DC6

DC Motor Drives
DC6 SERIES
INSTRUCTION MANUAL CONTENTS

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1. DESCRIPTION

1.1 General

SAFTRONICS type DC6 SCR converters are intended to power DC motors ranging from 5HP to 2000 HP.

The basic converter unit consists of:

a) A 6SCR power bridge.

b) A single control card type AA650 mounted on the power bridge assembly. The entire control circuit is accommodated on this card.

c) Synchronizing transformer assembly, upon which is mounted a relay logic PC board type A650-MB-2. This board is connected to the control card via a flat ribbon cable.

1.2 Standard Features

- Impedance-isolated armature feedback for a speed regulation of better than 5%.
- Isolated current feedback using current transformers.
- Visual indication of all important control points within the control card (light emitting diodes - LED’s).
- Single control card for quick replacement.
- Phase rotation protection with run interlocking and indication.
- Instantaneous protection against excessive current overload (ICT Current fault trip).
- Automatic resetting of ICT circuit when operating the normal STOP/START circuit.
- Stall-protection where power to the motor will cease after a stall period of longer than 12 seconds under current limit conditions.
- Adjustable maximum voltage with armature feedback.
- Adjustable maximum speed with tachometer feedback.
- Adjustable minimum speed.
- Adjustable acceleration (1-60 seconds).
- Adjustable deceleration (1-60 seconds).
- Adjustable current limit to the motor.
- Adjustable IR compensation.
- Adjustable velocity and current loop stabilities.
- Tachometer feedback loss protection i.e. the control will automatically revert to impedance-isolated armature feedback if the tachometer fails.
- Jogging facility with independent speed adjustment.
- 2-stage current limit for high initial starting torque requirement.
- Tachometer feedback for a speed regulation of better than 1.0%.

1.3 Optional Features

- Parallel 12-pulse operation.
- Multi-drive systems with accurate load sharing better than 3%.
- Input programming for follower drive applications.
- Constant kW/HP operation with a field current regulator.
- Constant current field regulator.
- Remote control station(s).
- Digital speed control for better than 0.1% regulation.

1.4 Power Bridge

Standard Protective Features

- Fast acting fuses.
1.4 Power Bridge cont’d

- Instantaneous protection against excessive current overload (Electronic protection - ICT).
- SCR protection against excessive dv/dt and over-voltage by means of individual R-C circuitry.
- Power bridge overtemperature protection to cut-out when stack temperature exceeds 85 degrees C (+/- 5°).

Optional Protective Features
Blower for cooling the DC motor, supplied via a contactor with thermal overload and using protection interlocked with the run control circuitry.

Power Bridge Rating Data
The DC6 series covers the power range of 5HP to 2000HP. The control circuit, however, remains basically the same for the full range up to 2000HP. The different bridge assemblies are listed in Table 1.

Table 1

<table>
<thead>
<tr>
<th>BASIC MODEL</th>
<th>MAXIMUM HP</th>
<th>ARMATURE VOLTAGE</th>
<th>MAX DC AMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>240V</td>
<td>480V</td>
<td>600V</td>
</tr>
<tr>
<td>DC6-61</td>
<td>15</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>DC6-126</td>
<td>30</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>DC6-251</td>
<td>75</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>DC6-350</td>
<td>100</td>
<td>200</td>
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<td>400</td>
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<td>DC6-800</td>
<td>250</td>
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<td>DC6-1000</td>
<td>300</td>
<td>600</td>
<td>800</td>
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<tr>
<td>DC6-1250</td>
<td>400</td>
<td>800</td>
<td>1100</td>
</tr>
<tr>
<td>DC6-2000</td>
<td>800</td>
<td>1750</td>
<td>2000</td>
</tr>
</tbody>
</table>

Derating Data
Table 1 lists the maximum continuous DC output current at a maximum ambient temperature of 40°C (104°F) and an altitude of 5,000 feet (2,000 meters). For ambient temperatures in excess of this value all powerstack assemblies must be derated by 1.5% per degree C. (.75°F). For altitudes in excess of 5,000 feet (2,000 meters) above sea level, all power stack assemblies must be derated by 1% for every 250 ft. (100 meters) above 5,000 ft. (2,000 meters).

Field Excitation Supply
Constant field excitation is supplied from a bridge rectifier having the voltage and current ratings listed in Table 2.

