General Service Bulletin

Intelligent Technology for Solid State Starter

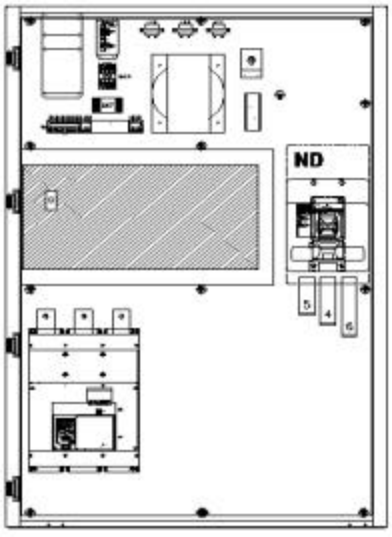
CVHE, CVHF, CVHG, CDHF, CVHG and CVGF

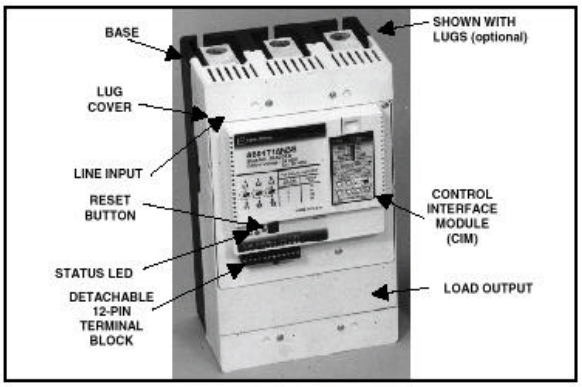
Order No: CVHE-SVB04B-EN October 12, 2002

Introduction

The purpose of this bulletin is to provide set-up, operation, troubleshooting and replacement information for the “IT” (Intelligent Technology) solid state starter used on CH530 equipped Trane CVHE, CVHF, CVHG, CDHF, CDHG and CVGF units. See Figure 1.

Figure 1 - Unit Mounted “IT” Solid State Starter





⚠ WARNING

Hazardous Voltage!

Starter and motor components may be energized even if the motor is not running. Disconnect all electric power including remote disconnects before servicing. Failure to disconnect power before servicing can cause severe personal injury or death.

CAUTION!

Equipment Damage!

Motor components may be energized even if the motor is not running. Do NOT apply a deep vacuum to the unit if the unit is energized. Disconnect all electric power before evacuating the chiller. Failure to do so may cause damage to the equipment.
Applying a deep vacuum to an IT Solid State Starter equipped unit, while power is applied to the unit, can cause an electrical arc-over inside the motor housing. This can cause motor winding or motor terminal damage or failure.

CAUTION!

Proper phasing of the line power supplied to the IT Solid State Starter is very important. Line power to the IT Starter MUST be phased A-B-C. Use a phase meter to confirm proper phase rotation before the first operation of the chiller. Failure to confirm proper power phasing before unit operation can result in equipment damage.
Note: Chillers with IT Starters that are shipped after November of 2002 will have phase rotation protection built into the IT Starter in order to better prevent equipment damage.

The Intelligent Technology Solid State Starter is applied “inside the delta”. As such, motor leads, terminals, and windings are energized continuously whenever the unit disconnect is closed, even if the unit is not running.

The Intelligent Technologies (IT) Inside the Delta Soft Starter is an electronic, self-contained, panel- or enclosure-mounted motor soft-starting device. It is intended to provide 3-phase delta-connected induction motors with a smooth start both mechanically and electrically. The IT line of soft starters utilizes six SCRs in 3 anti-parallel; one pair in series with each phase winding of the Delta-connected motor. Controlling the SCRs’ conduction period controls the voltage applied to the motor. This in turn controls the torque developed by the motor. After the motor reaches speed, contacts inside the starter are closed to bypass the SCRs.

The Intelligent Technologies (IT) Soft Starter is designed to fulfill the industrial service requirements for applications such as Chillers and Compressors where Wye-Delta starters are historically applied.

The Intelligent Technologies (IT) Soft Starter meets all relevant specifications set forth by NEMA ICS 1, ICS 2 and ICS 5, UL 508, IEC 60947-4-2, CE, and CSA. This user manual covers useful information that is necessary to know in order to set-up, operate, troubleshoot and maintain the IT Soft Starter.

