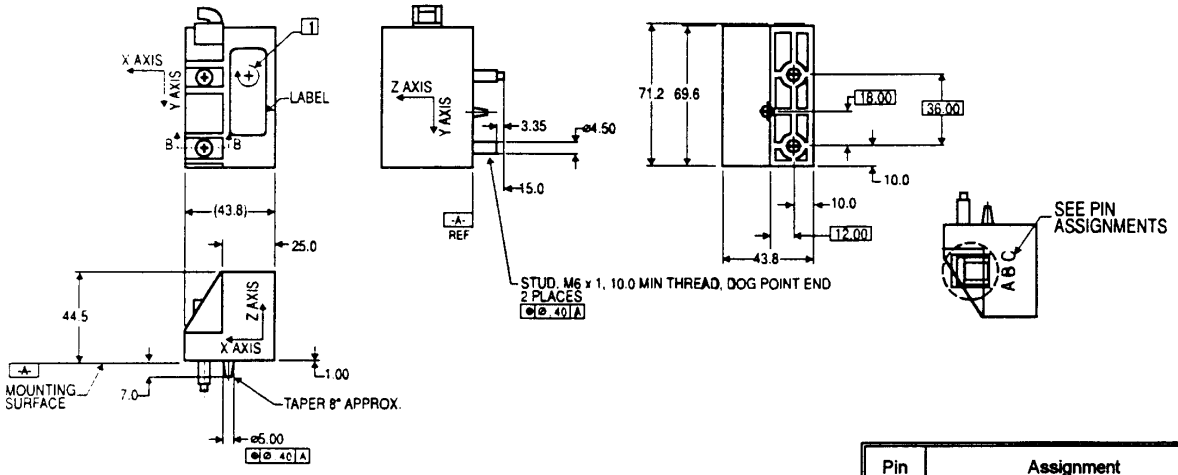
GyroChip®

Solid State Gyroscope

FIRST Project

AQRS-00064-109

PARAMETER	SUMMARY SPECIFICATION
POWER REQUIREMENTS	
Operating Voltage	+5 VDC ±0.25 VDC
Operating Current	20 mA (max.)
PERFORMANCE (typical for 5 Volt input)	
Range*	±64°/sec
Scale Factor*	
Full Range Output	+0.25 to +4.75 VDC
Nominal	35.16 mV/°/sec
Bias*	
Bias at Ambient	+2.50 VDC ±0.5
Bandwidth (90°)	>50 Hz
* Note: Output is ratiometric to supply voltage.	
ENVIRONMENTS	
Operating Temperature	70°F to 90°F
Storage Temperature	-40°F to +185°F
Vibration Operating	1.5 g RMS, 20 to 2,000 Hz
WEIGHT	125 grams max.

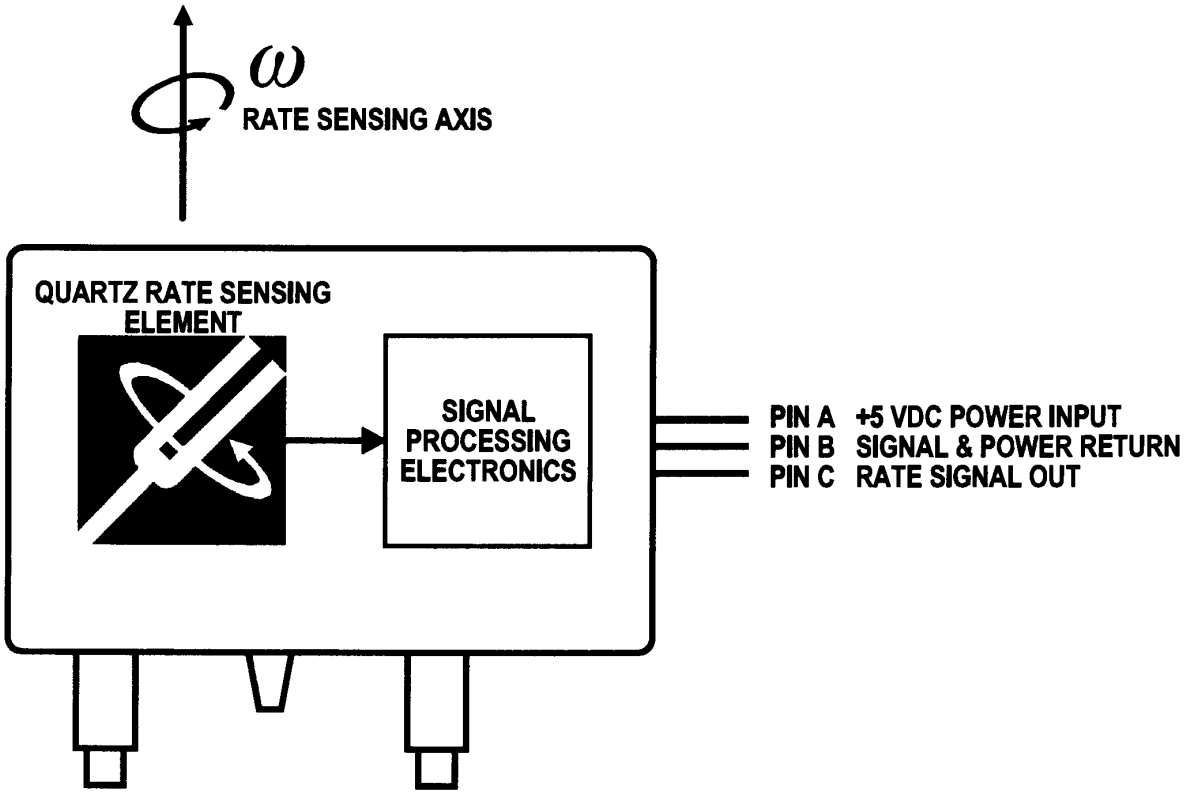


Not Supplied:
Mating Connector Kit (Pioneer Standard)
3 WAY Female – P/N 12064758 (1 ea.)
Terminal Female – P/N 12047767 (3 ea.)

NOTES:
1. ANGULAR RATE APPLIED AS SHOWN SHALL PRODUCE A MORE POSITIVE OUTPUT.
2. DIMENSIONS SHOWN ARE IN MILLIMETERS

Pin	Assignment
A	+5 VDC Input
B	Common
C	Rate Out (1Kohm output impedance)

Systron Donner Inertial Division • 2700 Systron Drive • Concord, California 94518 • Toll Free: (800) 227-1825
Sales: (925) 671-6601 • Customer Service: (925) 671-6499 • FAX: (925) 671-6647
European Business Office (Ashford, England): 44 1303 812778 • FAX: 44 1303 812708



Quartz Rate Sensor "GyroChip®"

NOT SUPPLIED:
Mating Connector Kit (Pioneer Standard)
3 Way Female - P/N 12064758 (1 ea.)
Terminal Female - P/N 12047767 (3 ea.)

NOTES:

- Rate Sensor Output is ratiometric to input power line voltage over the range of +4.75 to +5.25 VDC.
- Full scale factor rate range is ±64°/sec.
- Output signal is symmetrical about a +2.5 VDC (nominal) bias.
- Output Impedance is 1KΩ or less.

12/98:FIRSTOD CDR:JSAS

BEI SYSTRON DONNER INERTIAL DIVISION
SENSORS & SYSTEMS COMPANY

A Quartz Rotational Rate Sensor

Based on inertial-sensing principles, the quartz rate sensor provides a simple, reliable measurement of rotational velocity.

The use of a vibrating element to measure rotational velocity by employing the Coriolis principle is a concept that has been around for more than 50 years. In fact, the idea developed long ago out of the observation that a certain species of fly uses a pair of vibrating antennae to stabilize its flight. This sensing technique has been given a practical embodiment: the quartz rate sensor (QRS).

THEORY OF OPERATION

To understand how the QRS works requires familiarity with the Coriolis principle. Simply stated, this means that a linear motion within a rotating framework will have some component of velocity that is perpendicular to that linear motion.

The handiest example of the Coriolis effect is that exhibited by wind patterns on Earth. Convection cells in the atmosphere set up a wind flow from the poles toward the equator (with a north-south orientation). The Earth's rotation, however, causes these linear flows to develop a sideways (orthogonal) component of motion. This "bends" the wind from a north-south to an east-west direction. It is the Coriolis effect that creates the east-west "trade winds," and which is responsible for the spirals of clouds observed in satellite photos.

Now let's apply this principle to our rotation sensor. In Figure 1 you can see that the QRS is essentially divided into two sections: drive and pickup.

The drive portion looks and acts exactly like a simple tuning fork. Because the drive tines are constructed of crystalline quartz, it is possible to electrically "ring" this tuning fork. Each fork tine has a mass and an instantaneous radial velocity that changes sinusoidally as the tine moves back and forth. As long as the fork's base is stationary, the momenta of the two tines exactly cancel each other and there is no energy transfer from the tines to the base. In fact, it takes only ~6 μW of power to keep the fork ringing.

As soon as the tuning fork is rotated around its axis of symmetry, however, the Coriolis principle exerts a profound influence on the behavior of this mechanism.

By convention (the "right-hand rule"), the rotational vector ω_i is described by an arrow that is aligned with the axis of rotation. The instantaneous radial velocity of each of the tines will, through the Coriolis effect, generate a vector cross-product with this rotation vector.

The net effect is that each tine will generate a force perpendicular to the instantaneous radial velocity of each of the other tines:

$$F = 2 m\omega_i \bullet V_r \qquad (1)$$

where:

m = tine mass
ω_i = rotation rate
V_r = radial velocity

Note that this force is directly proportional to the rotation rate, and since the radial velocity of the tines is sinusoidal, the resultant force on each tine is also sinusoidal. Because the radial velocities of the two tines are equal and opposite, the Coriolis forces are equal and opposite, producing an oscillating torque at the base of the drive tine fork that is proportional to the input angular rate.

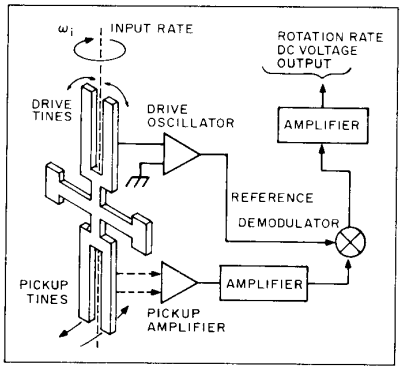


Figure 1. *An oscillating tuning fork senses rotational velocity by using the Coriolis force to translate the linear motion of the tines into an oscillating torque. This torque value is demodulated at the oscillation frequency to generate a DC voltage proportional to the rotation rate input.*

The pickup portion of the QRS now comes into play. The sinusoidal torque variation causes the pickup tines to begin moving tangentially to the rotation and at the same frequency as the drive vibration. Since the forces causing the pickup tines to move are directly proportional to the rotation rate, if there is no rotation the pickup tines will not move. The QRS can therefore truly detect a zero rotation input.

Once the pickup tines are in motion, it is a simple matter to amplify the pickup signal and then demodulate it using the drive frequency as a reference. One additional stage of amplification allows for some signal shaping and produces a DC signal output that is directly propor-

Scott D. Orlosky and Harold D. Morris, Systron Donner, a BEI Electronics Company

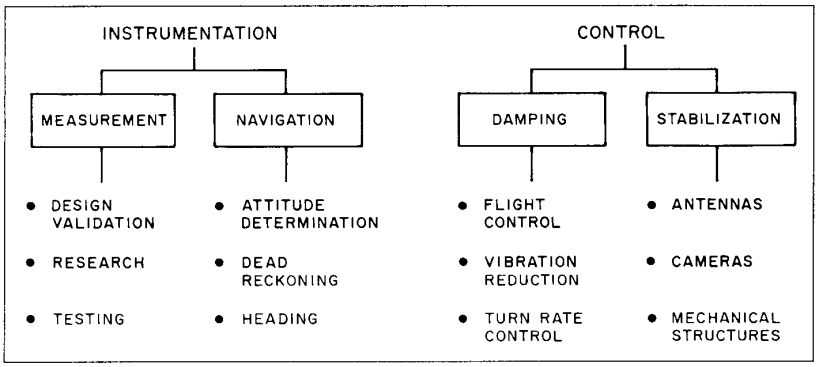


Figure 2. *A variety of instrumentation and control applications can benefit from rotational velocity as a means of improving designs, adding navigational capability to autonomous vehicles, and damping out unwanted motions of control surfaces or gimballed platforms.*

tional to the input angular rate. All of the electronics are fairly simple, and can be contained within the same package as the sensing element.

CONSTRUCTION

The QRS is fabricated from a wafer of single-crystal, synthetically grown quartz. The material's piezoelectric properties are particularly stable over temperature and time. Quartz exhibits a high modulus of elasticity and therefore can be made to ring very precisely with a high Q (quality factor). In addition, quartz can be worked by using conventional wet chemical etch production techniques similar to those favored by the semiconductor industry for producing chips.

APPLICATIONS

Until recently, the most common rotation sensors based on the principles of inertial mechanics were spring-restrained spinning-wheel gyroscopes. These tend to be large and heavy, and to consume large quantities of power. They also tend to wear out after only a few thousand hours of operation and so cannot be used continuously for long periods of time. Their use has been restricted to highly specialized applications such as in military aircraft and missiles, where the short mission times and availability of maintenance personnel made their use practical. By contrast, QRS technology, with its MTBF >100,000 hours and the low cost of ownership, is attractive to industrial and commercial customers as well. QRS applications fall into two broad categories: open-loop, or instrumentation applications; and closed-loop, or control applications (see Figure 2).

INSTRUMENTATION

These applications involve either instrumenting a structure for purposes of determining its rates of rotational motion (measurement), or processing that information in real time to generate information about orientation (navigation). Typical examples of rotational velocity measurement include instrumenting vehicles for crash studies, determining dynamics of specific platforms (e.g., boats, trains, robots, or even human beings), and environmental measurements such as earthquakes and wave motions.

Measurement. One key element in measurement system design is to determine the peak rotational velocities involved to ensure that an instrument with the proper range is used. If the selected range of the QRS is too low, the output will be clipped and valuable information will be lost.

A fairly straightforward way to determine the correct range requirement is to establish two parameters: the frequency of movement of the structure to be instrumented; and the peak angular displacement of that movement. Let's assume that we want to determine the dynamics of a vehicle's body roll while it takes a turn. The body roll motion can be described as:

$$\theta = A \cdot \sin(2\pi \cdot F_n \cdot t) \text{ in degrees} \quad (2)$$

where:

A = amplitude of movement
F_n = frequency of movement

The parameter of interest for measuring angular velocity is the change in angular position with time, or $(d\theta/dt)$. Taking the derivative of the above equation:

$$(d\theta/dt) = A \cdot 2\pi \cdot F_n \cdot \cos(2\pi \cdot F_n \cdot t) \quad (3)$$

Let's assume that the natural frequency of the vehicle suspension system is 6 Hz, and the peak body roll is 10°. By substituting these into Equation 3:

$$\begin{aligned}(d\theta/dt) &= 10 \cdot 2\pi \cdot 6 \cdot \cos(2\pi \cdot 6 \cdot t) \\ &= 377 \cdot \cos(37.7 \cdot t)°/s \quad (4)\end{aligned}$$

Since the cosine term has a maximum value of 1, the peak rotational velocity is 377°/s. So even a seemingly benign environment, a 10° roll at 6 Hz, generates fairly high peak rotational velocities.

Navigation. Navigation applications are becoming increasingly interesting for the QRS, expecially in light of the availablity of GPS receivers at a reasonable cost. In principle, by reading the output from the rotation sensor (rotational velocity) and integrating this output over time, it is possible to determine the sensor's angular displacement. A QRS can be used for sensing vehicle yaw as part of a navigation package (see Figure 3).

SYSTEM COMPONENTS

Anti-Aliasing Filter. Because a computer interface requires the use of an analog-to-digital (A/D) converter, the output from the QRS becomes part of a sampled data stream. In order to prevent aliasing of the output, a filter must be used with the corner frequency usually set at 1/4 to 1/2 of the sampling frequency.

A/D Converter. The A/D conversion should be carried out immediately after anti-aliasing since this puts the converter close to the QRS and reduces the overall noise of the system, yielding the most stable results. A 12-bit converter is generally adequate. The sample frequency should be appropriate for the system, but typical values range from 100 Hz to 1000 Hz.

Bandpass Filter. This filter is tailored to the specific application. When the sensor is used as part of a head-mounted display for a virtual reality application, for example, it is not necessary to track very small, high-frequency head movements because they may simply be part

of the normal jostling associated with interactive game playing. Only larger, definite head swings need attention.

Similarly, low-frequency variations in the QRS output, which are usually associated with changes in environmental temperatures or warm-up, are not meaningful tracking information and should be rejected.

These two scenarios determine the lower and upper ranges of the bandpass filter. A reasonable starting point would be to choose upper and lower corner frequencies of 0.1 Hz and 10 Hz.

Integrator. This is where the angular velocity information is turned into angular position. Since the initial conditions are indeterminate at start-up, it is recommended that a reset capability be included. This allows you to initialize the integrator to zero or some known position at startup.

The portion of the platform that is to be measured must usually be held very steady during startup so that the initial conditions represent as closely as possible a true "zero input" state. Any residual error at startup will cause the apparent output from the integrator to drift.

One method to reduce the startup error is to average the input to the integrator for a few seconds during the initialization sequence, and then subtract this average value to establish the zero point.

As a practical matter, it is virtually impossible to measure the "pure" rotational velocity without introducing or reading some error at the same time. This accumulation of errors means that over time, the true angular position and the calculated angular position will diverge. The sensor output may not be drifting, but the apparent calculated angle is.

The rate of this divergence is determined by a variety of factors including: how well the initial conditions are established; the accuracy of the alignment of the sensor to the true axis of rotation; the quantization errors of the signal (if it has been digitized); and the stability of the environment in which the measurement is being done.

For most practical applications, therefore, the QRS is used only for short-term navigation. In order to prevent these incremental errors from growing too large, the common practice is to periodically update, or correct, the calculated angle

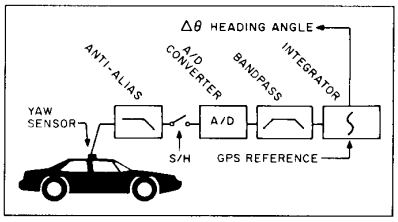


Figure 3. *By combining the quartz rotation sensor (QRS) with a fixed reference such as a GPS receiver, a complete navigation system can be created for an automobile. Attention to signal processing design as well as to blending the GPS reference signal produces a system that can cope with extended GPS blackouts.*

through the use of a fixed, external reference as shown in Figure 3.

The reference selected will depend on the situation; examples include a GPS signal, a corner-cube with optical line-of-sight, or an encoded magnetic signal. In fact, the combination of dead reckoning between fixed reference updates is a nearly ideal means of navigation through a variety of dynamic environments.

This method has been used for autonomous delivery robots in hospitals, automated forklifts in warehouses, and emergency vehicles deployed in urban environments.

CONTROL

To employ the QRS in control applications requires an understanding of how it works as part of a system. The typical system model takes into account the magnitude and phase relationships of the sensor response.

Damping. The ability to accurately measure rotational velocity opens up new possibilities for control of structures. One of the most useful types of

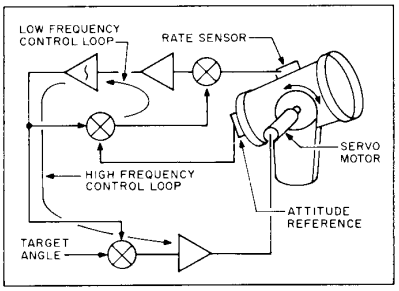


Figure 4. *As part of an attitude control system for a mobile telescope, the QRS can be combined with a simple tilt sensor to provide both absolute pointing accuracy as well as stability. Rapid motions are compensated for in the high-frequency control loop, while the low-frequency control loop provides a vertical reference to gravity.*

control applications is to damp out the resonant behavior of mechanical systems. Very few mechanical systems produce pure linear motion—most machines have parts that rotate or pivot. Aircraft, land vehicles, and ships are governed by means of roll, pitch, and/or yaw controls. By monitoring and controlling these motions it is possible to provide active roll damping on ships, remove "Dutch roll" from aircraft flight, reduce body roll on a car as it takes a turn, or damp out end-effector shake in an industrial robot.

Stabilization. This is a special instance of closed-loop control—stabilization—in which the item being controlled is intended to remain stationary even during movement of the platform to which it is attached. It is important that the QRS be tightly coupled mechanically to the object to be controlled, usually a camera or an antenna on a multi-axis gimbal. This gimbal mechanism must have no mechanical resonances in the bandwidth of the servo-control loop.

The system designer must take into account the transfer function of the system servo-loop and ensure enough phase margin to prevent oscillation. Because it is often necessary to independently move the camera or antenna, a commandable DC offset must be included in the control loop to allow an operator to rotate and point the camera in the gimbal. This method has been used successfully to stabilize antennas aboard ships and land vehicles, as well as cameras aboard helicopters and survey airplanes.

An example of such an application is shown in Figure 4. Here, the QRS is used as part of a servo-control loop to provide an absolute pointing angle in attitude as well as image stability for a mobile telescope.

For simplicity it is assumed that the telescope is mounted on a platform that can rotate only in attitude, and that the control mechanism is therefore an attitude control system only. The principle described can be applied to the other axes of rotation.

Refer first to the high-frequency control loop portion of Figure 4. Assume that this circuit is designed to operate at 10 Hz, which is a typical value for a servo control. Let's further assume that the telescope has a rotational inertia J =

12 slug-ft^2.

Since: $\omega_n^2 = K_s/J$
then: $K_s = (10 \cdot 2 \cdot \pi)^2 \cdot 12$
$= 47{,}300$ ft-lb./rad (5)

where:

ω_n = corner frequency of servo-loop
K_s represents the servo stiffness

The preceding implies that an external torque of 10 ft-lb. will allow a movement of only 10/47,300 = 0.0002 rad, or 0.7 arc-min.

Now let's look at the low-frequency control loop portion of Figure 4. This will act as a vertical reference unit and ensure that the absolute pointing angle of the telescope matches the commanded (or target) angle. To accomplish this, a stable, long-term attitude reference must be provided.

For most systems, gravity does the job quite nicely. A simple tilt sensor is always referenced to local gravity, and over a fairly narrow range it will behave linearly. To avoid coupling-in any high-frequency movements that are, by definition, not gravity related, this reference is part of a control loop with a time constant of typically 100 s. This allows the attitude reference to closely follow the typical platform motions you might find on most common mobile platforms, i.e., ships, trains, or planes.

In general, the loop will incorporate a proportional and differential control element that does not appear in the figure.