Table 2

<table>
<thead>
<tr>
<th>AC SUPPLY VOLTAGE</th>
<th>DC FIELD SUPPLY VOLTAGE</th>
<th>MAXIMUM DC CURRENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>240V 3 Phase</td>
<td>150V</td>
<td>10A</td>
</tr>
<tr>
<td>480V 3 Phase</td>
<td>300V</td>
<td>440V</td>
</tr>
<tr>
<td>600V 3 Phase</td>
<td>300V</td>
<td>440V</td>
</tr>
</tbody>
</table>
2. INSTALLATION

2.1 General

Unless the unit has been specifically designed for poor environmental conditions, it must be installed in an area where the following conditions exist:

a) Ambient temperature does not exceed 40°C (104°F)

b) Ambient temperature is not less than 10°C (50°F)

c) Altitude above sea level in excess of 5,000 ft. (2,000 meters) must be taken into account as in Derating Data, Section 1.4.

d) Ambient air is reasonably clean and dry. It must be free of flammable or combustible vapors, steam or corrosive gases.

e) The clearance around the cabinet must be sufficiently large to:
   i) Provide full accessibility to the front.
   ii) Provide a non-restricted airflow (with a minimum of 1” clearance) from the intake and exhaust ventilation louvers.

2.2 External Cabling

It is most important that the AC supply to the unit is of the correct voltage and current rating. It should be kept in mind that where the specified drive unit voltages and/or currents are not available, an interstage transformer will be necessary. All external connections must be made according to the Engineering drawing supplied. All power and control cable ratings should be referred to the National Electrical Code Handbook.

Cable Current Ratings

Table 3 lists the maximum continuous current which the AC and DC cables must carry for the various drive types. If the system uses a transformer, then the AC ratings are for the transformer secondary. Primary ratings must be determined by the transformer rating.

Table 3

<table>
<thead>
<tr>
<th>DRIVE TYPE</th>
<th>MAXIMUM ARMATURE AMPS (AVG)</th>
<th>3 PHASE SUPPLY AMPS (RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC6-61</td>
<td>60</td>
<td>49</td>
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<tr>
<td>DC6-126</td>
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<td>DC6-1000</td>
<td>1000</td>
<td>816</td>
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<tr>
<td>DC6-1250</td>
<td>1250</td>
<td>1020</td>
</tr>
<tr>
<td>DC6-2000</td>
<td>2000</td>
<td>1632</td>
</tr>
</tbody>
</table>

Motor Field Cable Current Ratings

Motor field cable current ratings are determined by the motor being used. This can normally be ascertained by referring to the motor nameplate. A cable rating of 20 amps should be adequate for the full range up to 1500 HP. The cable insulation rating should not be less than 600V.
Control Signal Cable Consideration

All control signal cables must have a current rating of at least 5 Amps and the insulation rating should be 600V. TACH and SPEED CONTROL signal wiring should be interconnected by means of cables with individually shielded and twisted cables.

For extra protection against electro-magnetic interference and mechanical damage, PVC covered shielded cables should be run completely in steel conduit, separately from power and AC control cables. The shields of the individual cables should then be terminated together at one point in the control cabinet at the control circuit common (where specified). It should be noted that the shields must be grounded at one point only, preferably the control cabinet, to avoid unwanted ground current loops.

All control cables should be kept away, as far as possible from high power cables, preferably run in a separate channel.

Motor Connections to DC6

CCW ROTATION
(FACING DRIVE SHAFT)

CW ROTATION
(FACING DRIVE SHAFT)

NOTE: Shielded cables must be continuous with no breaks in the shield.
3. STARTUP

3.1 Adjustment Prior To Operation

When all cable connections have been thoroughly checked out according to the Engineering drawing, power may be applied to the drive unit, but the Start circuit must not be operated at this point.

The following adjustments should be made on the AA650 control card:

- RV6 - MAXIMUM SPEED (tach feedback) - Fully counter-clockwise
- RV3 - RATE I (Acceleration Rate) - Fully clockwise
- RV4 - RATE II (Deceleration Rate) - Fully clockwise
- RV5 - STABILITY (Speed) - Mid Position
- RV9 - CURRENT LIMIT - Fully clockwise
- RV7 - MINIMUM SPEED - Fully counter-clockwise
- RV8 - IR COMPENSATION - Fully counter-clockwise
- RV2 - AV (Max. Armature Voltage) - Fully counter-clockwise
- RV1 - CS (Current Stability - Factory Set) - Mid position approx.

The state of the LED's on the AA650 control card should be as follows:

- V (-12 Volt Supply) - Glowing brightly
- R (Run indication) - Off
- DV (Speed Reference) - Off
- VA (Speed Error Amplifier Output) - Off
- CA (Current Error Amplifier Output) - Off
- ST (Stall Sensing) - Glowing brightly
- TR (Trip Circuit) - Off or On*
- 2S (2-Stage Current Limit Circuit) - Off
- Φ Phase Rotation Indication - Glowing brightly
- +V (+12 Volt Supply) - Glowing brightly
- Φ1, Φ2, Φ3 (Comparator Output Indication) - Glowing dimly

*The TRIP LED should come on after the run command is applied to the drive.

