City of Wichita Re-Use Water Pump Station
46 33 13 Sodium Hypochlorite Generating Equipment
Watson Marlow Dosing Skid Only
July, 2015

Project:
City of Wichita Re-Use Water Pump Station

Submitted to:
Wildcat Construction Co., Inc.
3219 W May
Wichita, KS 67213

Engineer:
MKEC
411 N. Webb Rd
Wichita, KS 67206

Submitted by:
Fluid Equipment
500 W. 5th Street
Kansas City, MO 64105

1. Provide NEMA 4X toggle type disconnect switch for each motor, mounted on skid and pre-wired.
2. Provide NEMA 1 VFDs, not mounted to skid, for field wiring in MCC room. Coordinate communication protocols and cards with Pedrotti.
3. Need cutsheets for ball valves. Hayward ported true union valves are specified.
4. Skid should be made of corrosion resistant materials, such as stainless or fiberglass, not galvanized carbon steel.
5. Pulsation dampener wetted materials shall not be carbon steel and shall be compatible with the pumped fluids.
6. Provide projected pump hose life.

Date Received: 7/22/16

A – Approved
B – Approved as Noted
C – Partial Approval, Resubmit as needed
D – Revise and Resubmit
E – For Reference/No Acceptance

500 W. 5th Street, Kansas City, MO 64105
Ph: 816.795.8511 F: 816.795.8926

MKEC ENGINEERING, INC.
411 North Webb Road – Wichita, KS 67206

☐ Reviewed ☐ Reviewed As Noted
☑ Revise and Resubmit ☐ Rejected
☐ Not Required by the Contract Documents

Reviewed for conformance with the design concept of the project and compliance with the information given in the contract documents. Contractor is responsible for: dimensions to be confirmed and correlated at the job site; information that pertains solely to the fabrication process or to techniques of construction; and coordination of work of all other trades. If "Resubmit" or "Rejected" are not checked resubmission is neither desired or required.

By: Keith Scarberry Date: 07/22/2016

Submittal Table of Contents

FLUID EQUIPMENT
A COGENT COMPANY

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Shop Drawings

Project Name:	City of Wichita, KS
Project Location:	Wichita, KS
PO Number:	2199444
WMFTG Job Number:	S013091
Section Number	M6.1- 46 33 13.F.9- Sodium Hypochlorite General Equipment/Sodium Hypochlorite Dosing Pumps
Equipment:	One (1) Bredel 25 Duplex (Duty/Standby) Skid System Sodium Hypochlorite Dosing Pumps
Engineer:	Consulting Engineer
Contractor:	Wildcat Construction
Manufacturer:	Watson-Marlow Fluid Technology Group 37 Upton Technology Drive Wilmington, MA 01887 Tel: 800-282-8823 Fax: 978-658-0041
Manufacturer's Contact:	Ambarneil Roy
Mfg. Representative:	Fluid Equipment Co. 2535 S Leonine Wichita, KS 67217 Tel: 316-630-0075 Fax: 316-634-1613
Submittal Number:	M6.1-46 33 13.F.9-001-01
Number of Copies:	1 EC
Submitted	6/30/2016

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I. Data Sheet with Installation Guidelines

PART 9: PRESSURE GAUGE AND DIAPHRAGM SEAL

I. Pressure Gauge Data
II. Diaphragm Seal Data

PART 10: PULSATION DAMPENER

I. Datasheet
II. Installation & Maintenance Manual

WATSON MARLOW
Fluid Technology Group

Part 1: Design Parameters and Outline Specification

CONTACT INFORMATION

The following points of contact are available if you have any questions regarding the associated support categories.

Equipment Inquiry Support

Ambarneil Roy
Ambarneil.Roy@wmftg.com
Tel: 949-371-2487

Submittals, Response Letters, Resubmittal Requests

Tanim Ahmed
Tanim.Ahmed@wmftg.com
Tel: 978-988-5325

O&M Manuals, Lesson/Training Plans, Warranty Statements, Miscellaneous Documentation

Rebecca Whalen
Rebecca.Whalen@wmftg.com
Tel: 978-658-4381

Customer Support, New Orders, Order Status, Shipping, Insurance Requests, W-9 Forms, Contract Review

Georgette Cabrera
Georgette.Cabrera@wmftg.com
Tel: 949-613-7823

Schedule Field Service

Marilyn Trinidad
Marilyn.Trinidad@wmftg.com
Tel: 949-613-7333

Ordering Spare Parts

Fluid Equipment Co.
2535 S Leonine
Wichita, KS 67217
Tel: 316-630-0075
Fax: 316-634-1613

Post-Sale Technical Engineer

Eric Coulombe
Eric.Coulombe@wmftg.com
Tel: 978-988-1426

DESIGN PARAMETERS

Scope

Watson-Marlow, as the contracted tubing pump manufacturer, is pleased to submit its Shop Drawings for review detailing all items supplied by Watson-Marlow under Section M6.1- 46 33 13.F.9-Sodium Hypochlorite General Equipment/Sodium Hypochlorite Dosing Pumps. Watson-Marlow's intended scope of supply, as offered in our Bid Date Scope Letter and described below is based upon requirements listed by the above specification section.

This proposal includes only equipment mentioned herein and does not include, nor infers inclusion of, any additional equipment, piping, valves, wiring, services, testing, etc. regardless of its relation to the listed equipment. Such services and equipment are to be supplied by the Contractor.

WATSON-MARLOW SCOPE OF EQUIPMENT SUPPLY / BILL OF MATERIALS		
Item Number	Quantity	Description
1	1	Bredel 25 Duplex (Duty/Standby) Skid System • (2) Bredel 25 Hose Pump Assembly • (1) PVC Calibration Column • (1) Pressure Relief Valve • (1) Pressure Gauge/Diaphragm Seal Assembly • (1) Pulsation Dampener
2	2	Vacon X4 VFD
3	4	Bredel 25 EPDM Hose
4	4	Bredel Hose Lubricant

ENGINEERING COMMENTS MADE AT TIME OF BID

The following comments were issued at the time of bid and are again listed below for your consideration.

SPECIFICATION	COMMENTS
General	Watson-Marlow is an equipment supplier, not a contractor and assumes no roles of the contractor.
Section F.9	Watson-Marlow takes exception to the back pressure valves listed under this section. The Bredel 25 pumps do not require the use of back pressure valves for proper operation.

EQUIPMENT OUTLINE SPECIFICATION

[MATERIAL] FABRICATED SKID PLUMBED SKID SYSTEM WITH PLUMBED BACK PANEL (QUANTITY: 1)	
Type/Model	Bredel 25 Duplex (Duty/Standby) Skid Assembly
Skid Material	Stainless Steel 304
Pipe	Schedule 80 PVC
Pipe Fittings	Schedule 80 PVC
Isolation Valves	True Union Ball Valve-Vented- 1" NPT, PVC
Design	See Drawing

BREDEL 25 HOSE PUMP (QUANTITY: 2)	
Name of Pump Manufacturer	Watson-Marlow, Inc.
Model, P/N	Bredel 25, 225US3
Flow/Revolution	0.300 L/Rev (0.079 G/Rev)
Pump Speed	31 RPM
Nominal Flow	5,250 L/hr (23.1 GPH) pressure up to 16 Bar (232 psi)
Port Sizes	25mm
Hose/Insert Material	EPDM Hose/ PVDF Hose Insert
Construction	Pump Supports: Galvanized Steel Pump Hardware and Hose Clamp: Galvanized Steel Flanges & Flange Brackets: Galvanized Steel
Assembly Details	See Drawings
Paint	Bredel Red
Port Position	2
Net Weight of Pumphead	39 kg (85.98 lbs)

GEAR REDUCER (QUANTITY: 1)	
Name of Manufacturer	Nord
Model, P/N	SK373.1F-56C-32
Speed	32 RPM
Gearing Ratio	54.00
Number of Gearing Stages	3- Stage
Gearbox Frame	56C
Paint	Bredel Red
Net Weight of Gearing	26 lbs

MOTOR (QUANTITY: 1)	
Name of Manufacturer	Baldor
Model, P/N	VEM3546
Horsepower	1 HP
Enclosure/Turndown	TEFC
Voltage	208-230/460

Service Factor	1.15
Nominal Efficiency Rating	85.5
Synch RPM	1800
Frame Size	56C
Insulation	F
Paint	Bredel Red
Weight	39 lbs
NEMA Design Code	B
Full Load Amperage	1.5

VARIABLE FREQUENCY DRIVE (QUANTITY: 2)	
Name of Manufacturer	Machine Drive
Model, P/N	VACONX4C20020C
Type	Vacon X Series, F0 Frame
Input Voltage	200-240 VAC Input
Output Voltage (to Motor)	230 VAC Output
Enclosure	IP66/NEMA 4X
Design	See Drawing

CALIBRATION COLUMN (QUANTITY: 1)	
Name of Manufacturer	Griffco
Model, P/N	CC10000-S
Material	PVC
Diameter	6.95”
Length	25”
Capacity	10,000mL
Scale	100mL/ 5 GPH
Connections	2” Threaded
Design	See Drawing

PRESSURE RELIEF VALVE (QUANTITY: 1)	
Name of Manufacturer	Griffco
Model, P/N	PRG100-PV
Body Material	PVC
Seal Material	Viton Diaphragm
Connection Size	1” NPT Threaded
Pressure Adjustment	10-150 psi

PRESSURE GAUGE WITH DIAPHRAGM SEAL (QUANTITY: 1)	
Name of Manufacturer	Pilgrim Instrument
Model, P/N	WMP-0139

Pressure Gauge	Ashcroft 25 1009SL 02L 160# Pressure Gauge, 2.5” Dial, Stainless Steel Glycerin Filled Case, 316 Stainless Steel Tube and Socket, 160 psig Range, ¼” Lower Process Connection
Diaphragm Seal	Plast-O-Matic GGTS1-PV Diaphragm Seal, Teflon Diaphragm, PVC Lower Housing, 1” NPT Process Connection, Halocarbon System Fill

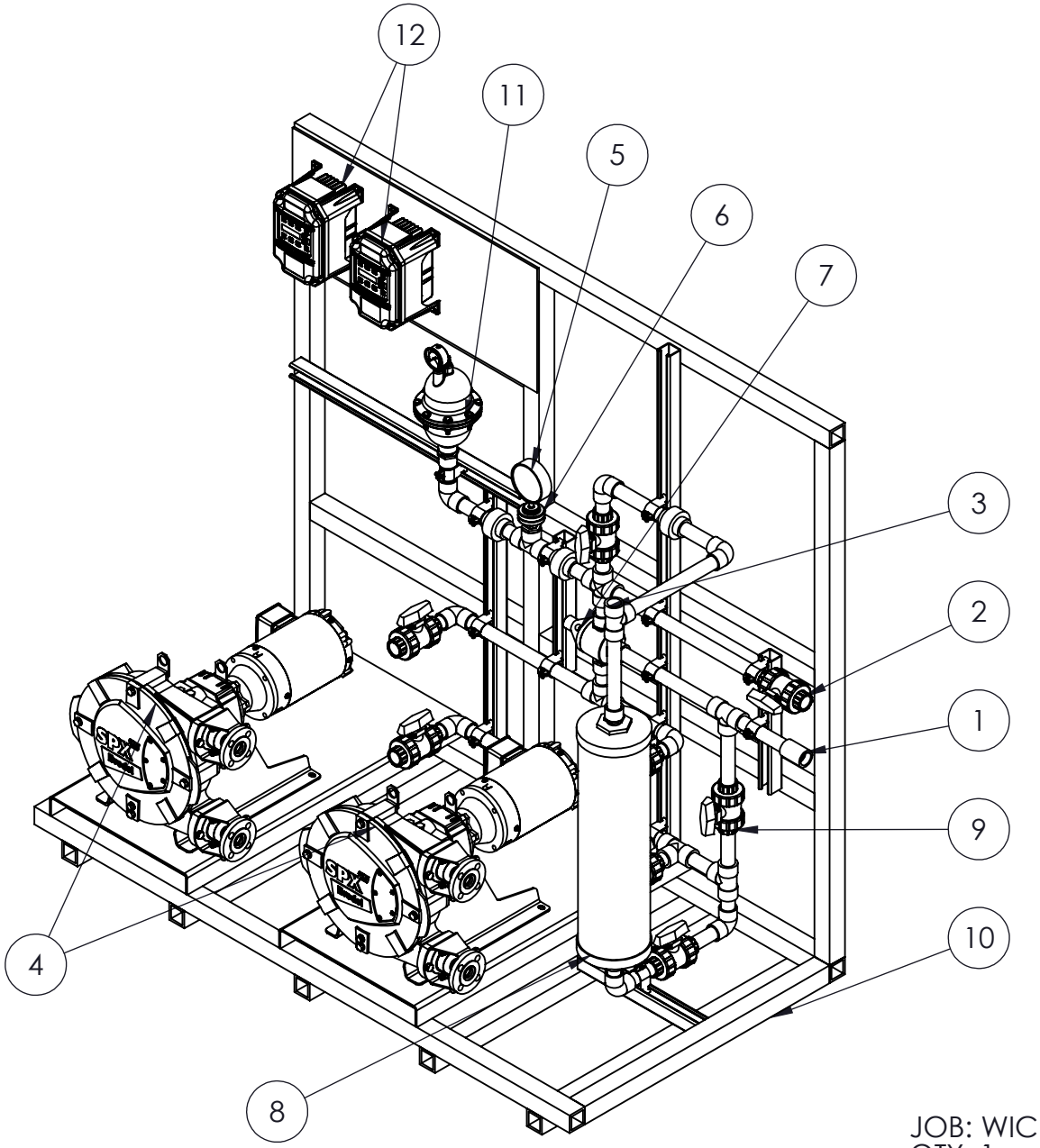
PULSATION DAMPENER (QUANTITY: 1)	
Name of Manufacturer	Blacoh
Model, P/N	CT3040ND-1
Air Control	CHARGE
Bladder Material	EPDM
Capacity	85 Cubic inches/ 1.4 Liters
Inlet Size	1” FNPT
Max Pressure	300 Psi/ 20.6 Bar
Nonwetted Housing	Carbon Steel
Wetted Housing	Carbon Steel
Weight	15 lbs

ANCILLARY EQUIPMENT/CONTRACTED SPARES			
ITEM	**QUANTITY**	**DESCRIPTION**	**PART NUMBER**
1	4	Bredel 25 EPDM Hose	28-025020
2	4	Bredel Hose Lubricant	28-911143

WATSON MARLOW
Fluid Technology Group

Part 2: Chemical Metering Skid

ITEM NO.	DESCRIPTION	QUANTITY
1	SUCTION - 1" NPT, PVC	1
2	DISCHARGE - 1" NPT, PVC	1
3	VENT	1
4	PUMP - BREDEL 25 PUMP	2
5	PRESSURE GAUGE - 1/4" NPT	1
6	DIAPHRAM SEAL - 1" NPT X 1/4" NPT	1
7	PRESSURE RELIEF VALVE - 1" NPT, PVC	1
8	CALIBRATION COLUMN - 10,000 mL	1
9	TRUE UNION BALL VALVE - VENTED - 1" NPT, PVC	8
10	SS 304 SKID	1
11	PULSATION DAMPENER	1
12	VFD	2



JOB: WICHITA, KS
QTY: 1

1 ISO VIEW

CRITICAL DIMENSIONS ARE MARKED ▼

3rd ANGLE PROJECTION

DO NOT SCALE

ORIGINAL SHT. SIZE ANSI A

ORIGINAL SCALE 1:16

DIMENSIONS IN INCHES

TOLERANCES UNLESS OTHERWISE STATED

MILLIMETRES ±XX ANGULAR ± 0°
ONE DECIMAL ±XX
TWO DECIMAL ±XX
HOLES ±XX

Watson-Marlow Pumps Group
37 Upton Technology Park, Wilmington, MA 01887
Tel: 800-282-8823
Fax: 978-658-0041

TITLE

DUTY-STANDBY
BREDEL 25 DUPLEX CHEMICAL METERING SKID

DRAWN WWW	DATE 07/07/16
RELEASED	DATE
FIRST USED ON	
SIMILAR TO	
SUPERSEDES	
SHEET 1 OF 4	
DRAWING NO.	
BREDEL25DPLXSKID	

ITEM NO.	DESCRIPTION	QUANTITY
1	SUCTION - 1" NPT, PVC	1
2	DISCHARGE - 1" NPT, PVC	1
3	VENT	1
4	PUMP - BREDEL 25 PUMP	2
5	PRESSURE GAUGE - 1/4" NPT	1
6	DIAPHRAM SEAL - 1" NPT X 1/4" NPT	1
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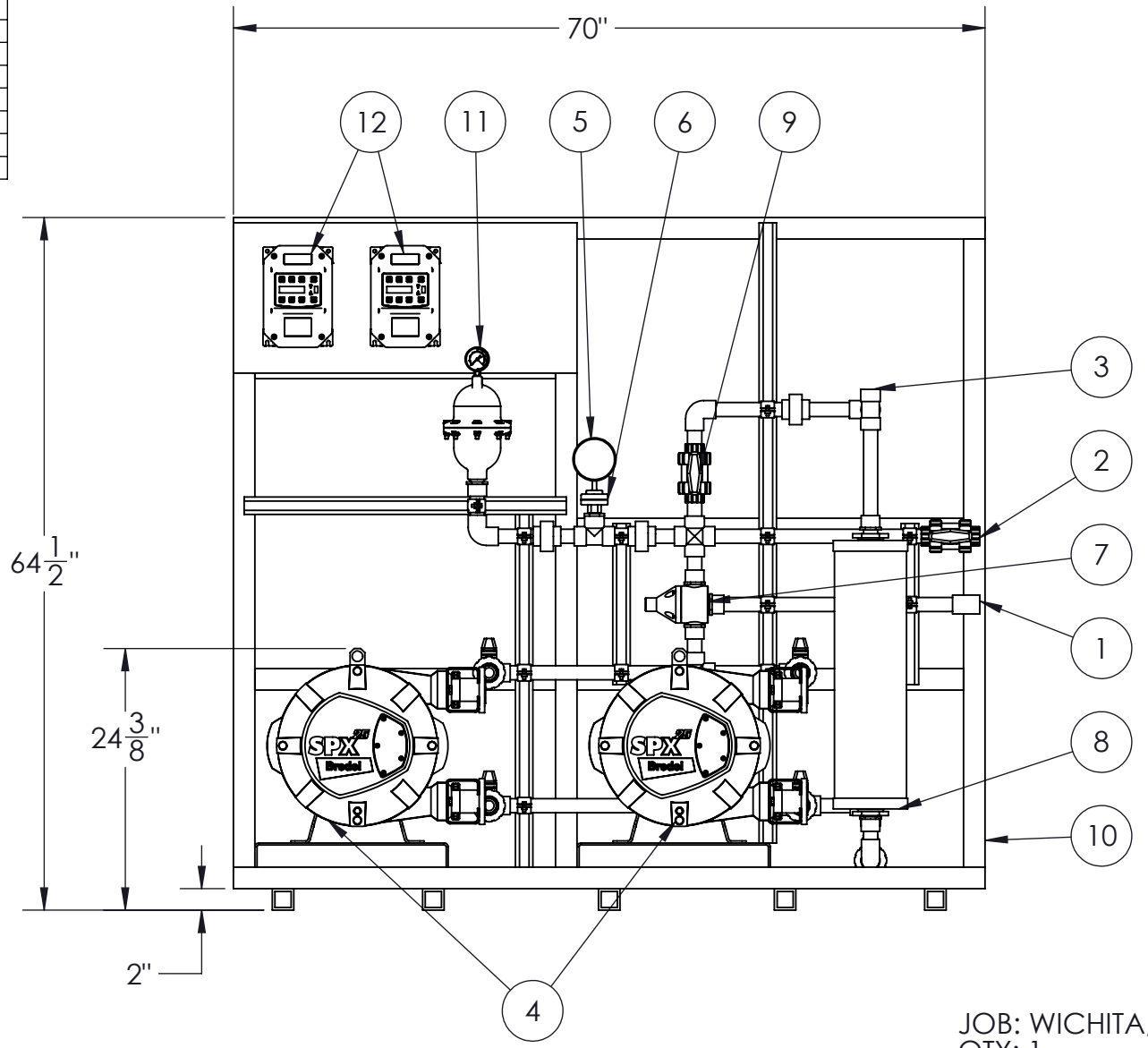

JOB: WICHITA, KS
QTY: 1

2 FRONT VIEW

3rd ANGLE PROJECTION

DO NOT SCALE

CRITICAL DIMENSIONS ARE MARKED ▼

ORIGINAL SHT. SIZE ANSI A

ORIGINAL SCALE 1:16

DIMENSIONS IN INCHES

TOLERANCES UNLESS OTHERWISE STATED

MILLIMETRES ±XX ANGULAR ± 0°

ONE DECIMAL ±XX

TWO DECIMAL ±XX

HOLES ±XX

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Fax: 978-658-0041

TITLE

DUTY-STANDBY
BREDEL 25 DUPLEX CHEMICAL METERING SKID

DRAWN WWW	DATE 07/07/16
RELEASED	DATE
FIRST USED ON	
SIMILAR TO	
SUPERSEDES	
SHEET 2 OF 4	
DRAWING NO.	BREDEL25DPLXSKID

ITEM NO.	DESCRIPTION	QUANTITY
1	SUCTION - 1" NPT, PVC	1
2	DISCHARGE - 1" NPT, PVC	1
3	VENT	1
4	PUMP - BREDEL 25 PUMP	2
5	PRESSURE GAUGE - 1/4" NPT	1
6	DIAPHRAM SEAL - 1" NPT X 1/4" NPT	1
7	PRESSURE RELIEF VALVE - 1" NPT, PVC	1
8	CALIBRATION COLUMN - 10,000 mL	1
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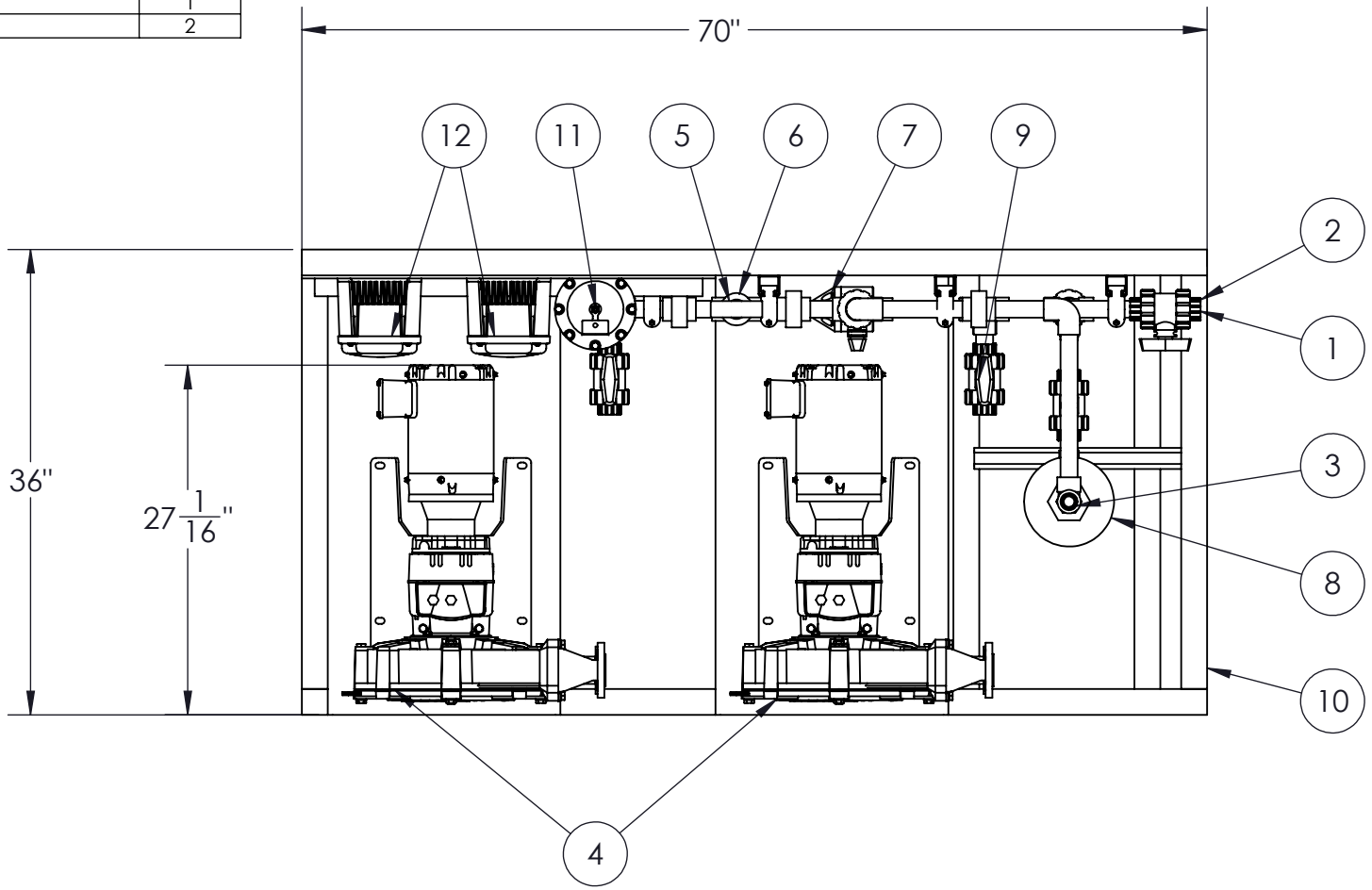

JOB: WICHITA, KS
QTY: 1

3 TOP VIEW

3rd ANGLE PROJECTION

DO NOT SCALE

CRITICAL DIMENSIONS ARE MARKED ▼

ORIGINAL SHT. SIZE ANSI A

ORIGINAL SCALE 1:14

DIMENSIONS IN INCHES

TOLERANCES UNLESS OTHERWISE STATED

MILLIMETRES ±XX ANGULAR ± 0°
ONE DECIMAL ±XX
TWO DECIMAL ±XX
HOLES ±XX

Watson-Marlow Pumps Group
37 Upton Technology Park, Wilmington, MA 01887
Tel: 800-282-8823
Fax: 978-658-0041

TITLE

DUTY-STANDBY
BREDEL 25 DUPLEX CHEMICAL METERING SKID

DRAWN WWW	DATE 07/07/16
RELEASED	DATE
FIRST USED ON	
SIMILAR TO	
SUPERSEDES	
SHEET 3 OF 4	
DRAWING NO.	
BREDEL25DPLXSKID	

ITEM NO.	DESCRIPTION	QUANTITY
1	SUCTION - 1" NPT, PVC	1
2	DISCHARGE - 1" NPT, PVC	1
3	VENT	1
4	PUMP - BREDEL 25 PUMP	2
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6	DIAPHRAM SEAL - 1" NPT X 1/4" NPT	1
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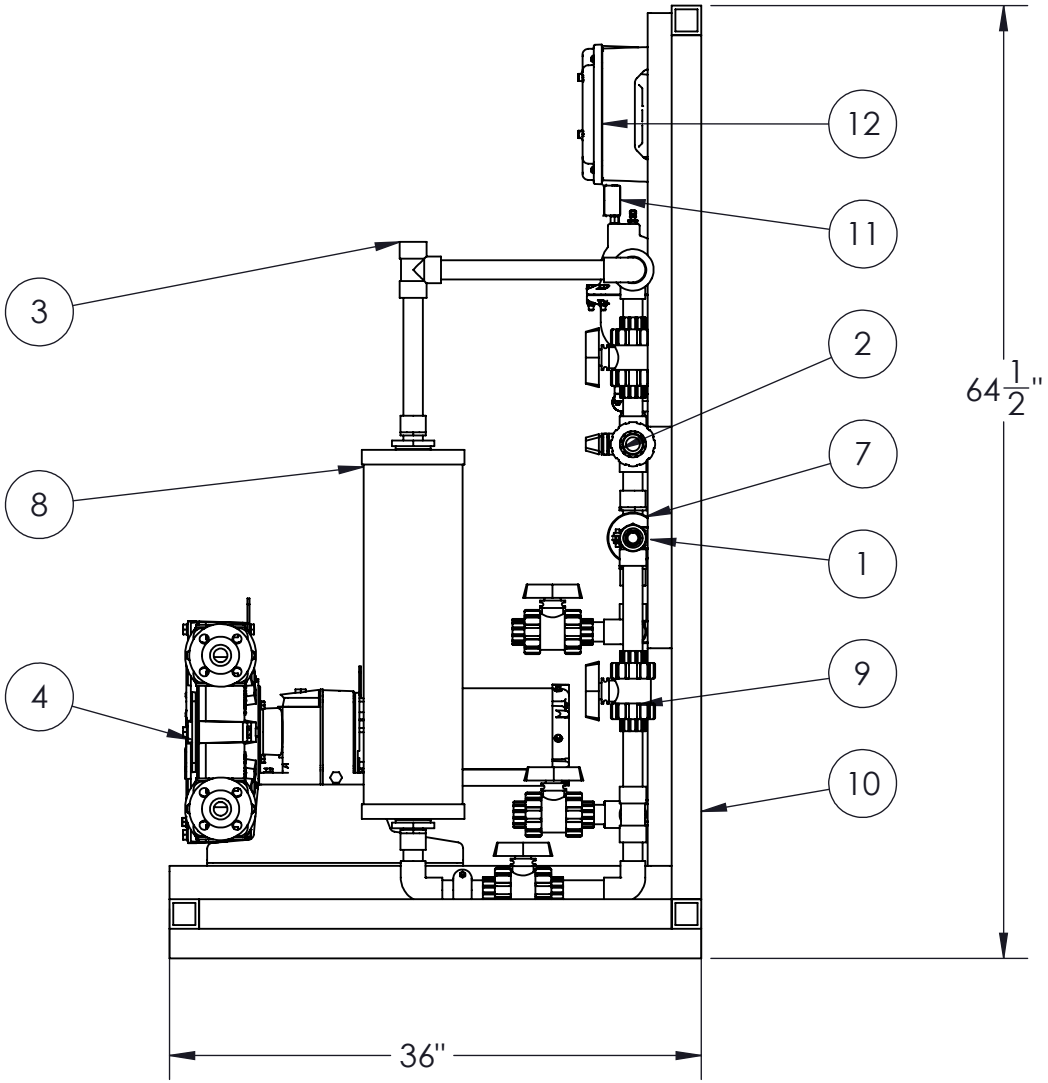

JOB: WICHITA, KS
QTY: 1

4 SIDE VIEW

CRITICAL DIMENSIONS ARE MARKED ▼

3rd ANGLE PROJECTION

DO NOT SCALE

ORIGINAL SHT. SIZE ANSI A

ORIGINAL SCALE 1:13

DIMENSIONS IN INCHES

TOLERANCES UNLESS OTHERWISE STATED

MILLIMETRES ±XX ANGULAR ± 0°
ONE DECIMAL ±XX
TWO DECIMAL ±XX
HOLES ±XX

Watson-Marlow Pumps Group
37 Upton Technology Park, Wilmington, MA 01887
Tel: 800-282-8823
Fax: 978-658-0041

TITLE

DUTY-STANDBY
BREDEL 25 DUPLEX CHEMICAL METERING SKID

DRAWN WWW	DATE 07/07/16
RELEASED	DATE
FIRST USED ON	
SIMILAR TO	
SUPERSEDES	
SHEET 4 OF 4	
DRAWING NO.	
BREDEL25DPLXSKID	

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Fluid Technology Group

Part 3: Bredel 25 Hose Pump Specification and Performance

Bredel 25

Bredel SERIES

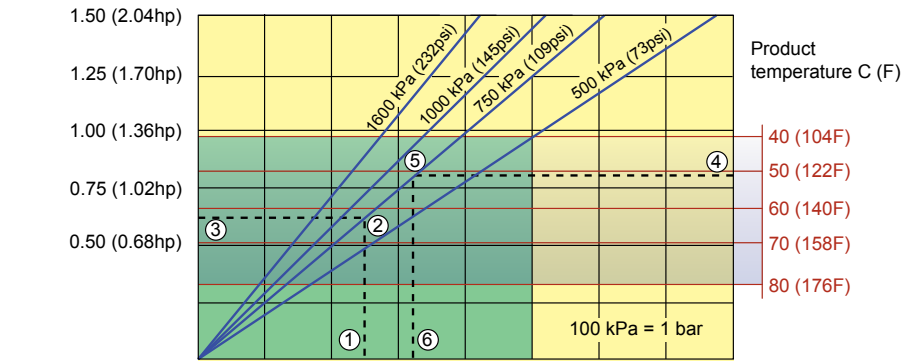
Bredel Hose Pumps

FEATURES AND BENEFITS

- **Sealless, valveless pumping principle for reliable, low maintenance metering, dosing and transfer**
- **Flow rates up to 5,250 L/hr (23.1 USGPM) and pressures up to 16bar (232 psi)**
- **Dry running and self-priming, with up to 9.5 meters (30 foot) suction lift capability**
- **Robust design for aggressive chemicals or abrasives**
- **Compact direct coupled design to maximise gearbox life**
- **Simple hose change decreases cost of ownership, downtime and need for parts inventory**

PERFORMANCE

Bredel 25



Pump speed	rpm	20	40	60	80	100	120	140	160
Capacity	L/h	360	720	1080	1440	1800	2160	2520	2880
Capacity	USGPM	1.6	3.2	4.8	6.4	7.9	9.5	11.1	12.7

Continuous Duty

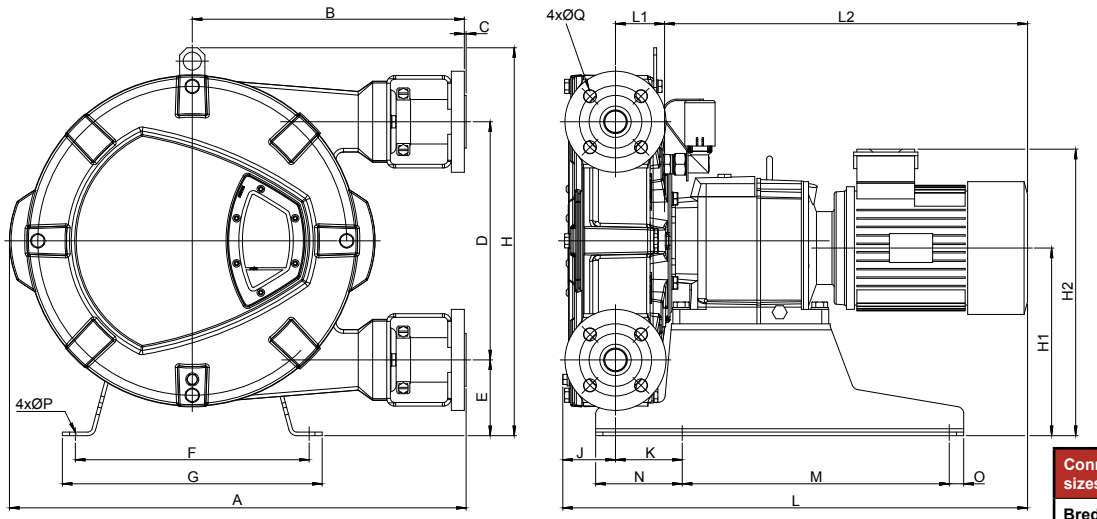
Intermittent Duty*

* Maximum 2 hours operation followed by minimum 1 hour stop

1. Flow required indicates pump speed
2. Calculated discharge pressure
3. Net motor power required
4. Product temperature
5. Calculated discharge pressure
6. Maximum recommended pump speed

Note: The area of continuous operation diminishes with increased product temperatures.
For product temperatures >40C (104F), the area of continuous operation is limited by the corresponding red temperature line.

DIMENSIONS



Connector sizes	ANSI 150#	EN DIN	JIS
Bredel 25	1"	25mm	25mm

Type	A	B	C	D	E	F	G	H	H1	H2max	J	K	Lmax	L1	L2max	M	N	O	ØP	ØQ	R
Bredel 25 (mm)	521	304	2.5	264	98	279	315	460	222	359	66	97	592	58	468	305	120	15	12	14	85
Bredel 25 (inches)	20.5	12	0.09	10.4	3.9	11	12.4	18.1	8.7	14.1	2.6	3.8	23.3	2.3	18.4	12	4.7	0.6	0.47	0.6	3.3

TECHNICAL SPECIFICATIONS

	Bredel 25
Flow range	up to 2,880 L/hr (12.7 USGPM)
Capacity	0.300 L/rev (0.079 G/rev)
Minimum starting torque	115Nm (1018 inch-lbs)
Hose lubricant required	2 litres (0.53 USG)
Pumphead weight	39kg (85.98lbs)
Max inlet pressure	3.5 bar abs (51 psia)
Common features	
Suction pressure	0.05bar abs (0.73 psia)
Maximum discharge pressure	1600 kPa (16 bar) (232psi)
Product temperature range*	-10C up to 80C (14F up to 176F)
Ambient temperature range**	-20C up to 45C (-4F up to 113F)

*Please consult your Bredel representative for lower or higher temperature operation.
**Allowable ambient temperature is based on pump capabilities and may be further limited by gearbox ambient capabilities

MATERIALS OF CONSTRUCTION

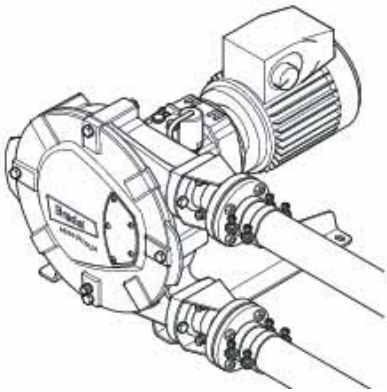
Components	Materials
Pump housing	Cast iron
Rotor	Cast iron
Pressing shoes	Aluminium or epoxy
Cover	Cast iron
Brackets	Galvanized steel
Flanges	Galvanized steel
Inserts	PVC
Support frame	Galvanized steel
Hose clamps	Galvanized steel
Seals	Neoprene or nitrile

Options	Features
Available hose materials	EPDM
Available flanges	ANSI
Available inserts	Bredel standard or with sanitary connectors
High+low level float switch	Max. 2A, 230 V AC/DC, max. 40VA ATEX: max. 50 mA, max. 28V AC/DC
Integrated FI for stand alone speed control	Factory programmable from 12-80 Hz
Revolution counter	For maintenance and /or metering

Bredel Hose Pumps
wmpg.com
+44 (0)1326 370 370
info@wmpg.com

Hose pump series
Bredel 25

Manual



CONTENTS

1 GENERAL

1.1 How to use this manual

This manual is intended as a reference book by means of which qualified users are able to install, commission and maintain the hose pumps mentioned on the front cover.

1.2 Original instructions

The original instructions for this manual have been written in English. Other language versions of this manual are a translation of the original instructions.

1.3 Other supplied documentation

Documentation of components such as electric motors, gearboxes, etc. is normally not included in this manual. But if additional documentation is supplied, you must follow the instructions in this additional documentation.

1.4 Service and support

For information with respect to specific adjustments, installation, maintenance or repair jobs which fall beyond the scope of this manual, contact your Bredel representative. Make sure you have the following data at hand:

- Serial number hose pump
- Article number pump hose
- Article number gearbox
- Article number electric motor
- Article number frequency controller

You will find these data on the identification plates or stickers of the pumphead, the pump hose, the gearbox and the electric motor. Refer to § 4.1.1.

1.5 Environment and disposal of waste

	**CAUTION** Always observe the local rules and regulations with respect to processing (non reusable) parts of the hose pump.

Inquire within your local government about the possibilities for reuse or environment-friendly processing of packaging materials, (contaminated) lubricant and oil.

2 SAFETY

2.1 Symbols

In this manual the following symbols are used:

	**WARNING** Procedures which, if not carried out with the necessary care, may result in serious damage to the hose pump or in serious bodily harm.
	**CAUTION** Procedures which, if not carried out with the necessary care, may result in serious damage to the hose pump, the surrounding area or the environment.
	Remarks, suggestions and advice.
	**WARNING** Procedures, remarks, suggestions or advice which refer to use in potentially explosive atmospheres in accordance with the ATEX Directive 94/9/EC.

2.2 Intended use

The hose pump is exclusively designed for pumping suitable products. Every other or further use is not in conformance with the intended use.
The "Intended use" as laid down in EN 292-1 is "… the use for which the technical product is intended in accordance with the specifications of the manufacturer, inclusive of his indications in the sales brochure". In case of doubt it is the use which appears to be its intended use judging from the construction, execution

and function of the product. Observing the instructions in the user's documentation also belongs to intended use.
Only use the pump in accordance with the intended use described above. The manufacturer cannot be held responsible for damage or harm resulting from misuse. If you want to change the application of your hose pump, contact your Bredel representative first.

2.3 Use in potentially explosive atmospheres

The *pump head* and *gearbox* mentioned in this manual are suitable for use in a potentially explosive atmosphere. The pumps mentioned meet the requirements as stated in the European Directive 94/9/EC (ATEX Directive).
The pumps belong to:

- Group II Appliances, category 2 GD ck T4

2.4 Responsibility

The manufacturer does not accept any responsibility for damage or harm caused by not (strictly) observing the safety regulations and instructions in this manual and the also supplied documentation, or by negligence during installation, use, maintenance and repair of the hose pumps mentioned on the front cover. Depending on the specific working conditions or accessories used, additional safety instructions can be required.
Immediately contact your Bredel representative, if you noticed a potential danger while using your hose pump.

	**WARNING** The user of the hose pump is always fully responsible for observing the local valid safety regulations and directives. Observe these safety regulations and directives when using the hose pump.

2.5 Qualification of the user

The installation, use and maintenance of the hose pump should only be performed by well-trained and qualified users. Temporary staff and persons in training may use the hose pump only under the supervision and responsibility of trained and qualified users.

2.6 Regulations and instructions

- Everyone who works with the hose pump must be aware of the contents of this manual and observe the instructions with great care.
- Never change the order of the actions to be carried out.
- Always store the manual near the hose pump.

3 WARRANTIES

The manufacturer offers a two-year warranty on proper workmanship of all parts of the hose pump. Exclusion is made for normal wear and tear of consumables such as pump hoses, lubricant, hose clamps, pressing shoes, ball bearings, wear rings, seals and rubber bushes, or parts which have been misused or damaged through negligence.

This manufacturer's warranty is null and void for any user who has substituted the parts of an alternate manufacturer into a Watson-Marlow Bredel (hereafter called Bredel) hose pump.

Damaged parts may be returned to the manufacturer for warranty analysis. If failure was determined caused by faulty workmanship, the manufacturer will repair or replace the faulty component.
The parts must be accompanied by a fully completed and signed health and safety form, as present in the back of this manual. The form must be applied to the outside of the shipping carton.
Parts which have been contaminated or which have been corroded by chemicals or other substances that can pose a health risk must be cleaned before they are returned to the manufacturer. Furthermore, it should be indicated on the health and safety form, which specific cleaning procedure has been followed, and it should be indicated that the equipment has been decontaminated. The safety form is required at all items, even if the parts have not been used.

Warranties purporting to be on behalf of Bredel made by any person, including representatives of Bredel, its subsidiaries, or its distributors, which do not accord with the terms of this warranty shall not be binding upon Bredel. unless expressly approved in writing by a Director or Manager of Bredel.

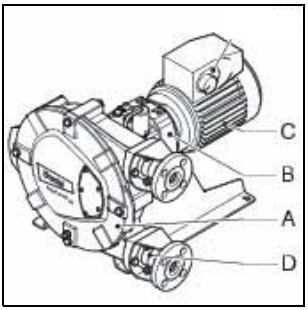
4 DESCRIPTION

4.1 Identification of the product

4.1.1 Identification of the product

The hose pump can be identified based on the identification plates or stickers on:

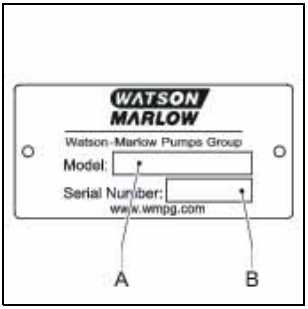
A: Pump head
B: Gearbox
C: Electric motor
D: Pump hose



4.1.2 Identification of the pump

The identification plate on the pump head contains the following data:

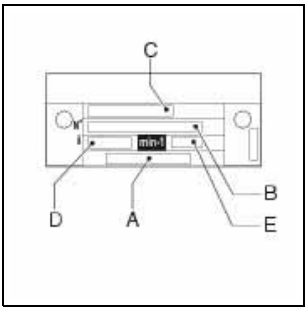
A: Pump model
B: Serial number



4.1.3 Identification of the gearbox

The identification plate on the gearbox contains the following data:

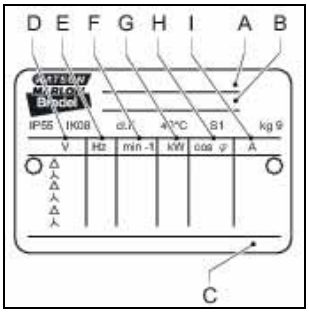
A: Article number
B: Serial number
C: Type number
D: Reduction ratio
E: Number of revolutions per minute



4.1.4 Identification of the electric motor

The identification plate on the electric motor contains the following data:

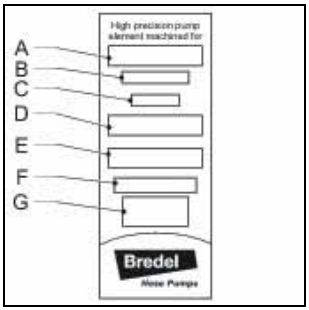
A: Type number
B: Serial number
C: Article number
D: Mains
E: Frequency
F: Speed
G: Power
H: Power factor
I: Current



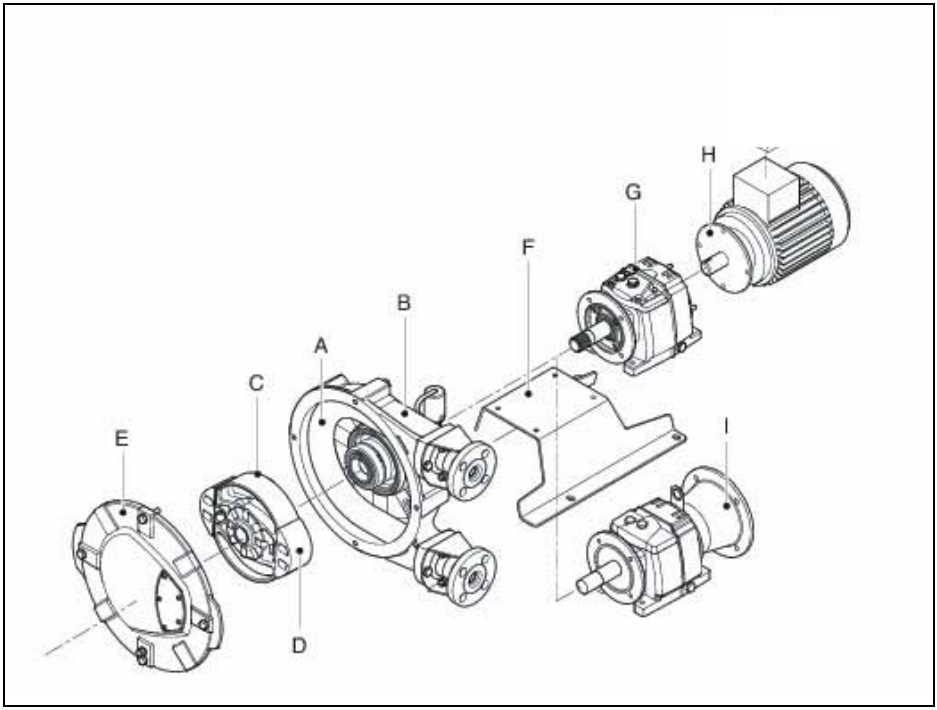
4.1.6 Identification of the pump hose

The identification sticker on the pump hose contains the following data:

A: Pump type
B: Reorder number
C: Internal diameter
D: Type of material of inner liner
E: Remarks, if applicable
F: Maximum permissible working pressure
G: Production code



4.2 Construction of the pump

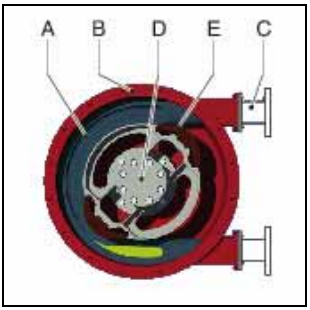


A: Pump hose
B: Pump housing
C: Rotor
D: Pressing shoes
E: Cover
F: Support
G: Gearbox
H: Electric motor
I: Adapter without motor (option)

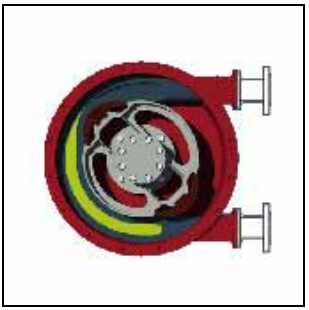
4.3 Operation of the pump

The heart of the pump head consists of a specially constructed pump hose (A) which lies contorted against the inside of the pump housing (B). Both ends of the hose are connected to the suction and discharge lines by means of a flange construction (C). A bearing-mounted rotor (D) with two facing pressing shoes (E) is in the center of the pump head.

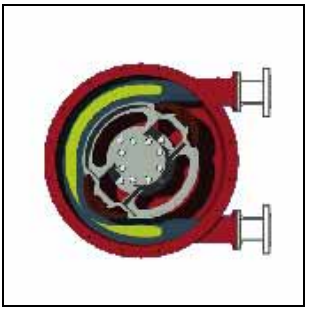
In phase 1 the lower pressing shoe compresses the pump hose by the rotational movement of the rotor, forcing the fluid through the hose. As soon as the pressing shoe has passed, the hose recovers to its original shape due to the mechanical properties of the material.



In phase 2 the product is drawn into the hose by the (continuous) turning motion of the rotor.



In phase 3, the second pressing shoe will subsequently compress the pump hose. Due to the continuous rotating movement of the rotor not only new product is sucked in, but also the already present product is pressed out by the pressing shoe. When the first pressing shoe runs from the pump hose, the second pressing shoe has already closed the pump hose and the product is prevented from flowing back. This method of liquid displacement is also known as the "positive displacement principle".

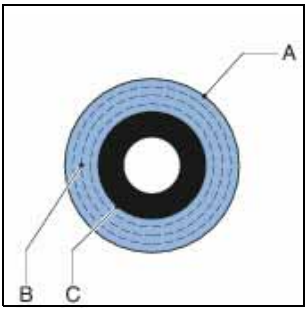


4.4 Pump hose

4.4.1 General

The pump hose is made of special rubbers, reinforced with nylon cords and is constructed as follows:

A: Outer extruded layer made of natural rubber
B: Four nylon reinforcement layers
C: Inner extruded liner



The pump hose liner material should be chemically resistant with the product to be pumped. Dependent on the specific requirements of your application a corresponding pump hose must be selected. For each pump model various hose types are available.
The material of the inner liner of the pump hose determines the hose type. Each hose type is marked by a unique color code.

Hose type	Material	Color code
NR	Natural rubber	Purple
NBR	Nitrile rubber	Yellow
EPDM	EPDM	Red
CSM	CSM	Blue

Natural Rubber*
Always the first choice hose. A highly dynamic material, which has excellent abrasion resistance and mechanical strength, and is generally resistant to diluted acids and alcohols.
Max. liquid temperature 80 °C (175 °F).
Min. temperature -20 °C (-5 °F).

Nitrile rubber*
A highly abrasion proof and wear resistant material that is generally resistant to oils, fats, alkaline, and detergents. Suitable for a wide range of food handling and meets FDA and 3A standards.
Max. liquid temperature 80 °C (175 °F).
Min. temperature -10 °C (15 °F).

EPDM*
Good chemical resistance especially to concentrated acids, ketones, and alcohols.
Max. liquid temperature 90 °C (195 °F).
Min. temperature -10 °C (15 °F).
Consult Bredel technical services for details on higher temperature operation, up to 90 °C (195 °F) with EPDM.

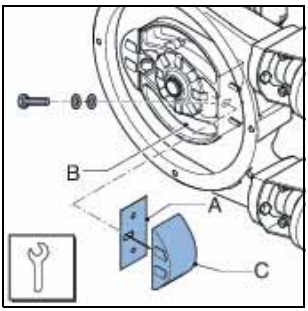
CSM*
Good chemical resistance for strong oxidizing products like concentrated acids and oxygen generating substances.
Max. liquid temperature 80 °C (175 °F).
Min. temperature -10 °C (15 °F)
Consult Bredel technical services for RPM limitations when using CSM.

	* Consult your Bredel representative for more detailed information about the chemical and temperature resistance of pump hoses.

The Bredel pump hoses have been carefully machined, therefore there are minimum tolerances in wall thickness. This is very important to guarantee the correct compression of the pump hose, because:

- When the compression is too high, it creates a load on the pump and pump hose that is too high, which may result in a reduction of the life of the pump hose and bearings.
- When the compression is too low this will result in high velocity backflow (slip). Backflow results in a reduction of pump performance, hydraulic efficiency, and negatively impact the life of the pump hose.

4.4.2 Hose compression force adjustment (shimming)



In order to achieve optimal life of the pump hose, the compression force of the pump hose can be adjusted by placing a number of shims under the pressing shoes. The shims (A) are fitted between the rotor (B) and the pressing shoe (C). The number of shims will vary for each discharge pressure situation.

The paragraph 7.8 describes how to select and install the shims.

4.4.3 Lubrication and cooling

The pump head, in which the rotor and pump hose can be found, is filled with Bredel Genuine Hose Lubricant. This lubricant lubricates the movement between the hose and the pressing shoes and dissipates the generated heat via the pump housing and the cover.

The lubricant is food grade. See § 10.1.4 for the required quantity and NSF registration.

	Consult your Bredel representative for lubrication recommendations when operating the hose pump below 2 rpm.

4.5 Gearbox

The hose pump types described in this manual use coaxial gearbox units.
The gearboxes are fitted with a foot rest. The outgoing shaft has been fitted with a spline.

4.6 Electric motor

If the electric motor has been standard supplied by the manufacturer, it is an integrated standardized squirrel-cage motor. Refer to § 10.4 for specifications. If the pump is to be used in potentially explosive atmospheres, contact your Bredel representative.

4.8 Available options

The following options are available for the hose pump:

- High (lubricant) level float switch
- Low (lubricant) level float switch
- Revolution counter
- Epoxy pressing shoes
- Stainless steel 316 flanges, flange brackets, hose clamps, support and mounting articles
- Pump support for non-standard gearbox types
- Special configuration for use in potentially explosive atmospheres.

	The high level float switch is mandatory for use in potentially explosive atmospheres. If the pump is to be used in potentially explosive atmospheres, contact your Bredel representative.

5 INSTALLATION

5.1 Unpacking

When unpacking carefully follow the instructions as given on the packaging or on the hose pump.

5.2 Inspection

Check that your delivery is correct and check it for any transport damage. Refer to § 4.1.1. Report any damage immediately to your Bredel representative.

5.3 Installation conditions

5.3.1 Ambient conditions

Make sure that the hose pump is in an area where the ambient temperature during operation is not lower than -20 °C (-4 °F) and not higher than +45 °C (+113 °F).

5.3.2 Set-up

- The pump materials and protective layers are suitable for indoor set-up and a protected outdoor set-up. Under certain conditions the pump is suitable for limited outdoor set-up or a salty or aggressive atmosphere. Consult your Bredel representative for more information.
- Make sure that the floor surface has a maximum slope of 10 mm per meter (0.12 inch per foot).
- Make sure that there is sufficient room around the pump to carry out the necessary maintenance.
- Make sure that the room is sufficiently ventilated, so that the heat developed by the pump and drive can be dissipated. Keep some distance between the ventilation cover of the electric motor and the wall to allow the supply of cooling air.

5.3.3 Pipework

When determining and connecting suction and discharge lines consider the following points:

- **Do** keep delivery and suction lines as short and direct as possible.
- Keep the piping at a minimum equal to or greater than the bore size of the pump. Increase the bore size of the pipe work when the duty fluid has a high velocity or inertia. This will help keep friction and impulse losses to a minimum. Where critical velocities are a concern consult your Bredel representative.
- **Do** limit the presence of sharp bends in the process lines. Make sure that the radius of any bends is as large as possible (R=4d to 5d). It is recommended to use Y-connections instead of T-connections.
- Consult your Bredel representative for recommendations on mounting pulsation dampening devices. A pulsation dampener and/ or inlet pulse accumulator may be necessary if the relative density and pump speed is high and the line lengths are long.
- The self-priming and positive displacement nature of peristaltic pumps means that valves are not required. If for whatever reason, valves are fitted into the system, they must have a straight fluid path and cause minimum restriction to flow in the pumping circuit. Note that check valves directly in the process stream may increase pulsation and negatively impact hose life.
- For ease of hose changing and some pulsation suppression, it is recommended to use a segment of flexible hose between the pump flange and hard piping of the suction and/or discharge line. A segment of three quarters (3/ 4) of the pump hose length for the flexible pipe work is recommended. Bredel also recommends installing an isolation valve and

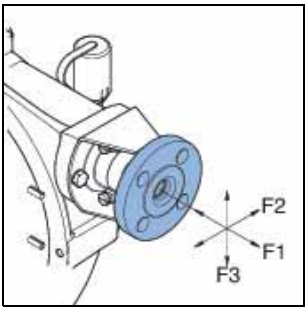
pipe-drain in the suction and discharge pipe work to allow fluid isolation and drainage from the pump during maintenance. Following these recommendations will help minimize process fluid exposure by maintenance personnel.

- For the flexible hoses select compatible materials and ensure the installation is suited for the design pressure of the system.
- Prevent any possibilities of exceeding the maximum working pressure of the hose pump. Refer to § 10.1.1. If necessary install a pressure relief valve or shutdown switch. Consult your Bredel representative for more detailed information.

⚠	**CAUTION** Consider the maximum permissible working pressure on the discharge side. Exceeding the maximum working pressure may lead to serious damage to the pump.

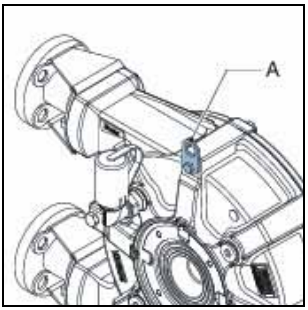
- Make sure that the maximum forces on the flanges are not exceeded. The permissible loads are given in the following table.

Maximum permissible loads on the pump flange		
Force	**Unit**	**Bredel 25**
F1	N	600
	lbf	135
F2	N	500
	lbf	112
F3	N	200
	lbf	45

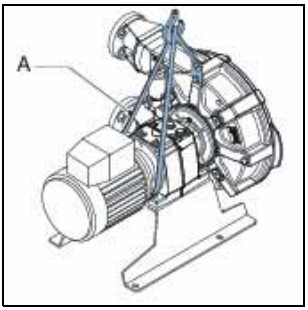


5.4 Lifting and moving the pump

For lifting and moving the *pump head*, it has been fitted with a lifting strip. This lifting strip (A) is fitted on the rear of the pump head. For the weights, refer to § 10.1.5.



The complete hose pump, i.e. pump head, gearbox and electric motor, must be lifted using the lifting strip of the pump head plus additional support using suitably rated straps or slings (A). For the weights, refer to § 10.1.5.



⚠	**WARNING** If the pump is to be lifted ensure that all standard lifting practices are adhered to and carried out by qualified personnel only.

5.5 Placing the pump

Position the pump on a horizontal surface. Use suitable anchor bolts to attach the pump to the floor surface.

6 COMMISSIONING

6.1 Preparations

	**WARNING** A Bredel VFD that is fitted *without the control switch* starts automatically when power is applied.

	**WARNING** Disconnect and lock the power supply to the pump drive before any work is carried out. In case the motor is fitted with a frequency controller and has a single-phase power supply, wait two minutes to make sure that the capacitors have discharged.

1. Connect the electric motor and, if present, the frequency controller in conformance with the locally applicable rules and regulations. Refer to § 5.3.4. Have the electrical installation work be carried out by qualified personnel.

2. Check that the lubricant level is above the minimum level line in the inspection window. If necessary refill Bredel Genuine Hose Lubricant via the breather/vent plug. See also § 7.4.

3. Check the rotation of the rotor. The rotational direction of the rotor must match the configuration of suction and discharge piping.

4. Check that the correct number of shims corresponds with your application. Refer to § 10.1.7.
   For adjusting the compression force of the hose, refer to § 7.8.

6.2 Commissioning

1. Connect the pipework.

2. Make sure that there are no obstructions such as closed valves.

3. Switch on the hose pump.

4. Check the rotation of the rotor.

5. Check the capacity of the hose pump. If the capacity differs from your specification, follow the instructions in chapter 9 or consult your Bredel representative.

6. Check the capacity range of the frequency controller. In case of any deviations consult the documentation of the supplier.

7. Check the hose pump in accordance with points 2 to 4 of the maintenance table from § 7.2.

7 MAINTENANCE

7.1 General

	**WARNING** Disconnect and lock the power supply to the pump drive before any work is carried out. In case the motor is fitted with a frequency controller and has a single-phase power supply, wait two minutes to make sure that the capacitors have discharged.

	**WARNING** Only use original Bredel parts when maintaining the hose pump. Bredel cannot guarantee correct operation and any consequential damage that occurs from the use of non-original Bredel components. See also chapters 2 and 3.

7.2 Maintenance and periodic inspections

The following maintenance scheme shows the maintenance and periodic inspections that need to be carried out on the hose pump to guarantee an optimal safety, operation and life of the pump.

Point	Action	To be carried out	Remark
1	Check the lubricant level.	Before startup of the pump and on a scheduled interval during operation.	Make sure that the lubricant level is above the minimum level line in the inspection window. If necessary refill the lubricant. See also § 7.4.
2	Check the pump head for any leakage of lubricant around the cover, the flanges and the rear of the pump head.	Before startup of the pump and on a scheduled interval during operation.	See § 9.
3	Check the gearbox on any leakage.	Before startup of the pump and on a scheduled interval during operation.	In case of leakage consult your Bredel representative.
4	Check pump for deviating temperature or strange noises.	On a scheduled interval during operation.	See § 9.
5	Check pressing shoes for excessive damage.	When replacing the pump hose.	See § 7.6.
6	Internal cleaning of the pump hose.	Cleaning of the system or product change.	See § 7.3.
7	Replacing pump hose.	Preventive, this means after 75% of the hose life of the first hose.	See § 7.6.
8	Changing lubricant.	After every 2nd hose change or after 5,000 service hours, whichever comes first or after hose rupture.	See § 7.4
9	Changing oil in gearbox.	Refer to lubricant table in § 10.2.	See § 7.5.
10	Replacing pump seal.	If necessary.	See § 7.7.3.
11	Replacing wear ring.	If necessary.	See § 7.7.3.

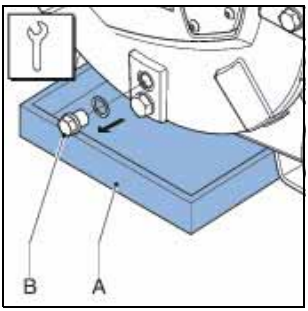
Point	Action	To be carried out	Remark
12	Replacing pressing shoes.	Wear on the running surface.	See § 7.7.2.
13	Replacing bearings.	If necessary.	See § 7.7.3.
		In potentially explosive atmospheres preventive after 20,000 hrs. service or when damage is suspected.	See § 7.7.2. Exclusively applicable in potentially explosive atmospheres (Group II Appliances, category 2 GD c k T4).
14	Cleaning the hose pump.	In potentially explosive (dust) atmospheres, the dust must be removed regularly.	Exclusively applicable in potentially explosive atmospheres (Group II Appliances, category 2 GD c k T4).

7.3 Cleaning the pump hose

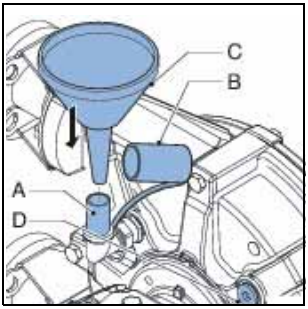
Running the pump with clean water can clean the inside of the pump hose. If a cleaning fluid is added to the water, attention must be given to its compatibility with the hose liner material, and also the temperature at which the cleaning procedure will be performed. Sometimes a cleaning sponge can be very helpful.
With many products, it is necessary to clean the pump hose immediately once the pump is stopped to avoid sedimentation and/or hardening of the product within the hose that can cause damage upon restart.

7.4 Changing lubricant

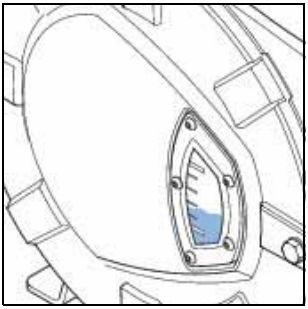
1. Place a tray (A) under the drain plug in the cover of the pump. Remove the drain plug (B). Catch the lubricant from the pump housing in the tray. Position the drain plug and tighten it firmly.



2. The pump housing can be filled with lubricant via the breather/vent (A) on the rear of the pump housing. For this purpose remove the breather cap (B) and position a funnel (C) in the breather. In order to facilitate the filling with lubricant the breather cap (D) on the rear of the pump housing can be removed. Pour the lubricant in the pump housing via the funnel.



3. Keep on pouring until the lubricant level has risen at least until just above the minimum level line in the inspection window.



	For the required quantity of lubricant, refer to § 10.1.4.

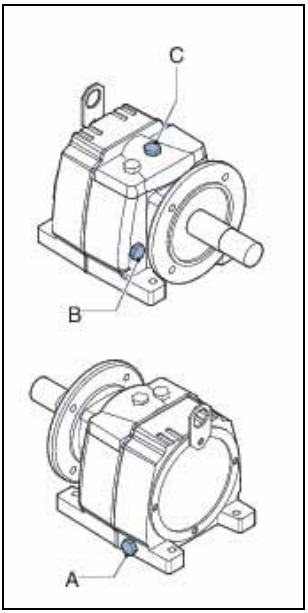
7.5 Changing oil in gearbox

1. Isolate the pump from the electrical supply.

2. Remove plug (A) and let the oil run out of the gearbox.

3. The plug (A) is magnetically loaded. In this way metal particles in the oil are pulled to the plug. Clean the plug and remove any metal particles if necessary. Check that the sealing ring is not damaged and replace it if necessary. Place the plug back in the gearbox and tighten it firmly.