Environmental Requirements

- Operating ambient temperature range -40C to 50C (-40F to 122F).
- Storage temperatures range -50C to 70C (-58F to 158F).
- Elevation up to 2000 meters (6600 feet). Above 2000 meters derate 0.5% per 100 meters (330 feet) up to a maximum of 5000 meters (16000 feet).

- Maximum humidity 95% non-condensing.
- Clean, dry, non-corrosive.

Available Sizes

- 110 mm (110-233 amp)
- 200 mm (234-526 amp)
- 290 mm (527-1472 amp)

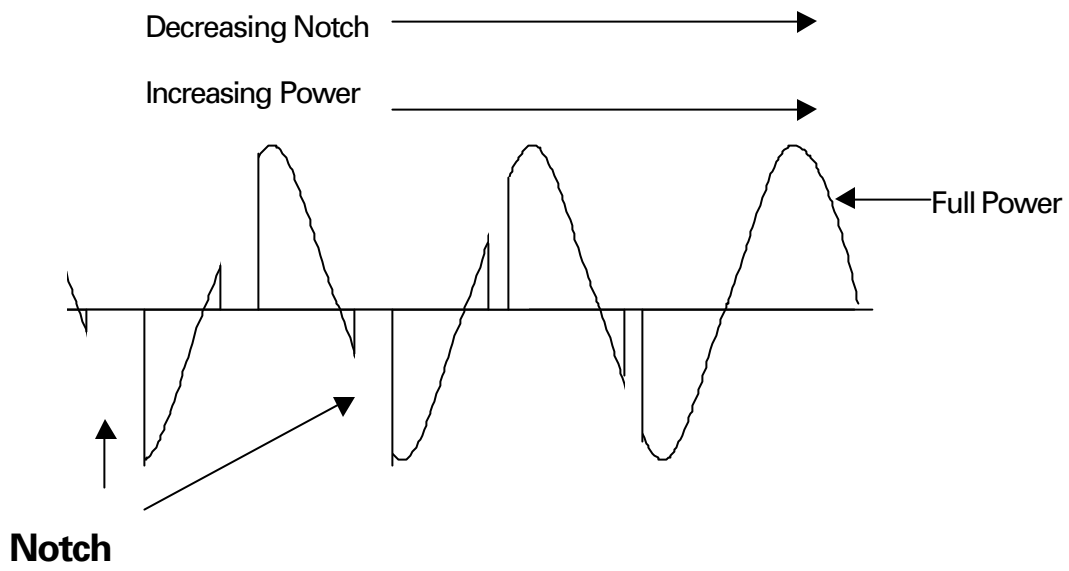
Available Voltage Range

- 200-600 Vac 50 and 60 Hertz

Operating Theory

The IT starter uses micro-processor controlled Silicon Controlled Rectifiers (SCRs) to "notch" or temporarily modify the voltage sine wave of each power leg passing through the starter. The larger the "notch" is, the less power and torque will be available to provide work in the motor. During starting process, the notch is large and is progressively reduced in size in order to provide more power and motor torque. The size of the notch can be expressed in the terms of the degrees of the sine wave that it consumes. Refer to Figure 2.

Figure 2 - Shows Example of Size of Notch in Terms of the Degrees of the Sine Wave that it Consumes.



Settings and Interface

To program and operate the IT starter, a "Control Interface Module" (CIM) is used. The CIM is mounted on the front face of the IT starter. The CIM contains the dip switches and rotary controls used to select the settings of the IT starter. Also on the CIM are LEDs that provide status concerning unit operation and faults.

Note that any change to a dip switch will cause all LEDs to flash momentarily. Any adjustment to a rotary control will cause the LEDs to light, and they will stay lit until the adjustment has been completed.