SUMMARY

A new type of sensor has been developed that can add significantly to the capabilities of engineers and designers alike. Based on inertial-sensing principles, the quartz rate sensor provides a simple, reliable measurement of rotational velocity that can be used to instrument structures in new ways and gain a more in-depth insight into designs; to aid in short-term navigation of autonomous mobile platforms; and to allow for improved methods of stabilizing structures.

Scott D. Orlosky is Director for Commercial Business and Harold D. Morris is Chief Scientist, Systron Donner Inertial Division, a BEI Electronics Company, 2700 Systron Dr., Concord, CA 94518; 510-671-6601, fax 510-671-6647.

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DELPHI INTERIOR AND LIGHTING

BOSCH VAN DOOR MOTOR SPECS

No Load Speed:	75 RPM
Stall Torque Clockwise:	34 Nm
Stall Torque Counter-Clockwise:	30 Nm
Stall Current:	44 Amps
All specs at 12 Vdc.	

Bosch Motors are used in the 1999 Toyota Sienna and the 1999 Ford Windstar. If you wish to purchase an additional Bosch motor, you must buy the entire "Power Sliding Door unit". The Bosch motor is the right hand side motor. Great care must be taken when removing the motor from the front door unit. The retaining clips must be removed from the output shaft or damage will occur to the shaft

FISHER-PRICE MOTOR INFORMATION

The following are approximate performance data for the Fisher-Price motor/gearbox sets supplied in the kits. The motor used is a Mabuchi model RS-550PF-6534.

Motor no-load speed	15,000 RPM
Motor stall current	57 A
Motor stall torque	0.363 N-m
Gearbox ratio	147:1
No-load speed w/gearbox	100 RPM (estimated)
Stall torque w/gearbox	34.7 N-m (estimated)

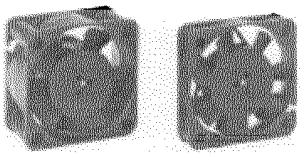
GLOBE MOTOR

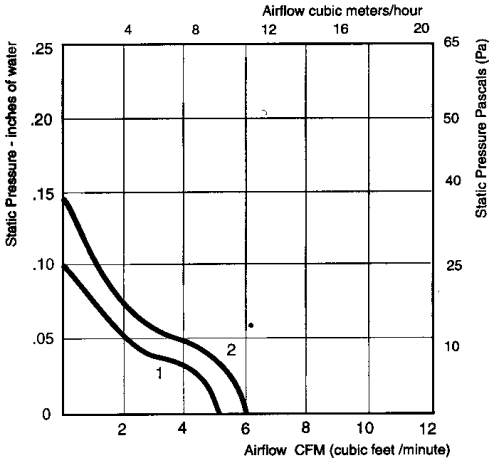
GLOBE MOTOR AND DRIVE ASSEMBLY SPECS

	Motor with Drive Assembly	Motor Only
No Load Speed:	87 RPM ± 1	97 RPM
Stall Torque:	150 In-lb	30 oz-in
Stall Current:	18.5 Amps	18.5 Amps
No Load Current	0.820 Amps	0.820 Amps
	All specs at 10 Vdc.	

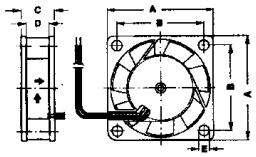
Warning: The Globe Motor cannot support side loads.

40 x 10 or 20 mm (1.6" X 0.4 or 0.8"") Brushless DC — 400 Series





DIMENSIONS



Part Number	DIMENSIONS inch (mm) A	B	C	D	E
412F / 414F	1.57	1.26	.39	.24	.138
	(40)	(32)	(10)	(6)	(3.5)
412 / 414	1.57	1.26	.79	.63	.169
	(40	(32)	(20)	(16)	(4.3)

1.57" X 1.57" X .39 or .79" Brushless DC, Plastic, Air Exhaust – Over Struts

Curve	PART NUMBER	Type of Bearing	DC Volts	Voltage Range	Watts	CFM @ 0"	dBA	Temp. Max °C	Wgt. (oz)	Features	Approvals* UL	CSA	VDE
1	**412F**	Sleeve	12	10.2 - 13.8	0.7	5	26	70	.6	28 AWG 12.2" Leads	√	√	√
2	**412FH**	Sleeve	12	10.2 - 13.8	0.8	6	28	70	.6	28 AWG 12.2" Leads	√	√	√
1	**414F**	Sleeve	24	20.4 - 27.6	0.7	5	26	70	.6	28 AWG 12.2" Leads	√	√	√
2	**412**	Sleeve	12	10.2 - 13.8	0.9	6	26	70	1.0	28 AWG 12.2" Leads	√	√	√
2	**414**	Sleeve	24	20.4 - 27.6	0.9	6	26	70	1.0	28 AWG 12.2" Leads	√	√	√

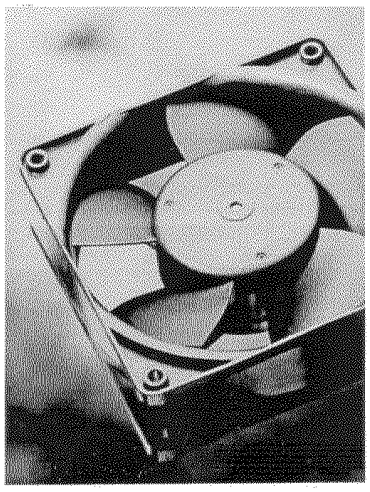
* UL yellow card E38324, CSA file 27697, VDE file 3072

HIGH PERFORMANCE
SINTEC
SLEEVE BEARING SYSTEM

CONSTRUCTION MOUNTING & CONNECTION	**Mounting:**	From either face using four holes	**Connection:**	Lead wires color coded, red (+), blue (-)
	Weight:	F models: 0.6 oz (17g); 1.0 oz (27g)		
	Housing:	Plastic with plastic impeller		

28

Call **ebm/Papst** at 860-674-1515 • Fax 860-674-8536 • E-mail: sales@ebm.com for Technical Assistance



PAPST

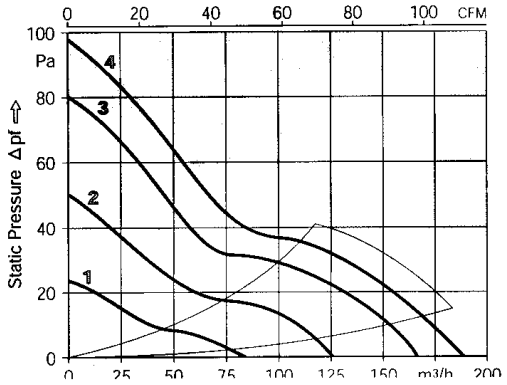
- DC fans with electronically commutated external rotor motor. Fully integrated commutation electronics.
- With electronic protection against reverse polarity, blocking and overloading by PTC-resistor; partially impedance protected.
- Fan of fibreglass reinforced plastic. PBTP housing, PA impeller.
- Air exhaust over struts. Rotational direction CCW looking at rotor.
- Electrical connection via 2 leads AWG 22, TR 64. Stripped and tinned ends
- Mass 290 g.

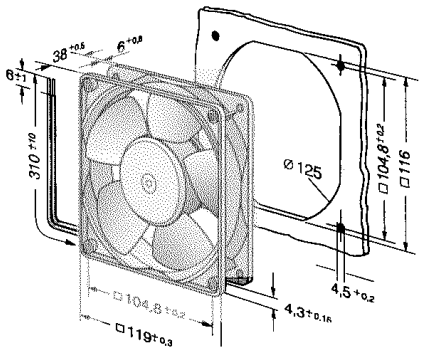
SERIES 4200

119x119x38mm

Air flow	Air flow	Nominal Voltage	Voltage Range	Noise		Sintec-Sleeve Bearings / Ball Bearings	Power Input	Nominal Speed	Temperature Range	Service Life L_{10} at 40 °C at $t_{max.}$		Curve	Type
m³/h	CFM	V DC	V DC	dB(A)	bels	○/●	Watt	min⁻¹	°C	Hours	Hours		
86	50.6	12	7...14.5	29	4.2	●	1.2	1600	-20...+75	80000 / 35000		1	4212L
127	74.7	12	7...14.5	38	4.9	○	2.2	2350	-20...+75	70000 / 30000		2	4212GM
127	74.7	12	7...14.5	38	4.9	●	2.2	2350	-20...+75	70000 / 30000		2	4212M
165	97.1	12	7...14.5	45	5.6	●	4.3	3050	-20...+75	62500 / 27500		3	4212
184	108.3	12	7...14.5	49	5.9	●	5.3	3400	-20...+65	60000 / 32500		4	4212H
86	50.6	24	12...28	29	4.2	●	1.2	1600	-20...+75	80000 / 35000		1	4214L
165	97.1	24	12...28	45	5.6	○	4.3	3050	-20...+75	62500 / 27500		3	4214G
165	97.1	24	12...28	45	5.6	●	4.3	3050	-20...+75	62500 / 27500		3	4214
184	108.3	24	12...28	49	5.9	○	5.3	3400	-20...+65	60000 / 32500		4	4214GH
184	108.3	24	12...28	49	5.9	●	5.3	3400	-20...+65	60000 / 32500		4	4214H
165	97.1	48	36...56	45	5.6	●	4.3	3050	-20...+75	62500 / 27500		3	4218
184	108.3	48	36...56	49	5.9	●	5.6	3400	-20...+65	60000 / 32500		4	4218H

Attention:
In the forseeable future the 4200 fan series will be removed from the range and replaced by the products of the new series 4200N.





Innovation First FIRST Victor 883

November 2000 **Data Sheet**

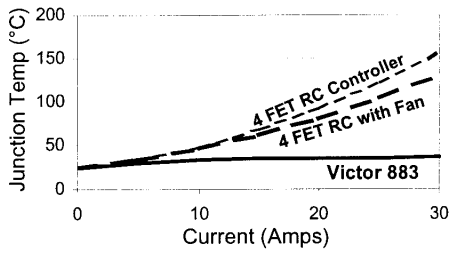
General Description:

The Victor 883 is a speed controller specifically engineered for robotic applications. The high current capacity, low voltage drop, and peak surge capacity make the Victor 883 ideal for drive systems while its braking options and precise control meet the demanding needs of arms and lift systems. Innovative FET switching architecture and an integral cooling fan ensures cool FET junction temperatures. The low voltage drop and high switching speed ensures the motor receives maximum power, providing significant improvements in acceleration, direction changes, and lifting torque.

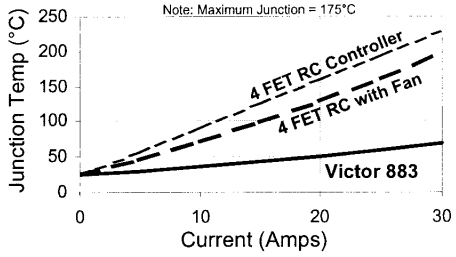
Features:

- 12 low Rds(on) FETs, 6 forward and 6 reverse
- extremely fast FET rise/fall time
- brake or coast option (used while in neutral)
- simplified calibration procedure
- pre-calibrated for the FIRST control system
- identifies absence of PWM input
- integral fan to provide optimized cooling
- sturdy high current screw terminal connections
- high visibility LED
- rugged construction
- two mounting hole for secure installations

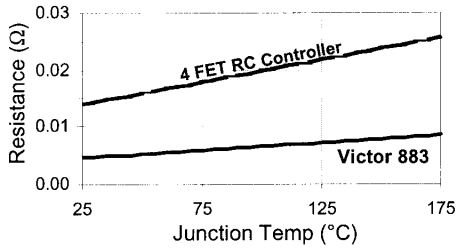
Junction Temp Vs. Current at Full Throttle



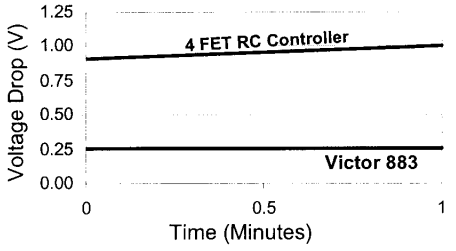
Junction Temp Vs. Current at Low Throttle

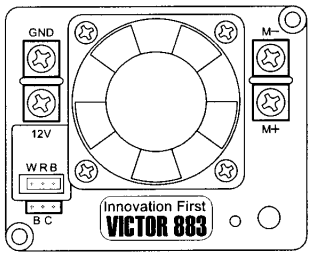


FET On-Resistance Vs. Temperature



Voltage Drop Vs. Run Time

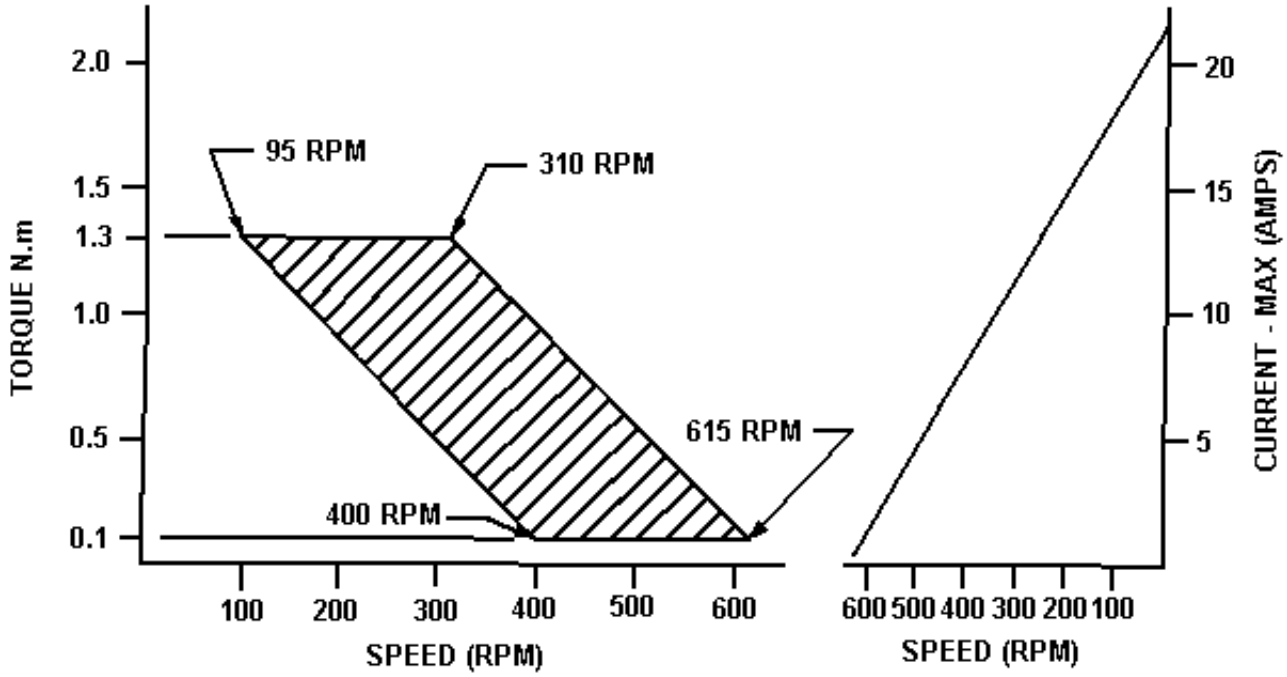


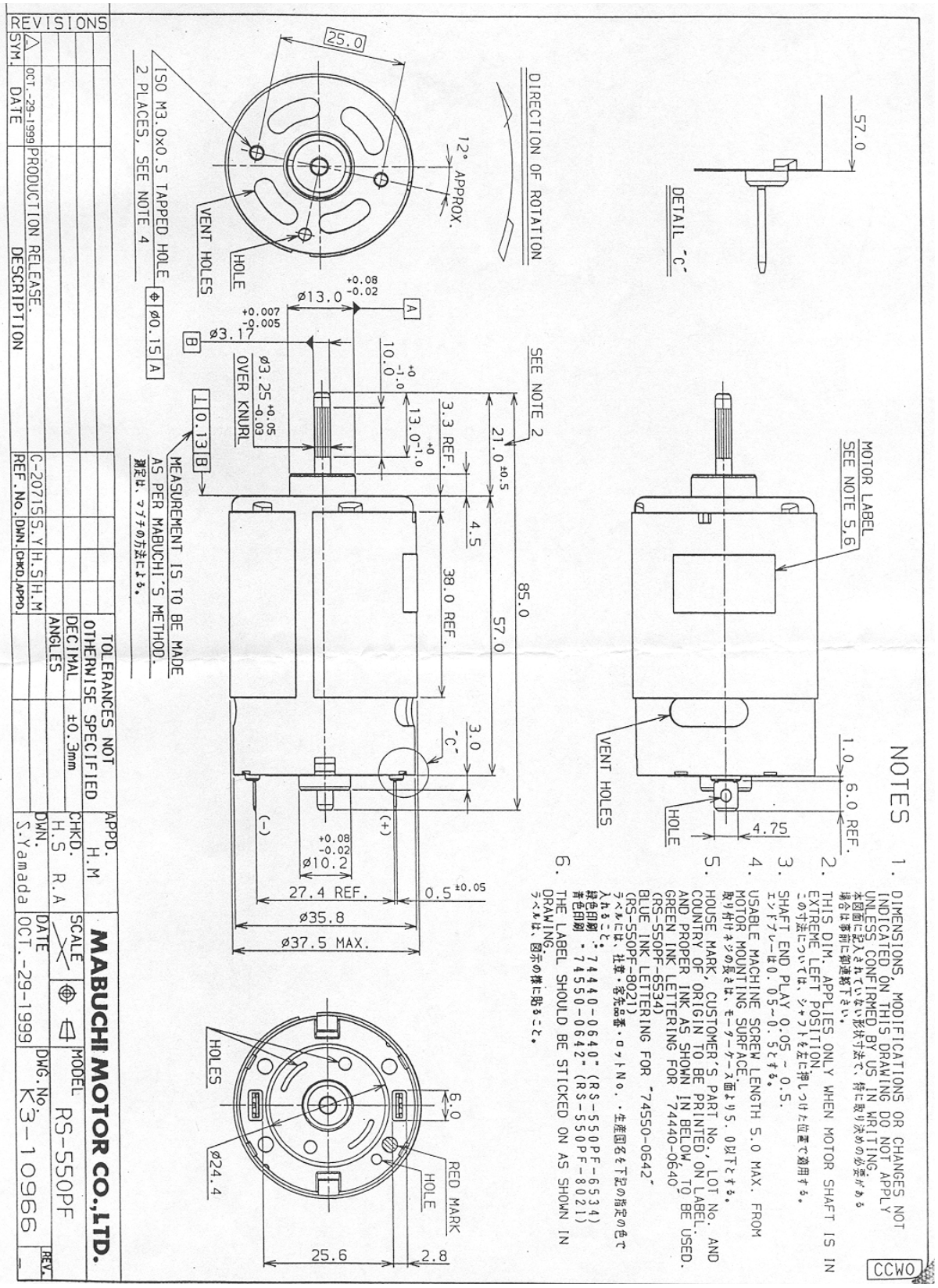


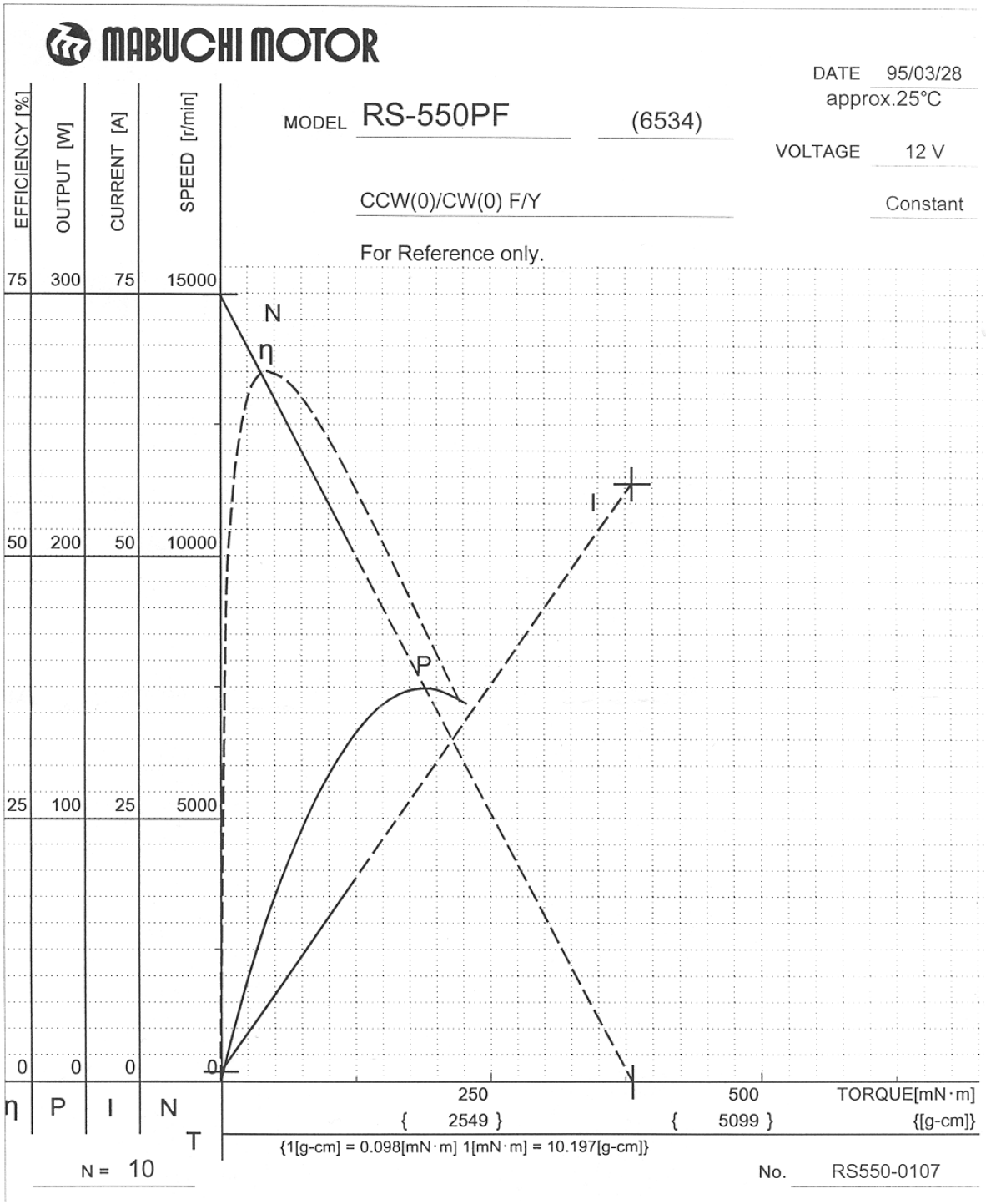
Parameter	Conditions	Min	Typ	Max	Units
DC Input Voltage		7	12	15	V
Forward On-Resistance	Measured at 30A		.0148		Ω
Reverse On-Resistance	Measured at 30A		.0148		Ω
3 FET On-Resistance	Use for comparison	.0037		.0051	Ω
Switching Frequency			2000		Hz
Recommended for Continuous Use				40	A
Current, Low Throttle	FET Thermal Limit			105	A
Current, Full Throttle	FET Thermal Limit			420	A
Current, Continuos	Electrical Limit			348	A
Current, Pulse	<300 µS			1200	A