4. Remove level plug (B) and filling plug (C) and position a funnel in the hole and fill the gearbox with oil until the oil just comes out of the level plug hole (B). Wait shortly to let out any entrapped air. Place plug (B) and filling plug (C) back and tighten them firmly.



	For the required lubricant, refer to § 10.2.

	**WARNING** To prevent damage to the gears, do not operate the pump unless proper volume of oil is filled into the gearbox.

5. Switch on the electrical supply to the pump.

7.6 Replacing pump hose

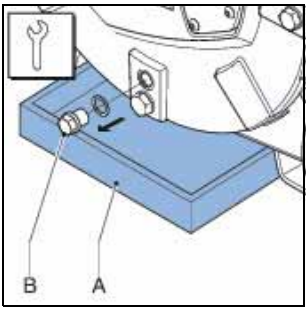
7.6.1 Removing pump hose

⚠	**CAUTION** For all weight and torque adjustment, please refer to the technical information section at the rear of this manual.

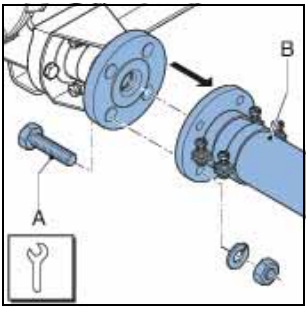
1. Isolate the pump from the electrical supply.

2. Close any shut-off valves in both the suction and discharge line to minimize product loss.

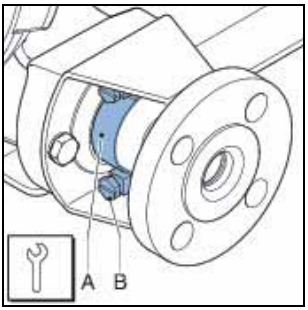
3. Place a tray (A) under the drain plug in the bottom of the pump head. The tray must be large enough to contain the lubricant, possibly contaminated with product fluid, from the pump head. Remove the drain plug (B). Catch the lubricant from the pump housing in the tray. Check that the breather vent mounted on the rear is not obscured. Position the drain plug and tighten it firmly.



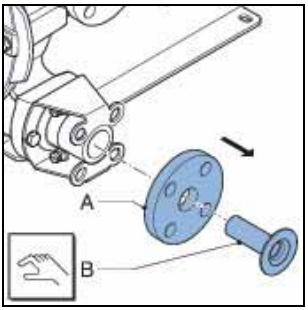
4. Loosen the retaining bolts (A) of both the suction and discharge line (B). Disconnect the suction and discharge lines.



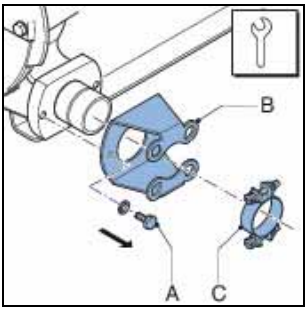
5. Loosen hose clamp (A) of both the inlet and outlet ports by loosening retaining bolt (B).



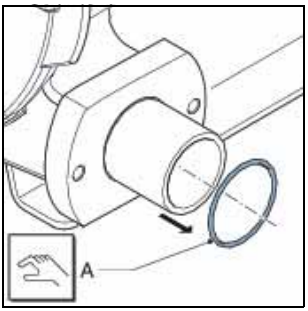
6. Pull the insert (B) from the hose and remove the flanges (A). Carry out this procedure both for the inlet and outlet ports.



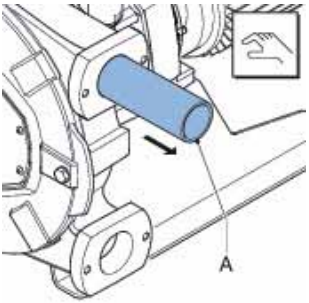
7. Loosen the retaining bolts (A) of the flange bracket (B) and remove the bolts. Slide the flange bracket and the hose clip (C) off the hose. Carry out this procedure both for the inlet and outlet ports.



8. Slide off the sealing ring (A). Check that the sealing ring is not deformed or damaged and replace it if necessary. Carry out this procedure both for the inlet and outlet ports.



9. Switch on the electrical supply.



⚠	**WARNING** Removal of the hose is a powered process and requires rotation of the pump. Ensure body and tools are clear from moving parts prior to proceeding with hose removal.

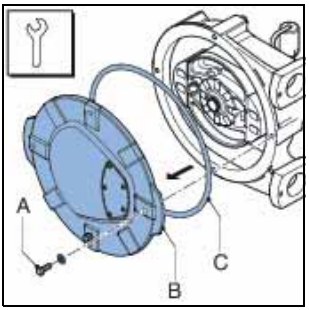
10. Power out the hose (A) from the pump chamber by jogging the drive motor.

⚠	**WARNING** During jogging the drive: - Do not stand in front of the pump ports. - Do not try to guide the hose by hand.

7.6.2 Cleaning the pump head

1. Isolate the pump from the electrical supply.

2. Remove the cover (B) by loosening the retaining bolts (A).



3. Check the sealing ring (C) and replace it if necessary.

4. Rinse the pump head with clean water and remove all residues. Make sure that no rinsing water remains in the pump head.

5. Check the pressing shoes for wear or damage and replace them if necessary. Refer to § 7.7.2. Also see the maintenance scheme in § 7.2.

	**CAUTION** When the pressing shoes are worn the compression force of the hose decreases. If the compression force is too low, this results in a loss of capacity by the backflow of the liquid to be pumped. Backflow results in a reduction of the life of the pump hose.

6. Replace the cover and fasten the retaining bolts with the correct torque. Refer to § 10.1.6.

7. Switch on the electrical supply to the pump.

7.6.3 Fitting the pump hose

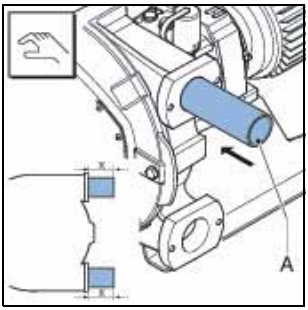
	**WARNING** Fitting the pump hose is a powered process and requires pump rotation. Ensure the pump cover is properly fitted and that body and tools are clear from moving parts.

	**WARNING** For all weight and torque adjustment, please refer to the technical information section at the rear of this manual.

1. Clean the (new) pump hose on the outside and fully lubricate it with Bredel Genuine Hose Lubricant.

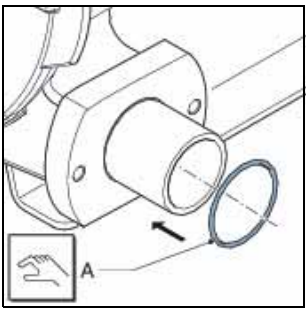
2. Turn on the pump and note the direction of the pump rotation.

3. Fit the pump hose (A) via one of the ports – whichever is the suction based on rotation direction. Feed the hose into the port and allow the pressing shoe to draw the hose in the pump housing. The rotor will move the hose.

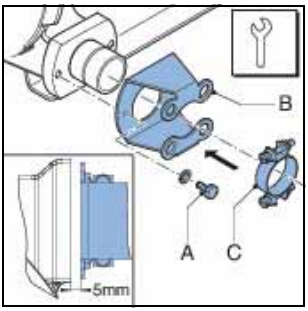


⚠	**WARNING** During jogging the drive: - Do not stand in front of the pump ports. - Do not try to guide the hose by hand.

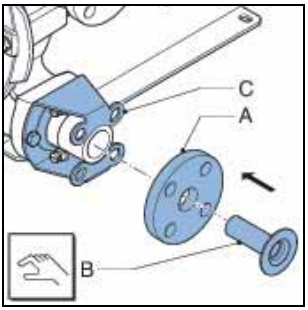
4. Stop the motor when the hose sticks out equally from both sides of the pump housing.
5. First fit the inlet port. Fit the sealing ring.
   Before mounting, check that the sealing ring (A) is not deformed or damaged and replace it if necessary.



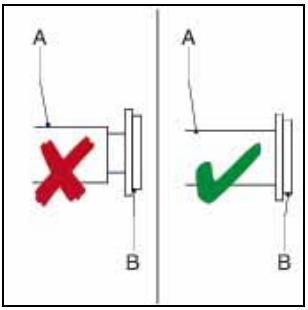
6. Before fitting check that the hose clamp is not damaged and replace it if necessary. Slide the flange bracket (B) and the hose clamp (C) over the hose together. Align the holes in the flange bracket with the ones at the front of the port. Position the two retaining bolts (A) and tighten them until they are approx. 5 mm (3/16”) from the port, so that the gap between the flange bracket and the port remains.



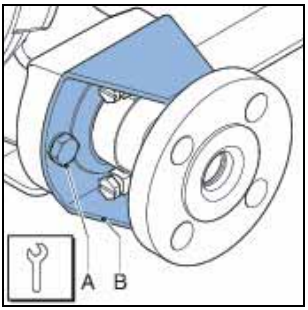
7. Slide insert (B) in flange (A) and press the insert in the hose. If necessary lubricate the insert with Bredel Genuine Hose Lubricant in order to simplify mounting. Make sure that the holes in flange (A) are aligned with the holes in flange bracket (C). Check that the insert is in the correct place. If the insert is not positioned correctly the product to be pumped may leak or the lubricant may leak.



8. Turn the rotor in such a way that the hose (A) is pressed firmly against the flange surface (B).



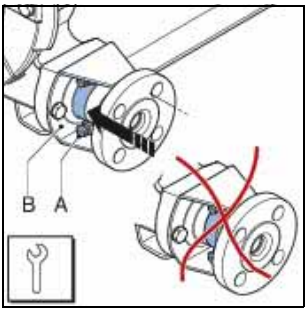
9. Now fully tighten the retaining bolts (A) of the flange bracket (B). Make sure the bolts are tightened with the correct torque. Refer to § 10.1.6.



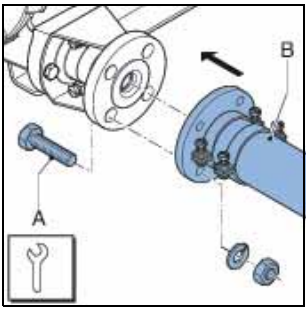
10. Position hose clamp (A) against O-ring chamber of the flange bracket (B) and fasten the retaining bolt. Make sure the bolts are tightened with the correct torque. Refer to § 10.1.6.

11. Now fit the other port. For this port proceed in the same way as described above for the inlet port.

12. Fill the pump housing with Bredel Genuine Hose Lubricant. Refer to § 7.4.



13. Fit the suction and discharge lines (B) and the retaining bolts (A). Tighten the retaining bolts with the correct torque. Refer to § 10.1.6.



7.7 Exchanging replacement parts

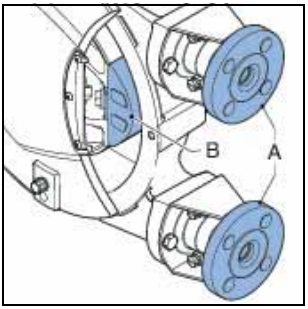
7.7.1 General

⚠	**CAUTION** Items may be heavy. For all weight and torque adjustments for replacement procedures under this section, please refer to the technical information in chapter 10.

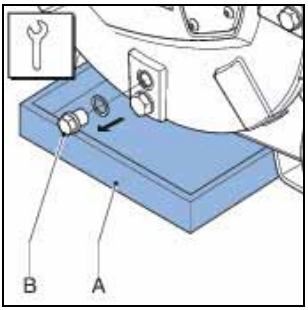
7.7.2 Replacing pressing shoes

1. Jog the motor until the pressing shoe (B) is positioned between the inlet and outlet port (A).

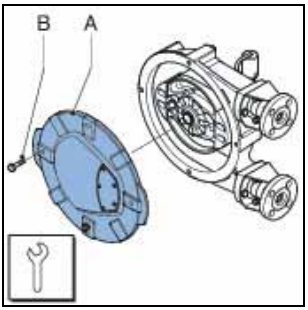
2. Isolate the pump from the electrical supply.



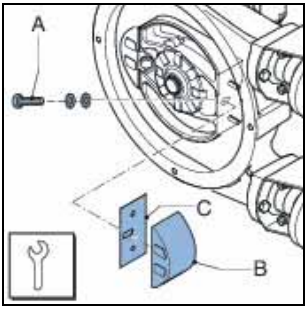
3. Place a tray (A) under the drain plug in the cover of the pump. Remove the drain plug (B). Catch the lubricant from the pump housing in the tray. Position the drain plug and tighten it firmly.



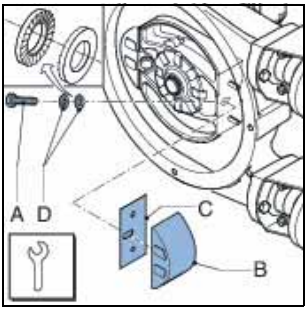
4. Remove the cover (A) by loosening the four retaining bolts (B).



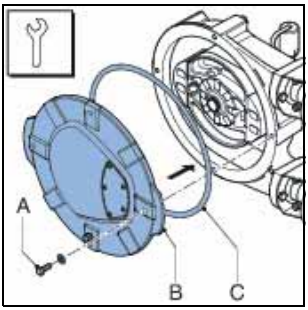
5. Loosen the retaining bolt (A) of the pressing shoe (B) and remove the shoe. Remove the shims (C) if present.



6. Fit the removed shims (C) again. Position the (new) pressing shoe (B), check that the Nord-Lock® rings (D) have been positioned correctly and tighten the retaining bolt(s) (A) a few turns. Refer to § 10.1.6.



7. Check the gasket (C) for damage and replace if necessary. Refit the cover (B). Make sure that the 4 bolts (A) are refitted and that they are tightened in the correct order, diagonally opposite each other. Refer to § 10.1.6.



8. Switch on the electrical supply.

9. Jog the motor until the second pressing shoe is positioned between the inlet and outlet port.

10. Isolate the pump from the electrical supply.

11. Repeat the procedure for removing and fitting this second pressing shoe by repeating steps 4 through 8.

12. Refill the lubricant. Refer to § 7.4.

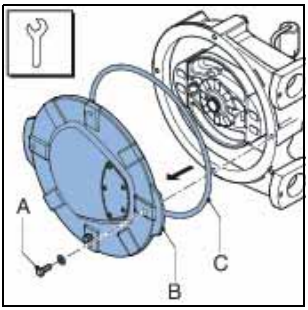
7.7.3 Replacing seal ring, bearings and wear ring

1. Remove the pump hose. Refer to § 7.6.1.

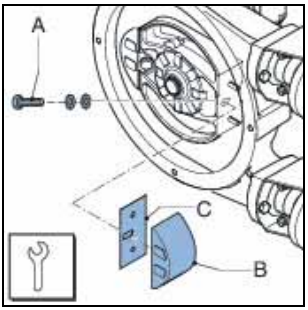
2. Isolate the pump from the electrical supply.

3. Remove the cover (B) by loosening the retaining bolts (A).

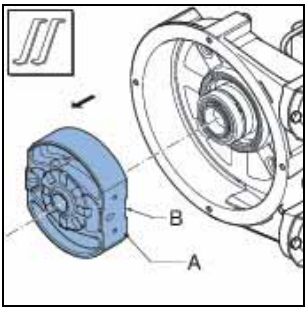
4. Check the sealing ring (C) and replace it if necessary.



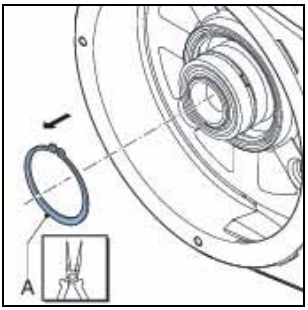
5. Loosen the retaining bolt (A) of both pressing shoes (B). Remove the shims (C) if present.



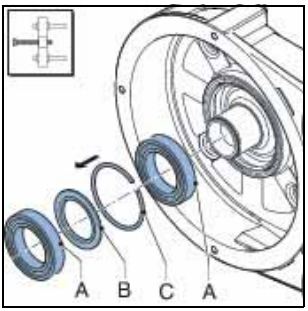
6. Use two crow bars to remove rotor (A). Position both crow bars behind the recesses (B) in the rotor and push the rotor from the hub.



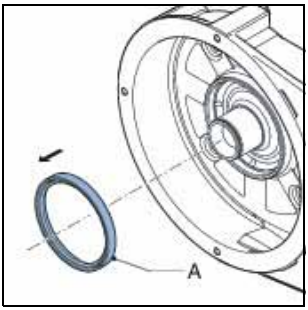
7. Dismount the retaining circlip (A) with the correct tool.



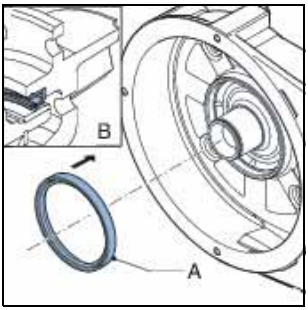
8. Dismount the bearings (A) with the correct tool, the spacer ring (B) and the retaining circlip (C).



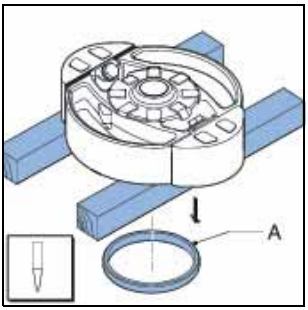
9. Remove the seal (A). Clean and degrease the bore.



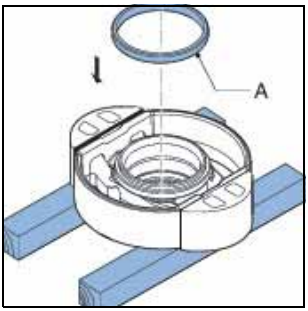
10. Fit a new seal (A) using good engineering practises. The seal must be fitted in the correct orientation (B). Make sure that the open side points to the pump cover.



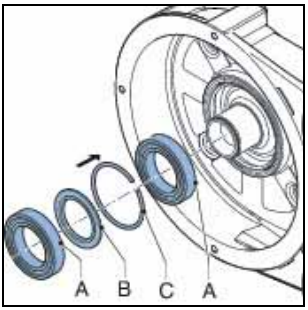
11. Support the rotor with wooden blocks at 90° to the spokes, with the ring (A) facing down. Position a suitable punch against the rear of the glued wear ring. Prevent damage to the wear ring seat or other parts.



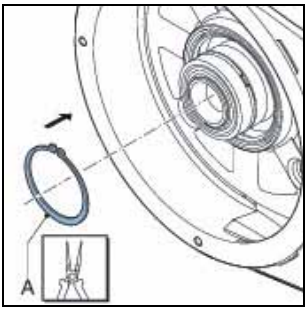
12. Turn the rotor over. Make sure that the seats of the new wear ring (A) and rotor are clean, dry and free of grease. Apply Loctite® type 641 or 603 both on the rotor and the wear ring. Position the new wear ring with the tapered edge facing up. Use a plastic hammer to fit the ring on the rotor until it touches the rotor completely.



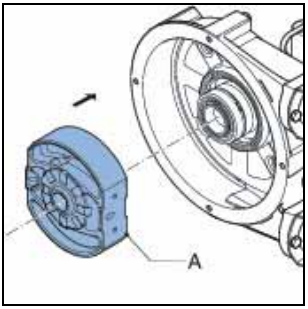
13. Check that the hub is clean and free of grease. Fit the bearings and the rings now.
The bearings are placed on the hub with a slight interference fit. Use a pressing tool to press the bearings on the hub.



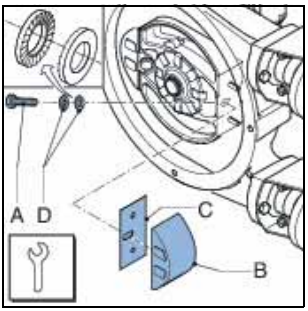
14. Mount the retaining circlip (A).



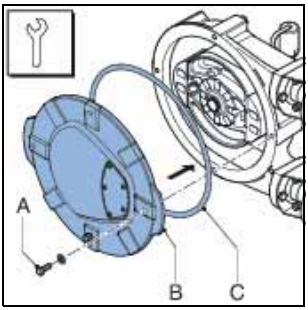
15. Fit rotor (A). The rotor is placed on the bearings with a loose fit. Press the rotor on the hub until it sticks.



16. Fit the removed shims (C) again. Position the (new) pressing shoe (B), check that the Nord-Lock® rings (D) have been positioned correctly and tighten the retaining bolt(s) (A) a few turns. Refer to § 10.1.6.



17. Check the gasket (C) for damage and replace if necessary. Refit the cover (B). Make sure that the 4 bolts (A) are refitted and that they are tightened in the correct order, diagonally opposite each other. Refer to § 10.1.6.



18. Switch on the electrical supply to the pump.

19. Fit the (new) pump hose. Refer to § 7.6.3.

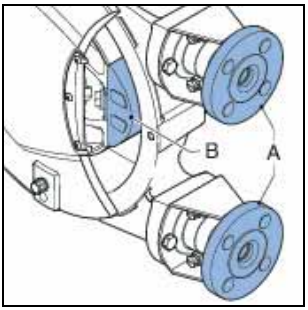
7.8 Adjusting hose compression force (shimming)

Remove the pump cover before fitting and removing shims. In order to determine the correct number of shims for your specific application refer to § 10.1.7.

⚠	**CAUTION** Too many shims, this means a too high compression force on the pump hose, will create a too high load on the pump head and pump hose, which may result in a reduction of the life of the pump hose and bearings.

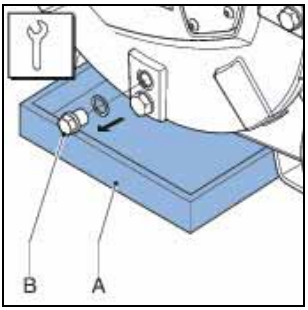
⚠	**CAUTION** Too few shims, this means a too low compression force on the pump hose, create a loss of yield and slip or backflow. Backflow results in a reduction of the life of the pump hose.

1. Jog the motor until the pressing shoe (B) is positioned between the inlet and outlet port (A).

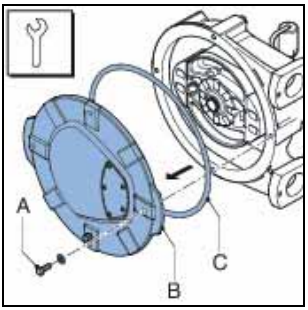


2. Isolate the pump from the electrical supply.

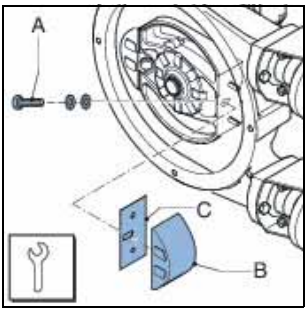
3. Place a tray (A) under the drain plug in the cover of the pump. Remove the drain plug (B). Catch the lubricant from the pump housing in the tray. Position the drain plug and tighten it firmly.



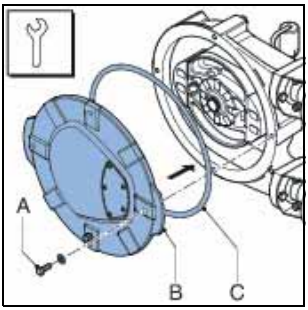
4. Remove the cover (B) by loosening the retaining bolts (A).



5. Loosen the retaining bolt (A) of the pressing shoe (B). Fit the shims (C) or remove them, until the correct number of shims is present. Refer to § 10.1.7.
Fasten the retaining bolt of the pressing shoe with the correct torque. Refer to § 10.1.6.



6. Refit the cover (B). Check the gasket (C) for damage and replace if necessary. Make sure that all bolts (A) are refitted and that they are tightened in the correct order, diagonally opposite each other. Refer to § 10.1.6.



7. Switch on the electrical supply.

8. Jog the rotor until the second pressing shoe is positioned between the inlet and outlet port.

9. Isolate the pump from the electrical supply.

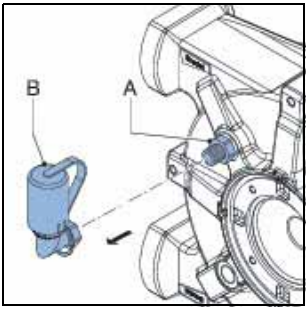
10. Repeat the procedure for this pressing shoe by repeating steps 4, 5, 6 and 7.

11. Refill the lubricant via the breather. Refer to § 7.4.

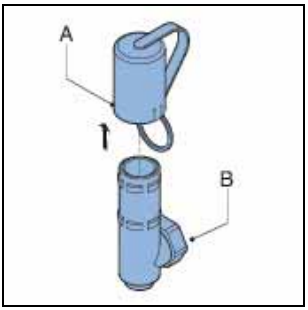
7.9 Fitting options

7.9.1 Fitting a high-level float switch

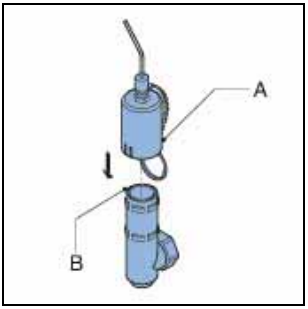
1. Remove the standard breather (B) on the rear of the pump, by removing it from crimp connector (A).



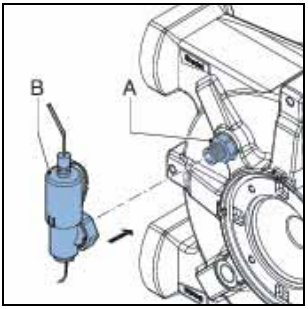
2. Slide the standard breather cap (A) from breather (B).



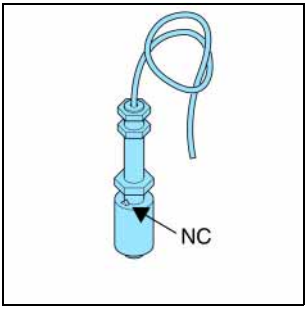
3. Replace the standard breather cap with the breather cap with high level float switch (A) and slide it over breather (B).



4. Mount the breather (B) on the rear of the pump, by mounting it on crimp connector (A).



5. Connect the high-level float switch to the auxiliary power circuit via the 2 meter (6.5 feet) long PVC cable (2 x 0.34 mm^2, 2 x 22 AWG). Bear in mind that the electrical contact of the float switch is normally closed (NC). The knob is upwards for normally closed operation. When the lubricant level is (too) high the contact will open.



Specifications*	
Voltage:	Max. 230 V AC/DC
Current:	Max. 2 A
Power:	Max. 40 VA

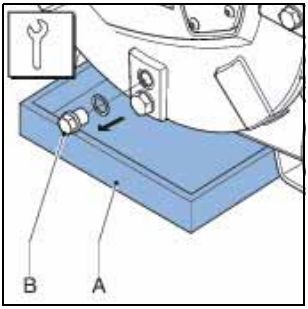
* For use in non-explosive atmospheres

	Where the floater is constructed to stop the equipment, operating has to be arranged so that the stop function locks-out, preventing the equipment from being re-started without re-setting. Check if the floater is mounted with the NC sign at the top.

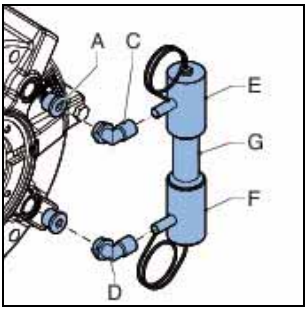
7.9.2 Fitting a high and low level float switch

	For specifications, refer to § 7.9.1.

1. If the pump is filled with lubricant this must be removed first. Place a tray (A) under the drain plug in the cover of the pump. Remove the drain plug (B). Catch the lubricant from the pump housing in the tray. Position the drain plug and tighten it firmly.



2. Remove the plugs (A) and (B) on the rear of the pump head.
Position the quick couplings (C) and (D) in both openings.
Clamp both connection tubes (E) and (F) on the riser pipe (G) and the quick links (C, D).

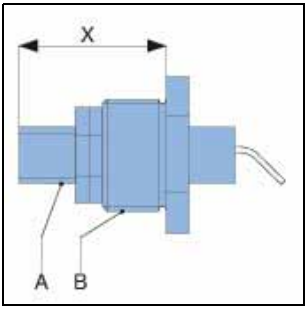


3. Connect the high and low-level float switch to the electrical supply. Bear in mind that the electrical contact of the float switch is normally closed (NC).
This means that:
- the contact of the high level float switch opens at a (too) high lubricant level;
- the contact of the low level float switch opens at a (too) low lubricant level.

4. Make sure the lubricant returns to the prescribed level. Refer to § 7.4.

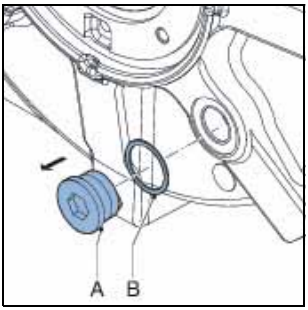
7.9.3 Replacing the revolution counter

1. Fit the inductive sensor (A) in stop (B) and adjust it to dimension "X" as indicated in the table below. Tighten the adjusting nuts with a torque of 25 Nm (220 lbf in).

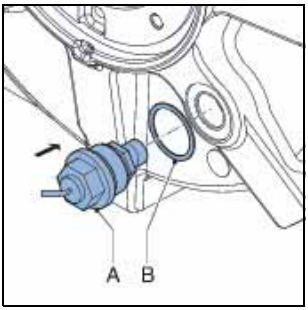


Dimension "X" ± 0.1 mm (± 0.004 inch)	
Bredel 25	
26 mm (1.02 inch)	

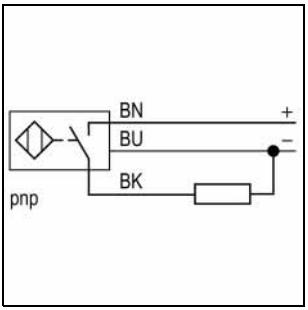
2. Remove stop (A) which is on the horizontal center line at the rear of the pump housing. Check that the sealing ring (B) is not damaged and replace it if necessary.



3. Fit the stop with the inductive sensor (A) together with sealing ring (B) on the pump housing.



4. Connect the sensor via the 2-meter (6.5-feet) long PVC cable (3 x 0.34 mm^2, 3 x 22 AWG).



Specifications*	
Voltage:	10...30 VDC
Current:	Max. 150 mA

* For use in non-explosive atmospheres

5. Make sure the lubricant returns to the prescribed level. Refer to § 7.4.

8 STORAGE

8.1 Hose pump

- Store the hose pump or pump parts in a dry area. Make sure that the hose pump or pump parts are not exposed to temperatures lower than -40 °C (-104 °F) or higher than +70 °C (158 °F).
- Cover the openings of the inlet and outlet ports.
- Prevent corrosion of untreated parts. For this purpose use the correct protection or packaging means.
- After a long period of standstill or storage (i.e. pump is idle for a period of longer than one continuous month), the static load on the pump hose may cause permanent deformation, which will reduce the life of the pump hose and may cause difficulty in starting.
  To prevent deformation of the hose, pump motor should be jogged on a monthly basis to allow repositioning of the shoe on the hose.
  If motor jogging is not possible and long term shutdown is expected, remove a pressing shoe and turn the rotor so far that the second pressing shoe is in front of the inspection window. In this way there is no load put on the pump hose. When startup is again expected, replace the pressing shoes, the proper number of shims, and the lubricant.

8.2 Pump hose

- Store the pump hose in a cool and dark room. After two years the hose material will age, which will reduce the life of the hose.

9 TROUBLESHOOTING

WARNING
Disconnect and lock the power supply to the pump drive before any work is carried out.
In case the motor is fitted with a frequency controller and has a single-phase power supply, wait two minutes to make sure that the capacitors have discharged.

If the hose pump does not function (correctly), consult the following checklist to see if you can remedy the error yourself. If this is not the case, contact your Bredel representative.

Problem	Possible cause	Correction
Failure to operate.	No voltage.	Check that the supply power switch is on.
		Check the electrical supply is available at the pump.
		Check current limit of electrical source to pump.
	Stalled rotor.	Check that hose and lubricant are loaded properly and pressing shoes are shimmed properly.
	Lubricant level monitoring system has been activated.	Check that the lubricant level monitoring system has stopped the pump. Check the lubricant level and proper functioning of the level switch(es).

Problem	Possible cause	Correction
High pump temperature.	Non-standard hose lubricant used.	Consult the Bredel representative for the correct lubricant.
	Low lubricant level.	Add Bredel Genuine Hose Lubricant. For the required amount of lubricant refer to § 10.1.4.
	Product temperature too high.	Consult the Bredel representative about the maximum temperature range of the product.
	Internal friction on the hose caused by blocked or poor suction characteristics.	Check pipework/valves for blockages. Ensure that the suction pipework is as short as possible and that the diameter is large enough.
	Over-shimming of the pump rotor shoes.	Consult the diagram. Refer to § 10.1.7. Remove excess shims.
	High pump speed.	Reduce pump speed to a minimum. Consult with your Bredel pump representative for advice on optimum pump speeds.

Problem	Possible cause	Correction
Low capacity / pressure.	Shut-off valve in the suction line (partly) closed.	Fully open the shut-off valve.
	Under shimming of the pressing shoes.	Check shimming. Refer to § 10.1.7. Fit the correct number of shims.
	Hose failure or badly worn hose.	Replace hose. Refer to § 7.6.
	Partial blockage of the suction line or too little product on the suction side.	Ensure that the suction line is clear of blockages and that sufficient product is available.
	Connections and hose clamps not correctly mounted, which allows the pump to draw in air.	Tighten connections and hose clamps.
	You are starving the pump because the speed is too high for your suction pressure.	Consult your Bredel representative for a recommendation.
Vibration of the pump and pipework.	Suction and discharge lines are not secured correctly.	Check and secure pipework.
	High pump speed with long suction and discharge lines or high relative density or a combination of these factors.	Reduce pump speed. Reduce the line lengths on both suction and discharge where possible. Consult your Bredel representative for a recommendation.
	Too narrow diameter of suction and/or discharge line.	Increase the diameter of the suction/discharge lines.

Problem	Possible cause	Correction
Short hose life.	Chemical attack of the hose.	Check the compatibility of the hose material with the product to be pumped. Consult your Bredel representative for correct hose selection.
	High pump speed.	Reduce pump speed.
	High discharge pressures.	It is recommended that the pressure on the discharge of the pump does not exceed 1600 kPa (232 psi). Check that the discharge line is not blocked, the shut-off valves are fully opened and the pressure relief valve functions properly (if present in the discharge line).
	High product temperature.	Consult your Bredel representative for correct hose selection.
	High pulsations.	Restructure the discharge and inlet conditions.
Hose pulled into the pump.	Insufficient or no hose lubricant in the pump head.	Add extra lubricant. Refer to § 7.4.
	Incorrect lubricant: no Bredel Genuine Hose Lubricant in the pump head.	Consult the Bredel representative for the correct lubricant.
	Extremely high inlet pressure - larger than 300 kPa (43.5 psi).	Reduce the inlet pressure.

Problem	Possible cause	Correction
Lubricant leakage at flange bracket.	Hose blocked by an incompressible object in the hose. The hose cannot be compressed and will be pulled into the pump housing.	Remove hose, check for blockages and replace if necessary.
	Bolts of flange bracket loose.	Tighten to the specified torque settings. Refer to § 10.1.6.
	Bolts of hose clamps loose.	Tighten to the specified torque settings. Refer to § 10.1.6.
Leakage from the rear of the pump housing "Buffer zone".	Damaged sealing ring.	Replace sealing ring.

10 SPECIFICATIONS

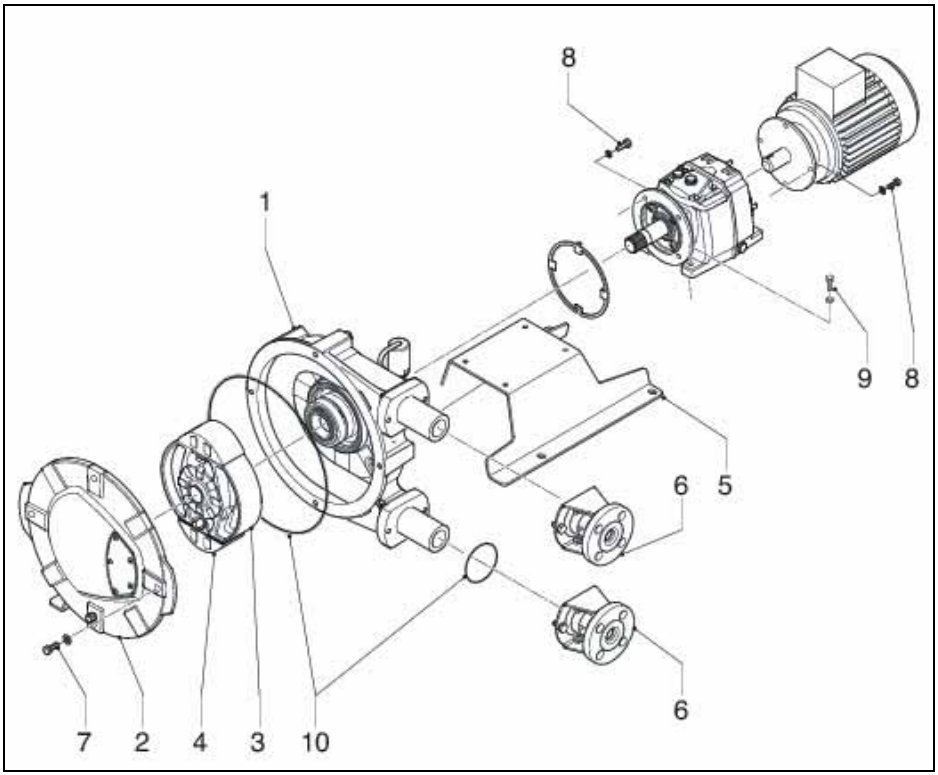
10.1 Pump head

10.1.1 Performance

Description	Unit	Bredel 25
Max. capacity, continuous	m^3/h	1.80
	GPM	7.92
Max. capacity, intermittent*	m^3/h	2.88
	GPM	12.68
Capacity per revolution	l/rev	0.300
	Gal/rev	0.079
Max. permissible discharge	kPa	1600
	PSI	232
Permissible ambient temperature	°C	-20 to +45
	°F	-4 to +113
Permissible product temperature	°C	-10 to +80
	°F	+14 to +176
Sound level on 1 m	dB(A)	70

* Intermittent duty: "Let the pump stand still to cool down for at least 1 hour after 2 hours of operation".

10.1.2 Materials



Pos	Description	Material
1	Pump housing	Cast-iron
2	Cover	Cast-iron
3	Pump rotor	Cast-iron
4	Pressing shoe	Aluminum
5	Pump support	Mild steel, galvanized*
6	Flange bracket	Mild steel, galvanized*
7	Mounting material of pump cover	Mild steel, galvanized*
8	Mounting material of drive system	Mild steel, galvanized*
9	Mounting material of pump support	Mild steel, galvanized*
10	Seals	Neoprene or Nitrile

* Available in Stainless Steel upon request.

10.1.3 Surface treatment

- After surface preparation, one layer of two-component acrylate is used for surface protection. Standard color is RAL 3011, however other colors are optional. Contact your Bredel representative for details on surface treatment.
- All galvanized parts, exclusive of mounting articles, have been provided with an electrolytic zinc layer of 15 - 20 microns (0.6 - 0.8 mil).

10.1.4 Lubricant table pump

	Unit	Bredel 25
Lubricant	-	Bredel Genuine Hose Lubricant
Required quantity	Liters	2
	Gallons	0.5

Bredel Genuine Hose Lubricant is registered at NSF: NSF Registration N^{o} 123204; Category Code H1. See also: www.NSF.org/USDA.

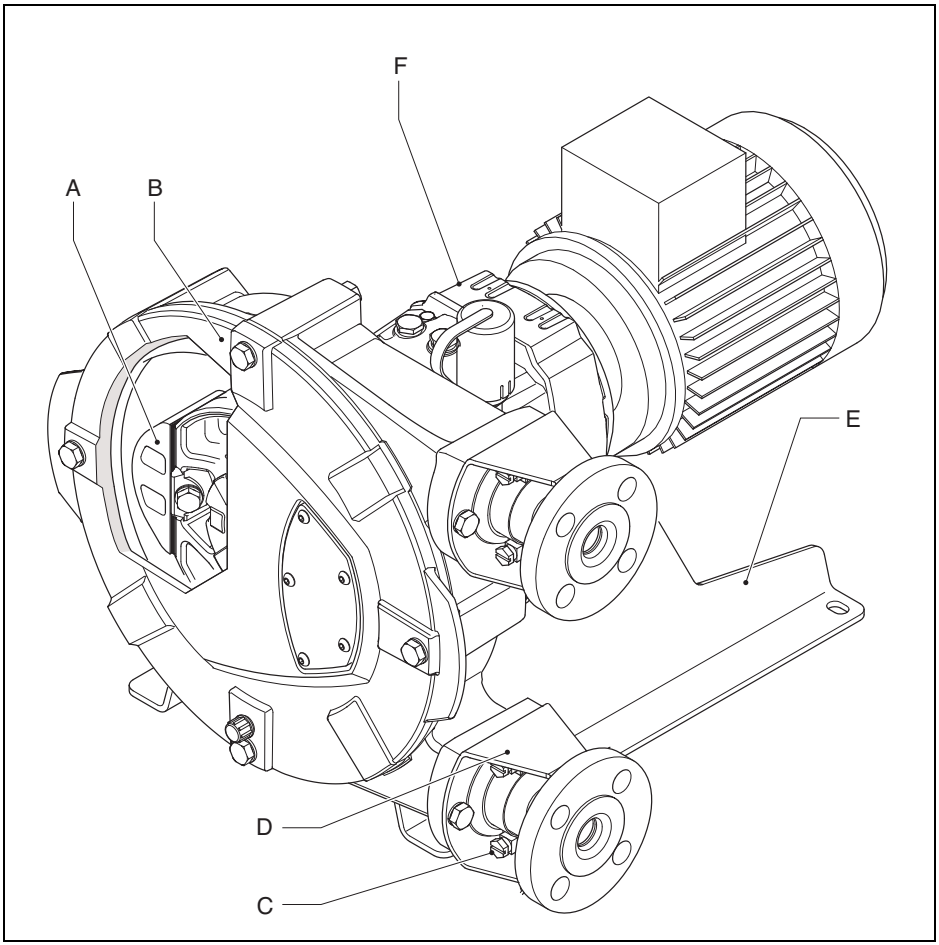
The relative density of Bredel Genuine Hose Lubricant is 1.245.

	Should you require additional information with respect to the safety data sheet, consult your Bredel representative.

10.1.5 Weights

Description	Weight [kg/lbs]	
	Bredel 25	
Unit	**kg**	**lbs**
Pump head	39	86
Flange connection (2x), without inserts	3.72	8
Stainless steel insert (2x)	0.26	0.6
Hose	2	4.4
Lubricant	2.5	5.5
Sub total pump head	**47.5**	**104.5**
Pump support	5.7	12.6
Mounting material gearbox-pump head	0.3	0.7
Gearbox (model B3-B5)	15.5	34.2
Electric motor	17.3	38.1
Varmeca	3	6.6
Total weight of unit	**89.3**	**196.9**
Pump cover (with inspection window)	9.4	20.7
Rotor	5.4	11.9
Pressing shoe	0.4	0.9

10.1.6 Torque figures



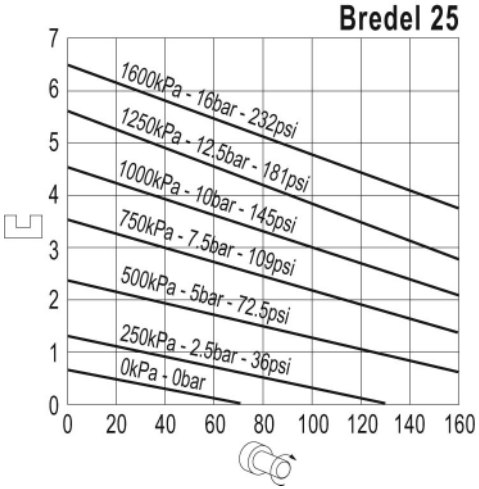
Pos	Description	Unit	Bredel 25
A	Pressing shoe	Nm	50
		lbf in	440
B	Cover	Nm	50
		lbf in	442
C	Hose clamp	Nm	25
		lbf in	220

Pos	Description	Unit	Bredel 25	
D	Flange bracket	Nm	50	
		lbf in	442	
E	Support	Nm	25	
		lbf in	221	
F	Gearbox	Nm	25	
		lbf in	221	

Pos	Description	Thread, A/F	
		Bredel 25	
A	Pressing shoe	M10 17 mm	
B	Cover	M10 17 mm	
C	Hose clamp	M8 13 mm	
D	Flange bracket	M10 17 mm	
E	Support	M8 13 mm	
F	Gearbox	M8 13 mm	

10.1.7 Shims specifications

- When the product temperatures are above 60 °C (140 °F) always use one shim less than indicated in the diagrams.
- Always round up the number of shims.



10.2 Lubricant table gearbox

Below is an overview of some of the recommended lubricants for the *co-axial gearbox*. In the majority of the cases, a mineral oil ISO VG 220 is recommended. In case of extreme ambient temperatures or a relatively wide range of ambient temperatures, a synthetic oil is recommended. Contact your Bredel representative for advice.

Recommended lubricants for the Bredel co-axial gearboxes			
Oil type	Mineral oil	Synthetic oil	
Change oil every	5000 hours	20,000 hours	
Ambient temperature	-10 °C to +40 °C	-40 °C to +80 °C	-30 °C to +60 °C
	14 °F to 104 °F	-40 °F to 176 °F	-22 °F to 140 °F
DIN (ISO)	CLP (CC)	CLP HC	CLP HC
ISO, NLGI	VG220	VG220	VG150
Mobil	Mobilgear 630	Mobil SHC 630	Mobil SHC 629
Shell	Shell Omala 220	Shell Omala 220 HD	
Klüber	Klüberoil GEM 1-220	Klübersynth GH4-220	Klübersynth EG 4-150
Aral	Aral Degol BG 220	Aral Degol PAS220	
BP	BP Energol GR-XP 220		
Tribol	Tribol 1100/220	Tribol 1510/220	
Texaco	Meropa 220	Pinnacle EP220	Pinnacle EP150
Optimol	Optigear BM 220	Optigear Synthetic A220	
Fuchs	Renolin CLP 220	Renolin Unisyn CLP220	

Recommended lubricants for the Bredel co-axial gearboxes			
Oil type	Synthetic oil		
Change oil every	20,000 hours		
Ambient temperature	-30 °C to -10 °C	-30 °C to +60 °C	-30 °C to +40 °C
	-22 °F to 14 °F	-22 °F to 140 °F	-22 °F to 104 °F
DIN (ISO)	CLP HC	HCE	E
ISO, NLGI	VG32	VG460	VG460

Recommended lubricants for the Bredel co-axial gearboxes			
		Foodgrade*	Biology**
Mobil	Mobil SHC 624		
Shell		Shell Cassida Fluid GL 460	
Klüber	Klüber-Summit HySyn FG32	Klüber oil 4UH1-460	Klüberbio CA2-460
Aral		Aral Eural Gear 460	Aral Degol BAB 460
Texaco	Cetus PAO 46		
Optimol		Optileb GT 460	Optisynt BS460

* For use in the foodstuffs industry. Meets the requirements of the USDA (United States Department of Agriculture): lubricant is suited for unforeseen contact with foodstuffs.

** Lubricant for use in agricultural areas and nature reserves.

10.3 Gearbox

Co-axial gearbox with helical gears. Standard as a 2 and 3 stage version.

Mounting position	IM 2001 (IM B35) foot flange gearbox with splined shaft in horizontal position.
Motor adapter	Electric motor has been integrated in the gearbox housing, by which the smallest possible dimension is achieved.
Optional motor adapter	Adapters in conformance with IEC-B5 or NEMA TC.

10.4 Electric motor

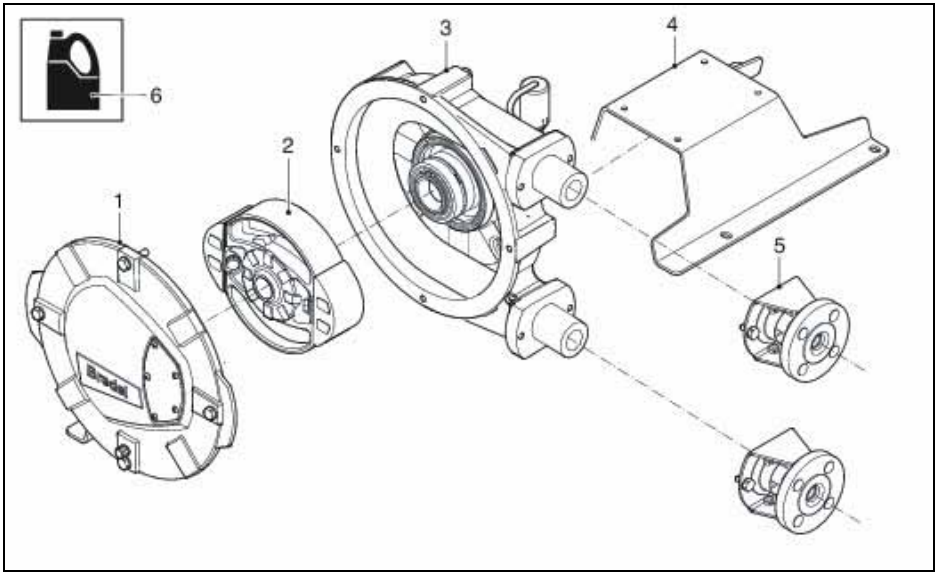
Standard electric motor design is an enclosed three-phase asynchronous motor. A thermal safety device to prevent motor overload is optional.

	In case of doubt about the local applicable regulations for the drive connection, contact your Bredel representative.

Protection class	IP55/IK08
Insulation class	F
Increase in temperature	Within class B
Voltage/frequency	230/400 V - 3 phases - 50 Hz or 230/460 V - 3 phases - 60 Hz

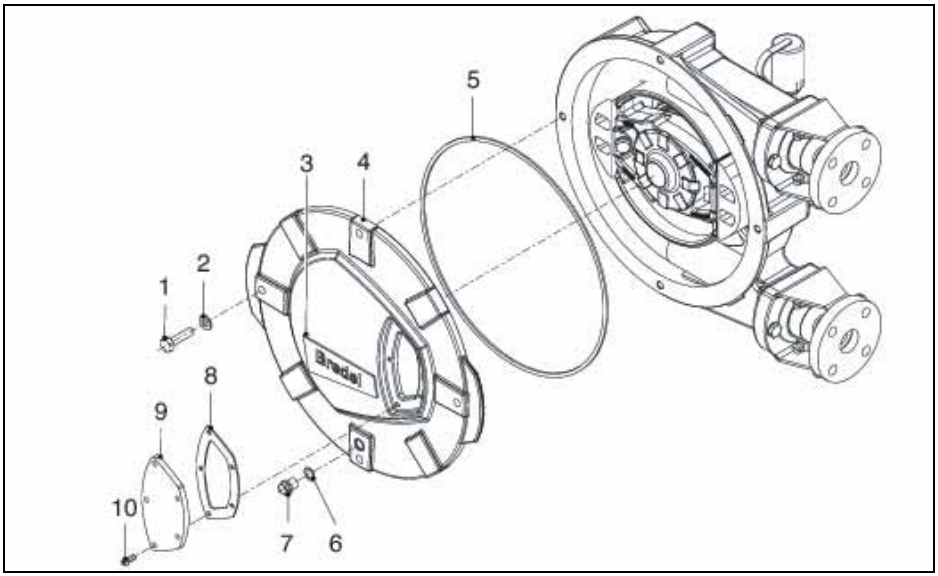
10.6 Parts list

10.6.1 Overview



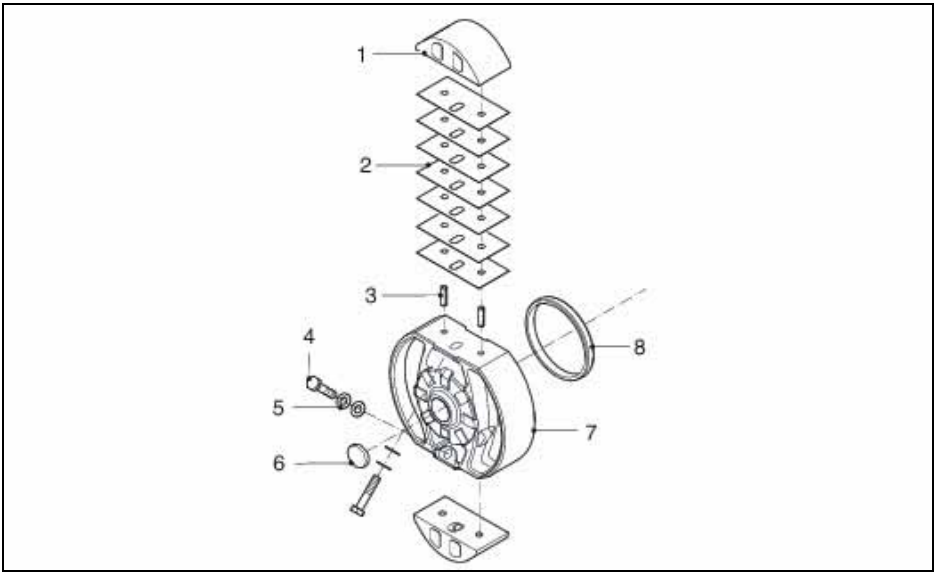
Pos.	Description
1	Cover assembly. Refer to § 10.6.2.
2	Rotor assembly. Refer to § 10.6.3.
3	Pump housing assembly. Refer to § 10.6.4.
4	Pump support assembly. Refer to § 10.6.5.
5	Flange assembly. Refer to § 10.6.6.
6	Lubricant. Refer to § 10.6.8.

10.6.2 Cover assembly



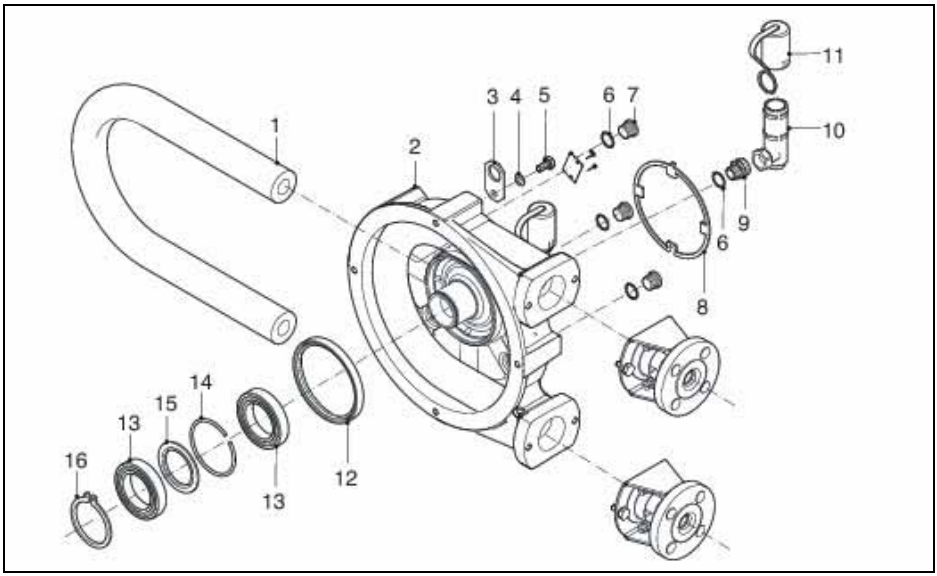
Pos.	Qty.	Description	Product codes for parts of pump type
			Bredel 25
1	4	Bolt, hex. head	F101058
2	4	Washer	F322013
3	1	Sticker	225238
4	1	Cover	225102
5	1	Quad ring	225123
6	1	Gasket	F342019
7	1	Drain cap	F911502
8	1	Gasket	225156
9	1	Inspection window	225155
10	5	Round head screw	F552036
	6		

10.6.3 Rotor assembly



Pos.	Qty.	Description	Product codes for parts of pump type	
			Bredel 25	
1	2	Pressing shoe	225110	
2	14	Shim	225107	
	10			
3	4	Spiral clamping bush	F415084	
4	2	Bolt, hex. head	F101060	
5	2	Nord-Lock ring	F349006	
6	1	Sealing cap	S417007	
7	1	Rotor	225103	
8	1	Wear ring	29120202	

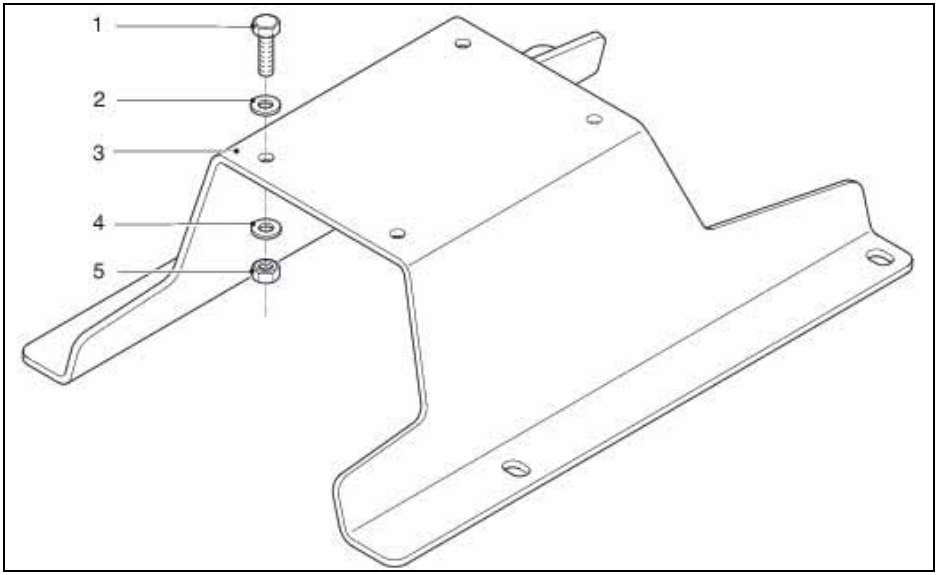
10.6.4 Pump housing assembly



Pos.	Qty.	Description	Product codes for parts of pump type
			Bredel 25
1	1	NR	025020
	1	NBR	025040
	1	CSM	025070
	1	EPDM	025075
2	1	Pump housing	225101
3	1	Lifting strip	29065361
4	1	Washer, Spring Lock	F336012
5	1	Bolt	F111096
6	4	Gasket	F342027
7	3	Stop	F901004
8	1	Seal	225114
9	1	Crimp connector	F602504
10	1	Breather	29095146
11	1	Breather cap	29065223
12	1	Seal	S212411

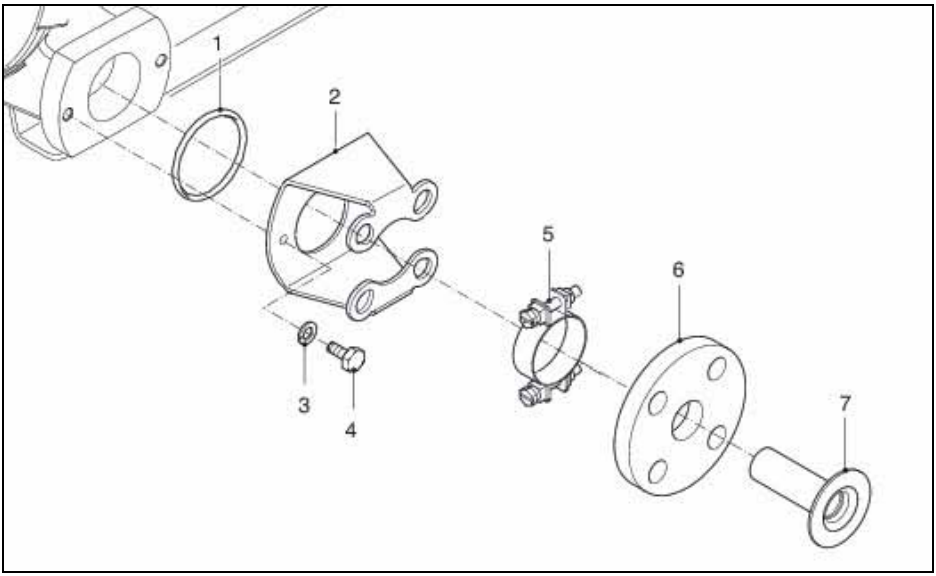
Pos.	Qty.	Description	Product codes for parts of pump type	
			Bredel 25	
13	2	Bearing	B141260	
14	1	Retaining circlip	29095297	
15	1	Spacer ring	29085201	
16	1	Retaining circlip	F343049	

10.6.5 Support assembly



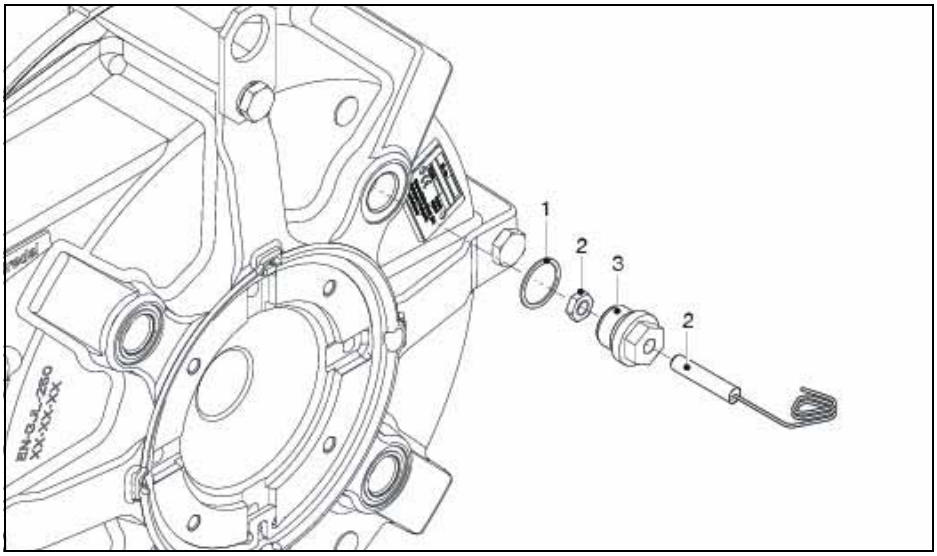
Pos.	Qty.	Description	Product codes for parts of pump type	
			Bredel 25	
1	4	Bolt	F111076	
2	4	Washer	F322012	
3	1	Pump support (standard)	225106	
4	4	Spring washer	F336011	
5	4	Nut	F301006	

10.6.6 Flange assembly



Pos.	Qty.	Description	Product codes for parts of pump type	
			Bredel 25	
1	2	O-ring	S112231	
2	2	Flange bracket, Steel	225197	
	2	Flange bracket, SS	225197A	
3	4	Washer, Spring Lock	F336012	
4	4	Bolt	F111096	
5	2	Hose clamp	C122004	
6	2	Flange, DIN Steel	025198	
	2	Flange, DIN SS	225199	
	2	Flange, ANSI Steel	025198A	
	2	Flange, ANSI SS	225199A	
7	2	Insert, SS	025186	
	2	Insert, PVC	025187	
	2	Insert, PP	025189	
	2	Insert PVDF	025190	

10.6.7 Revolution counter assembly



Pos.	Qty.	Description	Product codes for parts of pump type	
			Bredel 25	
1	1	Gasket	F342027	
2	1	Revolution counter	29040462	
3	1	Adapter	29027248	

10.6.8 Lubricant

Pos.	Qty.	Description	Product codes for parts of pump type	
			Bredel 25	
1	1	2 l (0.5 gal) can Bredel Genuine Hose Lubricant	902143	
	1	3 l (0.8 gal) can Bredel Genuine Hose Lubricant	-	
	1	0.5 l (0.13 gal) can Bredel Genuine Hose Lubricant	-	

SAFETY FORM

Product Use and Decontamination Declaration

In compliance with the **Health and Safety Regulations**, the user is required to declare those substances that have been in contact with the item(s) you are returning to Watson-Marlow Bredel B.V. or any of its subsidiaries or distributors. Failure to do so will cause delays in servicing the item or in issuing a response. Therefore, **please complete this form** to make sure we have the information before receipt of the item(s) being returned. A completed copy must be attached to **the outside of the packaging** containing the item(s). You, the user, are responsible for cleaning and decontaminating the item(s) before returning them.

Please complete a separate Decontamination Certificate for each item returned. **RGA/KBR no**.....

1 Company ....

Address ....

Postal code.....

Telephone ..... Fax number .....

2 Product .....

2.1 Serial Number .....

2.2 Has the Product been used?

YES ☐ NO ☐

If yes, please complete all the following paragraphs.

If no, please complete paragraph 5 only

3 Details of substances pumped

3.1 Chemical Names

a) .....

b) .....

c) .....

d) .....

3.2 Precautions to be taken in handling these substances:

a) .....

b) .....

c) .....

d) .....

3.3 Action to be taken in the event of human contact:

a) .....

b) .....

c) .....

d) .....

3.4 Cleaning fluid to be used if residue of chemical is found during servicing;

a) .....

b) .....

c) .....

d) .....

4 I hereby confirm that the only substances(s) that the equipment specified has pumped or come into contact with are those named, that the information given is correct, and the carrier has been informed if the consignment is of a hazardous nature.

5 Signed .....

Name .....

Position .....

Date .....

Note:

To assist us in our servicing please describe any fault condition you have witnessed.

.....

.....

.....

.....

.....