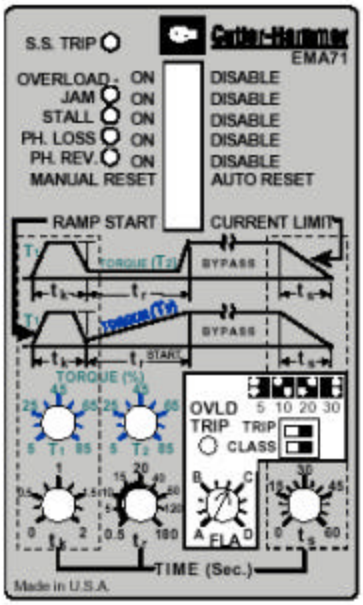
The IT starter does not have to be powered in order to make adjustments on the CIM. Once the unit is energized, the CIM will load its parameters into the IT starter. To verify the CIM is operational press the "fault reset" button that is just below the CIM. All LEDs will momentarily flash if the CIM is powered and communicating.

Dip and Rotary Switch Settings

Refer to the following table for the recommended settings on the CIM. If a switch is labeled "non-settable", this means that that feature is internally set at a fixed value for the Trane application, and it can not be changed using the switches. Moving the switch will have no effect.

CIM Dip or Rotary Switch	Settable/ Non-Settable	Default/Masked Setting
Overload	Non-settable	On
Jam	Non-settable	Disable
Stall	Non-settable	Disable
Phase loss	Non-settable	Disable
Phase reversal	Non-settable	Disable
Manual reset	Non-settable	Automatic reset
S.F. (special function)	Non-settable	Disable
Ramp start and Current limit	Settable	Ramp
T_1 (kick start)	Non-settable	0% torque
t_k (kick start time)	Non-settable	0 seconds
T_2 (advance or limit)	Settable	25%
t_s (soft-stop time)	Non-settable	0 seconds
t_r (ramp)	Settable	25 seconds
FLA	Non-settable	"D"
Overload Trip Class	Non-settable	Class 30

Figure 3 - Control Interface module (CIM)



The LEDs that are present next to the dip switches are not used to show the status of the dip switches because the features represented are not used in the Trane application. However, the LEDs are used when reading fault codes that may be present in the starter. Refer to the troubleshooting section of this manual.

Rotary Switch Settings
The lower portion of the CIM module contains several rotary switches that must be set to provide proper operation of the IT starter.

The **"T_1"** rotary switch is the kick start torque setting. Because kick start is not used in the Trane application it can remain set to 0% torque. Non-settable.

The **"t_k"** rotary switch is the kick start time setting. Because kick start is not used in the Trane application it can remain set to 0 seconds. Non-settable.

The **"T_2"** rotary switch is the initial torque setting for ramp starting, or it is the torque and current limit setting if the Current Limit method of starting is selected. Refer to the "Starting Options" section of this manual for the recommended settings.

The **"t_r"** rotary switch is the time setting for the ramp and current limit starting methods. Refer to the "Starting Options" section of this manual for the recommended settings.

The **"t_s"** rotary switch is the time setting for the "soft-stop" feature of the IT starter. Because soft stop is not used in the Trane application it can remain set at 0 seconds. Non-settable.

Overload Trip Settings
Overload protection for the Trane chiller motor is provided by the Trane unit control system. Because overload protection is not required from the IT starter, the overload trip settings are internally set to the highest settings of "D" and trip class 30. The overload trip settings on the CIM will have no effect, but can be set to "D" and trip class 30 in order to prevent confusion. Non-settable.

Solid State LED
An LED on the upper left corner of the CIM will be lit when the IT starter has tripped on a starter fault. Refer to the troubleshooting section of this manual.

Status LED
An LED labeled "Status" is provided on the front face of the IT starter. This LED will be green when power is on or during normal operation and will be red or off when a problem is present. Refer to the troubleshooting section of this manual.