KEYANG

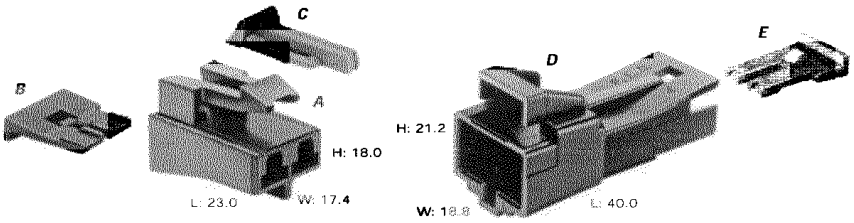
SEAT MOTOR SPEED-TORQUE CURVE




NOTES
1. DIMENSIONS, MODIFICATIONS OR CHANGES NOT INDICATED ON THIS DRAWING DO NOT APPLY UNLESS CONFIRMED BY US IN WRITING.
本図面に記入されていない形状寸法で、特に取り決めの必要がある場合は事前に御連絡下さい。
2. THIS DIM. APPLIES ONLY WHEN MOTOR SHAFT IS IN EXTREME LEFT POSITION
この寸法については、シャフトを左に押しつけた位置で適用する。
3. SHAFT END PLAY 0.05 ~ 0.5.
エンドプレーは0.05~0.5とする。
4. USABLE MACHINE SCREW LENGTH 5.0 MAX. FROM MOTOR MOUNTING SURFACE
取り付けネジの長さは、モーターケース面より5.0以下とする。
5. HOUSE MARK, CUSTOMER'S PART No., LOT No. AND COUNTRY OF ORIGIN TO BE PRINTED ON LABEL. AND PROPER INK AS SHOWN IN BELOW, TO BE USED.
GREEN INK LETTERING FOR "74440-0640" (RS-550PF-6534)
BLUE INK LETTERING FOR "74550-0642" (RS-550PF-8021)
ラベルには、社章・客先品番・ロットNo.・生産国名を下記の指定の色で入れること。
緑色印刷 : "74440-0640" (RS-550PF-6534)
青色印刷 : "74550-0642" (RS-550PF-8021)
6. THE LABEL SHOULD BE STICKED ON AS SHOWN IN DRAWING.
ラベルは、図示の様に貼ること。
CCWO
MOTOR LABEL
SEE NOTE 5,6
VENT HOLES
HOLE
DETAIL "C"
DIRECTION OF ROTATION
12° APPROX.
25.0
ISO M3.0x0.5 TAPPED HOLE
2 PLACES, SEE NOTE 4
MEASUREMENT IS TO BE MADE AS PER MABUCHI'S METHOD.
測定は、マブチの方法による。
SEE NOTE 2
HOLES
RED MARK
REVISIONS
SYM. DATE DESCRIPTION
C-20715 S.Y H.S H.M
REF. No. DWN. CHKD. APPD.
OCT.-29-1999 PRODUCTION RELEASE.
TOLERANCES NOT OTHERWISE SPECIFIED
DECIMAL ±0.3mm
ANGLES
APPD. H.M
CHKD. H.S R.A
DWN. S.Yamada
MABUCHI MOTOR CO.,LTD.
SCALE
DATE OCT.-29-1999
MODEL RS-550PF
DWG.No. K3-10966
REV.



480 • Metri-Pack Series



Total Mated Length: 53.9mm

A PART NO: **12064749**
DESCRIPTION: Connector 2F
SIZE: 23.0L x 18.0H x 17.4W
COLOR: Black
MATERIAL: PA66 HS IM
TERMINALS: See Page 92

B PART NO: **12059860**
DESCRIPTION: TPA
COLOR: Md. Gray
MATERIAL: PA66 HS IM

C PART NO: **12052834**
DESCRIPTION: CPA
COLOR: Green
MATERIAL: PP

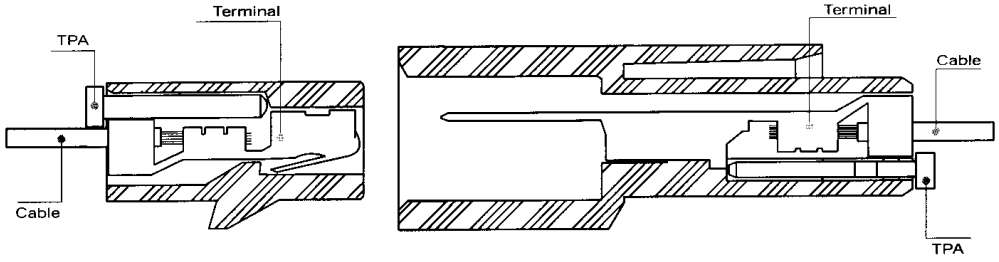
D PART NO: **12064750**
DESCRIPTION: Connector 2M (Clip Slot)
SIZE: 40.0L x 21.2H x 18.8W
COLOR: Black
MATERIAL: PA6
TERMINALS: See Page 93

E PART NO: **12064751**
DESCRIPTION: TPA
COLOR: Natural
MATERIAL: PA66 HS IM

Metri-Pack Series • 480

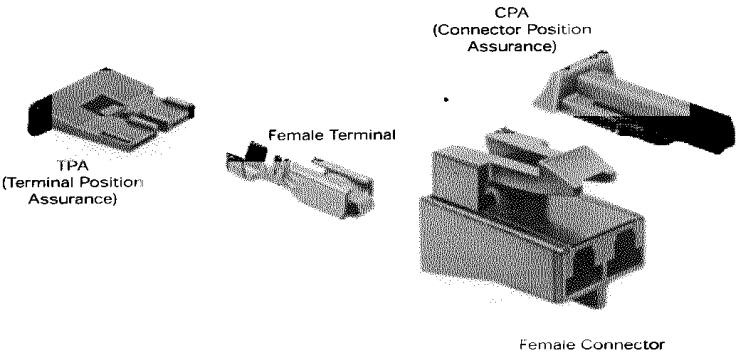
UNSEALED

Cross Sectional View



Female Connector

Male Connector



Female Connector

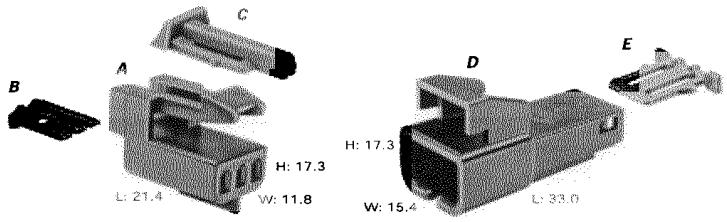
480 FEMALE TERMINALS UNSEALED

Part #	Cable Range (mm²)	Material	Plating
12084595	5.0	Tin Brass	Tin
12052221	3.0	Tin Brass	Tin
12124304	2.0-1.0	Tin Brass	Tin
12015860	0.80	Tin Brass	Tin
12052219	0.50-0.35	Tin Brass	Tin
12020366	1.0-0.50 (1 Req'd.) 0.80-0.50 (1 Req'd.)	Tin Brass	Tin

480 FEMALE CONNECTORS UNSEALED

# Cavities	Connector	Color	Material	TPA
1	12015952	Md. Gray	PA66 HS IM	–
2	12064749	Black	PA66 HS IM	12059860

Metri-Pack Series •150



Total Mated Length: 47.1mm

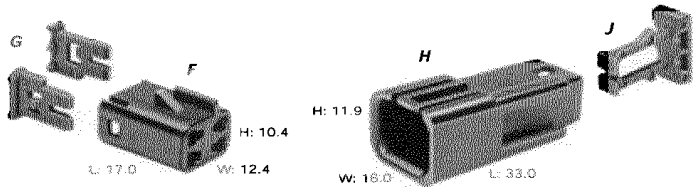
A PART NO: **12064758**
DESCRIPTION: Connector 3F
SIZE: 21.4L x 17.3H x 11.8W
COLOR: Black
MATERIAL: PA66 HS IM
TERMINALS: See Page 54

B PART NO: **12047783**
DESCRIPTION: TPA
COLOR: Md. Gray
MATERIAL: PA66 HS IM

C PART NO: **12052834**
DESCRIPTION: CPA
COLOR: Green
MATERIAL: PP

D PART NO: **12064759**
DESCRIPTION: Connector 3M (Clip Slot)
SIZE: 33.0L x 17.3H x 15.4W
COLOR: Black
MATERIAL: PBT
TERMINALS: See Page 55

E PART NO: **12047784**
DESCRIPTION: TPA
COLOR: Gray
MATERIAL: PBT



Total Mated Length: 42.2mm

F PART NO: **12047785**
DESCRIPTION: Connector 4F
SIZE: 17.0L x 10.4H x 12.4W
COLOR: Black
MATERIAL: PA66 HS IM
TERMINALS: See Page 54

G PART NO: **12047664**
DESCRIPTION: TPA
NUMBER REQ: 2
COLOR: Md. Gray
MATERIAL: PA66 HS IM

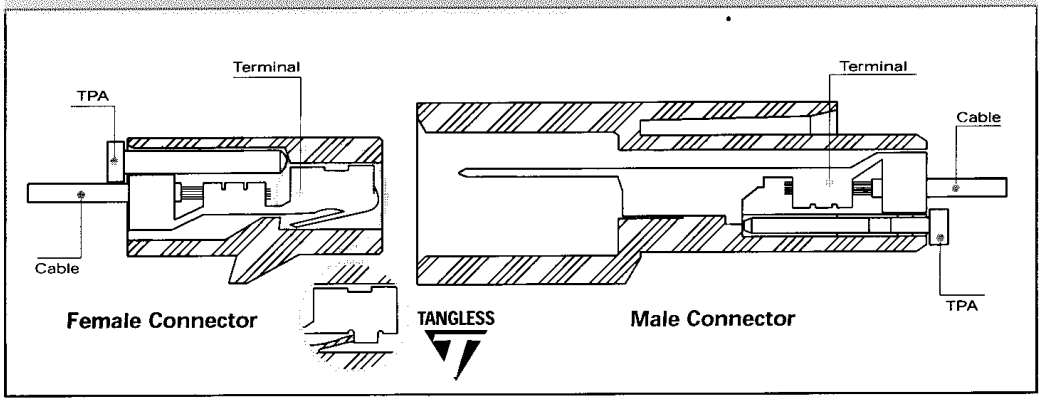
H PART NO: **12047786**
DESCRIPTION: Connector 4M (Clip Slot)
SIZE: 33.0L x 11.9H x 16.0W
COLOR: Black
MATERIAL: PA66 HS IM
TERMINALS: See Page 55

J PART NO: **12047787**
DESCRIPTION: TPA
COLOR: Blue
MATERIAL: PBT

Metri-Pack Series • 150

UNSEALED

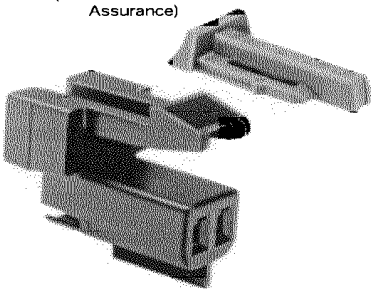
Cross Sectional View



TPA
(Terminal Position Assurance)

Female Terminal

CPA
(Connector Position Assurance)



Female Connector

150 FEMALE TERMINALS UNSEALED

Part #	Cable Range (mm²)	Material	Plating
12047767	1.0-0.80	Silicon Bronze	Tin
12064971	0.50-0.35	Silicon Bronze	Tin

TANGLESS

150 TANGLESS FEMALE TERMINALS UNSEALED

Part #	Cable Range (mm²)	Material	Plating
12129484	1.0-0.80	Silicon Bronze	Tin
12129373	0.5-0.35	Silicon Bronze	Tin

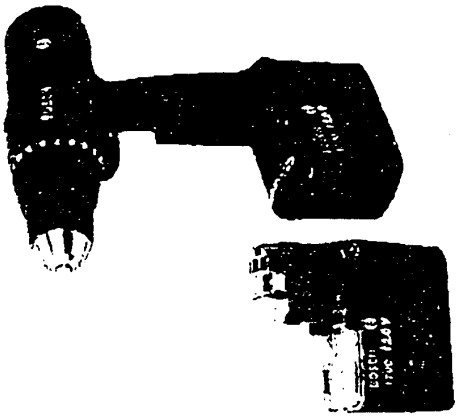
150 FEMALE CONNECTORS UNSEALED

# Cavities	Connector	Color	Material	TPA
1	12047682	Black	PA66 HS IM	–
2	12047662	Black	PA66 HS IM	12047664
2	12052832	Black	PA66 HS IM	12047664
3	12047781	Black	PA66 HS IM	12047783
3	12064758	Black	PA66 HS IM	12047783
4	12047785	Black	PA66 HS IM	12047664
4	12064760	Black	PA66 HS IM	12047664
4	12092162	Black	PA66 HS IM	12092164
6	12064762	Gray	PBT	12064764
8	12047886	Black	PA66 HS IM	12045689
8	12064766	Blue	PBT	12064768
10	12064769	Natural	PBT	12064771

Bosch

BOSCH

PRODUCT SUMMARY



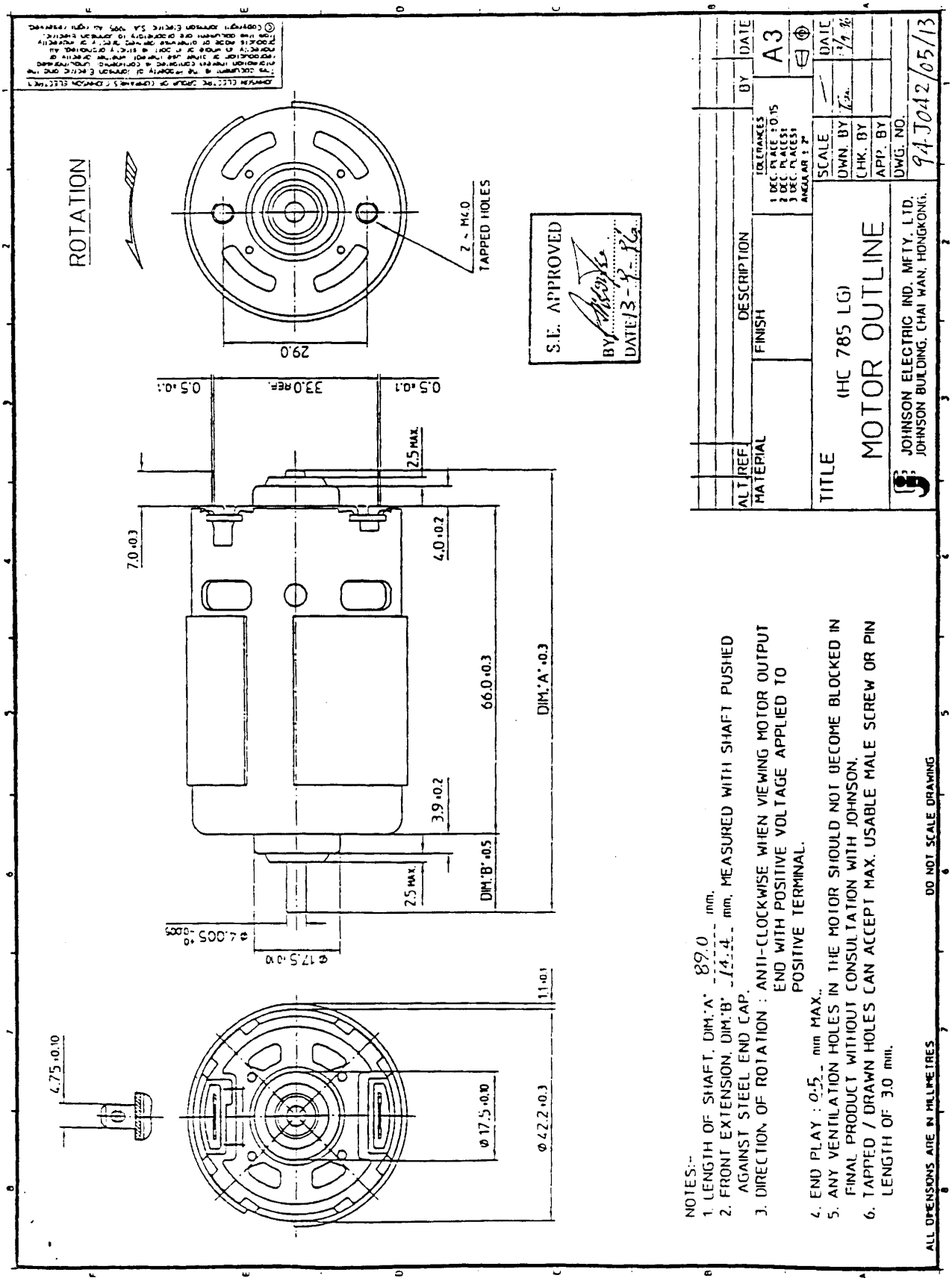
MODEL: 3310K-10

PRODUCT: 12 Volt Drill Driver

UPC CODE: 000 346 301960

KEY PRODUCT FEATURES:

- 12 Volt Power
- 225 Inch Lbs Torque
- T-Handle Styling and Balance
- VSR Switch 0-400 / 0-1200 RPM
- Clutch with 15 Torque Settings



JOHNSON ELECTRIC

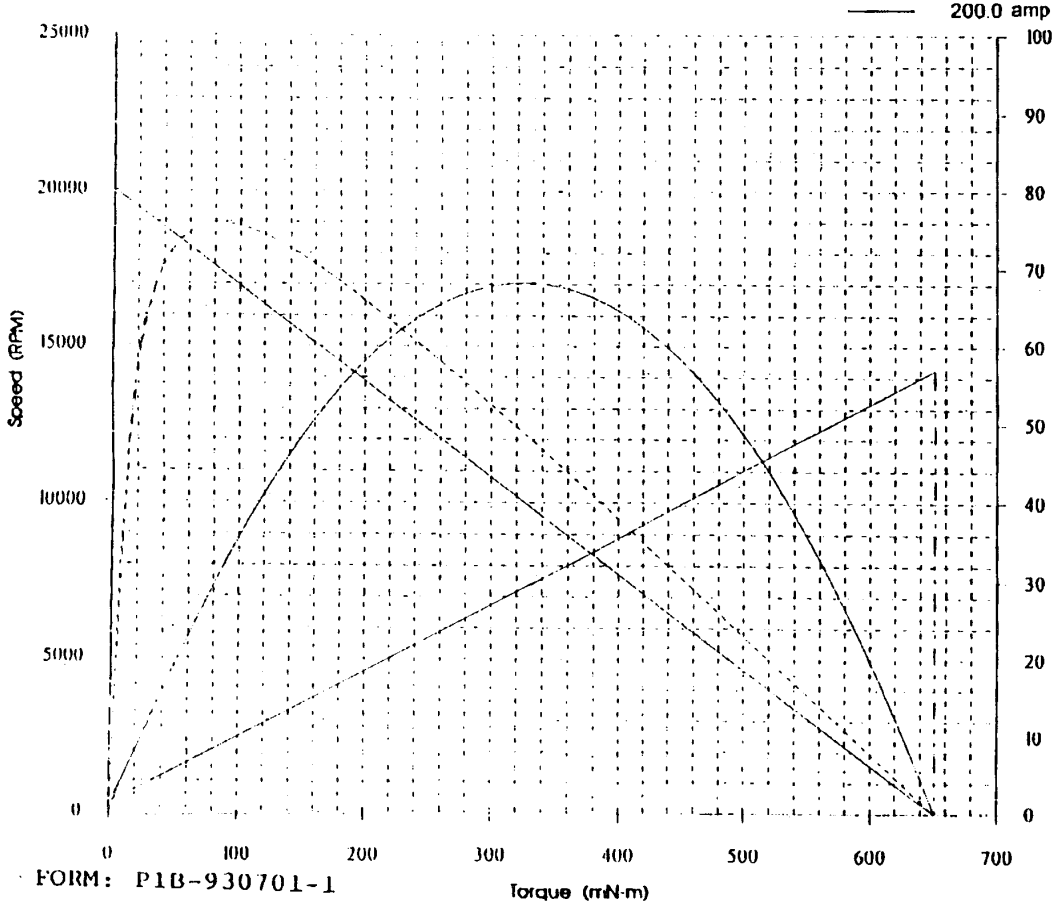
JOHNSON ELECTRIC INDUSTRIAL MANUFACTORY LTD.

35 years of exellence in micromotors

Johnson Building, 14 -16 Lee Chung Street, Hong Kong

SOF NO : 28189 94J042/05/13 Date : 10/09/96
Winding : 80- 10.0
Motor test reference no : HC785LG/ES/35060/3E1/F

Full scale : — ·-·— 100 % eff
------ 500.0 watt
——— 200.0 amp



FORM: P1B-930701-1

Performance (In an ambient temperature of 25-30 °C)
Motor tested rapidly to prevent significant temperature rise.

At a constant voltage of	:	12.00	Volts
With a circuit resistance of	:	0.000	Ohms

At NO LOAD

Speed	:	20023	RPM
Current	:	2.450	AMPS

At stall (Extrapolated)

Torque	:	650.982	mN-m
Current	:	114.002	AMPS

At maximum efficiency

Efficiency	:	75.84	%
Torque	:	84.628	mN-m
Speed	:	17420	RPM
Current	:	16.952	AMPS

At maximum Power output

Output	:	341.02	Watts
Torque	:	325.491	mN-m
Speed	:	10012	RPM
Current	:	58.226	AMPS

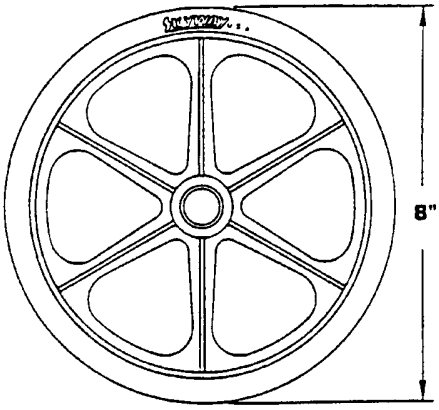
Characteristics

Torque constant	:	5.836	mN-m/AMP
E.M.F. constant	:	5.836	mV/rad/sec
Dynamic resistance	:	0.105	Ohms
Motor regulation	:	30.759	RPM/mN-m

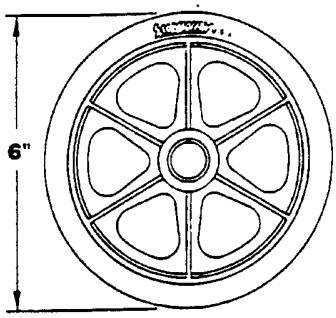
Skyway

4451 Caterpillar Rd., Redding, CA 96003
916/243-5151 (FAX 916/243-5104)

STANDARD UTILITY WHEELS
WHEELCHAIR WHEEL ACCESSORIES
WHEELCHAIR WHEELS
CASTER WHEELS

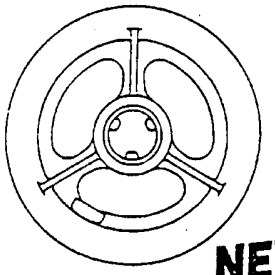


8" CASTER NON-PNEUMATIC



6" CASTER NON-PNEUMATIC

SKYWAY 6" and 8" Non-Pneumatic caster wheels feature a molded DuPont ZYTEL® nylon wheel with a coinjected Monsanto Santoprene® thermoplastic rubber molded-on tire.