Watson-Marlow Pumps Group
37 Upton Technology Park
Wilmington, MA 01887
USA
Telephone: 800 - 282 - 8823
978 - 658 - 6168
Fax: 978 - 658 - 0041

Internet: www.wmpg.com
E-mail: support@wmpg.us

29210307 TS 02-021-F

Subject: **General paint specification**				Code: **TS07-004**	Rev. **E**
Designed:	ON	Datum:	12-9-07	Ref.:	
Checked:	DS	Datum:	12-9-07		

Paint specification for Bredel Hose Pumps: Bredel series

Surface preparation

1. Sandblasting, material conditions conform A Sa 2½
2. Impermeable coating, oxylane based

Housing outside and Cover

Coating:	1 layer of 2 component high solid polyurethancoating based on acrylate – isocyanate combination.
Dry film thickness:	DFT 60 – 80 micron
Colour:	RAL 3011, Red

Housing inside / Rotor / Hub

Coating:	1 layer of 2 component high solid polyurethancoating based on acrylate – isocyanate combination.
Dry film thickness:	DFT 30 – 40 micron
Colour:	RAL 3011, Red

Subject: **General paint specification**				Code: **TS07-004**	Rev. **E**
Designed:	ON	Datum:	12-9-07	Ref.:	
Checked:	DS	Datum:	12-9-07		

Paint specification for Bredel Hose Pumps: APEX series

Surface preparation

1. Sandblasting, material conditions conform A Sa 2½
2. Impermeable coating, oxylane based

Housing outside

Coating:	1 layer of 2 component high solid polyurethancoating based on acrylate – isocyanate combination.
Dry film thickness:	DFT 60 – 80 micron
Colour:	RAL 3011, Red

Housing inside

Coating:	1 layer of 2 component high solid polyurethancoating based on acrylate – isocyanate combination.
Dry film thickness:	DFT 30 – 40 micron
Colour:	RAL 3011, Red

Subject: **General paint specification**				Code: **TS07-004**	Rev. **E**
Designed:	ON	Datum:	12-9-07	Ref.:	
Checked:	DS	Datum:	12-9-07		

Paint specification for Bredel Hose Pumps: Bredel CIP series

Surface preparation

1. Sandblasting, material conditions conform A Sa 2½
2. Impermeable coating, oxylane based

Housing outside and Cover

Coating:	1 layer of 2 component acrylate – isocyanate combination coating contains additional pigments based on zinc phosphate
Thickness:	DFT 60 – 80 micron
Colour:	RAL 9010, White

Housing inside / Rotor / Hub

Coating:	1 layer of 2 component acrylate – isocyanate combination coating contains additional pigments based on zinc phosphate
Thickness:	DFT 30 – 40 micron
Colour:	RAL 9010, White

Subject: **General paint specification**				Code: **TS07-004**	Rev. **E**
Designed:	ON	Datum:	12-9-07	Ref.:	
Checked:	DS	Datum:	12-9-07		

Paint specification for Bredel Discharge pulsation damper PD series

Surface preparation

1. Sandblasting, material conditions conform A Sa 2½ except machined parts
2. Impermeable coating, oxylane based

Housing outside

Coating:	1 layer of 2 component acrylate – isocyanate combination coating contains additional pigments based on zinc phosphate
Thickness:	DFT 60 – 80 micron
Colour:	RAL 3011, Red

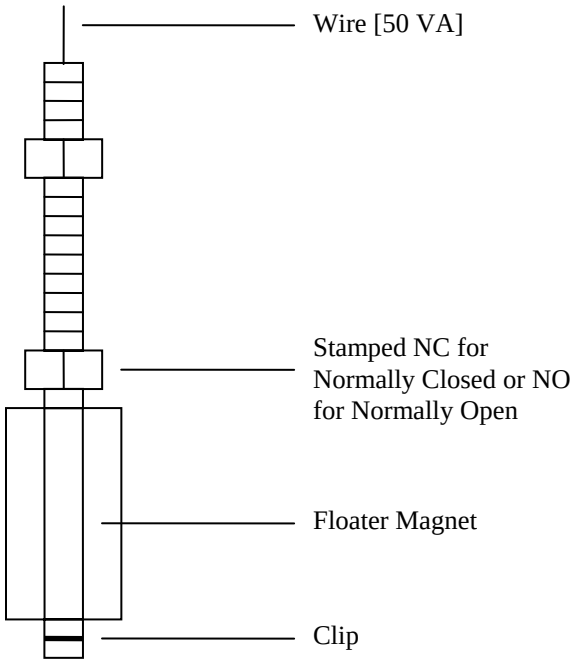
Rev.	Description	Changed	Checked	Date
A	Specification updated to 1 layer system	VM	--	30-03-2009
B	Specification updated	VM	RZ	12-08-2009
C	Specification *** added	DH	PVDS	13-10-2011
D	Specification APEX added	VM	PVDS	04-11-2011
E	SPX rebranded to Bredel; spec. *** removed	AK	PvdS	27-08-2013

HIGH LUBRICANT LEVEL SENSOR

FLOAT SWITCHES FOR HOSEPUMPS:

Note: If float switch is to be used in an explosion proof environment, an intrinsically safe relay is required (relay is not the responsibility of Watson-Marlow/Bredel Pumps)

High level switches are devices used for sensing the lubricant level inside the pump casing. Upon hose failure, product being pumped will enter the pump housing through the damaged hose. The pumped product will mix with the hose lubricant causing the level in the pump to rise. A high level float switch installed near the top of the pump casing through the vent cap and will sense the failure which, if wired to the motor starter or speed controller, will shut the pump down. This becomes critical if the pump is left unattended for long periods of time. If the pump is allowed to run with an abrasive product in the pump housing, the pressing shoes or housing can be damaged.



SPECIFICATION

The high level switch is, as standard, configured in the NORMALLY CLOSED position. Converting the switch to NORMALLY OPEN is a simple matter of removing the “clip“ and “flipping over” the floater magnet. The floater magnet has a NO stamped on one end and an NC on the other. The easy way of determining if the switch is NO or NC is to look at the designation closest to the connecting wires.

The switch is rated for the following maxima:
Current Max: 1A
Voltage Max: 250V
Power Max: 50VA

Safety Data Sheet
[According to ISO/DIS 11014]

printing date: 18.08.2015 revision date: 18-08-2015

Section 1 – Identification of the substance / preparation and of the company

Product identifier / product name:	LUBRICANT/COOLANT for BREDEL HOSEPUMP “Genuine Hose Lubricant”, 'FOOD GRADE' NSF Registration No123204, Category Code H1
Relevant identified use:	Lubricant, Coolant
Details of the supplier of the SDS:	Watson-Marlow Bredel B.V. Sluisstraat 7, 7491 GA tel.: +31 74 3770000 P.O.Box 47, 7490 AA fax.: +31 74 3761175 DELDEN, the Netherlands
Information provided by:	Tel.: +31 (0)74 3770000 E-mail: hosepumps@wmpg.com
Emergency information::	Tel.: +31 (0)74 3770000

Section 2 – Hazards identification

Classification of the substance/mixture:

According to Directive 67/548/EEC or 199/45/EC: not classified

According to regulation (EC) No 1272/2008 (CLP): not classified

Information concerning particular hazards for human and the environment: not applicable

NFPA-Ratings for USA: Health = 0; Fire = 1; Reactivity = 0

The product does not have to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Section 3 – Composition / information on ingredients

Chemical Characterization: Mixture of substances

Ingredient Name	CAS No.	EINECS No.	% w/w	REACH registration number
Glycerol	56-81-5	200-289-5	50-100	Not applicable
1,2-Propylene Glycol	57-55-6	200-338-0	2.5-10	01-2119456809

Remark Glycerol: REACH not applicable according to Annex V of the REACH regulation EC 1907/2006

Section 4 – First aid measures

General	No special measures required.
Inhalation	Remove victim into fresh air.
Skin contact	Remove contaminated clothing. Rinse skin immediately with plenty of water. (shower if necessary).
Eye contact	Remove contact lenses, if present. Rinse immediately thoroughly and long (at least 15 min.) with plenty of water.
Ingestion	Rinse mouth with water. Seek medical attention.

Section 5 – Fire fighting measures

Suitable extinguishing media	Powder, water spray, foam, carbon dioxide.
Special procedures	Apply water spray or fog to cool nearby equipment. Avoid fire-fighting water to enter environment.
Special exposure hazards	Fire may liberate carbon monoxide (CO) and smoke.
Special protective equipment	Wear fully protective suit.

Section 6 – Accidental release measures

Personal precautions	Not required.
Environmental precautions	Dilute with plenty of water.
Methods for cleaning up	Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust). Dispose of the material collected according to regulations.

Safety Data Sheet
[According to ISO/DIS 11014]

printing date: 18.08.2015 revision date: 18-08-2015

Section 7 – Handling and storage

Handling:

Information for safe handling	No special measures required.
Information about protection against explosions and fires	No special measures required.

Storage:

Requirements to be met by storerooms and receptacles	Suitable material for receptacles: stainless and carbon steel and plastics.
Information about storage in one common storage facility	Not required.
Further information about storage conditions	This product is hygroscopic. Protect product from humidity and water.

Section 8 – Exposure controls / personal protection

Component ***Glycerol*** with limit values that require monitoring at the workplace	Indicative limit: Long-term value: 10 mg/m³ (mist particulates).
Component **1,2-*Propylene Glycol*** with limit values that require monitoring at the workplace:	Indicative limit: Long-term value: 50 mg/m³ (mist particulates).
REACH DNEL (derived no effect level)	For Glycerol no DNEL valid. For 1,2-Propylene Glycol Systemic effects: Long-term value: 168 mg/m³ Local effects: Long-term value: 10 mg/m³ Remark: The product does not contain any relevant quantities of materials with respect to values that should be monitored at the workplace.
Additional information	The lists valid during the making were used as basis.
General protective measures	The usual precautionary measures are to be adhered to when handling chemicals.
Breathing equipment	Not required.
Protection of hands	Safety gloves recommended: Neoprene Nitrile rubber, NBR Fluorocarbon rubber (Viton)
Penetration time of glove material	The determined penetration times according to EN 374 part III are not performed under practical conditions. Therefore a maximum wearing time, which corresponds to 50% of the penetration time, is recommended.
For the permanent contact of a maximum of 15 minutes gloves made of the following materials are suitable	Butyl rubber.
Eye protection	Goggles recommended.
Hygiene measures	When using, do not eat, drink or smoke.

Section 9 – Physical and chemical properties

Form	Fluid.
Colour	Clear green.
Odor	Odorless.
Boiling point/Boiling range	260 °C (500°F).
Solidification point	-30 °C (-22 °F).
Flash point	>100 °C (>212 °F) (ASTM D6450).
Ignition temperature	~ 370 °C (~698 °F).
Danger of explosion	Product is not explosive. However, formation of explosive air/vapor mixtures are possible.
Explosion limits: lower	2.6 Vol %.
Explosion limits: high	11.3 Vol %.
Vapour pressure at 20°C	1.3 hPa (130 Pa; 1 mm Hg).
Density at 20°C	~ 1.245 g/cm³ (ISO 2811-2).
Water solubility	Fully miscible.
Ethanol solubility	Fully miscible.
pH	Neutral.
Viscosity (20°C)	600-700 mPa·s (ASTM D2196).

Section 10 – Stability and reactivity

Thermal decomposition / Conditions to avoid	No decomposition if used according to specifications.
Materials to avoid	Oxidizing agents.
Hazardous decomposition products	Fire may liberate carbon monoxide (CO) and smoke.

Section 11 – Toxicological information

Acute toxicity:

Oral (LD50)	Glycerol (100%): >12000mg/kg (rat, literature). 1,2 Propylene Glycol (100%): 20000mg/kg (rat, literature).
Primary irritant effect: skin Skin (LD50)	No irritant effect. Glycerol (100%) >10000mg/kg (rabbit, literature). 1,2-Propylene Glycol (100%):>20000mg/kg (rabbit,literature).
Primary irritant effect: skin	No irritant effect.
Primary irritant effect: eyes	No irritating effect.
Sensitization:	No sensitizing effects known.
Additional toxicological information:	The product is not subject to classification according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version. When used and handled according to specifications, the product does not have any harmful effects to our experience and the information provided to us.

Section 12 – Ecological information

Information about elimination (persistence and degradability)	Easily biodegradable Biodegradability: > 85%.
Aquatic toxicity: fish toxicity:	LC50: > 5000 mg/l, literature.
Behaviour in sewage processing plants	In case of judicious use the product does not cause disturbances in water purification plants, according to experiences made so far.
General notes	Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water. Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system. Classification according VwVwS dated May 1999. (German legislation)

Section 13 – Disposal considerations

Product:

Recommendation	Must not be disposed together with household garbage. Do not allow product to reach sewage system.

Uncleaned packaging

Recommendation	With due observance of local regulations, for instance transport to refuse incinerator.
Recommended cleansing agent	Water, if necessary together with cleansing agents.

Section 14 – Transport information

Transport/Additional information	Not dangerous according to the ADR/RID, IMDG and ICAO/IATA and DOT specifications.

Section 15 –- Regulatory information

Cancerogenity categories:

EPA (Environmental Protection Agency)	None of the ingredients is listed.
IARC (International Agency for Research on Cancer)	None of the ingredients is listed.
NTP (National Toxicology Program)	None of the ingredients is listed.
TLV (Threshold Limit Values established by ACGIH)	None of the ingredients is listed.
MAK (German Maximum Workplace Concentration)	None of the ingredients is listed.
NIOSH-Ca (National Institute for Occupational Safety & Health)	None of the ingredients is listed.
OSHA-Ca (Occupational Safety & Health Administration)	None of the ingredients is listed.

Product related hazard information	Observe the general safety regulations when handling chemicals. The product is not subject to identification regulations according to directives on hazardous materials.
Water hazard class	Water hazard class 1 (Self-assessment): slightly hazardous for water.

Safety Data Sheet
[According to ISO/DIS 11014]

printing date: 18.08.2015 revision date: 18-08-2015

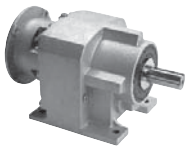
Section 16 – Other information

Disclaimer

Disclaimer of liability: the information in this SDS was obtained from sources which we believe are reliable.
However, the information is provided without any warranty, express or implied, regarding its correctness.
The conditions or methods of handling, storage, use or disposal of the product are beyond our control and may be beyond our knowledge.
For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of the product.
This SDS was prepared and is to be used only for this product.
If the product is used as a component in another product, this SDS information may not be applicable.

WATSON MARLOW
Fluid Technology Group

Part 4: Gear Reducer



SK 373.1
NEMA C + W
Ratings & Combinations

Model Type	Gear Ratio i_{tot}	Output Speed n_2 [rpm]	Output Torque $T_{2\ max}$ [lb-in]	Maximum input power◈ [hp]	[hp]	[hp]	Input Shaft W	NEMA C-Face* Available Combinations 56C					
SK 373.1													
	54.00	32	1859	0.96	0.63	0.48	X	X					
	343.92	5.1	1682	0.14	0.09	0.07	X	X					
	Based upon1750 rpm Input Speed			**1750 rpm**	**1150 rpm**	**875 rpm**		**1 hp**	**2 hp**	**5 hp**	**10 hp**	**20 hp**	**30 hp**
				Input Speed				**Cface Adapter Maximum Input Power ***					

◈ The maximum input power limit shown is the largest motor power typically combined with the gear unit. These values shown are not the mechanical limit and often may be increased through discussion with our sales or engineering department.

* The NEMA C-face power limit must also be considered when selecting a reducer. The C-face Adapter's Maximum Input Power values are displayed under the Available combinations and based on a 1750 rpm motor.

lb	W	56C	140TC
SK 373.1	26	24	24

1. Importance of the operating instructions

These operating instructions are intended to provide general information and safety guidelines. It is the responsibility of the buyer, machine builder, installer and user of the NORD product to make sure that all the proper safetynotes and operating instructions have been reviewed and understood. If the contents of this instruction or any applicable operating instructions are not understood, please consult NORD.

⚠ *WARNING* ⚠

Electric motors, gearmotors, electrical brakes, variable frequency drives, and gear reducers contain potentially dangerous high-voltage, rotating-components and surfaces that may become hot during operation. All work involved in the transport, connection, commissioning and maintenance of any NORD product must be carried out by qualified and responsible technicians.

2. Inspect incoming freight

Before accepting shipment from the freight company, thoroughly inspect the NORD equipment for any shipping and handling damage. If any goods called for in the bill of lading or express receipt are damaged, or if the quantity is short, do not accept until the freight express agent makes an appropriate notation on your freight bill or express receipt. If any concealed loss or damage is discovered later, notify your freight carrier or express agent at once, and request a formal review of your claim.

Claims for loss or damage in shipment must not be deducted from the NORD invoice, nor should payment of the NORD invoice be withheld awaiting adjustment of such claims, as the carrier guarantees safe delivery. NORD will try to assist in collecting claims for loss or damage during shipment; however, this willingness on our part does not remove the transportation company's responsibility in reimbursing you for collection of claims or replacement of material.

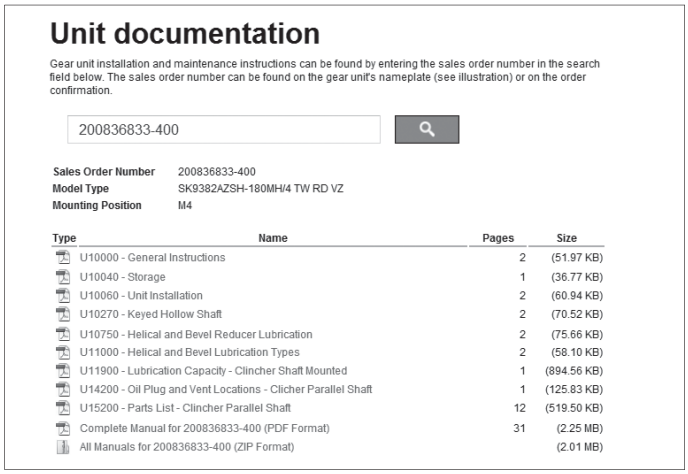
3. Obtaining detailed operating instructions

One can receive the detailed installation and maintenance instructions by entering a serial number (or NORD order number) at the appropriate location on the NORD web site.

i. Record the serial number from your gearmotor, gear reducer, or motor nameplate, or record the serial number found on your order confirmation.

ii. Go to **www.nord.com/docs** to download the appropriate operating instructions.

EXAMPLE: www.nord.com/docs



Unit documentation

Gear unit installation and maintenance instructions can be found by entering the sales order number in the search field below. The sales order number can be found on the gear unit's nameplate (see illustration) or on the order confirmation.

200836833-400

Sales Order Number	200836833-400
Model Type	SK9382AZSH-180MH/4 TW RD VZ
Mounting Position	M4

Type	Name	Pages	Size
	U10000 - General Instructions	2	(51.97 KB)
	U10040 - Storage	1	(36.77 KB)
	U10060 - Unit Installation	2	(60.94 KB)
	U10270 - Keyed Hollow Shaft	2	(70.52 KB)
	U10750 - Helical and Bevel Reducer Lubrication	2	(75.66 KB)
	U11000 - Helical and Bevel Lubrication Types	2	(58.10 KB)
	U11900 - Lubrication Capacity - Clincher Shaft Mounted	1	(894.56 KB)
	U14200 - Oil Plug and Vent Locations - Clicher Parallel Shaft	1	(125.83 KB)
	U15200 - Parts List - Clincher Parallel Shaft	12	(519.50 KB)
	Complete Manual for 200836833-400 (PDF Format)	31	(2.25 MB)
	All Manuals for 200836833-400 (ZIP Format)		(2.01 MB)

4. Intended use

NORD is a supplier of electric motors, gearmotors, reducers, electromechanical brakes, mechanical variators, and electrical variable frequency drives that are intended for commercial installations on larger systems and machines.

⚠ *WARNING* ⚠

NORD does not accept any liability for damage or injury caused by:

- Inappropriate use, operation or adaptation of the drive system.
- Unauthorized removal of housing covers, safety and inspection covers, guarding, etc.
- Unauthorized modifications to the drive system.
- Improper servicing or repair work on the drive system.
- Damage caused during shipment or transportation.
- Disregard of the important Safety Notes or Operating Instructions.

5. Notes concerning warranty and liability

All units are supplied according to the terms described in our standard "Conditions of Sale." The unit limited warranty is also defined in our "Conditions of Sale" and is located in the back of our product catalogs as well as the back of your order invoice.

All NORD Safety Notes and all related NORD Operating instructions shall be considered up-to-date at the time in which they were compiled by the buyer, machine builder, installer or user. NORD reserves the right to incorporate technical modifications and information updates to any safety/operating instructions that are within the scope of providing additional knowledge or clarification, communicating design changes, or product enhancements. Information updates may include any NORD product, or subsequent products purchased and supplied by NORD; No specific claims can be derived from the information or illustrations and descriptions contained in the safety notes or related operating instructions.

⚠ *WARNING* ⚠

NORD assumes no liability for personal injury, equipment damage or malfunctions resulting from failure to comply with any installation safety notes. The applicable national, regional, and local work regulations and safety requirements must also be complied with. Failure to comply with any safety notes or regulations may result in serious injury, damage to property, or even death.

6. Checklist for installation and operation

☑ Verify that the purchased NORD product has been supplied with the expected accessories & options. Check the received goods and packing slip to make sure items are properly received.

☑ Make sure that you have all of the required Operating Instructions for your NORD electric motor, gearmotor, reducer, electromechanical brake, mechanical variable speed drives, or electrical variable frequency drives.

☑ Consult NORD if you feel you are missing any documentation or if you have questions.

SAFETY NOTES

1. Safety & information symbols

All work including transportation, storage, installation, electrical connection, commissioning, servicing, maintenance and repair must be performed **only by qualified specialists or personnel**. It is recommended that repairs to NORD Products are carried out by the NORD Service Department. Instructions related to operational safety will be emphasized as shown.

Symbol	Meaning
⚠	**General Warning or Hazard -** Severe risk or danger of personal injury or death by working around dangerously high electrical voltage or moving machinery. Proper safety precautions must be taken.
STOP	**Possible Harmful Situation -** Care must be taken to avoid the possibility of damaging the drive unit, driven machine, or the environment.
i	**Important Note -** Useful note or tip to help assure trouble-free operation.
♻	**Material Disposal Note -** Important note concerning suggested material disposal.

2. Safety warnings

⚠ GENERAL WARNINGS ⚠

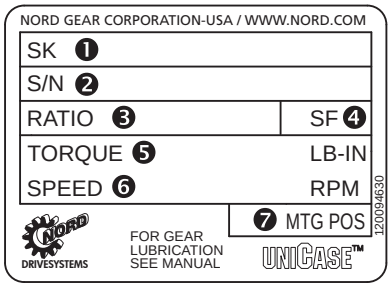
- All work involved in the transport, connection, commissioning and maintenance of any NORD product must be carried out by qualified and responsible technicians. All applicable national, regional, and local work regulations and safety requirements must also be complied with. **NORD assumes no liability for personal injury, accidental death, or equipment damage and malfunctions resulting from failure to comply with installation or operating instructions, safety notes, or any work regulations and laws!**
- Gear unit installation and maintenance work may only be performed when no power is available to the prime mover or motor. Electric motors, electrical brakes, and variable frequency drives, contain potentially dangerous high-voltage. Prior to installation or maintenance, shut down the power at the circuit breaker or power switch. **While working on the drive, make sure the power from the prime mover is isolated or secured on "lock-out" to prevent accidental start-up and to safeguard against injury!**
- Surfaces of motors and gear units may become hot during operation or shortly after start-up. In some instances additional protection against accidental contact may be necessary. **Use caution to avoid burns or serious injury!**

3. Observe published performance range & nameplate data

STOP HARMFUL SITUATION STOP

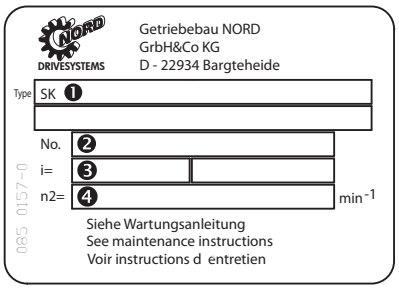
Observe the data on all reducer nameplates and verify published ratings for the NORD item/s in question. Do not operate any NORD equipment outside the published performance range. Failure to comply may result in damage to the drive unit, driven machine, or the environment.

U.S. Nameplate



❶ Model/Type
❷ Serial Number
❸ Gear Ratio
❹ Service Factor
❺ Torque Rating
❻ Output Speed RPM
❼ Mounting Position

European Nameplate



❶ Model/Type
❷ Serial Number
❸ Gear Ratio
❹ Speed

4. Transportation and handling

Make sure that all eyebolts and lifting lugs are tight and lift only at designed points. Protect the mounting surface from possible damage during transportation.

⚠ WARNING ⚠

Do not attach other machinery or loads to the NORD assembly, since the supplied lifting bolts are not designed for this purpose.

If the gearmotor or assembly is equipped with two suspension eye bolts, then both locations should be used for transportation and placement of the unit; in this case the tension force of the slings must not exceed a 45° angle.

In some instances it may be appropriate to use additional lifting straps or slings in order to assure safe transportation of the assembly. Always use sufficiently rated handling equipment and ensure that adequate safety measures are taken to protect personnel from injury during transportation. Once the NORD assembly is properly installed, remove the transportation fixtures.

7. DISPOSAL

MATERIAL DISPOSAL

Properly dispose of all used gear units and internal parts in accordance with all local regulations. In particular, all lubricants must be properly collected and disposed.

For confirmation of specific materials used in a specific reducer or gearmotor assembly, please consult NORD with the appropriate unit identification or serial number.

Components	Material
Gear wheels, shafts, rolling bearings, parallel keys, snap rings, spacers, shims, etc.	Steel
Gear housing and housing components	Cast iron or Aluminum (depending on type and size)
Worm gears	Bronze alloy
Radial seals, sealing caps, and rubber components	Elastomers with some steel
Coupling components	Plastic or Elastomer with Steel
Housing gaskets and flat oil seals	Asbestos-free sealing or gasket material (various types used)
Gear Oil	Mineral, SHC-Synthetic or PG-Synthetic (can vary)

STORAGE & COMMISSIONING

1. Storage

IMPORTANT NOTE

For storage periods longer than 9 months, or for storage in less than desirable conditions, please consult NORD for recommendations.

Storage for up to 9 months is possible, so long as the following conditions are observed:

- Store the gear unit in its actual mounting position in accordance with the specified oil fill-level, in a clean and dry temperature controlled area. Avoid temperature fluctuations within the range of 0°C and 40°C (32°F to 104°F) and avoid relative humidity conditions in excess of 60%.
- Protect all exposed or unpainted shaft and flange surfaces with an anti-corrosion agent or grease.
- Store in a location free from shock and vibration, to avoid false brinelling of bearing elements and raceways.
- Whenever possible, rotate the shafts periodically, by hand if necessary, to help prevent brinelling (bearing damage) and to help keep the shaft seals pliable.
- Avoid direct exposure to the sun or UV light and aggressive or corrosive materials in the environment (ozone, gases, solvents, acids, caustic solutions, salts, radioactivity, etc.

2. Commissioning

Prior to gear unit start-up, complete the following:

- Check the lubricant and be sure the gear unit is filled with the proper oil type, to the proper level, as determined by the mounting position.

IMPORTANT NOTE

Some smaller gear units are supplied as maintenance free/ lubricated for life gear units. Oil level may not be checked on some of these units.

- Check the condition of all shaft seals and all assembled flange gasket areas. If any change is detected in the shape, color, hardness or permeability, or if any leaks are detected, the corresponding shaft seals and/or gaskets must be replaced.
- Remove all anti-corrosive metal protectant from otherwise bare metal surfaces. Follow product manufacturers directions and warnings during surface protection removal.
- Check the resistance of all motor and brake windings to verify the integrity of the winding insulation and inspect all terminal box openings and wire connection areas to verify that all components are dry and free of corrosion.

3. Long-Term Storage

By taking special precautions, problems such as seal leakage and reducer failure due to the lack of lubrication, improper lubrication quantity, or contamination can be avoided. The following precautions will protect gear reducers during periods of extended storage:

- Store the gear unit in its actual mounting position in accordance with the specified oil fill-level, in a clean and dry temperature controlled area. Avoid temperature fluctuations within the range of 0°C and 40°C (32°F to 104°F) and avoid relative humidity conditions in excess of 60%.
- Fill the reducer full with oil that is compatible with the product normally used or recommended during service.
- Apply grease to all unpainted or unprotected shafts, bores, keyways, flange surfaces, tapped holes, and to the exterior of all oil seals.
- Store in a location free from shock and vibration, to avoid false brinelling of bearing elements and raceways.
- Once every few months rotate the input shaft approximately 10-20 revolutions to redistribute the weight of gears and shafts and to prevent brinnelling of the bearings and drying of the seal track.
- Avoid direct exposure to the sun or UV light and aggressive or corrosive materials in the environment (ozone, gases, solvents, acids, caustic solutions, salts, radioactivity, etc.)

4. Commissioning After Long-Term Storage

- Remove all anti-corrosive metal protectant from otherwise bare metal surfaces. Follow product manufacturers directions and warnings during surface protection removal.
- Drain the reducer and refill it with the proper type and amount of lubricant.
- Observe start-up and initial operation to make sure there are no seal or gasket leaks, or unusual sounds, vibration or heat rise during operation.
- Check the resistance of all motor and brake windings to verify the integrity of the winding insulation and inspect all terminal box openings and wire connection areas to verify that all components are dry and free of corrosion.

UNIT INSTALLATION

1. Installation site

Drives must be properly installed if they are to produce the rated torque. Improper installation may lead to oil leaks, reduced life, or even catastrophic failure. NORD gear drives and motors are intended to be installed at a suitable mounting site under the following conditions:

- Unimpeded airflow to and around the units.
- Accessibility to oil drain, level and breather plugs.
- On brakemotors, allow adequate space for removing the fan guard and replacing and adjusting the brake.
- Mounting surfaces must be flat, torsionally rigid, and dampened against vibration.
- Unless special measures are taken, the immediate vicinity around the gear drive or motor should not be exposed to any aggressive or corrosive substances, contaminated air, ozone, gases, solvents, acids, alkalis, salts, radioactivity, etc.

2. Mounting position

Reducer mounting position charts illustrate the standard mounting positions for horizontal and vertical mounting. All gear units are assembled with the oil fill-level, oil-drain and vent plugs installed in their proper locations, **according to the customer-specified mounting position**. For mounting orientations other than shown consult NORD Gear.

STOP *HARMFUL SITUATION* STOP

The gear reducer may not receive proper lubrication if the unit is not mounted in the position for which it is designed. Observe the mounting position designated on the reducer nameplate, or specified in the order acknowledgement. Consult NORD prior to changing mounting position in the field. While it is often possible to simply relocate the oil fill-level and vent locations, and adjust the oil fill amount, in some cases, different mounting positions may lend themselves to different internal construction features.

3. Reducer mounting

- The support foundation must be straight, level and flat. Whether the gear unit is foot-mounted or flange-mounted, NORD recommends that the straightness and flatness of the customer-supplied support foundation follow **Table 1**.
- The gear unit must be properly aligned with the driven shaft of the machine in order to prevent additional stress or load forces from being imposed upon the gear unit.
- To facilitate oil drainage it may be desirable to elevate the gear box foundation above the surrounding support structure.
- All bolting surfaces must be clean and free from contamination and corrosion.

Table 1: Recommended Straightness and Flatness of Customer-Supplied Support Foundation

Above (in)	To & Including (in)	General Tolerance on Straigtness & Flatness ISO 2768-2, Tolerance Class K
0.00	0.39	+/- 0.002 in
0.39	1.18	+/- 0.004 in
1.18	3.9	+/- 0.008 in
3.9	11.8	+/- 0.016 in
11.8	39	+/- 0.024 in
39	118	+/- 0.031 in

Above (mm)	To & Including (mm)	General Tolerance on Straigtness & Flatness ISO 2768-2, Tolerance Class K
0	10	+/- 0.05 mm
10	30	+/- 0.1 mm
30	100	+/- 0.2 mm
100	300	+/- 0.4 mm
300	1000	+/- 0.6 mm
1000	3000	+/- 0.8 mm

Straightness: Based upon the length of the corresponding line.

Flatness: Based upon the longer lateral surface or the diameter of the circular surface.

STOP *HARMFUL SITUATION* STOP

The responsibility for the design and construction of the support foundation is with the user. The foundation must be adequate to withstand normal operating loads and possible overloads while maintaining alignment to attached system components under such loads. ***Motors and drive components mounted on prefabricated base plates can become misaligned during shipment. Always check alignment after installation.***

4. Steel foundation

An engineered structural steel foundation should be designed to provide adequate rigidity and prevent loads from distorting the housing or causing misalignment of internal gears and shafts. When foot-mounting the gear reducer, a base plate or sole plate with suitable thickness (generally equal or greater than the thickness of the drive feet) should be securely bolted to steel supports and extend under the entire gear drive assembly. When flange-mounting the gear unit, the bulk head plate must be engineered to minimize buckling distortions and support the cantilevered weight of the gear unit or gear motor.

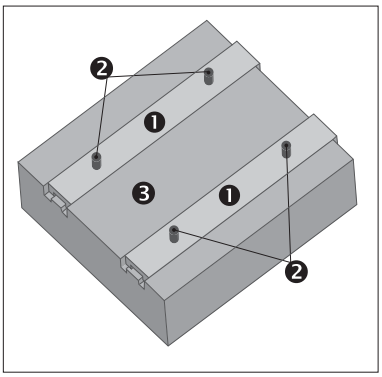
STOP *HARMFUL SITUATION* STOP

Do not weld on the gear unit or use the gear unit as an earth or ground connection for any welding procedure as this may cause permanent damage to the bearings and gears.

5. Concrete foundation

If a concrete foundation is used, allow the concrete to set firmly before bolting down the gear drive. Grout structural steel mounting pads and bolts of sufficient size into the concrete, to adequately distribute the load stress onto the concrete foundation.

Figure 1: Concrete Foundation



❶ Grouted Structural Steel Mounting Pads
❷ Mounting Bolts
❸ Concrete Foundation

6. Bolt connections for footed & flange mounted units

NORD footed reducers and flange-mount reducers (with B5 flange) have clearance designed into the mounting holes to allow for some minor adjustments in alignment. Bolt size, strength and quantity should be verified to insure proper torque reaction capacity whatever the mounting arrangement. Tightening torque for gear reducer mounting bolts, and recommended fastener grades, are provided in Table 2.

Table 2A: Tightening Torque for Inch Reducer Mounting Bolts

Thread Size	Grade SAE 5 / ASTM A449		Grade SAE 8	
(in)	(lb-ft)	(Nm)	(lb-ft)	(Nm)
1/4-20	7.1	9.6	10.0	13.6
5/16-18	16	21	22	30
3/8-16	28	37	39	53
1/2-13	69	93	98	132
5/8-11	138	188	195	264
3/4-10	247	334	348	472
7/8-9	396	537	558	757
1-8	592	802	833	1,130
1 1/8-7	-	-	1,233	1,672
1 1/4-7	-	-	1,717	2,327
1 3/8-6	-	-	2,267	3,073
1 1/2-6	-	-	2,983	4,045
1 3/4-5	-	-	4,458	6,045

- Calculated tightening torques are based a conventional 60°, clean and dry (un-lubricated) thread, with thread-friction and head-friction equal to 0.15.
- When using inch-fasteners, NORD recommends a minimum Grade SAE 5 (ASTM A-449) for sizes up to 1-8 UNC, and Grade SAE 8 for all larger sizes.

Table 2B: Tightening Torque for Metric Reducer Mounting Bolts

Above	ISO Grade 8.8		ISO Grade 10.9		ISO Grade 12.9	
(mm)	(lb-ft)	(Nm)	(lb-ft)	(Nm)	(lb-ft)	(Nm)
M4	2.4	3.2	3.5	4.7	4.1	5.5
M5	4.7	6.4	6.9	9.3	8.1	11
M6	8	11	12	16	14	19
M8	20	27	29	39	34	46
M10	39	53	58	78	67	91
M12	68	92	100	135	110	155
M14	107	145	159	215	180	250
M16	170	230	247	335	290	390
M18	240	325	343	465	400	540
M20	339	460	487	660	570	770
M22	465	630	664	900	770	1,050
M24	583	790	848	1,150	960	1,300
M27	848	1,150	1,217	1,650	1,440	1,950
M30	1,180	1,600	1,660	2,250	1,950	2,650
M36	2,050	2,780	2,884	3,910	3,470	4,710
M42	3,297	4,470	4,639	6,290	5,560	7,540
M48	4,940	6,700	7,010	9,500	8,260	11,200

- Calculated tightening torques are based on a conventional 60°, clean and dry (un-lubricated) thread, with thread-friction and head-friction equal to 0.15.
- When using metric-fasteners, NORD recommends a minimum ISO Grade 8.8 bolt.

7. Mounting the prime mover

When the motor is not flange mounted or integrally mounted to the gearbox, it is important to properly secure and align the gear drive with respect to the driven machine before attempting to align the prime mover or motor.

A. After the main gear drive is properly aligned and bolted in place, align the prime mover with respect to the reducer input shaft.

B. Use shims under the feet of the prime mover as needed, and secure in place with the proper mounting bolts. Dowel pins may be field-installed to help prevent misalignment and ensure proper realignment if removed for service.

IMPORTANT NOTE

When using a high speed coupling connection between the prime mover and the reducer, check alignment per the coupling manufacturers recommendations. If the coupling is misaligned, the reducer alignment or shimming is incorrect. Re-align the gear reducer and re-check the high-speed coupling alignment before re-aligning the motor.

1. Solid shaft diameter tolerance

Reducer input and output shaft extensions have a diameter tolerance as specified in **Table 1**.

Table 1: Solid Shaft Diameter Tolerance

Above ø (in)	To & Including ø (in)	Tolerance (in)
0.375	1.750	+0.0000 / -0.0005
1.750	7.500	+0.0000 / -0.0010

Above ø (mm)	To & Including ø (mm)	Tolerance (mm)	ISO 286-2 Fit Class
10	18	+0.012 / +0.001	k6
18	30	+0.015 / +0.002	k6
30	50	+0.018 / +0.002	k6
50	80	+0.030 / +0.011	m6
80	120	+0.035 / +0.013	m6
120	180	+0.040 / +0.015	m6
180	190	+0.046 / +0.017	m6

2. Fitting drive elements onto the reducer solid shaft

Solid input and output shaft extensions are provided with a drill and tap feature as indicated in Table 2. When installing drive elements such as coupling hubs, pulleys, sprockets, or gears, NORD recommends using the threaded hole in the end of the shaft, along with a suitable assembly device fitted into the threaded hole.

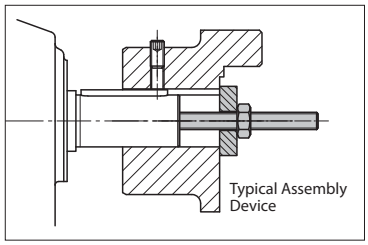


Table 2: Solid Shaft End - Threaded Holes

Above ø (in)	To & Including ø (in)	Tap size & Depth (in)
0.375	0.500	10-24 x 0.43 in
0.500	0.875	1/4-20 x 0.59 in
0.875	0.938	5/16-18 x 0.71 in
0.938	1.100	3/8-16 x 0.87 in
1.100	1.300	1/2-13 x 1.10 in
1.300	1.875	5/8-11 x 1.42 in
1.875	3.500	3/4-10 x 1.73 in
3.500	5.125	1-8 x 2.63 in
5.125	7.500	1 1/4 - 7 x 3.15

Above ø (mm)	To & Including ø (mm)	Tap Size & Depth (mm)
10	13	M4 x 10 mm
13	16	M5 x 12.5 mm
16	21	M6 x 16 mm
21	24	M8 x 19 mm
24	30	M10 x 22 mm
30	38	M12 x 28 mm
38	50	M16 x 36 mm
50	85	M20 x 42 mm
85	130	M24 x 50 mm
130	190	M30 x 60 mm

HARMFUL SITUATION

DO NOT DRIVE or **HAMMER** the coupling hub, pulley, sprocket, or gear into place. An endwise blow to the reducer shaft can generate damaging axial forces and cause damage to the reducer housing, bearings or internal components.

WARNING

To avoid serious injury the user must provide suitable safety guards for all rotating shafts and shaft components such as couplings, chain drives, belt drives, etc. All guarding must adhere to local regulations and safety standards.

3. Installing interference-fit hubs to the reducer shaft

Prior to installing any interference-fit hubs to the reducer shaft, consult with the manufacturer to determine proper assembly and fit. Interference-fits usually require heating the coupling, sprocket or gear hub, per the manufacturer's recommendations. Coupling hub installation typically follows ANSI/AGMA 9002-A86. Always make sure the reducer shaft seals are protected from the heat source. Apply uniform heat to the drive element hub to prevent distortion. NORD does not recommend heating the drive element hub beyond 212°F to 275°F (100°C to 135° C).

WARNING

When using heat to mount a drive element hub, do not use open flame in a combustible atmosphere or near flammable materials. Use suitable protection to avoid burns or serious injury.

HARMFUL SITUATION

When using external chain or belt drives, make sure the reducer is sized so that the shaft and bearings have adequate capacity. To avoid unnecessary bearing loads and additional shaft deflection, mount all power take-off devices (sprockets, pulleys, etc.) so that the applied load center is as close to the gear housing as possible and check component alignment and tension of any belts or chains per the manufacturer's recommendation. Do not over tighten the belts or chains.

4. Coupling installation

The performance and life of any coupling depends upon how well it is installed. Coupling hubs are typically mounted flush with the shaft ends, unless specifically ordered for overhung mounting. Shaft couplings should be installed according to the coupling manufacturer's recommendations for gap, angular and parallel alignment. To help obtain critical shaft alignment coupling hubs may be installed to the machine shafts prior to final shimming or tightening of the foundation bolts. Proper coupling alignment allows for thermal and mechanical shaft movement during operation and ensures that only torque (no radial load) is transmitted between the mating shafts.

Coupling gap and angular alignment

The shaft gap must be sufficient to accommodate any anticipated thermal or mechanical axial movement. When setting the coupling gap, insert a spacer or shim stock equal to the required spacing or gap between the coupling hub faces. Measure the clearance using feeler gauges at 90-degree intervals, to verify the angular alignment.

Parallel (or offset) alignment

Mount a dial indicator to one coupling hub, and rotate this hub, sweeping the outside diameter of the other hub. The parallel or offset misalignment is equal to one-half of the total indicator reading. Another method is to rest a straight edge squarely on the outside diameter of the hubs at 90° intervals and measure any gaps with feeler gauges. The maximum gap measurement is the parallel or offset misalignment.

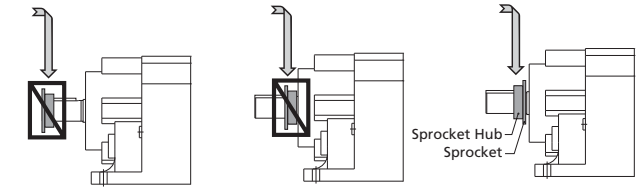
Check alignment

After both angular and parallel alignments are within specified limits, tighten all foundation bolts securely and re-check critical alignment. If any of the specified limits for alignment are exceeded, realign the coupling.

5. Installing sheaves (pulleys), sprockets and gears

To avoid unnecessary bearing loads and additional shaft deflection, mount all power take-off devices (sprockets, pulleys, gears, etc.) so that the applied load center is as close to the gear housing as possible, as shown in **Figure 2**.

Figure 2: Sprocket or Gear Mounting



Preferred Mounting of Sprocket or Gear

Align the driver sheave or sprocket with the driven sheave or sprocket by placing a straight-edge length-wise across the face of the sheaves or sprockets. Alignment of bushed sheaves and sprockets should be checked only after bushings have been tightened. Check horizontal shaft alignment by placing one leg of a square or a level vertically against the face of the sheave or sprocket.

Always check component alignment and tension any belts or chains per the manufacturer's recommendation. The ideal belt or chain tension allows proper wrap of the driver and driven wheels, while maintaining the lowest possible tension of the belts or chain, so that no slipping occurs under load conditions. Check belt or chain tension frequently over the first 24 to 48 hours of operation.

STOP *HARMFUL SITUATION* STOP

When using external chain or belt drives, make sure the reducer is sized so that the shaft and bearings have adequate capacity. To avoid unnecessary bearing loads and additional shaft deflection, mount all power take-off devices (sprockets, pulleys, etc.) so that the applied load center is as close the gear housing as possible and check component alignment and tension of any belts or chains per the manufacturer's recommendation. Do not over tension the belts or chains.

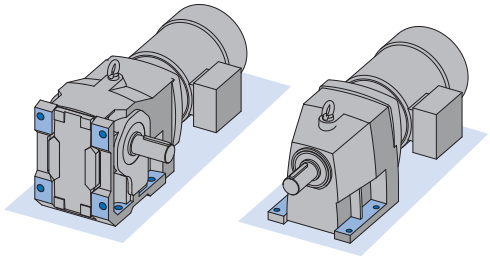
6. Outboard pinion gear alignment

Align outboard pinion gears and adjust the gear tooth clearance according to the manufacturer's recommendations, checking for acceptable outboard pinion tooth contact. The foundation bolts may have to be loosened and the gear unit moved slightly to obtain proper gear tooth contact. After the unit is moved to correct tooth contact, the prime mover may need to be realigned.

REDUCER MOUNTING
FOOTED & FLANGE MOUNT GEAR UNITS

1. Foot-mounted reducers

When installing the foot-mounted gear unit, observe the flatness specifications and bolt tightening torque guidelines provided in U10060 and make sure the mating mounting surface and reducer feet are clean and free of debris. Use of shims under the feet of the gear unit may be required in order to align the output shaft to the driven equipment. Make sure that all feet are supported so that the housing will not distort when it is bolted down. Improper shimming will cause mis-alignment and may reduce the life of the gear unit or cause component failure. Dowel pins may be field-installed to help prevent misalignment and ensure proper realignment if removed for service.



IMPORTANT NOTE

Gear units may be subjected to radial loads or side pull, caused by external chain drives or belt drives. In these instances it is recommended that the mounting base be designed with a slide-plate adjustment to accommodate extra slack in the chain or the belt after the feet are loosened. When using an external chain or belt drive, make sure the reducer is sized so that the shaft and bearings have adequate capacity.

2. Flange-mounted reducers (with B5 flange)

When using the B5 flange to mount the gear unit, the bulk head plate must be engineered to minimize buckling distortions and support the cantilevered weight of the gear reducer or gearmotor. On the B5 mounting flange NORD provides a pilot register or and the flange pilot tolerance as listed per Table 1. When the mating hole is designed with the proper fit, the flange pilot tenon provides a means of accurately positioning the reducer while the hold-down bolts are properly secured; once the reducer is secured, the tenon helps prevent movement of the reducer and it helps locate the center of the reducer output shaft.

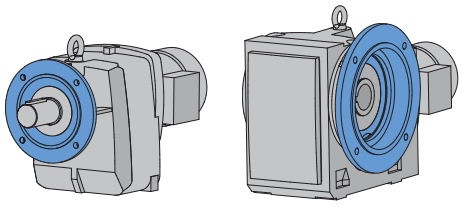


Table : Flange Pilot Tolerance

Above ø (in)	To & Including ø (in)	Tolerance (in)	ISO 286-2 Fit Class
1.969	3.150	+0.0005 / -0.0003	j6
3.150	4.724	+0.0005 / -0.0004	j6
4.724	7.087	+0.0006 / -0.0004	j6
7.087	9.055	+0.0000 / -0.0005	h6
9.055	9.843	+0.0000 / -0.0011	h6
9.843	12.402	+0.0000 / -0.0013	h6
12.402	15.748	+0.0000 / -0.0014	h6
15.748	19.685	+0.0000 / -0.0016	h6

Above ø (mm)	To & Including ø (mm)	Tolerance (mm)	ISO 286-2 Fit Class
50	80	+0.012 / -0.007	j6
80	120	+0.013 / -0.009	j6
120	180	+0.014 / -0.011	j6
180	230	+0.000 / -0.013	h6
230	250	+0.000 / -0.029	h6
250	315	+0.000 / -0.032	h6
315	400	+0.000 / -0.036	h6
400	500	+0.000 / -0.040	h6

When installing the flange mounted gear unit, observe the flatness specifications and bolt tightening torque guidelines provided in U10060. Make sure the mating mounting surface and reducer flange are clean and free of debris. Use a straight edge or parallel bar to check for high spots on the mating mounting surface and remove any raised material around the mounting holes.

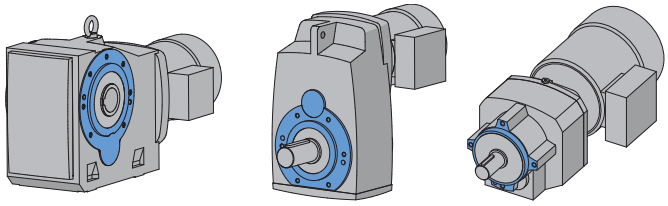
Set the gear unit into place and tighten the bolts until they are snug. Before final bolt-tightening check for any material gaps between the mating surfaces and if shimming is required, use "U" shaped shims at least 2 times the width of the bolt. Avoid over shimming a very irregular surface as this will make it very difficult to achieve proper alignment.

IMPORTANT NOTE

For heavy shock applications, it is advisable to field-install dowel pins through the mounting flange connection (in addition to the mounting bolts). This will help control flange movement or flange rotation and relieve the mounting bolts from this additional stress.

3. Flange-mounted reducers (with B14 flange)

When using the B14 flange to mount the gear unit, the bulk head plate must be engineered to minimize buckling distortions and support the cantilevered weight of the gear reducer or gearmotor. When properly installed, the output flange of the reducer housing is designed to enable the permissible torques and radial forces to be reliably transmitted by the bolt connections.



IMPORTANT NOTE

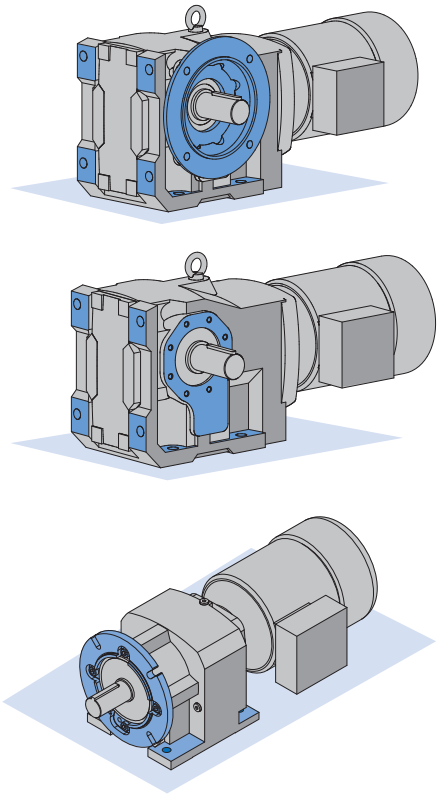
When using the B14 flange-face for mounting, if dowel pin holes are provided in addition to the threaded holes, then it is advisable to also use the proper dowel pins, to help control flange movement or flange rotation and relieve the mounting bolts from this additional stress This is especially important for heavy shock applications.

4. Foot & flange reducer housings

Some gear reducer housings are available with a foot and an output flange. Units with a foot and a B5 Flange are designated with the suffix XF after the primary model number and units with a B14 face-flange are designated with the suffix XZ after the primary model number. When a gear unit is provided with both a foot and a flange, the foot is consider the primary mounting surface. The flange is generally considered to be the secondary mounting option and it is intended that this surface be used for auxiliary add on elements that place minimal load stress on the reducer housing.

HARMFUL SITUATION

To prevent overstress on the main gear unit housing, never tighten the reducer mounting feet and the mounting flange against one-another. Auxiliary add-on elements that are mounted to the reducer flange, must not transmit excessive force, torque or vibration to the main gear housing.



HELICAL & BEVEL REDUCER LUBRICATION

1. Importance of proper lubrication

Proper gearbox lubrication is essential in order to reduce friction, heat, and component wear. Lubricants reduce heat and wear by inserting a protective "fluid boundary" between mating parts and preventing direct metal to metal contact. Lubricants also help prevent corrosion and oxidation, minimize foam, improve heat transfer, optimize reducer efficiency, absorb shock loads and reduce noise.

Most NORD reducers are shipped from the factory with a pre-determined oil fill level in accordance to the specified reducer size and mounting position.

2. Standard oil type

The following tables indicate the standard oil fill type used. Please see user manual U11000 for more specific information and for optional helical and bevel gear lubricants:

Serviceable Gear Units	
Helical In-line	Standard Oil Fill: ISO VG 220, Mineral Oil
Clincher Parallel-Shaft	
Right-Angle Bevel	
NORDBLOC® Series In-line	
NORDBLOC®.1 Series In-line	
Standard Series In-line	

IMPORTANT NOTE

For shipping purposes, the following large Clincher™ gear units are supplied without oil:
• Clincher™ Sizes SK11282, SK11382 and SK12382

Maintenance-free / Lubricated For Life Gear Units	
Clincher™ sizes SK0182NB, SK0282NB & SK1382NB	Standard Oil Fill: ISO VG220 SHC/PAO Synthetic Oil
NORDBLOC® Sizes SK172, SK272, SK371F, SK372, SK373, SK320	

IMPORTANT NOTE

Maintenance-free units are supplied as sealed units with no vent-plug. Consult NORD prior to ordering if interested in ordering any of the above sizes as serviceable gear units.

IMPORTANT NOTE

Consult the sticker adjacent to the fill plug to determine the type of lubricant installed at the factory. Some units have special lubricants designed to operate in certain environments or intended to extend the service life or service temperature range of the lubricant. If in doubt about which lubricant is needed for a certain application, please contact NORD Gear.

3. Lubrication replacement

If the gear unit is filled with mineral oil, the lubricant should be replaced at least after every 10,000 operating hours or after every two years. If the gear unit is filled with synthetic oil, the lubricant should be replaced at least after every 20,000 operating hours or after every four years. Often gear reducers are exposed to extreme ambient conditions, hostile environments, wet conditions, or dirty and dusty operating areas. Especially in these situations, it is important to establish a condition-based oil service interval.

4. Oil viscosity

Viscosity, or the oil's resistance to shear under load, is often considered the single most important property of any gear oil.

- Often one will consider making a viscosity correction to the oil to improve the performance when operating the gear unit at low temperature or high temperature.
- In cases of extreme load conditions, gear pairs and antifriction bearings may be more susceptible to sliding or scuffing wear. In these operating conditions, it may also be beneficial to consider an increased lubrication viscosity and/or a lubrication with improved antiwear additive packages.

IMPORTANT NOTE

The user should consult with their primary lubrication supplier before considering changes in oil type or viscosity.

5. Maximum oil sump temperature limit

To prevent reducer overheating, the reducer's maximum oil sump temperature limit must not be exceeded for prolonged periods of operation (up to 3 hours continuous operation depending upon reducer size).

Oil Type	Maximum Oil Temperature Limit	
	NORD	AGMA 9005-D94
Mineral	80-85°C (176-185°F)	95°C (203°F)
Synthetic	105°C (220°F)	107°C (225°F)

IMPORTANT NOTE

Use caution when specifying gear reducers for high temperature service. If there is concern about exceeding the allowable safe operating temperatures, please consult NORD to discuss alternatives.

6. The importance of routine oil analysis

Routine oil analysis, sound lubrication practices, and good tracking of oil performance trends will help establish proper lubrication maintenance and change-out intervals. To maximize equipment reliability, NORD Gear generally recommends a condition-based lubrication maintenance program. One may take exceptions to this general recommendation on sealed-for-life or maintenance-free gear units or smaller and less costly gear units. In these instances, the replacement cost of the gear unit is often small compared to the costs associated with this type of oil analysis program.

STOP *HARMFUL SITUATION* **STOP**

NORD suggests replacing the gear oil if oil analysis indicates any of the following:

- Viscosity has changed by approximately 10% or more.
- Debris particles (silicon, dust, dirt or sand) exceed 25 ppm.
- Iron content exceeds 150-200 ppm.
- Water content is greater than 0.05% (500 ppm).
- The total acid number (TAN) tests indicate a significant level of oxidative break-down of the oil, and a critical reduction in performance; If the TAN number measured changes by more than 5% over the new oil, then an oil change would be recommended.

7. Mounting position and oil fill quantity

All NORD Gear reducers are shipped from the factory with a pre-determined oil fill level in accordance to the specified reducer size and mounting position. ***For additional information, please see the seperate mounting position diagrams and the corresponding oil fill quantity tables for the specified gear unit.***

The gearbox nametag will indicate the mounting position that was provided. ***For mounting orientations other than shown in the mounting position charts, please consult NORD Gear.***

STOP *HARMFUL SITUATION* **STOP**

Actual oil volume can vary slightly depending upon the gear case size, mounting and ratio. Prior to commissioning the reducer, check the oil-fill level using the reducer's oil-level plug and drain or add additional oil as needed. The minimum acceptable oil level is 0.15 in (4mm) below the oil level hole.

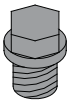
8. Oil plug locations

All gear units are assembled with the oil fill-level, oil-drain and vent plugs installed in their proper locations, according to the specified mounting position. All standard plugs are metric and utilize sealing gaskets between the head of the plug and the reducer housing.

9. Drain and fill-level plugs

All reducer drain plugs are metric socket head cap screws. For easier identification, it is NORD's standard practice to provide a hex-head screw for the fill-level plug. For ease of draining the used oil from the gear reducer, use the socket head screw located at the lowest part of the gearbox.

Drain Plug



Fill Level Plug

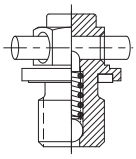
10. Vent plug locations

Reducer venting allows for air pressure differences that occur during operation, between the inner space of the reducer and the atmosphere, while ensuring leak-free operation. The AUTOVENT™ is standard for all vented gear units, unless otherwise noted.

AUTOVENT™ - The AUTOVENT™ helps prevent bearing and gear damage by behaving like a check valve to block the entry of foreign material (water, dust, corrosives, etc.). The breather opens at approximately 2-3 psi during operation and closes tightly as the gearbox cools. This option is perfect for humid conditions and wash-down environments, helping to maintain proper oil cleanliness, and reducing foaming and oxidation. NORD may choose to offer one of two style options as shown in Figure 1. The Type 2 AUTOVENT™ comes closed upon delivery with a transportation sealing plug (see Warning).

Figure 1 AUTOVENT™ Types

Type 1



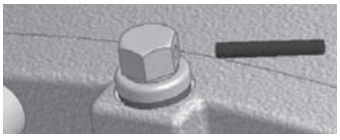
Type 2 with transportation plug

Open Vent - An optional open vent can be supplied by NORD. The open vent comes closed upon delivery with a transportation sealing plug (see Warning).

⚠ *WARNING* ⚠

To prevent build-up of excessive pressure, sealed vents must be activated as shown prior to gear unit start up.

Sealed vent



Activated vent

Filtered Vent - NORD may offer an optional filtered vent, which allows gases to permeate, but does not allow dust and debris to pass through the vent.

HELICAL & BEVEL REDUCER LUBRICATION TYPES

Lubrication Tables – Helical and Bevel Gear Units

Standard Oil Lubricants

ISO Viscosity	Oil Type	Ambient Temperature Range	Manufacturer Brand/Type	Notes
VG220	MIN-EP	0 to 40°C (32 to 104°)	Mobilgear 600XP220	♦❶
	PAO	-35 to 60°C (-31 to 140°F)	Mobil SHC630	♦❷
	FG	-5 to 40°C (23 to 104°F)	Fuchs FM220	♦

Optional Oil Lubricants

ISO Viscosity	Oil Type	Ambient Temperature Range	Manufacturer Brand/Type	Notes
VG460	PAO	-35 to 80°C (-31 to 176°F)	Mobil SHC 634	-
	FG-PAO	-35 to 80°C (-31 to 176°F)	Mobil/Cibus SHC460	-
VG220	FG-PAO	-35 to 60°C (-31 to 140°F)	Mobil/Cibus SHC220	-
VG150	PAO	-35 to 25°C (-31 to 77°F)	Mobil SHC629	-

Grease Options (applied to greased bearings and seal cavities)

NLGI Grade	Grease Type/Thickener	Ambient Temperature Range	Manufacturer Brand/Type	Notes
NLGI 2	Standard (Li-Complex)	-30 to 60°C (-22 to 140°F)	Mobil Grease XHP222	♦❶
	High Temp (Polyurea)	-25 to 80°C (-13 to 176°F)	Mobil Polyrex EP 2	♦❷
	Food-Grade (AL-Complex)	-25 to 40°C (-13 to 104°F)	Mobil Grease FM222	♦

♦ Stocked Lubricants

❶ Standard product on serviceable gear units

❷ Standard product on maintenance free gear units

IMPORTANT NOTES

- The "Ambient Temperature" is intended to be an operation guideline based upon the typical properties of all the lubricant. The viscosity and other properties of the lubricant change based upon load, speed, ambient conditions, and reducer operating temperatures. The user should consult with their lubrication supplier & NORD gear before considering changes in oil type or viscosity.
- To prevent reducer overheating, observe the maximum operating oil temperature limits:
  Mineral Oil: 80-85 °C (176 – 180 °F).
  Synthetic Oil: 105 °C (225 °F).
- In the following instances, please consult NORD for specific recommendations:
  - √ Gear units will operate in high ambient temperature conditions exceeding 40 °C (104 °F).
  - √ Gear units will operate in cold ambient temperature conditions approaching 0 °C (32 °F) or lower.
  - √ Lower than an ISO VG100 viscosity oil is being considered for a cold-temperature service.
  - √ Fluid grease is required for lubricating the gear unit.
- Observe the general lubrication guidelines outlined in user manual U10750.

Oil Formulation Codes

MIN-EP - Mineral Oil with EP Additive
PAO-EP - Synthetic Polyalphaolefin Oil with EP Additive
PAO - Synthetic Polyalphaolefin Oil
PG - Synthetic Polyglycol Oil
FG - Food-Grade Oil
FG-PAO - Food-Grade, Synthetic Poyalphaolefin Oil
FG-PG - Food-Grade, Synthetic Polyglycol Oil

Lubrication Notes

- Avoid using (EP) gear oils in worm gears that contain sulfur-phosphorous chemistries, as these additives can react adversely with bronze worm gears and accelerate wear.
- Food grade lubricants must be in compliance with FDA 212 CFR 178.3570 and qualify as a NSF-H1 lubricant. Please consult with lubrication manufacturer for more information.
- When making a lubrication change, check with the lubrication supplier to assure compatibility and to obtain recommended cleaning or flushing procedures.
- Do not to mix different oils with different additive packages or different base oil formulation types. Polyglycol (PG) oils are not miscible with other oil types and should never be mixed with mineral oil or polyalphaolefin (PAO) synthetic oil.

NORD Gear Limited
Toll Free in Canada: 800.668.4378

NORD Gear Corporation
Toll Free in the United States: 888.314.6673

HELICAL & BEVEL REDUCER LUBRICATION TYPES

Oil Cross-reference Chart

ISO Viscosity	Oil Type	Ambient Temperature Range	Mobil	Shell	Castrol	FUCHS	KLÜBER LUBRICATION
VG150	MIN-EP	0 to 25°C (32 to 77°F)	Mobilgear 600XP150	Omala 150	Alpha SP150	Renolin EP150	Klüberoil GEM 1-150N
	PAO-EP	-30 to 25 °C (-22 to 77 °F)	Mobilgear SHC150	Omala HD 150	Alphasyn EP150	Gearmaster SYN150/NA	Klübersynth EG 4-150
	PAO	-30 to 25 °C (-22 to 77 °F)	Mobil SHC629	Omala RL 150	Alphasyn T150	Geralyn SF150	Klübersynth GEM 4-150N
	PG	-25 to 25 °C (-13 to 77 °F)	Mobil Glygoyle 150	Tivela S150	Alphasyn PG150	Renolin PG150	Klübersynth GH 6-150
	FG	0 to 25 °C (32 to 77 °F)	Mobil DTE FM 150	N/A	N/A	N/A	N/A
	FG-PAO	-25 to 25 °C (-13 to 77 °F)	N/A	N/A	N/A	Cassida GL150	Klüberoil 4 UH 1-150N
	FG-PG	-25 to 25 °C (-13 to 77 °F)	Mobil Glygoyle 150	N/A	N/A	N/A	Klübersynth UH1 6-150
VG220	MIN-EP	0 to 40°C (32 to 104°)	Mobilgear 600XP220	Omala 220	Alpha SP220	Renolin EP220	Klüberoil GEM 1-220N
	PAO-EP	-30 to 60 °C (-22 to 140 °F)	Mobilgear SHC220	Omala HD220	Alphasyn EP220	Gearmaster SYN220/NA	Klübersynth EG 4-220
	PAO	-30 to 60 °C (-22 to 140 °F)	Mobil SHC630	Omala RL220	Alphasyn T220	Geralyn SF220	Klübersynth GEM 4-220N
	PG	-25 to 60 °C (-13 to 140 °F)	Mobil Glygoyle 220	Tivela S220	Alphasyn PG220	Renolin PG220	Klübersynth GH 6-220
	FG	0 to 40°C (32 to 104°F)	Mobil DTE FM 220	N/A	N/A	Fuchs FM220	N/A
	FG-PAO	-25 to 60 °C (-13 to 140 °F)	Mobil/Cibus SHC220	N/A	N/A	Cassida GL220	Klüberoil 4 UH 1-220N
	FG-PG	-25 to 60°C (-13 to 140°F)	Mobil Glygoyle 220	N/A	N/A	Cassida WG220	Klübersynth UH 16-220
VG460	MIN-EP	0 to 40 °C (32 to 104 °F)	Mobilgear 600XP460	Omala 460	Alpha SP460	Renolin EP460	Klüberoil GEM 1-460N
	PAO-EP	-20 to 80 °C (-4 to 176 °F)	Mobilgear SHC460	Omala HD460	Alphasyn EP460	Gearmaster SYN460/NA	Klübersynth EG 4-460
	PAO	-20 to 80 °C (-4 to 176 °F)	Mobil SHC 634	Omala RL460	Alphasyn T460	Geralyn SF460	Klübersynth GEM 4-460N
	PG	-20 to 80 °C (-4 to 176 °F)	Mobil Glygoyle 460	Tivela S460	Alphasyn PG460	Renolin PG460	Klübersynth GH 6-460
	FG	0 to 40 °C (32 to 104 °F)	Mobil DTE FM460	N/A	N/A	Fuchs FM460	N/A
	FG-PAO	-20 to 80 °C (-4 to 176 °F)	Mobil/Cibus SHC460	N/A	N/A	Cassida GL460	Klüberoil 4 UH 1-460N
	FG-PG	-20 to 80 °C (-4 to 176 °F)	Mobil Glygoyle 460	N/A	N/A	Cassida WG460	Klübersynth UH1 6-460

Low-end service temperature limit may vary for a specific lubricant; Please also see the important notes on Page 1.