Starter Fault Relay

The IT solid state starter normally open control contacts found between terminals 95 and 98 are connected to a Trane CH530 dual low voltage binary input board (PN X13650728 J2-1, 2). The contact logic is:

No fault detected by starter = closed
Fault detected by starter = open
Power off to starter = open

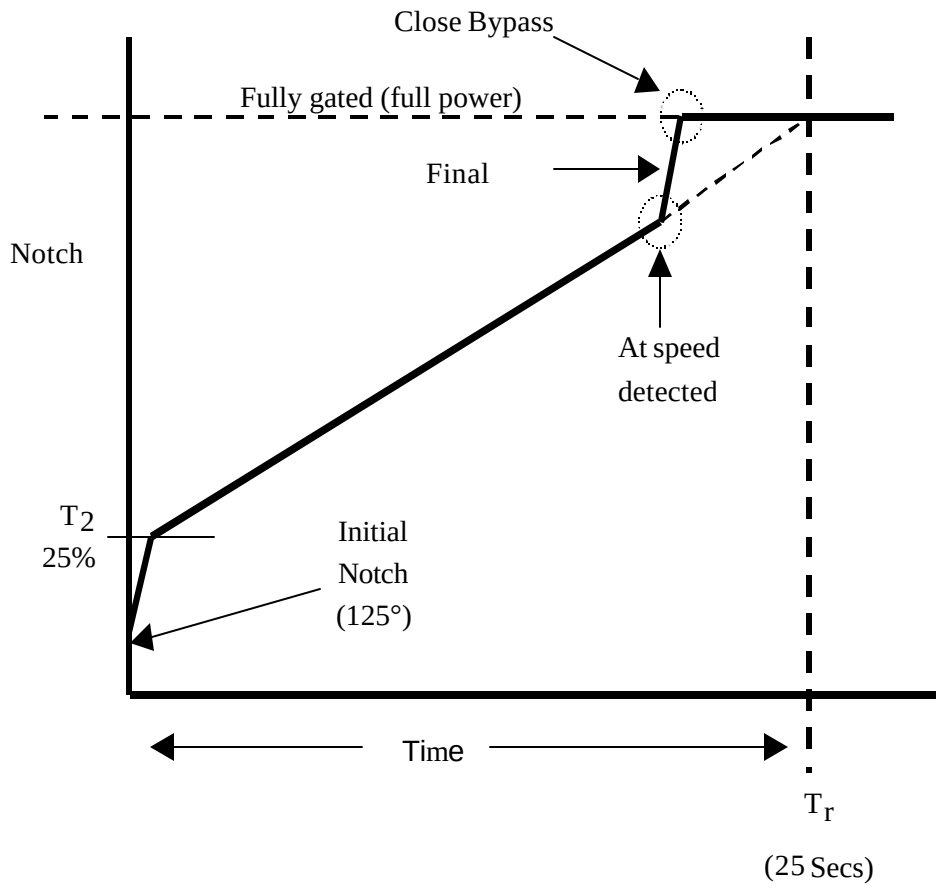
If there is a fault condition a Trane CH530 diagnostic "Solid State Starter Relay Open" will occur. The CH530 "Solid State Starter Relay Open" diagnostic is an MMR diagnostic and must be reset manually in the CH530.

The fault signal in the IT starter itself will be automatically cleared by the IT starter when a fault no longer exists.

