SAF Drives Inc.

## Installation & Operating Procedures

# Opal OP-STOP Series

### DC INJECTION BRAKE
### FOR 3 PHASE INDUCTION MOTORS


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## INSTALLATION & OPERATING PROCEDURE

***Revision 1.03 - 07/2011***

# FOR YOUR SAFETY

Only qualified personnel should install this equipment, after first reading and understanding all the information in this manual. All instructions should be strictly adhered to. The user should consult SAF Drives Inc. or a SAF OPAL Starters supplier for clarification of the contents of this manual should any doubt or questions arise.

The installation of this equipment must be conducted in accordance with all national, regional and local electrical codes.

All drawings and technical representations included in this manual are for typical installations and should not in any way be considered for specific applications or modifications. Consult SAF OPAL Starters for supplemental instructions.

SAF Drives Inc. accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation, application or adjustment of this equipment.

The contents of this manual are believed to be correct at the time of printing. In following with our commitment to the ongoing development and improvement of our products SAF OPAL Starters reserves the right to change the specification of this product and/or the content of this instruction manual without notice.

# TABLE OF CONTENTS

# 1 DESCRIPTION

## 1.1 OVERVIEW

The OP-STOP braking units provide smooth braking for AC induction motors. The brake units offer adjustable braking because they are current controlled. Unlike a mechanical brake, an electrical brake will never wear out. The brake operates by injecting DC current in two phases of the motor to rapidly decelerate it to zero speed.

These units can be supplied as an option to the OPAL solid state starter, or as stand alone units for new or retrofit installations.

SAF's OP-STOP braking modules offer a unique combination of features that make it very reliable, easy to use, and energy efficient. These features include:

- **Closed Loop Current Regulation:**

  The brake, operating with a closed loop current regulator, provides consistent torque every time. This torque is independent of line voltage variations.

- **Direct Power Connection:**

  The brake's power input is connected directly to the AC line, and the power output is connected directly to the motor, no contactors are required. The unit adapts itself to any input voltage between 200 and 600 VAC with no adjustments required.

- **Efficient Power Circuit:**

  The power circuit is an efficient four Silicon Controlled Rectifier ( SCR ) configuration which uses some of the SCR's as a "free wheeling diode", thus maximizing the DC current through the motor coils generated by the AC input current.

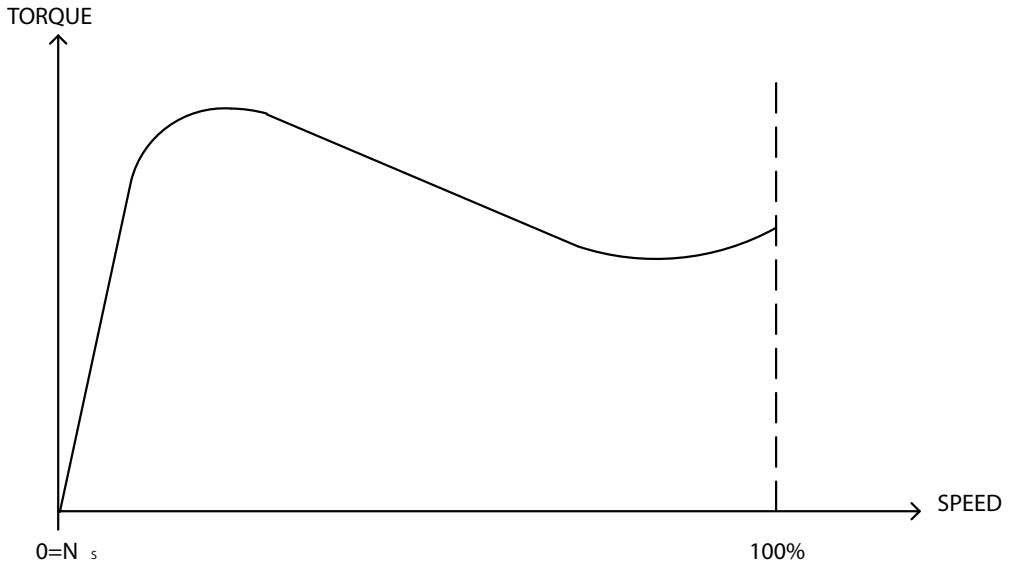
With every benefit there is usually a trade-off. Although the OP-STOP brake unit will never wear out like a mechanical brake, the trade-off is that should there be a loss of power, the brake unit will not operate without battery back-up. SAF can supply a reliable battery back-up to overcome this disadvantage.

Braking is initiated when the motor starter is opened and the voltage across the motor has dropped to below 30% or 80% of the line supply. DC injection is removed after an adjustable period has elapsed. It does not provide zero speed sensing, although a normally closed contact from a zero speed switch may be connected to the Disable Input.

If braking is released before the motor stops, the motor will coast to rest. If the braking remains on after the motor stops, the DC supply will provide a holding brake.

## 1.2 APPLICATION NOTES

The motor torque/speed characteristic of an induction motor under DC supply is similar to the normal curve published for constant frequency, at 50 or 60 Hz, but this time having "synchronous speed" zero RPM. This is illustrated below.




For smooth braking the DC current is typically adjusted to 300% of the motor nameplate current. The stopping time depends on the torque setting and also the inertia of the mechanical system.

Electric braking is not recommended for continuous or repetitive operation. The kinetic energy of the mechanical system is transformed into heat during braking ( energy conservation ). That heat is dissipated in the rotor of the motor.

On wound rotor motors the external rotor resistance will absorb most of the energy. On squirrel cage motors, overheating of the motor is a real danger if frequent operation is used.