NORDBLOC®.1 FOOTED OIL FILL QUANTITIES

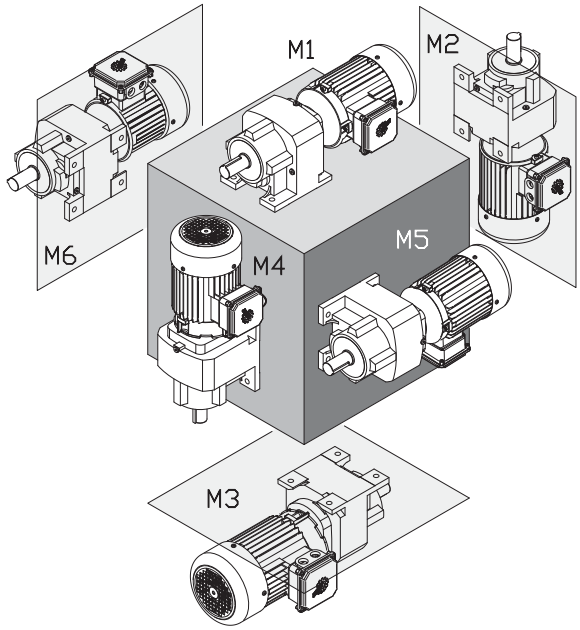
NORDBLOC®.1 footed lubrication

The following NORD Gear reducers are shipped from the factory with a pre-determined oil fill level in accordance to the specified reducer size and mounting position. For additional information, please refer to the "Oil Plug & Vent Locations" documentation for your gear unit.

STOP *HARMFUL SITUATION* **STOP**

Actual oil volume can vary slightly depending upon the gear case size, mounting and ratio. Prior to commissioning the reducer, check the oil-fill level using the reducer's oil level plug and drain or add addition oil as needed. The minimum acceptable oil level is 0.15 in (4mm) below the oil level hole.

For mounting orientations other than shown please consult NORD Gear. Reducer modifications may be required.

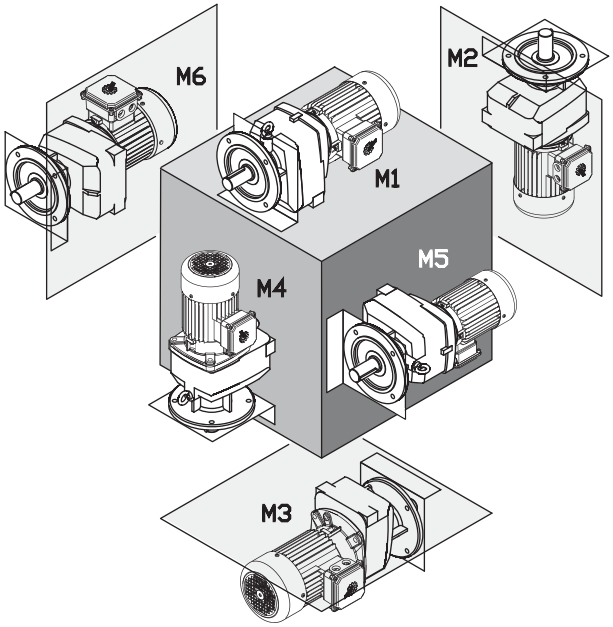


Type	M1		M2		M3		M4		M5		M6	
	Quarts	Liters	Quarts	Liters	Quarts	Liters	Quarts	Liters	Quarts	Liters	Quarts	Liters
SK 373.1	0.480	0.450	1.11	1.05	0.791	0.750	1.06	1.000	0.630	0.600	0.690	0.650

NORDBLOC®.1 FLANGED OIL FILL QUANTITIES

NORDBLOC®.1 flanged lubrication

The following NORD Gear reducers are shipped from the factory with a pre-determined oil fill level in accordance to the specified reducer size and mounting position. For additional information, please refer to the "Oil Plug & Vent Locations" documentation for your gear unit.



STOP *HARMFUL SITUATION* **STOP**

Actual oil volume can vary slightly depending upon the gear case size, mounting and ratio. Prior to commissioning the reducer, check the oil-fill level using the reducer's oil level plug and drain or add addition oil as needed. The minimum acceptable oil level is 0.15 in (4mm) below the oil level hole.

For mounting orientations other than shown please consult NORD Gear. Reducer modifications may be required.

Type	M1		M2		M3		M4		M5		M6	
	Quarts	Liters	Quarts	Liters	Quarts	Liters	Quarts	Liters	Quarts	Liters	Quarts	Liters
SK 373.1 F	0.480	0.450	1.11	1.05	0.791	0.750	1.06	1.000	0.630	0.600	0.690	0.650

WATSON MARLOW
Fluid Technology Group

Part 5: Motor

BALDOR
A MEMBER OF THE ABB GROUP

BALDOR • RELIANCE

Product Information Packet

VEM3546

1HP,1760RPM,3PH,60HZ,56C,3519M,TEFC,F1,N

Part Detail

Revision:	H	**Status:**	PRD/A	**Change #:**		**Proprietary:**	No
Type:	AC	**Prod. Type:**	3519M	**Elec. Spec:**	35WGM492	**CD Diagram:**	CD0005
Enclosure:	TEFC	**Mfg Plant:**		**Mech. Spec:**	35J302	**Layout:**	35LYJ302
Frame:	56C	**Mounting:**	F1	**Poles:**	04	**Created Date:**	08-05-2010
Base:	N	**Rotation:**	R	**Insulation:**	F	**Eff. Date:**	03-12-2014
Leads:	9#18					**Replaced By:**	
Literature:		**Elec. Diagram:**					

Nameplate NP1259L

CAT.NO.	VEM3546						
SPEC.	35J302M492G1						
HP	1						
VOLTS	208-230/460						
AMP	3.1-3/1.5						
RPM	1760						
FRAME	56C	**HZ**	60	**PH**	3		
SER.F.	1.15	**CODE**	L	**DES**	B	**CL**	F
NEMA-NOM-EFF	85.5	**PF**	71				
RATING	40C AMB-CONT						
CC		**USABLE AT 208V**	3.1				
DE	6205	**ODE**	6203				
ENCL	TEFC	**SN**					

Parts List

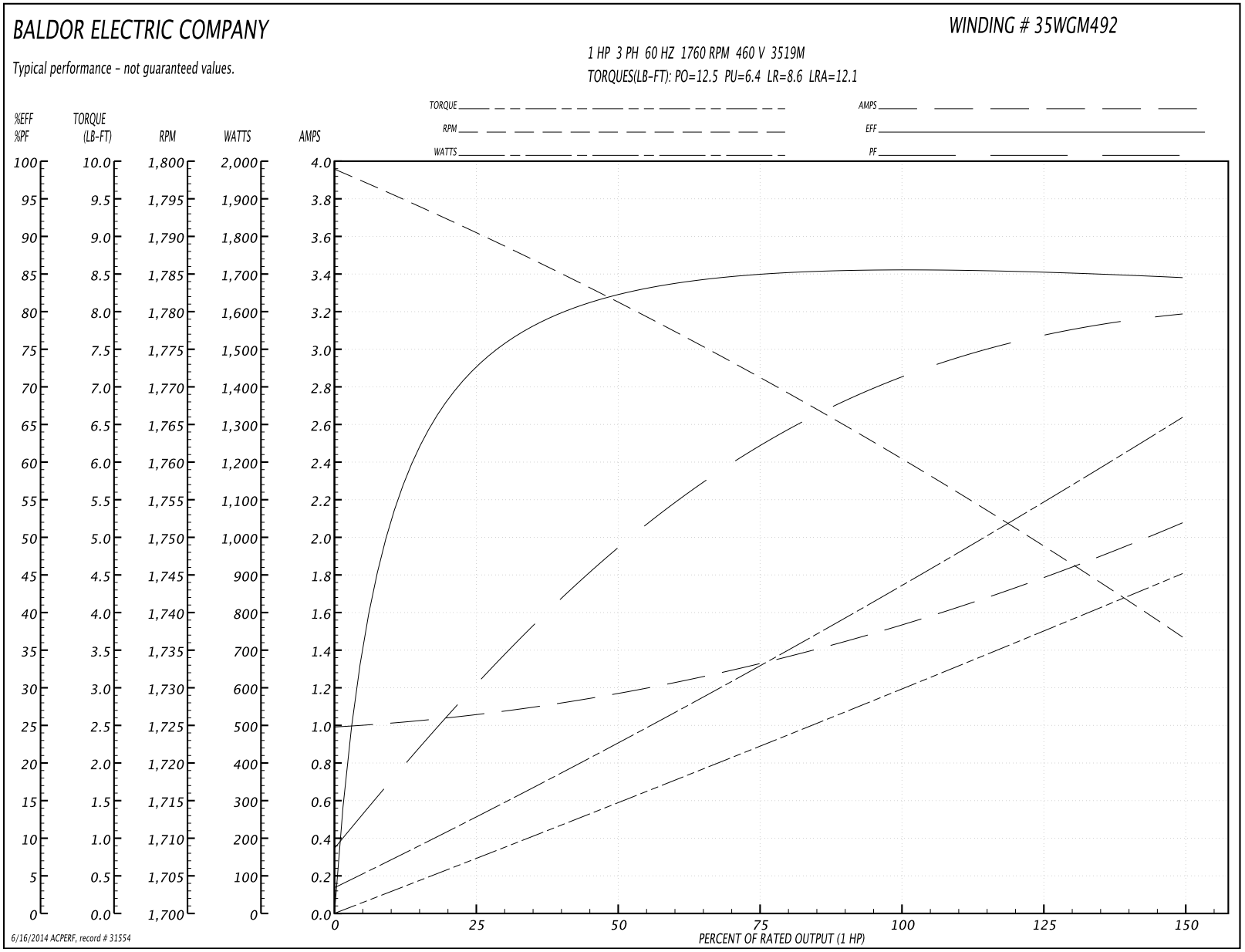
Part Number	Description	Quantity
SA200982	SA 35J302M492G1	1.000 EA
RA188287	RA 35J302M492G1	1.000 EA
34FN3002B01	EXTERNAL FAN, PLASTIC, .637/.639 HUB W/	1.000 EA
S/P107-000-001	SUPER E PROC'S-FS & WS PLTS-POLYREX EM G	1.000 EA
NS2512A01	INSULATOR, CONDUIT BOX X	1.000 EA
35CB3007	35 CB CASTING W/.88 DIA. LEAD HOLE	1.000 EA
36GS1000SP	GASKET-CONDUIT BOX, .06 THICK #SV-330 LE	1.000 EA
51XB1016A07	10-16 X 7/16 HXWSSLD SERTYB	2.000 EA
11XW1032G06	10-32 X .38, TAPTITE II, HEX WSHR SLTD U	1.000 EA
HW3001B01	003SS CUP WASHER, FOR #8 SCREW	1.000 EA
35EP3100M02	FREP TEFC 203 BRG W/O GRSR (RAISED FH MT	1.000 EA
HW5100A03SP	WAVY WASHER (W1543-017)	1.000 EA
35EP3300A33	SPL FACE MTD EP -ENCL-205 BRG	1.000 EA
51XN1032A20	10-32 X 1 1/4 HX WS SL SR	2.000 EA
XY1032A02	10-32 HEX NUT DIRECTIONAL SERRATION	4.000 EA
51XB1214A16	12-14X1.00 HXWSSLD SERTYB	1.000 EA
35FH4005A32SP	IEC FH NO GRSR W/3 HOLES - W/AUTOPHERETI	1.000 EA
51XW1032A06	10-32 X .38, TAPTITE II, HEX WSHR SLTD S	3.000 EA
35CB4521GX	CONDUIT BOX LID KIT	1.000 EA
51XW0832A07	8-32 X .44, TAPTITE II, HEX WSHR SLTD SE	4.000 EA
HW2501D13SP	KEY, 3/16 SQ X 1.375	1.000 EA
HA7000A01	KEY RETAINER 7/8" DIA SHAFT	1.000 EA
85XU0407S04	4X1/4 U DRIVE PIN STAINLESS	2.000 EA
HW3001B01	003SS CUP WASHER, FOR #8 SCREW	1.000 EA

Parts List (continued)

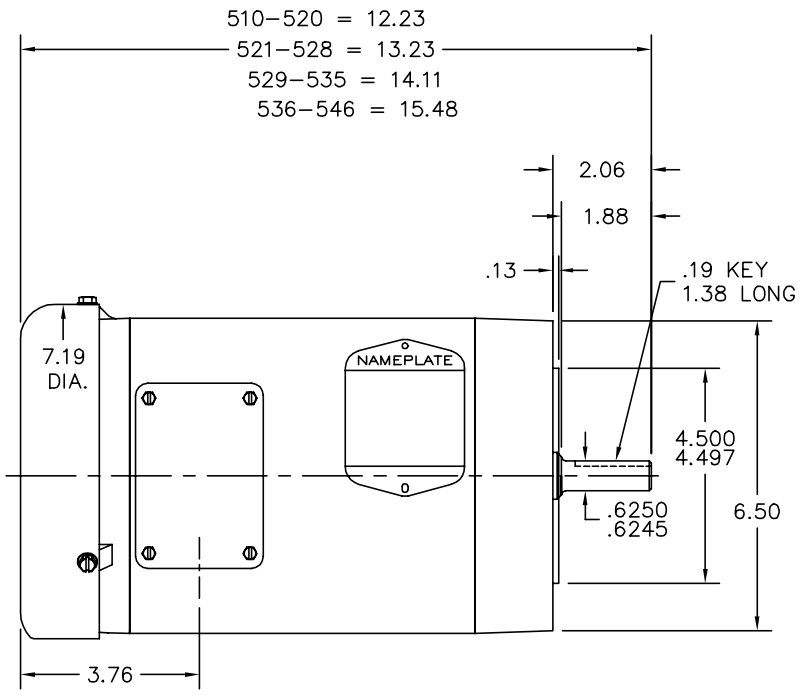
Part Number	Description	Quantity
MJ1000A75	GREASE, POLYREX EM EXXON (USe 4824-15A)	0.050 LB
MG1000Y03	MUNSELL 2.53Y 6.70/ 4.60, GLOSS 20,	0.017 GA
HA3100A12	THRUBOLT 10-32 X 7.375	4.000 EA
LB1125C02	SUPER-E (STOCK CTN LABEL SUPER-E WITH FL	1.000 EA
LC0005E01	CONN.DIA./WARNING LABEL (LC0005/LB1119)	1.000 EA
NP1259L	ALUM SUPER-E UL CSA-EEV CC NEMA PREMIUM	1.000 EA
35PA1066	PACKING GROUP COMBINED PRINT	1.000 EA
PK3082	STYROFOAM CRADLE	1.000 EA
LB1506	LABEL "AMERICAN MADE" 1.50 X 1.00	1.000 EA
MN416A01	TAG-INSTAL-MAINT no wire. (100/bx) 8/12	1.000 EA

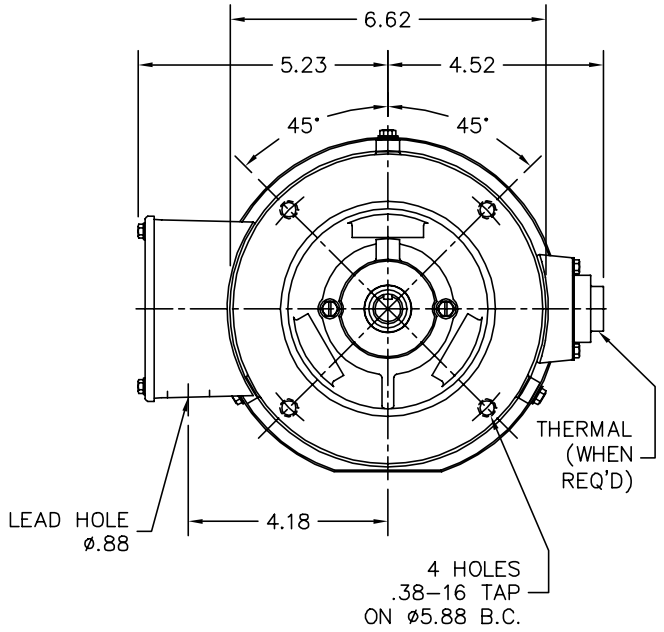
Performance Data at 460V, 60Hz, 1.0HP (Typical performance - Not guaranteed values)							
General Characteristics							
Full Load Torque:	2.97 LB-FT			**Start Configuration:**		DOL	
No-Load Current:	1.0 Amps			**Break-Down Torque:**		12.5 LB-FT	
Line-line Res. @ 25°C.:	16.05 Ohms A Ph / 0.0 Ohms B Ph			**Pull-Up Torque:**		6.4 LB-FT	
Temp. Rise @ Rated Load:	36 C			**Locked-Rotor Torque:**		8.6 LB-FT	
Temp. Rise @ S.F. Load:	43 C			**Starting Current:**		12.1 Amps	
Load Characteristics							
% of Rated Load	**25**	**50**	**75**	**100**	**125**	**150**	**S.F.**
Power Factor:	31.0	49.0	62.0	71.0	77.0	80.0	75.0
Efficiency:	72.2	82.1	84.8	85.6	85.3	84.4	85.4
Speed:	1790.9	1781.2	1771.5	1760.7	1749.1	1736.6	1754.0
Line Amperes:	1.05	1.15	1.33	1.54	1.79	2.07	1.69

Performance Graph at 460V, 60Hz, 1.0HP Typical performance - Not guaranteed values



35LYJ302





35LYJ302

CUSTOMER IS RESPONSIBLE FOR DETERMINING THAT BALDOR'S PRODUCT WILL PERFORM SUITABLY IN THE INTENDED APPLICATION.

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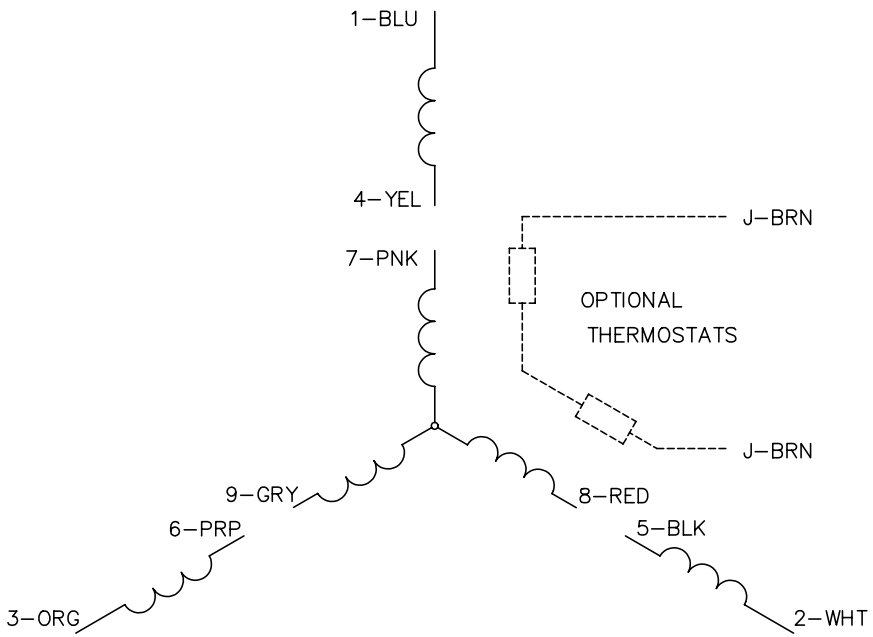
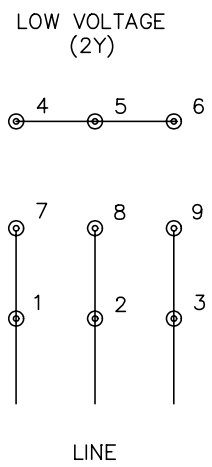
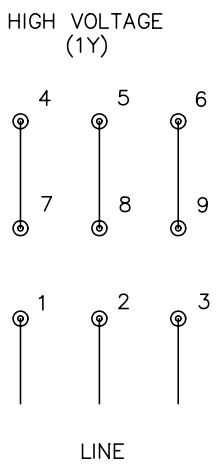
REV. LTR: C	VERSION: 02	TDR: 000000738205	
FILE: \AAA\00041\631		REVISED: 02:09:50 03/15/2012	VERT 56C TEFC 35M SUPER–E
MTL: –		BY: ENBENBO	SH 1 of 1

CD0005







NOTES:

1. INTERCHANGE ANY TWO LINE LEADS TO REVERSE ROTATION.
2. OPTIONAL THERMOSTATS ARE PROVIDED WHEN SPECIFIED.
3. ACTUAL NUMBER OF INTERNAL PARALLEL CIRCUITS MAY BE A MULTIPLE OF THOSE SHOWN ABOVE.
4. LEAD COLORS ARE OPTIONAL. LEADS MUST ALWAYS BE NUMBERED AS SHOWN.

CD0005

REV. DESC: REVISE TO SHOW OPTIONAL COLORS			BALDOR ELECTRIC Co.
REV. LTR: E	BY: JLP	REVISED: 01/19/99 10:15	TDR: 0171435
CD0005		FILE: AAA00005140	MDL: –
		MTL: –	3PH, DV, 9 LEADS

BALDOR • RELIANCE

Integral Horsepower
AC Induction Motors

Installation & Operating Manual

2/09 MN400

Table of Contents

Section 1
General Information

Overview This manual contains general procedures that apply to Baldor Motor products. Be sure to read and understand the Safety Notice statements in this manual. For your protection, do not install, operate or attempt to perform maintenance procedures until you understand the Warning and Caution statements.
A Warning statement indicates a possible unsafe condition that can cause harm to personnel.
A Caution statement indicates a condition that can cause damage to equipment.

Important: **This instruction manual is not intended to include a comprehensive listing of all details for all procedures required for installation, operation and maintenance. This manual describes general guidelines that apply to most of the motor products shipped by Baldor. If you have a question about a procedure or are uncertain about any detail, Do Not Proceed. Please contact your Baldor distributor for more information or clarification.**

Before you install, operate or perform maintenance, become familiar with the following:

- NEMA Publication MG-2, Safety Standard for Construction and guide for Selection, Installation and Use of Electric Motors and Generators.
- The National Electrical Code
- Local codes and Practices

Limited Warranty

www.baldor.com/support/warranty_standard.asp

Safety Notice: This equipment contains high voltage! Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt installation, operation and maintenance of electrical equipment.

Be sure that you are completely familiar with NEMA publication MG-2, safety standards for construction and guide for selection, installation and use of electric motors and generators, the National Electrical Code and local codes and practices. Unsafe installation or use can cause conditions that lead to serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

WARNING: **Disconnect all electrical power from the motor windings and accessory devices before disassembly of the motor. Electrical shock can cause serious or fatal injury.**

WARNING: **Be sure the system is properly grounded before applying power. Do not apply AC power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code and Local codes must be carefully followed.**

WARNING: **Avoid extended exposure to machinery with high noise levels. Be sure to wear ear protective devices to reduce harmful effects to your hearing.**

WARNING: **Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. When installing, protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.**

WARNING: **This equipment may be connected to other machinery that has rotating parts or parts that are driven by this equipment. Improper use can cause serious or fatal injury. Only qualified personnel should attempt to install operate or maintain this equipment.**

WARNING: **Do not by-pass or disable protective devices or safety guards. Safety features are designed to prevent damage to personnel or equipment. These devices can only provide protection if they remain operative.**

WARNING: **Avoid the use of automatic reset devices if the automatic restarting of equipment can be hazardous to personnel or equipment.**

WARNING: **Be sure the load is properly coupled to the motor shaft before applying power. The shaft key must be fully captive by the load device. Improper coupling can cause harm to personnel or equipment if the load decouples from the shaft during operation.**

WARNING: **Use proper care and procedures that are safe during handling, lifting, installing, operating and maintaining operations. Improper methods may cause muscle strain or other harm.**

WARNING: **Thermostat contacts automatically reset when the motor has slightly cooled down. To prevent injury or damage, the control circuit should be designed so that automatic starting of the motor is not possible when the thermostat resets.**

Safety Notice Continued

WARNING: **UL Listed motors must only be serviced by UL Approved Authorized Baldor Service Centers if these motors are to be returned to a hazardous and/or explosive atmosphere.**

WARNING: **Pacemaker danger – Magnetic and electromagnetic fields in the vicinity of current carrying carrying conductors and permanent magnet motors can result result in a serious health hazard to persons with cardiac pacemakers, metal implants, and hearing aids. To avoid risk, stay way from the area surrounding a permanent magnet motor.**

WARNING: **Before performing any motor maintenance procedure, be sure that the equipment connected to the motor shaft cannot cause shaft rotation. If the load can cause shaft rotation, disconnect the load from the motor shaft before maintenance is performed. Unexpected mechanical rotation of the motor parts can cause injury or motor damage.**

WARNING: **Use only UL/CSA listed explosion proof motors in the presence of flammable or combustible vapors or dust.**

WARNING: **Motors that are to be used in flammable and/or explosive atmospheres must display the UL label on the nameplate along with CSA listed logo. Specific service conditions for these motors are defined in NFPA 70 (NEC) Article 500.**

WARNING: **Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions, should be permanently guarded to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.**

Caution: **To prevent premature equipment failure or damage, only qualified maintenance personnel should perform maintenance.**

Caution: **Do not over–lubricate motor as this may cause premature bearing failure.**

Caution: **Do not over tension belts. Excess tension may damage the motor or driven equipment.**

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load (gears, pumps, compressors, or other driven equipment) from the motor shaft before lifting the motor.**

Caution: **If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20° angle from the shank of the eye bolt or lifting lug. Excessive lifting angles can cause damage.**

Caution: **To prevent equipment damage, be sure that the electrical service is not capable of delivering more than the maximum motor rated amps listed on the rating plate.**

Caution: **If a HI POT test (High Potential Insulation test) must be performed, follow the precautions and procedure in NEMA MG1 and MG2 standards to avoid equipment damage.**

If you have any questions or are uncertain about any statement or procedure, or if you require additional information please contact your Baldor distributor or an Authorized Baldor Service Center.

Receiving

Each Baldor Electric Motor is thoroughly tested at the factory and carefully packaged for shipment. When you receive your motor, there are several things you should do immediately.

1. Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered your motor.
2. Verify that the part number of the motor you received is the same as the part number listed on your purchase order.

Handling

The motor should be lifted using the lifting lugs or eye bolts provided.

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load (gears, pumps, compressors, or other driven equipment) from the motor shaft before lifting the motor.**

1. Use the lugs or eye bolts provided to lift the motor. Never attempt to lift the motor and additional equipment connected to the motor by this method. The lugs or eye bolts provided are designed to lift only the motor. Never lift the motor by the motor shaft or the hood of a WPII motor.
2. To avoid condensation inside the motor, do not unpack until the motor has reached room temperature. (Room temperature is the temperature of the room in which it will be installed). The packing provides insulation from temperature changes during transportation.
3. When lifting a WPII (Weather Proof Type 2) motor, do not lift the motor by inserting lifting lugs into holes on top of the cooling hood. These lugs are to be used for hood removal only. A spreader bar should be used to lift the motor by the cast lifting lugs located on the motor frame.

4. If the motor must be mounted to a plate with the driven equipment such as pump, compressor etc., it may not be possible to lift the motor alone. For this case, the assembly should be lifted by a sling around the mounting base. The entire assembly can be lifted as an assembly for installation.

   Do not lift the assembly using the motor lugs or eye bolts provided. Lugs or eye bolts are designed to lift motor only. If the load is unbalanced (as with couplings or additional attachments) additional slings or other means must be used to prevent tipping. In any event, the load must be secure before lifting. If the load is unbalanced (as with couplings or additional attachments) additional slings or other means must be used to prevent tipping. In any event, the load must be secure before lifting.

Storage

Storage requirements for motors and generators that will not be placed in service for at least six months from date of shipment.

Improper motor storage will result in seriously reduced reliability and failure. An electric motor that does not experience regular usage while being exposed to normally humid atmospheric conditions is likely to develop rust in the bearings or rust particles from surrounding surfaces may contaminate the bearings. The electrical insulation may absorb an excessive amount of moisture leading to the motor winding failure.

A wooden crate “shell” should be constructed to secure the motor during storage. This is similar to an export box but the sides & top must be secured to the wooden base with lag bolts (not nailed as export boxes are) to allow opening and reclosing many times without damage to the “shell”.

Minimum resistance of motor winding insulation is 5 Meg ohms or the calculated minimum, which ever is greater. Minimum resistance is calculated as follows: **Rm = kV + 1**

where: (Rm is minimum resistance to ground in Meg−Ohms and
kV is rated nameplate voltage defined as Kilo−Volts.)

Example: For a 480VAC rated motor Rm =1.48 meg−ohms (use 5 MΩ).
For a 4160VAC rated motor Rm = 5.16 meg−ohms.

Preparation for Storage

1. Some motors have a shipping brace attached to the shaft to prevent damage during transportation. The shipping brace, if provided, must be removed and stored for future use. The brace must be reinstalled to hold the shaft firmly in place against the bearing before the motor is moved.
2. Store in a clean, dry, protected warehouse where control is maintained as follows:
   a. Shock or vibration must not exceed 2 mils maximum at 60 hertz, to prevent the bearings from brinelling. If shock or vibration exceeds this limit vibration isolation pads must be used.
   b. Storage temperatures of 10°C (50°F) to 49°C (120°F) must be maintained.
   c. Relative humidity must not exceed 60%.
   d. Motor space heaters (when present) are to be connected and energized whenever there is a possibility that the storage ambient conditions will reach the dew point. Space heaters are optional.

   Note: Remove motor from containers when heaters are energized, reprotect if necessary.
3. Measure and record the resistance of the winding insulation (dielectric withstand) every 30 days of storage.
   a. If motor insulation resistance decreases below the minimum resistance, contact your Baldor District office.
   b. Place new desiccant inside the vapor bag and re−seal by taping it closed.
   c. If a zipper−closing type bag is used instead of the heat−sealed type bag, zip the bag closed instead of taping it. Be sure to place new desiccant inside bag after each monthly inspection.
   d. Place the shell over the motor and secure with lag bolts.
4. Where motors are mounted to machinery, the mounting must be such that the drains and breathers are fully operable and are at the lowest point of the motor. Vertical motors must be stored in the vertical position. Storage environment must be maintained as stated in step 2.

5. Motors with anti−friction bearings are to be greased at the time of going into extended storage with periodic service as follows:
   a. Motors marked “Do Not Lubricate” on the nameplate do not need to be greased before or during storage.
   b. Ball and roller bearing (anti−friction) motor shafts are to be rotated manually every 3 months and greased every 6 months in accordance with the Maintenance section of this manual.
   c. Sleeve bearing (oil lube) motors are drained of oil prior to shipment. The oil reservoirs must be refilled to the indicated level with the specified lubricant, (see Maintenance). The shaft should be rotated monthly by hand at least 10 to 15 revolutions to distribute oil to bearing surfaces.
   d. “Provisions for oil mist lubrication” − These motors are packed with grease. Storage procedures are the same as paragraph 5b.
   e. “Oil Mist Lubricated” − These bearings are protected for temporary storage by a corrosion inhibitor. If stored for greater than 3 months or outdoor storage is anticipated, connected to the oil mist system while in storage. If this is not possible, add the amount of grease indicated under “Standard Condition” in Section 3, then rotate the shaft 15 times by hand.
6. All breather drains are to be fully operable while in storage (drain plugs removed). The motors must be stored so that the drain is at the lowest point. All breathers and automatic “T” drains must be operable to allow breathing and draining at points other than through the bearings around the shaft. Vertical motors should be stored in a safe stable vertical position.
7. Coat all external machined surfaces with a rust preventing material. An acceptable product for this purpose is Exxon Rust Ban # 392.

Non−Regreaseable Motors

Non−regreasable motors with “Do Not Lubricate” on the nameplate should have the motor shaft rotated 15 times to redistribute the grease within the bearing every 3 months or more often.

All Other Motor Types

Before storage, the following procedure must be performed.

1. Remove the grease drain plug, if supplied, (opposite the grease fitting) on the bottom of each bracket prior to lubricating the motor.
2. The motor with regreasable bearing must be greased as instructed in Section 3 of this manual.
3. Replace the grease drain plug after greasing.
4. The motor shaft must be rotated a minimum of 15 times after greasing.
5. Motor Shafts are to be rotated at least 15 revolutions manually every 3 months and additional grease added every nine months (see Section 3) to each bearing.
6. Bearings are to be greased at the time of removal from storage.

Removal From Storage

1. Remove all packing material.
2. Measure and record the electrical resistance of the winding insulation resistance meter at the time of removal from storage. The insulation resistance must not be less than 50% from the initial reading recorded when the motor was placed into storage. A decrease in resistance indicates moisture in the windings and necessitates electrical or mechanical drying before the motor can be placed into service. If resistance is low, contact your Baldor District office.
3. Regrease the bearings as instructed in Section 3 of this manual.
4. Reinstall the original shipping brace if motor is to be moved. This will hold the shaft firmly against the bearing and prevent damage during movement.

Section 2
Installation & Operation

Overview Installation should conform to the National Electrical Code as well as local codes and practices. When other devices are coupled to the motor shaft, be sure to install protective devices to prevent future accidents. Some protective devices include, coupling, belt guard, chain guard, shaft covers etc. These protect against accidental contact with moving parts. Machinery that is accessible to personnel should provide further protection in the form of guard rails, screening, warning signs etc.

Location It is important that motors be installed in locations that are compatible with motor enclosure and ambient conditions. Improper selection of the motor enclosure and ambient conditions can lead to reduced operating life of the motor.

Proper ventilation for the motor must be provided. Obstructed airflow can lead to reduction of motor life.

1. **Open Drip−Proof/WPI** motors are intended for use indoors where atmosphere is relatively clean, dry, well ventilated and non−corrosive.
2. **Totally Enclosed and WPII** motors may be installed where dirt, moisture or dust are present and in outdoor locations.

Severe Duty, IEEE 841 and Washdown Duty enclosed motors are designed for installations with high corrosion or excessive moisture conditions. These motors should not be placed into an environment where there is the presence of flammable or combustible vapors, dust or any combustible material, unless specifically designed for this type of service.

Hazardous Locations are those where there is a risk of ignition or explosion due to the presence of combustible gases, vapors, dust, fibers, or flyings. Facilities requiring special equipment for hazardous locations are typically classified in accordance with local requirements. In the US market, guidance is provided by the National Electric Code.

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load (gears, pumps, compressors, or other driven equipment) from the motor shaft before lifting the motor.**

Mounting The motor must be securely installed to a rigid foundation or mounting surface to minimize vibration and maintain alignment between the motor and shaft load. Failure to provide a proper mounting surface may cause vibration, misalignment and bearing damage.

Foundation caps and sole plates are designed to act as spacers for the equipment they support. If these devices are used, be sure that they are evenly supported by the foundation or mounting surface.

After installation is complete and accurate alignment of the motor and load is accomplished, the base should be grouted to the foundation to maintain this alignment.

The standard motor base is designed for horizontal or vertical mounting. Adjustable or sliding rails are designed for horizontal mounting only. Consult your Baldor distributor or authorized Baldor Service Center for further information.

Alignment Accurate alignment of the motor with the driven equipment is extremely important. The pulley, sprocket, or gear used in the drive should be located on the shaft as close to the shaft shoulder as possible. It is recommended to heat the pulley, sprocket, or gear before installing on the motor shaft. Forcibly driving a unit on the motor shaft will damage the bearings.

1. **Direct Coupling**
   For direct drive, use flexible couplings if possible. Consult the drive or equipment manufacturer for more information. Mechanical vibration and roughness during operation may indicate poor alignment. Use dial indicators to check alignment. The space between coupling hubs should be maintained as recommended by the coupling manufacturer.
2. **End-Play Adjustment**
   The axial position of the motor frame with respect to its load is also extremely important. The motor bearings are not designed for excessive external axial thrust loads. Improper adjustment will cause failure.
3. **Pulley Ratio**
   The pulley ratio should not exceed 8:1.

Caution: **Do not over tension belts. Excess tension may damage the motor or driven equipment.**

4. **Belt Drive**
   Align sheaves carefully to minimize belt wear and axial bearing loads (see End-Play Adjustment). Belt tension should be sufficient to prevent belt slippage at rated speed and load. However, belt slippage may occur during starting.
5. Sleeve bearing motors are only suitable for coupled loads.

Doweling & Bolting After proper alignment is verified, dowel pins should be inserted through the motor feet into the foundation. This will maintain the correct motor position should motor removal be required. (Baldor motors are designed for doweling.)

1. Drill dowel holes in diagonally opposite motor feet in the locations provided.
2. Drill corresponding holes in the foundation.
3. Ream all holes.
4. Install proper fitting dowels.
5. Mounting bolts must be carefully tightened to prevent changes in alignment. Use a flat washer and lock washer under each nut or bolt head to hold the motor feet secure. Flanged nuts or bolts may be used as an alternative to washers.

WARNING: Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions, should be permanently guarded to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.

Guarding Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions. This is particularly important where the parts have surface irregularities such as keys, key ways or set screws. Some satisfactory methods of guarding are:

1. Covering the machine and associated rotating parts with structural or decorative parts of the driven equipment.
2. Providing covers for the rotating parts. Covers should be sufficiently rigid to maintain adequate guarding during normal service.

Power Connection Motor and control wiring, overload protection, disconnects, accessories and grounding should conform to the National Electrical Code and local codes and practices. Flying leads must be insulated with two full wraps of electrical grade insulating tape or heat shrink tubing.

Conduit Box For ease of making connections, an oversize conduit box is provided.
The box can be rotated 360° in 90° increments.
Auxiliary conduit boxes are provided on some motors for accessories such as space heaters, RTD's etc.

AC Power Connect the motor leads as shown on the connection diagram located on the name plate or inside the cover on the conduit box. Be sure the following guidelines are met:

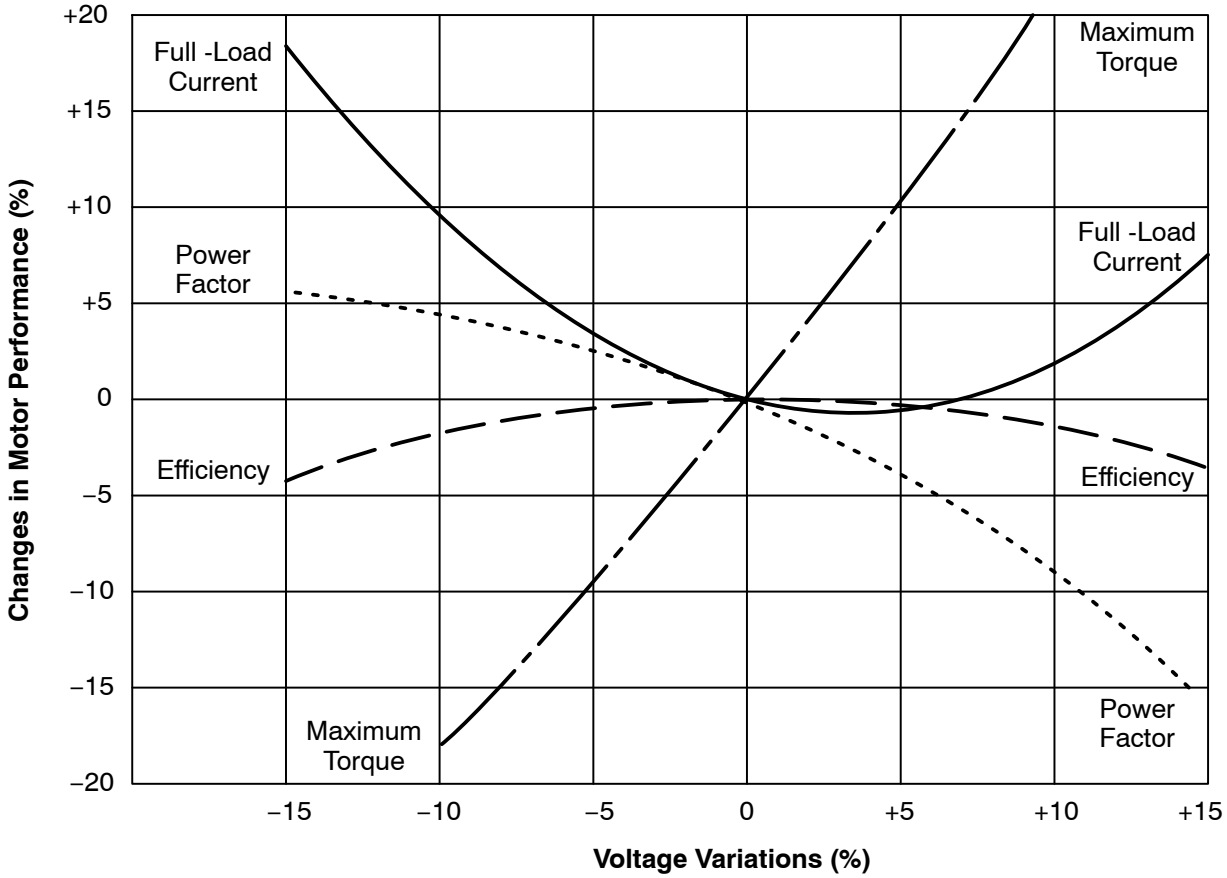
1. AC power is within ±10% of rated voltage with rated frequency. (See motor name plate for ratings).
   OR
2. AC power is within ±5% of rated frequency with rated voltage.
   OR
3. A combined variation in voltage and frequency of ±10% (sum of absolute values) of rated values, provided the frequency variation does not exceed ±5% of rated frequency.

Performance within these voltage and frequency variations are shown in Figure 2-2.

Figure 2-1 Accessory Connections

HEATERS H1 — H2 H1 — H2	One heater is installed in each end of motor. Leads for each heater are labeled H1 & H2. (Like numbers should be tied together).
THERMISTORS T1 — T2	Three thermistors are installed in windings and tied in series. Leads are labeled T1 & T2.
WINDING RTDS RED RED WHITE	Winding RTDs are installed in windings (2) per phase. Each set of leads is labeled W1, W2, W3, W4, W5, & W6.
BEARING RTD RED RED WHITE	* One bearing RTD is installed in Drive endplate (PUEP), leads are labeled RTDDE. * One bearing RTD is installed in Opposite Drive endplate (FREP), leads are labeled RTDODE. * Note RTD may have 2–Red/1–White leads; or 2–White/1–Red Lead.

Figure 2-2 Typical Motor Performance VS Voltage Variations



Rotation All three phase motors are reversible. To reverse the direction of rotation, disconnect and lock out power and interchange any two of the three line leads for three phase motors. For single phase motors, check the connection diagram to determine if the motor is reversible and follow the connection instructions for lead numbers to be interchanged. Not all single phase motors are reversible.

Adjustable Frequency Power Inverters used to supply adjustable frequency power to induction motors produce wave forms with lower order harmonics with voltage spikes superimposed. Turn−to−turn, phase−to−phase, and ground insulation of stator windings are subject to the resulting dielectric stresses. Suitable precautions should be taken in the design of these drive systems to minimize the magnitude of these voltage spikes. Consult the drive instructions for maximum acceptable motor lead lengths, and proper grounding.

First Time Start Up Be sure that all power to motor and accessories is off. Be sure the motor shaft is disconnected from the load and will not cause mechanical rotation of the motor shaft.

1. Make sure that the mechanical installation is secure. All bolts and nuts are tightened etc.
2. If motor has been in storage or idle for some time, check winding insulation integrity.
3. Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity.
4. Be sure all shipping materials and braces (if used) are removed from motor shaft.
5. Manually rotate the motor shaft to ensure that it rotates freely.
6. Replace all panels and covers that were removed during installation.
7. Momentarily apply power and check the direction of rotation of the motor shaft.
8. If motor rotation is wrong, be sure power is off and change the motor lead connections. Verify rotation direction before you continue.
9. Start the motor and ensure operation is smooth without excessive vibration or noise. If so, run the motor for 1 hour with no load connected.
10. After 1 hour of operation, disconnect power and connect the load to the motor shaft. Verify all coupling guards and protective devices are installed. Ensure motor is properly ventilated.

Coupled Start Up This procedure assumes a coupled start up. Also, that the first time start up procedure was successful.

1. Check the coupling and ensure that all guards and protective devices are installed.
2. Check that the coupling is properly aligned and not binding.
3. The first coupled start up should be with no load. Apply power and verify that the load is not transmitting excessive vibration back to the motor though the coupling or the foundation. Vibration should be at an acceptable level.
4. Run for approximately 1 hour with the driven equipment in an unloaded condition.

The equipment can now be loaded and operated within specified limits. Do not exceed the name plate ratings for amperes for steady continuous loads.

Jogging and Repeated Starts Repeated starts and/or jogs of induction motors generally reduce the life of the motor winding insulation. A much greater amount of heat is produced by each acceleration or jog than by the same motor under full load. If it is necessary to repeatedly start or jog the motor, it is advisable to check the application with your local Baldor distributor or Baldor Service Center.

Heating - Duty rating and maximum ambient temperature are stated on the motor name plate. Do not exceed these values. If there is any question regarding safe operation, contact your local Baldor District Office or Baldor Service Center.

Section 3
Maintenance & Troubleshooting

WARNING: UL Listed motors must only be serviced by UL Approved Authorized Baldor Service Centers if these motors are to be returned to a hazardous and/or explosive atmosphere.

General Inspection Inspect the motor at regular intervals, approximately every 500 hours of operation or every 3 months, whichever occurs first. Keep the motor clean and the ventilation openings clear. The following steps should be performed at each inspection:

WARNING: Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

1. Check that the motor is clean. Check that the interior and exterior of the motor is free of dirt, oil, grease, water, etc. Oily vapor, paper pulp, textile lint, etc. can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
2. Use a “Megger” periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance.
3. Check all electrical connectors to be sure that they are tight.

Relubrication & Bearings Bearing grease will lose its lubricating ability over time, not suddenly. The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions. Good results can be obtained if the following recommendations are used in your maintenance program.

Type of Grease A high grade ball or roller bearing grease should be used. Recommended grease for standard service conditions is **Polyrex EM (Mobil)**. Do not mix greases unless compatibility has been checked and verified.

Equivalent and compatible greases include:
Texaco Polystar, Rykon Premium #2, Pennzoil Pen 2 Lube and Chevron SRI.

Relubrication Intervals Recommended relubrication intervals are shown in Table 3-1. It is important to realize that the recommended intervals of Table 3-1 are based on average use.

Refer to additional information contained in Tables 3-2, 3-3 and 3-4.

Table 3-1 Relubrication Intervals *

NEMA / (IEC) Frame Size	Rated Speed - RPM					
	10000	6000	3600	1800	1200	900
Up to 210 incl. (132)	**	2700 Hrs.	5500 Hrs.	12000 Hrs.	18000 Hrs.	22000 Hrs.
Over 210 to 280 incl. (180)		**	3600 Hrs.	9500 Hrs.	15000 Hrs.	18000 Hrs.
Over 280 to 360 incl. (225)		**	* 2200 Hrs.	7400 Hrs.	12000 Hrs.	15000 Hrs.
Over 360 to 5800 incl. (300)		**	*2200 Hrs.	3500 Hrs.	7400 Hrs.	10500 Hrs.

* Relubrication intervals are for ball bearings.
For vertically mounted motors and roller bearings, divide the relubrication interval by 2.

** For motors operating at speeds greater than 3600 RPM, contact Baldor for relubrication recommendations.

Table 3-2 Service Conditions

Severity of Service	Hours per day of Operation	Ambient Temperature Maximum	Atmospheric Contamination
Standard	8	40° C	Clean, Little Corrosion
Severe	16 Plus	50° C	Moderate dirt, Corrosion
Extreme	16 Plus	>50° C* or Class H Insulation	Severe dirt, Abrasive dust, Corrosion, Heavy Shock or Vibration
Low Temperature		<–29° C **	

* Special high temperature grease is recommended (Dow Corning DC44). Note that Dow Corning DC44 grease does not mix with other grease types. Thoroughly clean bearing & cavity before adding grease.

** Special low temperature grease is recommended (Aeroshell 7).

Table 3-3 Relubrication Interval Multiplier

Severity of Service	Multiplier
Standard	1.0
Severe	0.5
Extreme	0.1
Low Temperature	1.0

Some motor designs use different bearings on each motor end. This is normally indicated on the motor nameplate. In this case, the larger bearing is installed on the motor Drive endplate. For best relubrication results, only use the appropriate amount of grease for each bearing size (not the same for both).

Table 3-4 Bearings Sizes and Types

Frame Size NEMA (IEC)	Bearing Description (These are the "Large" bearings (Shaft End) in each frame size)			
	Bearing	Weight of Grease to add * oz (Grams)	Volume of grease to be added	
			in^3	teaspoon
56 to 140 (90)	6203	0.08 (2.4)	0.15	0.5
140 (90)	6205	0.15 (3.9)	0.2	0.8
180 (100–112)	6206	0.19 (5.0)	0.3	1.0
210 (132)	6307	0.30 (8.4)	0.6	2.0
250 (160)	6309	0.47 (12.5)	0.7	2.5
280 (180)	6311	0.61 (17)	1.2	3.9
320 (200)	6312	0.76 (20.1)	1.2	4.0
360 (225)	6313	0.81 (23)	1.5	5.2
400 (250)	6316	1.25 (33)	2.0	6.6
440 (280)	6319	2.12 (60)	4.1	13.4
5000 to 5800 (315–450)	6328	4.70 (130)	9.2	30.0
5000 to 5800 (315–450)	NU328	4.70 (130)	9.2	30.0
360 to 449 (225–280)	NU319	2.12 (60)	4.1	13.4
AC Induction Servo				
76 Frame 180 (112)	6207	0.22 (6.1)	0.44	1.4
77 Frame 210 (132)	6210	0.32 (9.0)	0.64	2.1
80 Frame 250(160)	6213	0.49 (14.0)	0.99	3.3

* Weight in grams = .005 DB of grease to be added

Note: Not all bearing sizes are listed. For intermediate bearing sizes, use the grease volume for the next larger size bearing.

Caution: To avoid damage to motor bearings, grease must be kept free of dirt. For an extremely dirty environment, contact your Baldor distributor or an authorized Baldor Service Center for additional information.

Relubrication Procedure Be sure that the grease you are adding to the motor is compatible with the grease already in the motor. Consult your Baldor distributor or an authorized service center if a grease other than the recommended type is to be used.

Caution: Do not over−lubricate motor as this may cause premature bearing failure.

With Grease Outlet Plug

1. With the motor stopped, clean all grease fittings with a clean cloth.
2. Remove grease outlet plug.

Caution: Over−lubricating can cause excessive bearing temperatures, premature lubrication breakdown and bearing failure.

3. Add the recommended amount of grease.
4. Operate the motor for 15 minutes with grease plug removed. This allows excess grease to purge.
5. Re-install grease outlet plug.

Without Grease Provisions

Note: Only a Baldor authorized and UL or CSA certified service center can disassemble a UL/CSA listed explosion proof motor to maintain it's UL/CSA listing.

1. Disassemble the motor.
2. Add recommended amount of grease to bearing and bearing cavity. (Bearing should be about 1/3 full of grease and outboard bearing cavity should be about 1/2 full of grease.)
3. Assemble the motor.

Sample Relubrication Determination

Assume - NEMA 286T (IEC 180), 1750 RPM motor driving an exhaust fan in an ambient temperature of 43° C and the atmosphere is moderately corrosive.

1. Table 3-1 list 9500 hours for standard conditions.
2. Table 3-2 classifies severity of service as "Severe".
3. Table 3-4 shows that 1.2 in^3 or 3.9 teaspoon of grease is to be added.

Note: Smaller bearings in size category may require reduced amounts of grease.

Table 3-5 Troubleshooting Chart

Symptom	Possible Causes	Possible Solutions
Motor will not start	Usually caused by line trouble, such as, single phasing at the starter.	Check source of power. Check overloads, fuses, controls, etc.
Excessive humming	High Voltage.	Check input line connections.
	Eccentric air gap.	Have motor serviced at local Baldor service center.
Motor Over Heating	Overload. Compare actual amps (measured) with nameplate rating.	Locate and remove source of excessive friction in motor or load. Reduce load or replace with motor of greater capacity.
	Single Phasing.	Check current at all phases (should be approximately equal) to isolate and correct the problem.
	Improper ventilation.	Check external cooling fan to be sure air is moving properly across cooling fins. Excessive dirt build-up on motor. Clean motor.
	Unbalanced voltage.	Check voltage at all phases (should be approximately equal) to isolate and correct the problem.
	Rotor rubbing on stator.	Check air gap clearance and bearings.
		Tighten “Thru Bolts”.
	Over voltage or under voltage.	Check input voltage at each phase to motor.
	Open stator winding.	Check stator resistance at all three phases for balance.
	Grounded winding.	Perform dielectric test and repair as required.
	Improper connections.	Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity. Refer to motor lead connection diagram.
Bearing Over Heating	Misalignment.	Check and align motor and driven equipment.
	Excessive belt tension.	Reduce belt tension to proper point for load.
	Excessive end thrust.	Reduce the end thrust from driven machine.
	Excessive grease in bearing.	Remove grease until cavity is approximately $^3/_4$ filled.
	Insufficient grease in bearing.	Add grease until cavity is approximately $^3/_4$ filled.
	Dirt in bearing.	Clean bearing cavity and bearing. Repack with correct grease until cavity is approximately $^3/_4$ filled.
Vibration	Misalignment.	Check and align motor and driven equipment.
	Rubbing between rotating parts and stationary parts.	Isolate and eliminate cause of rubbing.
	Rotor out of balance.	Have rotor balance checked are repaired at your Baldor Service Center.
	Resonance.	Tune system or contact your Baldor Service Center for assistance.
Noise	Foreign material in air gap or ventilation openings.	Remove rotor and foreign material. Reinstall rotor. Check insulation integrity. Clean ventilation openings.
Growling or whining	Bad bearing.	Replace bearing. Clean all grease from cavity and new bearing. Repack with correct grease until cavity is approximately $^3/_4$ filled.

Suggested bearing and winding RTD setting guidelines

Most large frame AC Baldor motors with a 1.15 service factor are designed to operate below a Class B (80°C) temperature rise at rated load and are built with a Class H winding insulation system. Based on this low temperature rise, RTD (Resistance Temperature Detectors) settings for Class B rise should be used as a starting point. Some motors with 1.0 service factor have Class F temperature rise.

The following tables show the suggested alarm and trip settings for RTDs. Proper bearing and winding RTD alarm and trip settings should be selected based on these tables unless otherwise specified for specific applications.

If the driven load is found to operate well below the initial temperature settings under normal conditions, the alarm and trip settings may be reduced so that an abnormal machine load will be identified.

The temperature limits are based on the installation of the winding RTDs imbedded in the winding as specified by NEMA. Bearing RTDs should be installed so they are in contact with the outer race on ball or roller bearings or in direct contact with the sleeve bearing shell.

Winding RTDs – Temperature Limit In °C (40°C Maximum Ambient)

Motor Load	Class B Temp Rise ≤ 80°C (Typical Design)		Class F Temp Rise ≤ 105°C		Class H Temp Rise ≤ 125°C	
	Alarm	Trip	Alarm	Trip	Alarm	Trip
≤ Rated Load	130	140	155	165	175	185
Rated Load to 1.15 S.F.	140	150	160	165	180	185

Note: • Winding RTDs are factory production installed, not from Mod–Express.
• When Class H temperatures are used, consider bearing temperatures and relubrication requirements.

Bearing RTDs – Temperature Limit In °C (40°C Maximum Ambient)

Bearing Type Oil or Grease	Anti–Friction		Sleeve	
	Alarm	Trip	Alarm	Trip
Standard*	95	100	85	95
High Temperature**	110	115	105	110

Note: * Bearing temperature limits are for standard design motors operating at Class B temperature rise.
** High temperature lubricants include some special synthetic oils and greases.

Greases that may be substituted that are compatible with Polyrex EM (but considered as “standard” lubricants) include the following:

- Texaco Polystar
- Mobilith SHC–100
- Darmex 707
- Rykon Premium #2
- Pennzoil Pennzlube EM–2
- Darmex 711
- Chevron SRI #2
- Chevron Black Pearl
- Petro–Canada Peerless LLG

See the motor nameplate for replacement grease or oil recommendation.
Contact Baldor application engineering for special lubricants or further clarifications.

Baldor District Offices

UNITED STATES

ARIZONA

PHOENIX
4211 S 43RD PLACE
PHOENIX, AZ 85040
PHONE: 602-470-0407
FAX: 602-470-0464

ARKANSAS

CLARKSVILLE
1001 COLLEGE AVE.
CLARKSVILLE, AR 72830
PHONE: 479-754-9108
FAX: 479-754-9205

CALIFORNIA

LOS ANGELES
6480 FLOTILLA
COMMERCE, CA 90040
PHONE: 323-724-6771
FAX: 323-721-5859

HAYWARD
21056 FORBES STREET
HAYWARD, CA 94545
PHONE: 510-785-9900
FAX: 510-785-9910

COLORADO

DENVER
3855 FOREST STREET
DENVER, CO 80207
PHONE: 303-623-0127
FAX: 303-595-3772

9980 PARK MEADOWS DRIVE
SUITE 214
LONE TREE, CO 80124-6739
PHONE: 303-339-9629
FAX: 303-339-9633

CONNECTICUT

WALLINGFORD
65 SOUTH TURNPIKE ROAD
WALLINGFORD, CT 06492
PHONE: 203-269-1354
FAX: 203-269-5485

FLORIDA

TAMPA/PUERTO RICO/
VIRGIN ISLANDS
3906 EAST 11TH AVENUE
TAMPA, FL 33605
PHONE: 813-248-5078
FAX: 813-247-2984

GEORGIA

ATLANTA
62 TECHNOLOGY DR.
ALPHARETTA, GA 30005
PHONE: 770-772-7000
FAX: 770-772-7200

5490 MCGINNIS FERRY PLACE
SUITE 133
ALPHARETTA, GA 30005
PHONE: 770-752-4254
FAX: 770-752-4257

ILLINOIS

CHICAGO
4 SAMMONS COURT
BOLINGBROOK, IL 60440
PHONE: 630-296-1400
FAX: 630-226-9420

INDIANA

COLUMBUS
3300 TENTH ST
COLUMBUS, IN 47201
PHONE: 812-378-2556
FAX: 812-378-2555

INDIANAPOLIS
5525 W. MINNESOTA STREET
INDIANAPOLIS, IN 46241
PHONE: 317-246-5100
FAX: 317-246-5110

IOWA

DES MOINES
1800 DIXON STREET, SUITE C
DES MOINES, IA 50316
PHONE: 515-263-6929
FAX: 515-263-6515

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LAWRENCE, KS 66049
PHONE: 785-749-4339
FAX: 785-749-4217

MARYLAND

BALTIMORE
6660 SANTA BARBARA RD.
SUITE 22-24
ELKRIDGE, MD 21075
PHONE: 410-579-2135
FAX: 410-579-2677

MASSACHUSETTS

BOSTON
6 PULLMAN STREET
WORCESTER, MA 01606
PHONE: 508-854-0708
FAX: 508-854-0291

MICHIGAN

DETROIT
33782 STERLING PONDS BLVD.
STERLING HEIGHTS, MI 48312
PHONE: 586-978-9800
FAX: 586-978-9969

GRAND RAPIDS
668 THREE MILE ROAD NW
GRAND RAPIDS, MI 49504
PHONE: 616-785-1784
FAX: 616-785-1788

MINNESOTA

MINNEAPOLIS
21080 134TH AVE. NORTH
ROGERS, MN 55374
PHONE: 763-428-3633
FAX: 763-428-4551

MISSOURI

ST LOUIS
422 INDUSTRIAL DRIVE
MARYLAND HEIGHTS, MO 63043
PHONE: 314-298-1800
FAX: 314-298-7660

KANSAS CITY
1501 BEDFORD AVENUE
NORTH KANSAS CITY, MO 64116
PHONE: 816-587-0272
FAX: 816-587-3735

NEW YORK

AUBURN
ONE ELLIS DRIVE
AUBURN, NY 13021
PHONE: 315-255-3403
FAX: 315-253-9923

NORTH CAROLINA

GREENSBORO
1220 ROTHERWOOD ROAD
GREENSBORO, NC 27406
PHONE: 336-272-6104
FAX: 336-273-6628

OHIO

CINCINNATI
2929 CRESCENTVILLE ROAD
WEST CHESTER, OH 45069
PHONE: 513-771-2600
FAX: 513-772-2219

CLEVELAND
8929 FREEWAY DRIVE
MACEDONIA, OH 44056
PHONE: 330-468-4777
FAX: 330-468-4778

29525 CHAGRIN BLVD SUITE 208
CLEVELAND, OH 44122
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FAX: 216-360-4172

OKLAHOMA

TULSA
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BIXBY, OK 74008
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FAX: 918-366-9338

OREGON

PORTLAND
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TUALATIN, OR 97062
PHONE: 503-691-9010
FAX: 503-691-9012

PENNSYLVANIA

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KING OF PRUSSIA, PA 19406
PHONE: 610-768-8018
FAX: 215-672-5759

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MEMORIAL HIGHWAY
PENNSAUKEN, NJ 08110
PHONE: 856-661-1442
FAX: 856-663-6363

PITTSBURGH
159 PROMINENCE DRIVE
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PHONE: 724-889-0092
FAX: 724-889-0094

TENNESSEE

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FAX: 901-365-3914

TEXAS

ADDISON
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ADDISON, TX 75001
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FAX: 972-242-1505

DALLAS
3040 QUEBEC
DALLAS, TX 75247
PHONE: 214-634-7271
FAX: 214-634-8874

HOUSTON
4647 PINE TIMBERS
SUITE # 135
HOUSTON, TX 77041
PHONE: 713-895-7062
FAX: 713-690-4540

UTAH

SALT LAKE CITY
2230 SOUTH MAIN STREET
SALT LAKE CITY, UT 84115
PHONE: 801-832-0127
FAX: 801-832-8911

VIRGINIA

RICHMOND
6767 FOREST HILL AVE STE 305
RICHMOND, VA 23225
PHONE: 804-545-6848
FAX: 804-545-6840

WASHINGTON

KIRKLAND, WA
550 KIRKLAND WAY STE 205
KIRKLAND, WA 98033
PHONE: 425-952-5000
FAX: 775-255-8019

WISCONSIN

MILWAUKEE
2725 SOUTH 163RD STREET
NEW BERLIN, WI 53151
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FAX: 262-784-1215

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WAUKESHA, WI 53188
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FAX: 262-437-0258

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FAX: 479-648-5895

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FAX: 780-438-2600

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EDMONTON, ALBERTA T5M 3T9
PHONE: 780-822-7865
FAX: 780-822-7878

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MISSISSAUGA, ONTARIO L4Z 1S6
PHONE: 905-890-5110
FAX: 905-890-5540

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OAKVILLE, ONTARIO L6H 6R1
PHONE: 905-829-3301
FAX: 905-829-3302

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FAX: 514-422-8982

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MONTREAL, QUEBEC H3J 1R5
PHONE: 514-933-2711
FAX: 514-933-8639

VANCOUVER,
BRITISH COLUMBIA
1538 KEBET WAY
PORT COQUITLAM,
BRITISH COLUMBIA V3C 5M5
PHONE 604-421-2822
FAX: 604-421-3113

WINNIPEG, MANITOBA
54 PRINCESS STREET
WINNIPEG, MANITOBA R3B 1K2
PHONE: 204-942-5205
FAX: 204-956-4251

AUSTRALIA

UNIT 3, 6 STANTON ROAD
SEVEN HILLS, NSW 2147, AUSTRALIA
PHONE: (61) (2) 9674 5455
FAX: (61) (2) 9674 2495

UNIT 8, 5 KELLETTS ROAD
ROWVILLE, VICTORIA, 3178
AUSTRALIA
PHONE: (61) (3) 9753 4355
FAX: (61) (3) 9753 4366

EL SALVADOR

RESIDENCIAL PINARES DE SUIZA
POL. 15 #44,
NVA. SAN SALVADOR, EL SALVADOR
PHONE: +503 2288-1519
FAX: +503 2288-1518

CHILE

LUIS THAYER OJEDA 166,
OF 402 – PROVIDENCIA
SANTIAGO, CHILE
PHONE: 56-2-290-0762
FAX: 56-2-290-0762

CHINA

5299 BEI SONG ROAD
SONGJIANG
201611 SHANGHAI, CHINA
PHONE: +86 21 5760 5335
FAX : +86 21 5760 5336

UNIT 905, 9TH FLOOR,
TOWER B WANDA PLAZA
NO. 93 JIANGUO ROAD,
CHAOYANG DISTRICT
BEIJING, 100022, CHINA
PHONE +86 (010) 58205516
FAX +86 (010) 58204231

GERMANY

DIESELSTRASSE 22
D-85551 KIRCHHEIM
MUNICH, GERMANY
PHONE: +49 89 90 5080
FAX: +49 89 90 50 8492

HERMANN-HEINRICH-GOSSEN-
STRASSE 3
D-50858 KÖLN, GERMANY
PHONE: 49 2234 37941 0
FAX: 49 2234 37941 64

INDIA

14, COMMERCE AVENUE
MAHAGANESH COLONY
PAUD ROAD
PUNE – 411038
MAHARASHTRA, INDIA
PHONE: 91 20 25452717, 25452718
FAX: 91 20 25452719

ITALY

BALDOR ASR AG
SUCCURSALE DI MENDRISIO
VIA BORROMINI, 20A
CH-6850 MENDRISIO
SWITZERLAND
PHONE: 0041 91 640 99 50
FAX: 0041 91 630 26 33

JAPAN

DIA BLDG 802,
2-21-1 TSURUYA-CHO,
KANAGAWA-KU
YOKOHAMA, 221-0835, JAPAN
PHONE: 81-45-412-4506
FAX: 81-45-412-4507

KOREA

RM 1715, SUSEO TOWER, 725,
SUSEO-DONG, GANGNAM-GU,
SEOUL 135-757 KOREA
TEL : (82) 2 2226 9369
FAX : (82) 2 2226 9368

MEXICO

LEON, GUANAJUATO
KM. 2.0 BLVD. AEROPUERTO
LEÓN 37545, GUANAJUATO, MÉXICO
PHONE: 52 477 761 2030
FAX: 52 477 761 2010

MIDDLE EAST & NORTH AFRICA

VSE INTERNATIONAL CORP.
P. O. BOX 5618
BUFFALO GROVE, IL 60089-5618
PHONE: 847 590 5547
FAX: 847 590 5587

SINGAPORE

18, KAKI BUKIT ROAD 3
#03-09 ENTREPRENEUR
BUSINESS CENTRE
SINGAPORE 415978
PHONE: (65) 6744 2572
FAX: (65) 6747 1708

PANAMA

AVE. RICARDO J. ALFARO
EDIFICIO SUN TOWERS MALL
PISO 2, LOCAL 55
CIUDAD DE PANAMÁ, PANAMÁ
PHONE: +507 236-5155
FAX: +507 261-5355

SWITZERLAND

POSTFACH 73
SCHUTZENSTRASSE 59
CH-8245 FEUERTHALEN
SWITZERLAND
PHONE: +41 52 647 4700
FAX: +41 52 659 2394

TAIWAN

1F, NO 126 WENSHAN 3RD STREET,
NANTUN DISTRICT,
TAICHUNG CITY 408
TAIWAN R.O.C
PHONE: (886) 4 238 04235
FAX: (886) 4 238 04463

UNITED KINGDOM

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BRISTOL BS32 0BF U.K.
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FAX: +44 1454 859001

VENEZUELA

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CALIFORNIA NORTE
CARACAS, 1070 VENEZUELA
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FAX: 58-412-322-5790

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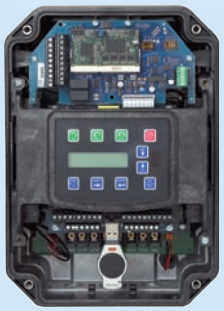
THE TOUGHEST AC DRIVES ON THE PLANET!