Starting Options

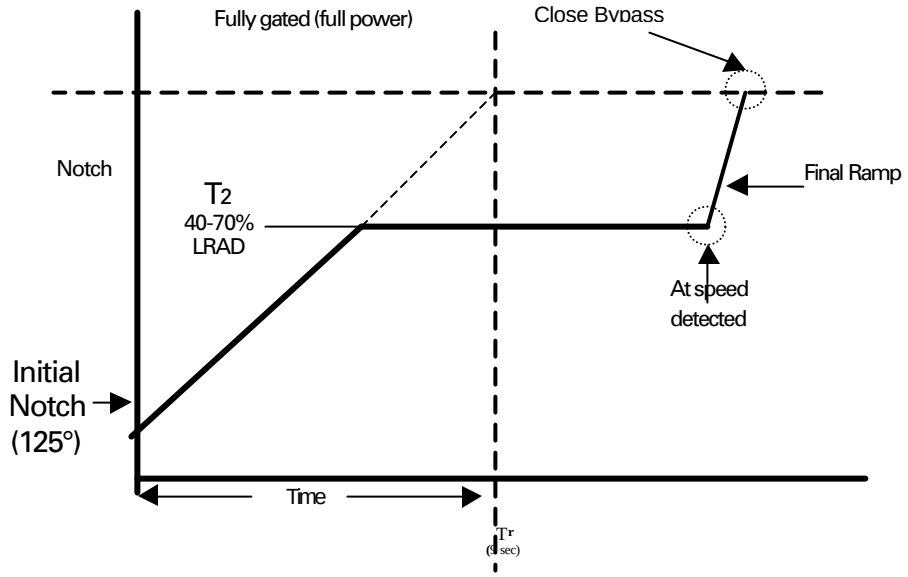
The Trane applied IT starter does not use Cutler-Hammer's Kick Start feature. Of the two types of starting that are available, the most commonly used (and Trane's default method) is the "Ramp" start. The Ramp starting method is selected using the Ramp Start or Current Limit dipswitch on the CIM. In the Ramp starting sequence, the motor is first energized at the largest possible notch size (125°) and then is ramped very quickly to a slightly smaller notch size that provides an initial torque value. The initial torque value can be set using the rotary switch labeled "T_2" on the CIM; the Trane recommended setting for T_2 is 25%. After reaching the initial torque setting, the notch size is then decreased (and the torque is increased) over the range of the acceleration ramp start time. The acceleration ramp start time can be set using the rotary switch labeled "t_r" on the CIM; the Trane recommended setting for t_r is 25 seconds. This will result in a smooth increase in the power that is applied to the motor. When the starter microprocessor controls sense the motor is up to speed, the starter will quickly ramp to full power (no notch) within 2 seconds and the starter's internal bypass contacts will then close. Refer to Figure 4.

Figure 4 – Ramp Start



A second method of starting using Current Limit is available for use when it is desired to limit the maximum amount of current drawn during the chiller starting. The Current Limit starting method may be selected using the Ramp Start and Current Limit dipswitch on the CIM. In the Current Limit starting method the power is smoothly ramped from the initial notch up to the 2 setting, which is typically 15 to 50% of torque (40 to 70% of LRAD). The current limit torque value can be set using the rotary switch labeled "T_2" on the CIM; the Trane recommended setting for T_2 is 25%. After reaching the current limit torque value, the notch size and power is then held at that value while the motor accelerates. How quickly the starter ramps up towards the T_2 setting is determined by the setting of t_r. The t_r is set using its rotary switch on the CIM; it is typically set at 9 seconds for this type of starting. Refer to Figure 5.

Figure 5 - Current Limit Start



The Trane recommended setting for T_2 when using current limit starting is 25%, which will limit current to approximately 50% of LRAD. If job site conditions require other torque or current values, the table below can be used as a guideline for setting T_2. T_2 must always be set large enough to ensure that the motor will successfully start and accelerate under all conditions.

Torque Setting (T_2)	Approximate % of Locked Rotor (LRAD)
56%	75%
45%	67%
36%	60%
27%	52%
19%	44%
14%	37%
9%	30%

Sequences

Starting – The CH530 chiller control will issue a start command from terminal J8-1 on the starter module to the start and permissive terminals on the IT starter. Holding relay 2K11 will also be energized and will hold it in to make the temporary start signal into a continuous run signal.

When the start and run signal is received on the start and permissive terminals of the IT, the IT will immediately begin to fire the SCRs at the widest possible notch (125°). The rate at which the notch is then reduced and the power to the motor increased, is then determined by the method of starting that is selected (I.E., Ramp or Current Limit).

Motor Acceleration - Regardless of the starting method used the Trane chiller unit controls will allow a maximum of 27 seconds from commanding a start signal and applying power to the solid state starter, to receiving the up-to-speed signal. If the motor acceleration is not confirmed within 27 seconds the unit controls will issue a stop command to the starter and a diagnostic will occur. The failure to accelerate diagnostic requires a manual reset of the unit controls.

Bypass – A bypass contactor exists inside the IT starter, in parallel with the SCRs. The contactor will carry 100% of chiller RLA . It will not, under normal starting or running circumstances, make or break current that is greater than the frame amps of the starter. The bypass contactor is energized when the motor is “at speed” and the SCRs are fully phased on (zero notches). During stopping the bypass contactor will be de-energized only after the SCRs are fully phased on. The bypass contactor will not break full load current during a loss of voltage; the SCRs will be gated on to take the load.