Keeping DC current on the motor stator for a short time after the motor has stopped is quite acceptable. The heat produced by the I2R losses are not significant, and they are dissipated in the stator only, not in the rotor where the rotational energy is dissipated.

## 1.3 CONTROLS

The OP-STOP unit contains two major parts, the power circuit and the control card.

The power circuit is a 4 SCR single phase full wave controlled rectifier. This configuration optimizes the DC current injected to the motor per input current.

The control is contained in a single PC board, CA398. This board is common to all OP-STOP models.

### 1.3.1 CA398 LOGIC

DC injection will be applied to the motor when two conditions are met. The starter is opened and the motor terminal voltage has decayed to 30% or 80%, jumper dependent, of the line voltage. The starter can not be energized for a period of 1-2 seconds after the DC injection cycle.

This design has the significant advantage that the braking module will remain off in the case of having an open auxiliary contact from either a broken wire or faulty contact. The braking action can be externally defeated at any time by applying 115 VAC to the Disable Input.

The braking action is inhibited when an instantaneous over current is detected. The IOC fault is detected and latched until the Reset switch is pressed. A form C relay contact is available to interlock the brake unit from the motor starter. The starter cannot be energized while DC current is being applied to the motor or during a fault condition.

### 1.3.2 CA398 REGULATION

The brake module operates in current control at all times. The current is adjusted via an internal potentiometer and the current feedback signal is generated by a current transformer mounted on the AC line. A unique circuitry reconstructs the free wheeling current in the DC output for accurate current regulation.

The output of the current regulator is used in a comparator circuit that performs the phase control on two SCR's. The other two SCR's are fully phased on to provide free wheeling action, minimizing the ripple current.

Two opto-couplers are used to generate the line synchronization signal. Each opto output is used to generate a ramp that is used in the comparator with the current regulator output.
The motor voltage feedback is used to sense voltage levels for proper sequencing and not to perform any regulation.

# 2 SPECIFICATIONS

## 2.1 POWER RATING

| | |
|---|---|
| **POWER** | 200-600VAC, 50/60 Hz |
| **CONTROL** | 115 VAC, 50 Hz or 120 VAC, 60 Hz |
| **RATING** | Intermittent duty, See Section 2.2<br>300% for 30 seconds, once every 30 minutes<br>All models have 1600V PIV SCR's |
| **CONTACTS** | DC injection relay contacts rated at 1A, 120VAC |
| **PROTECTION** | Short circuit by HRC fuses or circuit breaker<br>(supplied upon request)<br>Voltage surge protection by snubber's and MOV's across the SCR's |

## 2.2 CURRENT AND FUSE RATING

| CURRENT RATING | | | | | |
|---|---|---|---|---|---|
| **DCI MODEL** | **AMPS** | **MOTOR HP @ 575 V** | **MOTOR HP @ 460V** | **FUSE AMPS** | **SCR TYPE** |
| DCI-20 | 20.0 | 20.0 | 15.0 | 20.0 | Module |
| DCI-40 | 40.0 | 40.0 | 30.0 | 40.0 | Module |
| DCI-80 | 80.0 | 75.0 | 60.0 | 80.0 | Module |
| DCI-125 | 125.0 | 125.0 | 100.0 | 125.0 | Module |
| DCI-200 | 200.0 | 200.0 | 150.0 | 200.0 | Disc |
| DCI-300 | 300.0 | 300.0 | 250.0 | 300.0 | Disc |
| DCI-500 | 500.0 | 500.0 | 400.0 | 500.0 | Disc |

### 2.2.1 NOTES

2.2.1.1 The HP listing is for reference only. For proper selection use the current rating.

2.2.1.2 The fuses recommended are Class J time-delay type. This fuse is being suggested even though it may not protect the SCR in an output shorted condition while braking. It will protect the unit when starting to operate into a shorted output. In the case of a shorted SCR, the fuse is there to clear the fault only.

2.2.1.3 The RMS AC line current is equal to : AC RMS = DC Amps x √ Duty Cycle Assuming 10A motor, OP-STOP set at 300% current (30 A DC), free wheeling for 70% of the cycle, then the AC current is 16A.

2.2.1.4 All OP-STOP models are built without cooling fans because they are short duty rated.

## 2.3 SERVICE CONDITIONS

**ELEVATION** For altitudes in excess of 2000 meters / 6600 feet above sea level, all assemblies must be derated 1% for every 100 meters / 330 feet above

**AMBIENT TEMPERATURE** Do not install in areas where ambient temperature falls below 0°C / 32°F or exceeds 40°C / 104°F

## 2.4 DIMENSIONS

| DCI MODEL | Height × Width × Depth | |
|---|---|---|
| | **CHASSIS** | **NEMA 1 / NEMA 12** |
| DCI-20 | 43cm × 22cm × 15cm | 33cm × 22cm × 18cm |
| | 16" × 8.5" × 6" | 13" × 8.5" × 7" |
| DCI-40 | 43cm × 25cm × 19cm | 33cm × 22cm × 18cm |
| | 17" × 10" × 8.5" | 17" × 12" × 8.5" |
| DCI-80 | 43cm × 27cm × 21cm | 43cm × 30cm × 27cm |
| | 17" × 10" × 8.5" | 17" × 12" × 10.5" |
| DCI-125 | 53cm × 27cm × 23cm | 53cm × 30cm × 27cm |
| | 21" × 10.5" × 9" | 21" × 12" × 10.5" |
| DCI-200 | 28cm × 33cm × 27cm | 61cm × 61cm × 30cm |
| | 11" × 13" × 10.5" | 24" × 24" × 12" |
| DCI-300 | 42cm × 37cm × 28cm | 76cm × 61cm × 30cm |
| | 16.5" × 14.5" × 11" | 30" × 24" × 12" |
| DCI-500 | 45cm × 42cm × 36cm | 76cm × 61cm × 30cm |
| | 17.5" × 16.5" × 14" | 30" × 24" × 12" |

**NOTE:** For dimensions of OP-STOP units in conjunction with SAF's OPAL solid state starter, refer to the OPAL manual reversing chassis dimensions.