The Vacon X4 and X5 AC Drives are designed for REAL world that is not gentle or forgiving to electronic products. They have been designed to keep driving in harsh environments and are built from the ground up to survive hostile conditions and still be simple to use. They are built to be mounted where the work is, not hidden in another enclosure or room that adds costs and space.

The same enclosures that can survive in the harsh industrial world makes them ideal when cleanliness is extremely important, such as the Food and Beverage industry where high pressure washings are needed on a regular basis. The Vacon X4 and X5 drives, through 100 HP, exceed the specifications of their rated NEMA 4X / IP66 Indoor and Outdoor Use enclosures. AND all models up through 30 HP can withstand high pressure washdown of 1,000 PSI at 6 inches!

The Vacon X Series drives have the brains to go with their brawn. All models are packed with advanced control and operation features that make them the best choice for everything from simple, stand-alone applications to advanced system-level controls.

The Vacon X Series drives also boast the easiest programming and operation in the industry. The bright, clear, backlit display provides an easy to read and customizable view for operation and programming. The Vacon X Series keypad has large, well marked buttons to control all aspects of the drive operation and programming.



The Vacon X4 has the toughness and features to handle most industrial jobs with ease. If the application is more unique, the X5 accepts option boards, and has a USB interface, fully coated PC boards for added protection and other advanced features such as a real-time-clock.

A tough enclosure, an easy to read display, simple programming and the confidence of knowing you can mount the drive almost anywhere make the Vacon X4 and Vacon X5 drives the only choice.

Toughest packaging

- NEMA 4X / IP66 Indoor and Outdoor Use enclosures through 100 HP; NEMA 12 / IP55 for 125 HP and above
- Withstands 1,000 PSI washdown at 6 inches on models though 30 HP
- Thick injected foam and metal covers protect against bumps and misuse
- Mounts close to the motor to eliminate long motor lead problems

Easiest to use

- Simple intuitive programming
- Multi-language display – no codes to learn
- Wireless programming using PDA-trAC+® for Windows Mobile 5®
- Application Marcos make set-up a breeze

Most versatile

- Operate form keypad, remote signals, computers or any combination
- Mount them where you use them
- Built-in 9-step PLC functions (25-step with X5)
- ARCTIC Mode maintains safe operating temperature in cold locations

SIMPLE TO OPERATE

Basic operations are a breeze with Vacon's enhanced keypad. The familiar design uses color-coded buttons with text and symbols, remains easy-to-use and understand, yet offers an unprecedented breadth of functionality. With a few simple touch commands, operators have access to parameters for configuration, start-up, operation and troubleshooting.

- Run set-up macros for fan, pump, or sensorless vector applications with real time clock capabilities. Collect real time data and event logs using a choice of communication protocols or through the standard USB port.

- Expand the basic operations with predefined macro commands that simplify common application set ups. One-touch menu selection collects the most frequently used parameters and presets them with common application settings. Collect real time data and event logs using a choice of communication protocols or through standard USB port.

Vacon's user-friendly keypad makes operation simple. The easy-to-read display communicates status information.

PDA-trAC+® software allows Pocket PC devices with infra-red networking capabilities to be used for accurate product configuration. No more need for special cables, adapters or opening enclosures to change a setting! Download your free copy from our web site: www.vacon.com

- The user-connection terminal strip handles common jobs with ease while providing application flexibility with extra inputs and relays not found on other drives.
- Standard "Built-In" Dynamic Braking Resistors virtually eliminate nuisance trips, providing more uptime.
- 60:1 constant torque turn down ratio provides low speed performance when you need it. Optional performance with enhanced turndown ratio using encoder feedback option.

ADVANCED VACON X5 FEATURES

USB FUNCTIONS

- Parameter Save / Recall
- Save parameter set to USB stick and upload to another drive
- Stored data easily opened with Microsoft Excel
- Ability to define custom file name (numbers or text)
- Easy firmware upgrades using standard USB memory stick

REAL TIME CLOCK FUNCTION

- Control operation based on time-of-day. Separate weekday and weekend settings available
- Fault Information — real time data is stored with all faults
- Signals an event via text on the display or contact closure, independent of drive operation
- Keeper Function — logs time-based data from external or internal signals
- Data read via serial communication or transferred to USB Memory Stick

PROGRAM SEQUENCER ENHANCEMENTS

- Improved functionality is closer to traditional PLC than available with current X4
- New loop and branch capabilities available
- Real Time Clock — time-of-day (TOD) enable function, allows programmed operation to specific periods of the day or week

OPTIONS

The ability to accept option boards enhances the Vacon X5's application flexibility.

Current options afford Vacon X5 Profibus with the opportunity to communicate on powerful serial communication networks like DeviceNet, Ethernet IP, Profibus and Modbus TCP/IP. An additional option affords the opportunity to interface a shaft mounted optical encoder to the Vacon X5 for improved performance. All options include five (5) channels of 115Vac control options.

Remote IP66-rated keypad are also available for both the Vacon X4 and X5 drives.

APPLICATIONS

Municipal Water Supply Application — User needs to gather information on a scheduled basis of the amount of water that is pumped out of a municipal well. The readings must be gathered weekly and be in thousands of gallons per day. The Keeper function can gather this automatically and the operator only needs to download once a week. The information is in CSV format that will open in Excel with defined headers.

Unattended Operation — Energy savings add up every day with Vacon X5's time-of-day functionality providing automated startup of critical operating systems. Prior to the arrival of the production team, each morning the dust collector, cooling fans and even the lights in a foundry all start-up to full operating status without the need for human intervention. At the end of the day, no one needs to remember to shut these systems down. The Vacon X5 takes care watching the clock for you. Saving energy is just one of the benefits delivered by the Vacon X5.

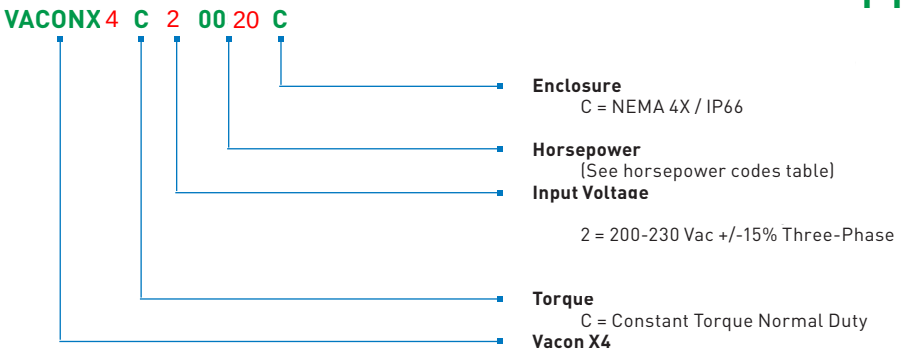
PRODUCT RANGE

VACON X Series 200-230 Vac 3-ph, NEMA 4X/IP66 Indoor and Outdoor, EMC Class C4

Product Code		Motor Shaft Power and Current							Frame	Option Board
Vacon X4		Heavy Duty (150%)			Normal Duty (120%)			OL Amps (1 Min/10 Min)	Size	(Y/N)
		HP	kW	Amps	HP	kW	Amps			

VACONX4C20020C		1	0.75	4.2	2	1.5	6.8	8.2	F0	N

TYPE DESIGNATION CODE



VACON X4 AND VACON X5 SPECIFICATIONS

Environmental	Operating temperature	-10°C to +40°C (14°F to 104°F)			
	Storage temperature	-20°C to 65°C (-4°F to 149°F)			
	Humidity	0% to 95% non-condensing			
	Altitude	1,000 m (3,300 ft) without derating			
	Maximum vibration	Per EN50178: Frame Size 0 and 1 5G			
	Acoustic noise	80 dba sound power at 1 m (3 ft)			
	Cooling	1 - 5 HP models: Natural convection 7.5 - 200 HP: Forced air (temperature controlled external fan)			
	Protection Level	1 – 100 HP models: NEMA 4X / IP66 Indoor or Outdoor Use			
	Agency approvals	UL, cUL, CE			
Electrical	Input voltage	200-230 Vac, 3 phase, +/- 15% 1-25 HP			
	Line frequency	50 / 60 Hz +/-2 Hz			
	Source kVA (maximum)	10 times the unit rated kVA (65kA maximum)			
	DC bus voltage for: Overvoltage trip Dynamic brake activation Normal undervoltage (UV) trip	115 Vac models 406 Vdc 388 Vdc 199 Vdc	230 Vac models 406 Vdc 388 Vdc 199 Vdc	460 Vac models 814 Vdc 776 Vdc 397 Vdc	575 Vac models 1017 Vdc 970 Vdc 497 Vdc
	Control system	V/Hz or Sensorless Vector Control (SVC) Carrier frequency = 1 to 16 kHz programmable			
	Output voltage	0 to 100% of line voltage, 3 phase			
	Overload capacity	120% of rated RMS current for 60 seconds (Normal Duty rating) 150% of rated RMS current for 60 seconds (Heavy Duty rating)			
	Frequency output	Range: 0.1 – 400Hz; Stability: 0.1Hz, 0.1% analog over 24 hours +/- 10°C			
Control Features	Reference inputs	3 – Analog / digital input: 0-5 / 0-10 Vdc, 0-4/20mAdc, 0-1/10/100kHz; each includes independent calibration adjustments			
	Reference supply voltage	10 Vdc (10 mAdc maximum)			
	Digital inputs (10)	Off = 0 to 3 Vdc, On = 10 to 32 Vdc (pull-up logic), selectable between pull-up and pull-down logic			
	Digital supply voltage	24 Vdc (150 mAdc maximum)			
	Preset frequencies	X4: 8 preset frequencies; X5: 16 preset frequencies			
	Digital outputs	2 SPDT relay output: 130 Vac, 1 Amp / 250 Vac, 0.5 Amp 2 open collector outputs 50 mA per device			
	Analog output	0-10Vdc (5mA max) / 0-4/20mAdc (500 ohm load)			
	DC holding/injection braking	At start, stop, by frequency with adjustable current level and time or continuous DC injection by digital input			
	Current limit	Four-quadrant adjustable from 5 to 150%			
	Speed ramps	Primary and alternate adjustable from 0.1 to 3200.0 seconds			
	Voltage boost	Adjustable fixed boost or adjustable auto boost			
	Voltage characteristic	V/Hz - Linear, pump, fan or 2-piece linear; Sensorless Vector			
	Timed overload	Adjustable inverse time trip (shear pin, 30 sec, 60 sec, 5 minutes) for standard or inverter-duty motors			
	Protective features	Overcurrent, Overvoltage fault, ground fault, short circuit, Dynamic Brake overload, drive temperature, power wiring fault. Drive-timed overload, input voltage quality, overvoltage ridethrough			
	Program Sequence Controller	X4: 9-step, PLC-type functionality to control speed, direction and ramp times based on time, analog input, digital input or pulse count. X5: 25-step, PLC-type functionality that can control speed, direction and ramps based on time, analog input,digital input, or pulse input. Conditional branching, addressable outputs and real time operations possible.			
	PI and PID Feedback	X4: PI Process control available with the use of a customer supplied transducer, either 0-10Vdc, 4-20mA or optical encoder input to the drive. X5: Process control available with the use of a customer supplied transducer, either 0-10Vdc, 4-20mA or optical encoder input to the drive. Includes an optional sleep mode, activated when the loop is satisfied.			

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X4 AC Drive

User's Manual

Need Help?

This manual answers most installation and startup questions
that may arise. However, if you have any problems,
please let your first call be to us.

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8:00 AM to 5:00 PM, Eastern time
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(+1 877-822-6606)
After-hours support is also available

= cannot change in Run
Bold type = Level 1 parameter

Summary of X4 Parameters

No.	Parameter Name	Options	Default	User Setting	See Page
001	**Model Number**	**Model Dependent**	**Read-only**		**60**
002	Software Rev	0.00-99.99	Read-only		60
003	Rated Current	0.0-200.0 A	Read-only		60
005	Serial No. 1	0-65535	Read-only		60
006	Serial No. 2	0-65535	Read-only		60
010	**Last Fault**	**text string**	**Read-only**		**60**
025	4th Fault	text string	Read-only		60
040	3rd Fault	text string	Read-only		60
055	2nd Fault	text string	Read-only		60
070	1st Fault	text string	Read-only		60
102	**Output Freq**	**0.0-400.0 Hz**	**Read-only**		**61**
103	**Output Voltage**	**0-600 V**	**Read-only**		**61**
104	**Output Current**	**0.0-200.0 A**	**Read-only**		**61**
105	**Drive Load**	**-200.0-200.0%**	**Read-only**		**61**
106	**Load Torque**	**-200.0-200.0%**	**Read-only**		**61**
107	**Drive Temp**	**-20.0-200.0 °C**	**Read-only**		**61**
108	Total Run Time	0.0-6553.5 h	Read-only		61
109	Power On Hours	0-65535 h	Read-only		61
110	Stator Freq	0.0-400.0 Hz	Read-only		61
111	**DC Bus Voltage**	**0 - 1000 Vdc**	**Read-only**		**61**
115	Drive Power Out	0.0-200.0%	Read-only		61
201	**Input Mode**	**text string**	**Local Only**		**62**
202	**Rev Enable**	**text string**	**Forward**		**62**
203	Stop Key Remote	text string	Coast		62
204	Ref Select	text string	Vin1		63
205	Vin1 Config	text string	0-10V		63
206	Vin1 Offset	0.0% to 100.0 %	0.00%		63
207	Vin1 Span	10.0% to 200.0%	100.00%		64
208	Cin Config	text string	0-20mA 50		64
209	Cin Offset	0.0% to 100.0%	0.0%		64
210	Cin Span	10.0% to 200.0%	100.0%		64
211	Vin2 Config	text string	0-10V		64
212	Vin2 Offset	0.0% to 100.0 %	0.00%		64
213	Vin2 Span	10.0% to 200.0%	100.00%		64
214	Vin1 Filter Time	0 to 1000 ms	20 ms		64
215	Cin Filter Time	0 to 1000 ms	20 ms		64
216	Vin2 Filter Time	0 to 1000 ms	20 ms		65
217	Trim Ref Enable	text string	Disabled		65
218	Trim % Factor	-100.0 - 100.0%	0.0%		65
222	Ref Loss Config	text string	No Fault		65
301	**Min Frequency**	**0.0 - Max Freq.**	**0.0 Hz**		**65**
302	**Max Frequency**	**0.0 - 400.0 Hz**	**60.0 Hz**		**65**
303	**Preset Freq 1**	**Min Freq-Max Freq**	**5.0 Hz**		**65**
304	Preset Freq 2	Min Freq-Max Freq	10.0 Hz		65
305	Preset Freq 3	Min Freq-Max Freq	20.0 Hz		65
306	Preset Freq 4	Min Freq-Max Freq	30.0 Hz		65
307	Preset Freq 5	Min Freq-Max Freq	40.0 Hz		65
308	Preset Freq 6	Min Freq-Max Freq	50.0 Hz		65

(cont'd)

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter 201 (Input Mode) can be addressed by Modbus address 40201.

= cannot change in Run
Bold type = Level 1 parameter

No.	Parameter Name	Options	Default	User Setting	See Page
309	Cut-Off Freq	0.0-5.0 Hz	0.0 Hz		66
401	Ramp Select	text string	ART-DI		66
402	**Accel Time 1**	**0.1-3200.0 sec**	**5.0 sec**		**66**
403	**Decel Time 1**	**0.1-3200.0 sec**	**5.0 sec**		**66**
404	Accel Time 2	0.1-3200.0 sec	3.0 sec		67
405	Decel Time 2	0.1-3200.0 sec	3.0 sec		67
406	DC Inject Config	text string	DC at Stop		67
407	DC Inject Time	0.0-5.0 sec	0.2 sec		67
408	DC Inject Level	0.0% to 100.0%	50.0%		67
409	DC Inj Freq	0.0 to 20.0 Hz	0.0 Hz		68
410	DB Config	text string	Internal		68
414	S Ramp Rounding	1 - 100%	25%		68
490	**App Macro**	**text string**	**Factory**		50
491	**Seq Appl**	**text string**	**Disabled**		50
492	**SIO Visible**	**text string**	**No**		50
501	V/Hz Select	text string	Linear Fixed		69
502	**Voltage Boost**	**0.0-50%**	**1.0%**		69
503	V/Hz Knee Freq	25.0-400.0 Hz	60.0 Hz		69
504	Skip Freq Band	0.2-20.0 Hz	0.2 Hz		70
505	Skip Freq 1	Min Freq-Max Freq	0.0 Hz		70
506	Skip Freq 2	Min Freq-Max Freq	0.0 Hz		70
507	Skip Freq 3	Min Freq-Max Freq	0.0 Hz		70
508	Skip Freq 4	Min Freq-Max Freq	0.0 Hz		70
509	Rated Mtr Volt	100V-690V	Model Dependent		70
510	Rated Mtr FLA	50% - 200% of ND Rating	ND Rating		70
511	Rated Mtr RPM	0-24000 rpm	1750 rpm		70
512	Midpoint Freq	0.0 Hz-V/Hz Knee Freq	60.0 Hz		70
513	Midpoint Volt	0.0-100.0%	100.0%		70
514	Motor RS	0.0-655.35 Ohms	Model Dependent		70
515	Power Factor	0.50-1.00	0.80		70
516	Slip Comp Enable	text string	No		71
517	Single Phase	text string	No		71
519	Find Mtr Data	Not active / Motor RS	Not active		71
520	Filter FStator	1 - 100 ms	8 ms		71
521	Start Field En	Yes / No	No		71
522	Filter Time Slip	10 - 1000 ms	100 ms		71
523	Id Percent	0 - 200%	Read-only		72
524	Iq Percent	0 - 200%	Read-only		72
525	Power Fail Config	text string	CTS No Msg		72
526	UV Ride-Thru En	text string	w/ LVT		72
600	Current Lim Sel	text string	Fixed Lvls		73
601	Cur Lim Mtr Fwd	5%-150%	120%		73
602	Cur Lim Mtr Rev	5%-150%	120%		73
603	Cur Lim Reg Fwd	5%-150%	80%		73
604	Cur Lim Reg Rev	5%-150%	80%		73
605	Cur Lim Freq	0-400 Hz	3.0 Hz		73
606	Ramp Time CL	0.1-3200.0 sec	1.0 sec		73
607	Cur Limit Minimum	0 - 50%	10%		73
608	Restart Number	text string	0		74
609	Restart Delay	0-60 sec	60 sec		74

(cont'd)

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter 201 (Input Mode) can be addressed by Modbus address 40201.

= cannot change in Run
Bold type = Level 1 parameter

No.	Parameter Name	Options	Default	User Setting	See Page
610	Timed OL Select	text string	Std Ind 60s		74
613	Max Regen Ramp	100 - 1000%	300%		74
614	Stability Gain	0 - 10	Model Dependent		75
615	Stability Rate	0 - 1000	Model Dependent		75
700	**Vmet Config**	**text string**	**Freq Out**		75
701	Vmet Span	0.0-200.0%	100.0%		75
702	Imet Config	text string	Drive Load		75
703	Imet Span	0.0-200.0%	100.0%		75
704	Imet Offset	0.0-90.0-%	0.0%		75
705	**Relay 1 Select**	**text string**	**Drv Fault**		76
706	**Relay 2 Select**	**text string**	**Drive Run**		76
707	DO1 Select	text string	Drv Ready		76
708	DO2 Select	text string	At Speed		76
720	Active Logic	text string	Active High		76
721	D1 Configure	text string	Preset 1		77
722	D2 Configure	text string	Preset 2		77
723	D3 Configure	text string	Preset 3		77
724	D4 Configure	text string	Alt Ramp		77
725	D5 Configure	text string	Fault Reset		77
726	MOL Polarity	text string	NO Operate		77
727	MOL Configure	text string	MOL		77
801	Program Number	0-9999	0		77
802	Start Options	text string	LS Lockout		78
803	PWM Frequency	0.6-16.0 kHz	3.0 kHz		78
804	Display Mode	text string	Std Disply		78
805	Display Units	alphanumeric	RPM:1		79
809	Display Scale	1-65535	1		79
810	Language	text string	English		79
811	Access Code	0-9999	0		79
812	Freq Ref Output	text string	6FS		79
813	Speed Ratio	0.0-200.0%	100.0%		79
814	Display Status	text string	Drive load		80
816	Fly Catch Mode	Sweep FWD / REV / F/R	Sweep FWD		80
850	PI Configure	text string	No PI		80
851	PI Feedback	text string	Vin1		80
852	PI Prop Gain	0-2000	0		80
853	PI Int Gain	0-10000	0		81
854	PI Feed Gain	0-2000	1000		81
855	PI Error 1	0.00-100.00%	Read-only		81
856	PI Error 2	0.00-100.00%	Read-only		81
857	PI High Corr	0.00-100.00%	100.00%		81
858	PI Low Corr	0.00-100.00%	0.00%		81
900	SIO Protocol	text string	RTU N81		81
901	SIO Baud Rate	text string	9600		81
902	Comm Drop #	1-247	1		81
903	SIO Timer	0.0-60.0 sec	1.0 sec		81
904	SIO Cntl Word	text string	0x0000		82
905	Ext Ref Freq1	Min-Max Freq	0.0 Hz		82
906	Ext Ref Freq2	Min-Max Freq	0.0 Hz		82

(cont'd)

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter 201 (Input Mode) can be addressed by Modbus address 40201.

= cannot change in Run
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No.	Parameter Name	Options	Default	User Setting	See Page
908	Status Word	text string	Read-only		82
909	DI Status	text string	Read-only		82
910	Vin1 Status	0.00-100.00%	Read-only		83
911	Cin Status	0.00-100.00%	Read-only		83
912	Vin2 Status	0.00-100.00%	Read-only		83
913	Output Status	text string	Read-only		83
914	Vmet Status	0.00-100.00%	Read-only		83
915	Imet Status	0.00-100.00%	Read-only		83
916	Infrared Baud	n/a	9600		83
931	Seq Cntl 1	n/a	00000000000		83
932	Seq Cntl 2	n/a	00000000000		83
933	Seq Cntl 3	n/a	00000000000		83
934	Seq Cntl 4	n/a	00000000000		83
935	Seq Cntl 5	n/a	00000000000		83
936	Seq Cntl 6	n/a	00000000000		83
937	Seq Cntl 7	n/a	00000000000		83
938	Seq Cntl 8	n/a	00000000000		83
939	Seq Cntl 9	n/a	00000000000		83
951	Seq Count 1	0-65535	0		84
952	Seq Count 2	0-65535	0		84
953	Seq Count 3	0-65535	0		84
954	Seq Count 4	0-65535	0		84
955	Seq Count 5	0-65535	0		84
956	Seq Count 6	0-65535	0		84
957	Seq Count 7	0-65535	0		84
958	Seq Count 8	0-65535	0		84
959	Seq Count 9	0-65535	0		84

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter 201 (Input Mode) can be addressed by Modbus address 40201.

CONTENTS

Chapter 1: Introduction

1.1 Product Overview

Although the X4 AC drive is small in size, it is big on performance. It is an economical yet powerful solution for many industrial applications. It features remote communications capability (using Modbus® protocol), a keypad for easy configuration, and standard NEMA 4X / IP66 and NEMA 12 / IP55 enclosures that eliminate the need for mounting in a separate enclosure.

The X4 product family includes a wide variety of models to suit almost any input voltage requirement. An 'x' in the following table indicates what models are currently available. Refer to "Chapter 2: Technical Characteristics" on page 11 for help in interpreting model numbers.

Horsepower	Input Voltage			
	115 Vac 1 Phase	230 Vac 3 Phase	460 Vac 3 Phase	575 Vac 3 Phase
1	x	x	x	x
2		x	x	x
3		x	x	x
5		x	x	x
7.5		x	x	x
10		x	x	x
15		x	x	x
20		x	x	x
25		x	x	x
30		x	x	x
40			x	x
50			x	x
60			x	x
75			x	x
100			x	x
125			x	x
150			x	x
200			x	x

1.2 Overview of This Manual

This manual contains specifications, receiving and installation instructions, configuration, description of operation, and troubleshooting procedures for X4 AC drive devices.

For experienced users, a Quick Start section begins on page 58. A summary of parameters begins on page iii of this manual.

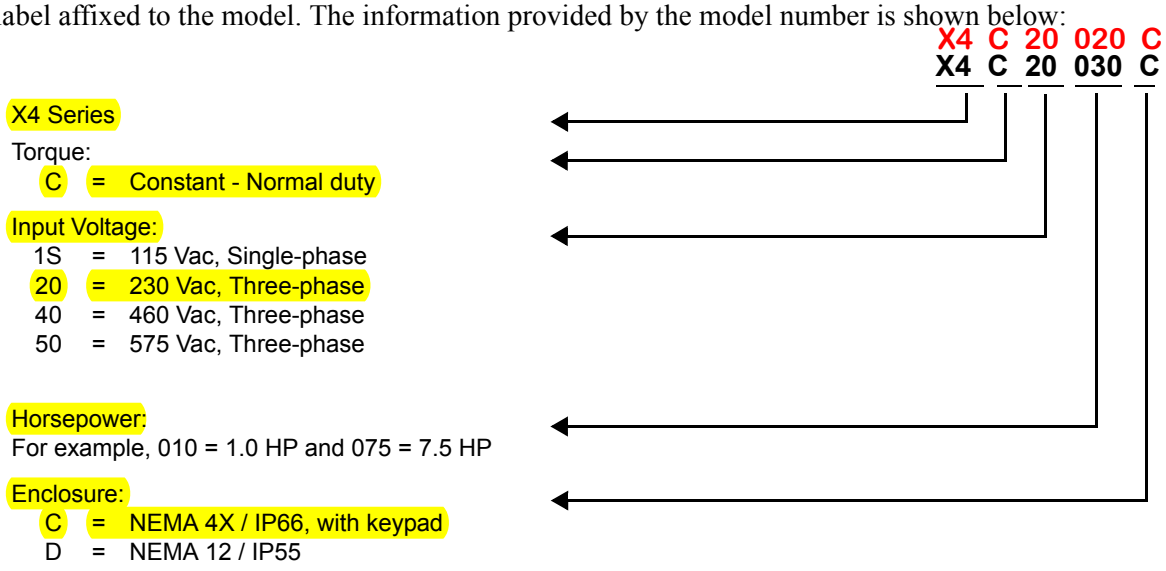
1.3 User's Manual Publication History

Date	Form Number	Nature of Change
June 2005	1428	First release
March 2006	1428B	Minor corrections throughout manual. Clarification of technical information and specifications. Added X4 models for Frame Size 2. Reformatted to larger page-size document; separated appendices from manual to be available on the web site (www.vacon.com).
August 2006	1428C	Minor corrections and enhancements throughout manual. Added 40 and 50 HP models.
June 2007	1428D	Added 60-200 HP models, new parameters. Minor corrections and reformatting throughout manual.
March 2008	1428E	Minor changes to format, copyright information, and logo Minor corrections throughout manual
May 2008	1428F	Minor corrections throughout manual; added new EU Declaration of Conformity
June 2008	1428G	Changed corporate information for Vacon Incorporated
November 2008	DPD00088 (1st release under this number)	Changed installation diagrams to reflect changes in product; changed photographs of product; added information to Chapter 2 on current surges and voltage transients; deleted mention of Model X4C20300C; other minor changes and corrections.
April 2009	DPD00088A	Revised EU Declaration of Conformity

Chapter 2: Technical Characteristics

2.1 Interpreting Model Numbers

The model number of the X4 AC drive appears on the shipping carton label and on the technical data label affixed to the model. The information provided by the model number is shown below:



2.2 Power and Current Ratings

115 Vac Ratings

Model number	Normal Duty		Input current (A)		Output current (A)		Heavy Duty		Input current (A)		Output current (A)	
	HP	kW	-	115 Vac	-	230 Vac	HP	kW	-	115 Vac	-	230 Vac
X4C1S010C	1	0.75	-	15	-	4.2	0.5	0.37	-	11	0	2.2

230 Vac Ratings

Model number	Normal Duty		Input current (A)		Output current (A)		Heavy Duty		Input current (A)		Output current (A)	
	HP	kW	200 Vac	230 Vac	200 Vac	230 Vac	HP	kW	200 Vac	230 Vac	200 Vac	230 Vac
X4C20010C	1	0.75	5.6	4.8	4.8	4.2	0.5	0.37	2.9	2.5	2.5	2.2
X4C20020C	2	1.5	9	7.8	7.8	6.8	1	0.75	5.6	4.8	4.8	4.2
X4C20030C	3	2.2	12.7	11	11	9.6	2	1.5	9	7.8	7.8	6.8
X4C20050C	5	4	20.2	17.5	17.5	15.2	3	2.2	12.7	11	11	9.6
X4C20075C	7.5	5.5	29.2	25.3	25.3	22	5	4	20.2	17.5	17.5	15.2
X4C20100C	10	7.5	37.2	32.2	37.2	28	7.5	5.5	29.2	25.3	25.3	22
X4C20150C	15	11	52.1	46.4	48.3	42	10	7.5	37.2	32.2	37.2	28
X4C20200C	20	15	68.3	57.4	62.1	54	15	11	52.1	46.4	48.3	42
X4C20250C	25	18.5	82.3	73.8	78.2	68	20	15	68.3	57.4	62.1	54

NOTE: All 230 Vac models can be operated at single-phase, with 50% derating

2.3 Environmental Specifications

Operating temperature	**For 2003, 2005, 5005, 2030, 4030, and 5030 models:** –10 °C to +35 °C (14 °F to 95 °F) **For all other models:** –10 °C to +40 °C (14 °F to 104 °F)
Storage temperature	–20 °C to +65 °C (-4 °F to 149 °F)
Humidity	0% to 95% non-condensing
Altitude	1000 m (3300 ft) without derating
Maximum vibration	per EN50178 (1g @ 57-150 Hz)
Acoustic noise	80 dba sound power at 1 m (3 ft), maximum
Cooling	1 to 5 HP models: Natural convection 7.5 to 200.0 HP models: Forced air **Note:** 575Vac 5 HP model has a fan.

2.4 Electrical Specifications

Input voltage	X4C2x models: 200-230 Vac, 3 phase, +/- 15%			
Line frequency	50 / 60 Hz ±2 Hz			
Source kVA (maximum)	10 times the unit rated kVA (see note below)			
DC bus voltage for:	**115 Vac models**	**230 Vac models**	**460 Vac models**	**575 Vac models**
Overvoltage trip	406 Vdc	406 Vdc	814 Vdc	1017 Vdc
Dynamic brake activation	388 Vdc	388 Vdc	776 Vdc	970 Vdc
Nominal undervoltage (UV) trip	199 Vdc	199 Vdc	397 Vdc	497 Vdc
Control system	V/Hz or SVC Carrier frequency = 1 - 16 kHz, programmable; 8 kHz max. for 125-200 HP models			
Output voltage	3-phase: 0 to 100% of incoming line (0-230 Vac for 115 Vac models)			
Overload capacity	120% of rated normal duty rms current for 60 seconds 150% of rated heavy duty rms current for 60 seconds			
Frequency range	0.1 to 400 Hz			
Frequency stability	0.1 Hz (digital), 0.1% (analog) over 24 hours +/- 10 °C			
Frequency setting	By keypad or by external signal (Speed Pot 0 to 5 Vdc; 0 to 10 Vdc; 0 to 20 mA, or 4 to 20 mA) OR by pulse train up to 100 kHz			

Note: Unit Rated kVA = rated Voltage x rated Current x 1.732

2.5 Control Features Specifications

Vin1 reference input	0-5/10 Vdc, 0/4-20 mAdc (250 Ω load) 6FS pulse train input, 0-1/10/100 kHz pulse input, inverted function, 0-5-10 bipolar input, broken wire detection. Span and offset adjustment.
Vin2 reference input	0-5/10 Vdc, 0-5-10 bipolar input, inverted function, broken wire detection, span and offset adjustment. Programmable for frequency reference or current limit input.
Cin reference input	0/4-20 mAdc (50 Ω load), inverted function, span and offset adjustment. Programmable for frequency reference or current limit input.
Reference voltage	10 Vdc (10 mAdc maximum)
Digital inputs - 10	Off=0 to 3 Vdc; On=10 to 32 Vdc (pullup logic), selectable between pullup and pulldown logic
Digital supply voltage	24 Vdc (150 mAdc maximum)
Preset frequencies	3 inputs for seven preset frequencies (selectable)
Digital outputs	2 SPDT relay output - 130 Vac, 1 A/250 Vac, 0.5 A 2 open collector outputs 50 mA per device
Digital pulse train output	Open collector output pulse train proportional to output frequency
Vmet analog output	0 to 10 Vdc (5 mAdc maximum)
Imet analog output	0-20 mAdc output into a 500 Ω load (maximum)
DC holding / injection braking	At start, stop, by frequency with adjustable current level and time or continuous DC injection by digital input.
Current limit	Four quadrant adjustable from 5 to 150%
Speed ramps	Primary and alternate adjustable from 0.1 to 3200.0 seconds
Voltage boost	Fixed boost adjustable from 0 to 50%, or auto boost in Vector mode
Voltage characteristic (V/Hz)	Linear, pump, fan or 2-piece linear
Timed overload	Adjustable inverse time trip (shear pin, 30 sec, 60 sec, 5 min), standard or inverter-duty motors
Protective features	Overcurrent, overvoltage fault, ground fault, short circuit, dynamic brake overload, drive temperature, power wiring fault, drive timed overload, input voltage quality, overvoltage ridethrough
Program Sequence Logic Controller (PSLC)	9-step PLC type functionality that can control speed, direction, and ramps based on time, analog input, digital input, or pulse input.
Serial communications	Modbus Standard: RTU or ASCII

2.6 Dimensions and Weights

Table 2-1 lists dimensions and weights for the X4 frame size 0, 1, 2, and 3 models. Dimensions and weights for the X4 frame size 4 and 5 models are shown in Table 2-2 on page 18.

See Figures 2-1, 2-2, 2-3, 2-4, 2-5, and 2-6 on pages 16 - 19 for locations of dimensions. Dimensions A through Q are in inches / millimeters (in/mm). Weight is in pounds / kilograms (lb/kg).

Table 2-1: Dimensions and Weights for Frame Sizes 0 - 2

Frame		0		
Voltage		115 Vac	230 Vac	460 Vac
Horsepower		1	1-3	
Dimensions inches (mm) (See the corresponding X4 diagrams on following pages	A	9.47 (241)		
	B	6.50 (165)		
	C	6.08 (155)		
	D	8.45 (215)		
	E	5.69 (145)		
	F	0.28 (7.11)		
	G	3.84 (98)		
	H	2.77 (70)		
	J	1.93 (49)		
	K	2.85 (72)		
	L	3.75 (95)		
	M	0.88 (22)		
	N	N/A		
	P	N/A		
	Q	N/A		
Weight lb (kg)		8.5 (3.85)		

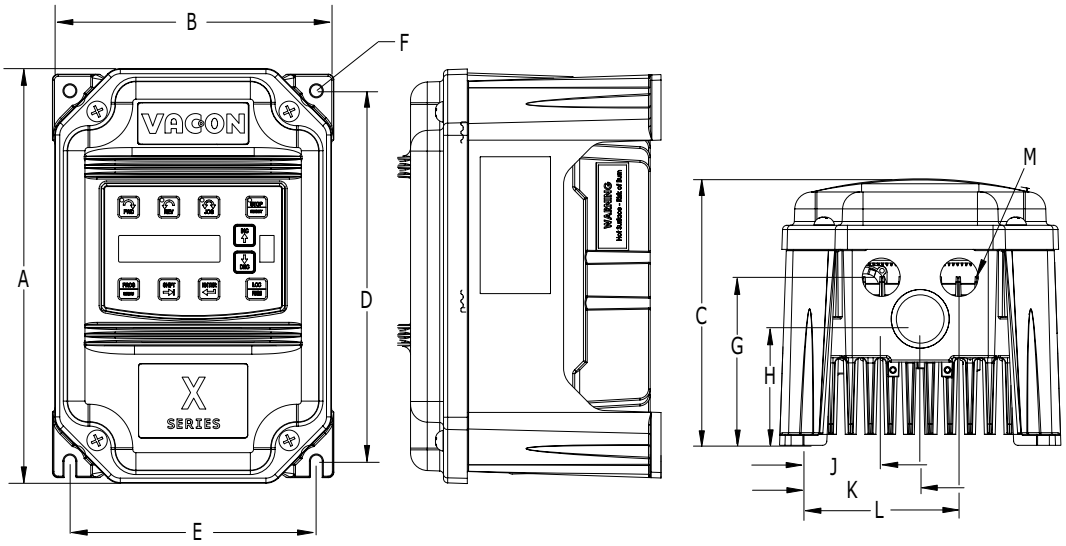


Figure 2-1: X4 Frame Size 0 Models

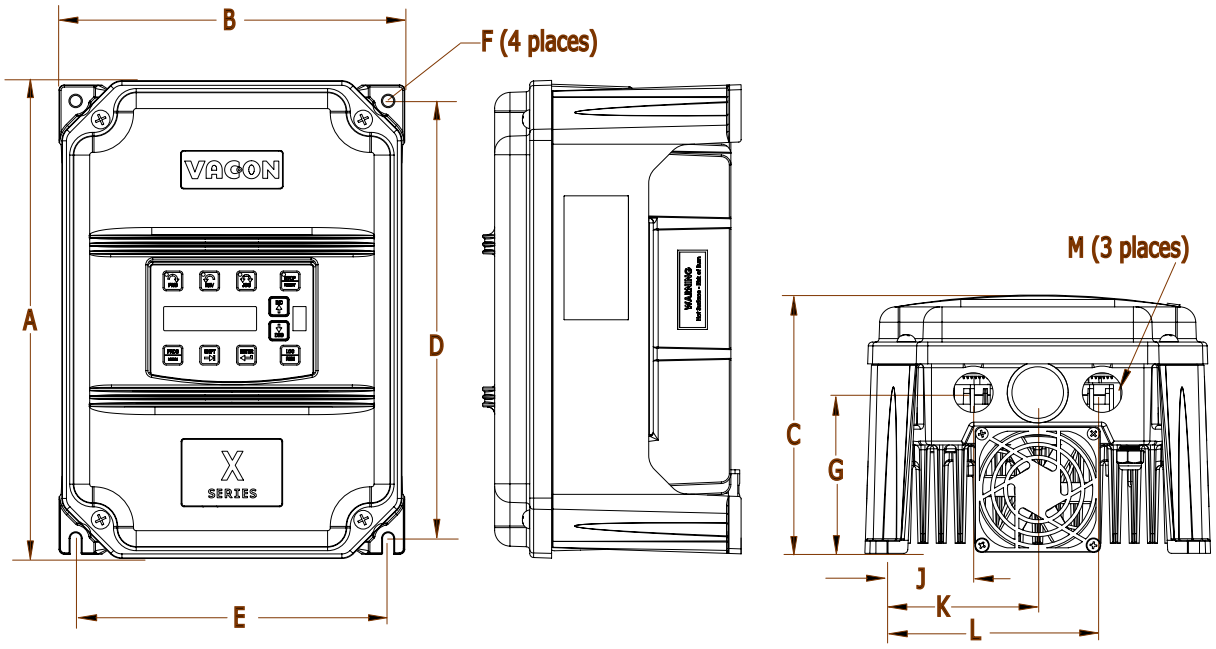


Figure 2-2: X4 Frame Size 1 Models

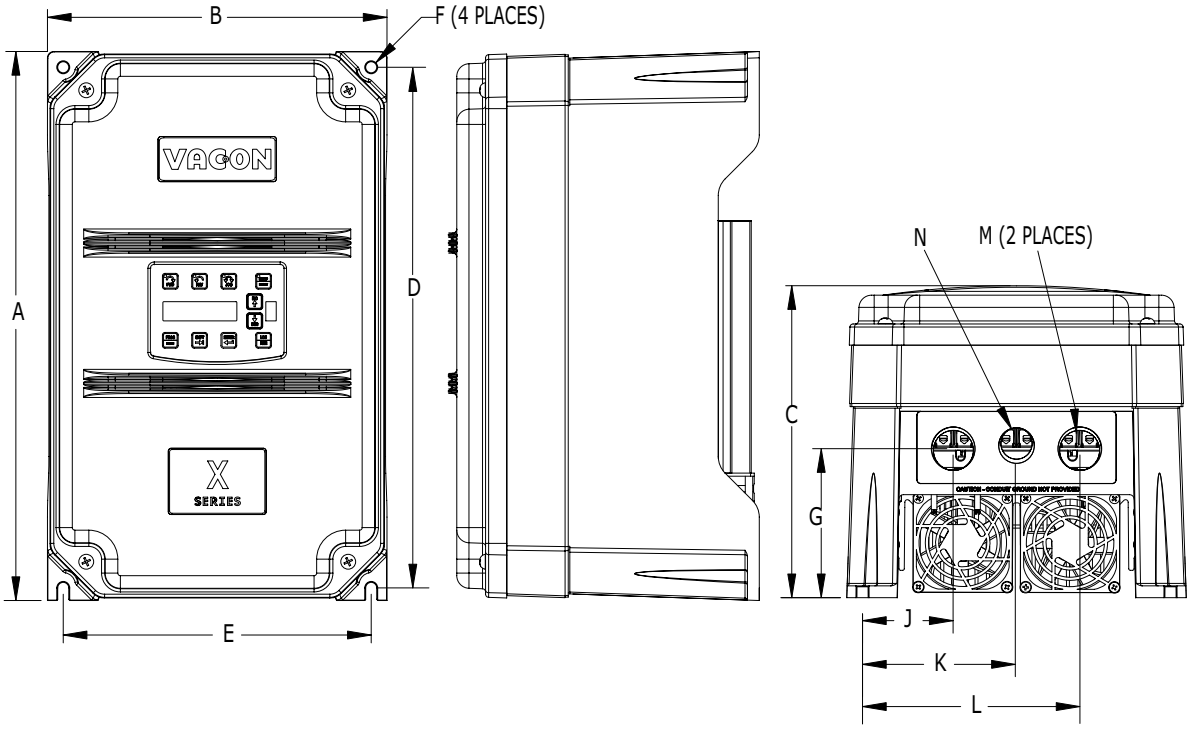


Figure 2-3: X4 Frame Size 2 Models

Chapter 3: Receiving and Installation

3.1 Preliminary Inspection

Before storing or installing the X4 AC drive, thoroughly inspect the device for possible shipping damage. Upon receipt:

1. Remove the drive from its package and inspect exterior for shipping damage. If damage is apparent, notify the shipping agent and your sales representative.
2. Remove the cover and inspect the drive for any apparent damage or foreign objects. (See Figure 3-1 on page 22 for locations of cover screws.) Ensure that all mounting hardware and terminal connection hardware is properly seated, securely fastened, and undamaged.
3. Read the technical data label affixed to the drive and ensure that the correct horsepower and input voltage for the application has been purchased.
4. If you will be storing the drive after receipt, place it in its original packaging and store it in a clean, dry place free from direct sunlight or corrosive fumes, where the ambient temperature is not less than -20 °C (-4 °F) or greater than +65 °C (+149 °F).

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Do not operate or install any drive that appears damaged.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

Ne faites pas fonctionner et n'installez pas tout variateur de vitesse qui semble être endommagé.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

3.2 Installation Precautions

Improper installation of the X4 AC drive will greatly reduce its life. Be sure to observe the following precautions when selecting a mounting location. **Failure to observe these precautions may void the warranty!** See the inside front cover of this manual for more information about the warranty.

- Do not install the drive in a place subjected to high temperature, high humidity, excessive vibration, corrosive gases or liquids, or airborne dust or metallic particles. See Chapter 2 for temperature, humidity, and maximum vibration limits.
- Do not mount the drive near heat-radiating elements or in direct sunlight.
- Mount the drive vertically and do not restrict the air flow to the heat sink fins.
- The drive generates heat. Allow sufficient space around the unit for heat dissipation. See "Dissipation Requirements" on page 21.

3.3 Dissipation Requirements

Table 3-1: Dissipation Requirement for X4 Models *(Page 1 of 2)*

Model	Required Dissipation for Models Entirely Inside an Enclosure at Rated Current, 3KHz Carrier Frequency (Watts)	Required Dissipation When Fins are External to the Enclosure (Watts)
X4C20020C	71	17

3.4 Cover Assembly and Torque Specifications

Figure 3-1 shows the locations of the X4 cover screws. The torque range for the X4 covers is 18-26 in/lbs.

Figure 3-1: X4 Cover Assembly and Screw Locations

Torque specifications for control terminals and power terminals are listed in "General Wiring Information" on pages 25 and 26.

3.5 Serial Number Label

All X4 AC drives are warranted for three years from date of manufacture, or two years from the date of installation, whichever comes first. For a more detailed description of the warranty policy, visit our web site at http://www.vacon.com. To determine if your drive is within the warranty time frame, find the bar code label or look in the lower left of the technical nameplate. The serial number can be broken down as follows:

yywwxxxx = **yy**...year of manufacture

ww...week of manufacture

xxxx...sequential number drive during that week

3.6 Conduit Usage

The X4 drive in the NEMA 4X / IP66 enclosure is rated for 1000 psi washdown from 6 inches. To keep this rating, the use of a sealed conduit is required. The use of a Romex-type conduit will not prevent water entry into the enclosure. If the approved conduit is not used, all warranty claims against water damage will be void.

3.7 Condensation

The washdown process of an X4 drive may create a temperature and humidity change in and around the drive. If the unit is mounted in a cool environment and washed down with higher-temperature water, as the drive cools to room temperature, condensation can form inside the drive, especially around the display. To prevent this from happening, avoid using sealed connectors around rubber-coated cables to seal the drive. These do not allow any air transfer and hence create a level of condensation and humidity that exceeds the drive's rating.

Chapter 4: Connections

⚠ DANGER

HAZARDOUS VOLTAGE

- Read and understand this manual in its entirety before installing or operating the X4 AC drive. Installation, adjustment, repair, and maintenance of these drives must be performed by qualified personnel.
- Disconnect all power before servicing the drive. **WAIT 5 MINUTES** until the DC bus capacitors discharge.
- **DO NOT** short across DC bus capacitors or touch unshielded components or terminal strip screw connections with voltage present.
- Install all covers before applying power or starting and stopping the drive.
- The user is responsible for conforming to all applicable code require-ments with respect to grounding all equipment.
- Many parts in this drive, including printed circuit boards, operate at line voltage. **DO NOT TOUCH.** Use only electrically-insulated tools.

Before servicing the drive:

- Disconnect all power.
- Place a “DO NOT TURN ON” label on the drive disconnect.
- Lock the disconnect in the open position.

Failure to observe these precautions will cause shock or burn, resulting in severe personal injury or death.

⚠ DANGER

TENSION DANGEREUSE

- Lisez et comprenez ces directives dans leurs intégralité avant d’installer ou de faire fonctionner le variateur de vitesse X4. L’installation, le réglage, les réparations et l’entretien des ces variateurs de vitesse doivent être effectuées par du personnel qualifié.
- Coupez toutes les alimentations avant de travailler sur le variateur de vitesse. **ATTENDEZ CINQ MINUTES** pour que la décharge des condensateurs du bus cc s’effectue.
- NE court-cuitez PAS les condensateurs du bus cc ou ne touchez pas aux composantes non blindées ou aux connexions des vis du bornier si l’appareil est sous tension.
- Installez tous les couvercles avant de mettre le variateur de vitesse sous tension, de le mettre en marche ou de l’arrêter.
- L’utilisateur est responsable de la conformité avec tous les codes électriques en vigueur concernant la mise à la terre de tous les appareils.
- De nombreuses pièces de ce variateur de vitesse, y compris les cartes de circuits imprimés, fonctionnent à la tension du secteur. **N’Y TOUCHEZ PAS**. N’utilisez que des outils dotés d’une isolation électrique.

Avant tout entretien ou réparation sur le variateur de vitesse:

- Coupez toutes les alimentations.
- Placez une étiquette «NE PAS METTRE SOUS TENSION» sur le sectionneur du variateur de vitesse.
- Verrouillez le sectionneur en position ouverte.

Si ces précautions ne sont pas respectées, cela causera une électrocution ou des brûlures, ce qui entraînera des blessures graves ou la mort.

4.1 Introduction

This chapter provides information on connecting power and control wiring to the X4 AC drive.

4.2 General Wiring Information

4.2.1 Wiring Practices

When making power and control connections, observe these precautions:

- Never connect input AC power to the motor output terminals T1/U, T2/V, or T3/W. Damage to the drive will result.
- Power wiring to the motor must have the maximum possible separation from all other power wiring. Do not run in the same conduit; this separation reduces the possibility of coupling electrical noise between circuits.
- Cross conduits at right angles whenever power and control wiring cross.
- Good wiring practice also requires separation of control circuit wiring from all power wiring. Since power delivered from the drive contains high frequencies which may cause interference with other equipment, do not run control wires in the same conduit or raceway with power or motor wiring.

4.2.2 Considerations for Power Wiring

Power wiring refers to the line and load connections made to terminals L1/R, L2/S, L3/T, and T1/U, T2/V, T3/W respectively. Select power wiring using these guidelines:

- Use only UL-recognized wire.
- Wire voltage rating must be a minimum of 300 V for 230 Vac systems and 600 V (Class 1 wire) for 460 or 575 Vac systems.
- Wire gauge must be selected based on 125% of the continuous input current rating of the drive. Wire gauge must be selected from wire tables for 75 °C insulation rating, and must be of copper construction. The 230 V 7.5 and 15 HP models, and the 460 V 30 HP models require 90 °C wire to meet UL requirements. See Chapter 2 for the continuous output ratings for the drive.
- Grounding must be in accordance with NEC and CEC. If multiple X4 drives are installed near each other, each must be connected to ground. Take care not to form a ground loop.

See Table 4-1 on page 26 and Table 4-2 on page 26 for information on power terminal wiring specifications.

Table 4-1: X4 Power Terminal Wiring Specifications

Frame Size	Specifications			
	Torque Nom.	Torque Max.	Max. Wire Size	Strip Length
Size 0	12 in-lbs	13 in-lbs	12-24 AWG	5/16" (0.3125")

Note: *Wire type not specified by the manufacturer. Some types of wire may not fit within the constraints of the conduit entry and bend radius inside the drive..*

Table 4-2: User-Supplied Terminal Cross-Reference

Wire Size	Manufacturer	Manufacturer's P/N	Manufacturer	Manufacturer's P/N
3 AWG	T&B	54107		
2 AWG	T&B	54107		
1 AWG	T&B	54108		
1/0 AWG	T&B	54152-TB	Burndy	YA25-L6BOX
2/0 AWG	T&B	54157	Burndy	YA26-L5BOX
3/0 AWG	T&B	54162-TB	Burndy	YA27-LBOX
4/0 AWG			Burndy	YA28-LBOX
250 MCM			Burndy	YA29-LBOX
300 MCM			Burndy	YA30-L
350 MCM			Burndy	YA31-L
400 MCM			Burndy	YA32-L1

4.2.3 Considerations for Control Wiring

Control wiring refers to the wires connected to the control terminal strip. Select control wiring as follows:

- Shielded wire is recommended to prevent electrical noise interference from causing improper operation or nuisance tripping.
- Use only UL recognized wire.
- Wire voltage rating must be at least 300 V for 230 Vac systems. It must be at least 600 V for 460 or 575 Vac systems.

See Table 4-3 below for a summary of control terminal wiring specifications.

Table 4-3: X4 Control Wiring Specifications

X4 Size / Models	Specifications
All Sizes / Models	4.4 in-lbs maximum torque 12-24 awg wire 9/32" strip length

4.3 Input Line Requirements

4.3.1 Line Voltage

See "Power and Current Ratings" on page 12 for the allowable fluctuation of AC line voltage for your particular X4 model. A supply voltage above or below the limits given in the table will cause the drive to trip with either an overvoltage or undervoltage fault.

Exercise caution when applying the X4 AC drive on low-line conditions.

For example, an X4 2000 series unit will operate properly on a 208 Vac line, but the maximum output voltage will be limited to 208 Vac. If a motor rated for 230 Vac line voltage is controlled by this drive, higher motor currents and increased heating will result.

Therefore, ensure that the voltage rating of the motor matches the applied line voltage.

4.3.2 Line Capacity

If the source of AC power to the X4 AC drive is greater than 10 times the kVA rating shown in Table 4-4 below, an isolation transformer or line reactor is recommended. Consult the factory for assistance in sizing the reactor.

Table 4-4: X4 Line Capacity (kVA)

Drive HP	1	2	3	5	7.5	10	15	20	25	30	40	50	60	75	100	125	150	200
Transformer kVA	2	4	5	9	13	18	23	28	36	42	57	70	90	112	150	180	220	250

Note: *X4 AC drive devices are suitable for use on a circuit capable of delivering not more than 65,000 rms symmetrical amperes at 10% above the maximum rated voltage.*

4.3.3 Phase Imbalance

Phase voltage imbalance of the input AC source can cause unbalanced currents and excessive heat in the drive's input rectifier diodes and DC bus capacitors. Phase imbalance can also damage motors running directly across the line. The phase imbalance should not exceed 2% of the voltage rating.

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Never use power-factor correction capacitors on motor terminals T1/U, T2/V, or T3/W of the X4 AC drive. Doing so will damage the semiconductors.

Failure to follow this instruction can result in injury or equipment damage.

⚠ ATTENTION

RISQUE DE DOMMAGES MATÉRIELS

Ne raccordez jamais de condensateurs de correction du facteur de puissance aux bornes T1/U, T2/V, ou T3/W du moteur du variateur de vitesse X4. Car cela endommagera les semiconducteurs.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

4.3.4 Single-phase Operation

X4 AC drive 230 Vac models ranging from 1 to 5 HP are designed for both three-phase and single-phase input power. If one of these models is operated with single-phase power, use any two line input terminals. The output of the device will always be three-phase.

The safe derating of the X4 series of drives is 50% of the nominal current (HP) rating. Consult the factory with the particular application details for exact derating by model.

4.3.5 Ground Fault Circuit Interrupters

X4 drives rated for 115 Vac are **not** designed to operate with ground fault circuit interrupters (GFCI). The GFCI breakers are designed for residential use to protect personnel from stray currents to ground. Most GFCI breakers will shut off at 5 mA of leakage. It is not uncommon for an AC drive to have 30 to 60 mA of leakage.

4.3.6 Motor Lead Length

Vacon, Inc. recommends that the total lead length should not exceed the motor manufacturer's guidelines. Line disturbance and noise can be present in motor wiring of any distance. As a rule of thumb, any non-inverter duty motor should have a reactor or filter added when the motor lead length exceeds 150 feet. The carrier frequency for the drive should also be reduced using parameter **803 (PWM Frequency)**.

Nuisance trips can occur due to capacitive current flow to ground. These currents can cause shock to personnel and can create problems within the motor. Care should be taken when working in these areas.

Some applications can have a restricted lead length because of type of wire, motor type, or wiring placement. Consult the factory and the motor manufacturer for additional information.

4.3.7 Using Output Contactors

Contactors in the output wiring of an AC drive may be needed as part of the approved safety circuit. Problems can arise if these contactors are opened for the safety circuit and the drive is left in run mode of operation. When the contactor is open, the drive is in a no-load, no-resistance state, but is still trying to supply current to the motor. However, when the contactor closes, the drive sees the motor resistance and instantly demands current. This inrush of current when the contactor closes can fault or cause failure to the drive.

To prevent problems, interlock an auxiliary contact to the drive's Run or Enable circuit to stop the drive when the contactor opens. In this way, the drive will be disabled and no inrush will occur when the contactor is closed again.

4.4 Terminals Found on the X4 Power Board

4.4.1 Description of the Terminals

Table 4-5 describes the X4 power terminals.

Table 4-5: Description of X4 Power Terminals

Terminal	Description
L1/R L2/S L3/T	These terminals are the line connections for input power. (Single-phase 115 and 230 Vac, 1 to 5 HP models connect to any two of these terminals.)
T1/U T2/V T3/W	These terminals are for motor connections.

Note that earth ground is on the terminal strip (see Figure 4-1 below). Dynamic brake (DB) connections are not on the terminal strip, but on "fast on" (spade) connectors for models up to 30 HP, and on the terminal strip for models 40 HP and larger. See page 32 for specific information about dynamic braking.

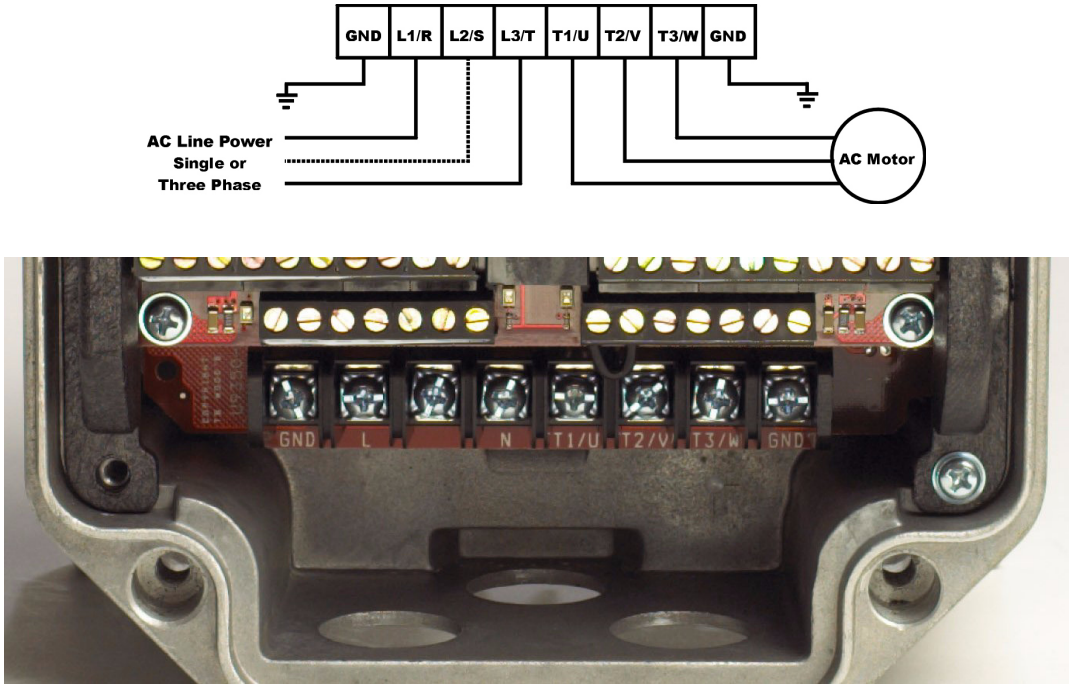


Figure 4-1: X4 Power Terminals

Figure 4-2: Power Terminals on Higher-HP Models

4.4.2 Typical Power Connections

See Section 4.3 starting on page 27 for input line requirements.

Note that when testing for a ground fault, do not short any motor lead (T1/U, T2/V, or T3/W) back to an input phase (L1/R, L2/S, or L3/T).

It is necessary to provide fuses and a disconnect switch for the input AC line in accordance with all applicable electrical codes. The X4 AC drive is able to withstand a 150% overload for 60 seconds for heavy duty rating, and 120% overload for normal duty rating.

The fusing and input protection of the drive must always meet UL, NEC (National Electric Code), and CEC (Canadian Electric Code) requirements. All fuse ratings included in Table 4-6 below are for reference only and do not supersede code requirements. The recommended supplier is Bussman.

Table 4-6: Fuse Ratings *(Page 1 of 2)*

Model Number	Fuse Size 115 Vac JJS/JJN	Fuse Size 208 Vac JJS/JJN	Fuse Size 230 Vac JJS/JJN	Fuse Size 380 Vac JJS	Fuse Size 460 Vac JJS	Fuse Size 575 Vac JJS
X4C20020C	—	15	10	—	—	—

4.5 Dynamic Braking

The X4 AC drive is supplied with an integrated dynamic braking (DB) resistor, and is designed to have adequate dynamic braking for most applications. In cases where short stopping times or high inertia loads require additional braking capacity, install an external resistor.

Note: External braking cannot be added to **Size 0** models. For **Size 4** (60-100 HP) and **Size 5** (125-200 HP) models, additional external dynamic braking requires a kit that provides the connections to the braking transistors. The **XDBKITS4** and **XDBKITS5** kits can be purchased through local distributors. Frame **Sizes 3 - 5** have both the DC positive and negative bus terminals available, making the drive compatible with either an external resistor or a combination resistor / chopper type of dynamic braking kit.

If an external resistor is used for dynamic braking (not applicable for Size 0 models), **the internal resistor must be disconnected**. Internal DB resistors are connected with fast-on terminals. To install an external resistor, first disconnect the internal DB resistor (or resistor**s** in 460 and 575 Vac models) and properly terminate the wires leading to it. Then connect the external resistor fast-on terminals where the internal resistor had been connected.

Changes to parameter **410 (DB Config)** must be made when using external DB resistors.

Verify with the manufacturer of the selected resistor that the resistor is appropriate for your application. Contact Vacon's Electronic Application Engineering (see inside front cover of this manual) for further assistance with other possible sizing limitations.

Refer to Table 4-7 on page 32 for information about dynamic braking capacity for each X4 model.

Table 4-7: X4 Dynamic Braking Capacity ***(Page 1 of 2)*** *(* Note that the asterisked X4 model numbers cannot have external braking added)*

Model	KW	Standard Resistance (ohms)	Standard DB % of Drive Power	Min. Allowed Res. (ohms)	Max. Peak Watts	Max. Ext. DB % of Drive Power
20020*	1.5	125	82%	--	--	--

4.6 Terminals Found on the X4 Control Board

4.6.1 Description of the Control Terminals

Figure 4-3 shows the control terminals found on the I/O board of the X4 AC drive. See page 14 for specifications. Table 4-8 on page 35 describes the control terminals.

The drive's control terminals are referenced to earth ground through a resistor / capacitor network. Use caution when connecting analog signals not referenced to earth ground, especially if the communications port (J3) is being used. The J3 port includes a common reference that can be connected to earth ground through the host PLC or computer.

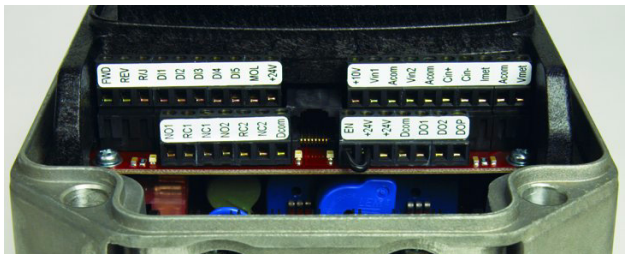


Figure 4-3: X4 Control Terminals

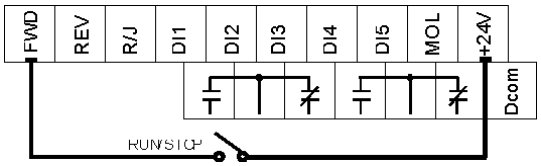
Table 4-8: Description of X4 Control Terminals *(Page 1 of 2)*

Terminal	Description
Vmet	Analog output 1, which is a dedicated voltage output. The default signal range is from 0 to 10 Vdc (5 mA maximum). It is proportional to the variable configured by parameter **700 (Vmet Config)** (see page 75). It may be calibrated while the drive is running via parameter **701 (Vmet Span)** (see page 75).
Imet	Analog output 2, which is a dedicated current output. The default signal ranges from 0 to 20 mAdc (50 to 500 Ω). It is proportional to the variable configured by parameter **702 (Imet Config)** (see page 75).It may be calibrated while the drive is running via parameters **704 (Imet Offset)** and **703 (Imet Span)** (see page 75).
Vin1	Analog Input 1, which is used to provide speed references. The default input signal is 0 to 10 Vdc (the type of input signal is selected with parameter **205 (Vin1 Config)**; see page 63). Parameters **206 (Vin1 Offset)** and **207 (Vin1 Span)** may be used to offset the starting value of the range and the size of the range, respectively; see page 63 for more information. If a 0 to 20 mAdc input signal is configured, the burden is 250 Ω. If a 0 to 10 Vdc input signal is configured, the input impedance is 475 kΩ. A potentiometer with a range of 1 to 10 kΩ is suggested for this input.
+10	This terminal is a +10 Vdc source for customer-supplied potentiometers. The maximum load on this supply cannot exceed 10 mAdc.
Cin+ / Cin-	Current Input. The default input signal is 4-20 mA, although this range may be adjusted by using parameters **209 (Cin Offset)** (which configures an offset for the range) and **210 (Cin Span)** (to reduce or enlarge the range — for example, setting this parameter to 50% results in a range of 4-12 mA). See page 64 for more information on these parameters. The burden for this terminal is 50 Ω.
Vin2	Voltage Input 2, which is used to provide speed references. The default input signal is 0 to 10 Vdc (the type of input signal is selected with parameter **211 (Vin2 Config)**; see page 64). Parameters **212 (Vin2 Offset)** and **213 (Vin2 Span)** may be used to offset the starting value of the range and the size of the range, respectively; see page 64 for more information. A potentiometer with a range of 1 to 10 kΩ is suggested for this input.
Acom	Common for the Analog Inputs and Outputs. Note that while there are three Acom (common) terminals, they connect to the same electrical point.
+24	A source for positive nominal 24 Vdc voltage, and has a source capacity of 150 mA.
FWD	Forward Direction Selection terminal. This may be connected for two-wire maintained or three-wire momentary operation.
REV	Reverse Direction Selection Terminal. This may be connected for two-wire maintained or three-wire momentary operation.
R/J	Run/Jog Selector. When this terminal is connected to +24 or common (depending upon Active Logic setting), momentarily connecting either FWD or REV to +24 results in a latched run mode (3-wire operation).
MOL	Motor Overload input terminal. This requires a N/O or N/C contact for operation, referenced to +24 or COM, depending on Active Logic setting.