NEW

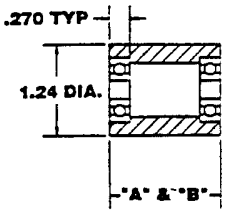
5" CASTER PNEUMATIC OR NON-PNEUMATIC

Accepts 6" x 1-1/4" Pneumatic Tires. Also Accepts Various 5" & 6" Non-Pneumatic Snap-On Tires. Available Only In Hub #1. 1" Precision Bearing.

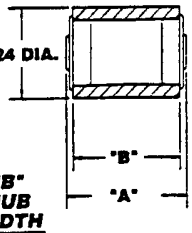
CASTER HUB SPECIFICATIONS

Hub configurations shown are SKYWAY standards, however, if you require a custom design, we stand ready to work with you to create a special hub to suit your needs.

5" Caster Only Available with Standard Hub #1, 1" Overall Width.



HUB #1
Precision Bearing Hub
7/8" O.D. Maximum x 5/16" and 3/8" I.D.'s



HUB #2
Unground, Flanged Bearing Hub
.906 O.D. Maximum x 1/4", 5/16", 3/8" and 7/16" I.D.'s

	BASIC OVERALL	"A" ACROSS BEARING REFERENCE	"B" HUB WIDTH
PRECISION BEARING			
HUB #1 For 5", 6" & 8" casters only	1"	.99	.98
HUB #1 For 6" & 8" casters only	1-1/2"	1.50	1.48
HUB #1 For 6" & 8" casters only	2-3/16"	2.18	2.17
UNGROUND, FLANGED BEARING			
HUB #2 For 6" & 8" casters only	1"	1.23	.98
HUB #2 For 6" & 8" casters only	2-3/16"	2.43	2.17
HUB #2 For 6" & 8" casters only	1-1/2"	1.73	1.48

MODEL VB3: USED WITH THE SAME CONFIDENCE AS A FUSE.

YESTERDAYS TECHNOLOGY

FUSE: Locating a blown plastic incased fuse in the panel is difficult since visual detection can only be made by its removal. Replacement fuses are usually packaged in groups of various ratings which you do not need, or all of the same ratings in anticipation of the need for continuous replacement. The fuse is a very inconvenient, antiquated means of protection.

CIRCUIT BREAKERS: Little improvement has been made in this field in the last 30 to 40 years. In the cycling type the sensoring elements lose contact pressure as the current increases, promotes arcing, tacking and may stick causing the breaker to fail. The non-cycling breakers with the same type sensor, use a heater wire to prevent the contacts from closing, generating excessive heat that can effect the calibration of other breakers, which contribute to the extensive use of the fuse.

DESIRED OBJECTIVES

PROVIDE:

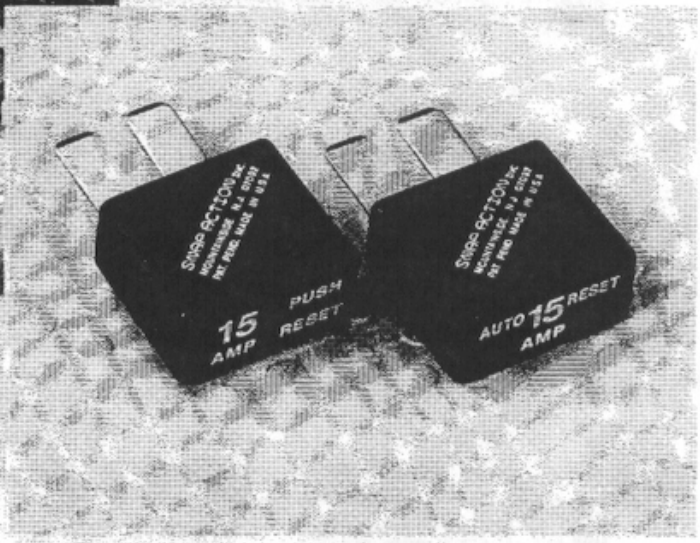
- Calibrated snap acting sensor which opens with significant amplitude, due to maximum current and contact pressure being reached simultaneously.
- Convenient visible evidence of an over-load condition (VB3-M).
- Mechanical means of holding the open circuit condition (SAE Type II).
- Manual means of resetting.
- SAE Type I cycling unit with a well defined timed open/close cycle.
- A small cross-section area of the sensor for a fail-safe condition.
- A size and configuration for fuse replacement.

ELIMINATE:

- Sensors with decreasing contact pressure that tend to arc, tack and weld.
- Heater wires that generate significant heat to maintain an open circuit condition (SAE Type II).
- The large mass of the sensor that will not provide a fail-safe condition.

TO FUSE OR NOT TO RE-FUSE? NO LONGER THE QUESTION.

Locating the cause of overload can take many blown fuses. **ONE MODEL VB3 IS THE ANSWER.**



CAPABLE OF WITHSTANDING NUMEROUS HIGH OVERLOADS YET SENSITIVE ENOUGH TO ULTIMATELY FAIL SAFE.

Model VB3-M (left) & VB3-A (right), shown above with standard terminal configuration.

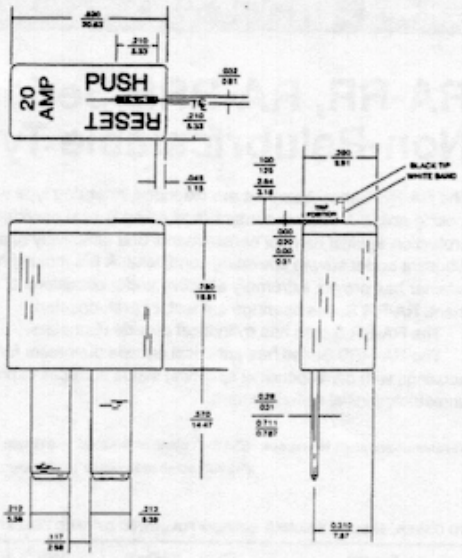
TOMORROWS STANDARD – AVAILABLE TODAY

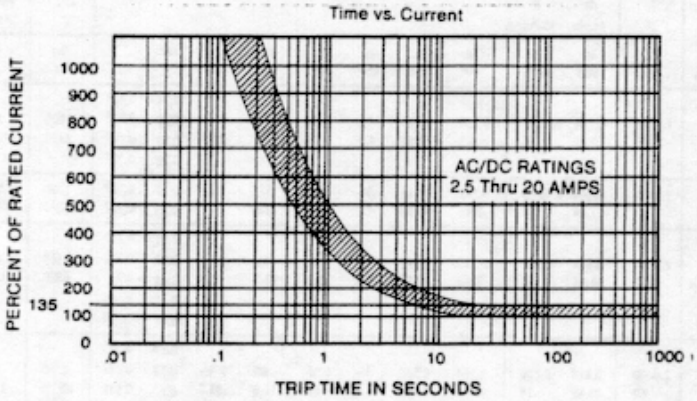
QUALITY:

- Snap Action sensor provides increasing contact pressure to effect trip, and promotes wiping action of contacts.
- Trip time of 2.6 to 6.5 seconds with 200% overload for all ratings.
- Precise correlation of trip time to rating in any unit.
- Must hold 100% — must trip 135%
- Withstands normal start-up and short duration surges without nuisance tripping.
- Fast response time.
- Unusual tolerance to vibration and shock environment.
- 100% final inspection test before the name goes on.

FEATURES:

- Housed in engineering plastic (non-corrosive - U.L. rated 94VO).
- Visual trip indicator is push to rest (Model VB3-M).
- SAE Type (self-resetting) has well defined open/close cycle on over-load. (Model VB3-A)
- Cannot be held manually closed (trip free).
- Ambient compensated (to 40°C).
- Introduces new convenience and quality to circuit protection.





SPECIFICATIONS

MODELS: VB3-A Cycling (SAE Type I), VB3-M Manual, reset non-cycling new concept (SAE Type II)

VOLTAGE: Up to 50 V.D.C.

RATINGS: 3 thru 20 AMPS

TEMPERATURE COMPENSATION: To 40°C

CALIBRATION: Must carry rated current at 25°C & 40°C. Must trip 135% of rating within ten minutes.

RESET TIME: Less than 15 seconds.

3,4,5,6,7.5,10,12.5,15,20 & 25 & 30 AMPS. NOW AVAILABLE

ORDERING INFORMATION

EXAMPLE: VB3- M20 -F57

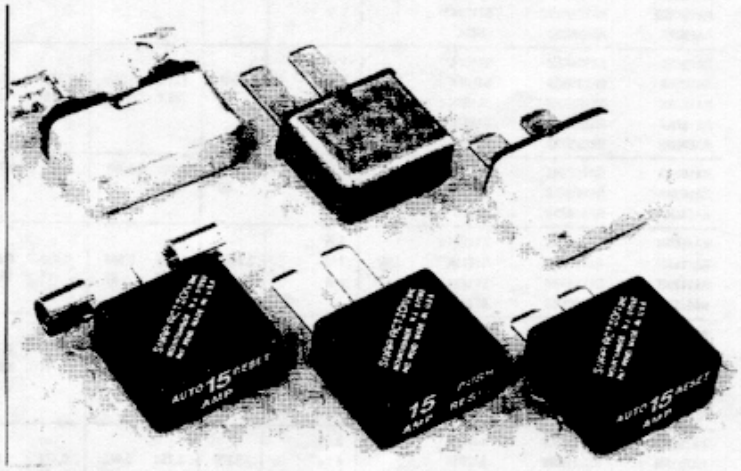
SERIES NUMBER:

TYPE RESET: A (automatic), M (manual)

AMP RATING: 3 thru 20

TERMINAL CONFIGURATION: F57 standard (flat .570x.110x.032). Consult factory for other terminal designs and modifications.

AUTO – TRUCK – RV's
AVIATION – MARINE
GENERATORS – BATTERY CHARGES
AND MANY OTHER
AC OR DC APPLICATIONS



MODEL VB3 REPLACES SENSORS WHICH LOSE CONTACT PRESSURE.

Terminal configuration can be provided to fit nearly any application.

Part 1
QOU Miniature Circuit Breakers and Switches

This part of the catalog introduces QOU miniature circuit breakers and switches. QOUs are individually mounted with lugs on both the line and load end of the circuit breaker or switch. This section covers:

- Construction standards
- Ratings and tripping characteristics
- Catalog numbers used when ordering (to specify the circuit breaker and accessories used with it)
- Return and exchange policies

Part 2, Application Information, provides application information on QOU miniature circuit breakers and switches. They are presented in sections based on their voltage ratings as shown below:

Sections by Voltage Ratings		
Section	Voltage Rating	Page
1	120/240Vac and 240Vac	9
2	277Vac	16

Part 3, Accessories, lists the accessories used with QOU miniature circuit breakers and switches. Ordering information for the accessories is also provided.

The **Glossary defines terms used in this catalog.**

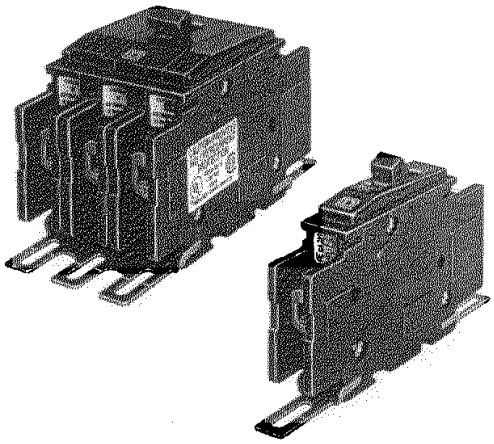
Introduction
A circuit breaker is defined by the National Electrical Manufacturers Association (NEMA) as, "a device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overcurrent, without damage to itself when properly applied within its rating." A molded case circuit breaker is "one that is assembled as an integral unit in a supportive and enclosing housing of insulating material." Miniature molded case circuit breakers are intended for use in residential and commercial applications, and are tested and listed according to UL 489 Standard for molded case circuit breakers and enclosures.

Square D manufactures thermal-magnetic, magnetic only, and electronic trip molded case circuit breakers. QOU miniature circuit breakers and switches are described in this catalog. Molded case thermal-magnetic and magnetic only circuit breakers, along with molded case switches are described in Catalog Class 601. Electronic trip circuit breakers are described in Catalog Class 602. Insulated case electronic trip circuit breakers are described in Catalog Class 603. Catalogs Class 601, 602 and 603 are separate publications available from Square D.

QOU Miniature Circuit Breaker Types

This catalog discusses the following types of miniature circuit breakers:

- QOU Thermal-magnetic circuit breakers
- QOU Non-Automatic Switches



QOU Thermal-Magnetic Circuit Breakers
Thermal-magnetic circuit breakers are the most common overcurrent protection devices. Their primary functions are to provide a means to manually open a circuit and automatically open a circuit under overload or short circuit conditions. Thermal-magnetic circuit breakers use bimetals and electromagnetic assemblies to provide overcurrent protection. Their characteristic inverse time response to overload conditions is ideally suited for many different residential and commercial applications.

QOU Non-Automatic Switches
QOU Non-Automatic switches are intended for use as disconnect devices only. UL Standard 1087 requires switches to be protected by a thermal-magnetic circuit breaker (or fuse) of equivalent rating. QOU switches are UL listed for use on circuits capable of delivering not more than 10,000 amperes when protected by an equivalent rated circuit breaker or fuse.

QOU switches contain no automatic tripping mechanisms and **do not provide overcurrent protection.**

QOU switches are available in two- and three-pole, 60, 100, and 125 ampere construction for 240Vac.

Tripping Mechanisms

A tripping mechanism is an assembly within the circuit breaker molded case that causes the circuit breaker to open automatically under sustained overload or short-circuit conditions.

The tripping mechanisms in two- and three-pole circuit breakers operate such that an overcurrent on any given pole of the circuit breaker will cause all poles of the circuit breaker to open simultaneously. Thermal and magnetic factory calibration (with current) is performed on each pole of every circuit breaker manufactured by Square D.

QOU
Miniature Circuit Breakers and Switches

The following mechanisms operate to trip the circuit breaker:

- Thermal trip
- Magnetic trip
- Optional shunt trip accessory

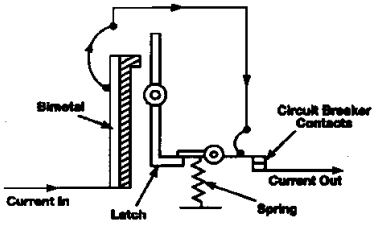
NOTE: Shunt trip is described in **Part 3, Accessories.**

The sensing system of a thermal-magnetic circuit breaker is an integral part of the circuit breaker that continually monitors the current flowing through the circuit breaker. It detects abnormal current conditions and, depending on the magnitude of the current, initiates an inverse-time or an instantaneous tripping response. This action causes the tripping mechanism to open the circuit breaker contacts and interrupt current flow. The speed of the tripping process must be controllable and inversely matched to the severity of the overcurrent. The QOU miniature circuit breaker has an over-center toggle mechanism for quick-make, quick-break action with positive handle indication. The handle assumes a position between ON and OFF when the circuit breaker has tripped.

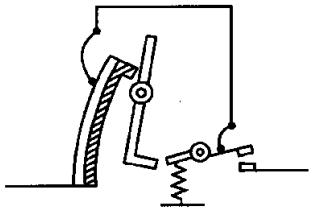
Thermal-magnetic circuit breakers have two tripping elements.

Thermal Trip: The circuit breaker thermal trip element is an rms (root mean squared) current sensing device. The thermal element or bimetal is constructed from metals of dissimilar rates of expansion bonded together. The thermal element responds to overloads by reacting to the heat generated both by the current flowing through the circuit breaker and by the heat contribution from ambient conditions. The bending force of the bimetal causes the circuit breaker to trip. *(See Figure 1.)* The deflection of the bimetal is predictable as a function of current and time. This is the inverse time tripping characteristics of the thermal element (i.e., the tripping time decreases as the magnitude of the current increases).

Square D calibrates the thermal elements and they are not field adjustable. The thermal trip elements are calibrated for 40°C ambient temperature per UL Standard 489.



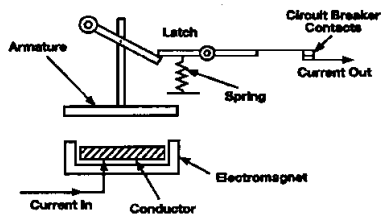
Normal Condition



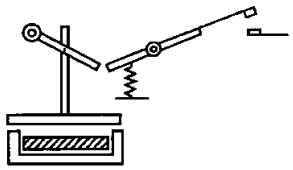
Thermal Trip Condition

Figure 1

Magnetic Trip: The magnetic (instantaneous) trip element uses an electromagnetic assembly to trip the circuit breaker instantaneously (with no intentional delay) at or above a predetermined current value. During a short circuit of sufficient magnitude, the high-level current passing through the conductor rapidly increases the magnetic field of the electromagnet which attracts the armature. As the armature is drawn toward the electromagnet, it initiates an unlatching action and opens the circuit breaker contacts. *(See Figure 2.)*



Normal Condition



Magnetic Trip Condition

Figure 2

Line and Load Connections

QOU miniature circuit breakers are supplied with two types of lug configurations as standard, depending on the continuous current rating.

- 10 - 70 ampere one- and two- pole - reversible lugs
- 10 - 60 ampere three pole - reversible lugs
- Other ampere ratings - forward lugs only

These circuit breakers are provided with box-type lugs that are UL listed to accept copper or aluminum wire. Optional terminations, such as quick connectors are also available. **See Section 3 - Accessories** for more information on terminations.

Mounting Provisions

QOU miniature circuit breakers are supplied with mounting brackets for both line and load side support. Mounting brackets are field installable and can be attached to the front or back of the circuit breaker molded case. **See Section 3 - Accessories** for more information on mounting brackets.

10 - 70 ampere one- and two-pole, and 10 - 60 ampere three-pole QOU's are also supplied with slots in the molded case for DIN rail mounting. These miniature circuit breakers are designed for use with a 7.5 mm X 35 mm DIN mounting rail.

The DIN rail mounting feature will be available on 80-100A one-pole, 80-125A two-pole, and 70-125A three-pole QOUs beginning January 1995.

Trip Indicator

When the QOU miniature circuit breaker is tripped, the handle assumes a position between ON and OFF (the tripped position) and the red VISI-TRIP® indicator appears in a window in the circuit breaker case. The circuit breaker and VISI-TRIP indicator is reset by pushing the handle to OFF and then to ON.

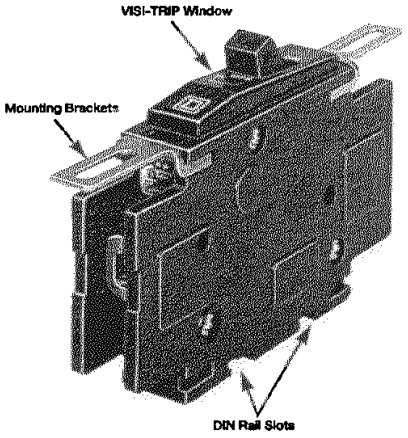


Figure 3

Circuit Breaker Tripping Characteristics

The tripping characteristics of thermal-magnetic circuit breakers are represented by a characteristic tripping curve. The curve shows the amount of time required for a circuit breaker to trip for overcurrent levels through the entire tripping range of the circuit breaker.

Thermal Tripping Characteristics

The top portion of the characteristic tripping curve displays the circuit breaker's thermal response. On overcurrent levels, up to the instantaneous tripping level, thermal tripping occurs when the bimetal in the circuit breaker responds to heat associated with the overcurrent. The larger the overcurrent, the faster the circuit breaker operates to open the circuit (inverse time).

Magnetic (Instantaneous) Tripping Characteristics

The bottom portion of the tripping curve displays the instantaneous tripping response of the circuit breaker. This takes place when overcurrents of sufficient magnitude operate the magnetic tripping mechanism. Magnetic tripping occurs with no intentional delay.

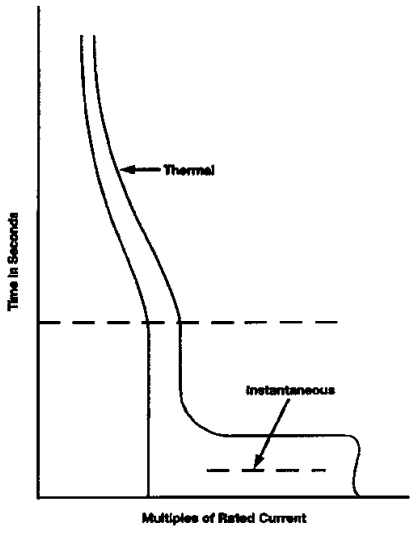


Figure 4

Construction

Square D QOU miniature circuit breakers are manufactured and tested according to the following standards:

- UL Standard 489
- NEMA Standard AB-1
- Canadian Standards Association CSA C22.2 No. 5.1

QOU switches comply with:

- UL Standard 1087
- Canadian Standards Association CSA C22.2 No. 5.2

NOTE: Circuit breakers are to be applied by guidelines detailed in the NEC and other applicable electrical codes.

Specifications

Cases for QOU miniature circuit breakers and switches are constructed of a glass-reinforced insulating material that provides high dielectric strength. Current carrying components are isolated from the handle. The handle position indicates whether the circuit breaker is OFF, ON, or tripped.

QOU miniature circuit breakers:

- have common tripping of all poles
- have a VISI-TRIP® trip indicator
- can be flush, surface, or DIN rail mounted
- operate in any position
- are fully tested, UL Listed, and CSA certified for reverse connection without restrictive line/load markings

QOU
Miniature Circuit Breakers and Switches

Tripping System
QOU miniature circuit breakers have a permanent trip unit that contains a factory preset thermal and magnetic trip element in each pole. The thermal trip element is rms sensing.