Stopping Profile – When the chiller controls remove the 24-vdc signal from the start and permissive terminals and asks the IT starter to stop, the SCRs will be fully phased on. The bypass contactor will be de-energized, and the SCRs will then be turned off at the earliest available zero current cross (when the current sine wave passes through zero). The stopping profile time from removal of the 24-vdc signal shall be less than 50ms. The SCRs shall not, under normal circumstances, make or break current greater than the chiller’s RLA. Trane does not use the soft stopping profile.

Starter Device Input and Output

A 12-pin detachable terminal block is provided on the front of the IT starter to connect the starter to the control circuit of the chiller.
The terminals are labeled:

"-" = 24-vdc common.

"+" = 24-vdc supply.

"P" = Permissive input. If power is not present on this terminal the unit will not start or run. For Trane applications this terminal should be connected with a jumper to terminal 1.

"1" = Start input. This terminal receives the start/run signal from the chiller control system.

"2" = Jog forward input. This terminal is not used on the Trane application.

"3" = Overload disable input. This terminal is not used on the Trane application.

"4" = Fault reset input. This terminal is not used on the Trane application. The fault flash codes will appear if 24-vdc is applied continuously to this terminal.

"13" and "14" = Terminals 13 and 14 provide a "up–to-speed" signal back to the chiller control system. It is a normally open relay that closes its contacts when the IT starter determines the motor has successfully accelerated.

"95" = Common for the starter fault relay of the IT starter.

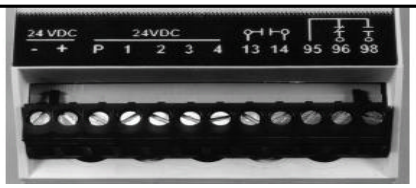
"96" = Normally closed contact for the starter fault relay of the IT starter. This contact provides a fault signal to the chiller control system.

OK = closed
Fault = open
No Power = open

"98" = Normally open contact for the starter fault relay of the IT

Each connection in the terminal block is capable of holding one or two 0.33-2.5mm² (#22 - #14 AWG) wires, or one 4mm² (#12 AWG) wire. Each terminal should be tightened to 0.4 N-m (3.5 In-Lb.).

⚠ Caution	⚠ Attention
Only apply 24V DC to the control terminal block unless specified otherwise in this manual. All control wiring is #22 - #12 AWG. Failure to follow this caution could result in severe damage to the controller.	Appliquer seulement une tension de 24 V c.c. aux bornier sauf avis contraire dans ce manuel. Toute la filerie de commande est de calibre 22 à 12 AWG. L'inobservation de cette mesure pourrait causer des dommages importants au contrôleur.



Accessories

MOVs – Most utility power systems experience periodic transient voltages. Line or power factor correction capacitor switching, nearby lightening strikes, utility supply faults, or a user starting or shutting down a large load such as a motor can cause these voltages. The IT starter has been designed to handle transient voltages of up to 4kV lasting up to 20 seconds. If transient voltages of greater magnitude or of a longer duration than the standard withstands rating capability are expected, then a protective module must be installed. The protective module contains Metal Oxide Varistors (MOVs). MOVs are devices that remain in a passive state until a transient voltage occurs. Under the transient condition the MOV turns on and holds the peak line voltage down to a level that is less than the IT transient voltage rating. When the transient clears, the MOV returns to a passive state. MOVs are factory installed on a new starter, or they may be purchased for installation in the field. Contact Trane AfterMarket for information concerning the purchase and installation of MOVs.

PFCCs – If Power Factor Correction Capacitors (PFCCs) are installed on the system they must NOT be connected to the load side of the IT starter. Do NOT connect PFCCs between the IT starter and the motor. PFCCs must be installed on the line side of the IT starter. A separate isolation contactor is required to energize the capacitors. The capacitors are only energized after the motor is up to speed.

Troubleshooting

The following section presents information useful for diagnosing a problem with the Trane applied IT starter. While many potential situations are outlined, it is possible you may run into a problem that is not covered here. If you have worked through the following troubleshooting procedure and find that you require further assistance, please contact the appropriate business unit technical service group. Please always have the following information ready when you call or use web resources:

Trane Sales Order Number	
Trane Unit Serial Number	
Unit Design RLA	
Starter Catalog Number	
Style Number	
Starter Serial Number	
CIM Dip Switch Settings	
CIM Rotary Switch Settings	

Before You begin To Troubleshoot:

⚠ WARNING

Hazardous Voltage!