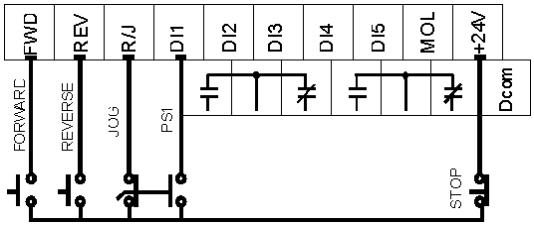
Table 4-8: Description of X4 Control Terminals *(Page 2 of 2)*

Terminal	Description
EN	Enable terminal. A jumper is placed between this terminal and the +24 terminal at the factory. You may replace this with a contact, if desired. The circuit from EN to +24 must be closed for the drive to operate. Note that unlike all other terminals, this terminal cannot be configured for "pull-down logic." That is, a high input to this terminal is always regarded as true, and **must** be present for the drive to operate.
Dcom	Digital Common for use with digital inputs and +24 internal power.
DI1-DI5	Digital inputs. The function of a digital input is configured by the parameter with the same name as the digital input (for example, DI2 is configured by parameter **722 (DI2 Configure**); see page 77).
NC1 NO1 RC1	The first auxiliary relay. The function of the relay is set by parameter **705 (Relay 1 Select)** (see page 76); the default setting is for the relay to activate when a fault occurs (Drv Fault). Terminal NO1 is the normally-open contact, which closes when the relay is activated. Terminal NC1 is the normally-closed contact, which opens when the relay is activated. Terminal RC1 is the common terminal.
NC2 NO2 RC2	The second auxiliary relay. The function of the relay is set by parameter **706 (Relay 2 Select)** (see page 76); the default setting is for the relay to activate when the drive is running (Drv Run). Terminal NO2 is the normally-open contact; it will close when the relay is activated. RC2 is the common terminal.
DO1 DO2	Digital Outputs 1 and 2. The function of the outputs is set by parameters **707 (DO1 Select)** and **708 (DO2 Select)**. The default setting for DO1 is Drive Ready; for DO2 it is At Speed. See page 76.
DOP	Open collector transistor output that supplies a pulse train proportional to speed. The frequency of the output is set by parameter **812 (Freq Ref Output)** to either 6x or 48x the running frequency. The output has a maximum rating of 28 Vdc and requires a pull-up resistor (4.7 kOhms) if using the drive's internal supply. Note that if you are using a high-impedance meter to this terminal, the pull-up resistor value may need to change. Please consult the factory for more information.

4.6.2 Typical Connection Diagrams for Digital Inputs



Typical connection for 2-wire control



Typical connection for 3-wire control

Figure 4-4: Connections for 2-wire and 3-wire Control

Table 4-9: Selection of Preset Speeds

PS3 (Bit 3)	PS2 (Bit 2)	PS1 (Bit 1)	Speed Selected
0	0	0	Normal reference speed as defined by parameters **201 (Input Mode)** and **204 (Ref Select)**
0	0	1	Preset frequency F1 (**303**-F1).
0	1	0	Preset frequency F2 (**304**-F2).
0	1	1	Preset frequency F3 (**305**-F3).
1	0	0	Preset frequency F4 (**306**-F4).
1	0	1	Preset frequency F5 (**307**-F5).
1	1	0	Preset frequency F6 (**308**-F6).
1	1	1	Maximum frequency (**302, Max Frequency**).

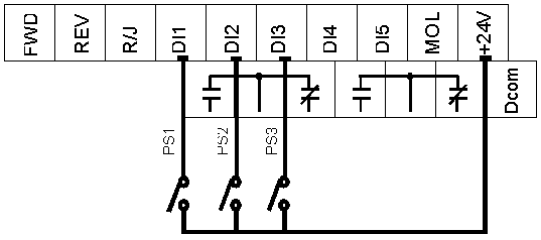


Figure 4-5: Connections for Preset Speeds

4.6.3 Typical Connection Diagrams for Analog Inputs

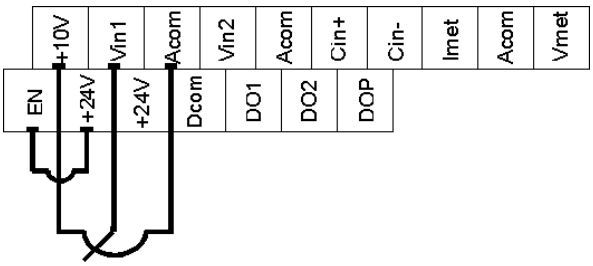


Figure 4-6: Connections for Speed Potentiometer

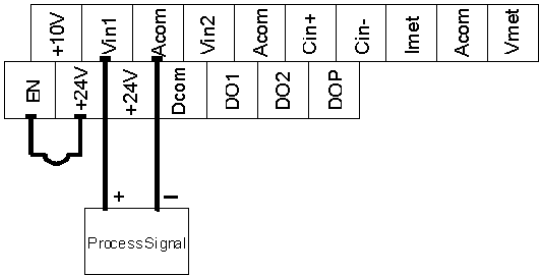


Figure 4-7: Connections for Process Signal

4.6.4 Typical Connection Diagrams for Analog Outputs

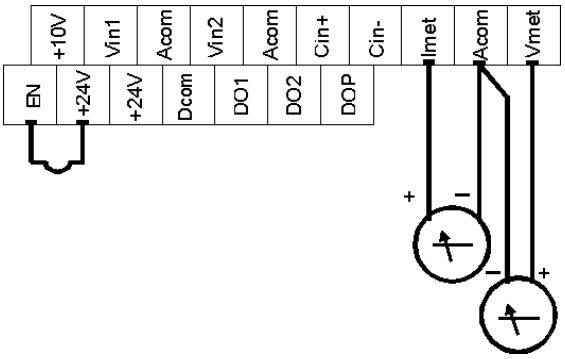
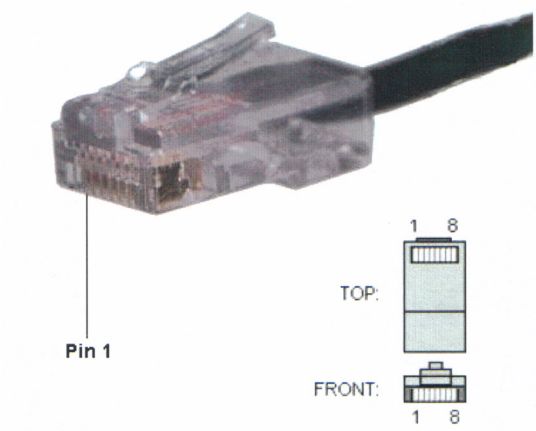


Figure 4-8: Connections for Process Meters

4.6.5 Modbus Connection Diagram



Pin Number	Signal
1	+24 Vdc
2	NC
3	SIO+
4	NC
5	NC
6	SIO-
7	Ground
8	Ground

Figure 4-9: RS-485 Connector (Modbus) Pinout

4.7 Reducing Current Surges and Voltage Transients

Inrush currents to coils of magnetic contactors, relays, and solenoids associated with or near the drive can induce high current spikes in the power and control wiring, causing faulty operation. If this occurs, a snubber network consisting of a series resistor and capacitor for AC loads, or a free-wheeling or flyback diode for DC loads, can be placed across the relay coil to prevent this condition. The following component values should be used for 115 VAC or 230 VAC relays or solenoids.

For Main Circuit Contactors and Solenoids
C = 0.2 MFD, 500 VDC R = 500 5 Watts

For Auxiliary Control Circuit Relays
C = 0.1 MFD, 500 VDC R = 200 2 Watts

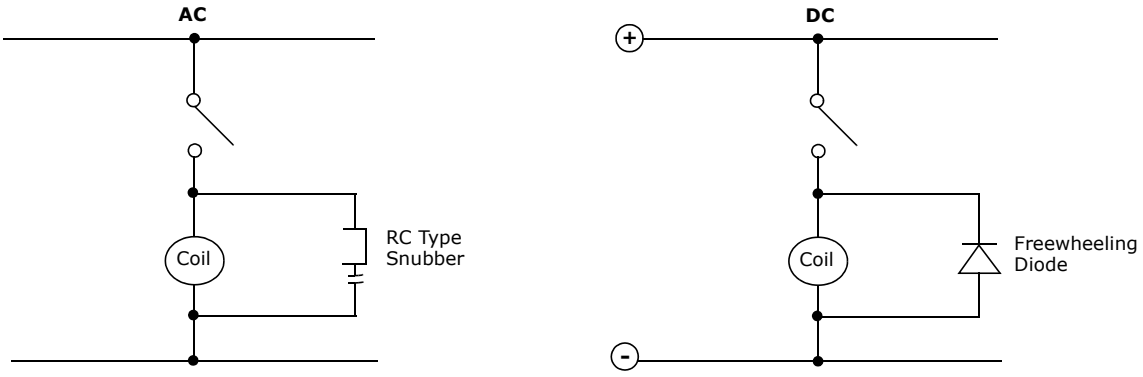


Figure 4-10: Connection Diagram for AC and DC Relay Coils and Solenoids

For magnetic contactors, relays, and solenoids energized from a DC source, use a free-wheeling diode of the high-speed, fast-recovery type. Connect the diode across the coil as shown above in Figure 4-10. The diode current and voltage should be selected using the following formulae:

$$\text{Diode Current Rating (A)} = \frac{\text{Coil Capacity (VA)}}{\text{Rated Voltage of Coil (V)}}$$

$$\text{Diode Voltage Rating} = \text{Rated Voltage of Coil (V)} \times 2$$

Chapter 5: Keypad Operation and Programming

5.1 Introduction

The X4 AC drive is pre-programmed to run a standard, 4-pole AC induction motor. For many applications, the drive is ready for use right out of the box with no additional programming needed. The digital keypad controls all operations of the unit. The ten input keys allow "press and run" operation of the motor (Operation mode) and straightforward programming of the parameters (Program mode)..

Figure 5-1: The X4 Keypad

To simplify programming, the parameters are grouped into three levels:

1. Enter **Level 1** by pressing the Program (PROG) key at any time. Level 1 allows you to access the most commonly used parameters.
2. Enter **Level 2** by holding down the SHIFT key while pressing the PROG key. Level 2 allows access to all X4 parameters, including those in Level 1, for applications which require more advanced features.
3. Enter **Macro mode** by holding the Program (PROG) key down for more than 3 seconds. The display then shows "Hold PROG for Macro Mode." See Chapter 6, "Using Macro Mode," starting on page 49, for more information.

The summary of parameters found before the Table of Contents notes whether a parameter is in Level 1. "Chapter 7: X4 Parameters" on page 59 gives full information about what level a parameter is in.

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter **201** (Input Mode) can be addressed by Modbus address 40201.

Want to get started quickly? See the "Quick Start" section on page 58.

5.2 Keypad Operation

Parameter **201, Input Mode** (see page 62), determines whether the X4 AC drive accepts its Run/Stop and speed commands from the digital keypad or from the input terminals. Table 5-1 describes the function of the keys in Operation mode.

Table 5-1: Function of Keys in Operation Mode (X4 Running or Stopped)

	Initiates forward run when pressed momentarily. If the drive is running in reverse when **FWD** is pressed, it will decelerate to zero speed, change direction, and accelerate to the set speed. The green FWD designation in the key illuminates whenever a FWD command has been given. When both the FWD and REV lights are on, the DC braking function is active.
	Initiates reverse run when pressed momentarily. If the drive is running in forward when **REV** is pressed, it will decelerate to zero speed, change direction, and accelerate to the set speed. The green REV in the key illuminates whenever a REV command has been issued. When both the FWD and REV lights are on, the DC braking function is active.
	Causes a Ramp-to-Stop when pressed. Programmable to Coast-to-Stop by parameter **401, Ramp Select** (page 66). The red STOP indicator in the key illuminates whenever a STOP command has been given. If the drive has stopped because of a fault, this indicator flashes to call attention to the display. The **STOP** key also functions as a fault RESET key.
	Press the **JOG** key to enter Jog mode. The green JOG indicator in the key illuminates when the drive is in the JOG mode of operation. To jog the motor in either direction, press either the **FWD** or **REV** (if REV is enabled in parameter **202**). The motor will operate at the speed programmed in parameter **303**. To exit Jog mode, press the **JOG** key again.
	When the drive is stopped, pressing this key increases the desired running speed. When the drive is running, pressing this key increases the actual running speed in **0.1 Hz increments.** Holding the **SHIFT** key while pressing the **INC** (UP arrow) key moves the decimal place to the left with each press (0.1 Hz, 1.0 Hz, 10.0 Hz increments).
	When the drive is stopped, pressing this key decreases the desired running speed. When the drive is running, pressing the **DEC** (down arrow) key decreases the actual running speed in **0.1 Hz increments.** Holding the **SHIFT** key while pressing the **DEC** key moves the decimal place to the right with each press (10.0 Hz, 1.0 Hz, 0.1 Hz increments). ***NOTE: The operating speed for the drive is stored on Power Down.***
	Pressing this key while a parameter is displayed allows that parameter to have its value changed by use of the INC and DEC (up and down arrow) keys. The P indicator flashes to show that the parameter can be programmed. See also the descriptions for the **INC** and **DEC** keys to see how they work with the **SHIFT** key.
	The **ENTER** key has no function when the drive is running or stopped. **ENTER** can be used to store the speed command so that it is saved through a power-down. To enable this function, see the description for parameter **802** (Start Options) on page 78.
	Whether the drive is running or stopped, pressing this key places the drive in Program mode. See Table 5-2 on page 42 for more information on how this key functions.
	Pressing this key toggles drive control between the LOCal and REMote control modes, as selected by parameter **201** (Input Mode). It can be configured to shift: • the Run/Stop command (either FWD or REV) • the speed reference signal • both of the above It can also be set to "disabled," which is the factory setting. It will operate either in Stop mode or while the drive is running. If power is removed and reapplied, the memory will retain the last selected function.

You can access **Program mode** by stopping the X4 drive and pressing the **Program** (PROG) key for Level 1 access; or holding down **SHIFT** while pressing **PROG** for Level 2 access. Pressing and holding the **Enter** key and then pressing the **Program** key will show only those parameters that have been changed from the factory defaults. Table 5-2 describes the function of the keys in Program mode.

Table 5-2: Function of Keys in Program Mode

	Press this key to have the drive enter Program mode and have Level 1 parameters available. (To access Level 2 parameters, hold down **SHIFT** while pressing this key; to access Macro mode, hold down the **PROG** key for more than 3 seconds.) Once Program mode is active, pressing this key at any time returns the drive to the Operation mode. If an Access Code has been programmed, it must be entered to proceed with programming. See Parameter **811 (Access Code)** (page 79).
	NOTE: *To see what parameters have changed from the factory default, press **ENTER** + **PROG**. If the display flashes "Factory Defaults," no parameters have changed.*
	In the Program mode, pressing this key scrolls **forward** through the parameters. If the P indicator is flashing, it increases the value of the parameter. To change the scroll rate, hold the **SHIFT** key at the same time to increase the scroll rate; release the **SHIFT** key to return to the normal scroll rate. Press the **ENTER** key to store the new value.
	In the Program mode, pressing this key scrolls **backward** through the parameters. If the P indicator is flashing, it decreases the value of the parameter. To change the scroll rate, hold the **SHIFT** key at the same time to increase the scroll rate; release the **SHIFT** key to return to the normal scroll rate. Press the **ENTER** key to store the new value.
	NOTE: *If the P indicator on the keypad display is flashing, momentarily pressing and releasing both the **INC** and **DEC** keys at the same time restores the parameter to the factory default value. Press **ENTER** to store the new value.*
	Pressing this key while a parameter is displayed allows that parameter to have its value changed by use of the **INC** and **DEC** (up and down arrow) keys. The P indicator flashes to show that the parameter can be programmed. See also the descriptions for the **INC** and **DEC** keys to see how they work with the **SHIFT** key.
	This key must be pressed after the value of a parameter has been changed to store the new value. The display will show "stored" for one second indicating that the new value has been entered into memory.
	NOTE: *The X4 unit allows you to view only those parameters that have changed. If you press keypad keys ENTER and PROGram simultaneously, only those parameters that have been changed from the factory defaults will be shown.*

Table 5-3: Function of Keys in Fault Mode

	In Fault mode, pressing the **INC** (up arrow) and **DEC** (down arrow) keys allows the operator to view the drive's status immediately before the fault occurred. Use the **INC** or **DEC** keys to scroll through the status parameters. Press the **STOP** (Reset) key to return to normal operation.
	See "Chapter 8: Troubleshooting" on page 93 for information about viewing Advanced Fault Codes and understanding error codes.
	The red STOP key functions as a reset button when in Fault mode. If the drive has stopped because of a fault, this light flashes to call attention to the display.

5.3 LCD Displays

The X4 drive's digital keypad display provides information such as source of drive control, status, mode, and access rights.

5.3.1 Control

The first 3 characters of the display show the source of control for the drive:

Display Values	Meaning
LOC	Local control via the keypad
REM	Remote control from the terminal strip
SIO	Remote control via the RS485 Serial SIO Link
SQx	Control via the Program Sequencer
MEA	The Stator Resistance Measurement is armed

5.3.2 X4 Keypad Status and Warning Messages

Table 5-4 shows X4 keypad status messages that may appear during operation:

Table 5-4: Keypad Status States *(Page 1 of 2)*

Message	Meaning
Stopped	The drive is not spinning the motor or injecting DC voltage. The drive is ready to run when given the proper signal.
FWD Accel	The drive is spinning the motor in the forward direction and the speed of the motor is increasing.
REV Accel	The drive is spinning the motor in the reverse direction and the speed of the motor is increasing.
FWD Decel	The drive is spinning the motor in the forward direction and the speed of the motor is decreasing.
REV Decel	The drive is spinning the motor in the reverse direction and the speed of the motor is decreasing.
Jog FWD	The drive is jogging in the forward direction.
Jog REV	The drive is jogging in the reverse direction.
FWD At Spd	The drive is spinning the motor in the forward direction and the speed of the motor is at the reference frequency.
REV At Spd	The drive is spinning the motor in the reverse direction and the speed of the motor is at the reference frequency.
Zero Speed	The drive has an active run signal but the motor is not spinning because the reference speed to the drive must be 0.0 Hz.
DC Inject	The drive is injecting DC voltage into the motor.
Faulted	The drive is faulted.
Reset-Flt	The drive is faulted, but has the possibility of being automatically reset.
LS Lockout	Line-Start Lockout functionality has become active. This means there was an active run signal during power-up or when a fault was reset. This run signal must be removed before the Line-Start Lockout functionality will be removed.
Catch Fly	The Catch on the Fly functionality is actively searching for the motor frequency.

Table 5-4: Keypad Status States *(Page 2 of 2)*

Message	Meaning
Forward	The drive is running forward without accelerating, decelerating or residing at the reference frequency. This means that something is keeping the drive from the reference frequency (for example, Current Limit).
Reverse	The drive is running in reverse without accelerating, decelerating or residing at the reference frequency. This means that something is keeping the drive from the reference frequency (for example, Current Limit).
Not Enabled	The drive is not allowed to run either because the digital input enable is not active or because ARCTIC mode has shut down the run operation.
Volt Range	The drive has not met the input voltage voltage requirements that it needs to be able to run. In other words, the Bus Voltage of the drive is either too low or too high.
Low Voltage	The drive has reached an undervoltage state.
Kpd Stop	A stop command was given from the keypad when the keypad was not the active control source. To remove this condition, the run signal to the drive must be removed.

Table 5-5 shows X4 keypad warning messages that may appear during operation:

Table 5-5: Keypad Warnings

Message	Meaning
DB Active	The DB Resistor is being actively pulsed.
Curr Limit	The drive is operating in current limit.
HS Fan Err	Either the heatsink fan should be on and is off, or vice-versa.
Addr XXX	This is the node address of the drive when it receives a valid message through the IR port address to another node. The XXX will be replaced with the node address.
High Temp	The temperature of either the heatsink or the control board is nearing a high temperature limit that will fault the drive.
Low Temp	The temperature of either the heatsink or the control board is nearing a low temperature limit that will fault the drive.
Vac Imblnce	Either the drive has lost an input phase or the input voltage is unbalanced more than 2%.
Power Supp	A power supply short occurred.
Seq Dwell	The sequencer is active, but the transition to the next step is halted.
Int Fan Err	Either the internal fan is on and should be off, or vice-versa.
DB OverTemp	The temperature of the DB Resistor is nearing a high temperature and will fault the drive.
ARCTIC Mode	The ARCTIC DB Resistor mode is actively pulsing the DB Resistor.
CPU Warning	A system error occurred in the software of the X4.
Mtr Measure	An RS Measurement is armed or active.
IR Active	Valid IR communications are occurring.
Seq Running	The program sequencer functionality is active.

5.3.3 Rights

After Program mode is entered, the operator's access rights are displayed:

Display Values		
ACCESS RIGHTS	**P**	This indicates that while in Programming mode, parameter data can be changed.
	V	If the drive is in Run mode (FWD or REV) when the PROG key was pressed, parameters can be viewed, but not changed.
	The first character of the second line indicates if the particular parameter can be changed **(P)** or only examined **(V)**. If an attempt is made to change data while in the View (V) mode, the message ****NO ACCESS**** will appear for one second.	

5.3.4 Other Data

The top line gives 16-character description of the parameter being accessed. The parameter number will flash when data is being changed. Up to 10 characters are used to display the information stored in the parameter. Some parameters have a unit designator such as:

s Seconds
h Hours
C Degrees centigrade
Hz Hertz
% Percent
A Amperes

When the drive stops because of a fault trip, a unique error message will be displayed, along with the flashing STOP indicator. "Pages," or screens of information are available concerning the actual fault and drive status.

"Chapter 8: Troubleshooting" on page 93 gives information about fault codes and troubleshooting.

5.4 Keypad Display Window

The keypad display provides information on drive operation and programming. Special symbols provide further information about drive operation (see the following section). Figure 5-2 shows an example of the X4 keypad display.

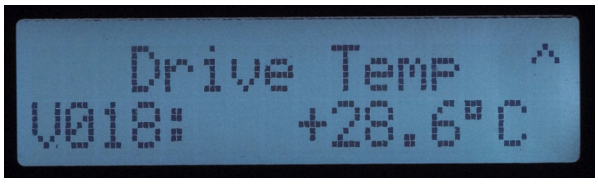


Figure 5-2: X4 Keypad Display

5.5 Programming

5.5.1 Accessing Parameters

When PROG (or SHIFT+PROG) is pressed after application of power or a fault reset, parameter **201, Input Mode,** is always the first parameter displayed. Figure 5-3 shows a typical programming display.

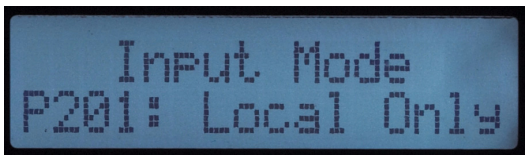


Figure 5-3: Typical Programming Display

If a different parameter is accessed and Program mode is exited, that parameter is the first one displayed the next time Program mode is entered. The drive remembers a different "last parameter accessed" for Levels 1 and 2.

5.5.2 Changing the Display Scroll Rate

Pressing the **INC** or **DEC** keys (up or down arrows) causes the display to scroll at a slow rate. To increase the scroll rate, hold the **SHIFT** key at the same time that you press the **INC** key. Release the **SHIFT** key to return to the slow scroll rate. This procedure works in all programming and operation modes.

5.5.3 Programming Procedure

To program the value of a parameter, follow these steps:

1. Press the Program (**PROG**) key to enter Level 1 Program mode. To enter Level 2, press **SHIFT+PROG**. The P indicator will appear on the display. You must enter one level of programming or the other; you cannot switch between levels without exiting Program mode.

   *Note that some parameters cannot be changed in Run mode. For example, if you wish to program parameter **201, Input Mode**, you must stop the drive before beginning programming. Refer to the Parameter Summary Table at the front of this manual to see which parameters cannot be changed in Run mode (they appear as shaded entries in the table).*

2. Press the **INC** or **DEC** keys to access the desired parameter.
3. Press the **SHIFT** key to allow the value to be changed. The P indicator starts to blink.
4. Press the **INC** or **DEC** keys to select the new value.
5. Press the **ENTER** key to store the new value. The display shows "Stored" for one second.
6. Press the **PROG** key to exit the Program mode, or the **INC** or **DEC** keys to select a new parameter.

To program a text parameter, follow these steps:

1. Like other parameters, text parameters use the **INC/DEC** (up/down arrow) and **SHIFT** keys for editing. A line appears under the character that you are changing.
2. Press **SHIFT** to advance to the next character that you want to change.
3. Use the **INC** or **DEC** keys to change the character value.
4. Press **ENTER** to store the edited text.

5.5.4 Restoring Factory Settings

Whenever a parameter's value is being changed (noted by the P indicator flashing), the original factory setting for that parameter may be restored by pressing and releasing both the **INC** and **DEC** keys simultaneously and then pressing the **ENTER** key.

To restore ALL parameters to factory settings, or to recall a previously stored parameter set, see parameter **801, Program Number** (page 77).

5.5.5 Viewing Parameters That Have Changed

The X4 unit allows you to view only those parameters that have changed. If you press the **ENTER** and **PROG** keys simultaneously, only those parameters that have been changed from the factory defaults will be shown. Note that all parameters, regardless of Level 1 or 2 default location, will be shown. If other parameters need to be changed, press the **PROG** key to exit this mode in either Level 1 or 2, as needed.

5.5.6 Using Macro Mode

A special Macro programming mode is available with the X4 series of AC drives. The Macro programming mode allows you to customize the most common parameters for your application in the Level 1 group. Macro mode provides special parameters for activating modes of operation by macros, program sequencer, or serial communications.

Parameters that are important to the drive's operation are also included in the Macro mode. Although these parameters are also available with standard programming, the Macro mode allows you to quickly and easily configure the drive with essential parameters.

See "Chapter 6: Using Macro Mode and Getting a Quick Start" on page 49, for detailed information about using macros to program the X4 drive.

5.6 Measuring Stator Resistance (RS Measurement)

5.6.1 Activating Automatic RS Measurement Using the Keypad

1. Make sure there is no load applied to the motor and that the motor shaft is free to spin without damage or injury.
2. Enter the Macro programming mode of the X4 keypad by pressing and holding the PROG key until the parameter "Appl Macro" appears on the keypad. This takes about two seconds.
3. Scroll through the parameters of the X4 Macro programming mode and configure the following parameters to the data provided on the nameplate of the motor:
   - Rated Volt (**509**)
   - Rated Mtr FLA (**510**)
   - Rated Mtr RPM (**511**)
   - Power Factor (**515**)
4. Change parameter "Find Mtr Data" (parameter **519**) to a value of "Motor RS." At this point, the RS Measurement will be armed.
5. Exit the Macro programming mode by pressing the **PROG** key.
6. The Operate screen shows in two ways that an RS Measurement is ready to be made. First, the Control path status field displays "MEA." Second, a "Mtr Measure" warning flashes, both of these signifying that a measurement is about to be taken.

7. Start the RS Measurement by pressing the **FWD** key. The measurement can only be made with the **FWD** key. The FWD / REV terminals and the **REV** key will not work.
8. The measurement will begin as the drive injects voltage to the motor at zero frequency. The test lasts about two seconds.
9. If the test was successful, the drive will stop and return to the configured control path. The "Motor RS" parameter will contain a new value that is the calculated resistance of the motor.
10. If the test was not successful, the drive will fault with a "RS Meas. Fail" message (Fault 34). If the test fails, you may want to try the test again with a different "Rated Mtr FLA" or different Current Limit percentage.
11. If the measurement process fails for any reason, it is possible to physically measure motor resistance by using an ohmmeter and dividing the result by 2. Then enter this value manually into parameter **514** (Motor RS).

5.6.2 Activating Automatic RS Measurement via Serial Link (Modbus)

1. Make sure there is no load applied to the motor and that the motor shaft is free to spin without damage or injury.
2. Configure the following parameters to the data provided on the nameplate of the motor:
   - Rated Volt (**509**)
   - Rated Mtr FLA (**510**)
   - Rated Mtr RPM (**511**)
   - Power Factor (**515**)
3. Change parameter "Find Mtr Data" (**519**) to a value of "Motor RS." At this point, the RS Measurement will be armed.
4. Start the RS Measurement by writing a value of 0x0007 to parameter "SIO Cntl Word" (**904**).
5. The measurement begins as the drive injects voltage to the motor at zero frequency. The test lasts about two seconds.
6. If the test was successful, the drive will stop and return to the configured control path. The "Motor RS" parameter will contain a new value that is the calculated resistance of the motor.
7. If the test was not successful, the drive will fault with a "RS Meas. Fail" message (Fault 34). If the test fails, you may want to try the test again with a different "Rated Mtr FLA" or different Current Limit percentage.
8. If the measurement process fails for any reason, it is possible to physically measure motor resistance by using an ohmmeter and dividing the result by 2. Then enter this value manually into parameter **514** (Motor RS).

Chapter 6: Using Macro Mode and Getting a Quick Start

A special Macro programming mode is available with the X4 series of AC drives. The Macro programming mode allows you to customize quickly the most common parameters for your application in the Level 1 group. Macro mode provides special parameters for activating modes of operation by macros, program sequencer, or serial communications.

Parameters important to the drive's operation are also included in Macro mode. Although these parameters are also available with standard programming, the Macro mode allows you to easily configure the drive with essential parameters.

Macros configure what advanced functions will be active in the drive. A macro can also change the default or visibility of a parameter within the programming levels. **Parameter 490 (Appl Macro)** configures what macro will be active in the drive. **Parameter 491 (Seq Appl)** configures the visibility of sequencer parameters and the time base of the sequencer. **Parameter 492 (SIO Visible)** configures whether or not SIO parameters are visible. (See page 50.)

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter **201** (Input Mode) can be addressed by Modbus address 40201.

6.1 Entering Macro Mode

To enter the Macro mode, press and hold the PROGram key for more than three seconds. The drive then enters Macro mode and displays "Hold PROG for Macro Mode." Following is a list of the different macros available and their features. A description of parameters used in Macro mode begins on page 50.

Factory	The Factory macro provides a simple way to restore the factory default parameter listings.
Fan	The Fan macro provides a basic set-up for Fan applications. Parameters such as the V/Hz curve and terminal strip operation are available in Level 1 programming.
Fan w/ PI	The Fan w/ PI macro allows for a simple set-up for Fan applications requiring process control. Parameters such as the V/Hz curve, terminal strip operation, and PI configuration parameters are available in Level 1 programming.
Pump	The Pump macro provides a basic set-up for Pump applications. Parameters such as the V/Hz curve and terminal strip operation are available in Level 1 programming.
Pump w/ PI	The Pump w/ PI macro allows for a simple set-up for Pump applications requiring process control. Parameters such as the V/Hz curve, terminal strip operation, and PI configuration parameters are available in Level 1 programming.
Vector	The Vector macro activates the sensorless vector control algorithm. When an operation requires low speed and high torque, this macro should be activated.

6.2 Description of Parameters Used in Macro Mode

Parameters **490, 491, and 492** are used only in the Macro mode. Parameters **509, 510, 511, 801, and 810** are used in both Macro and Level 2 programming. X4 parameters are described in "Chapter 7: X4 Parameters" on page 59 of this manual.

490 Appl Macro	Default: Factory	Range: text string Macro

This parameter configures what macro will be active in the drive. A macro will change a default or visibility of a parameter.

The following data values may be assigned to this parameter:

Macro	Description
Factory	Provides a simple way to restore factory default parameter listings.
Fan	Provides a basic set-up for Fan applications, including V/Hz curve and terminal strip operation in Level 1 programming.
Fan w/PI	Provides a simple set-up for Fan applications that require process control. Parameters such as V/Hz curve, terminal strip operation, and PI configuration are available in Level 1 programming.
Pump	Provides a basic set-up for Pump applications, including V/Hz curve and terminal strip operation in Level 1 programming.
Pump w/PI	Provides a simple set-up for Pump applications requiring process control. Parameters such as V/Hz curve, terminal strip operation, and PI configuration are available in Level 1 programming.
Vector	Activates the sensorless vector control algorithm. When an operation requires low speed and high torque, this macro should be activated. Note that in Vector control, the drive automatically runs the Motor Rs measurements when leaving PROGram mode.

491 Seq Appl	Default: Disabled	Range: text string Macro

This parameter configures sequencer parameters are visible and the time base of the sequencer. The time base may change depending on the timing loops used.

The following data values may be assigned to this parameter:

Macro Value	Description
Disabled	Sequencer disabled and parameters hidden.
1sec Base	Sequencer enabled and 1 second time base.
.1sec Base	Sequencer enabled and 0.1 second time base.
.01sec Base	Sequencer enabled and 0.01 second time base.

492 SIO Visible	Default: No	Range: text string Macro

This parameter configures whether SIO parameters are visible.

The following data values may be assigned to this parameter:

Macro Value	Description
No	SIO parameters hidden.
Yes	SIO parameters visible.

509 Rated Mtr Volt	Default: Model dependent	Range: 100 V - 690 V Level 2, Macro

The Rated Motor Voltage parameter configures the rated motor voltage, and allows a user to enter the rated voltage from the motor nameplate to provide optimal control and protection. This is usually the amount of voltage delivered to the motor terminals at the setting of parameter **503 (V/Hz Knee Freq**).

510 Rated Mtr FLA	Default: ND Rating	Range: 50% of ND rating - 200% of ND rating Level 2, Macro

The Rated Motor FLA parameter allows a user to enter the rated FLA from the motor nameplate to provide optimal control and protection. This parameter should be configured to the value on the nameplate of the motor, as that value is used in calculating the percentage of current at which the drive is operating.

For information on motor timed overload operation, and how parameter **510** works with it, see page 74.

511 Rated Mtr RPM	Default: 1750 rpm	Range: 0-24000 rpm Level 2, Macro

This parameter replaces the slip compensation parameter setting of the drive so the user does not need to calculate it.

514 Motor RS	Default: Model-dependent	Range: 0.00-655.35 Ohms Level 2

This parameter allows direct entry of the Stator Resistance (Rs) of the motor for better vector performance. The motor manufacturer can provide this information, or you can physically measure this value with an ohmmeter. From the line-to-line measurement of motor resistance, enter half the measured value. See "Measuring Stator Resistance (RS Measurement)" on page 47.

515 Power Factor	Default: 0.80	Range: 0.50 - 1.00 Level 2

This parameter allows direct entry of the motor's power factor for better vector performance. The motor manufacturer can provide this information.

519 Find Mtr Data	Default: Not Active	Range: text string Macro

This parameter activates the drive's ability to measure the stator resistance of the attached motor. The automatic stator resistance measurement can be performed either through the keypad or through the serial link. See "Measuring Stator Resistance (RS Measurement)" on page 47 for more information about this parameter. The following data values may be assigned:

Parameter Value	Description
Not Active	No stator RS measurement.
Motor RS	Automatic RS measurement using macro procedure.

801 Program Number	Default: 0	Range: 0 to 9999 Level 2, Macro

This parameter (Special Program Number) provides a method of enabling hidden functions in the drive and storing parameters to the customer set.

Data Value	Special Function Configured
0	Standard program
1	Reset all parameters to factory default values (display = SETP).
2	Store customer parameter values (display = STOC).
3	Load customer parameter values (display = SETC).
4	Swap active parameters with customer stored settings.

810 Language	Default: English	Range: text string Level 2, Macro

This parameter configures the language in which text strings will be displayed.

The following data values may be assigned to this parameter:

Parameter Value
English
Spanish
German
Italian
French

6.3 Macro Mode Applications and Included Parameters

The tables below list the different applications and the Level 1 parameters included in the macro for that application. The Factory Application macro is the core package (listed in Table 6-1); the other macros include the Factory Application macro parameters as well as the ones listed in their respective tables (Tables 6-2, 6-3, 6-4, 6-5, and 6-6). The macro mode applications are as follows:

Factory Application (Table 6-1)

Fan Application (Table 6-2)

Fan with PI Application (Table 6-3)

Pump Application (Table 6-4)

Pump with PI Application (Table 6-5)

Vector Application (Table 6-6)

Table 6-1: Factory Application Macro

Para. #	Parameter Name	Default	See Page
001	Model Number	Read-only	60
010	Last Fault	Read-only	60
102	Output Freq	Read-only	61
103	Output Voltage	Read-only	61
104	Output Current	Read-only	61
105	Drive Load	Read-only	61
106	Load Torque	Read-only	61
107	Drive Temp	Read-only	61
111	DC Bus Voltage	Read-only	61
201	Input Mode	Local Only	62
202	Rev Enable	Forward	62
301	Min Frequency	0.0 Hz	65
302	Max Frequency	60.0 Hz	65
303	Preset Freq 1	5.0 Hz	65
402	Accel Time 1	5.0 sec	66
403	Decel Time 1	5.0 sec	66
502	Voltage Boost	0.0%	69
610	Timed OL Select	Std Ind 60s	74
700	Vmet Config	Freq Out	75
705	Relay 1 Select	Drv Fault	76
706	Relay 2 Select	Drive Run	76

Table 6-2: Fan Application Macro *(Core Factory Application from Table 6-1, **plus** the following parameters)*

Para. #	Parameter Name	Default	See Page
203	Stop Key Remote	Coast	62
204	Ref Select	Vin1	63
205	Vin1 Config	0-10 V	63
206	Vin1 Offset	0.00%	63
207	Vin1 Span	100.00%	64
406	DC Inject Config	DC at Start	67
501	V/Hz Select	Fan Fixed	69
504	Skip Freq Band	0.2 Hz	70
505	Skip Freq 1	0.0 Hz	70
608	Restart Number	0	74
609	Restart Delay	60 sec	74
702	Imet Config	Current Out	75
703	Imet Span	100.0%	75
704	Imet Offset	0.0%	75
721	DI1 Configure	Preset 1	77
722	DI2 Configure	Preset 2	77
723	DI3 Configure	Preset 3	77
724	DI4 Configure	Ref Switch	77
725	DI5 Configure	Fault Reset	77
803	PWM Frequency	16.0 kHz	78
804	Display Mode	Output Freq	78

Table 6-3: Fan with PI Application Macro *(Core Factory Application from Table 6-1, **plus** the following parameters)*

Para. #	Parameter Name	Default	See Page
203	Stop Key Remote	Coast	62
204	Ref Select	Vin1	63
205	Vin1 Config	0-10 V	63
206	Vin1 Offset	0.00%	63
207	Vin1 Span	100.00%	64
208	Cin Config	0-20 mA 50	64
209	Cin Offset	0.0%	64
210	Cin Span	100.0%	64
211	Vin2 Config	0-10 V	64
212	Vin2 Offset	0.00%	64
213	Vin2 Span	100.00%	64
401	Ramp Select	ART-DI	66
406	DC Inject Config	DC at Start	67
501	V/Hz Select	Fan Fixed	69
504	Skip Freq Band	0.2 Hz	70
505	Skip Freq 1	0.0 Hz	70
608	Restart Number	0	74
609	Restart Delay	60 sec	74
702	Imet Config	Current Out	75
703	Imet Span	100.0%	75
704	Imet Offset	0.0%	75
721	DI1 Configure	Preset 1	77
722	DI2 Configure	Preset 2	77
723	DI3 Configure	Preset 3	77
724	DI4 Configure	Ref Switch	77
725	DI5 Configure	PI Enable	77
803	PWM Frequency	16.0 kHz	78
804	Display Mode	Output Freq	78
850	PI Configure	No PI	80
851	PI Feedback	Vin1	80
852	PI Prop Gain	0	80
853	PI Int Gain	0	81
854	PI Feed Gain	1000	81
857	PI High Corr	100.00	81
858	PI Low Corr	0.00%	81

Table 6-4: Pump Application Macro *(Core Factory Application from Table 6-1, **plus** the following parameters)*

Para. #	Parameter Name	Default	See Page
203	Stop Key Remote	Coast	62
204	Ref Select	Vin1	63
205	Vin1 Config	0-10 V	63
206	Vin1 Offset	0.00%	63
207	Vin1 Span	100.00%	64
401	Ramp Select	ART-DI	66
501	V/Hz Select	Pump Fxd	69
608	Restart Number	0	74
609	Restart Delay	60 sec	74
702	Imet Config	Current Out	75
703	Imet Span	100.0%	75
704	Imet Offset	0.0%	75
721	DI1 Configure	Preset 1	77
722	DI2 Configure	Preset 2	77
723	DI3 Configure	Preset 3	77
724	DI4 Configure	Ref Switch	77
725	DI5 Configure	Fault Reset	77
803	PWM Frequency	16.0 kHz	78
804	Display Mode	Output Freq	78

Table 6-5: Pump with PI Application Macro *(Core Factory Application from Table 6-1, **plus** the following parameters)*

Para. #	Parameter Name	Default	See Page
203	Stop Key Remote	Coast	62
204	Ref Select	Vin1	63
205	Vin1 Config	0-10 V	63
206	Vin1 Offset	0.00%	63
207	Vin1 Span	100.00%	64
208	Cin Config	0-20 mA 50	64
209	Cin Offset	0.0%	64
210	Cin Span	100.0%	64
211	Vin2 Config	0-10 V	64
212	Vin2 Offset	0.00%	64
213	Vin2 Span	100.00%	64
401	Ramp Select	ART-DI	66
406	DC Inject Config	DC at Stop	67
501	V/Hz Select	Pump Fxd	69
504	Skip Freq Band	0.2 Hz	70
505	Skip Freq 1	0.0 Hz	70
608	Restart Number	0	74
609	Restart Delay	60 sec	74
702	Imet Config	Current Out	75
703	Imet Span	100.0%	75
704	Imet Offset	0.0%	75
721	DI1 Configure	Preset 1	77
722	DI2 Configure	Preset 2	77
723	DI3 Configure	Preset 3	77
724	DI4 Configure	Ref Switch	77
725	DI5 Configure	PI Enable	77
803	PWM Frequency	16.0 kHz	78
804	Display Mode	Output Freq	78
850	PI Configure	No PI	80
851	PI Feedback	Vin1	80
852	PI Prop Gain	0	80
853	PI Int Gain	0	81
854	PI Feed Gain	1000	81
857	PI High Corr	100.00	81
858	PI Low Corr	0.00%	81

Table 6-6: Vector Application Macro *(Core Factory Application from Table 6-1, **plus** the following parameters)*

Para. #	Parameter Name	Default	See Page
501	V/Hz Select	Vector	69
509	Rated Mtr Volt	Model dependent	70
510	Rated Mtr FLA	ND rating	70
511	Rated Mtr RPM	1750 rpm	70
514	Motor RS	Model dependent	70
515	Power Factor	0.8	70
516	Slip Comp Enable	No	71
519	Find Mtr Data	Not Active	71
520	Filter FStator	8 mS	71
521	Start Field En	No	71
522	Filter Time Slip	100 mS	71
523	Id Percent	Read-only	72
524	Iq Percent	Read-only	72
803	PWM Frequency	3.0 kHz	78
804	Display Mode	Std Display	78

6.4 Quick Start

The following procedure is for operators using simple applications, who would like to get started quickly. *Be sure to read and understand all the sections in this chapter before proceeding with these instructions.* If you are using remote operators, substitute the speed potentiometer for the **INC** and **DEC** keys (up and down arrows), and the remote Run/Stop switch for the **FWD** key in the following instructions.

⚠ CAUTION

IMPROPER EQUIPMENT COORDINATION

Verify that proper voltage is connected to the drive before applying power.

Failure to observe this instruction can result in injury or equipment damage.

⚠ ATTENTION

MAUVAISE COORDINATION DES APPAREILS

Vérifiez que l'onduleur est raccordée à la bonne tension avant de le mettre sous tension.

Si cette directive n'est pas respectée, cela peut entraîner des blessures corporelles ou des dommages matériels.

1. Follow all precautions and procedures in "Chapter 3: Receiving and Installation" on page 20.
2. Find the motor nameplate, and using parameters **509 (Rated Mtr Volt)**, **510 (Rated Mtr FLA)**, **511 (Rated Mtr RPM)**, and **515 (Power Factor)**, set up the motor parameters appropriately. Parameter **514 (Motor RS)** should also be set up accurately so the drive can run its routine to measure motor stator resistance. (See "Measuring Stator Resistance (RS Measurement)" on page 47.)
3. Apply AC power to the input terminals. For about 2 seconds the display will show all segments active. The display then changes to zeros.
4. The factory settings are for keypad-only operation in the forward direction—that is, the **REV** key is disabled. Press the **FWD** key, which causes the FWD indicator to illuminate.
5. Press the **INC** key to increase the desired running frequency. When the display gets to 0.1 Hz, the drive starts to produce an output.
6. When the motor starts to turn, check the rotation. If the motor is turning in the wrong direction, *press **STOP**, remove AC power, and wait for all indicators to go out*. After the STATUS indicator has gone out, reverse any two of the motor leads at T1/U, T2/V, or T3/W.
7. The X4 drive is preset to run a typical NEMA B 4-pole induction motor to a maximum speed of 60.0 Hz with both acceleration and deceleration times set to 5.0 seconds.
8. Use the **INC** and **DEC** keys to set the proper running speed of the motor and the **FWD** and **STOP** keys to control its operation.

Note that the X4 external cooling fans operate continuously for the first five minutes of power-up time; after this point, they operate only as needed to control the operating temperature of the drive.

Chapter 7: X4 Parameters

7.1 Introduction

The X4 AC drive incorporates a comprehensive set of parameters that allow you to configure the device to meet the requirements of your particular application.

Note that pressing the **PROG** key enters Level 1 programming. Press **SHIFT+PROG** to enter Level 2 programming. Press **ENTER+PROG** to show only those parameters that have changed from the factory default values.

This chapter describes the available parameters and the values that may be assigned to them. The parameter summary table at the front of this manual provides a summary of all parameters including their ranges and default values.

Note that all parameters can be addressed by adding 40000 to the parameter number. For example, parameter **201** (Input Mode) can be addressed by Modbus address **40201**.

7.2 Level 1 Parameters

The most commonly configured X4 parameters are stored in a group named Level 1. This group is easily accessed by pressing the **PROG** key as described in "Chapter 5: Keypad Operation and Programming" on page 40. The following table lists the parameters in this group; for further information on the parameter, please turn to the indicated page.

Table 7-1: Parameters Available in Level 1 Programming (Factory Macro)

Para. #	Parameter Name	See Page	Para. #	Parameter Name	See Page
001	Model Number	60	303	Preset Freq 1	65
010	Last Fault	60	402	Accel Time 1	66
102	Output Freq	61	403	Decel Time 1	66
103	Output Voltage	61	502	Voltage Boost	69
104	Output Current	61	610	Timed OL Select	74
105	Drive Load	61	700	Vmet Config	75
106	Load Torque	61	705	Relay 1 Select	76
107	Drive Temp	61	706	Relay 2 Select	76
111	DC Bus Voltage	61			
201	Input Mode	62			
202	Rev Enable	62			
301	Min Frequency	65			
302	Max Frequency	65			

7.3 Description of Parameters

Table 7-2 lists the X4 parameters in the order in which they appear in the keypad display. For each parameter, the table lists the default value and range and also describes the use of the parameter.

Table 7-2: Description of X4 Parameters *(Page 1 of 25)*

001 Model Number	Read-Only	Range: text string Level: 1,2
Parameter **001**, the **Model Number** parameter, contains the portion of the X4 model number related to voltage and horsepower. The number format is *vvhhf*, where *vv* is the code for the input voltage (19=115 Vac single-phase; 20=230 Vac, three-phase; 40=460 Vac, three-phase; 50=575 Vac, three-phase); *hh* is horsepower; and *f* is the fractional part of the horsepower. Example: **20020** = 230 Vac, three-phase, 2.0 HP model.		
002 Software Rev	Read-Only	Range: 0.00-99.99 Level: 2
Parameter **002,** the **Software Revision** parameter, displays the software revision that is installed in the drive. **Options:** 0.00-99.99		
003 Rated Current	Read-Only	Range: 0.0-200.0 A Level: 2
Parameter **003,** the **Rated Current** parameter, displays the normal duty current rating of the model of drive.		
005 Serial No 1	Read-Only	Range: 0-65535 Level: 2
Parameter **005, Serial No 1**, contains a number that corresponds to the year and week in which the drive was manufactured.		
006 Serial No 2	Read-Only	Range: 0-65535 Level: 2
Parameter **006, Serial No 2**, contains a number that determines the number of the drive that was manufactured during the week of Serial No 1. **Options:** 0.00-99.99		
010 Last Fault	Read-Only	Range: text string Level: 1,2
Parameter **010, Last Fault**, lists the fault that occurred most recently. For more information, refer to Chapter 8, Troubleshooting, beginning on page 93.		
025 4th Fault	Read-Only	Range: text string Level: 2
Parameter **025, 4th Fault**, lists the fault that occurred 1 before the last fault. For more information, refer to Chapter 8, Troubleshooting, beginning on page 93.		
040 3rd Fault	Read-Only	Range:text string Level: 2
Parameter **040, 3rd Fault**, lists the fault that occurred 2 before the last. For more information, refer to Chapter 8, Troubleshooting, beginning on page 93.		
055 2nd Fault	Read-Only	Range: text string Level: 2
Parameter **055, 2nd Fault**, lists the fault that occurred 3 before the last. For more information, refer to Chapter 8, Troubleshooting, beginning on page 93.		
070 1st Fault	Read-Only	Range:text string Level: 2
Parameter **070, 1st Fault**, lists the fault that occurred 4 before the last. For more information, refer to Chapter 8, Troubleshooting, beginning on page 93.		

Table 7-2: Description of X4 Parameters *(Page 2 of 25)*

102 Output Freq	Read-Only	Range: 0.0 to 400.0 Hz Levels 1,2
Parameter **102**, the **Output Frequency** parameter, shows the frequency being applied to the motor connected to the drive (ramp).		
103 Output Voltage	Read-Only	Range: 0 to 600 V Levels 1,2
Parameter **103**, the **Output Voltage** parameter, displays the output voltage of the drive.		
104 Output Current	Read-Only	Range: 0.0 to 200.0 A Levels 1,2
Parameter **104**, the **Output Current** parameter, displays the output current of the drive.		
105 Drive Load	Read-Only	Range: -200.0% to 200.0% Levels 1,2
Parameter **105**, the **Drive Load** parameter, shows the percentage torque of the drive when operating below the knee frequency. It displays Load Torque if the frequency is below FKNEE, and displays Power if above FKNEE. The output current is measured with the motor power factor applied to an accuracy of ±20%.. The parameter value is positive when the motor is pulling a load ("motoring mode") and negative when being pulled by a load ("regenerative mode").		
106 Load Torque	Read-Only	Range: -200.0%-200.0% Levels 1,2
Parameter **106**, the **Load Torque** parameter, displays the load torque of the drive.		
107 Drive Temp	Read-Only	Range: -20.0 to 200.0 °C Levels 1,2
Parameter **107**, the **Drive Temp** parameter, shows the actual temperature of the drive's heatsink. The drive will fault when the internal temperature reaches 85°C.		
108 Total Run Time	Read-Only	Range: 0.0 - 6553.5 h Level: 2
Parameter **108**, **Total Run Time**, is a resettable timer for drive operation. To reset the timer, enter 10 in parameter **801, Program Number**.		
109 Power On Hours	Read-Only	Range: 0 - 65535 h Level: 2
Parameter **109**, **Power On Hours**, displays how long the drive has been powered up.		
110 Stator Freq	Read-Only	Range: 0.0-400.0 Hz Level: 2
Parameter **110**, **Stator Frequency**, displays the frequency the drive is applying to the motor stator.		
111 DC Bus Voltage	Read-Only	Range: 0-1000 Vdc Level: 1,2
Parameter **111**, **DC Bus Voltage**, displays the voltage on the DC bus.		
115 Drive Power Out	Read-Only	Range: 0.0%-200.0% Level: 2
This parameter displays the power being output by the drive in terms of drive rating. The measurement is calculated by scaling the Load Torque value by the ratio of Volt-Amps to Rated Volt-Amps, and adjusted by Output Frequency.		

Table 7-2: Description of X4 Parameters *(Page 3 of 25)*

201 Input Mode	Default = Local only	Range: text string Levels 1,2

Parameter **201**, the **Input Mode** parameter, configures local and remote control of the Start/Stop source and the reference source. Refer to "Appendix A: Parameter 201 Options" on page 99, for more information.

The following data values may be assigned to this parameter:

Parameter Value	Run/Stop Control
Local only	Local keypad operation only
Remote only	Terminal strip operation only
L/R Rem Ref	LOCal Keypad Start/Stop and Speed REMote Keypad Start/Stop, Terminal Strip Speed Reference
L/R Rem Ctl	LOCal Keypad Start/Stop and Speed REMote Keypad Speed Reference, Terminal Strip Start/Stop
L/R Rem Bth	LOCal Keypad Start/Stop and Speed REMote Terminal Strip Start/Stop and Speed Reference
EMOP{1} {2} {4}	Terminal strip operation using Increase/Decrease buttons
EMOP2{1} {3} {4}	Terminal strip operation using Increase/Decrease buttons
LOC/EMOP{1} {2} {4}	LOCal Keypad Start/Stop and Speed REMote Terminal strip operation using Increase/Decrease
LOC/EMOP2{1} {3} {4}	LOCal Keypad Start/Stop and Speed REMote Terminal strip operation using Increase/Decrease

Notes:

1. Electronic Motor Operated Potentiometer (EMOP): simulates the **INC / DEC** keys on keypad using external remote N/O pushbuttons
2. Commanded output frequency returns to the value of parameter **301 (Min Frequency)** when the drive is stopped.
3. Commanded output frequency remains at the previous setpoint when the drive is stopped.
4. The parameters that set the functions of the designated digital inputs for EMOP must be configured as "EMOP+" and "EMOP–" to complete the implementation.

202 Rev Enable	Default = Forward	Range: text string Levels 1,2

Parameter **202,** the **Rev Enable** parameter, configures whether the REV key on the keypad is functional. If this parameter is configured to "Forward," then pressing the REV key on the keypad will have no effect. Note that this parameter does not affect terminal strip operation.

The following data values may be assigned to this parameter:

Parameter Value	Description
Forward	Forward Only, REV key disabled
FWD/REV	FWD and REV keys enabled

203 Stop Key Remote	Default = Coast	Range: text string Level: 2

Parameter **203,** the **Stop Key Remote** parameter, configures how the Stop key on the keypad will operate when the keypad is not the drive's control source (terminals, SIO, or SEQ).

The following data values may be assigned to this parameter:

Parameter Value	Description
Coast	Drive will coast to a stop
Ramp	Drive will ramp to a stop using Decel #1
Disabled	Stop key will have no function

Table 7-2: Description of X4 Parameters *(Page 4 of 25)*

204-Ref Select	Default = Vin1	Range: text string Level: 2

Parameter **204**, the **Ref Select** parameter, configures how the reference is determined when the reference source is configured to terminals.

The following data values may be assigned to this parameter:

Parameter Value	Description
Vin1	Vin1 terminal (configured by parameter 205)
Cin	Cin terminal (configured by parameter 208)
Vin2	Vin2 terminal (configured by parameter 211)
Vin1 6FS{3}	Vin1 terminal with 6x pulse train from an X4, WFC, WF2 drive
Vin1 48FS{3}	Vin1 terminal with 48x pulse train from an X4, WFC, WF2 drive
Vin1+Cin	Sum of signal at Vin1 and the signal at Cin
Vin1+Vin2	Sum of signal at Vin1 and the signal at Vin2
Vin1-Cin	Difference between the signal at Vin and the signal at Cin
Vin1-Vin2	Difference between the signal at Vin and the signal at Vin2
Max Input{2}	Greatest signal between Vin, Vin2 and Cin
Vin1/Cin DI{1}	Switch between Vin and Cin using a Digital Input
Vin1/2 DI{1}	Switch between Vin and Vin2 using a Digital Input
Vin1/KYP DI{1}	Switch between Vin and Keypad reference using Digital Input
Cin/KYP DI{1}	Switch between Cin and Keypad reference using Digital Input

Notes:

1. The parameter that sets the function of the designated digital input must be configured as "Ref Switch" to complete the implementation.
2. The "Max Input" option will compare the inputs of all three analog inputs (Vin1, Vin2, Cin) and take the analog input with the highest percentage input after span, offset, and inversion is applied.
3. When using a 6FS signal, parameter **205** should be set to 0-10V.

205 Vin1 Config	Default = 0-10V	Range: text string Level: 2

Parameter **205, Vin1 Config,** selects the type of signal for analog input Vin1. Vin1 can be voltage, current, or pulse train input. This parameter also determines input range, impedance, and characteristics. Use parameters **206 (Vin1 Offset)** and **207 (Vin1 Span)** to customize the selected range. The following data values may be assigned to this parameter:

Parameter Value	Description
0-10V	0-10Vdc signal (use with Vin1 6FS and Vin1 48FS options)
0-10V Brk W	0-10Vdc signal with broken wire detection for speed pot operation
0-10V I	0-10Vdc signal Inverted
0-10V Bipol	0-10Vdc signal (5Vdc is stop with 0Vdc Full Rev and 10Vdc Full FWD)
0-5V	0-5Vdc signal
0-5V I	0-5Vdc signal Inverted
0-20mA 250	0 to 20 mA current signal with 250 Ohm load
0-20mA 250I	0 to 20 mA current signal with 250 Ohm load Inverted
4-20mA 250	4 to 20 mA current signal with 250 Ohn load load
4-20mA 250I	4 to 20 mA current signal with 250 Ohm load Inverted
PT 0-1kHz	0 to 1 kHz pulse train
PT 0-10kHz	0 to 10 kHz pulse train
PT 0-100kHz	0 to 100 kHz pulse train

Inverted signal response means that minimum input signal produces maximum inverter output frequency and maximum input signal produces minimum output frequency.

206 Vin1 Offset	Default = 0.00%	Range: 0.0 to 100.0% Level: 2

Parameter **206, Vin1 Offset,** configures the input range (offset) for analog input Vin1 that will affect speed or torque limit functions. It is expressed as a percentage of the maximum value of the input signal.

Note that if the input signal drops below the offset value or if the input signal is lost (if no offset is configured), fault 22 will be generated. See parameter **222** for options related to the drive's response to loss of input signal.

Table 7-2: Description of X4 Parameters *(Page 5 of 25)*

207 Vin1 Span	Default = 100%	Range: 10.0 to 200.0% Level: 2

Parameter **207,** the **Vin1 Span** parameter, is used to alter the input range (span) of the input signal for analog input Vin1 that will affect speed or torque limit functions. For example, if parameter **205, Vin1 Config,** selects the 0 to 10 Vdc input signal, setting this parameter to 50% reduces it to 0 to 5 Vdc.

208-Cin Config	Default = 0-20mA 50	Range: text string Level 2

Parameter **208, Cin Config,** selects the type of signal for analog input Cin. Parameters **209 (Cin Offset)** and **210 (Cin Span)** may be used to customize the selected range. The following data values may be assigned to this parameter:

Parameter Value	Description
4-20mA 50	4 to 20 mA current signal with 50 Ohm load
4-20mA 50I	4 to 20 mA current signal with 50 Ohm load Inverted
0-20mA 50	0 to 20 mA current signal with 50 Ohm load
0-20mA 50I	0 to 20 mA current signal with 50 Ohm load Inverted

Inverted signal response means that minimum input signal produces maximum inverter output frequency and maximum input signal produces minimum output frequency.

209 Cin Offset	Default = 0.0%	Range: 0.0% to 100.0% Level: 2

Parameter **209, Cin Offset,** configures the offset for analog input Cin expressed as a percentage of the maximum value of the input signal. See parameter **222** for options related to the drive's response to loss of input signal.

210 Cin Span	Default = 100.0%	Range: 10.0% to 200.0%

Parameter **210, Cin Span,** is used to alter the range of the input signal for analog input Cin. For example, if parameter **208 (Cin Config)** selects the 0 to 20 mA input signal, setting this parameter to 50% reduces it to 0 to 10 mA.

211 Vin2 Config	Default = 0-10 V	Range: text string Level: 2

Parameter **211, Vin2 Config,** selects the type of signal for analog input Vin2. Parameters **212 (Vin2 Offset)** and **213 (Vin2 Span)** may be used to customize the selected range. The following data values may be assigned to this parameter:

Parameter Value	Description
0-10V	0-10Vdc signal
0-10V Brk W	0-10Vdc signal with broken wire detection for speed pot operation
0-10V I	0-10Vdc signal inverted
0-10V Bipol	0-10Vdc signal (5Vdc is stop with 0Vdc Full REV and 10Vdc Full FWD
0-5V	0-5Vdc signal
0-5V I	0-5Vdc signal inverted

212 Vin2 Offset	Default = 0.0%	Range: 0.0% to 100.0% Level: 2

Parameter **212, Vin2 Offset,** configures the offset for analog input Vin2 expressed as a percentage of the maximum value of the input signal. See parameter **222** for options related to the drive's response to loss of input signal.

213 Vin2 Span	Default = 100%	Range: 10.0 to 200.0%

Parameter **213, Vin2 Span,** is used to alter the range of the input signal for analog input Vin2. For example, if parameter **211 (Vin2 Config)** selects the 0 to 10Vdc input signal, setting this parameter to 50% reduces it to 0 to 5Vdc.

214 Vin1 Filter Time	Default = 20 ms	Range: 0 to 1000 ms Level: 2

This parameter configures the time constant of a filter for the Vin1 analog input. When the parameter value is set to 0 ms, there is no software filtering of the analog input. A value above 0 ms causes the drive to filter the analog signal. **Note that long filter times will create a delay in the drive response to signal changes.**

215 Cin Filter Time	Default = 20 ms	Range: 0 to 1000 ms Level: 2

This parameter configures the time constant of a filter of the Cin analog input. When the parameter value is set to 0 ms, there is no software filtering of the analog input. A value above 0 ms causes the drive to filter the analog signal. **Note that long filter times will create a delay in the drive response to signal changes.**

Table 7-2: Description of X4 Parameters *(Page 6 of 25)*

216 Vin2 Filter Time	Default = 20 ms	Range: 0 to 1000 ms Level: 2

This parameter configures the time constant of a filter for the Vin2 analog input. When the parameter value is set to 0 ms, there is no software filtering of the analog input. A value above 0 ms causes the drive to filter the analog signal. **Note that long filter times will create a delay in the drive response to signal changes.**

217 Trim Ref Enable	Default = Disabled	Range: text string Level: 2

This parameter enables or disables trimming of the drive reference by an analog input and selects which analog input will perform the trimming function.

Speed Reference = Main reference + (Trim % Factor) * value of Parameter 217 * Max Frequency / 100%

Parameter Value	Description
Disabled	No trimming of drive reference
Vin1	Value of Vin1 will be used in the calculation above
Vin2	Value of Vin2 will be used in the calculation above
Cin	Value of Cin will be used in the calculation above
Fxd Trim %	Value of Fxd Trim % will be used

Drive Reference = Drive Reference + (Trim % Factor) * Max Frequency / 100%

Note that setting a parameter for a Bipolar input value allows trimming both positive and negative around the reference value.

218 Trim % Factor	Default = 0.0%	Range: -100.0% to +100.0% Level 2

This parameter determines the percentage of the analog input signal selected in **Parameter 217, Trim Ref Enable**, that will affect the reference signal.

222 Ref Loss Config	Default = No Fault	Range: text string Level 2

This parameter allows for the control of the drive's response to a 4-20mA input on either the Vin1 or Cin input terminals when the input drops below approximately 3mA. The default value is No Fault. The options for this parameter are:

Retain Spd	Hold the last operating speed
Preset Spd2	Go to the speed programmed at address 304
Fault	Drive faults with an F22 Reference Loss indication
No Fault	Drive does NOT fault; operating frequency drops to the limit set at **Parameter 301, Min Frequency**

301 Min Frequency	Default = 0.0%	Range: 0.0-Max Freq

Parameter **301, Minimum Frequency**, configures the minimum frequency output of the drive. This parameter governs the minimum frequency when operating from the keypad or from an analog input. The preset speeds can be set lower than the minimum frequency in parameter 301.

302 Max Frequency	Default: 60 Hz	Range: 0.0 to 400.0 Hz

Parameter **302**, the **Maximum Frequency** parameter, configures the maximum frequency output of the drive.

303 Preset Freq 1 (Jog Ref)	Default: 5 Hz	Range: Min-Max Freq Levels 1,2 for 303 Level 2 for 304-308
304 Preset Freq 2	Default: 10 Hz	
305 Preset Freq 3	Default: 20 Hz	
306 Preset Freq 4	Default: 30 Hz	
307 Preset Freq 5	Default: 40 Hz	
308 Preset Freq 6	Default: 50 Hz	

These parameters configure six preset speeds in addition to the normal reference speed of the drive (as defined by parameters **201 (Input Mode)** and **204 (Ref Select**) and the maximum frequency of the drive (as set with parameter **302, Max Frequency**). Thus, in effect, you may choose to operate the drive at up to eight different speeds.

The eight speeds are selected by a combination of three digital inputs (PS1, PS2, PS3). A wiring scheme for utilizing preset speeds is provided on page 37 along with a truth table showing what combination of inputs results in the selection of which speeds.

Note that parameter **Parameter 303 (Preset Freq1)** also serves as the reference frequency for jogging.

Table 7-2: Description of X4 Parameters *(Page 7 of 25)*

309 Cut-Off Freq	Default: 0.0 Hz	Range: 0.0 to 5.0 Hz Level 2

This parameter sets the point where the drive no longer attempts to spin the motor. The range of this parameter is 0.0-5.0 Hz. When the parameter is configured to a value of 0.0 Hz, the drive will operate with no Cut-off Frequency. If the function is enabled, the drive will be able to ramp up through the cut-off frequency range, as in normal operation. If the speed command falls below the cut-off frequency, the drive stops "gating" the outputs and coasts down to zero speed. The keypad display will indicate Zero Speed, and the Forward or Reverse LED will be lit depending on the command. When the reference returns to a value greater than the cut-off frequency, the drive will ramp from 0.0 Hz to the reference frequency.