Terminations
The box-type lugs supplied on QOU miniature circuit breakers are UL listed to accept solid or stranded, aluminum or copper conductors. These lugs are UL listed to be used with wire rated at 60°C, 75°C and 90°C (sized according to the NEC 75°C temperature rating). See **Section 3 - Accessories** for more information on terminations.

UL Requirements
A UL label on the QOU miniature circuit breaker indicates that the circuit breaker meets the requirements of UL Standard 489 for molded case circuit breakers.

A UL label also means the production procedure is monitored by UL inspectors for continuing conformance to UL performance requirements. These requirements are based on sound engineering principles, research, records of test and field experience, and information gathered from users and inspection authorities.

UL HACR Type
Fifteen through sixty (15 - 60) ampere one-, two-, and three-pole QOU miniature circuit breakers are UL listed as HACR type. HACR is a term used to designate circuit breakers which have been certified to be used on heating, air conditioning and refrigeration loads. This means that these circuit breakers can be used to meet the requirements of Sections 430 and 440 of the NEC. Article 430-53(c) indicates that each circuit breaker must be of the inverse-time type and be approved for group installation. Section 440 lists the requirements for application and selection of the branch circuit overcurrent protective device for air conditioning and refrigeration equipment.

High Magnetic
QOU-HM circuit breakers are recommended for area lighting (athletic fields, parking lots, outdoor signs, etc.) when using lamps of inherent high inrush current or individual dimmer applications. These circuit breakers are available in 15 and 20 amperes only.

QOU-HM circuit breakers are manufactured with the magnetic trip point calibrated at a higher level than standard QOU circuit breakers. The table below lists the magnetic trip levels to which high magnetic circuit breakers are calibrated.

Circuit Breaker	Maximum Full Cycle Magnetic Hold Level
15 ampere	315 to 525 amperes
20 ampere	322 to 537 amperes

UL 489 Test Procedures

Limited Available Fault Current Tests
UL requires a series of tests on a single set of sample circuit breakers for compliance with UL Standard 489. The tests for thermal-magnetic circuit breakers are described below.

Since QOU switches are derivatives of QOU miniature circuit breakers, some testing of switches is identical to that for circuit breakers. These tests include a 600% overload performance test.

200% Thermal Calibration
Each pole of the circuit breaker must trip within a specified time limit when carrying 200% of its ampere rating.

135% Thermal Calibration
With all poles connected in series, the circuit breaker must trip within a specified time limit when carrying 135% of its ampere rating.

Overload
The circuit breaker is operated making and breaking 600% of its ampere rating, but not less than 150A.

For circuit breakers through 100A, the number of 600% operations is 35 manual open and close and 15 manual close and automatic open. For 125A circuit breakers, the number of operations is 50 manual open and close.

Temperature Rise
While carrying 100% of rated current at a 40°C ambient temperature and mounted in open air, the circuit breaker is checked for temperature rise on a wiring terminal. The temperature rise must not exceed a 50°C rise above ambient temperature and must be within specified limits.

Endurance
The circuit breaker must successfully complete the number of switching operations shown in the following table. One switching operation includes a motion to turn the circuit breaker "ON", and a motion to turn the circuit breaker "OFF".

Amperes	Full Load Operations	No Load Operations
0-100	6,000	4,000
125	4,000	4,000

Switching Duty
The switching duty (SWD) listing applies only to 15A and 20A circuit breakers rated at 277Vac or less. The circuit breakers are subjected to specified temperature rise tests at predetermined periods during the endurance operations.

Calibration Retest
Both the 200% and 135% thermal calibration tests are repeated.

Short Circuit
For circuit breakers rated 240V, two short-circuit tests per pole and one test with all poles connected in series are performed.

For example, a 3-pole circuit breaker receives seven short circuit tests.

For circuit breakers rated 120/240V, three tests are made with all poles connected in series.

The circuit breaker is connected to the test circuit using wire correctly sized for the rating of the circuit breaker. The line leads are not more than 4 feet in length and the load leads are not more than 10 inches in length

An additional short-circuit bus connected test is required for frame sizes or construction groups below 100 amperes.

NOTE: Successful testing requires that the current be interrupted while maintaining the integrity of all conductors and connections.

Trip Out
The 200% thermal calibration test is repeated following the short circuit tests.

Dielectric
The circuit breaker must withstand, for one minute, twice its rated voltage plus 1000V:

- Between line and load terminals with the circuit breaker open, that is, with the circuit breaker either tripped or OFF,
- Between terminals of opposite polarity with the circuit breaker closed, and
- Between live parts and the overall enclosure with the circuit breaker both open and closed.

No conditioning of the circuit breaker can take place during or between tests. There also can be no failure of functional parts at the conclusion of the sequences.

High Available Fault Current Tests

After qualifying a set of circuit breakers to the standard tests, a manufacturer can have additional circuit breaker samples tested on higher than standard available fault currents.

The following performance requirements apply:

200% Thermal Calibration
Each pole of the circuit breaker must trip within a specified time limit when carrying 200% of its continuous current rating.

Short Circuit
With the load side terminals connected by 10 inch lengths of specified wire, the circuit breaker is exposed to a short-circuit current. After successful interruption the circuit breaker is reset and closed again on the short circuit.

Trip Out
Each pole of the circuit breaker must trip within a specified time limit when carrying 250% of its continuous current rating.

Dielectric Withstand
The circuit breaker is subjected to twice its rated voltage, but not less than 900V.

Ratings for QOU Miniature Circuit Breakers

QOU circuit breakers are selected by their ratings. The ratings must meet or exceed the parameters of the electrical system on which they are used.

Voltage Rating
A circuit breaker can be rated for alternating current (ac) or direct current (dc) or both. The established voltage rating of a circuit breaker is based on design parameters such as clearance of current carrying parts and dielectric withstand tests both through air and over surfaces. Voltage ratings indicate the maximum voltage for the electrical system on which the circuit breaker can be applied. QOU miniature circuit breakers are available in the following voltages:

- 120/240Vac
- 240Vac
- 48Vdc
- 60Vdc
- 277Vac available as UL 1077 recognized supplementary protector only (not a branch circuit breaker).

Continuous Current Rating
The continuous current rating (or handle rating) of a circuit breaker is defined by NEMA as: "The maximum direct current or rms current, in amperes, at rated frequency which a device or assembly will carry continuously without exceeding the specified limits of observable temperature rise." QOU circuit breakers are available in the following continuous current ratings: 10A, 15A, 20A, 25A, 30A, 35A, 40A, 45A, 50A, 60A, 70A, 80A, 90A, 100A, and 125A.

UL Standard 489 states that circuit breakers must carry 100% of their continuous current rating indefinitely (without tripping) at 40°C in free air. QOU circuit breakers are rated, per the NEC, to carry 80% of their continuous current ratings in the intended enclosure. The continuous current rating is indicated on the handle of each circuit breaker.

Interrupting Ratings
The interrupting rating of a circuit breaker is the highest current at rated voltage that the circuit breaker is intended to interrupt under standard test conditions. Circuit breakers must be chosen with interrupting ratings equal to or greater than the available short circuit current at the point where the circuit breaker is applied in a system.

Circuit Breaker Type	Number of Poles	Ampere Rating	UL Listed Interrupting Rating RMS Sym. Amps.			
			ac Volts		①dc Volts	
			120/240	240	48	60
QOU	1	10-70	10 kA	NA	5 kA	NA
		80-100	10 kA	NA	NA	5 kA
	2	10-70	10 kA	NA	5 kA	NA
		80-125	10 kA	NA	NA	5 kA
	3	10-70	NA	10 kA	5 kA	NA
		80-100	NA	10 kA	NA	5 kA
QOU-H	2	15-30	NA	5 kA	NA	NA

① dc ratings do not apply to circuit breakers rated for 10 amperes
NA = Not applicable

QOU
Miniature Circuit Breakers and Switches

Ambient Temperature Rating

To meet the requirements of UL Standard 489 and CSA, thermal-magnetic circuit breakers are designed, built and calibrated for use on 50/60 Hertz (Hz) AC systems in a 40°C ambient temperature.

The ambient temperature is the temperature of the air surrounding a circuit breaker. Thermal-magnetic circuit breakers are temperature sensitive devices, and their rated continuous current carrying capacity is based on a UL specified 40°C calibration temperature. The ambient temperature can affect the thermal (overload) tripping characteristics of thermal-magnetic circuit breakers. When applying the circuit breaker at a temperature other than 40°C, it may be necessary to rerate the circuit breaker to compensate for ambient conditions. Conductors are sized using the ampacity rerating factors shown on the bottom of NEC Table 310-16 when designing systems for ambient temperatures other than 40°C.

Thermal-magnetic circuit breakers use bimetal strips that bend in response to temperature changes. Current flowing through the circuit breaker creates most of the heat that causes the tripping action. The ambient temperature surrounding the circuit breaker either adds to or subtracts from this available heat.

Rerating of Thermal-Magnetic Circuit Breakers for Ambient Conditions

Square D thermal-magnetic circuit breakers are to be applied in ambient temperatures within a range of -10°C to +60°C. Use the following rerating guidelines:

1. At ambient temperatures between 25°C and 40°C, no rerating is necessary.
2. At ambient temperatures between -10°C and +25°C, thermal-magnetic circuit breakers carry more than their continuous current rating without tripping. Wire and equipment damage can result if they are not in the same low ambient environment as the circuit breaker.

   If closer protection of the equipment and wire is required, the increased current carrying capacity of the circuit breaker at the lower ambient temperature should be taken into consideration.
3. At ambient temperatures between 41°C and 60°C thermal-magnetic circuit breakers carry less than their continuous current rating and must be carefully selected to prevent nuisance tripping.

The following procedure is used to determine the continuous current carrying capacity of a thermal-magnetic circuit breaker at an ambient temperature other that 40°C:

1. Refer to the ambient rerating curve, *Figure 5*.
2. Select the curve for the specific amperage rating of the circuit breaker involved. Note that the curve crosses the 40°C ambient temperature line at the circuit breaker's UL Listed continuous current rating (handle rating).
3. Follow the curve to the ambient temperature in which the circuit breaker will be installed.
4. Read the continuous current carrying capacity at the left axis point.
5. Apply any other applicable factors, such as 80% loading per the NEC.

For example, *Figure 5* shows the ambient rerating curves for QOU miniature circuit breakers. Determine the continuous current carrying capacity of an 80A circuit breaker applied at 50°C by finding 50 on the horizontal axis and reading up to the 80A curve and over to the vertical axis on the left-hand side. The circuit breaker is rerated to carry 75A when applied at 50°C. If the circuit breaker is used on a continuous load (three hours or more), Paragraph 220-3(a) of the NEC requires that loading not exceed 80% of the rating (75A x .80 = 60A).

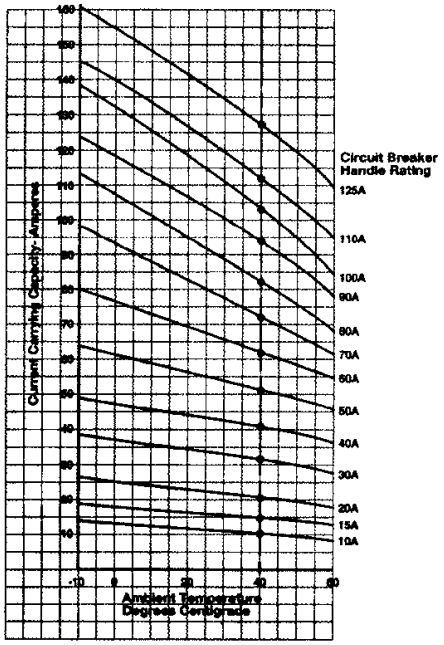


Figure 5

Frequency Rating

The standard rated frequency for circuit breakers is 60 Hz, but Square D circuit breakers can be applied on 50 Hz systems without thermal or magnetic rerating. Other frequencies can affect the thermal, magnetic and short-circuit tripping characteristics of circuit breakers.

Applying thermal-magnetic circuit breakers at frequencies above 50/60 Hz requires special consideration of the effects of high frequency on circuit breaker tripping characteristics. Thermal and magnetic operations must be treated separately.

Thermal Tripping Performance

At frequencies below 60 Hz, the thermal rerating of thermal-magnetic circuit breakers is negligible. However, at frequencies above 60 Hz, thermal rerating is required. High frequency operation causes abnormal heat rise in the current carrying parts because of the skin effect. One of the most common frequency applications is at 400 Hz.

See *Figure 6*. For example , when applying a 100A QOU circuit breaker on a 400 Hz system, the circuit breaker's current carrying capacity is as follows:

- Non-continuous loads (less than three hours): The QOU circuit breaker may be applied at .78 of its rating, or 78A.
- Continuous loads (three hours or more): Paragraph 220-3(a) of the NEC requires that circuit breaker loading does not exceed 80% of its rating when used for continuous loads. Therefore the current carry capacity of a 100A QOU circuit breaker operating under continuous load at 400 Hz would be 100 x .78 x .80 = 62A.

At frequencies above 60 Hz, the interrupting rating of thermal-magnetic circuit breakers is less than the 60 Hz interrupting rating. Unless specifically marked for use on 400 Hz systems, the interrupting rating of Square D circuit breakers is reduced to 1/10th of the 60 Hz interrupting rating.

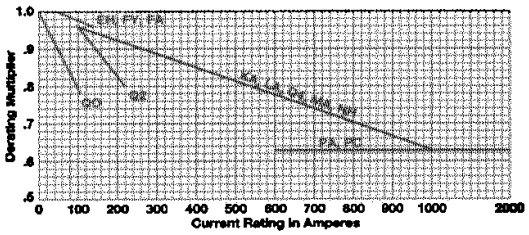


Figure 6: 400 Hz Thermal Rerating Multiplier

Magnetic Tripping Performance

At frequencies above 60 Hz, more current is necessary to magnetically trip a circuit breaker than at 60 Hz. *Figure 7* shows the multipliers of 60 Hz current that it takes to magnetically trip a circuit breaker when applied at various frequencies. For example, at 60 Hz it takes 700 amperes or more to magnetically trip a 100A QOU circuit breaker. At 400 Hz it takes 1820 amperes (2.6 multiplier) or more to magnetically trip the same circuit breaker.

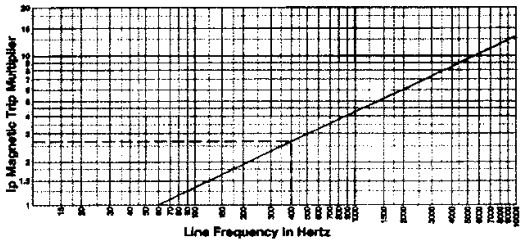


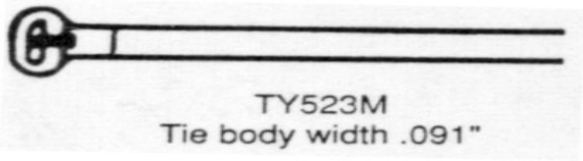
Figure 7: 60 Hz Current Multipliers

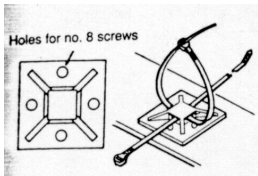
Thomas&Betts

Standard nylon 6/6 cable ties

Cat. No.	Bulk Pkg. Cat. No.	Body Width (in.)	Length (in.)	Max. Wire Bundle Dia. (in.)	Tensile Strength (lbs.)
TY52315M	TYB2315M	0.091	7.00	1.500	18

Cable ties made from natural nylon 6/6 are excellent performers in most applications. Nylon 6/6 is recommended for use in temperatures ranging form 185°F to -40°F.





Accepting cable ties in either of two directions at 90°, this nylon, adhesive-backed base has two advantages: It eliminates errors in pre-mounting the base with respect to its orientation to wire bundle direction. It also is a convenient way to mount wire bundles at cross-over points. Four optional mounting holes are included.

Two-way adhesive mounting base

Bulk Pkg. Cat. No.	Mounting Method	Maximum Tie Width Accom.	Width (in.)	Length (in.)	Material	Bulk Pkg. Quan.
TC345AFR	Adhesive	.190	.125	.125	Flame retardant	1000
TC345AX	Adhesive	.190	.125	.125	Weatherable nylon	

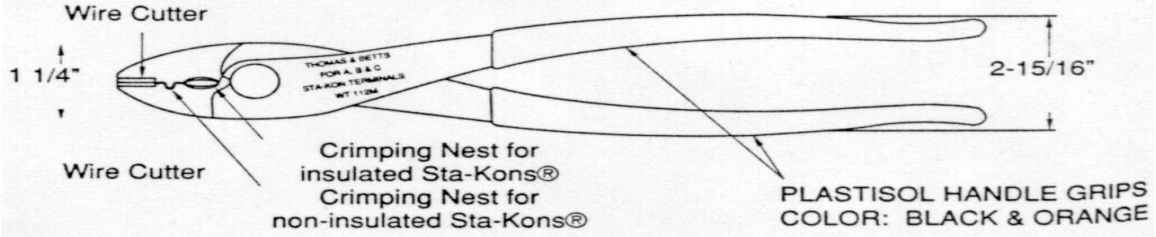
WT111M

WT112M

These tools are designed in a variety of styles—some with wire cutters and strippers—for installation of the various STA-KON terminal series. #22-10 AWG wire range.

Plier Type Tools

Cat. No.	Description	Std. Pkg.	Wt. Each
WT110M	A, B, C non-insulated terminal and splices and A, B non-insulated terminals with insulation grip	1	1
WT111M	A, B, C, PT non-insulated terminal and splices	1	1
WT112M	RA, RB, A, B, C, non-insulated and RC insulated nylon and vinyl terminal and splices	1	1



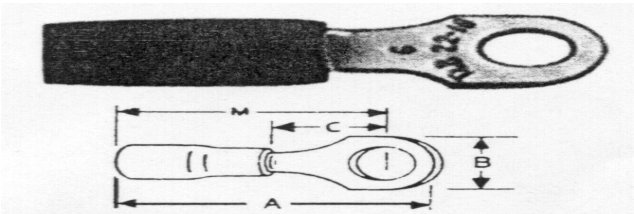
WT112M

Installs insulated and non-insulated Sta-Kon terminals, splices, disconnects, and wire joints 22-10 AWG.

Nylon Insulated Ring - Insulation Grip

Cat. No.	Bulk Pkg. Cat. No.	Wire Range	Max. Ins.	Bolt Hole	Wt./Lbs. Per 1000	Dimensions A	B	C	M
	RAX63*	26-24	0.125	#6	3	0.57	0.25	0.22	0.72
RA18-6	RA853	22-16	0.136	#6	2	0.83	0.26	0.25	0.71
RC10-6	RC333	12-10	0.210	#6	3	1.00	0.37	0.27	0.81
RE6-14	RE267	6-5	0.420	#10	16	1.65	0.49	0.28	1.40

Not Listed By U.L. CSA
Installing tools: WT200, WT112M, WT145C, WT1455, ERG-2001, ERG-2003, WT145A, WT2130A (RC, RBC)

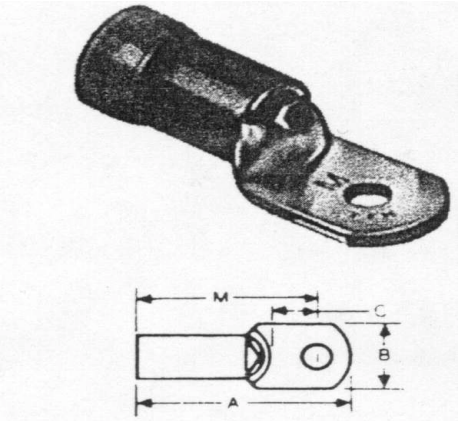


Self-insulated with high dieletric-strength nylon sleeves, these ring terminals are recommended for temperatures up to 105°C. An inner bronze insulation grip sleeve lengthens the flexing radius of the conductor and eliminates conductor creep. The nylon jacket is color-coded:

Color Code	*Wire Range*
yellow	*26-22*
red	*22-16*
blue	*18-14*
yellow	*12-10*

Most standard bulk catalog numbers can be put on Mylar Tape for reel fed applications (i.e. 12050 tool and application dies). See page O1149.

Please put the suffix M for Mylar Tape RA2573M.



Stock Thickness:

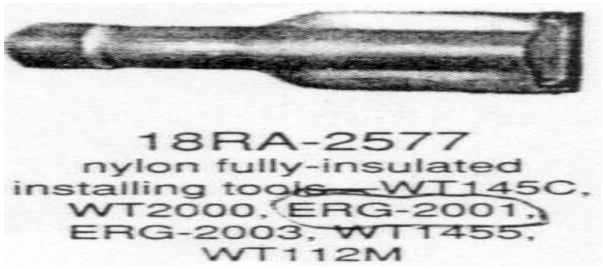
RH = .05
RJ = .06
RK = .06
RL = .07
RM = .07
RE = .04
RF = .04
RG = .05

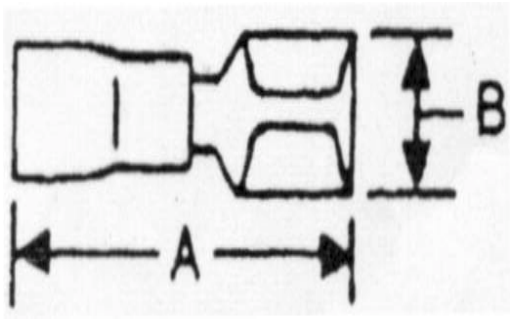
Disconnect terminals provide a quick, reliable method of connection to terminal blocks and boards without the use of tools. They are supplied in a variety of styles to meet virtually all quick-disconnect requirements. Female disconnect terminals and matching male tabs accommodate a range of 22-10 AWG, and are available in non-insulated, partially insulated, and fully insulated styles, in both nylon and vinyl. They are available in various tab widths including 0.250", 0.187" and 0.110", and a combination size. A unique construction of the female disconnect offers long term dependability. The brazed seam serrated barrel provides maximum tensile strength.