## 2.5 SCR INSTALLATION SPECIFICATIONS

2.5.1.1 SCR TIGHTENING PROCEDURE

2.5.1.2 Clean both heat sink and SCR surfaces.

2.5.1.3 Apply a thin layer of joint compound (Noalox) to both SCR surfaces.

2.5.1.4 Observe correct SCR polarity.

2.5.1.5 Install SCR so that roll pins engage dimples on both sides of the SCR.

2.5.1.6 Tighten clamp bolts evenly until finger-tight.

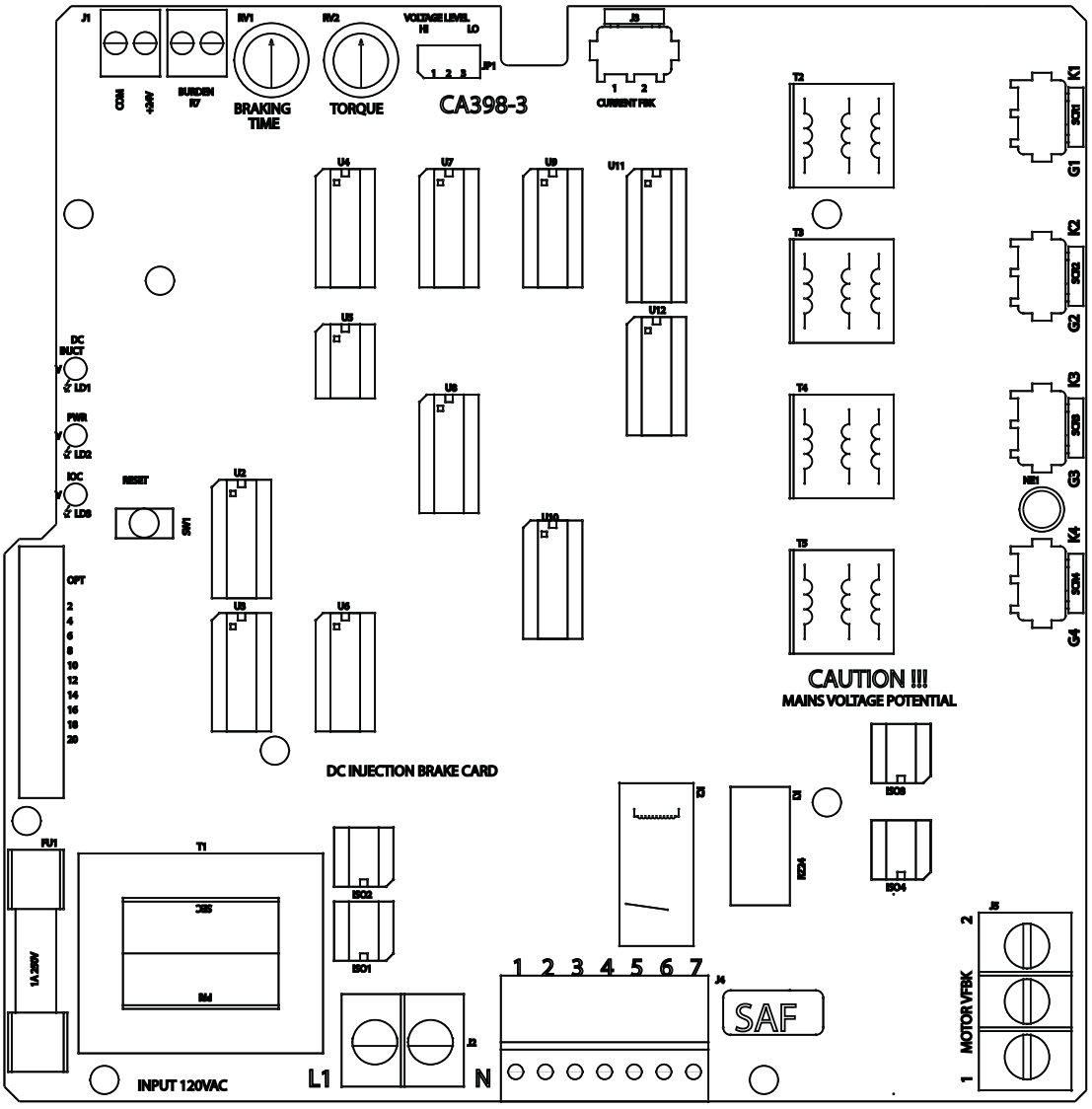
2.5.1.7 Tighten each bolt according to table below (based on number of spring bars and size of bars).