NOTE: If any of the LED’s do not conform to the pre-start list, do not immediately suspect the AA650 card of being faulty. First check out all external connections for short circuits and cross connections etc. The AA650 card has been thoroughly tested at the factory and it will be unlikely that this card would be at fault.

3.2 Initial Operation of the Drive Unit

Before running the drive, it will be necessary to carry out the following:

a) Operator’s speed control set to its zero-position. Where motorized potentiometers are used, this can be done by operating the Increase/Decrease speed buttons.
NOTE: In de-energized state, the field economy circuit will be operation. The field voltage will be at 2/3 normal level until the DC6 is started.

CAUTION: Dangerous voltage will be present if power is not removed.

NOTE: The Trip circuit may operate at 12 second intervals during this procedure and remove power from the motor. This is normal, and the Stop/Start circuit should be re-activated after such a trip. Once the correct maximum motor current and speed has been set up, the Trip circuit will act correctly, that is only remove power from the motor if it has stalled for a period longer than 12 seconds under maximum current conditions.

### 3.3 Maximum Speed Adjustment

Start the drive and set the operator’s speed control to maximum. Adjust the control “AV” (RV2) on the control card for the correct maximum armature voltage indicated on the motor nameplate. Once this adjustment has been carried out, the tach connections can be restored to the drive unit.

### With Tach Feedback(Optional)

Set the operator’s Speed Control to maximum, and check the motor speed by holding a hand tach to the motor shaft or by checking the tachogenerator voltage. The standard tach type 5PY used by Saftronics is rated at 50 Volts/1000RPM. This should, however, be confirmed by referring to the tach nameplate. It will also be noted that with the Speed Control set at maximum, the DV lamp on the AA650 card will glow brightly. Adjust the Maximum speed control, RV6 on the AA650 card, for the required maximum speed; usually 1750RPM, or 87.5 Volts on the 5PY tach.

Set the operator’s Speed Control to zero while the drive unit is on, and adjust the Minimum speed control, RV7 on the AA650 card, for the correct minimum speed.

CAUTION: Dangerous voltage will be present if power is not removed.

NOTE: The Trip circuit may operate at 12 second intervals during this procedure and remove power from the motor. This is normal, and the Stop/Start circuit should be re-activated after such a trip. Once the correct maximum motor current and speed has been set up, the Trip circuit will act correctly, that is only remove power from the motor if it has stalled for a period longer than 12 seconds under maximum current conditions.

### 3.4 Minimum Speed Adjustment

Note: If the tachometer is 100V/1000 rpm and the motor is 1750 rpm, then put an 82K resistor in series with the tach lead.
3.5 Tach Loss Protection Check

When steps 2.3.5, 2.3.6, and 2.3.7 have been carried out, it will be possible to check this feature as follows:

With the motor running at half speed, remove one of the tach connections from the drive. The control should now revert to impedance-isolated armature voltage feedback and the motor speed should only change marginally (it can either increase or decrease depending on the setting of “AV”, RV2, with respect to the Maximum speed adjustment).

3.6 Speed Stability Adjustment

When in operation, the drive unit regulator may be unstable. This becomes evident when the motor speed is unstable or erratic. The Stab control, RV5 on the AA650 control card, should be adjusted whenever necessary so that the motor speed is smooth and stable, with very little under or overshoot with speed changes.

3.7 Normal Current Limit Adjustment

With the motor running normally, at maximum speed, adjust the Current Limit control towards minimum until the motor speed starts dropping. Stop the drive unit, and switch off the AC supply. Disconnect the field supply from the motor, and jam the shaft to prevent it from turning. Field loss relay protection, FLR must be bypassed in the 120 vac control logic during this set up.

Restore power to the drive, set the speed control to minimum and press the Start pushbutton. Slowly increase the speed control to maximum. The motor armature current will rise to a low value, as indicated by an ammeter and the stall LED. ST will go off, indicating that there is a 12-second period in which the current limit can be set before the trip circuit comes into operation. Adjust the Current Limit (CL) control slowly toward motor nameplate full load current rating.

NOTE: The motor may stop completely, but this is quite normal.

NOTE: Compound Motors generate considerable torque even without SHUNT FIELD excitation, so it is advisable to leave the series field winding disconnected from the armature circuit as previously suggested (see section 3.1).