250 Series - Female Disconnects

Cat. No.	Bulk Pkg. Cat. No.	Wire Range	Max. Ins.	Tab Size	Wt./Lbs. Per 1000	Dimensions A	B
18RA-2577	RA2573	22-18	0.165	0.250 x 0.032	3	0.97	0.38
14RB-2577	RB2573	16-14	0.185	0.250 x 0.032	4	0.97	0.38
10RC-2577	RC2573	12-10	0.225	0.250 x 0.032	5	1.04	0.38

Material: brass, Finish: tin plated

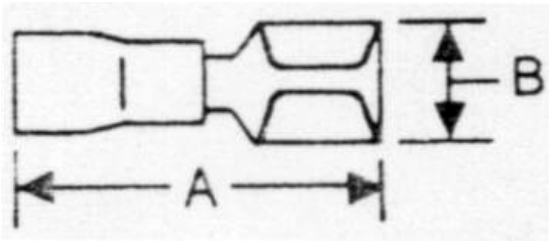


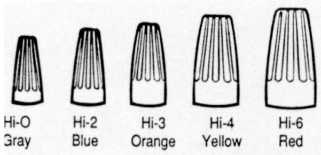


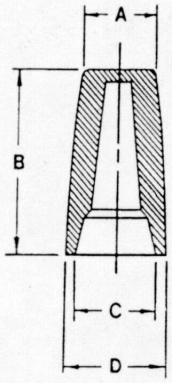
250 Series - Male Tabs

Cat. No.	Bulk Pkg. Cat. No.	Wire Range	Max. Ins.	Tab Size	Wt./Lbs. Per 1000	Dimensions A	B
18RA-251T	RA25177	22-18	0.150	0.250 x 0.032	5	1.13	0.45
14RB-251T	RB25177	16-14	0.170	0.250 x 0.032	5	1.13	0.45
10RC-251T	RC25177	12-10	0.210	0.250 x 0.032	5	1.17	0.45

Material: brass, Finish: tin plated







Easy Installation

Wire connectors are easy to use. They give you a mechanical advantage over conventional wire connectors.

1. Simply strip wires and push them firmly into our wire connector.
2. Twist the specially designed, comfortable feeling serrated cap tightly.
3. The internal wire spring produces a pressure that forms the wires into a tight, dependable joint.

Fixed Spring

Cat. No.	Color Code	Wire Range (AWG)	Min.	Max.	Voltage Rating	Dimensions A	B	C	D	Unit Qty.	Std. Pkg
10-100	Gray	22 to 16 Solid or Stranded	1#20 w/1#22	2#16		.203	.562	.328	.250	1	1000
10-102-H	Blue	22 to 14 Solid or Stranded	3#22	3#16	300 Volt Max.	.250	.687	.375	.312	1	1000
10-103-H	Orange	22 to 14 Solid or Stranded	3#22	2#14 1#18	600 Volt Max.	.312	.843	.437	.375	1	1000
10-104	Yellow	18 to 10 Solid or Stranded	1#14 w/1#18	1#10 w/1#14	Building Wire 1000 V.	.406	.937	.546	.468	1	1000
10-106-H	Red	18 to 10 Solid or Stranded	2#14	3#12	Max. in Signs & Fixtures	.468	1.04	.656	.531	1	1000

WIDE INNER RING BEARINGS

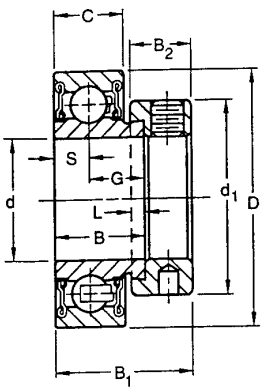
RA-RR, RA-RRB Series Non-Relubricatable Types

The RA-RR Series bearings are extended inner ring type with self-locking collar. A positive contact, land riding R-seal provides improved protection against harmful contaminants and effectively retains the lubricant under severe operating conditions. A 6/6 molded nylon retainer has proven extremely effective under conditions of misalignment. RA-RR Series bearings are factory prelubricated.

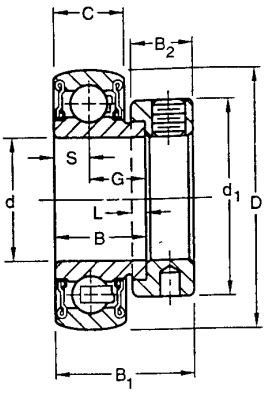
The RA-RR Series has cylindrical outside diameters.

The RA-RRB Series has spherical outside diameters for use in housings with corresponding spherical inside surfaces to provide unrestricted initial self-alignment.

Recommended shaft tolerances: 1/2"-1 15/16", nominal to -.0005", -.013mm; 2"-2 3/16", nominal to -.0010", -.025mm.



RA-RR Two Seals
Cylindrical O.D.



RA-RRB Two Seals
Spherical O.D.

TO ORDER, SPECIFY BEARING NUMBER FOLLOWED BY "AND COLLAR". EXAMPLE: RA100RRB AND COLLAR.

Bearing Number Cylindrical O.D.	Bearing Number Spherical O.D.	Collar Number	Basic Outer Size	Bore[1] d	O.D. D	Ring Widths B Inner	Ring Widths C Outer	S	G	L	d_1	B_2	B_1	Brg. & Collar Wt.		Static Load C_O	Extended Dynamic Rating C_E
				in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	lbs	kg	lbs N	lbs N
RA008RR	RA008RRB	S1008K		1/2										0.34	0.154		
RA009RR	RA009RRB	S1009K		9/16	1.5748	0.750	0.512[2]	0.256	0.494	9/32	1 1/4	17/32	1 1/8	0.32	0.145	1000	2360
RA010RR	RA010RRB	S1010K	203	5/8	40	19.05	13	6.5	12.55	4.0	28.6	13.5	28.6	0.28	0.127	4400	10600
RAE17RR	RAE17RRB	SE17K		17										0.28	0.127		
RA012RR	RA012RRB	S1012K	204	3/4	1.8504	0.844	0.591[3]	0.295	0.548	9/32	1 5/16	17/32	1 7/32	0.29	0.132	1400	3200
RAE20RR	RAE20RRB	SE20K		20	47	21.44	15	7.49	13.92	4.0	33.3	13.5	31	0.29	0.132	6200	14300
RA013RR	RA013RRB	S1013K		13/16										0.51	0.231		
RA014RR	RA014RRB	S1014K	205	7/8	2.0472	0.844	0.591	0.295	0.548	9/32	1 1/2	17/32	1 7/32	0.47	0.213	1560	3450
RA015RR	RA015RRB	S1015K		15/16	52	21.44	15	7.49	13.92	4.0	38.1	13.5	31	0.44	0.2	6950	15600
RA100RR	RA100RRB	S1100K		1										0.41	0.186		
RAE25RR	RAE25RRB	SE25K		25										0.41	0.186		
RA101RR	RA101RRB	S1101K		1 1/16										0.77	0.349		
RA102RR	RA102RRB	S1102K		1 1/8	2.4409	0.938	0.709	0.354	0.583	9/32	1 47/64	5/8	1 13/32	0.72	0.327	2280	4800
RA103RR	RA103RRB	S1103K	206	1 3/16	62	23.82	18	8.99	14.81	4.0	44.1	15.9	35.7	0.7	0.318	10000	21600
RA103RR2	RA103RRB2	S1103K3		1 1/4										0.65	0.295		
RAE30RR	RAE30RRB	SE30K		30										0.7	0.318		
RA104RR	RA104RRB	S1104K		1 1/4										1.24	0.562		
RA105RR	RA105RRB	S1105K	207	1 5/16	2.8346	1.000	0.748	0.374	0.626	9/32	2 1/8	45/64	1 17/32	1.19	0.54	3050	6400
RA106RR	RA106RRB	S1106K		1 3/8	72	25.4	19	9.5	15.9	4.0	54.40	17.1	38.9	1.13	0.513	13700	28500
RA107RR	RA107RRB	S1107K		1 7/16										1.05	0.476		
RAE35RR	RAE35RRB	SE35K		35										1.13	0.513		
RA108RR	RA108RRB	S1108KT		1 1/2	3.1496	1.188	0.866[4]	0.433	0.755	3/16	2 3/4	23/32	1 23/32	1.53	0.694	4000	8150
RA109RR	RA109RRB	S1109KT	208	1 9/16	80	30.18	22	11	19.18	4.8	60.3	18.3	43.7	1.43	0.649	17600	36000
RAE40RR	RAE40RRB	SE40K		40										1.43	0.649		
RA110RR	RA110RRB	S1110K		1 5/8										1.72	0.78		
RA111RR	RA111RRB	S1111K	209	1 11/16	3.3465	1.188	0.866	0.433	0.755	3/16	2 1/2	23/32	1 23/32	1.62	0.735	4000	8150
RA112RR	RA112RRB	S1112K		1 3/4	85	30.18	22	11	19.18	4.8	63.5	18.3	43.7	1.5	0.68	17600	36000
RAE45RR	RAE45RRB	SE45K		45										1.5	0.68		
RA113RR	RA113RRB	S1113K		1 13/16										1.94	0.88		
RA114RR	RA114RRB	S1114K		1 7/8	3.5433	1.188	0.866	0.433	0.755	3/16	2 3/4	23/32	1 23/32	1.83	0.83	4500	8800
RA115RR	RA115RRB	S1115K	210	1 15/16	90	30.18	22	11	19.18	4.8	69.9	18.3	43.7	1.70	0.771	19600	3900
RA115RR2	RA115RRB2	S1115K2		2										1.58	0.717		
RAE50RR	RAE50RRB	SE50K		50										1.79	0.771		
RA200RR	RA200RRB	S1200K		2										2.12	0.962		
RA201RR	RA201RRB	S1201K		2 1/16	3.9370	1.281	0.945	0.472	0.809	3/16	3	13/16	1 29/32	1.98	0.898		
RA202RR	RA202RRB	S1202K	211	2 1/8	100	32.54	24	11.99	20.55	4.8	76.2	20.6	48.4	1.89	0.857	5630	10800
RA203RR	RA203RRB	S1203K		2 3/16										1.78	0.807	25000	48000
RAE55RR	RAE55RRB	SE55K		55										1.78	0.807		

[1] Bore tolerance is nominal to +.0005", .013mm

[2] Spherical O.D. outer ring width is .472", 12mm

[3] Spherical O.D. outer ring width is .551", 14mm

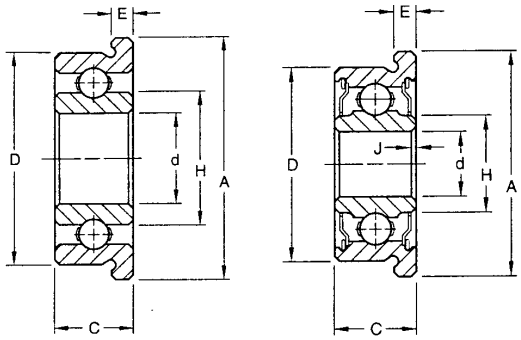
[4] Spherical O.D. outer ring width is .827", 21mm

Flanged Series

CYLINDRICAL O.D.

Four sizes in the cylindrical O.D. series are offered in a flanged construction. Flanged bearings have integral shoulders for mounting in through-bored housings. These flanged bearings have straight outside diameters and are interchangable with the corresponding unflanged sizes. The flanged group is available with double shields.

These bearings are electric motor quality for applications where extra quietness is a requirement.



Open Type | Shielded Type

DIMENSIONS – TOLERANCES

Bearing Number		Bore d		chamfer J x 45°		Outside Diameter D		Width C		Inner Ring Shoulder		Flange A		E		Shielded Type Overall Width		H		Wt		Static Load Rating C_o		Extended Dynamic Load Rating C_E	
		+0.0000" -0.0003"		+0.010" -0.000"		+0.000" -0.0004		+0.000" -0.005"				+0.005" -0.002"				+0.000" -0.005"									
open	shielded*	+0.000" mm -0.008 mm		+0.25 mm -0.00 mm		+0.000 mm -0.010 mm		+0.00 mm -0.13 mm		H min		+0.13 mm -0.05 mm		±0.002" ±0.05 mm		+0.00 mm -0.13 mm		H min							
		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kg.	lbs.	N	lbs.	N
F33K3	F33KDD3	0.1250	3.175	0.012	0.30	0.3750	9.525	0.156	3.96	0.202	5.13	0.440	11.18	0.030	0.76	0.156	3.96	0.183	4.65	0.01	0.005	48	212	160	710
F33K5	F33KDD5	0.1875	4.762	0.012	0.30	0.5000	12.700	0.156	3.96	0.270	6.86	0.565	14.35	0.042	1.07	0.196	4.98	0.248	6.30	0.01	0.005	110	490	325	1430
FS1K7	FS1KDD7[1]	0.2500	6.350	0.012	0.30	0.6250	15.875	0.196	4.98	0.349	8.86	0.690	17.53	0.042	1.07	0.196	4.98	0.332	8.43	0.01	0.005	125	560	365	1630
FS3K	FS3KDD[1]	0.3750	9.525	0.016	0.41	0.8750	22.225	0.219	5.56	0.517	13.13	0.969	24.61	0.062	1.57	0.281	7.14	0.475	12.06	0.02	0.009	310	1400	830	3650

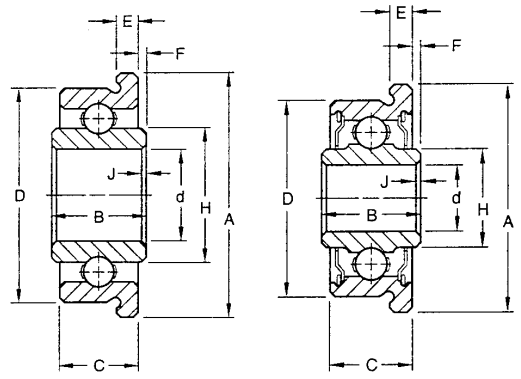
[1] Also available in stainless steel. To specify, add prefix "A" before bearing number.
* Also available with two contact seals. To specify, replace "KDD" in part number with "PP".

TAPERED O.D.

The F Flanged Series has shoulders integral with the bearings for mounting in through-bored housings. They are used where compactness is essential or where it is not desirable to machine housing shoulders. All sizes in this series have tapered outside diameters, and all are available with double shields.

These bearings are particularly suitable for such applications as precision instruments, packaging machinery, motion picture projectors and the like.Several sizes in this series are manufactured in both standard bearing quality, chromium-alloy, high carbon steel and stainless steel, as indicated in the tables. To specify stainless steel, use the prefix A before the basic bearing number. Example: AF4.

These bearings are electric motor quality for applications where extra quietness is a requirement.



Open Type | Shielded Type

DIMENSIONS – TOLERANCES

Bearing Number		Bore d		chamfer J x 45°		Outside Diameter D		Inner Width B		Ring Widths Inner Project F		H[3]		Outer Width C		taper	Flange A		E		Wt		Static Load Rating C_o		Extended Dynamic Load Rating C_E	
		+0.0003" -0.0000"		+0.010" -0.000"		+0.000" -0.0004"		±0.010"		+0.005"				+0.000" -0.004"		per	+0.005" -0.002"		±0.002"						
open	shielded	+0.008 mm -0.000 mm*		+0.025 mm -.00 mm		+0.000 mm -.010" mm		±.03 mm		±.13 mm		min		+.00 mm -0.10 mm		foot	+0.13 mm -0.05 mm		±0.002" ±0.05 mm						
		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kg.	lbs	N	lbs.	N
F2[1]	—	0.1875	4.762	0.010	0.25	0.4382	11.130	0.189	4.80	0.016	0.41	0.273	6.93	0.163	4.14	0.080	2.03	0.500	12.70	0.042	1.07	0.01	0.005	106	465	260	1160
—	F2DD-2	0.1250	3.175	0.010	0.25	0.3757	9.534	0.188	4.77	0.015	0.38	0.181	4.60	0.163	4.14	0.075	1.90	0.438	11.13	0.037	0.94	0.01	0.005	48	212	160	710
F3	—	0.1875	4.762	0.010	0.25	0.5632	14.305	0.218	5.54	0.015	0.38	0.273	6.93	0.195	4.95	0.080	2.03	0.625	15.88	0.042	1.07	0.01	0.005	110	490	325	1430
—	F3DD	0.1875	4.762	0.010	0.25	0.5632	14.305	0.250	6.35	0.015	0.38	0.245	6.22	0.226	5.74	0.068	1.73	0.625	15.88	0.042	1.07	0.01	0.005	110	490	325	1430
F4	F4DD	0.2500	6.350	0.010	0.25	0.6257	15.893	0.250	6.35	0.015	0.38	0.331	8.41	0.226	5.74	0.068	1.73	0.687	17.45	0.042	1.07	0.01	0.005	125	560	365	1630
F5	F5DD	0.3125	7.938	0.010	0.25	0.6882	17.480	0.250	6.35	0.015	0.38	0.410[2]	10.41	0.226	5.74	0.068	1.73	0.750	19.05	0.042	1.07	0.01	0.005	196	865	540	2400

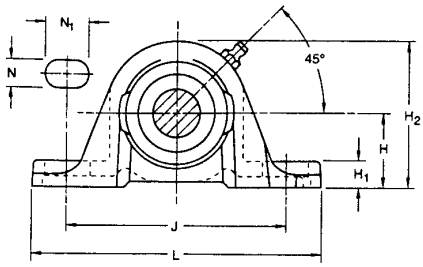
[1] Full type, no retainer. Not recommended for speeds over 500 RPM.
[2] H dimension is .381" (9.68 mm) for F5DD.
[3] Land dimension of the inner ring.

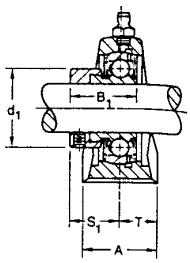
PILLOW BLOCKS/CAST IRON

VAK Standard Series

This streamlined, rugged one-piece VAK pillow block unit combines Fafnir's proven RAK housing and unique RA-RR extended inner ring bearing. The RA-RR bearing employs a positive contact land-riding seal and a Fafnir originated self-locking collar to assure positive shaft retention. The VAK pillow block can be mounted and will operate in any position. Bearing housed units are factory prelubricated but a grease fitting is provided to allow for relubrication if required.

Recommened shaft tolerances: ½"-1 15/16", nominal to -.0005", -.013mm;
2"-2 3/16", nominal to -.0010", -.025mm.





Bearing Data

Unit	Bearing Number	Dimensions and Load Ratings
VAK	GRA-KRRB	Page 163

TO ORDER, SPECIFY UNIT AND SHAFT DIAMETER. EXAMPLE: VAK 1"

Unit	Shaft Diam.	H	H_2	B_1	J	L	A	H_1	N	N_1	d_1	S_1	T	Bolt Size	Bearing Number	Collar Number	Housing Number	Unit Wt.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.				new	lbs
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			(old)	kg
VAK	½														GRA008RRB	S1008K		
VAK	9/16	1 1/16	2 3/32	1 1/8	3 5/8	4 7/8	1 3/16	11/32	7/16	7/8	1 1/4	7/8	19/32	3/8	GRA009RRB	S1009K	T-40238	1
VAK	5/8	26.99	53.2	28.6	92.1	123.8	30.2	8.7	11.1	22.2	28.6	22.2	15.1	10	GRA010RRB	S1010K	(T-30595)	0.454
VAK	17														GRAE17RRB	SE17K		
VAK	¾	1 1/4	2 15/32	1 7/32	3 25/32	5	1 1/4	15/32	7/16	25/32	1 5/16	59/64	5/8	3/8	GRA012RRB	S1012K	T-40239	1.24
VAK	20	31.75	62.7	31	96	127	31.8	11.9	11.1	19.8	33.3	23.4	15.9	10	GRAE20RRB	SE20K	(T-30555)	0.563
VAK	13/16														GRA013RRB	S1013K		
VAK	7/8	1 15/16	2 1/16	1 7/32	4 1/8	5 1/2	1 13/32	15/32	7/16	13/16	1 1/2	59/64	45/64	3/8	GRA014RRB	S1014K		
VAK	15/16	33.34	68.3	31	104.8	139.7	35.7	11.9	11.1	20.6	38.1	23.4	17.9	10	GRA015RRB	S1015K	T-30365	1.67
VAK	1														GRA100RRB	S1100K		0.758
VAK	25														GRAE25RRB	SE25K		
VAK	1 1/16														GRA101RRB	S1101K		
VAK	1 1/8	1 9/16	3 3/32	1 13/32	4 5/8	6 3/16	1 9/16	17/32	9/16	15/16	1 47/64	1 1/16	25/32	½	GRA102RRB	S1102K	T-40241	2.72
VAK	1 3/16	39.69	80.2	35.7	117.5	157.2	39.7	13.5	14.3	23.8	44.1	27	19.9	12	GRA103RRB	S1103K	(T-30300)	1.235
VAK	1 1/4 S														GRA103RRB2	S1103K3		
VAK	30														GRAE30RRB	SE30K		
VAK	1 1/4														GRA104RRB	S1104K		
VAK	1 5/16	1 13/16	3 5/8	1 17/32	5 1/8	6 9/16	1 25/32	21/32	9/16	31/32	2 1/8	1 5/32	57/64	½	GRA105RRB	S1105K	T-40242	3.51
VAK	1 3/8	46.04	92.1	38.9	130.2	166.7	45.2	16.7	14.3	24.6	54	29.4	22.7	12	GRA106RRB	S1106K	(T-30410)	1.594
VAK	1 7/16														GRA107RRB	S1107K		
VAK	35														GRAE35RRB	SE35K		
VAK	1 ½	1 15/16	3 15/16	1 23/32	5 3/8	7 1/16	1 7/8	¾	9/16	1 1/32	2 3/8	1 9/32	15/16	½	GRA108RRB	S1108KT	T-40243	4.48
VAK	1 9/16	49.21	100	43.7	136.5	179.4	47.6	19	14.3	26.2	60.3	32.5	23.8	12	GRA109RRB	S1109KT	(T-30484)	2.034
VAK	40														GRAE40RRB	SE40K		

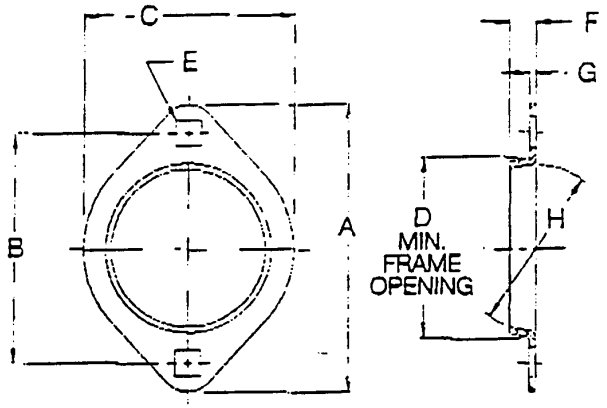
General Flangette Information

LUTCO is the largest manufacturer of precision flangettes in North America. With an extensive tooling inventory, we are able to offer a wide variety of standard and custom units.

Fit and surface contact between the flangettes and the bearing contribute to the life of the assembly. By allowing the bearing to misalign in the housing under a predetermined torque, premature failure can be eliminated. Sophisticated measuring and torque rating equipment are employed to provide statistical process control, through charting and minimum 1.0 CPK values.

For more specific information on the processes utilized, please contact the factory.