*** Note**: SMALL clamps are 4.25 inches / 10.5 cm and LARGE clamps are 5 inches / 12.5 cm.

| CLAMP SIZE | SPRING BARS | BOLT TURNS PAST FINGER TIGHT |
|---|---|---|
| SMALL | 1 | 0.8 |
| SMALL | 2 | 1 |
| LARGE | 3 | 1.8 |
| LARGE | 4 | 1.8 |

# 3 CARD FUNCTIONS

## 3.1 CARD LAYOUT




*CA398 – DC INJECTION CARD*

## 3.2 LED AND NEON INDICATIONS

| LED | NAME | COLOUR | DESCRIPTION |
|---|---|---|---|
| LD1 | DC INJCT | RED | On when unit is braking |
| LD2 | PWR | GREEN | Must be ON when 115VAC is applied |
| LD3 | IOC | RED | Instantaneous Over-Current fault indication when illuminated |
| NE1 | PHASE OK | ORANGE | Phase loss indication when neon not glowing |

## 3.3 ADJUSTMENTS

### 3.3.1 POTENTIOMETERS

| POT | NAME | RANGE | DEFAULT SETTING | DESCRIPTION |
|---|---|---|---|---|
| RV1 | BRAKING TIME | 1-60 sec | 30% | Adjust the braking time<br>CW rotation increases the time |
| RV2 | TORQUE | 100-300% | 50% | Adjust DC current<br>CW increases the braking torque (current) |

### 3.3.2 1LINK SELECTION

| LINK | NAME | POSITION | DESCRIPTION |
|---|---|---|---|
| JP1 | VOLTAGE LEVEL | LO (Normal) | Braking action starts when motor starter has opened and the motor terminal voltage has decreased to 30% of the line voltage. |
| | | HI | Braking action starts when motor starter has opened and the motor terminal voltage has decreased to 80% of the line voltage. See important notes below. |

HI setting is only used when the stopping time is critical and must be around 1-2 seconds. For this application 300% DC current is not adequate. Consult factory before using this jumper position.

When the OP-STOP is set on the HI level a current surge could occur due to the motor CEMF and the free wheeling action of the power circuit.

### 3.3.3 PUSHBUTTON

| PUSHBUTTON | NAME | DESCRIPTION |
|---|---|---|
| **SW1** | **RESET** | **Reset IOC fault trip** |

## 3.4 TERMINALS

### 3.4.1 CUSTOMER TERMINALS

| TERMINAL | NO. | DESCRIPTION |
|---|---|---|
| J2 | L1, N | 115 VAC control voltage input, L1 being hot and N, neutral<br>L1 input is protected with internal fuse, 1A 250VAC |
| J4 | 1, 2 | 115 VAC supply for external interlock contacts |
| | 3.0 | A normally open contact from the motor starter auxiliary must be connected between this teminal and terminals 1 or 2 to sense when the starter is de-energized to enable braking action<br>When using a SAF OPAL starter in conjuction with the OP-STOP, this terminal is to be jumpered to terminal 1 or 2 |
| | 4.0 | When 115VAC from terminals 1 or 2 is applied to this input, braking is disabled<br>Apply 115 VAC to this input to disable the brake |
| | 5.0 | Common DCI relay contact<br>The Form-C relay is de-energized while braking and when a fault exists |
| | 6.0 | Normally open DCI relay auxiliary contact |
| | -7.0 | Normally closed DCI relay auxiliary contact |
| R7 | 1, 2 | Burden resistor terminals for calibration of DC injection current<br>See table in Section 4.4 |

### 3.4.2 TERMINALS FOR INTERNAL USE

| TERMINAL | NO. | DESCRIPTION |
|---|---|---|
| J1 | 24V, COM | This terminal is used by SAF as a 24V input to provide battery back up for DC injection in case of power loss |
| J3 | 1, 2 | CURRENT FBK<br>From current transformer for motor current feedback |
| J5 | 1, 2 | MOTOR VFBK<br>From T1, T2 motor terminals for motor voltage feedback |
| SCR1 | G1, K1 | Gate connection to SCR 1 |
| SCR2 | G2, K2 | Gate connection to SCR 2 |
| SCR3 | G3, K3 | Gate connection to SCR 3 |
| SCR4 | G4, K4 | Gate connection to SCR 4 |
| OPT | 1-20 | Provided for ribbon cable link to SAF's OPAL starter<br>This provides signals from the OPAL to the OP-STOP that indicate the run status of the starter, replacing the auxiliary input and prevents starting during DC injection or a fault |

## 3.5 FAULTS

When a fault exists the OP-STOP DCI relay is de-energized, preventing a properly interlocked starter from being activated. When an OP-STOP is used in conjunction with a SAF OPAL starter, this interlock is also carried out through signals passed by the ribbon cable at OPT. When no faults exist and DC injection is not active, the DCI relay is energized. Therefore, if the 115 VAC supply is not present the "fail-safe" interlock will prevent the use of the starter. The faults are explained below.

### 3.5.1 PHASE LOSS

If the single phase power ( 200-600V ) to L1 and L2 terminals is not present, NE1 will be off and the DCI relay de-energized. When this condition is corrected the unit will allow the starter to be energized.

### 3.5.2 INSTANTANEOUS OVER CURRENT (IOC)

If the current feedback exceeds 1000% of the current setup by the burden resistor (Rb), the unit will trip on IOC and de-energize the DCI relay. LD2 will be illuminated to indicate an IOC fault and is reset via SW1, RESET. Causes of this fault may be a shorted output or simply a burden resistor sized too small. Refer to Section 4.4 for burden table.

# 4 INSTALLATION AND START UP

## 4.1 INSPECTION

The OP-STOP has been packaged to protect it from damage caused by normal handling during shipping; however mishandling may cause damage to the OP-STOP. Unpack the unit as soon as it is received and check for any shipping or storage damages. If damage is found, notify the carrier. Any damage claim must be filed by the customer since all shipments are F.O.B. SAF plant unless otherwise specified.