401 Ramp Select	Default: ART-DI	Range: text string Level: 2

The **Ramp Select** parameter configures when the alternate ramps of the drive will be active and whether the drive ramps to stop, or coasts to stop. The following data values may be assigned to this parameter:

Parameter Value	Type of Ramp	Ramp Configured by:
ART-DI	Ramp-to-Stop	**402 (Accel Time 1)** and **403 (Decel Time 1)** control the operation until terminal strip intervention through a properly-programmed digital input. With an active digital input, ramps **404 (Accel Time 2)** and **405 (Decel Time 2)** are active.
ART-F/R	Ramp-to-Stop	Running forward: **402 (Accel Time 1)** and **403 (Decel Time 1)** Running reverse: **404 (Accel Time 2)** and **405 (Decel Tiime 2)**
ART-Frq	Ramp-to-Stop	If the output frequency is less than preset frequency parameter **308 (Preset Freq 6)**, the active ramp is set by **402 Accel Time 1** and **403 Decel Time 1**. If the output frequency is equal to or greater than **308 (Preset Freq 6)**, the active ramp is set by **404 (Accel Time 2)** and **405 (Decel Time 2)**.
ART-Strt/RS	Ramp-to-Stop	This setting uses the Alternate Ramp for Acceleration (parameter **404**) to the set speed, then uses the Main ramps (parameters **402** and **403**) when the speeds are adjusted. The drive will revert to the Alternate Decel ramp (parameter **405**) when a Stop command is given.
S-Curve	Ramp-to-Stop	The drive uses **402 (Accel Time 1)** and **403 (Decel Time 1)** for total time and **414** as the S Ramp Rounding value. The amount of rounding is the same for that start and stop of the ramp time.
ART-DI CTS	Coast-to-Stop	Same as ART-DI but with Coast-to-Stop
ART-F/R CTS	Coast-to-Stop	Same as ART-F/R but with Coast-to-Stop
ART-Frq CTS	Coast-to-Stop	Same as ART-Frq but with Coast-to-Stop
ART-Str/CS	Coast-to-Stop	Same as ART-Strt but with Coast-to-Stop
S-Curve CTS	Coast-to-Stop	Same as S-Curve but with Coast-to-Stop

402 Accel Time 1	Default: 5.0 s	Range: 0.1 to 3200.0 s Levels 1,2

This parameter configures the default length of time to accelerate from 0 Hz to the value of parameter **302 (Max Frequency)**. This acceleration ramp is selected by parameter **401 (Ramp Select)**.

Note that extremely short acceleration times may result in nuisance fault trips.

403 Decel Time 1	Default: 5.0 s	Range: 0.1 to 3200.0 s Levels 1,2

This parameter configures the default length of time to decelerate from the value of parameter **302** (**Max Frequency**) to 0 Hz. The deceleration ramp is selected by parameter **401** (**Ramp Select**).

Note that extremely short deceleration times may result in nuisance fault trips or may require an external dynamic brake or regen current limit.

Table 7-2: Description of X4 Parameters *(Page 8 of 25)*

404 Accel Time 2	Default: 3.0 s	Range: 0.1 to 3200.0 s Level 2

This parameter provides an alternate ramping time for the drive when accelerating, configuring the length of time to accelerate from 0 Hz to the value of parameter **302 (Max Frequency)**. This acceleration ramp is selected by parameter **401 (Ramp Select)** or Sequencer configuration.

Note that extremely short acceleration times may result in nuisance fault trips.

405 Decel Time 2	Default: 3.0 s	Range: 0.1 to 3200.0 s Level 2

This parameter provides an alternate ramping time for the drive when decelerating, configuring the length of time to decelerate from the value of parameter **302 (Max Frequency)** to 0 Hz. This deceleration ramp is selected by parameter **401 (Ramp Select)** or Sequencer configuration.

Note that extremely short deceleration times may result in nuisance fault trips or may require an external dynamic brake or regen current limit.

406 DC Inject Config	Default: DC at Stop	Range: text string Level 2

DC injection braking may be used to stop the motor more quickly than is possible by either a ramp-to-stop or a coast-to-stop. The X4 drive allows DC braking to be initiated either when a digital input assigned to DC braking becomes true, when a specified frequency is reached, or when either of these events occurs.

When using a digital input for DC braking, you must use one of the DI parameters to configure the selected digital input for DC braking. The amount of braking force is set by parameter **408 (DC Inject Level)**. The length of time that the braking force is applied is determined by the time that the selected digital input is active. The second type of DC injection braking supported by the X4 drive is where DC braking occurs at a specified frequency. The duration of the braking is adjusted by parameter **407 (DC Inject Time)**.

With this type of braking, as the drive slows down after a Stop command, DC braking begins when the frequency reaches the value set in parameter **409 (DC Inj Freq)**. If the frequency at the time of a Stop command is less than that of **DC Inj Freq**, DC braking begins immediately. The braking continues for the time period specified by parameter **DC Inj Freq**. Once the time period elapses, the drive may be restarted.

Parameter Value	Description
DC at Stop	DC inject only on Stop
DC at Start	DC inject only on Start
DC at Both	DC inject only on both Start and Stop
DC on Freq	DC inject only on Stop below the set frequency

407 DC Inject Time	Default: 0.2 sec	Range: 0.0 to 5.0 sec Level 2

If parameter **406** is set to DC at Stop (see page 67), direct current is applied to the motor. This parameter, **DC Inject Time**, determines how long the direct current will be applied, and how long DC is applied at Start if programmed accordingly.

This parameter works in tandem with parameter **410 (DC Inject Config)** and the other parameters associated with DC Inject Config. That is, the time period configured by this parameter, **DC Inject Time**, determines how long DC injection braking will be active. When DC injection braking is controlled by a digital input, the braking continues for as long as the digital input is true, **plus** the time set by parameter **407 (DC Inject Time)**. When it is controlled by frequency, however, it continues for the length of time once the drive reaches the frequency set by parameter **409 (DC Inj Freq)**.

408 DC Inject Level	Default: 50.0%	Range: 0.0% to 100.0% Level 2

Configures the amount of DC injection that will occur when direct current is injected into the motor windings, which acts as a braking force. The amount of current is expressed as a percentage of nominal motor current. The braking force may be applied when starting or stopping. If this parameter is set to 0.0%, the DC injection is disabled.

Table 7-2: Description of X4 Parameters *(Page 9 of 25)*

409 DC Inj Freq	Default: 0 Hz	Range: 0.0 to 20.0 Hz Level 2

Configures the frequency under which direct current will be applied to the drive when **DC Inject Config** is set to "DC on Freq." If this parameter is set to 0.0, the parameter operates in the same way as "DC at Stop."

410 DB Config	Default: DB Internal	Range: 0-2 Level 2

Determines whether an external or internal dynamic brake is utilized or disabled. The drive provides an internal dynamic brake (DB) to assist in stopping. If desired, an external resistor can be connected to DB and B+ for additional capacity. **(Note:** Size 0 models cannot have an external brake added.)

The following data values may be assigned to this parameter:

Parameter Value	Description
DB Internal	Internal dynamic braking active
DB External	External dynamic braking active
No Dyn Brk	Dynamic braking circuit disabled
Int-ARCTIC	When DB Config is configured to "Int-ARCTIC," dynamic braking becomes active if the drive temperature drops below -7 degrees C. When the DB becomes active, an "ARCTIC Mode" warning flashes on the keypad. If the drive drops below -10 degrees C, the drive will be disabled and not allowed to run. The keypad will indicate a "Not enabled" state at this point. If the drive heats up after being below -10 degrees C, the drive must meet the following criteria before operating again: a) Drive temperature must be above -9 degrees C, and b) Drive temperature must stay above -9 degrees C until a time period has elapsed. The time period is dependent on how far below -10 degrees C the drive was. Each degree below -10 degrees C adds another 4 minutes before restart.

⚠ CAUTION

MOTOR OVERHEATING

Do not use DC injection braking as a holding brake, or excessive motor heating may result.

Failure to observe this instruction can result in equipment damage.

⚠ ATTENTION

SURCHAUFFE DU MOTEUR

N'utilisez pas le fraingres CC comme frein de maintien car cela peut entraîner une surchauffe excessive du moteur.

Si cette directive n'est pas respectée, cela peut entraîner des dommages matériels.

414 S Ramp Rounding	Default: 25%	Range: 1-100% Level 2

This parameter is used to define the amount of rounding or S-curve to the Accel and Decel ramp. The amount of rounding is split evenly between the beginning and the end of the ramp. A value of 1% would mean that the rounding of the ramp is near linear. A value of 50% would have 25% rounding at the start of the ramp and 25% at the end of the ramp.

Parameters 490, 491, 492: **See "Description of Parameters Used in Macro Mode" on page 50.**

Table 7-2: Description of X4 Parameters *(Page 10 of 25)*

501 V/Hz Select	Default: Linear Fxd	Range: 0 to 7 Level 2

The **V/Hz Characteristic Selection** parameter determines the characteristic of the V/Hz curve and whether any boost will be applied at starting. The following data values may be assigned:

Parameter Value	Description
Linear Auto	The Linear Auto selection operates the Vector algorithm and activates torque limiting functionality.
Linear Fxd	V/Hz curve with the amount of boost fixed at the value set in parameter **502 (Voltage Boost)**.
Pump Fxd	V/Hz curve with the amount of boost fixed at the value set in parameter **502 (Voltage Boost)**.
Fan Fxd	V/Hz curve with the amount of boost fixed at the value set in parameter **502 (Voltage Boost)**.
Linear 2pc	Activates parameters **512 (Midpoint Frq)** and **513 (Midpoint Volt)**. These parameters are used to define a midpoint through which the V/Hz curve passes so a custom curve may be created for special motor applications.
Vector	Activates the sensorless vector algorithm for high torque / low speed operation. A vector-duty motor should be used for this mode of operation. Vector mode does not use the Boost parameter (parameter **502**)

502 Voltage Boost	Default: 1.0%	Range: 0.0 to 50.0% Levels 1,2

Parameter **502, Voltage Boost**, increases the motor voltage at low speed to increase the starting torque of the motor. The parameter sets the amount of boost (expressed as a percentage of the default boost) to be applied at zero frequency. The amount of boost decreases linearly with increasing speed.

This parameter is used when parameter **501** is set with **fixed boost** options.

⚠ CAUTION

MOTOR OVERHEATING

Too much boost may cause excessive motor currents and motor overheating. Use only as much boost as is necessary to start the motor.

Failure to observe this instruction can result in equipment damage.

⚠ ATTENTION

SURCHAUFFE DU MOTEUR

Une amplification de puissance excessive peut entraîner des surintensités de courant et faire la surchauffe du moteur. N'utilisez que le niveau d'amplification nécéssaire pour démarrer le moteur.

Si cette directive n'est pas respectée, cela peut entraîner des dommages matériels.

503 V/Hz Knee Freq	Default: 60 Hz	Range: 25 to 400 Hz Level 2

This parameter sets the point on the frequency scale of the V/Hz curve at which the output is at full line voltage. Normally, this is set at the base frequency of the motor, but it may be increased to enlarge the constant torque range on special motors. Setting this parameter to a higher value can reduce motor losses at low frequencies.

Table 7-2: Description of X4 Parameters *(Page 11 of 25)*

504 Skip Freq Band	Default: 0.2 Hz	Range: 0.2 to 20.0 Hz Level 2
To reduce mechanical resonances in a drive system, the drive may be configured to "skip" certain frequencies. Once configured, the drive will accelerate or decelerate through the prohibited frequency band without settling on any frequency in the band. The X4 AC drive provides the capability to configure four prohibited frequency bands. Parameter **504 (Skip Freq Band)**, the Skip Frequency Band parameter, sets the width of the band above and below each of the prohibited frequencies set in parameters **505, 506, 507,** and **508 (Skip Freq 1,2,3, 4)**. For example, if this parameter is set to its default value of 1 Hz and parameter **505 (Skip Freq 1)** is set to 20 Hz, a skip band from 19 to 21 Hz is established.		
505 Skip Freq 1 **506 Skip Freq 2** **507 Skip Freq 3** **508 Skip Freq 4**	Default: 0.0 Hz	Range: Min Freq-Max Freq Level 2
As discussed in the description of parameter **504 (Skip Freq Band)**, the drive may be configured to skip certain frequencies. These three parameters set the center of the three skip frequency bands (with the width of each band being twice the value of parameter **504** — an equal amount above and below the skip frequency). For example, if parameter **504** is set to 2.5 Hz and parameter **508 (Skip Freq 4)** is set to 55 Hz, a skip band from 52.5 to 57.5 Hz is established.		
509 Rated Mtr Volt	Default: Model dependent	Range: 100 V - 690 V Level 2, Macro
The Rated Motor Voltage parameter configures the rated motor voltage, and allows a user to enter the rated voltage from the motor nameplate to provide optimal control and protection. This is usually the amount of voltage delivered to the motor terminals at the setting of **503 (V/Hz Knee Freq**).		
510 Rated Mtr FLA	Default: ND Rating	Range: 50% - 200% of ND rating Level 2, Macro
The Rated Motor FLA parameter allows a user to enter the rated FLA from the motor nameplate to provide optimal control and protection. This parameter should be configured to the value on the nameplate of the motor, as that value is used in calculating the percentage of current at which the drive is operating. For information on motor timed overload operation, and how parameter **510** works with it, see page 74.		
511 Rated Mtr RPM	Default: 1750 rpm	Range: 0-24000 rpm Level 2, Macro
This parameter replaces the slip compensation parameter setting of the drive so the user does not need to calculate it.		
512 Midpoint Freq	Default: 60.0 Hz	Range: 0.0 Hz-V/Hz Knee Freq Level 2
When parameter **501, V/Hz Select**, is configured to "Linear 2pc," this parameter, together with parameter **513, Midpoint Volt,** defines an additional point in the V/Hz characteristic.		
513 Midpoint Volt	Default: 100.0%	Range: 0.0%-100.0% Level 2
When parameter **501, V/Hz Select**, is configured to "Linear 2pc," this parameter, along with parameter **512, Midpoint Freq,** defines an additional point in the V/Hz characteristic.		
514 Motor RS	Default: Model dependent	Range: 0.00-655.35 Ohms Level 2, Macro
This parameter allows direct entry of the Stator Resistance (Rs) of the motor for better vector performance. The motor manufacturer can provide this information, or you can physically measure this value with an ohmmeter. From the line-to-line measurement of motor resistance, enter half the measured value. (See page 47 for more information.)		
515 Power Factor	Default: 0.80	Range: 0.50 - 1.00 Level 2, Macro
This parameter allows direct entry of the motor's power factor for better vector performance. The motor manufacturer can provide this information.		

Table 7-2: Description of X4 Parameters *(Page 12 of 25)*

516 Slip Comp Enable	Default: No	Range: text string Level 1,2

The following data values may be assigned to this parameter:

Parameter Value	Description
No	No Slip Compensation enabled
Yes	Slip Compensation enabled

Parameter **516** permits activation of slip compensation for better speed regulation. The motor rated speed must be entered into parameter **511 (Rated Mtr RPM)** for best results.

517 Single Phase	Default: No	Range: text string Level 2

The following data values may be assigned to this parameter:

Parameter Value	Description
No	No single phase input operation. Phase loss engaged.
Yes	Single phase operation. No phase loss.

519 Find Mtr Data	Default: Not active	Range: text string Macro

This parameter activates the drive's ability to measure the stator resistance of the attached motor. The automatic stator resistance measurement can be performed either through the keypad or through the serial link. See "Measuring Stator Resistance (RS Measurement)" on page 47 for more information about this parameter. The following data values may be assigned:

Parameter Value	Description
Not Active	No stator RS measurement.
Motor RS	Automatic RS measurement using macro procedure.

520 Filter FStator	Default: 8 ms	Range: 1 - 100 ms Level 2

This parameter filters the stator frequency applied to the motor, which can help tune the acceleration behavior of the motor. This is particularly helpful when using short ramps and operating the motor at a frequency above the "V/Hz Knee Freq" (**parameter 503**) value (field weakening area). Lower values allow dynamic currents to be produced, but with greater peaks. This could produce unstable states in the field weakening area. Low values for this parameter can cause overcurrent faults while accelerating to frequencies over the Knee Frequency. Higher values allow the drive to run more smoothly at frequencies over the Knee Frequency and protect the drive against overcurrents--often the case when using special motors or spindle drives.

521 Start Field En	Default: No	Range: text string Level 2

Parameter Value	Description
No	The shaft will begin rotating after receiving a Start command, without delay. If the application has heavy load conditions or short ramp times, this setting can produce very large starting currents, to overcome the inertia of the system. This may produce nuisance trips when starting.
Yes	The shaft will begin rotating after receiving a Start command, with delay. During this delay, the drive is building up the magnetic field in the motor. This allows the drive to start in vector mode with less starting current.

522 Filter Time Slip	Default: 100 ms	Range: 10 - 1000 ms Level 2

This parameter filters the slip frequency applied to the motor, which can help improve the dynamic response of the drive. This parameter produces the following results based on the parameter value:

If the parameter is configured to **100 ms**, the drive will produce stable conditions to a change in load, in most cases.

If the parameter is configured to **less than 100 ms**, the drive will be able to react quickly to a change in load, but may over-compensate its reaction to the load.

If the parameter is configured to **greater than 100 ms**, the drive will react very slowly to a change in load and will need a longer time to compensate for the difference between the setpoint and the actual frequency.

Table 7-2: Description of X4 Parameters *(Page 13 of 25)*

523 Id Percent	Default: Read-only	Range: 0 - 200% Level 2

This parameter shows the Flux producing current (as a percentage of motor rated current) that is being applied to the drive.

524 Iq Percent	Default: Read-only	Range: 0 - 200% Level 2

This parameter shows the Torque producing current (as a percentage of motor rated current) that is being applied to the drive.

525 Power Fail Config	Default: CTS No Msg	Range: text string Level 2

This parameter can be used to define how the drive responds to an undervoltage operation when parameter **501** is set for Vector or Linear Auto mode. The following data values may be assigned to this parameter:

Parameter Value	Description
CTS No Msg	The drive will coast to a stop when an undervoltage condition (power-down) is detected.
Coast Stop	The drive will coast to a stop when an undervoltage condition (power-down) is detected. In this mode, however, the drive will generate an undervoltage fault, which will be registered in the fault log as F32 with an advanced fault code of "1".
Ramp Down	With this setting, if power is lost, the drive ramps the motor down at a decel rate of **Decel 1**. When the drive is fully ramped down, the drive will generate an undervoltage fault. If power is restored, the drive will continue to ramp to a stop and will fault.
Quick Ramp	Same as Ramp Down, except the **shorter** ramp time (Decel 1 or Decel 2) will be used.
Controlled	With this setting, if power is lost, the drive decelerates the motor, trying to regulate the bus voltage to the undervoltage level. If power is restored, the drive accelerates to the command frequency without faulting. If the drive reaches the stopped condition, it will generate an undervoltage fault, F32 with an advanced fault code of "2". See "X4 Fault Codes" on page 93.
ContrNoMsg	Same as Controlled, but without generating an undervoltage fault.

Note: If parameter **501** is set to Vector, then the Current Limiting values will actually be Torque Limiting values.

526 UV Ride-Thru En	Default: w/ LVT	Range: text string Level 2

This parameter allows the function to disable either (a) undervoltage ride-through or (b) continuous Line Voltage Tracking (LVT) that produces dynamic Undervoltage Ride-Thru Thresholds. The following data values may be assigned to this parameter:

Parameter Value	Description
Disabled	This turns off the Undervoltage Ride-Thru function.
w/ LVT	This enables the standard Ride-Thru algorithm in the V/Hz modes and allows the choice of algorithm in the Linear Auto and Vector modes.
w/o LVT	This option operates in the same way as "w/ LVT" except that the Line Voltage Tracker function of the Undervoltage Ride-Thru is not active. The Line Voltage will be estimated on powering up the drive.
No UV Fault	With this option, the drive will do all it can to provide uninterrupted operation through UV events, but a UV fault will not be generated.

Table 7-2: Description of X4 Parameters *(Page 14 of 25)*

600 Current Lim Sel	Default: Fixed Lvls	Range: text string Level 2

The X4 drive provides a Current Limit feature. With this feature enabled, the drive's frequency is automatically reduced when operating in motoring mode to keep the measured torque within limits. When operating in regenerative mode, the output frequency can be automatically increased for the same reason. In addition to the current limit parameters that activate the Current Limit mode, more current limit parameters are available to adjust the drive's response to the load demands. The following data values may be assigned to this parameter:

Parameter Value	Description
Fixed Lvls	The fixed levels set in parameters **601, 602, 603** and **604** determine the current limit in each of the four quadrants of operation.
Vin2	Vin2 analog input sets the current limit value, range 0-200%
Cin	Cin analog input sets the current limit value, range 0-200%
Vin2 Motor	Vin2 analog input sets the motoring current limit value, range 0-200%
Cin Motor	Cin analog input sets the motoring current limit value, range 0-200%
Vin2 F-Mtr	Vin2 analog input sets the FWD motoring current limit value, range 0-200%
Cin F-Motor	Cin analog input sets the FWD motoring current limit value, range 0-200%

Note: Current limit is only available when Parameter **502** is set to Linear Auto. If Parameter **502** is set to Vector, then the Current Limiting values will actually be Torque Limiting values.

601 Cur Lim Mtr Fwd	Default: 120%	Range: 5-150% Level 2

This parameter sets the current limiting point when the drive is in motoring mode in the forward direction. The limit is expressed as a percentage of the current capacity of the drive.

602 Cur Lim Mtr Rev	Default: 120%	Range: 5-150% Level 2

This parameter sets the current limiting point when the drive is in motoring mode in the reverse direction. The limit is expressed as a percentage of the current capacity of the drive.

603 Cur Lim Reg Fwd	Default: 80%	Range: 5-150% Level 2

This parameter sets the current limiting point when the drive is in regenerative mode in the forward direction. The limit is expressed as a percentage of the current capacity of the drive.

604 Cur Lim Reg Rev	Default: 80%	Range: 5-150% Level 2

This parameter sets the current limiting point when the drive is in regenerative mode in the reverse direction. The limit is expressed as a percentage of the current capacity of the drive.

605 Cur Lim Freq	Default: 3.0 Hz	Range: 0.0 - 400.0 Hz Level 2

This parameter sets the frequency where current limit becomes active. This value will also be the frequency point the drive will decelerate the motor to during Motoring Current Limit.

606 Ramp Time CL	Default: 1.0 sec	Range: 0.1-3200.0 sec Level 2

This parameter determines the ramp rate when the drive enters Current Limit, and defines the ramping rate of the drive when in a current limiting mode. If the drive is in regenerative current limit, it is an acceleration time. If the drive is in motoring current limit, it is a deceleration time.

607 Cur Lim Minimum	Default: 10%	Range: 0 - 50% Level 2

This parameter limits the lowest amount of current (or torque) limiting that can occur when the limit threshold is determined by an analog input.

Table 7-2: Description of X4 Parameters *(Page 15 of 25)*

608 Restart Number **609 Restart Delay**	Default: 0 Default: 60 sec	P608 Range: 0-8 P609 Range: 0-60 sec Level 2

You may configure the drive to attempt to re-start a specified number of times after certain faults occur. Chapter 8 lists all faults and notes which ones may be reset automatically.

The number of attempts at re-starting is set with parameter **608 (Restart Number).** A value of 0 prevents the drive from attempting a re-start). The time duration that must elapse between re-start attempts is set with parameter **609 (Restart Delay).** The type of start to be attempted is set with parameter **802 (Start Options)**; see page 78).

If the number of attempted re-starts is exceeded, the drive will trip with a fault and will stop operating. **Resetting the fault can result in instant starting.** (See page 93 for more information on faults and troubleshooting.)

Note that for 2-wire operation, the FWD or REV terminal must still be active for the drive to attempt a re-start.

Also note that the counter for attempted re-starts will not reset to zero until ten minutes after a successful re-start.

⚠ WARNING

UNINTENDED EQUIPMENT ACTION

Ensure that automatic re-starting will not cause injury to personnel or damage to equipment.

Failure to observe this instruction can result in serious injury or equipment damage.

⚠ AVERTISSEMENT

ACTIONNEMENT INVOLONTAIRE DE L'APPAREIL

Assurez-vous qu'un redémarrage automatique n'entraînera ni des blessures au personnel ni des dommages matériels.

Si cette directive n'est pas respectée, cela peut entraîner des blessures graves ou des dommages matériels.

610 Timed OL Select	Default: Std Ind 60s	Range: text string Level 2

Two parameters in the X4 work together to configure how the motor timed overload operates: Parameter **510 (Rated Mtr FLA)** and parameter **610 (Timed OL Select)**.

Parameter **510 (Rated Mtr FLA)** should be configured to the value on the nameplate of the motor. This value is used in calculating the percentage of current at which the drive is operating.

Set parameter **610** to one of the following data values to configure the desired overload characteristic:

Options	Trip Time	Motor Type	Motor Class
Std Ind Shp	0 sec	Standard Induction	N/A
Std Ind 30s	30 sec	Standard Induction	1
Std Ind 60s	60 sec	Standard Induction	2
Std Ind 5mn	300 sec	Standard Induction	10
In Duty Shp	0 sec	Inverter Duty	N/A
In Duty 30s	30 sec	Inverter Duty	1
In Duty 60s	60 sec	Inverter Duty	2
In Duty 5mn	300 sec	Inverter Duty	10

Timed OL Select determines the graph of Trip (Fault) Time vs. Percent Current that is used by the Motor TOL functionality. This protective feature is speed-dependent to handle standard induction motors whose cooling is limited by the shaft-mounted fan. Blower-cooled motors and most inverter-duty motors do not have this limitation.

613 Max Regen Ramp	Default: 300%	Range: 100 - 1000% Level 2

This parameter operates as a percentage of the longest ramp time. This time then defines the amount of time a deceleration to stop can take without causing a "Regen Timeout" fault. For example, if "Decel Time 1" is 5.0 seconds, "Decel Time 2" is 10.0 seconds, and "Max Regen Ramp" is 300%, a deceleration to stop that takes more than 30 seconds will cause a "Regen Timeout" fault in the drive.

Table 7-2: Description of X4 Parameters *(Page 16 of 25)*

614 Stability Gain **615 Stability Rate**	Default: Model dependent	P 614: Range: 0-10 P 615: Range: 0-1000 Level 2

Both of these parameters can be used to resolve stability problems if they occur. Use Parameter 615 if the load has significant inertia with respect to the motor itself.

700 Vmet Config	Default: Freq Out	Range: text string Levels 1,2

This parameter configures the analog signal that will be applied to the Vmet output pin.

The following data values may be assigned to this parameter:

Para. Value	Description	Range Limit
Freq Out	Output frequency of the drive	Parameter max freq.
Voltage Out	Voltage being supplied to the motor	Rated motor voltage
Current Out	Current being supplied to the motor	200% of drive rating
Drive Load	Calculated percentage of drive rating	200% of drive rating
Drive Temp	Calculation of total drive temp rating	100% of unit temp rating
Stator Freq	Commanded frequency	100% of input config
Power Out	Calculated power output of drive	250% of drive rating
PI Fback	Allows the analog output to produce a signal in proportion to the PI feedback received.	
Load +/-	A 5v (50%) offset is introduced into the Vmet output; more positive outputs will be achieved with higher load values.	200% of drive rating

701 Vmet Span	Default: 100%	Range: 0.0%-200.0% Level 2

This parameter sets the span of the Vmet analog output.

702 Imet Config	Default: Drive Load	Range:text string Level 2

This parameter configures the analog signal that will be applied to the Imet output pin. The following data values may be assigned to this parameter:

Para. Value	Description	Range Limit
Freq Out	Output frequency of the drive	Parameter max freq.
Voltage Out	Voltage being supplied to the motor	Rated motor voltage
Current Out	Current being supplied to the motor	200% of drive rating
Drive Load	Calculated percentage of drive rating	200% of drive rating
Drive Temp	Calculation of total drive temp rating	100% of unit temp rating
Stator Freq	Commanded frequency	100% of input config
Power Out	Calculated power output of drive	250% of drive rating
PI Fback	Allows the analog output to produce a signal in proportion to the PI feedback received.	100% of feedback signal

703 Imet Span	Default: 100%	Range: 0.0%-200.0% Level 2

This parameter sets the span of the Imet analog output.

704 Imet Offset	Default: 0.0%	Range: 0.0%-90.0% Level 2

This parameter sets the offset of the Imet analog output.

Table 7-2: Description of X4 Parameters *(Page 17 of 25)*

705 Relay 1 Select **706 Relay 2 Select** **707 DO1 Select** **708 DO2 Select**	Default: Drv Fault Default: Drv Run Default: Drv Ready Default: At Speed	Range: text string Levels 1, 2 for Parameters 705-706 Level 2 for Parameters 707-708

These four parameters configure what condition will cause relays R1, R2, DO1, and DO2 to activate. Parameter **705** is associated with relay R1; parameter **706** with relay R2; parameter **707** with DO1; and parameter **708** with relay DO2. The following values may be assigned:

Parameter Value	Description
Drv Ready	The drive is ready. (The relay will be open in Fault and Low Voltage conditions.)
Drv Fault	A fault occurs. (If automatic fault reset and re-start is enabled, only faults that cannot be reset will activate the relay. The relay will also activate for faults that can be reset when the number of re-start attempts exceeds the value set in parameter **608 (Restart Number)**.)
Drive Run	The drive has received a direction command.
Running FWD	The motor is running in Forward.
Running REV	The motor is running in Reverse.
Zero Speed	The drive is in Run mode, but the speed reference is 0 Hz.
At Speed	The drive has reached reference speed.
Freq Limit	The drive limit is active when the speed commanded exceeds the value of parameter **306, Preset Freq 4**.
Freq Hyst	This is active when the speed exceeds parameter **306 (Preset Freq 4)** but is less than parameter **307 (Preset Freq 5)**.
Current Lim	Current Limit mode is active.
High Temp	The temperature limit of the drive has been exceeded.
Local Mode	The keypad is the control path for reference speed and control functions.
SeqOut-00 SeqOut-01 SeqOut-10 SeqOut-11	Programmed sequence step active. SeqOut-00, SeqOut-01, SeqOut-10, SeqOut-11 are all status outputs linked to a step in the program sequencer. See "Using the X4 Program Sequencer" on page 84 for more information.
ARCTIC	When a digital output is configured to use this option, the output will be active when the Arctic Mode is turning on the DB resistor. This option will turn on when the temperature drops below the Arctic mode entry point, which is -7 degrees C. This will work even if Arctic Mode is not enabled.
Ref Loss	Independent of the status of parameter **222 (Ref Loss Config)**, this selection activates the digital output when a 4-20mA input to either the VIN1 or CIN inputs drop to approximately 3mA.

720 Active Logic	Default: Active High	Range: text string Level 2

This parameter configures the input state of all the digital inputs except the EN digital input. The EN digital input is always active high. The following data values may be assigned to this parameter:

Parameter Value	Description
Active Low	Low input is true ("pull-down logic")
Active High	High input is true ("pull-up logic")

Table 7-2: Description of X4 Parameters *(Page 18 of 25)*

721 DI1 Configure **722 DI2 Configure** **723 DI3 Configure** **724 DI4 Configure** **725 DI5 Configure** **727 MOL Configure**	Default: Preset 1 Default: Preset 2 Default: Preset 3 Default: Alt Ramp Default: Fault Reset Default: MOL	Range: text string Level 2

Parameters 721-725 configure the function that the digital inputs DI1-5 will perform when active. Parameter 727 serves as the selection for the operation of the MOL terminal. Polarity of the MOL digital input is still determined by parameter 726, MOL Polarity. The options for these and all of the additional digital input parameters are as follows:

Parameter Value	Description
Preset 1	Preset Speed Input 1 (PS1).
Preset 2	Preset Speed Input 2 (PS2).
Preset 3	Preset Speed Input 3 (PS3).
Coast Stop	Activates a Coast-to-Stop condition.
DC Inject	Begins DC injection braking.
Loc/Rem	Switches from Local to Remote mode.
Alt Ramp	Activates Alternate Ramp.
Fault Reset	Resets a fault.
EMOP+	EMOP increases speed.
EMOP-	EMOP decreases speed.
PI Enable	Enables PI control.
Ref Switch	Switches speed reference signals.
Cur Lim Dis	Disables Current Limit mode.
CurLimIMax	Sets all Current Limit inputs at the maximum value the drive will allow.
SL Override	Takes control away from the serial link.
Seq 1	Sequencer input 1.
Seq 2	Sequencer input 2.
Seq 3	Sequencer input 3.
Seq Dwell	Sequencer dwell mode (pause).
Seq Advance	Sequencer advance (skip).
FLY Dis	Disable Catch-on-fly operation.
MOL	Motor Overload input for external customer connection.

726 MOL Polarity	Default: NO Operate	Range: text string Level 2

This parameter sets the Motor Overload input polarity. The following data values may be assigned to this parameter:

Parameter Value	Description
NC Operate	A normally closed (NC) connection allows the unit to operate; the drive faults when the connection opens.
NO Operate	A normally open (NO) connection allows the unit to operate; the drive faults when the connection closes.

801 Program Number	Default: 0	Range: 0 to 9999 Level 2, Macro

This parameter (Special Program Number) provides a way of enabling hidden functions in the drive and storing parameters to the customer set.

Data Value	Special Function Configured
0	Standard program
1	Reset all parameters to factory default values (display = SETP).
2	Store customer parameter values (display = STOC).
3	Load customer parameter values (display = SETC).
4	Swap active parameters with customer stored settings.
10	Reset Total Run Time, parameter **108**.

Table 7-2: Description of X4 Parameters *(Page 19 of 25)*

802 Start Options	Default: LS Lockout	Range: text string Level 2

The Start Options parameter configures the Line Start Lockout functionality of the drive. All data values ending with "2" allow you to press the Enter key to store the customer speed reference value on the keypad. You must press and hold the Enter key for two seconds to save the speed command. The following data values may be assigned:

Data Value	Description
LS Lockout	(Line Start Lockout). If maintained contact run operators are used, they must be opened and then re-closed for the drive to start after AC power is applied.
AutoStart	When AC power is applied, if a Run command is present through the terminal strip, the drive will start.
LSL w/FLY	This setting has both LS Lockout and Catch on the Fly enabled at the same time.
Auto w/FLY	This setting has both Auto-Start and Catch on the Fly enabled at the same time.
LS Lockout2	(Line Start Lockout). If maintained contact run operators are used, they must be opened and then re-closed for the drive to start after AC power is applied.
AutoStart2	When AC power is applied, if a Run command is present through the terminal strip, the drive will start.
LSL w/FLY 2	This setting has both LS Lockout and Catch on the Fly enabled at the same time.
Auto w/FLY2	This setting has both Auto-Start and Catch on the Fly enabled at the same time.

803 PWM Frequency	Default: 3.0 kHz	Range: 0.6-16.0 kHz Level 2

The PWM Carrier Frequency parameter sets the carrier frequency of the Pulse-Width Modulation (PWM) waveform supplied to the motor. Low carrier frequencies provide better low-end torque, but produce some audible noise from the motor. Higher carrier frequencies produce less audible noise, but cause more heating in the drive and motor.

804 Display Mode	Default: Std Disply	Range: text string Level 2

The Display Mode parameter determines how the reference or output of the drive will be displayed to the user. If User Units is selected, parameter 805 allows you to customize the 3 unit values on the display. The following data values may be assigned to this parameter:

Parameter Value	Description
Std Disply	Standard commanded frequency
Out Freq	Output frequency actually sent to the motor
Stator Freq	Frequency of the stator
User Units	Custom units display based on value in parameter 805
RPM Units	Custom speed display with RPM as units
GPM Units	Custom speed display with GPM as units
FPM Units	Custom speed display with FPM as units
MPM Units	Custom speed display with MPM as units
PSI Units	Custom speed display with PSI as units
Degrees C	Custom display with degrees C
Degrees F	Custom display with degrees F
Time hrs	Custom display time in hours of operation
Time min	Custom display time in minutes of operation
Time sec	Custom display time in seconds of operation
Time sec	Custom display time in seconds of operation
Fbk RPM	Display is scaled to read in RPM based on the PI feedback input to an analog input
Fbk PSI	Display is scaled to read in PSI based on the PI feedback input to an analog input
Fbk GPM	Display is scaled to read in GPM based on the PI feedback input to an analog input
Fbk User	Display is scaled to read in User units (parameter 805) based on PI feedback input to an analog input

*When using any of the Time functions, these refer to "Retention Time." Retention time is an inverse function: as speed goes up, time goes down, and vice versa. It is typically used in oven-type applications. The value set in parameter **809 (Display Scale)** references the time of operation when running at Max. Frequency. For instance, if parameter **302 (Max. Frequency)** is set for 60 Hz, **804 (Display Mode)** is set for Time min, and **809 (Display Scale)** is set for 600, the scales of the display will read 60.0 min at maximum speed and increase in time (in minutes) up to the maximum scale of 6553.5 at minimum frequency.*

Table 7-2: Description of X4 Parameters *(Page 20 of 25)*

805 Display Units	Default: RPM: 1	Range:text string Level 2

This parameter determines the three-character customer display units used when parameter **804** is set to User Units. The last digit indicates the number of decimal places to be shown on the display. Up to three decimal places are possible.

809 Display Scale	Default: 1	Range: 1-65535 Level 2

This parameter determines how the reference or output of the drive will be displayed to the user. It selects the maximum scaling of the display when running at maximum frequency.

810 Language	Default: English	Range: text string Level 2, Macro

This parameter configures the language text strings will be displayed in. The following data values may be assigned:

Parameter Value

English	Italian
Spanish	French
German	

811 Access Code	Default: 0	Range: 0-9999 Level 2

The security **Access Code** allows the user to control access to the programmable functions of the inverter. The initial value of this parameter is 000, which signifies that no access code is necessary. Any number between 001 and 999 may be used for an access code, but is not necessary. If an access code is entered, you will not be able to view the values while scrolling through parameters. Only after the Shift key is pressed will the actual value appear.

To enter an access code, re-program parameter **811** as you would any other parameter. After the new value is stored, you have 10 minutes of free access. If you remove power and then restore it, you will need to enter the access code to change any program parameter. If you enter an incorrect access code, the drive displays **WRONG CODE** and allows only viewing rights to the various parameters. Once the correct code is entered, you again have 10 minutes of free access unless power is removed and restored. To disable the access code requirement, set parameter **811** back to 000.

812 Freq Ref Output	Default: 6FS	Range: text string Level 2

The **Frequency Reference Output** parameter determines the frequency pulse-train output from the DOP terminal. This digital output is a pulse train that can be linked to another drive or to a field meter for speed indication. The pulse train is a 50% duty cycle signal and requires a pull-up resistor of approximately 4.7 kOhms.

The following data values may be assigned to this parameter:

Parameter Value

6FS
48FS

813 Speed Ratio	Default: 100.0%	Range: 0.0%-200.0% Level 2

The **Master / Follower Speed Ratio** parameter allows the pulse train output of one X4 series drive (master) to be used to control the speed of up to 8 other follower drives. The output of each follower can be individually programmed, or trimmed "ON-THE-FLY" with this parameter. The range of adjustment is 0-200% of the master. This function only works when using the 6FS and 48FS functions in parameter **204**.

Table 7-2: Description of X4 Parameters *(Page 21 of 25)*

814 Display Status	Default: Drive Load	Range: text string Level 2

This parameter allows configuration of the additional parameter status field on the operate screen. The following fields can be configured:

Parameter Value	Description	Range Limit
Voltage Out	Voltage being supplied to the motor	Rated motor voltage
Current Out	Current being supplied to the motor	200% of drive rating
Drive Load	Calculated percentage of drive rating	200% of drive rating
Drive Temp	Calculation of total drive temp rating	100% of unit temp rating
Power Out	Calculated power output of drive	250% of drive rating
% of FLA	Calculated percentage of drive rating	Percent of motor FLA

816 Fly Catch Mode	Default: Sweep Fwd	Range: text string Level 2

This parameter configures how the "catch on the fly" operates.

Parameter Value	Description
Sweep Fwd	Catch on the fly algorithm sweeps through frequencies only in the forward direction while searching for the operating frequency
Sweep Rev	Catch on the fly algorithm sweeps through frequencies only in the reverse direction while searching for the operating frequency
Sweep F/R	Catch on the fly algorithm sweeps through frequencies in both directions while searching for the operating frequency. The direction that is chosen first depends on the direction of the command given to the drive. Note that this option is slower than the other two modes of operation.

850 PI Configure	Default: No PI	Range: text string Level 2

The PI Configure parameter determines what type of PI control is active in the drive.

PI can be active at all times, or activated using a digital input. If you select a digital input or function key as the means to enable PI control, remember to configure the parameter that sets the function of the digital input or function key to enable PI control to complete the implementation.

The following data values may be assigned to this parameter:

Parameter Value	Description
No PI	PI control is always inactive.
Dir F-FWD	Direct action with feed-forward.
Rev F-FWD	Reverse action with feed-forward.
Dir F-FWD E	Direct action with feed-forward, with PI enabled by DI.
Rev F-FWD E	Reverse action with feed-forward, with PI enabled by DI.
Dir Full	Direct action with full range.
Rev Full	Reverse action with full range.
Dir Full E	Direct action with full range, with PI enabled by DI.
Rev Full E	Reverse action with full range, with PI enabled by DI.

851 PI Feedback	Default: Vin1	Range: text string Level 2

The PI Feedback parameter configures the feedback signal to be used in PI control.

The following data values may be assigned to this parameter:

Parameter Value	Description
Vin1	Vin1 is the PI feedback.
Cin	Cin is the PI feedback.
Vin2	Vin2 is the PI feedback.

852 PI Prop Gain	Default: 0	Range: 0-2000 Level 2

The PI Proportional Gain parameter configures the proportional gain that is applied to the PI control.

Note: Value must be greater than 0 for this to be active.

Table 7-2: Description of X4 Parameters *(Page 22 of 25)*

853 PI Int Gain	Default: 0	Range: 0-10000 Level 2
The PI Integral Gain parameter configures the integral gain that is applied to the PI control. **Note:** Value must be greater than 0 for this to be active.		
854 PI Feed Gain	Default: 1000	Range: 0-2000 Level 2
The PI Feed Gain parameter allows the feedback signal to be scaled. A setting of 1000 indicates 100.0%.		
855 PI Error 1 **856 PI Error 2**	Default: Read-Only	Range: 0.00-100.00% Level 2
Both the PI Error 1 and PI Error 2 parameters are read-only; they provide feedback on how the PI control is operating.		
857 PI High Corr	Default: 100.00%	Range: 0.00-100.00% Level 2
This parameter sets the high limit of the PI output.		
858 PI Low Corr	Default: 0.00%	Range: 0.00-100.00% Level 2
This parameter sets the low limit of the PI output.		
900 SIO Protocol	Default: RTU N81	Range: text string Level 2 (SIO)
This parameter defines the protocol and the parity of the SIO port. The following data values may be assigned to this parameter: Parameter Value — Description RTU N81 — No parity, 8 data bits, 1 stop bit RTU N82 — No parity, 8 data bits, 2 stop bits RTU E81 — Even parity, 8 data bits, 1 stop bit RTU O81 — Odd parity, 8 data bits, 1 stop bit		
901 SIO Baud Rate	Default: 9600	Range: text string Level 2 (SIO)
This parameter defines the baud rate of the SIO port. The following data values may be assigned to this parameter: Parameter Value 4800 9600 19200 38400 57600		
902 Comm Drop #	Default: 1	Range: 1-247 Level 2 (SIO)
This parameter defines the network drop number for both SIO and IRDA communications.		
903 SIO Timer	Default: 1.0 sec	Range: 0.0-60.0 sec Level 2 (SIO)
This parameter defines a watchdog timer that will require a valid communication in the specified time period while in SIO control. If the requirement is not met, a fault occurs.		

Table 7-2: Description of X4 Parameters *(Page 23 of 25)*

904 SIO Cntl Word	Default: 0x0000	Range: text string Level 2 (SIO)

The SIO Control Word parameter allows control of the drive through Modbus communications.

The following bits are used with this parameter:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
8	Alt Ramp	0	SLC (Run)
9	PI Enable	1	SLF (Ref)
10	Not Used	2	FWD
11	Cur Lim	3	REV
12	DCI	4	FEXT2
13	CTS	5	Preset Input 1 (PS1)
14	Ref Switch	6	Preset Input 2 (PS2))
15	Fault Reset	7	Preset Input 3 (PS3)

905 Ext Ref Freq 1 **906 Ext Ref Freq 2**	Default: 0.0 Hz	Range: Min. Freq.-Max. Freq. Level 2 (SIO)

These parameters provide access for changing the frequency reference over the serial link.

908 Status Word	Default: Read-Only	Range: text string Level 2 (SIO)

The Status Word parameter provides status of the drive operation to a serial link user.

The following bits are used with this parameter:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
8	Alt Ramp	0	SLC (Run)
9	SL Override	1	SLF (Ref)
10	Remote	2	FWD run
11	Curr Lim	3	REV run
12	DCI	4	FEXT2
13	Jogging	5	Accel
14	Zero Spd	6	Decel
15	Drive Flt	7	At Speed

909 DI Status	Default: Read-Only	Range: text string Level 2 (SIO)

This parameter provides a 10-bit status display.

The following bits are used with this parameter:

9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
5	DI3 Input	0	FWD Input
6	DI4 Input	1	REV Input
7	DI5 Input	2	R/J Input
8	MOL Input	3	DI1 Input
9	EN Input	4	DI2 Input

Table 7-2: Description of X4 Parameters *(Page 24 of 25)*

910 Vin1 Status **911 Cin Status** **912 Vin2 Status**	Default: Read-Only	Range: 0.00-100.00% Level 2 (SIO)

Parameter **910** provides the input percentage applied to the Vin1 terminal; parameter **911** provides the input percentage applied to the Cin terminal; and parameter **912** provides the input percentage applied to the Vin2 terminal.

913 Output Status	Default: Read-Only	Range: text string Level 2 (SIO)

This parameter provides a 10-bit binary status display. A "1" in the status word indicates that the output is active.

The following bits are used with this parameter:

9	8	7	6	5	4	3	2	1	0

Bit	When Set to 1 Signifies	Bit	When Set to 1 Signifies
5	N/A	0	R1 Output
6	N/A	1	R2 Output
7	N/A	2	DO1 Output
8	N/A	3	DO2 Output
9	N/A	4	N/A

914 Vmet Status **915 Imet Status**	Default: Read-Only	Range: 0.00-100.00% Level 2 (SIO)

Parameter **914** provides the output percentage applied to the Vmet terminal; parameter **915** provides the output percentage applied to the Imet terminal.

916 Infrared Baud	Default: 9600	Range: text string Level 2 (SIO)

This parameter defines the baud rate of the IRDA port.

The following data values may be assigned to this parameter:

Parameter Value

9600
19200
38400
57600

931 Seq Cntl 1 **932 Seq Cntl 2** **933 Seq Cntl 3** **934 Seq Cntl 4** **935 Seq Cntl 5** **936 Seq Cntl 6** **937 Seq Cntl 7** **938 Seq Cntl 8** **939 Seq Cntl 9**	Default: 00000000000	Range: text string Level 2 (SEQ)

These parameters each provide a 10-bit binary status display. See "Using the X4 Program Sequencer" on page 84.

The following bits are used with each of these parameters:

Bit 0-2=Speed Sel
Bit 3=Accl Sel
Bit 4-6=Event Length
Bit 7-8=Dir Sel
Bit 9-10=Output Sel

Table 7-2: Description of X4 Parameters *(Page 25 of 25)*

951 Seq Count 1 **952 Seq Count 2** **953 Seq Count 3** **954 Seq Count 4** **955 Seq Count 5** **956 Seq Count 6** **957 Seq Count 7** **958 Seq Count 8** **959 Seq Count 9**	Default: 0	Range: 0-65535 Level 2 (SEQ)
These parameters configure the time, number of pulses, or analog level of sequencer steps 1 through 9, respectively. See "Using the X4 Program Sequencer" on page 84.		

7.4 Using the X4 Program Sequencer

The X4 AC drive offers functionality that allows users to program up to nine independent operation states of the drive. This functionality is called the "program sequencer" because it allows the drive to sequence through the operation states programmed by the user. The X4 Program Sequencer can be used in applications that would normally require external intelligence, such as a simple programmable logic controller.

7.4.1 Enabling the X4 Program Sequencer

The X4 Program Sequencer can be enabled with parameter 491 (Seq Appl), found in the Application Macro programming mode of the X4 keypad. This parameter configures:

- Whether the sequencer is enabled,
- The time base used for all timing of the sequencer,
- Whether other sequencer parameters are visible in Level 2 programming.

Table 7-3 shows the options for this parameter:

Table 7-3: Seq Appl Parameter Options

Options	Value	Meaning
Disabled	0	The Sequencer mode of the X4 is not active and the sequencer parameters are not visible in Level 2 programming.
1 sec base	1	The Sequencer mode of the X4 is active, sequencer parameters are visible in Level 2, and all timing for the sequencer will be on a 1-second base.
.1 sec base	2	The Sequencer mode of the X4 is active, sequencer parameters are visible in Level 2, and all timing for the sequencer will be on a .1-second base.
.01 sec base	3	The Sequencer mode of the X4 is active, sequencer parameters are visible in Level 2, and all timing for the sequencer will be on a .01-second base.

7.4.2 Controlling the X4 Program Sequencer

The Program Sequencer can be activated and controlled from either the keypad or the terminal strip. It is not possible to control the sequencer through the serial link. The control method of the program sequencer is determined by parameter **201, Input Mode**. Setting the Input Mode parameter also

allows switching from Sequencer mode to normal keypad operation by way of the Local/Remote switch. Table 7-4 illustrates possible program sequencer control configurations.

Table 7-4: Program Sequencer Control Configuration

Input Mode Setting	Input Mode Value	Local Operation	Remote Operation
Local Only	0	Sequencer control via keypad (FWD/ Stop) Default Seq Ref is keypad	N/A
Remote Only	1	N/A	Seq control via FWD terminal Default Seq Ref is "Ref Select"
L/R Rem Ref	2	Normal X4 keypad operation (Sequencer disabled)	Seq control via keypad (FWD/Stop) Default Seq Ref is "Ref Select"
L/R Rem Ctl	3	Normal X4 keypad operation (Sequencer disabled)	Seq control via FWD terminal Default Seq Ref is keypad
L/R Rem Bth	4	Normal X4 keypad operation (Sequencer disabled)	Seq control via FWD terminal Default Seq Ref is "Ref Select"
EMOP	5	Sequencer not enabled	Sequencer not enabled
EMOP2	6	Sequencer not enabled	Sequencer not enabled
LOC/EMOP	7	Sequencer not enabled	Sequencer not enabled
LOC/EMOP2	8	Sequencer not enabled	Sequencer not enabled

Note: *If Input Mode is configured to any of the EMOP options, the sequencer is not available.*

Keypad Control (Activation) of the X4 Program Sequencer

When activating or controlling the X4 Program Sequencer from the keypad, pressing the FWD key commands the drive to cycle through the programmed states of the sequencer one time only (one-shot operation). One-shot operation will run the sequencer until state 9 is reached, or until any state that is not changed from the default is reached.

Pressing the SHIFT and FWD keys simultaneously causes the programmed sequence to repeat until the Stop key is pressed (continuous operation). In continuous mode, the sequencer runs until state 9 or any state that is not changed from the default is reached; it then jumps back to state 1.

Note that the REV key has no function in the sequencer mode.

Terminal Control of the X4 Program Sequencer

When activating or controlling the X4 Program Sequencer from terminals, continuous and one-shot operation is determined by whether the drive is wired for 2-wire or 3-wire control. If the terminal is set up for 2-wire control, the sequencer operates in continuous mode (R/J terminal inactive). This will run the sequencer until the Forward command is removed. If the terminal is set up for 3-wire control, the sequencer runs one cycle when the FWD terminal is activated.

Note that the REV terminal has no function in sequencer mode.

X4 Sequencer Dwell Functionality

The X4 sequencer has the capability to dwell, or pause, in a state and disregard any command to advance to the next state. This can be done in two different ways, and both methods can be used at the same time.

If the sequencer is actively running and the Enter key is pressed from the Operate screen of the X4 keypad, the sequencer will dwell in the current state (it will never advance to the next state). While the sequencer is dwelling, a warning of "Seq Dwell" will flash on the Operate screen. To leave the dwell state, press the Enter key again from the Operate screen.

The sequencer Dwell mode can also be entered by programming a digital input to "Seq Dwell." The sequencer will then dwell in the current state, for as long as the digital input is active.

X4 Sequencer Advance Functionality

The sequencer has the ability to allow the user to advance to the next state without satisfying the conditions programmed to advance. To do this, program a digital input to "Seq Advance." When a digital input program to this option changes from inactive to active, a running sequencer will advance one state. This feature is useful when debugging a sequence with long time intervals.

7.4.3 Sequencer State Configuration Overview

Each state of the program sequencer is defined by five characteristics:

- Direction in which the drive will operate
- Speed at which the drive will operate
- Ramp selection of the drive
- Output configuration (relays and digital outputs) of the drive
- How the sequencer advances to the next state.

These five characteristics are configured by two parameters for each state. These parameters are named "Seq Cntl X" and "Seq Count X," where X represents the state number of the sequencer. The "Seq Cntl X" parameter is a binary parameter that sets each of the five characteristics listed above. "Seq Count X" configures the threshold that the sequencer will use in determining when to advance by the method programmed in the control parameter. The bit patterns of the Seq Cntl X" parameters are shown in Figure 7-1:

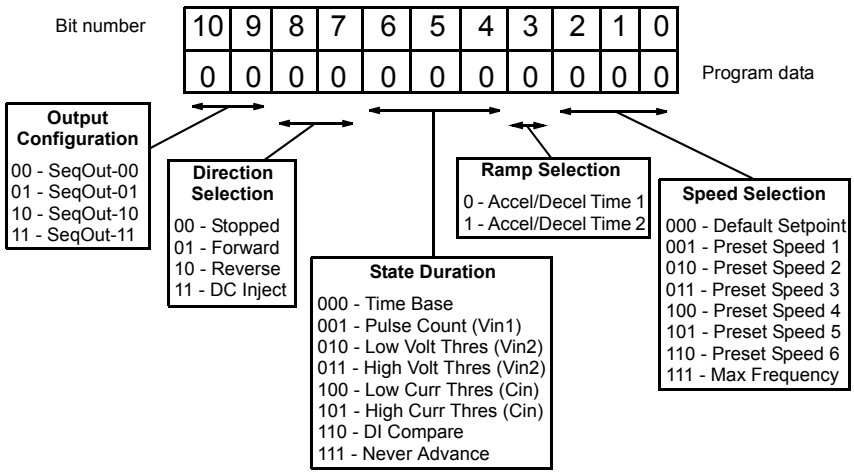


Figure 7-1: Seq Cntl Parameter, Bit Definition

X4 Sequencer Speed Selection

Table 7-5 gives more information on the speed selection options available in the X4 sequencer by programming bits 0, 1, and 2 of each state's control parameter. The options include any Preset Speed, Max Frequency, or allowing the reference to be determined in the normal X4 control path.

Table 7-5: Speed Selection Options

Binary Value	Definition (Resulting Speed)
000	Speed selection as in normal X4 operation, as defined by parameters **204** (Ref Select) and **201** (Input Mode).
001	Value of parameter Preset Speed 1(**303**)
010	Value of parameter Preset Speed 2(**304**)
011	Value of parameter Preset Speed 3(**305**)
100	Value of parameter Preset Speed 4(**306**)
101	Value of parameter Preset Speed 5(**307**)
110	Value of parameter Preset Speed 6(**308**)
111	Value of parameter Max Frequency (**302**)

X4 Sequencer Ramping Selection

When the sequencer is active, the active ramp is no longer determined by parameter "Ramp Select." The user, however, does have the choice of using the main ramps (Accel Time 1/Decel Time1), or the alternate ramps (Accel Time 2/Decel Time 2) for each independent state. This is determined by bit 3 of the control parameter. If bit 3 is set to 1, then the alternate ramps are used (Accel Time 2/ Decel Time 2).

Sequencer Output Configuration

The X4 Program Sequencer allows digital outputs to be activated during states of the sequencer. This function could be used to activate other devices in a system or to signal to an operator when a part of the sequence is active. The user sets the digital output by setting bits 9 and 10 of the control parameter with a binary value, and then sets a digital output parameter with the option for that same binary value. For example, if a control state was output configured for a binary value of 11, then any digital output configured to "SeqOut-11" would be activated during that time.

Sequencer Direction Selection

The sequencer allows each state to be configured as running **Forward**, **Reverse**, **Stopped**, or **DC Injected** by setting bits 7 and 8 of the control parameters.

Sequencer State Duration

Bits 4, 5, and 6 of each sequencer control parameter specify how that step will allow advancement to the next step. The options for advancement are **time**, **pulse input**, **voltage threshold**, **current threshold**, or **digital input comparison**. After the advancement method is selected with these bits, the threshold of advancement is determined by the state's count parameter (see the next paragraph).

Sequencer State Advance Threshold (via Count Parameter)

The sequencer count parameters work in conjunction with the state duration configuration in the control parameter to determine when to advance to the next state. The function of this parameter is dependent on the state duration configuration as defined in Table 7-6 on page 88. The range of data

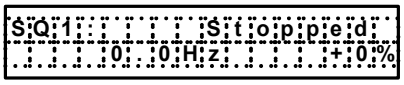
programmed into this parameter can be from 0 to 65,535, and can represent time, pulse counts, analog voltage thresholds, analog current thresholds, or digital comparison values.

Table 7-6: Seq Count Definition Based on Cntl Parameter Configuration

<table>
<tr><th>Bits 4,5,6 of Seq Cntl</th><th colspan="5">Description of Seq Count Function</th></tr>
<tr><td rowspan="5">000</td><td colspan="5">Time Base - The current sequencer state will last for a time interval equal to the number “Seq Count X” multiplied by the time base configured in the Seq Appl parameter.</td></tr>
<tr><td colspan="2">Seq Appl Setting</td><td colspan="2">Time to Advance</td><td>Maximum Sequence Time</td></tr>
<tr><td colspan="2">1 sec Base</td><td colspan="2">(1 sec) * (Seq Count X)</td><td>18.2 hours</td></tr>
<tr><td colspan="2">.1 sec Base</td><td colspan="2">(0.1 sec) * (Seq Count X)</td><td>1.82 hours</td></tr>
<tr><td colspan="2">0.1 sec Base</td><td colspan="2">(0.01 sec) * (Seq Count X)</td><td>10.92 minutes</td></tr>
<tr><td>001</td><td colspan="5">Pulse Count - The current sequencer state will last until the number of pulses programmed into “Seq Count X” is detected on terminal Vin1.</td></tr>
<tr><td>010</td><td colspan="5">Low Analog Voltage Threshold - The active sequencer state lasts until the voltage signal applied to terminal Vin2 is < a value programmed into “Seq Count X.” The value programmed into “Seq Count X” should be the percentage of input after span and offset are applied (where 100.00% = 10000).
Note: The % of analog input after span and offset can be read in parameter 912, Vin2 Status.</td></tr>
<tr><td>011</td><td colspan="5">High Analog Voltage Threshold - The active sequencer state lasts until the voltage signal applied to terminal Vin2 is > a value programmed into “Seq Count X.” The value programmed into “Seq Count X” should be the percentage of input after span and offset are applied (where 100.00% = 10000).
Note: The % of analog input after span and offset can be read in parameter 912, Vin2 Status.</td></tr>
<tr><td>100</td><td colspan="5">Low Analog Current Threshold - The active sequencer state lasts until the current signal applied to Cin terminals is < a value programmed into “Seq Count X.” The value programmed into “Seq Count X” should be the percentage of input after span and offset are applied (where 100.00% = 10000).
Note: The % of analog input after span and offset can be read in parameter 911, Cin Status.</td></tr>
<tr><td>101</td><td colspan="5">High Analog Current Threshold - The active sequencer state lasts until the current signal applied to Cin terminals is > a value programmed into “Seq Count X.” The value programmed into “Seq Count X” should be the percentage of input after span and offset are applied (where 100.00% = 10000).
Note: The % of analog input after span and offset can be read in parameter 911, Cin Status.</td></tr>
<tr><td rowspan="10">110</td><td colspan="5">Digital Comparison - The active sequencer state lasts until the binary value of digital inputs configured to Seq1, Seq2, and Seq3 is equal to the value programmed into "Seq Count X."
Note: For this option to work, "DIx Configure" parameters must be set to "Seq1," "Seq2," and "Seq3.”</td></tr>
<tr><td rowspan="2">Seq Count</td><td colspan="3">Digital Input Terminals</td><td rowspan="2">Description</td></tr>
<tr><td>Seq1</td><td>Seq2</td><td>Seq3</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>No input active</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>Seq1 active</td></tr>
<tr><td>2</td><td>0</td><td>1</td><td>0</td><td>Seq2 active</td></tr>
<tr><td>3</td><td>1</td><td>1</td><td>0</td><td>Seq1 & Seq2 active</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>1</td><td>Seq3 active</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>1</td><td>Seq1 & Seq3 active</td></tr>
<tr><td>6</td><td>0</td><td>1</td><td>1</td><td>Seq2 & Seq3 active</td></tr>
<tr><td>7</td><td>1</td><td>1</td><td>1</td><td>Seq1, Seq2, Seq3 active</td></tr>
<tr><td>111</td><td colspan="5">The sequencer will never advance if this option is selected.</td></tr>
</table>

7.4.4 Sequencer Status Indicators

When the sequencer is enabled, the control path indication field on the keypad will indicate SQ*x*, where *x* represents the active state of the sequencer. A sample operate screen (where the sequencer is in state 1) is shown below:



When the sequencer is running, a warning, "Seq Running," will flash on the screen to indicate that the drive control state may change without user input. For example:

When the sequencer is dwelling (pausing) in a state, a warning, "Seq Dwell," will flash on the screen to indicate that the sequencer will not advance. For example:

7.4.5 Sample Sequencer Program

A machine is required to run in the forward direction at 50 Hz for one hour, then quickly decelerate to a stop. While stopped, a digital output must be enabled to sound an alarm to an operator. After two minutes, the machine must accelerate in the reverse direction to 5 Hz until a limit switch is activated., causing the drive to decelerate to a stop. The following three sequential states can be programmed using only the drive:

Table 7-7: Sample Sequencer Program Requirements

	State 1	State 2	State 3
Direction Selection	Forward	Stop	Reverse
Speed Selection	50 Hz	Zero speed	5 Hz
Ramp Selection	Primary	Alternate	Primary
Output Configuration	SeqOut-00	SeqOut-01	SeqOut-10
State Duration	1 hour	2 minutes	Until DI active

First, since two of the sequential states are time-based, the proper setting of the "Seq Appl" parameter must be determined. Since there is not time required that has resolution needed of less than one second, the "1 sec Base" option is the easiest to use. If greater resolution is needed (for example, if a state needed to last for 2.5 seconds), another option should be chosen.

Since the sequence requires use of a digital input and a digital output, two non-sequencer parameters need to be used. Set the parameter "DI1 Configure" to "Seq1" and the parameter "DO1 Configure" to "SeqOut-01."

Since control of the sequencer is only needed from the keypad, the configuration of the "Input Mode" parameter should be "Local Only."

Required parameter modifications for this program are provided in Table 7-8, with explanations.

Table 7-8: Required Parameter Settings for Sample Sequencer Program

Parameter	Value	Explanation
Seq Appl	"1 sec Base"	Sets 1 second time increments
DI1 Configure	"Seq1"	Allows DI1 to end state 3
DO1 Configure	"SeqOut-01"	Allows DO1 to be active in state 2
Preset Speed 1	5 Hz	Speed for state 3
Preset Speed 6	50 Hz	Speed for state 1
Seq Cntl1*	00010000110	No outputs/FWD/Timed/Primary Ramp/Preset Speed 6
Seq Count 1	3600	1 hour = 3600 seconds
Seq Cntl 2*	01000001000	Enable Output/Stop/Timed/Alt Ramp/Speed Ignored
Seq Count 2	120	2 minutes = 120 seconds
Seq Cntl 3*	00101100001	No outputs/REV/DI Value/Primary Ramp/Preset Speed 1
Seq Count 3	1	Seq1 active

Worksheet for Sequencer Program Setup *(remove and make a copy for each machine as needed)*

	Output Configuration		**Direction Selection**		**State Duration**			**Ramp Selection**	**Speed Selection**		
Step											
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Chapter 8: Troubleshooting

8.1 X4 Fault Codes

Table 8-1 shows the fault codes that may be displayed during X4 AC drive operation, along with suggestions for recovering from the fault condition.

When faults occur, you can access the status parameters that are saved along with the fault (Advanced Fault history). To view these parameters, which store the drive's status at the time of the fault, view **Fault History**, and select **Last Fault**. Press the **Shift** key while viewing the last fault, and then use the **UP** and **DOWN** arrow keys to scroll through the stored drive status parameters. Press the **Shift** key again to return to the programming mode fault parameter.

Table 8-1: X4 Fault Codes *(Page 1 of 5)*

Code	Fault Display	Description	Adv. Fault Code	Explanation	Suggestions for Recovery
1	System	System fault	0,1,2	Internal microprocessor problem	Consult factory for repair or replacement.
			3	Thermistor profile incorrect	Consult factory for repair or replacement.
2	EE Checksum	Checksum error	0	Memory problem when reflashing the drive's memory	• Reset drive to factory settings. • Consult factory.
			1,2,3	Conflict in drive's memory	• Reset drive to factory settings. • Consult factory.
			4	Unable to write an EE parameter after a parameter has been changed through the keypad or SIO	• Reset drive to factory settings. • Consult factory.
			5	The drive is receiving EE write requests faster than they can be processed. This would typically be caused by writing parameters too frequently through Modbus.	Slow down the frequency of Modbus writes.
3	Curr Calibr	Current calibration fault	0	Current calibration fault on phase T1/U	• Check the motor connections to the terminal strip of the drive and at the motor. • Have motor checked. • Consult factory for repair or replacement of drive.
			1	Current calibration fault on phase T2/V	
			2	Current calibration fault on phase T3/W	
4	Power Supp	Power supply fault	0	5V supply is below 4 Vdc for more than 100 ms	• Increase resistance between REF and analog inputs. • Check wiring to REF terminals. • Consult factory.
6	IOC Trip	Instantaneous overcurrent trip	0	Short circuit was detected on power-up	• Remove the short from the power wiring • Check for shorted motor • Consult factory.
			1	Short circuit was detected during operation	
7	MOL	MOL contact fault	0	The MOL digital input was activated, depending on pull-up or pull-down logic configuration	Reset MOL contact or remove condition causing the MOL contact activation.

Note: Shaded faults are auto-resettable, except where noted.