3.8 Two-stage Current Limit Adjustment (Optional)

With the two-stage current limit feature, it will be essential that the Burden Resistor be sized to give the desired break away current. Standard drives are supplied with Burden Resistors sized for approximately 150% of full load current of the motor, with full clockwise rotation of the current limit potentiometer.

The normal running current limit point can be set by inserting a resistor of a specified value in place of the 0 ohm Resistor supplied with the standard card. This resistor is R214 on the AA650 control card.

For a 200% break away current, the normal running current limit can be set by choosing a resistor from the table below:
To set current limit with this option (two stage current limit) follow the procedure laid out in section 3.7 above.

After the current limit has been set to the break away current, the drive automatically adjusts the current limit setting to the normal running limit after the 2S led has turned on.

### 3.9 IR Compensation

#### General
IR compensation must only be used with Armature Feedback control and should never be used with Tach Feedback control. Therefore, where tach feedback is used, this control must remain in the full counter-clockwise position. Furthermore, the motor must be coupled to the machine before this adjustment is carried out. The purpose of IR Compensation is to compensate for IR losses in the motor such that low speed holding capability is improved with armature feedback control.

#### IR Compensation Adjustment
With the drive in operation at half speed, slowly adjust the IR compensation control (RV8) clock-wise until there are signs of instability with quick speed changes from 25% to 75%. Slowly adjust the IR compensation control towards minimum again until all signs of instability have disappeared. This will be the maximum amount of the IR compensation that the machine will allow with good stability. It should be kept in mind that where the machine is new or reconditioned, it may be “tight” initially, and it may be found necessary to reduce the amount of IR compensation at a later stage to prevent instability.

### 3.10 Acceleration/Deceleration Adjustment
The acceleration and deceleration control RATE I and RATE II respectively, can be adjusted for the required acceleration and deceleration to suit the application.

### 3.11 Jog Speed Adjustment
Where this feature is supplied, the Jog pushbutton must be pressed and the Jog Speed control on the A650-MB-2 control board must be adjusted for the desired jog speed.

### 3.12 General
When all adjustments have been carried out, reconnect the series (compound) field (see p4). It must be ensured that the series field is correctly connected such that it assists the main shunt field of the motor and not oppose it.
4. DIAGRAMS

4.1 Block Diagram
4.4 A650 Control Schematic cont'd
5. BURDEN RESISTORS

<table>
<thead>
<tr>
<th>HP</th>
<th>240 VAC</th>
<th>480 VAC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current F/B CT</td>
<td>Burden resistor ohms</td>
</tr>
<tr>
<td>5</td>
<td>1500:1</td>
<td>120</td>
</tr>
<tr>
<td>7.5</td>
<td>1500:1</td>
<td>82</td>
</tr>
<tr>
<td>10</td>
<td>1500:1</td>
<td>56</td>
</tr>
<tr>
<td>15</td>
<td>1500:1</td>
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<td>20</td>
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<td>40</td>
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<td>50</td>
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<td>60</td>
<td>2500:1</td>
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<tr>
<td>75</td>
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<tr>
<td>100</td>
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<tr>
<td>125</td>
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<td>-</td>
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<tr>
<td>800</td>
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<td>-</td>
</tr>
</tbody>
</table>

Burden resistor calculation:
R = 1.53 x CT / FLA
Where R = burden resistor in ohms,
CT = Current F/B ratio
FLA = Motor full load amps
Example: FLA = 100, CT = 1500:1, then
R = 1.53 x 1500 / 100 = 23 ohms, use 22 ohm, 3 watts.
6. TROUBLESHOOTING

The three most frequent causes of a drive system or major component malfunction are:

1. Fuse failure.
2. Discontinuity in a circuit, caused by a broken or loose connection of the wiring.
3. Circuit grounding, caused by faulty or damaged insulation or wiring or a loose component coming in contact with ground.

If a drive or major component, that has been operating properly, suddenly malfunctions, do not make any adjustments or replace any components without first checking:

1. For blown fuses.
2. All connections for tightness.
3. All wiring for breaks.
4. All wires for faulty or damaged insulation.

If, after making the above checks, trouble is still encountered, refer to the following trouble shooting table.