If the OP-STOP is not installed when received, store it in a clean, dry, well ventilated area, free from heat, humidity, oil, dust and metal particles.

## 4.2 SAFETY PRECAUTIONS

**CAUTION**

**Equipment is at line voltage when AC power is connected. Pressing "STOP" pushbutton does not remove AC mains potential. All phases must be disconnected before it is safe to work on machinery or touch motor terminals or control equipment parts.**

**CAUTION**

**Disconnect incoming voltage from unit before opening load side during DC injection. Failure to observe this precaution can result in damage to disconnecting device and/or bodily injury.**

The electrical code requires all equipment, starter motor, operator station, brake, etc... to be grounded properly. An incoming circuit breaker or disconnect switch must be locked open before wiring and servicing this electrical brake, motor, or other related equipment. This equipment must be installed and serviced only by qualified personnel, familiar with this unit. The user is responsible for ensuring that proper short circuit protection is provided by either a circuit breaker or HRC fuses.

## 4.3 MOUNTING GUIDELINES

Standard Nema 1 OP-STOP units must be installed indoors in a well ventilated area, free from heat, humidity, oil, dust and metal particles.

One foot of clearance must be kept around the perimeter of the unit in a naturally cooled setup. The equipment must be mounted away from any heat source. See Section 2 for additional specifications and derating. Be aware that the heatsink may reach temperatures of 70°C / 158°F during normal operation. Do not install the unit in contact with any material that can not accept this temperature.

The OP-STOP must be mounted vertically and where it will not experience excessive shock or vibration.

## 4.4 WIRING GUIDELINES

Follow all local electrical codes for installation requirements and wire sizing. Size the power wiring as per local code and on long wire runs it is recommended to use a larger wire size.

Power factor correcting capacitors MUST NOT be connected to the OP-STOP output. If desired, they must be connected on the line side of the unit. Capacitors can be connected before starting or preferably after the motor has reached full speed.

## 4.5 START UP

### 4.5.1 CHECKS BEFORE POWER-UP

4.5.1.1 Ensure that all electrical connections are completed as shown on schematics in section 6, and that connections are properly tightened. The most important connection is the interlock between the OP-STOP and the starter.

4.5.1.2 Ensure that the burden resistor is equal or larger than the value listed in the table below or calculated by the following equation:

***Rb = Effective Current Transformer Ratio ÷ Motor Nameplate Amps***

4.5.1.3 Set JP1 link to LO.

4.5.1.4 Adjust RV2, braking torque, and RV1, braking time to 50%

4.5.1.5 Install a Disable switch between terminals 2 and 4 of J3 in the open position. Switch is to be closed once the motor has reached zero speed or if any problems occur during braking.

4.5.1.6 If a Disable switch is not used, then set RV2 to 30%, about 20 seconds or lower.

**WARNING!**

**DO NOT OPEN LOAD SIDE DISCONNECT DEVICE DURING DC INJECTION CYCLE. FAILURE TO OBSERVE THIS WARNING WILL RESULT IN DAMAGE TO THE DISCONNECTING DEVICE AND MAY CAUSE PERSONAL INJURY.**

| MODEL | MOTOR AMPS | BURDEN RESISTOR (¼ W) | EFFECTIVE CT RATIO |
|---|---|---|---|
| SS6-15 with DCI | 10.0 | 68 Ω | 750 : 1 |
| | 15.0 | 47 Ω | |
| DCI-20 or SS6-30 with DCI | 20.0 | 39 Ω | 750 : 1 |
| | 30.0 | 27 Ω | |
| DCI-40 or SS6-50 with DCI | 40.0 | 39 Ω | 1500 : 1 |
| | 50.0 | 33 Ω | |
| DCI-80 or SS6-80 with DCI | 60.0 | 39 Ω | 2500 : 1 |
| | 80.0 | 33 Ω | |
| DCI-125 or SS6-125 with DCI | 100.0 | 27 Ω | 2500 : 1 |
| | 125.0 | 22 Ω | |
| DCI-200 or SS6-200 with DCI | 150.0 | 18 Ω | 2500 : 1 |
| | 200.0 | 12 Ω | |
| DCI-300 or SS6-360 with DCI | 200.0 | 27Ω | 5000 : 1 |
| | 300.0 | 18 Ω | |
| DCI-500 or SS6-500 with DCI | 400.0 | 22 Ω | 8500 : 1 |
| | 500.0 | 18 Ω | |

## 4.5.2 WITH POWER ON

4.5.2.1 Run the motor up to full speed and command the starter off. If the motor reaches zero speed from the DC injection cycle, close the switch to the Disable Input to disable the braking.