2 Bolt Self-Aligning Flangettes



PART NUMBER	A In. mm	B In. mm	C In. mm	D In. mm	E In. mm	F In. mm	G In. mm	H nom. mm	RADIAL LOAD LBS. N	UNIT WT. LBS.
2 BOLT										
35MST	2 7/8 73.0	2 1/2 63.50	2 6/16 58.74	1 5/8 41.28	9/32 7.14	7/32 5.54	0.054 1.37	35	350 1556	0.06
40MST	3 3/16 80.96	2 1/2 63.50	2 5/16 58.74	1 7/8 47.63	9/32 7.14	9/32 7.14	0.075 1.905	40	750 3100	0.08
47MST	3 5/16 90.49	2 13/16 71.44	2 5/8 66.68	2 3/16 55.56	11/32 8.73	5/16 7.94	0.083 2.11	47	900 3900	0.10
52MST	3 3/4 95.25	3 76.20	2 51/64 71.04	2 3/8 60.33	11/32 8.73	11/32 8.73	0.083 2.11	52	1000 4450	0.11
62MST	4 7/16 112.71	3 9/16 90.49	3 5/16 84.14	2 13/16 71.44	13/32 10.31	3/8 9.53	0.104 2.64	62	1400 6200	.0.33
72MST	4 15/16 125.41	3 15/16 100.01	3 11/16 93.66	3 3/16 80.96	13/32 10.31	13/32 10.31	0.104 2.64	72	1750 7500	0.40

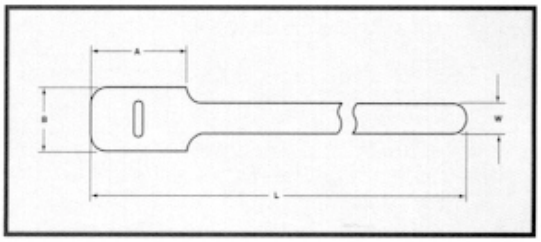
For Torque rated flangettes, add the prefix "T".
Add, "ZP" for standard zinc plate and "YZP" for yellow chromate finishes.
Special designs available upon request.

CABLE MANAGEMENT ACCESSORIES

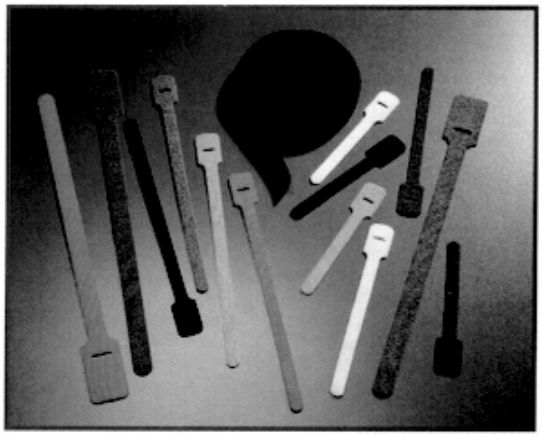
GRIP TIES

Available in a large color variety as well as different sizes including 6", 8", 11", and 15", the Grip Tie is versatile enough for applications ranging from network installations to bundling power cords. An assortment pack containing the four different sizes and six different colors is also available. For custom-cut lengths, the VELCRO® brand strap also comes on a five yard roll.

** VELCRO® is registered trademark for fasteners of the Velcro companies.*



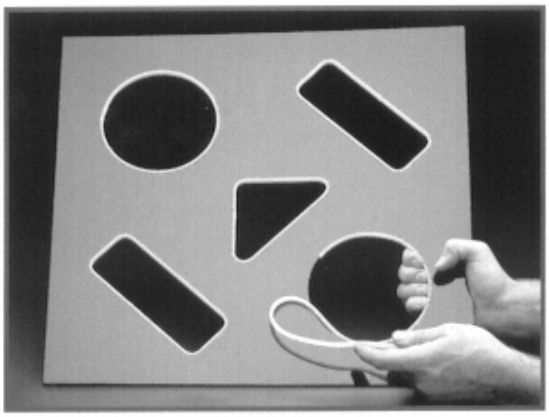
The Grip Tie is a low profile, one-piece fastening device. Constructed of VELCRO®* brand polyethylene hook and nylon loop, laminated back to back, the Grip Tie features quick release for repetitive access to cable and wire. It can be opened and closed numerous times without failure. The Grip Tie is reusable, adjustable, releasable, and easy to install. Its design provides ease of installation in tight areas such as telecommunications closets and will not get caught on other cables. The tie also will not cause damage to Category 5 cable or fiber optic cable since it cannot be overcinched.



Tyton Hellermann Part No.	Color	Bundle Diameter	Tensile Strength	Length (L)	Width (W)	Head Length (A)	Head Width (B)	Pkg. Qty.
6" Straps								
GT.375X60C2	Black	1"	42 lbs.	6"	.375"	1.5"	.75"	100
GT.50X60P2	Black	1"	45 lbs.	6"	0.5"	1.5"	1"	10
GT.50X60C2	Black	1"	45 lbs.	6"	0.5"	1.5"	1"	100
GT.50X62P2	Red	1"	45 lbs.	6"	0.5"	1.5"	1"	10
GT.50X62C2	Red	1"	45 lbs.	6"	0.5"	1.5"	1"	100
GT.50X63P2	Orange	1"	45 lbs.	6"	0.5"	1.5"	1"	10
GT.50X63C2	Orange	1"	45 lbs.	6"	0.5"	1.5"	1"	100
GT.50X64P2	Yellow	1"	45 lbs.	6"	0.5"	1.5"	1"	10
GT.50X64C2	Yellow	1"	45 lbs.	6"	0.5"	1.5"	1"	100
GT.50X65P2	Green	1"	45 lbs.	6"	0.5"	1.5"	1"	10
GT.50X65C2	Green	1"	45 lbs.	6"	0.5"	1.5"	1"	100
GT.50X66P2	Blue	1"	45 lbs.	6"	0.5"	1.5"	1"	10
GT.50X66C2	Blue	1"	45 lbs.	6"	0.5"	1.5"	1"	100
8" Straps								
GT.50X80P2	Black	1.75"	50 lbs.	8"	0.5"	1.5"	1"	10
GT.50X80C2	Black	1.75"	50 lbs.	8"	0.5"	1.5"	1"	100
GT.50X82P2	Red	1.75"	50 lbs.	8"	0.5"	1.5"	1"	10
GT.50X82C2	Red	1.75"	50 lbs.	8"	0.5"	1.5"	1"	100
GT.50X83P2	Orange	1.75"	50 lbs.	8"	0.5"	1.5"	1"	10
GT.50X83C2	Orange	1.75"	50 lbs.	8"	0.5"	1.5"	1"	100
GT.50X84P2	Yellow	1.75"	50 lbs.	8"	0.5"	1.5"	1"	10
GT.50X84C2	Yellow	1.75"	50 lbs.	8"	0.5"	1.5"	1"	100

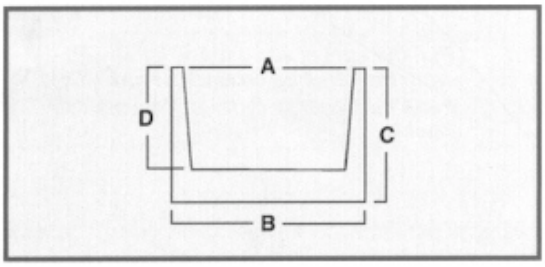
GROMMET

Tyton Hellermann's Flexiform grommet is a unique, continuous wire protection product which fits easily in all shapes and sizes of holes without the aid of tools or adhesives. Since Flexiform can be cut to the right length with scissors, it eliminates waste, helping keep grommet stock to a minimum. Tyton Hellermann's Flexiform flexible panel grommet can be used on any type of material including wood, steel, aluminum, plexiglass, and glass. It is available in 9 sizes for thicknesses from .016" to .512". The standard color is natural. Materials: polyethylene, nylon, and P.T.F.E. (Teflon®).



Material	Reference	Maximum Operating Temperature	Pkg. Qty.
Polyethylene	FP_	176°F (80°C)	One 82 foot (25 meters) reel
Nylon	FH_	275°F (135°C)	One 82 foot (25 meters) reel
P.T.F.E. (Teflon®)	FT_	500°F (260°C)	One 82 foot (25 meters) reel

The maximum operating temperatures shown above are dependent upon the environmental application.



Standard Dimensions (in inches)					
Size	A	B	C	D	For Thickness
AA	.037	.087	.094	.063	.016-.040
A	.055	.150	.157	.099	.016-.052
B	.091	.177	.157	.099	.052-.083
C	.130	.220	.157	.099	.083-.130
D	.197	.327	.228	.157	.130-.189
E	.260	.386	.241	.170	.189-.256
F	.319	.445	.256	.181	.256-.319
G	.394	.512	.256	.181	.319-.382
H	.512	.638	.256	.181	.382-.512

Note: Size AA is available in polyethylene only.
Note: Nylon is available in sizes A through E only.

Example Part Number

FP | AA

MATERIAL TYPE | SIZE

When ordering, add size to the material reference. For example, FPAA equals size AA in polyethylene material.

SPIRALWRAP

Spiralwrap protective sheathing allows flexible routing and lead-out of cables. The inner edges are beveled to prevent damage to cables. U.L. recognized Spiralwrap is reusable and resistant to most chemicals. Natural and black are standard colors (see material descriptions). Colors may be available dependent upon volume requirements. Contact Tyton Hellermann for more information.

Installation

Spiralwrap can be installed in two basic ways:

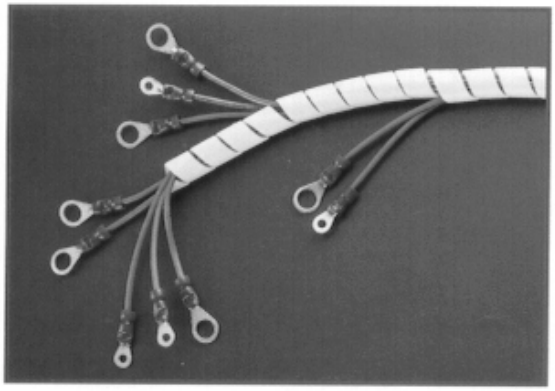
In a gapped installation, Spiralwrap is wrapped with space between the sheathing. This accommodates wire breakouts and also keeps the wire bundle flexible.

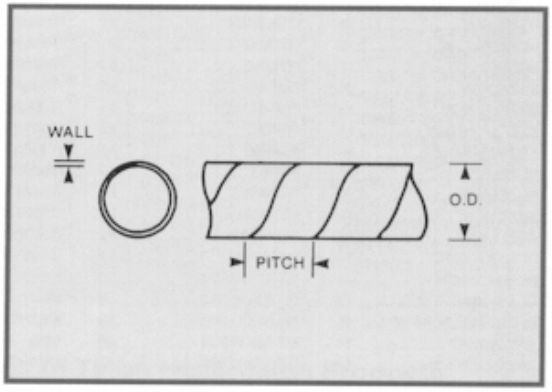
In a butted installation, Spiralwrap is wrapped so the sheathing completely insulates the wire bundle. This provides superior abrasion resistance and additional rigidity.

Spiralwrap Material Specifications

Standard Dimensions (in inches)													
Materials	Max. Oper. Temp.	Min. Oper. Temp.	Abrasion Resist. Lower No.s Better mg.loss per M Cycles	Dielectric Constant	Tensile Strength @ 73˚F		Specific Gravity D792 -50	Water Absorption %D-570	Flammability	Effect of Solvents	Effect of Acids	Effect of Alkalies	MIL Spec. & Approvals
					D-638 -52Tpsi	D-412 -51Tpsi							
Clear Non-Flame Retardant Polyethylene Ideal for general applications. Not affected by ordinary solvents and extremely resistant to abrasion. (Ref.NFP)	215˚F 101˚C	-105˚F -76˚C	22	2.50	–	1800	0.92	.014	Flammable	None below 122˚F 50˚C	None	None	Fed. Spec. LP390 MIL I-631D MIL P-21922A
Black Non-Flame Retardant Polyethylene Ultraviolet resistant for outdoor use. Has the same qualities as clear polyethylene but also contains an ultraviolet absorber which permits it to be used in direct sunlight for long periods of time. (Ref. NFPO)	215˚F 101˚C	-105˚F -76˚C	20	2.60	–	2000	0.93	.030	Flammable	None below 122˚F 50˚C	None	None	Fed. Spec. LP390 MIL I-631D MIL P-21922A

Spiralwrap is also available in flame retardant polyethylene, nylon and P.T.F.E Teflon® (Teflon is a DuPont Trademark).

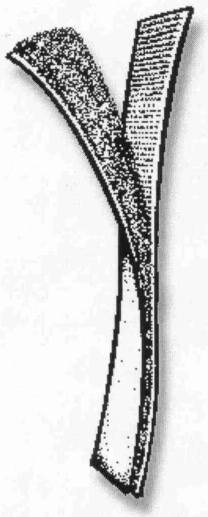




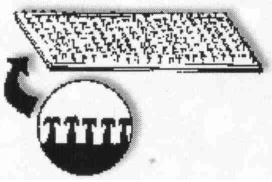
Tyton Hellermann Part No.	Materials	Outside Diameter		Nominal Dimensions Wall		Pitch		Maximum Bundle		Weight	Pkg. Qty.
		Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Lb./M ft	
1NFP9C	Non-Flame	.125	(3.18)	.032	(.81)	.187	(4.75)	1/16 to 1/2	(1.60 to 12.7)	4	
2NFP9C	Retardant	.250	(6.35)	.045	(1.14)	.375	(9.53)	3/16 to 2	(4.75 to 50.8)	12	
2.5NFP9C	Polyethylene	.375	(9.53)	.052	(1.32)	.438	(11.13)	5/16 to 3	(7.92 to 76.2)	22	One
3NFP9C	(Ref. NFP)	.500	(12.70)	.062	(1.57)	.563	(14.30)	3/8 to 4	(9.52 to 102)	35	100'
4NFP9C		.750	(19.05)	.065	(1.65)	.750	(19.05)	3/4 to 5	(19.10 to 127)	58	Reel
5NFP9C		1.000	(25.40)	.095	(2.41)	1.000	(25.40)	1 to 7	(25.40 to 178)	105	
1NFP0C	Black	.125	(3.18)	.032	(.81)	.187	(4.75)	1/16 to 1/2	(1.60 to 12.7)	4	
2NFP0C	Non-Flame	.250	(6.35)	.045	(1.14)	.375	(9.53)	3/16 to 2	(4.75 to 50.8)	12	
2.5NFP0C	Retardant	.375	(9.53)	.052	(1.32)	.438	(11.13)	5/16 to 3	(7.92 to 76.2)	22	One
3NFP0C	Polyethylene	.500	(12.70)	.062	(1.57)	.500	(12.70)	3/8 to 4	(9.52 to 102)	35	100'
4NFP0C	(Ref. NFPO)	.750	(19.05)	.065	(1.65)	.750	(19.05)	3/4 to 5	(19.10 to 127)	58	Reel
5NFP0C		1.000	(25.40)	.095	(2.41)	1.000	(25.40)	1 to 7	(25.40 to 178)	105	

For other materials, contact Tyton Hellermann.

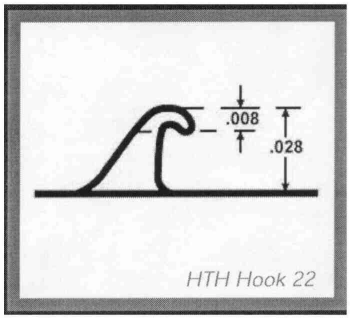
Hook & Loop Fastener Tapes



TYPE/BRAND	DESCRIPTION
VELCRO® brand woven nylon hook and loop	Industry-standard touch fasteners. 15 standard colors. Widths to 4".
VELCRO® brand knit loop	Wide variety of colors available. Widths to 60".
TEXACRO® brand woven nylon hook & loop	Value-packed, ready to ship traditional touch fasteners. 5 standard colors. Widths to 4".
VEL-STRETCH® brand Loop	An elastic loop with 55% stretch for high cycle life applications. Widths available: 5/8", 1", 1 1/2", 2". Available in black, white or beige.
MED-FLEX™ brand Loop	An elastic loop with 100% stretch for moderate cycle life applications. Widths available: 1", 1 1/2", 2". Available in white only.
VELCRO® brand Polyester Hook and Loop	For use where ultraviolet or chemical resistance may be required. Also recommended for applications in high humidity or moisture environments. Available widths: 1", 2".
MID-TEMP® brand Hook & Loop	A combination of NOMEX® yarn and non-corrosive metal. Designed for applications up to 450 degrees F.
HI-GARDE® brand Hook & Loop	All steel, heat and corrosion resistant, usage to 800 degrees F.
HI-AIR® brand Hook & Loop	Flame retardant. Specially woven from NOMEX® yarn. Meets and exceeds existing F.A.A. requirements.
HI-MEG® brand Hook & Loop	Electrically conductive, silver-coated fastening components offering excellent R.F.I. sheilding characteristics.
VELCRO® brand Molded Hook #8 (MVA #8)	A molded nylon arrowhead hook designed for high strength applications. Available in 1" widths and in natural or black



VELCRO® BRAND FASTENING SYSTEMS



Product Information Guide

ONE-WRAP®

FEATURING

ULTRA-MATE® BRAND HTH 22 HOOK

ONE-WRAP® (HTH 888) - A unique back-to-back fastening system featuring a polyethylene hook laminated to a nylon loop without the use of an adhesive.

ONE-WRAP® (HTH 889) - A flame retardant version of ONE-WRAP®. This product meets UL (Underwriter's Laboratory) requirements for a rating of 94-V2 and also meets requirements for FAR 25.853 A/B. *In addition, specified configurations of black ONE-WRAP® (HTH 889) meet the requirements for use in air handling applications in accordance with NEC's section 300-22 (C) & (D).*

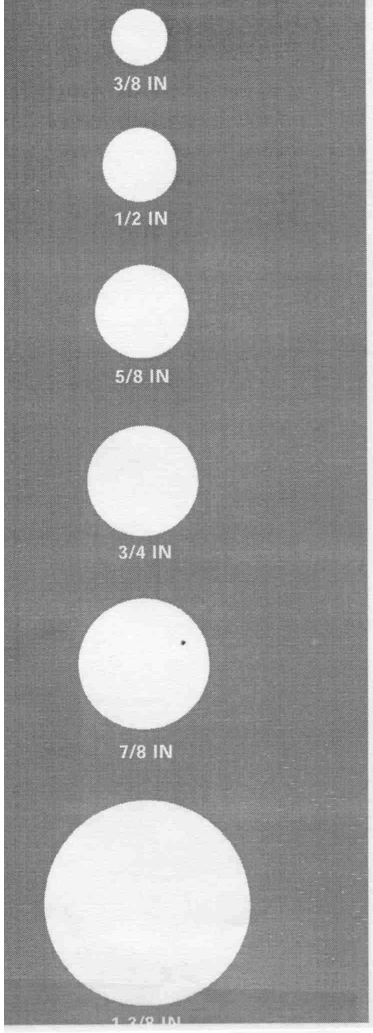
ONE-WRAP®:

- **Ideal for cord and cable control**
- **Can be slit, perforated and die-cut to meet specific requirements**
- **Can be cycled hundreds of times**
- **Operating temperature - 0 to 220 °F**

Product Name	888	889
Average Shear (PSI)	23	29
Average Peel (PIW)	0.5	0.6
Colors:	Black, White, Beige, Gray, Royal Blue, Red, Coachman Green, Yellow, Orange, Brown & Purple	Black & Light Blue
Standard Widths:	3/8", 1/2", 5/8", 3/4", 1", 1-1/2", 2", 3", & 4"	3/8", 1/2", 5/8", 3/4", 1", 1-1/2", 2", 3", & 4"
Standard Put-Ups	25 yard reels	25 yard reels
Minimums:	Standard Widths - 100 yards Non-Standard Widths - Inquire	Contact Market Manager

See Reverse Side For Pre-Cut ONE-WRAP® Cable Control Straps

VELCRO® FASTENING SYSTEMS



Product Information Guide

VELCOIN®

WOVEN NYLON FASTENERS

- Pre-cut, circular VELCRO® brand Hook 88 and Loop 1000
- Rounded corners for easy assembly - no more lifted edges
- Variety of backings available to meet specific requirements
- Colors available: Black, White, Beige

PRESSURE SENSITIVE VELCOIN®

- Available with acrylic-based (SPECTRUM™ 0172) or an olefin-based (VECTOR™ 0115) adhesive
- Hook and Loop components sold separately
- Minimum order - 10 reels

	Single Coin Across						
Width	3/8 IN	1/2 IN	5/8 IN	3/4 IN	7/8 IN	1 3/8 IN	1 7/8 IN
Number Of Coins Per Reel.	1880	1440	1200	1028	900	600	450

	Multiple Coins Across						
Width	3/8 IN	1/2 IN	5/8 IN	3/4 IN	7/8 IN	1 3/8 IN	1 7/8 IN
Number Of Coins Per Reel.	NA	8640	6400	4112	3600	NA	NA
# of Multiple Coins Across		6 across	5 across	4 across	4 across		

RECOMMENDED ADHESIVES AND SUBSTRATES

Test Materials	VECTOR™ (0115)	SPECTRUM™ (0172)
Aluminum, unpainted	Excellent	Good
Steel, unpainted	Excellent	Excellent
Rigid vinyl	Good	Excellent

STANDARD BACK AND SOLVENT-ACTIVATED VELCOIN®

- Standard back available for sewing applications
- Solvent-activated available for sealing or heat-activated applications
- Hook and Loop components sold separately
- Minimum order - see below

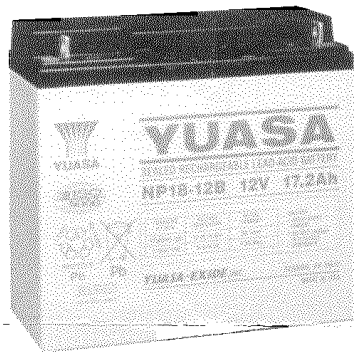
WIDTH	1/2 IN	5/8 IN	3/4 IN	7/8 IN	1 3/8 IN	1 7/8 IN
MINIMUM ORDER	28,800	24,000	20,571	18,000	12,000	9,000

SECTION NP18-12B

Sealed Rechargeable Lead-Acid Battery

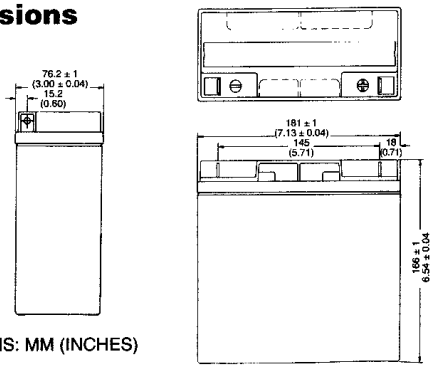
YUASA

NP18-12B
NP18-12BFR
12V, 17.2Ah



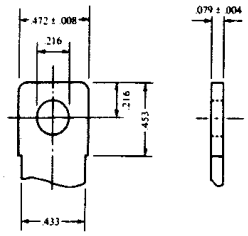
ISO 9000™
MANUFACTURED UNDER AN NSAI REGISTERED QUALITY SYSTEM

Dimensions



DIMENSIONS: MM (INCHES)

Terminal



INCH	= MM
.472	12.00
.453	11.50
.433	11.00
.216	5.50
.079	2.00

DIMENSIONS: INCHES

RECOGNIZED BY UL, File No. MH 16464

Specifications

Nominal Voltage 12V

Nominal Capacity
20 hr. rate of 0.86 A to 10.50 V 17.2 Ah
10 hr. rate of 1.6 A to 10.50 V 16.0 Ah
5 hr. rate of 2.9 A to 10.20 V 14.5 Ah
1 hr. rate of 12.0 A to 9.60 V 12.0 Ah

Weight (approx.) ..... 13.7 pounds (6200 gs.)