<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>PROBABLE CAUSES</th>
</tr>
</thead>
</table>
| Contactor will not energize when Start button is pressed | 1. Overload relay tripped.  
2. No control power. Check for 120 vac supply.  
3. Faulty or improper wiring between drive cabinet and operator's control station.  
4. Field loss relay contact open.  
5. Open contactor coil.  
| Output voltage does not increase as speed pot is turned up. | 1. Improper or defective wiring between cabinet and speed pot.  
2. Defective speed pot.  
3. Defective AA650 card. |
| Drive unstable.                         | 1. IR drop compensation set too high.  
2. Motor series field connected backwards.  
3. Defective AA650 card.  
4. Stability pot needs adjustment. |
| Speed drift or poor regulation          | 1. Current limit set too low.  
2. Motor overloaded.  
3. Defective AA650 card.  
2. Motor overloaded.  
3. Max speed pot not adjusted properly.  
4. Defective wiring between AA650 card and A650MB-2 assembly.  
5. Open scr gate.  
6. Low reference voltage |
<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>PROBABLE CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Ground in motor armature or field.</td>
</tr>
<tr>
<td></td>
<td>3. Defective SCR.</td>
</tr>
<tr>
<td></td>
<td>4. Defective AA650 card.</td>
</tr>
<tr>
<td></td>
<td>5. Defective A650MB-2 assembly.</td>
</tr>
<tr>
<td>AC line fuse/fuses blown</td>
<td>1. Shorted or grounded DC output wiring.</td>
</tr>
<tr>
<td></td>
<td>2. Grounded motor armature or field.</td>
</tr>
<tr>
<td></td>
<td>4. Defective SCR.</td>
</tr>
<tr>
<td>Control circuit fuse</td>
<td>1. Defective wiring or component contacting ground or other circuits.</td>
</tr>
<tr>
<td>blown</td>
<td>2. Shorted relay or contactor coil.</td>
</tr>
</tbody>
</table>

**State of LED’s**

- When power is applied:
  - V  R  DV  VA  CA  Ø1  Ø2  Ø3  ST  TR  2S  Ø  +V
  - LED off

- When the start pushbutton is pressed:
  - V  R  DV  VA  CA  Ø1  Ø2  Ø3  ST  TR  2S  Ø  +V
  - LED dim
  - LED on
## 7. SPARE PARTS

<table>
<thead>
<tr>
<th>PART DESCRIPTION</th>
<th>MODEL NUMBER</th>
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<tbody>
<tr>
<td></td>
<td>DC6-61</td>
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<tr>
<td>Control Card</td>
<td>AA650</td>
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<td>List Price</td>
<td>$1500</td>
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<tr>
<td>Recommended Quantity</td>
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<tr>
<td>Mother Board</td>
<td>A340001</td>
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<tr>
<td>240V</td>
<td>$600</td>
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<tr>
<td>Stack Overtemp Switch</td>
<td>S523002--</td>
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### FIELD LOSS RELAYS

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<th>PART NUMBER</th>
<th>LIST PRICE</th>
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<tbody>
<tr>
<td>0.25 - 1.0 Amps</td>
<td>A450001</td>
<td>$115</td>
</tr>
<tr>
<td>1.0 - 4.0 Amps</td>
<td>A450002</td>
<td>$115</td>
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<tr>
<td>4.0 - 10.0 Amps</td>
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<td>$115</td>
</tr>
<tr>
<td>2.0 - 6.0 Amps</td>
<td>A450004</td>
<td>$115</td>
</tr>
</tbody>
</table>
SAFTRONICS

8. WARRANTY

Saftronics warrants to buyer that products, and any services furnished hereunder will be free from defects in material, workmanship and title, and will be of the kind and quality specified in the quotation. The foregoing shall apply only to failures to meet said warranties (excluding any defects in title) which appear within one year from the date of shipment hereunder, provided, however, that if buyer, in the course of its regular and usual business, transfers title to or leases such products (including equipment incorporating such products) to a third party, such period shall run until one year from such transfer or lease or eighteen months from shipment by Saftronics whichever occurs first. The warranties and remedies set forth herein are conditioned upon (a) proper storage, installation, use and maintenance, and conformance with any applicable recommendations of Saftronics and, (b) buyer promptly notifying Saftronics of any defects and, if required, promptly making the product available for correction.

If any products or services fails to meet the foregoing warranties (except title), Saftronics shall thereupon correct any such failure either, at its option, (i) by repairing any defective or damaged part or parts of the products, or (ii) by making available FOB Saftronics plant or other point of shipment, any necessary repaired or replacement parts. The preceding paragraph sets forth the exclusive remedies for claims (except as to title) based on defect in or failure of products or services, whether claim in contract or tort (including negligence) and however instituted. Upon expiration of the warranty period, all such liability shall terminate. The foregoing warranties are exclusive and in lieu of all other warranties, whether written, oral, implied or statutory. No implied statutory warranty of merchantability or fitness for particular purpose shall apply and Saftronics will not be liable for any consequential damage arising from any product defect or failure to deliver on time. Saftronics does not warrant any products or services of others which buyer has designated.