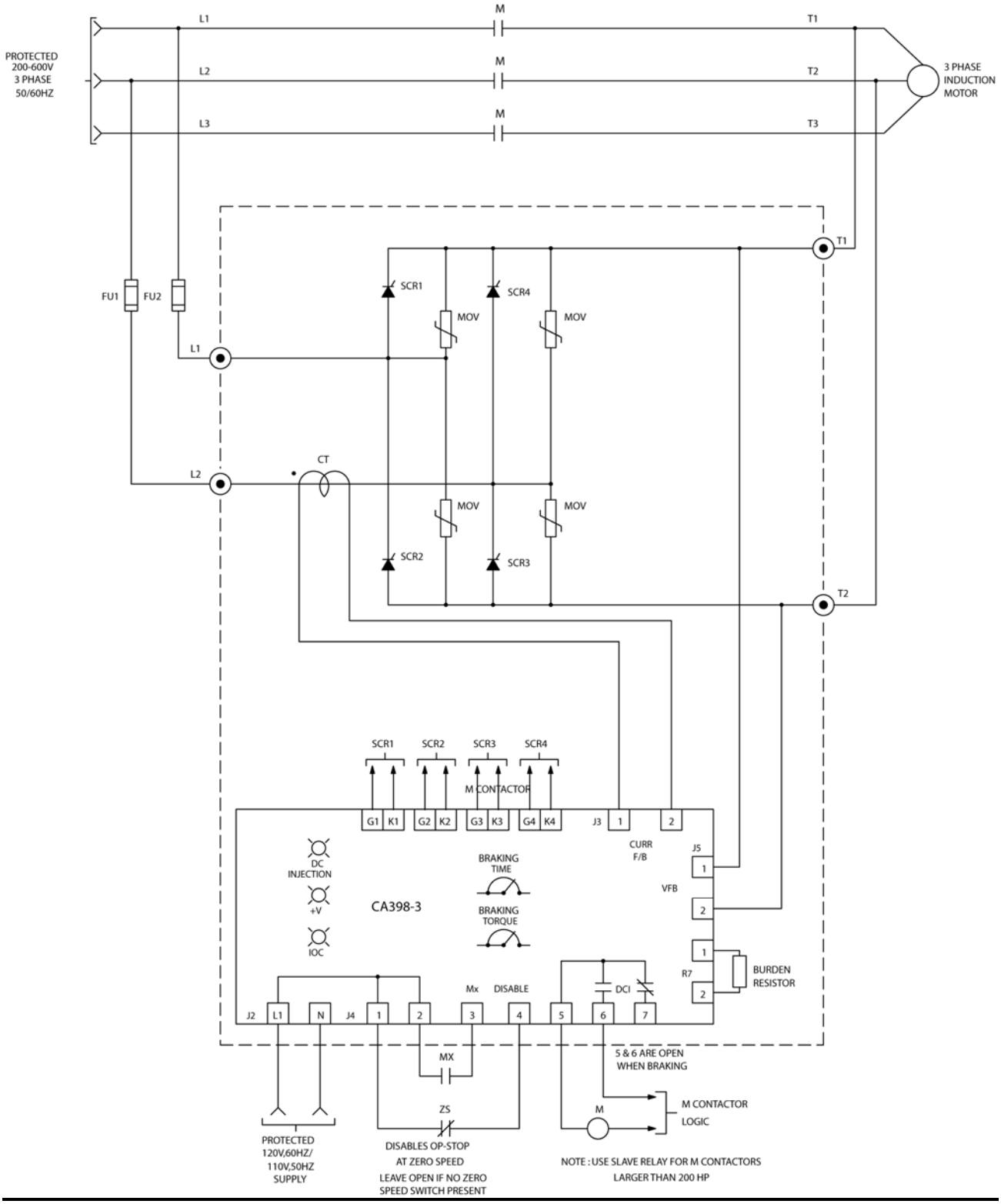
4.5.2.2 Re-adjust the braking torque pot, RV2, if the actual braking time has to be increased or decreased to bring the motor to zero speed.

4.5.2.3 Once the braking torque is set, then adjust RV1 to match the DC injection time with the actual stopping time of the motor. Typically, the injection should decease when the motor is at zero speed or shortly after. LD1, DC INJCT is an indication of braking. Each 10% graduation in RV1 corresponds to approximately 6 seconds.

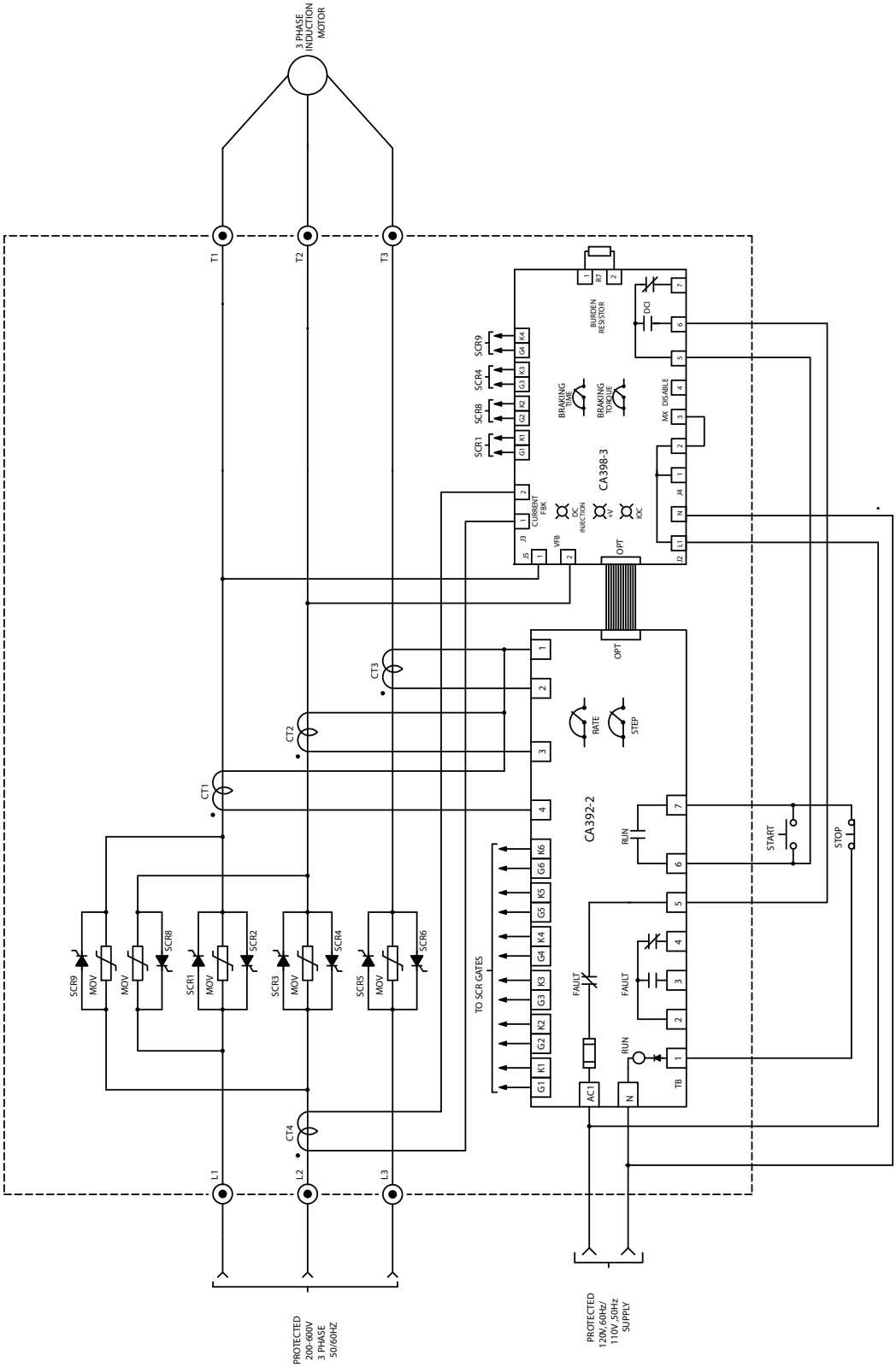
**WARNING!**
**ALLOW TIME FOR THE MOTOR TO COOL BEFORE ANOTHER START / STOP SEQUENCE IS INITIATED**
**FREQUENT START / STOP COULD CAUSE MOTOR DAMAGE DUE TO OVERHEATING**