Table 8-1: X4 Fault Codes *(Page 2 of 5)*

Code	Fault Display	Description	Adv. Fault Code	Explanation	Suggestions for Recovery
8	Model ID	ID # out of range	0,1,2	Control board is not reading the drive ID properly	Consult factory for repair or replacement.
10	Res Lockout	Restart lockout	0	The number of fault restarts is greater than the limit defined in the customer parameter.	Check the actual fault in the fault log and use the appropriate remedy.
11	Ground	Ground fault	0	The drive has detected current imbalance between output phases. Imbalance determined to be current flow to ground.	• Check for unbalanced currents. • Check for grounded motor leads or motor. • Consult factory.
12	Vac Imblnce	Input voltage imbalance	0	The drive has detected a single-phase condition or a voltage imbalance outside the drive's rating while running a load that could be damaging to the drive.	Check input voltage and current for imbalance, and correct.
13	OverVoltage	Overvoltage condition	0	The drive has detected an overvoltage condition during power-up *(not auto-resettable)*.	Verify incoming line power is within specification. Add reactor or transformer to correct.
			1,3	The drive has detected an overvoltage condition during a running condition.	Verify incoming line power and check for regenerative load. Reduce Regen load or add dynamic braking resistors. Regen Current Limit may help; consult factory.
			2	The drive has detected an overvoltage condition on power-up on the load side.	Verify incoming line power is within specification. Add reactor or transformer to correct.
15	Dyn Brake	Dynamic brake overload	0	The DB circuit is active on power-up *(not auto-resettable)*	Check for failed braking transistor. Consult factory.
			1	The DB circuit is being activated for too long, possibly causing the resistor to overheat or fail.	Reduce braking cycle or increase capacity. Activate current limit; consult factory.
			2	The DB circuit is overloaded because of too large a regenerative load.	Reduce braking cycle or increase capacity. Activate current limit; consult factory.
			3,4,5	The DB circuit is faulty on power-up *(not auto-resettable)*.	Consult factory.
18	OverCurrent	Overcurrent condition	0	The drive sensed an overcurrent condition on power-up *(not auto-resettable)*.	Check for failed output power device or shorted motor.
			1	The drive sensed an overcurrent condition during operation. The current has exceeded the safe operation point of power devices.	Reduce load on motor. Verify that Motor FLA is programmed correctly. Check for mechanical binding and shock loading.

Note: Shaded faults are auto-resettable, except where noted.

Table 8-1: X4 Fault Codes *(Page 3 of 5)*

Code	Fault Display	Description	Adv. Fault Code	Explanation	Suggestions for Recovery
19	Over Temp	Over- temperature condition	0	The temperature of the heatsink exceeded a temperature limit.	Check that ambient temperature does not exceed drive's rating. Check for fan operation (assuming drive has fans installed).
			1	The temperature of the control board exceeded a temperature limit.	Check that ambient temperature does not exceed drive's rating. Check for fan operation (assuming drive has fans installed).
			2	The drive sensed the heatsink thermistor sensor is faulty or not connected properly.	Check thermistor connections or replace. Consult factory.
			3	The drive sensed the control board thermistor sensor is faulty or not connected properly.	Check thermistor connections or replace. Consult factory.
20	Motor TOL	Motor timed overload trip	0	The drive detected an overload that exceeds the customer's defined overload setting.	Check load current demand. Verify Motor FLA is programmed to the correct value. Verify TOL characteristic is correct for the application.
21	Low Temp	Low temperature	0	This fault occurs if the temperature of the heatsink falls below -10.0 degrees C.	Verify that ambient temperature is within the drive's specifications; increase the ambient temperature if necessary.
22	Ref Loss	Speed reference loss	0	The drive detected the analog input was configured to fault if the input current went below the level specified by customer parameters.	Check physical connections for reference signal. Check that programming for 4-20 mA signal is correct. Verify that signal to the drive is correct.
23	Brk Wire	Broken wire detection	0	The drive detected that the potentiometer circuit wiring opened and generated a fault.	Check wiring for loss of connection to control terminals. Check that a proper-value potentiometer is installed.
24	Keypad Loss	Keypad loss	0	This fault occurs because of a problem with the keypad or a keypad connection. It occurs if the drive detects that it cannot read any key presses.	**Note:** The keypad is not intended for remote mounting without the use of an X4 Remote Keypad option. See Chapter 9 for more information on X4 Optional Equipment.
			1	This fault occurs because of a problem with the keypad, a keypad connection, or the wrong keypad is being used. It occurs if the keypad ID for an X4 cannot be read.	
			2	This fault occurs because of a problem with the keypad or a keypad connection. It occurs if the drive detects that it cannot write to the LCD.	

Note: Shaded faults are auto-resettable, except where noted.

Table 8-1: X4 Fault Codes *(Page 4 of 5)*

Code	Fault Display	Description	Adv. Fault Code	Explanation	Suggestions for Recovery
25	Comm Loss	Communication loss	0	This fault occurs when the drive is in a serial link control path and the amount of time since the last Modbus comm. exceeds the time set in parameter **903 (SIO Timer)**.	Check connections to the Modbus port. Adjust value of parameter **903 (SIO Timer)** as needed.
26	Regen Time	Regen timeout	0	This fault occurs if the drive takes more time to decelerate to a stop than is allowed. The timeout is determined by the longest deceleration ramp time (Decel1 or Decel2) plus the Regen Timeout parameter.	Reduce the amount of regenerative energy or iincrease the Regen timeout parameter.
27	Pwr Bridge	Power bridge fault	0,1,2	The drive detected a failure in the output power devices.	Check for failed input power device.
28	Drive TOL	Drive timed overload	0	The drive sensed an overload that exceeded the drive rating.	Check that load conditions do not exceed the drive's rating (120% for 60 seconds from nameplate current rating for normal duty and 150% or rated current for 60 seconds heavy duty).
29	Stuck Key	Stuck key error	0	This fault occurs if a key press is detected upon power-up. This would occur because of a defective keypad or because someone was holding down a key when powering-up the drive.	Check for stuck keypad and repair or replace. Consult factory.
30	Param Range	Parameter out of range	0	One of the customer parameters is out of range.	Check for a parameter value saved out of the standard range. Reset parameters to factory default. Consult factory.
31	Pwr Wiring	Power wiring error	0	This fault flags a problem with the drive wiring.	Check that input power wiring is not connected to load power terminals. Consult factory.
			1	This fault can occur if an IOC fault is detected during the power wiring test.	

Note: Shaded faults are auto-resettable, except where noted.

Table 8-1: X4 Fault Codes *(Page 5 of 5)*

Code	Fault Display	Description	Adv. Fault Code	Explanation	Suggestions for Recovery
32	Low Voltage (Undervoltage)	Low voltage trip	0	This fault occurs if a power dip occurs when the drive is operating, and the drive is not able to ride through the power dip before shutting off outputs.	Verify that input line power is within the drive's specifications. Add a transformer or reduce demands to power feed. Consult factory.
			1	This fault occurs when an undervoltage condition (power-down) is detected, **and** when parameter **501** is set for Vector or Linear Auto mode, with "Coast Stop" assigned as the parameter value. In undervoltage conditions, the drive coasts to a stop, and generates an undervoltage fault.	
			2	This fault occurs when an undervoltage condition (power-down) is detected, **and** when parameter **501** is set for Vector or Linear Auto mode, with "Controlled" assigned as the parameter value. In undervoltage conditions, the drive decelerates the motor. If power is restored, the drive accelerates to the command frequency without faulting; if the drive stops, it generates an undervoltage fault.	
33	1Ph Overload	1Ph overload	0	If the user configures parameter **517 (Single Phase)** for single-phase operation, this fault occurs if the bus voltage ripple is outside the limit of the drive.	Check that input power demand does not exceed the drive's capacity for single-phase operation. Consult factory.
34	RS Meas. Fail	Stator resistance measurement failed	0	If the drive cannot measure the stator resistance properly, this fault occurs.	Try the routine again and if the fault occurs twice, consult the factory.
35	Fan Loss	Loss of fan control or operation	0	There is a problem with the heat sink fan.	Consult factory.
			1	There is a problem with the internal fan. This occurs only on Size 4 and 5 models. All other models display a fan error warning. Note that this is lack of fan control, so the fan can be spinning and this fault will still occur. This can happen if the fan is on and should not be, or if the fan feedback signals are obstructed from getting to the control board.	

Note: Shaded faults are auto-resettable, except where noted.

Chapter 9: X4 AC Drive Options

PDA-trAC+® For Pocket PC

The wireless optical interface on the **X4** allows data transfer for X4 AC Drive settings, using the PDA-trAC+ to upload, download, edit, and save drive parameters easily and conveniently. This software can be downloaded from our web site at www.vacon.com, or contact your sales representative.

WIN-trAC® and WIN-trAC PRO® Drive Supervisor

This Windows®-based software program provides a simple and unique way to configure, monitor, diagnose, control, and manage drive applications. **WIN-trAC**, for single-drive, point-to-point applications, is provided free with the SIOC03 adapter for drives. **WIN-trAC PRO**, configured for multi-drive applications, must be registered for use.

Serial Communications Adapter

Part Numbers: **SIOC03**

This adapter is required when you are connecting to a PC. It converts the RS-232 serial output on the PC to RS-485 accepted by the drive. Cables and our WIN-trAC software package are bundled with this option.

Remote Keypad for X4 when used as a panel-mounted drive (Sizes 0 - 2)

Part Number: **XRKPM**

This Remote Keypad kit can be used when a Size 0 - 2 **X4** model is mounted inside a host enclosure, and when programming and operation need to be done on the front of the enclosure. The kit comes with a keypad and adapter assembly that replaces the standard keypad on the drive. The original keypad assembly is removed and discarded, or can be kept as a spare for other drive models not using the XRKPM option. The option includes a standard 12-foot ribbon cable. When installed properly, the remote keypad meets NEMA 4x/IP66 standards and the drive rating will be IP20.

Remote Keypad for X4 when used as a wall-mounted drive (Sizes 0 - 2)

Part Number: **XRKWM**

This Remote Keypad kit can be used when a Size 0 - 2 **X4** model is mounted in a stand-alone configuration, and when programming and operation need to be done in another location. The kit comes with a keypad and adapter assembly that replaces the standard keypad on the drive. The remote keypad can be mounted up to 100 feet from the drive, and requires a 15-conductor shielded cable to be supplied by the user. When installed properly, both the remote keypad and drive meet NEMA 4x/IP66 standards.

Remote Keypad Mounting Kit for X4 (Sizes 3 through 5)

Part Number: **XRKMK**

This Remote Keypad kit can be used with a Size 3, 4, or 5 **X4** model to allow the keypad to be mounted in another location. The kit comes with an adapter assembly to allow the existing keypad to be remotely mounted. The remote keypad can be mounted up to 100 feet from the drive, and requires a 15-conductor shielded cable to be supplied by the user. When installed properly, both the remote keypad and drive will meet the unit's core enclosure standards, either NEMA 4x/IP66, or NEMA 12/IP55.

Appendix A: Parameter 201 Options

The following table shows how parameter **201** (Input Mode) options function in local or remote mode.

Parameter 201 Option	Local		Remote	
	Speed Control	**Start/Stop Control**	**Speed Control**	**Start/Stop Control**
Local Only	Keypad	Keypad	None	None
Remote Only	None	None	Speed potentiometer, terminal strip signals	Terminal strip switch network
L/R Rem Ctl	Keypad	Keypad	Keypad	Terminal strip switch network
L/R Rem Ref	Keypad	Keypad	Speed potentiometer, terminal strip signals	Keypad
L/R Rem Bth	Keypad	Keypad	Speed potentiometer, terminal strip signals	Terminal strip switch network
EMOP_EMOP2	None	None	Terminal strip momentary pushbuttons	Terminal strip switch network
LOC / EMOP_EMOP2	Keypad	Keypad	Terminal strip momentary pushbuttons	Terminal strip switch network

EU Declaration of Conformity

WE: Vacon, Inc.
3181 Black Gap Road
Chambersburg, PA 17202 USA

hereby declare that the products:

Product Name: Vacon X Series AC Drives;

Model Designation: Vacon X4CxxxxxC(or D) and X5CxxxxxC(or D) and X5CxxxxxC09

have been designed and manufactured in accordance with standards:

Low Voltage Directive:	EN50178 Electronic equipment for use in power installations
Electromagnetic compatibility:	The models listed above do not include internal EMC filters and external equipment must be used to achieve EN61800-3 compliance. Units in the 380-460V range (as denoted with a 1 suffix, e.g. XxC4xxxxC1) include internal EMC filters, and fulfill the requirements of the 2nd environment (EN61800-3 category C3; EN55011 class A2). XxC40750C through XxC42000D meet the 2nd environment requirements without added filters.

The products referenced above are for the use of control of the speed of AC motors.

Via internal mechanisms and Quality Control, it is verified that these products conform to the requirements of the Directive and applicable standards.

Chambersburg, PA, USA — February 27, 2009

Frank H. Custis
Product Marketing Manager
Harsh Duty Drives
Vacon

VACON

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DPD00088A

WATSON MARLOW
Fluid Technology Group

Part 7: Calibration Column

Griffco Valve Inc.
6010 N. Bailey Ave, Ste 1B
Amherst, NY 14226 USA
Phone: +1 716-835-0891
Fax: +1 716-835-0893
sales@griffcovalve.com
www.griffcovalve.com

PVC CALIBRATION COLUMNS

Griffco calibration cylinders are designed to enhance the performance of chemical feed systems by providing a verification of the flow rate of the chemical feed pump. Robust construction of clear PVC with an easy to read graduation in mL and gph. Available in three models: EZ-Clean, Vented, and Open Top; and in 15 sizes: 100 mL through 40,000 mL as detailed here.

Features:

- **High Reliability / Low Cost**
- **High Contrast Graduation Markings**
- **Clear Easy-View Tube**
- **Robust Schedule 40 Pipe Construction**
- **Direct GPH Readout**
- **Sealed Top with Overflow Connection**
- **Optional EZ-Clean Model**
- **Optional Open Top with Dust Cap**

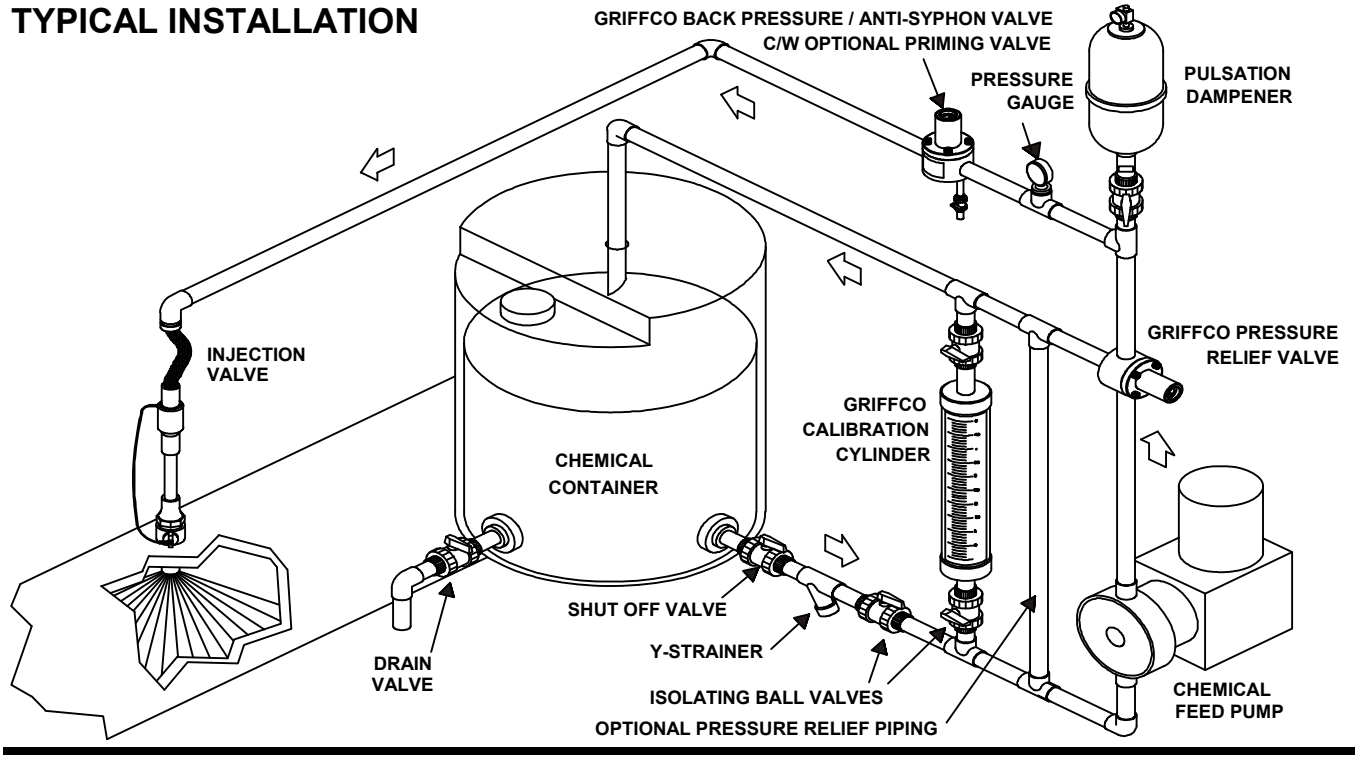
Operation:

Griffco calibration cylinders are installed in the suction line to the chemical metering pump. Two isolating valves, (not supplied) must be installed in the suction line as per the drawing below. The top of the cylinder should be vented back to the storage tank or to drain.
Fill the cylinder to the top mark then close the valve from the chemical tank. Switch on the chemical feed pump and draw down the chemical in the cylinder for 30 seconds. Switch the pump off. The reading on the right side of the cylinder is a direct readout of USgph.
Alternatively, observe the volume withdrawn on the mL scale. To convert to LPH or GPH use this formula:

LPH = 3.6 x [mL] ÷ Time (sec)
GPH = 0.951 x [mL] ÷ Time (sec)

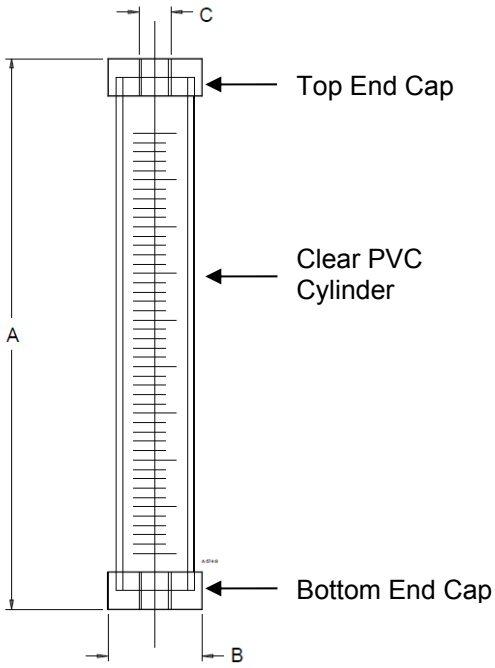
Note: Max. cylinder pressure is 15 psi.

TYPICAL INSTALLATION



Description of models:

Sealed:
Top is glued to cylinder and contains a vent or overflow connection. (FNPT). Used in applications where there is a positive suction head and a permanent installation is desired.



Capacity (mL) ◊	Max Flow ▲ (USgph)	(lph)	Scale (mL)	Scale ▲ (gph)	A (in)	B (in)	C (in)
10,000	317.0	1200	100	5	25	6.95	2

▲ Max Flow and gph scale are based on 30 second drawdown
◊ For 60 sec draw down, double capacity in mL or flow size

* Reference only

Codes for Ordering PVC Calibration Columns:

CC □□□□ □ □ □
1 **2** **3** **4**

1 = Size

10000 – 10000 mL

2 = Top End Cap Style (Top Cap Only)

S – Sealed

3 = Connections

Blank – Threaded

4 = Oring Material (Union & EZ end cap orings)

Blank – FKM (Viton®)

WATSON MARLOW
Fluid Technology Group

Part 8: Pressure Relief Valve

Griffco Valve Inc.
6010 N. Bailey Ave., Ste 1B
Amherst, NY 14226 USA
Phone: +1 716 835-0891
Fax: +1 716 835-0893
sales@griffcovalve.com
www.griffcovalve.com

G - SERIES
PRESSURE RELIEF VALVE

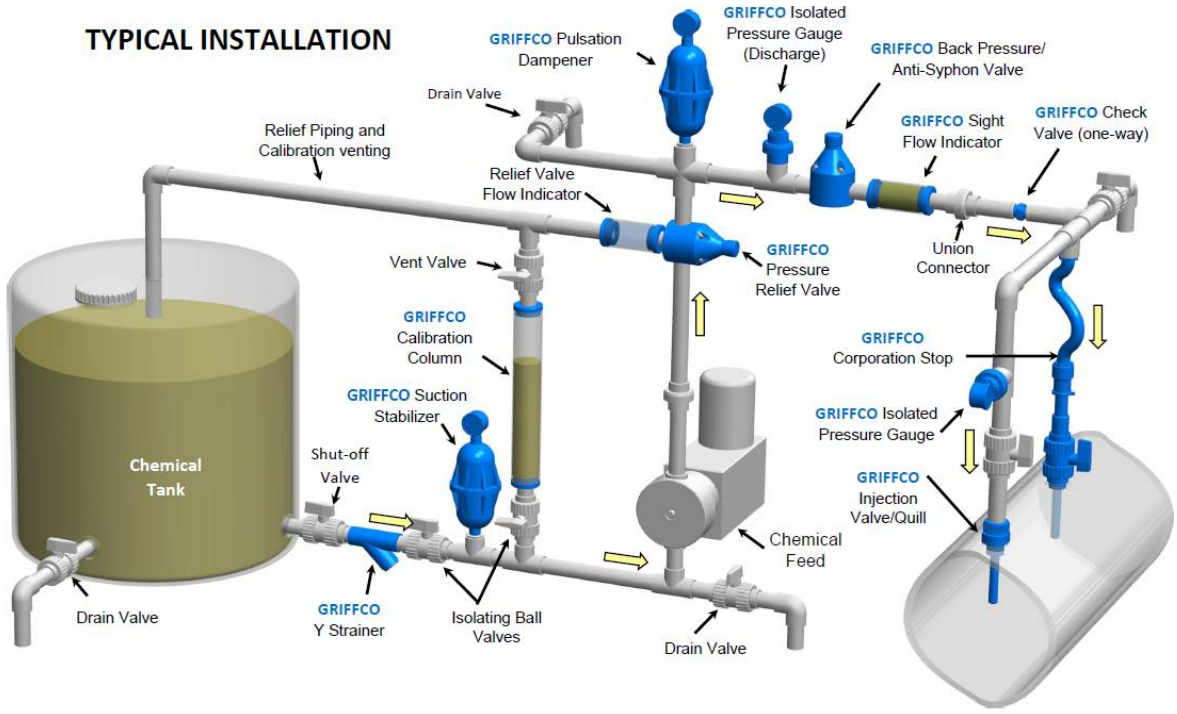
Griffco G-Series diaphragm pressure relief valves are designed to protect chemical feed systems from over pressure damage caused by defective equipment or a blockage in the chemical feed line. Robust construction ensures reliability in the rigorous service of municipal and industrial applications. Wetted materials include: **PVC, CPVC, PP, PVDF, PTFE, Halar, 316 SS, A20 and Hastalloy C**. Available sizes: 1/2" - 4".

Features:

- **Molded Noryl Top**
- **High Reliability / Low Cost**
- **Molded PTFE/EPDM Diaphragm**
- **Adjustable 10 - 150 PSI**
- **Optional: Other PSI Rated Valves**
- **2 & 3 Port Configurations**
- **Ventable to Suction Line**
- **Robust, Machined Construction**
- **Wide Range of Materials**

Operation:

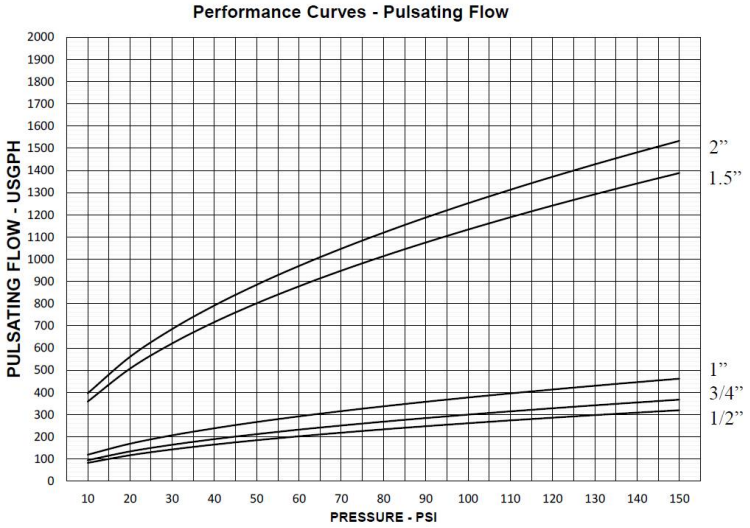
Griffco diaphragm pressure relief valves operate when the pressure in the chemical system exceeds the preset pressure of the valve. The diaphragm is held against the valve seat by an internal spring. When the preset pressure is exceeded the diaphragm is forced up and the chemical flows out the relief port, back to the chemical tank or to the suction side of the pump. The valves are pre-set at 50 psi, however they are field adjustable from 10 - 150 psi, (up to 350 psi) via the adjustment screw. The relief valve should be set approximately 15 psi higher than the system pressure. Installation should be made as close to the pump as possible, without any valves or accessories between the relief valve and the pump. Consult your pump manufacturer for their recommendations.



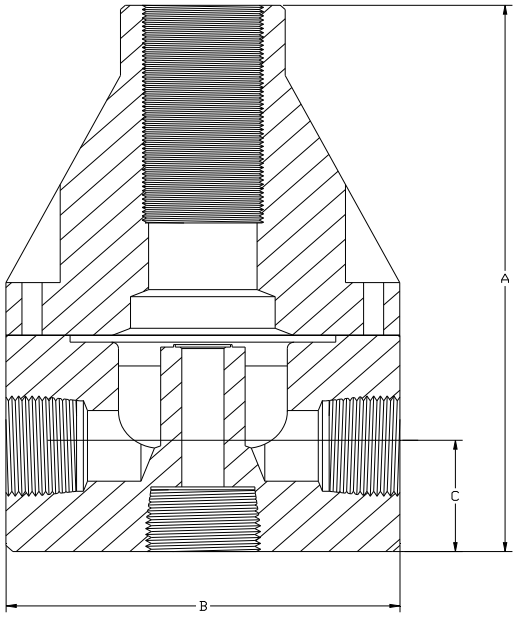
Technical Data:

Model PRG Sizes: PRG,			**1”**	
Connections:			**NPT**	
Pressure Adjustment			**Standard: 10 - 150 psi**	
Flow Rates @ 150 psi			**Shipping Weight: lbs**	
Size	**Pulsating**	**Continuous**	**Plastic**	
1”	**462 USgph**	**24.2 USgpm**	**3.5**	
Max Temperature: (°F)			**PVC: 140°**	
Max Operating Pressure (psi) @ 70 deg. F			**Plastic/Noryl: 375 psi**	**Metal/Metal: 2000 psi**
Materials of Construction:				
Diaphragm			**PTFE / EPDM, Optional: Viton**	
Valve Top			**Standard: Noryl (1/2” – 2”) PVC (3” & 4”) Optional: 316 SS L**	
Valve Body			**PVC**	

Performance Curves: (3” & 4” curves on request)



Dimensions:



DIMENSIONS: PRG - Series				
All Materials (1.5” and larger are 2 port only, no bottom port)				
Size	A (in.)	B (in.)	C (in.)	Orifice (in.)
1”	5.860	3.500	1.250	0.437

Product Codes For Ordering Pressure Relief Valves:

PRG, PRG2 (2 port) or ☐☐☐ ☐ ☐ ☐

1 2 3 4

1 = Size **2 = Material** **3 = Spring Opt** **4 = Options**

P - PVC — Blank - 10-150 psi — Blank - NPT Threaded; V - Viton Diaphragm

100 - 1”

Note: For Optional 2-Port pressure relief valve put “2” after PRG
Note: Option MSS only for use with 316SS, A20 & Hast C. valves
Note: 1.5” and larger are 2 port only, there is no bottom port.

Email: sales@griffcovalve.com **Website: www.griffcovalve.com**

WATSON MARLOW
Fluid Technology Group

Part 9: Pressure Gauge and Diaphragm Seal

Type 1009SW Stainless Case Gauge with Stainless Steel System

MADE IN THE USA

Compliant·RoHS 2002/95/EC·Compliant

FEATURES

- *Patented PowerFlex™ movement*
- *All stainless steel welded construction*
- *True Zero™ pointer indication*
- *NEW ventable plug*
- *NEW patent pending through-dial calibration*
- *NEW MSL helium leak tested to 1X10^{-6} ATM$^{\cdot cc/sec}$*
- *Meets ASME B40.100 standard*
- *RoHS Compliant*
- *CRN Approved*
- *5 year limited warranty*

Ashcroft is pleased to reintroduce the 1009SW Duralife® pressure gauge. This gauge has been upgraded with many new features outlined above while maintaining the tried and true performance and quality you have come to expect.

Duralife 1009SW gauges provide significant features and benefits. New features include a ventable plug that can be sealed or vented depending on your environment and a patent pending through-dial recalibration that reduces recalibration time.

The combination of features including the patented Power*Flex™* movement and optional *PLUS!™* Performance dampening system in the 1009SW is the finest gauge technology for vibration, shock and pulsation applications. Available in pressure ranges from vacuum to 15,000 psi, including compound and metric ranges.

PRODUCT SPECIFICATIONS

Ashcroft Type No.:	1009SW
Sizes:	2½″
Case:	304SS
Ring:	304SS polished bayonet
Window:	Polycarbonate
Dial:	Black figures on white background, aluminum
Pointer:	Friction adjust, black, aluminum
Bourdon Tube:	316L stainless steel
Socket:	316L Stainless Steel
Movement:	300 series stainless steel, Power*Flex™*, polyester segment, overload/underload stops
Connections:	¼ NPT, lower
Ranges:	Vac-15,000 psi and compound
Accuracy:	1% full scale. ASME Grade 1A[1]
Fill Plug:	Ventable
Protection:	Nema 4X / IP65 plug sealed Nema 3 / IP54 plug vented
Ambient Temperature Limitations:	–40°F to 200°F dry +20°F to 150°F glycerin filled –40°F to 150°F silicone filled (based on standard polycarbonate window)

OPTIONAL FEATURES

Liquid fill:	Glycerin (includes throttle plug)
Dampening:	*PLUS!™* Performance (LL) (includes throttle plug)
Window:	Safety Glass (SG)
Pointer:	Micrometer (MP)
Connections:	Metric and SAE on request
Mounting:	U-clamp (UC), Front flange (FF), Back flange (FW)
Dials:	Receiver ranges, refrigerant ranges. Custom dials

[1] When these gauges are liquid filled the total gauge accuracy may be as much as 1.5%

HOW TO ORDER (Typical example)

25 1009 SW (L) 02L XXX 160#

Dial Size: 2½″ (25)
Case Type: 1009
Tube and Socket Material: 316L SS
Liquid Filled: (glycerin) leave blank if dry
Connection Size: ¼ (02)
Connection Location: Lower (L)
Options:
Range: 0/100 psi

ISO 9001
REGISTERED FIRM

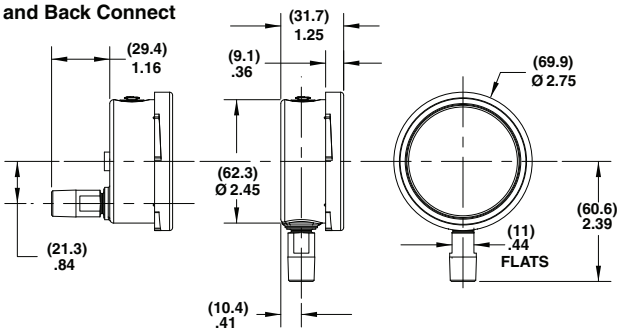
BULLETIN GS-3

Ashcroft Inc., 250 East Main Street, Stratford, CT 06614 USA
Tel: 203-378-8281 • Fax: 203-385-0408
email: info@ashcroft.com • www.ashcroft.com

Type 1009SW Stainless Case Gauge with Stainless Steel System

DIMENSIONS

2½˝ 1009 Lower and Back Connect



Maximum Gauges (PSI) Recommended At Given Fluid Line Temperatures*

LIQUID LINE TEMPERATURES**	77°F 22°C	104°F 40°C	140°F 60°C	158°F 70°C	185°F 85°C	212°F 100°C	239°F 115°C	284°F 140°C
GEON PVC (Polyvinyl Chloride)	0-250 PSI	0-177 PSI	0-57 PSI	N/R	N/R	N/R	N/R	N/R

* Measurements conducted at a maximum ambient temperature of 80°F (26°C).
** If actual fluid line temperature is in between listed ratings, use the next column to the right for maximum recommended gauge.

Gauge Guards & Model Numbers

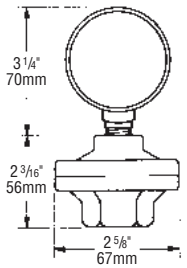


FIGURE 1

TYPE OF SERVICE	FIG. NO.	AVAILABLE GAUGE RANGES AS SHOWN	BARS	DIAPHRAGM MATERIALS	GAUGE GUARD MODEL NUMBERS
Pressure	1	0 - 160 PSI	0 - 11.04	PTFE	GGTS160-PV

Part numbers shown are for Geon PVC. For Corzan CPVC, change suffix -PV to -CP. For Natural Polypro, change suffix -PV to -NP. For Glass-Filled Polypro change suffix -PV to PP. For Kynar PVDF, change suffix -PV to -PF. Example: GGTS1-PF

* For other diaphragm materials, please consult factory.

** Viton FKM diaphragms used for additional sensitivity required on vacuum and low pressure (0-15 PSI) applications. When ordering Viton FKM in place of PTFE simply change the "T" in model number to "V".

Additional Model Number Information

If center back mounted gauge is ordered, conclude above model number with "-C" and use dimensional figure #2.

If a removable housing is ordered, conclude above model number with "-R" and add 1/4" to overall height of dimensional figure #1.

If both center back mounted gauge and removable housing are ordered, conclude above model number with "-CR" and add 1/4" to the overall height of dimension figure #2. Not available with Transparent Acrylic gauge shields.

If a Transparent Acrylic gauge shield is ordered, conclude above model number with "-S" and use dimensional figure #3.

If both center back mounted gauge and gauge shield are ordered, conclude above model number with "-CS" and use dimensional figure #4.

Note: Polypro models wuitable for one diaphragm service/replacement only.

NOTE: For other gauge guard information refer to:
CATALOG GGME: Miniature Diaphragm Seal/Gauge Guard **Catalog GGMU:** Ultra-Pure Gauge Guards

PLAST-O-MATIC VALVES, INC.
1384 Pompton Avenue,Cedar Grove, NJ 07009
(973) 256-3000 • Fax (973) 256-4745
www.plastomatic.com • info@plastomatic.com

AUTHORIZED PLAST-O-MATIC DISTRIBUTOR

WATSON MARLOW
Fluid Technology Group

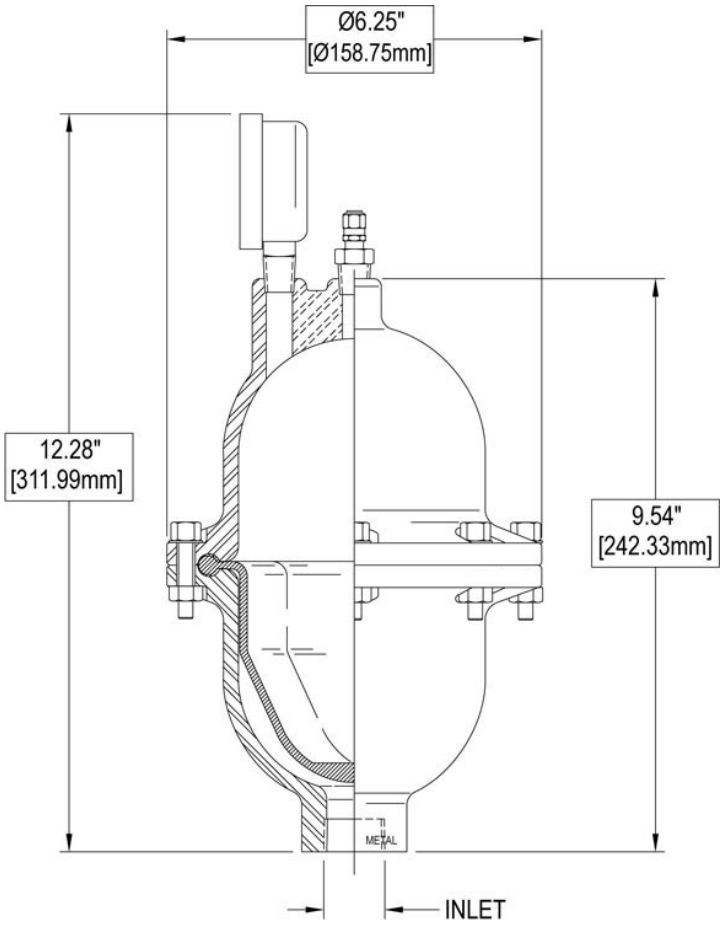
Part 10: Pulsation Dampener

BLACOH™ FLUID CONTROL

DIMENSIONAL DRAWING
CT3040ND-1

MODEL #:	CT3040ND-1
AIR CONTROL:	CHARGE
BLADDER:	EPDM
CAPACITY:	85 CUBIC INCHES/1.4 LITERS
INLET:	1" FNPT
MAXIMUM PRESSURE:	300 PSI/20.6 BAR
NONWETTED HOUSING:	CARBON STEEL
WETTED HOUSING:	CARBON STEEL
EST SHIP WEIGHT EACH:	15 LB

DIMENSIONAL DRAWING
(TOLERANCE ± .25")



601 COLUMBIA AVE. • BLDG. D • RIVERSIDE • CA • 92507 • USA
TEL: 800.603.7867 • 951.342.3100 • FAX: 951.342.3101
SALES@BLACOH.COM • WWW.BLACOH.COM

INSTALLATION & OPERATION MANUAL

SENTRY™

PULSATION & SURGE CONTROL

DAMPENER
(CHARGEABLE MODEL)

SENTRY dampeners are pressure vessels containing a flexible bladder or bellows inside that separates an inert pressurized gas (air or Nitrogen) from a system fluid in the lower chamber. Depending on how dampeners are configured, they are used as PULSATION DAMPENERS, INLET STABILIZERS or SURGE SUPPRESSORS to control pressure fluctuations and spikes in liquid piping systems.

Dampeners work on the principle that volume is inversely proportional to pressure (P1V1=P2V2). Compressed air or Nitrogen (**never** Oxygen) is introduced into the non-wetted side of the dampener. The gas charge is contained by the bladder or bellows preventing contact between the system fluid and the gas.

When the dampener is sized correctly, properly installed and charged according to the instructions provided, it will greatly reduce the damaging effects of pressure variations in piping systems and significantly improve the efficiency of transferring liquids.

All dampeners manufactured by BLACOH use pressure bodies made in the USA to insure quality. Prior to shipment, each and every dampener is factory tested at design pressure or higher to assure proper function and leak-free operation.

Foreign language versions available online at:
http://blacoh.com/literature.aspx

BLACOH™
FLUID CONTROL

TABLE OF CONTENTS

THE WORD "DAMPENER", AS USED IN THIS MANUAL, HAS THE SAME MEANING AS PULSATION DAMPENER, INLET STABILIZER, OR SURGE SUPPRESSOR.

SAFETY WARNINGS

Dampeners should only be installed, operated and repaired by experienced and trained professional mechanics. Read and observe all instructions and safety warnings in this Manual before installing, operating or repairing dampeners.

SAFETY SYMBOLS

The following symbols indicate cautions, warnings and notes that must be observed for safe and satisfactory installation, operation and maintenance of dampener.

	**WARNINGS**	Danger of serious injury or death could occur if these warnings are ignored.
	**CAUTIONS**	Equipment damage, injury or death could occur if these cautions are not observed.
	**NOTES**	Special instructions for safe and satisfactory installation, operation and maintenance.

GENERAL SAFETY

 **CAUTION!**

- Observe all safety symbols in installation and operation instructions.
- The internal dampener pressure will equal the maximum fluid pressure of the system in which it is installed.
- **DO NOT** exceed maximum allowable working pressure (MAWP) specified on dampener serial tag or marked on dampener. If serial tag is missing, **DO NOT** use dampener without consulting distributor or factory for maximum pressure rating.
- Always make sure safety shutoff valves, regulators, pressure relief valves, gauges, etc. are working properly before starting system or assembly.
- Verify dampener model received against purchase order and shipper.
- Before starting a system or assembly make certain the discharge point of the piping system is clear and safe, and all persons have been warned to stand clear.
- **DO NOT** put your face or body near dampener when the system or assembly is operating, or dampener is pressurized.
- **DO NOT** operate a dampener that is leaking, damaged, corroded or otherwise unable to contain internal fluid, air or gas pressure.
- **DO NOT** pump incompatible fluids through dampener. Consult distributor or factory if you are not sure of the compatibility of system fluids with dampener materials.
- Dampeners are designed to operate with compressed air or clean dry Nitrogen **only**. Other compressed gases have not been tested and may be unsafe to use. DO NOT USE OXYGEN.
- Always shut off air supply, remove internal dampener pressure, and shut dampener isolation valve before performing dampener maintenance or repair.
- Remove all pressure from dampener AND pumping system before disassembly, removal or maintenance.
- **Static spark can cause an explosion resulting in severe injury or death. Ground dampeners and pumping system when pumping flammable fluids or operating in flammable environments.**
- **NOTE: EC standard EN-13463-1 and EN-13463-5 (ATEX) require grounding (earthing) on dampeners when the potential for static sparking is present. A grounding point is located and marked on ATEX specific dampener models.**

EQUIPMENT MISUSE HAZARD

CAUTION!

General Safety

DO NOT misuse dampener, including but not limited to over-pressurization, modification of parts, using incompatible chemicals, or operating with worn or damaged parts. **DO NOT** use any gases other than compressed air or clean dry Nitrogen to charge dampener. **DO NOT USE OXYGEN.** Any misuse could result in serious bodily injury, death, fire, explosion or property damage.

Over-Pressurization

Never exceed the maximum pressure rating for the dampener model being used. Maximum allowable working pressure (MAWP) is specified on dampener serial tag or marked on dampener. Maximum allowable working pressure (MAWP) is rated at 70°F (21°C).

Temperature Limits

DO NOT exceed the operating temperature limits for the body and/or elastomer materials being used. Excessive temperature will result in dampener failure. For temperature limits, refer to the "Temperature Limits" section of the Manual. Temperature limits are stated at zero psi/bar.

Installation and Start-Up Hazards

Install dampener before charging or pressurizing. **DO NOT** start system or assembly without first charging or pressurizing dampener. Failure to charge may result in damage to the elastomeric bladder or PTFE bellows.

Temperature & Pressure Hazard

Temperature and pressure reduce the strength and chemical resistance of plastic, metal, elastomers and PTFE.

Charging / Pressurization

Charge or pressurize dampener with compressed air or clean dry Nitrogen only. **DO NOT USE OXYGEN.**

Dampener Bladder/Bellows Failure

Dampeners utilize an elastomeric membrane (bladder) or PTFE bellows to separate system fluid from the air supply or gas charge. When failure occurs, system fluid may be expelled from the air valve. Always perform preventive maintenance and replace bladder/bellows before excessive wear occurs. O-rings for PTFE bellows cannot be re-used.

Maintenance Hazards

Never over-tighten fasteners. This may cause leakage of system fluid and damage to dampener body. Bolts on metal models should not be reused as re-torquing reduces bolt strength. **AFTER MAINTENANCE OR RE-ASSEMBLY OF METAL MODELS, USE NEW FASTENERS AND TORQUE FASTENERS ACCORDING TO SPECIFICATION ON DAMPENER TAG.**

GENERAL INFORMATION

For safe and satisfactory operation of dampener, read all safety warnings and caution statements, and this complete Manual before installation, startup, operation or maintenance.

MUST READ BEFORE INSTALLATION

DO NOT use Oxygen to charge dampener. Use compressed air or clean dry Nitrogen only.

DO NOT exceed maximum allowable working pressure (MAWP) specified on dampener serial tag or marked on dampener.

Turn pump off and remove all pressure from system prior to dampener installation.

Always wear safety glasses and other appropriate safety equipment when installing, charging or repairing dampener.

Danger of static spark! Grounding precautions must be considered when dampener is used in flammable or explosive environments.

ATEX Models must be grounded (earthed) before operation.

DO NOT operate a dampener that is leaking, damaged, corroded or otherwise unable to contain internal fluid, air or gas pressure.

Temperature, pressure and chemicals affect the strength of plastic, elastomer, and metal components.

Many plastics lose strength rapidly as temperature increases. Consult factory if in doubt.

INSTALLATION NOTES

△ Dampening of flow pulsations can only be effective if 5 to 10 psi (0.4 to 0.7 bar) back pressure downstream of dampener is available. A BLACOH back pressure valve may be required downstream of dampener.

△ It is recommended that a BLACOH pressure relief valve be installed in all pump systems to ensure compliance with pressure limits on system equipment.

△ To avoid possible damage to bladder/bellows from a system pressure test, do the following: **Adjustable and Chargeable models** — charge dampener to 80% of the system test pressure prior to test. **Automatic models** — dampener must be equipped with a constant source of compressed air prior to test; connect a compressed air line and dampener will pressurize itself.

△ Install dampener in-line, as close to the pump discharge/inlet or quick closing valve as possible. Dampener installation should be no more than ten pipe diameters from pump discharge/inlet or quick closing valve.

△ It is recommended that an isolation valve be installed between the dampener and system piping.

ATEX STANDARD

△ Certain models made for the European market comply with the ATEX standard for use in potentially explosive atmospheres. These models have the AT designation at the end of the part number and comply with EC standard EN-13463-5 with protection degree of II 2GD TXC. AT models have a grounding lug and must be grounded (earthed) before operation.

MAINTENANCE

Remove all pressure from dampener AND pumping system before disassembly, removal or maintenance.

Dampeners require very little maintenance. There is only ONE wear part – the elastomeric bladder or the PTFE bellows. There is no need for lubrication.

Elastomeric bladder replacement should be part of a preventive maintenance program. Dampeners used in conjunction with diaphragm pumps should have the bladders replaced at least every second time the diaphragms in the pump are replaced. As with any pumping system, wear is dependent on many factors including material, temperature, chemicals, fluid abrasiveness and system design. This suggested maintenance program may need to be adjusted according to specific applications.

Periodic inspection of the dampener and fasteners should be conducted to visually check for signs of over-pressurization, fatigue, stress, or corrosion. Body housings and fasteners must be replaced at first indication of deterioration.

! **CAUTION! Replace nut and bolt fasteners on metal models at each re-assembly with fasteners of equal grade/strength value. DO NOT re-use old nuts and bolts.**

After the initial torque of fasteners, bolts will usually lose up to 20% of their strength when re-torqued. Failure to replace both nuts and bolts upon each vessel reassembly will void the product warranty given by Blacoh Fluid Control, Inc. and Blacoh Fluid Control, Inc. will have no liability whatsoever for any vessel failure or malfunction.

Where dampeners are used in corrosive environments, nut and bolt fasteners should be regularly inspected and replaced with nut and bolt fasteners of equal grade/strength value if corrosion is observed. Failure to conduct such regular inspections and replacement will void the product warranty given by Blacoh Fluid Control, Inc. and Blacoh Fluid Control, Inc. will have no liability whatsoever for any vessel failure or malfunction.

IMPORTANT! AFTER MAINTENANCE OR RE-ASSEMBLY OF METAL MODELS, USE NEW FASTENERS AND TORQUE FASTENERS ACCORDING TO SPECIFICATION ON DAMPENER TAG.

! **DO NOT** use dampener if the fasteners (nuts and bolts) are corroded. Check for fastener corrosion frequently, especially in atmospheres containing salt or corrosive chemicals, or if dampener leakage has occurred.

TEMPERATURE LIMITS

Operating temperatures are based on the maximum temperature of the wetted dampener components only. Non-wetted dampener components may have a lower temperature limit. Temperature and certain chemicals may reduce the maximum allowable working pressure (MAWP) of the dampener.

Elastomer Materials	Temperature Limits	Applications
Aflas	0°F to +400°F (-18°C to +204°C)	High temperature, petroleum based chemicals, strong acids and bases.
Buna	+10°F to +180°F (-12°C to +82°C)	Good flex life; use with petroleum, solvents and oil-based fluids.
FDA Buna	+10°F to +180°F (-12°C to +82°C)	FDA-approved food grade; similar characteristics of regular Buna.
EPDM	-60°F to +280°F (-51°C to +138°C)	Use in extreme cold; good chemical resistance with ketones, caustics.
Hypalon	-20°F to +275°F (-29°C to +135°C)	Excellent abrasion resistance; good in aggressive acid applications.
Neoprene	0°F to +200°F (-18°C to +93°C)	Good abrasion resistance and flex; use with moderate chemicals.
PTFE	+40°F to +220°F (+4°C to +104°C)	Bellows design; excellent flex life; use with highly aggressive fluids.
Santoprene	-20°F to +225°F (-29°C to +107°C)	Excellent choice as a low cost alternative for PTFE in many applications.
FDA Silicone	-20°F to +300°F (-29°C to +149°C)	FDA-approved food grade material; for use in food and pharmaceutical processing.
Viton	-10°F to +350°F (-23°C to +177°C)	Use in hot and aggressive fluids; good with aromatics, solvents, acids and oils.

CAUTION! Plastic materials lose strength as temperature increases which reduces the maximum pressure sustainable by the material.

Non-Metallic Body Materials	Temperature Limits	Applications
PVC	See chart below.	Good general chemical resistance; looses strength quickly as temperature rises.
CPVC	+32°F to +180°F (0°C to +82°C)	Chlorinated PVC (CPVC) retains strength to higher temperatures.
Acetal*	+32°F to +175°F (0°C to +79°C)	Good flex life; low moisture sensitivity; high resistance to solvents and chemicals.
Noryl	+32°F to +220°F (0°C to +104°C)	Good resistance to acids and bases; good temperature stability.
Polypropylene*	+32°F to +175°F (0°C to +79°C)	Good general purpose plastic; broad chemical compatibility at medium temperatures.
PTFE	+40°F to +220°F (+4°C to +104°C)	Use with highly aggressive fluids.
PVDF	+10°F to +200°F (-12°C to +93°C)	Excellent resistance to most acids and bases; highest temperature plastic available.

* **Conductive Acetal and Conductive Polypropylene available.**

CAUTION! PVC loses strength more rapidly than other plastic materials as temperature increases. Certain chemicals can also affect material strength reducing maximum pressure ratings. The chart below shows reduced maximum pressure ratings based on temperature for **PVC only**. Note that these are general guidelines only; selection of dampener materials must be determined by each individual application to avoid equipment damage and unsafe operation.

PVC Maximum Pressure Guidelines by Temperature							
Temperature	73.4°F (23° C)	80°F (27°C)	90°F (32°C)	100°F (38°C)	110°F (43°C)	120°F (48°C)	130°F (54°C)
Maximum Pressure	150 psi (10.3 bar)	142.5 psi (9.8 bar)	135 psi (9.3 bar)	112.5 psi (7.6 bar)	97.5 psi (6.7 bar)	90 psi (6.2 bar)	75 psi (5.2 bar)

INSTALLATION & OPERATION INSTRUCTIONS: DAMPENER (CHARGEABLE MODEL)

!	**DO NOT USE PLASTIC MODELS AS SURGE SUPPRESSORS AT QUICK CLOSING VALVES. USE METAL SURGE SUPPRESSORS FOR WATER HAMMER OR QUICK CLOSING VALVE APPLICATIONS. CONSULT FACTORY FOR OPTIONS.**
!	**ATEX MODELS MUST BE GROUNDED (EARTHED) BEFORE OPERATION.**
◈	Turn pump off and remove all pressure from system prior to dampener installation.
◈	Remove all pressure from dampener AND pumping system before disassembly, removal or maintenance.
◈	Use compressed air or clean dry Nitrogen to charge dampener. **DO NOT USE OXYGEN.**
◈	**DO NOT** exceed maximum allowable working pressure (MAWP) specified on dampener serial tag.
◈	**Always wear safety glasses and other appropriate safety equipment when installing, charging or repairing dampener.**
◈	**READ ALL SAFETY WARNINGS AND INSTALLATION & OPERATION INSTRUCTIONS IN THE MANUAL BEFORE INSTALLATION.**
◈	**IMPORTANT! AFTER MAINTENANCE OR RE-ASSEMBLY OF METAL MODELS, USE NEW FASTENERS AND TORQUE FASTENERS ACCORDING TO SPECIFICATION ON DAMPENER TAG.**
△	Before performing a system pressure test, dampener must be charged with 80% of system test pressure to avoid possible damage to bladder/bellows.

READ BEFORE INSTALLATION — PRE-CHARGE NOTES — READ BEFORE INSTALLATION

! **The following pre-charge notes are for plastic dampener models with a maximum pressure rating up to 150 psi (10.3 bar) and metal models with a maximum pressure rating up to 2000 psi (138 bar). NOTE: Dampener can be pre-charged with compressed air up to a maximum pressure of 150 psi (10.3 bar). If maximum pressure will exceed 150 psi (10.3 bar), dampener must be pre-charged with Nitrogen only. DO NOT USE OXYGEN.**

Pre-charge pressure should be checked at least monthly as gas molecules will diffuse through elastomeric bladders, the speed of which depends on the elastomer material, temperature and pressure. Checks must occur when no system pressure is present or inaccurate readings will be recorded. If temperature is above 72°F (22°C) and/or pressure is over 300 psi (20.7 bar), checks should be performed more frequently. **To prevent pre-charge loss through the fill valve, always replace the fill valve cap after charging.** A proper gas charge is the key to dampener effectiveness and bladder/bellows life.

READ BEFORE INSTALLATION — INSTALLATION FOR PUMP DISCHARGE PULSATION — READ BEFORE INSTALLATION

Step 1 — Installation Position

Install the dampener in-line, as close to the pump discharge as possible to absorb the pulse at its source and before any downstream equipment such as risers, valves, elbows, meters, or filters. Dampener installation should be no more than ten pipe diameters from pump discharge. If using a flexible connector on the discharge side of the pump between the pump and system piping, the dampener should be installed at the pump discharge manifold. The flexible connector should be attached to the dampener's tee and system piping (see FIGURE 1). Since pressure is equal in all directions, the dampener can be installed in a vertical, horizontal, or upside-down position. A vertical installation is recommended for better drainage of the dampener. Limitations for horizontal and upside-down mounting include high specific gravity, high viscosity, settling of solid material, or possible air entrapment, which could result in shortened bladder/bellows life and/or reduced dampening performance.

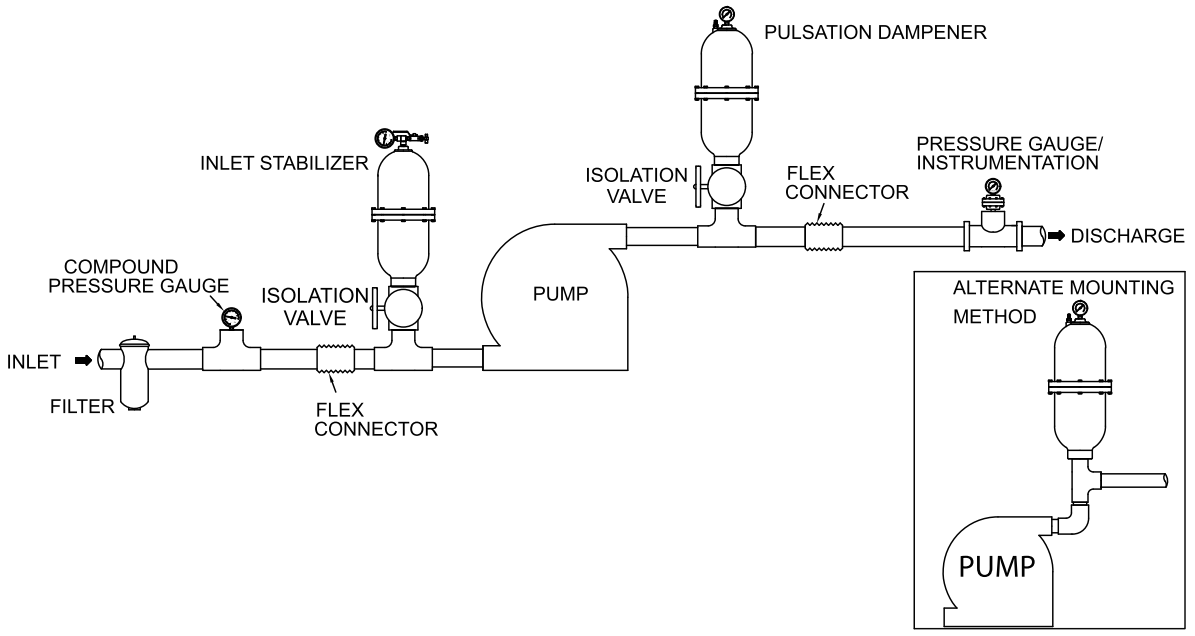
Step 2 — Charging and Start-Up (see Pre-Charge Notes)

Chargeable models do not require an air line connection. Dampener can be pre-charged with compressed air up to a maximum pressure of 150 psi (10.3 bar). If maximum pressure will exceed 150 psi (10.3 bar), dampener must be pre-charged with Nitrogen only. Use a hand pump, Nitrogen tank or air compressor to charge dampener. **DO NOT USE OXYGEN.** Charging hose kits are available from BLACOH.

Prior to starting the pump, pre-charge the dampener to approximately 80% of expected system pressure and replace fill valve cap. **DO NOT USE OXYGEN.** The pre-charge pressure in the dampener must always be lower than pump discharge pressure. Generally, pulsation is most effectively minimized when the gas pre-charge is 80% of system pressure. Start the pump to generate system pressure. The dampener charge pressure may need to be adjusted up or down to be most effective in reducing pulsation. **NOTE:** The most effective method to set the proper dampener charge is to install a pressure gauge downstream of the dampener and adjust the dampener to minimize needle movement on the gauge.

Once system pressure is in contact with the bladder/bellows, the gas charge will be compressed to the system pressure and the dampener gauge will read the system pressure, not the initial charge pressure. Once working pressure is achieved, adjustment may be necessary. Gradually increase or decrease the gas charge in the dampener by bleeding or filling through the gas valve. Allow the system to respond to each adjustment (this may take a minute or two) before making further adjustments.

FIGURE 1



MANUFACTURER'S LIMITED WARRANTY & RETURN POLICY

Standard Product Limited Warranty

Subject to the limitations set forth below, Blacoh Fluid Controls, Inc. ("Blacoh") warrants its products to be free from defects in material and workmanship under normal use, service, and maintenance in accord with Blacoh's published specifications for a period of two years from date of shipment by Blacoh (the "Warranty"). The EXCLUSIVE REMEDY for any product defect covered under this Warranty shall be one of the following, as determined by Blacoh in Blacoh's sole discretion: (a) refund of the purchase price; or (b) replacement or repair of the defective part or parts at Blacoh's facility. This Warranty will be null and void if the product is used in an inappropriate application or if the product has been altered, misapplied, improperly installed, or not properly inspected and maintained. To the maximum extent allowed by applicable law, Blacoh will not be responsible for nor have any liability for any "Damage," which means any of the following, whether the claim sounds in breach of contract, breach of warranty, tort, strict liability, implied contractual indemnity, or otherwise: (i) any damage, loss, or injury of any kind, or destruction, or death, whether or not caused by any defect in a Blacoh product and whether or not the Blacoh product is installed, used, operated, and/or maintained in accord with Blacoh instructions, to other products, machinery, buildings, property, or persons, and (ii) any costs, expenses, losses, or incidental, consequential, or special damages of any kind or nature, including but not limited to loss of profits, arising from or related to any Blacoh product, whether or not caused by any defect in a Blacoh product and whether or not the Blacoh product is installed, used, operated, and/or maintained in accord with Blacoh instructions. Damage resulting from chemical incompatibility or from over-pressurization of a product, whether from gas or fluid, is not covered under this Warranty, nor will Blacoh be responsible in any way for any such Damage. Because Blacoh does not determine and cannot anticipate or control the many different conditions under which its products may be used, Blacoh does not warranty the applicability, suitability, or fitness of any of its products for any particular use or purpose. Statements concerning the possible use of Blacoh products are not intended and shall not be interpreted as warranties of fitness for any specific use of such products. Each user of Blacoh products must conduct its own engineering analysis and tests to determine the suitability of each Blacoh product for the user's intended uses or purposes, including but not limited to chemical compatibility and pressurization, and any written or oral assistance from Blacoh in this regard does not relieve the user from exclusive responsibility for such engineering analysis and testing. Blacoh products are sold with only this limited Warranty, and each buyer assumes all responsibility for Damage (as defined above), including but not limited to, Damage arising from defects in Blacoh products and/or from the handling and use of Blacoh products whether used in accordance with Blacoh's directions or otherwise. Any products sold by Blacoh which are manufactured by and sold under the name of another company are NOT WARRANTED by Blacoh under the foregoing Warranty or otherwise. The buyer must rely exclusively on the product warranty, if any, given by such other company. Products manufactured by Blacoh as an original equipment manufacturer (OEM) to be sold by a customer under the customer's brand and name are warranted by Blacoh only under the above Warranty, and Blacoh shall have no liability whatsoever with respect to any representation or warranty given by such customer (or such customer's representatives, distributors, agents, employees, or independent contractors) to any of its buyers which is different in any respect whatsoever from the foregoing Warranty. EXCEPT FOR THE WARRANTY GIVEN ABOVE, WHICH IS SUBJECT TO THE ADDITIONAL LIMITATIONS STATED ABOVE, AND EXCEPT FOR THE ADDITIONAL LIMITED WARRANTY ON BLACOH'S PTFE BELLOWS STATED BELOW, BLACOH GIVES NO WARRANTY OF ANY NATURE WHATSOEVER, EXPRESS OR IMPLIED, WITH RESPECT TO ANY OF ITS PRODUCTS, INCLUDING WITHOUT LIMITATION NO WARRANTY OF MERCHANTABILITY AND NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. NO COURSE OF DEALING, USAGE OF TRADE, OR OTHER ORAL OR WRITTEN STATEMENTS SHALL MODIFY THE FOREGOING WARRANTY PROVISIONS AND LIMITATIONS IN ANY RESPECT WHATSOEVER. This Warranty shall be governed by and construed in accordance with the laws of the State of California.

PTFE Bellows Limited Warranty

In addition to Blacoh's Standard Product Limited Warranty and subject to the limitations set forth below, Blacoh warrants that its PTFE Bellows equipment ("PTFE Bellows") on Blacoh's PTFE Bellows-fitted pulsation dampener will perform in accordance with Blacoh's written product description for three years from date of shipment ("PTFE Bellows Warranty"). This PTFE Bellows Warranty applies only to PTFE Bellows that are sized, charged, installed, used, operated, and maintained strictly in accordance with all installation, use, operation, and maintenance instructions provided by Blacoh, and failure to properly size, charge, install, use, operate, and maintain the PTFE Bellows (or failure to do any of them) shall make the PTFE Bellows Warranty null and void. This PTFE Bellows Warranty does not include applications where failure of performance is due to an unbalanced pressure load or a transient pressure spike (sometimes called a water hammer). The EXCLUSIVE REMEDY for breach of this PTFE Bellows Warranty is replacement of the PTFE Bellows at Blacoh's facility, and not any other equipment or parts whatsoever, and Blacoh will not be responsible for any Damage or any other loss of any kind, including but not limited to incidental, consequential, or special damages (including but not limited to loss of profits), in any way arising from failure of the PTFE Bellows to perform in accordance with Blacoh's written product description. This PTFE Bellows Warranty shall be governed and construed in accordance with the laws of the State of California.

Warranty Claims

1. Prior to returning any product to Blacoh based on a claim of breach of Warranty or PTFE Bellows Warranty, a Blacoh Return Request form must be completed. The form will be reviewed by Blacoh to determine if a Return Merchandise Authorization (RMA) number will be issued. The issuance of an RMA number does not constitute Blacoh's acknowledgment or agreement that the warranty claim is justified or correct.
2. If an RMA number is issued by Blacoh, customer should then deliver the product in question to the address specified on the RMA, freight prepaid.
3. All products so returned to Blacoh based on a claim of breach of Warranty or of PTFE Bellows Warranty must be cleaned, sanitized and neutralized prior to shipment to Blacoh. Blacoh will not accept any part that contains corrosive chemicals, organic cultures, blood, any harmful residue or air borne materials that might contaminate a breathable atmosphere or put at risk any person or property. Any shipment that does not comply will be returned at the expense of the customer, or the customer will be required to arrange for pickup.
4. HAZMAT SHIPMENTS WILL BE REMOVED AND PROCESSED AT CUSTOMER'S EXPENSE.
5. Receipt by Blacoh of a return does not constitute Blacoh's agreement that Blacoh is in breach of its Warranty or PTFE Bellows Warranty.
6. If Blacoh determines that a defect in workmanship or material of a part has occurred, customer is not entitled to a complete unit replacement. In the event of such a defect, Blacoh will repair or replace the defective part or parts or refund the purchase price, as Blacoh determines in Blacoh's sole discretion.

New Product Returns

1. If a customer wishes to return a new, unused product, the customer must first request a Return Merchandise Authorization (RMA) number from Blacoh. Blacoh will determine if the unit can be returned for possible credit.
2. Product to be returned must be new, unused, and of current design and purchased within thirty (30) days of the return request. In addition the product must not have been damaged after original shipment by Blacoh.
3. Product returns must be delivered, freight prepaid.
4. Blacoh has the right to inspect all returned products prior to acceptance or rejection.
5. ALL RETURNS are subject to a minimum $25.00 or 20% restocking fee, whichever is greater. (Higher restocking fees may be charged on special items and some models may not be eligible for return). Returns accepted by Blacoh will be credited to the customer's account less the re-stocking fee. Refunds will not be issued.
6. Any outsourced product supplied by Blacoh will be subject to the warranty, return policy and re-stock fee charged by the manufacturer of the outsourced product.

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BLACOH™
FLUID CONTROL

BLACOH FLUID CONTROL, INC.

601 Columbia Ave, Bldg D
Riverside, CA 92507 USA

Phone: 951.342.3100
800.603.7867

Fax: 951.342.3101

Email: Sales@Blacoh.com

www.blacoh.com