Energy density (20 hr. rate)
..... 1.47 WH/cubic inch (90 WH/litre)

Specific energy (20 hr. rate)
..... 15.1 WH/pound (33.2 WH/kg)

Internal resistance of charged battery
..... 11 milliohms (approx.)

Maximum discharge current with standard terminals ..... 100 amperes

Maximum short-duration discharge current ..... 450 amperes

Operating temperature range
Charge ..... 5°F to 122°F (-15°C to 50°C)
Discharge ..... -4°F to 140°F (-20°C to 60°C)

Charge retention (shelf life) at 68°F (20°C)
1 month 97%
3 months 91%
6 months 85%

Life expectancy
Standby use ..... 3 to 5 years
Cycle use **(approx.)**
100% depth of discharge ..... 180 cycles
50% depth of discharge ..... 400 cycles
30% depth of discharge ... 1200 cycles

Sealed construction
Can be operated, charged or stored in any position without leakage.

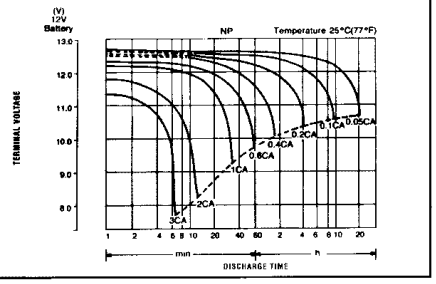
Standard terminal ..... Bolt fastened terminal

Housing material ..... ABS Resin or ABS Flame Retardant (UL94-V0)

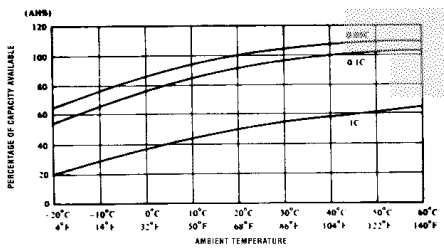
Hardware ..... 2- M5-.8 X 12mm Bolt w/nuts, lock washer & flat washer

YUASA™ EXIDE, INC.

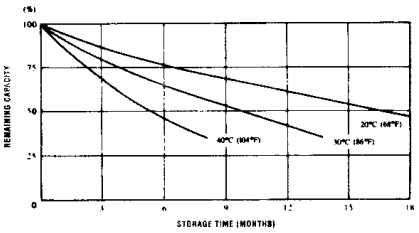
DISCHARGE CHARACTERISTIC CURVES



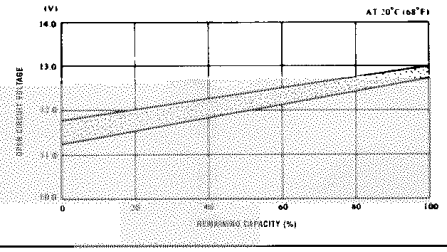
TEMPERATURE EFFECTS IN RELATION TO BATTERY CAPACITY



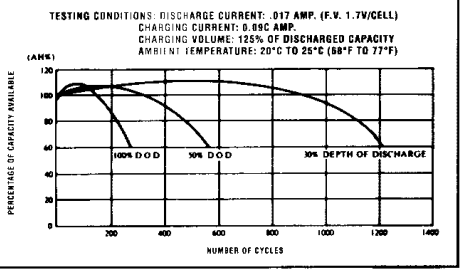
SELF DISCHARGE CHARACTERISTICS



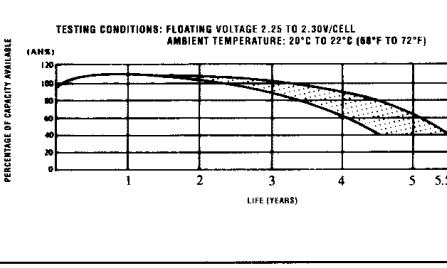
OPEN CIRCUIT VOLTAGE VS REMAINING CAPACITY



CYCLE SERVICE LIFE IN RELATION TO DEPTH OF DISCHARGE



FLOAT SERVICE LIFE



When the battery will be used by the current in excess of 3C, consult with Yuasa-Exide prior to use. *MADE IN THE USA*

CHARGING METHODS (At 20°C) **Cycle use:** Maximum charging current 0.25C
Charging voltage 14.4 TO 15.0V
Standby use: Float charging voltage 13.50 to 13.80V

CAUTION •Avoid short circuit
•Do not charge in a sealed container.

Distributed by:

LEAD RETURN RECYCLE

When ordering new batteries, also remember to properly recycle your old lead batteries. Most federal and state regulations require lead-acid batteries be recycled. Yuasa-Exide's nationwide service organization can arrange pickup, transportation to and recycling at any one of our company affiliated smelters. Call 1-800-972-7372 for more information.

YUASA™ EXIDE, INC.

Sales Offices

Eastern Region:	*201-641-5900 • 1-800-962-1287*
	FAX 201-641-8720
Western Region:	*562-949-4266 • 1-800-423-4667*
	FAX 562-949-5527
Corporate Office:	*P.O. Box 14145, Reading, PA 19612-4145*
	FAX 610-372-8613

Visit us on the web at: www.yuasa-exide.com

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Printed in USA

YUASA

January 5, 1999

To Whom It May Concern:

Subject: NP Battery Series Packaging Regulations

On behalf of Yuasa, Inc., I hereby certify that all Yuasa NP series batteries conform to the non-spillable battery requirements as established in the Code of Federal Regulations 49 (CFR 49), revised 10/1/98, section 173.159 (d), the International Air Transport Association (IATA), 40th Edition, Packing Instruction 806 and the International Maritime Dangerous Goods code (IMDG code), page 8121. Therefore, the basic description for all NP batteries is:

Batteries, wet, non-spillable, 8, UN2800, PG III

In addition, I further certify that all NP series batteries conform to IATA special provision A67 and IMDG code page 8121 for non-spillable batteries, which classifies them as non-regulated goods provided their terminals are packed in a manner so as to protect them from short circuits, whenever those regulations apply.

Sincerely,

Larry Burkert
Yuasa, Inc.
Packaging Engineer

YUASA EXIDE, INC.

12070 Telegraph Road
Suite 100
Santa Fe Springs, CA 90670
310/949-4266
1-800/423-4667
Fax 310/949-5527

MAY 5, 1995

To: Customers Of Yuasa-Exide, Inc. NP Series Batteries

Subject: **Air Transportation Requirements In Accordance With The International Air Transport Association (I.A.T.A.)**

We hereby certify that all Yuasa NP Series valve regulated lead acid batteries conform to the UN2800 classification as "Batteries, wet, non-spillable, electric storage".

We further certify that under I.A.T.A. Dangerous Goods Regulations, 35th Edition, Jan. 1, 1994, UN2800, Yuasa NP Series batteries meet the requirements and conform to special provision A67 classifying them as non-dangerous goods. The NP Series batteries are therefore exempt from the subject regulations for dangerous goods and are acceptable for transport on both cargo and passenger aircraft.

For reference:

I.A.T.A. Dangerous Goods Regulations, 35th Edition, Jan. 1, 1994 Section 4.4, Special Provisions:

A67) Non-spillable batteries are considered to be nondangerous if, at a temperature of 55 deg.C (130 deg.F), the electrolyte will not flow from a ruptured or cracked case and there is no free liquid to flow and if, when packaged for transport, the terminals are protected from short circuit.

YUASA -EXIDE, INC.

YUASA EXIDE, INC.

9/03/96

NOTICE TO ALL CUSTOMERS

SUBJECT: MATERIAL SAFETY DATA SHEET - LEAD-ACID BATTERY

As part of our ongoing commitment to provide customers with current safety and health information on our products, Yuasa-Exide, Inc. has developed the attached comprehensive Material Safety Data Sheet (MSDS) for its lead-acid batteries. This MSDS supersedes all previous documents for lead-acid batteries. → DATED 6/96

The enclosed MSDS has been prepared in accordance with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200) and is intended to assist you in complying with your obligations under the Standard. Please make this information available to your employees and any others who may handle or come into contact with our product.

Should you have any questions, please contact your Yuasa-Exide representative.

2400 Bernville Road Reading, PA 19605
P.O. Box 14145 Reading, PA 19612-4145
610/208-1991

YUASA EXIDE, INC.

MATERIAL SAFETY DATA SHEET

Revised 8/96
Page 1 of 7

I. PRODUCT IDENTIFICATION

Chemical/Trade Name (as used on label)

Lead-Acid Battery

Chemical Family/Classification

Electric Storage Battery

Manufacturer's Name/Address

Yuasa-Exide, Inc.
P.O. Box 14145
Reading, PA 19612-4145

Telephone

For information and emergencies, contact Yuasa-Exide., Environmental Resources Dept. (610) 208-1975.

24-hour Emergency Response Contact:
CHEMTREC (800) 424-9300

I. HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

Components	CAS Number	Approximate % by Wt. or Vol.	Air Exposure Limits (ug/m³) OSHA	ACGIH	NIOSH
Inorganic lead compound:					
Lead	7439-92-1	60	50	150	100
Antimony	7440-36-0	2	500	500	–
Arsenic	7440-38-2	0.2	10	200	–
Calcium	7440-70-2	0.2	–	–	–
Tin	7440-31-5	0.2	2000	2000	–
Electrolyte (sulfuric acid)	7664-93-9	10-30	1000	1000	1000
Case Material:		5-10	N/A	N/A	N/A
Polypropylene	9003-07-0				
Polystyrene	9003-53-6				
Styrene Acrylonitrile	9003-54-7				
Acrylonitrile Butadiene Styrene	9003-56-9				
Styrene Butadiene	9003-55-8				
Polyvinylchloride	9002-86-2				
Polycarbonate	–				
Hard Rubber	–				
Polyethylene	–				
Other					
Silicon dioxide (gel cell batteries only)	60676-86-0	10	N/A	N/A	N/A
Sheet Molding Compound (glass-reinforced polyester)	–	10	N/A	N/A	N/A

OTE: Inorganic lead and electrolyte (sulfuric acid) are the primary components of every battery manufactured by Yuasa-Exide, Inc. Other ingredients may be present dependent upon battery type. Contact your Yuasa-Exide representative for additional information.

III. PHYSICAL DATA

Electrolyte:

Boiling Point:	203 - 240°F	Specific Gravity (H_2O = 1):	1.215 to 1.350
Melting Point:	Not Applicable	Vapor Pressure (mm Hg):	10
Solubility in Water:	100%	Vapor Density (AIR = 1):	Greater than 1
Evaporation Rate (Butyl acetate = 1)	Less Than 1	% Volatiles by Weight:	Not Applicable

Appearance and Odor: Manufactured article; no apparent odor. Electrolyte is a clear liquid with a sharp, penetrating, pungent odor.

IV. FIRE AND EXPLOSION HAZARD DATA

Flash Point: Not Applicable Flammable Limits: LEL = 4.1% (Hydrogen Gas) UEL = 74.2%

Extinguishing media: CO_2; foam; dry chemical

Special Fire Fighting Procedures: If batteries are on charge, shut off power. Use positive pressure, self-contained breathing apparatus. Water applied to electrolyte generates heat and causes it to spatter. Wear acid-resistant clothing.

Unusual Fire and Explosion hazards: Highly flammable hydrogen gas is generated during charging and operation of batteries. To avoid risk of fire or explosion, keep sparks or other sources of ignition away from batteries. Do not allow metallic materials to simultaneously contact negative and positive terminals of cells and batteries. Follow manufacturer's instructions for installation and service.

V. REACTIVITY DATA

Stability: Stable X Unstable ____

Conditions to Avoid: Prolonged overcharge; sources of ignition

Incompatibility: (materials to avoid)

Sulfuric acid: Contact with combustibles and organic materials may cause fire and explosion. Also reacts violently with strong reducing agents, metals, sulfur trioxide gas, strong oxidizers and water. Contact with metals may produce toxic sulfur dioxide fumes and may release flammable hydrogen gas.

Lead compounds: Avoid contact with strong acids, bases, halides, halogenates, potassium nitrate, permanganate, peroxides, nascent hydrogen and reducing agents.

Hazardous Decomposition Products:

Sulfuric acid: Sulfur trioxide, carbon monoxide, sulfuric acid mist, sulfur dioxide, hydrogen.

Lead compounds: High temperatures likely to produce toxic metal fume, vapor or dust; contact with strong acid or base or presence of nascent hydrogen may generate highly toxic arsine gas.

VI. HEALTH HAZARD DATA

Routes of Entry:

Sulfuric acid: Harmful by all routes of entry.

Lead compounds: Hazardous exposure can occur only when product is heated, oxidized or otherwise processed or damaged to create dust, vapor or fume.

Inhalation:

Sulfuric acid: Breathing of sulfuric acid vapors or mists may cause severe respiratory irritation.

Lead compounds: Inhalation of lead dust or fumes may cause irritation of upper respiratory tract and lungs.

Ingestion:

Sulfuric acid: May cause severe irritation of mouth, throat, esophagus and stomach.

Lead compounds: Acute ingestion may cause abdominal pain, nausea, vomiting, diarrhea and severe cramping. This may lead rapidly to systemic toxicity and must be treated by a physician.

Skin Contact:

Sulfuric acid: Severe irritation, burns and ulceration.

Lead compounds: Not absorbed through the skin.

Eye Contact:

Sulfuric acid: Severe irritation, burns, cornea damage, blindness.

Lead compounds: May cause eye irritation.

Effects of Overexposure - Acute:

Sulfuric acid: Severe skin irritation, damage to cornea, upper respiratory irritation.

Lead compounds: Symptoms of toxicity include headache, fatigue, abdominal pain, loss of appetite, muscular aches and weakness, sleep disturbances and irritability.

Effects of Overexposure - Chronic:

Sulfuric acid: Possible erosion of tooth enamel; inflammation of nose, throat and bronchial tubes.

Lead compounds: Anemia; neuropathy, particularly of the motor nerves, with wrist drop; kidney damage; reproductive changes in males and females.

Carcinogenicity:

Sulfuric acid: The International Agency for Research on Cancer (IARC) has classified "strong inorganic acid mist containing sulfuric acid" as a Category I carcinogen, a substance that is carcinogenic to humans. This classification does not apply to liquid forms of sulfuric acid or sulfuric acid solutions contained within a battery. Inorganic acid mist (sulfuric acid mist) is not generated under normal use of this product. Misuse of the product, such as overcharging, may result in the generation of sulfuric acid mist.

Lead compounds: Lead is listed as a 2B carcinogen, likely in animals at extreme doses. Proof of carcinogenicity in humans is lacking at present.

Arsenic: Listed by National Toxicology Program (NTP), International Agency for Research on Cancer (IARC), OSHA and NIOSH as a carcinogen only after prolonged exposure at high levels.

HEALTH HAZARD DATA (Continued)

Medical Conditions Generally Aggravated by Exposure:

Overexposure to sulfuric acid mist may cause lung damage and aggravate pulmonary conditions. Contact of sulfuric acid with skin may aggravate skin diseases such as eczema and contact dermatitis. Lead and its compounds can aggravate some forms of kidney, liver and neurologic diseases.

Emergency and First Aid Procedures:

Inhalation:

Sulfuric acid: Remove to fresh air immediately. If breathing is difficult, give oxygen.

Lead: Remove from exposure, gargle, wash nose and lips; consult physician.

Ingestion:

Sulfuric acid: Give large quantities of water; do not induce vomiting; consult physician.

Lead: Consult physician immediately.

Skin:

Sulfuric acid: Flush with large amounts of water for at least 15 minutes; remove contaminated clothing completely, including shoes.

Lead: Wash immediately with soap and water.

Eyes:

Sulfuric acid and lead: Flush immediately with large amounts of water for at least 15 minutes; consult physician.

I. PRECAUTIONS FOR SAFE HANDLING AND USE

Spill or Leak Procedures:

Stop flow of material, contain/absorb small spills with dry sand, earth, vermiculite. Do not use combustible materials. If possible, carefully neutralize spilled electrolyte with soda ash, sodium bicarbonate, lime, etc. Wear acid-resistant clothing, boots, gloves, and face shield. Do not allow discharge of unneutralized acid to sewer.

Waste Disposal Methods:

Spent batteries: Send to secondary lead smelter for recycling.

Place neutralized slurry into sealed containers and dispose of as hazardous waste, as applicable. Large water-diluted spills, after neutralization and testing, should be managed in accordance with approved local, state and federal requirements. Consult state environmental agency and/or federal EPA.

Handling and Storage:

Store batteries in cool, dry, well-ventilated areas with impervious surfaces and adequate containment in the event of spills. Batteries should also be stored under roof for protection against adverse weather conditions. Separate from incompatible materials. Store and handle only in areas with adequate water supply and spill control. Avoid damage to containers. Keep away from fire, sparks and heat.

VII. PRECAUTIONS FOR SAFE HANDLING AND USE (Continued)

Precautionary Labelling:

POISON - CAUSES SEVERE BURNS

DANGER - CONTAINS SULFURIC ACID

VIII. CONTROL MEASURES

Engineering Controls:

Store and handle in well-ventilated area. If mechanical ventilation is used, components must be acid-resistant.

Work Practices:

Handle batteries cautiously to avoid spills. Make certain vent caps are on securely. Avoid contact with internal components. Wear protective clothing when filling or handling batteries.

Respiratory Protection:

None required under normal conditions. When concentrations of sulfuric acid mist are known to exceed PEL, use NIOSH or MSHA-approved respiratory protection.

Protective gloves:

Rubber or plastic acid-resistant gloves with elbow-length gauntlet.

Eye Protection:

Chemical goggles or face shield.

Other Protection:

Acid-resistant apron. Under severe exposure or emergency conditions, wear acid-resistant clothing and boots.

Emergency Flushing:

In areas where sulfuric acid is handled in concentrations greater than 1%, emergency eyewash stations and showers should be provided, with unlimited water supply.

IX. OTHER REGULATORY INFORMATION

NFPA Hazard Rating for sulfuric acid:

Flammability (Red)	=	0
Health (Blue)	=	3
Reactivity (Yellow)	=	2

Sulfuric acid is water-reactive if concentrated.

U.S. DOT: Wet (filled with electrolyte) batteries are regulated by U.S. DOT as hazardous material.

Proper Shipping Name:	Batteries, wet, filled with acid
Hazard Class/Division:	8
ID Number:	UN2794
Packing Group:	III
Label Required:	Corrosive

IX. OTHER REGULATORY INFORMATION (Continued)

U.S. DOT (Continued)

Note: Yuasa-Exide batteries which have met the test requirements for "non-spillable wet electric storage batteries", as provided in 49 CFR 173.159(d), are non-regulated by DOT when protected against short circuits and securely packaged. Contact your Yuasa-Exide representative to determine which non-spillable batteries have met these requirements.

If non-spillable wet electric storage batteries have not met these requirements, the following information would apply:

Proper Shipping Name: Batteries, wet, non-spillable
Hazard Class/Division: 8
ID Number: UN2800
Packing Group: III
Label Required: Corrosive

RCRA: Spent lead-acid batteries are not regulated as hazardous waste when recycled. Spilled sulfuric acid is a characteristic hazardous waste; EPA hazardous waste number D002 (corrosivity).

CERCLA (Superfund) and EPCRA:

(a) Reportable Quantity (RQ) for spilled 100% sulfuric acid under CERCLA (Superfund) and EPCRA (Emergency Planning Community Right to Know Act) is 1,000 lbs. State and local reportable quantities for spilled sulfuric acid may vary.

(b) Sulfuric acid is a listed "Extremely Hazardous Substance" under EPCRA, with a Threshold Planning Quantity (TPQ) of 1,000 lbs.

(c) EPCRA Section 302 notification is required if 1,000 lbs. or more of sulfuric acid is present at one site. The quantity of sulfuric acid will vary by battery type. Contact your Yuasa-Exide representative for additional information.

(d) EPCRA Section 312 Tier 2 reporting is required for batteries if sulfuric acid is present in quantities of 500 lbs. or more and/or if lead is present in quantities of 10,000 lbs. or more.

(e) Supplier Notification: This product contains toxic chemicals which may be reportable under EPCRA Section 313 Toxic Chemical Release Inventory (Form R) requirements. If you are a manufacturing facility under SIC codes 20 through 39, the following information is provided to enable you to complete the required reports:

Toxic Chemical	CAS Number	Approximate % by Weight
Lead	7439-92-1	60
Sulfuric Acid	7664-93-9	10-30
* Antimony	7440-36-0	2
* Arsenic	7440-38-2	0.2

If you distribute this product to other manufacturers in SIC Codes 20 through 39, this information must be provided with the first shipment of each calendar year.

Note: The Section 313 supplier notification requirement does not apply to batteries which are "consumer products".

* Not present in all battery types. Contact your Yuasa-Exide representative for additional information.

IX. OTHER REGULATORY INFORMATION (Continued)

TSCA

Ingredients in Yuasa-Exide's batteries are listed in the BCA Registry as follows:

	CAS No.	BCA Status
Electrolyte		
Sulfuric Acid (H_2SO_4)	7664-93-9	Listed
Inorganic Lead Compound		
Lead (Pb)	7439-92-1	Listed
Lead Oxide (PbO)	1317-36-8	Listed
Lead Sulfate ($PbSO_4$)	7446-14-2	Listed
Antimony (Sb)	7440-36-0	Listed
Arsenic (As)	7440-38-2	Listed
Calcium (Ca)	7440-70-2	Listed
Tin (Sn)	7440-31-5	Listed

CAA

Yuasa-Exide, Inc. supports preventative actions concerning ozone depletion in the atmosphere due to emissions of CFC's and other ozone depleting chemicals (ODC's), defined by the USEPA as Class I substances. Pursuant to Section 611 of the Clean Air Act Amendments (CAAA) of 1990, finalized on January 19, 1993, Yuasa-Exide, Inc. established a policy to eliminate the use of Class I ODC's prior to the May 15, 1993 deadline.