# 5 TYPICAL CONNECTIONS

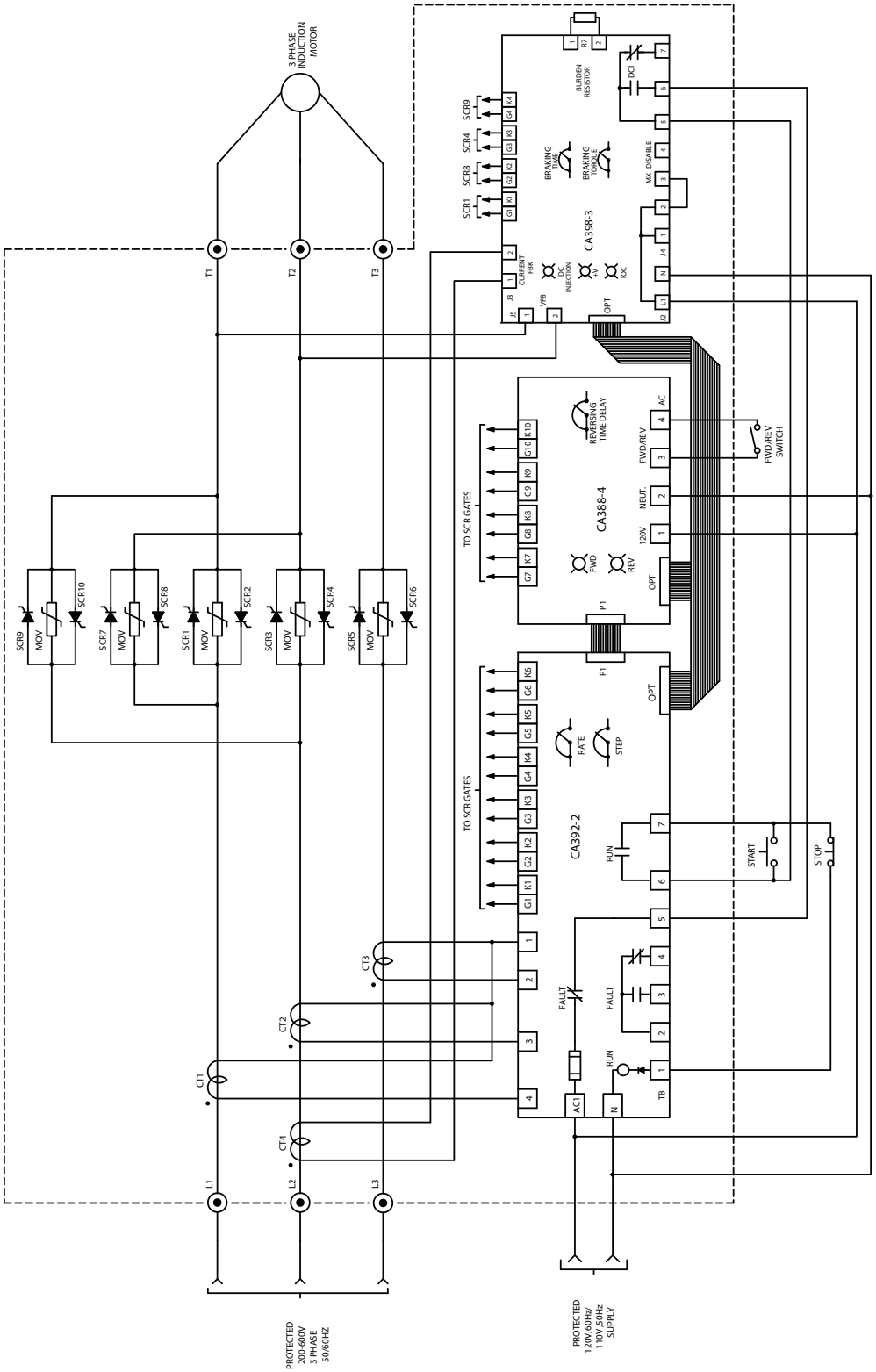
## *5.1 STAND ALONE DC INJECTION UNIT WITH ZERO SPEED DISABLE*



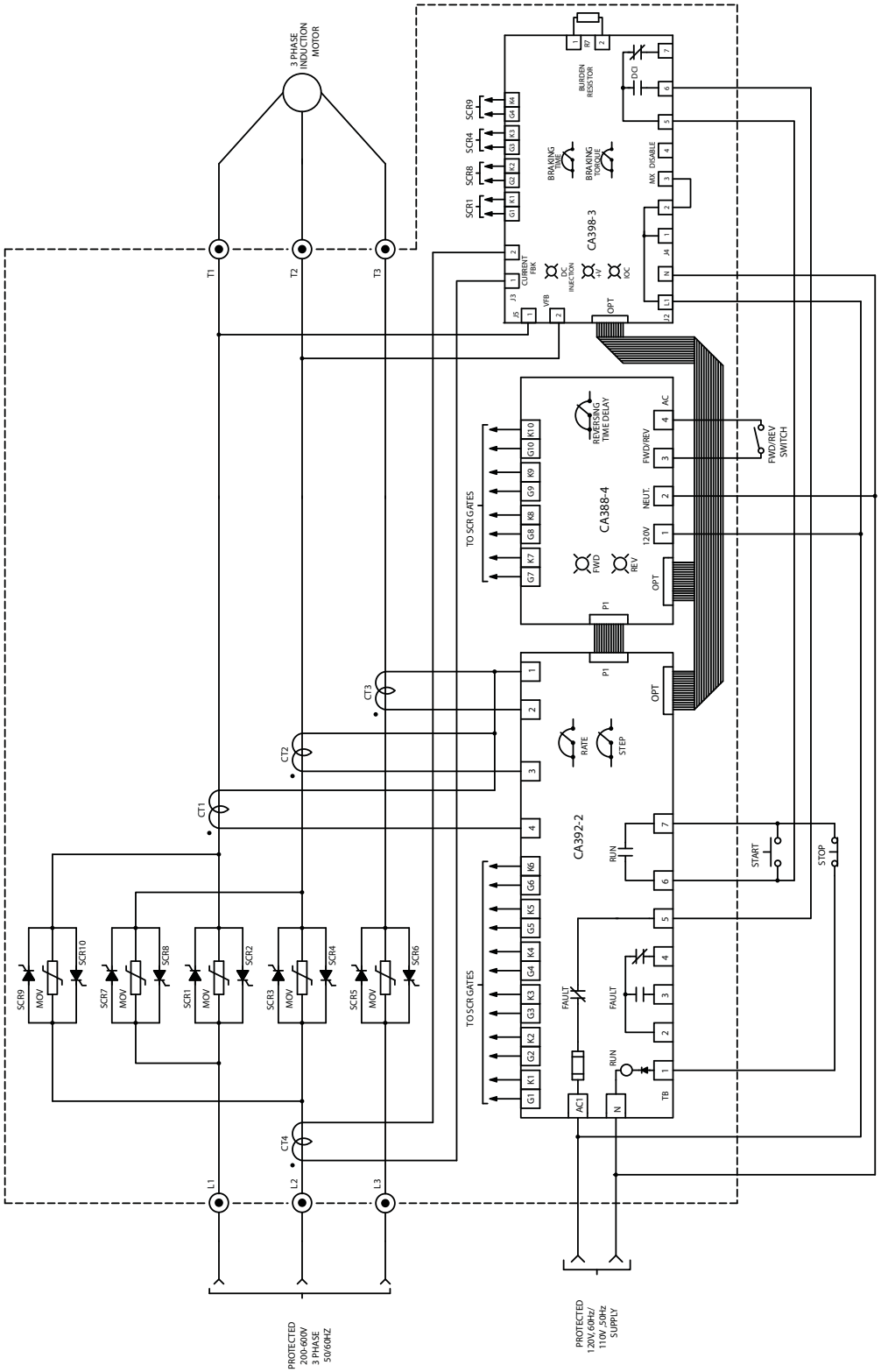
## 5.2 OPAL STARTER WITH DC INJECTION



## 5.3 REVERSING OPAL STARTER WITH DC INJECTION, 125 AMPS AND BELOW



## 5.4 REVERSING OPAL STARTER WITH DC INJECTION, 200 AMPS AND ABOVE



# 6 SPARE PARTS

| OP-STOP MODEL | CT RATIO | CT PART NO. | SCR PART NO. | SNUBBER CARD | CONTROL CARD DESCRIPTION |
|---|---|---|---|---|---|
| DCI-20 | 1500:1 | T261123 | N10SP03 | CA524 | CA398 |
| DCI-40 | 1500:1 | T261123 | N10SP06 | CA524 | CA398 |
| DCI-80 | 2500:1 | T262230 | N10SP16 | CA524 | CA398 |
| DCI-125 | 2500:1 | T262230 | N20SP06 | CA524 | CA398 |
| DCI-200 | 2500:1 | T262230 | N728452 | CA232 | CA398 |
| DCI-300 | 5000:1 | T265320 | N718602 | CA232 | CA398 |
| DCI-500 | 8500:1 | T268320 | N718133 | CA232 | CA398 |

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