! **Use extreme caution when service related work, adjustments, measurements or other service work is performed with power on.**

! **If troubleshooting procedure requires equipment to be energized, all work must be performed by properly qualified personnel, following appropriate safety practices and precautionary measures.**

Failure to do so could cause death or serious injury.

We highly recommend you read this entire section of the manual before troubleshooting the IT starter.

You may want to obtain the following equipment to aid you in troubleshooting:

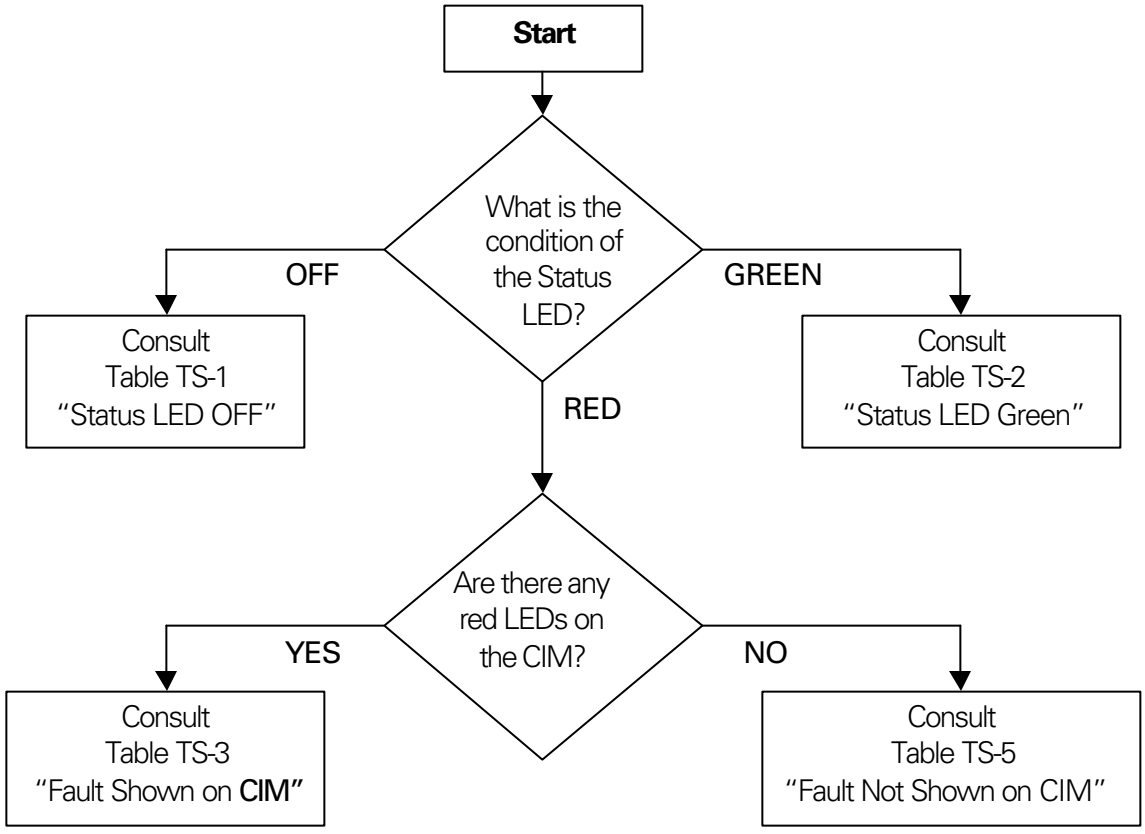
Multimeter

Clamp-on ammeter

Define the Problem:

The IT starter fails to start. No power is applied to the motor.	Use Flowchart #1
The IT starter trips during startup, or fails to reach rated speed before going into bypass.	Use Flowchart #1
The IT starter trips or stops running during normal conditions.	Use Flowchart #1
None of the above descriptions match the problem.	Use Flowchart #2

Flow Chart 1



Flow Chart 2

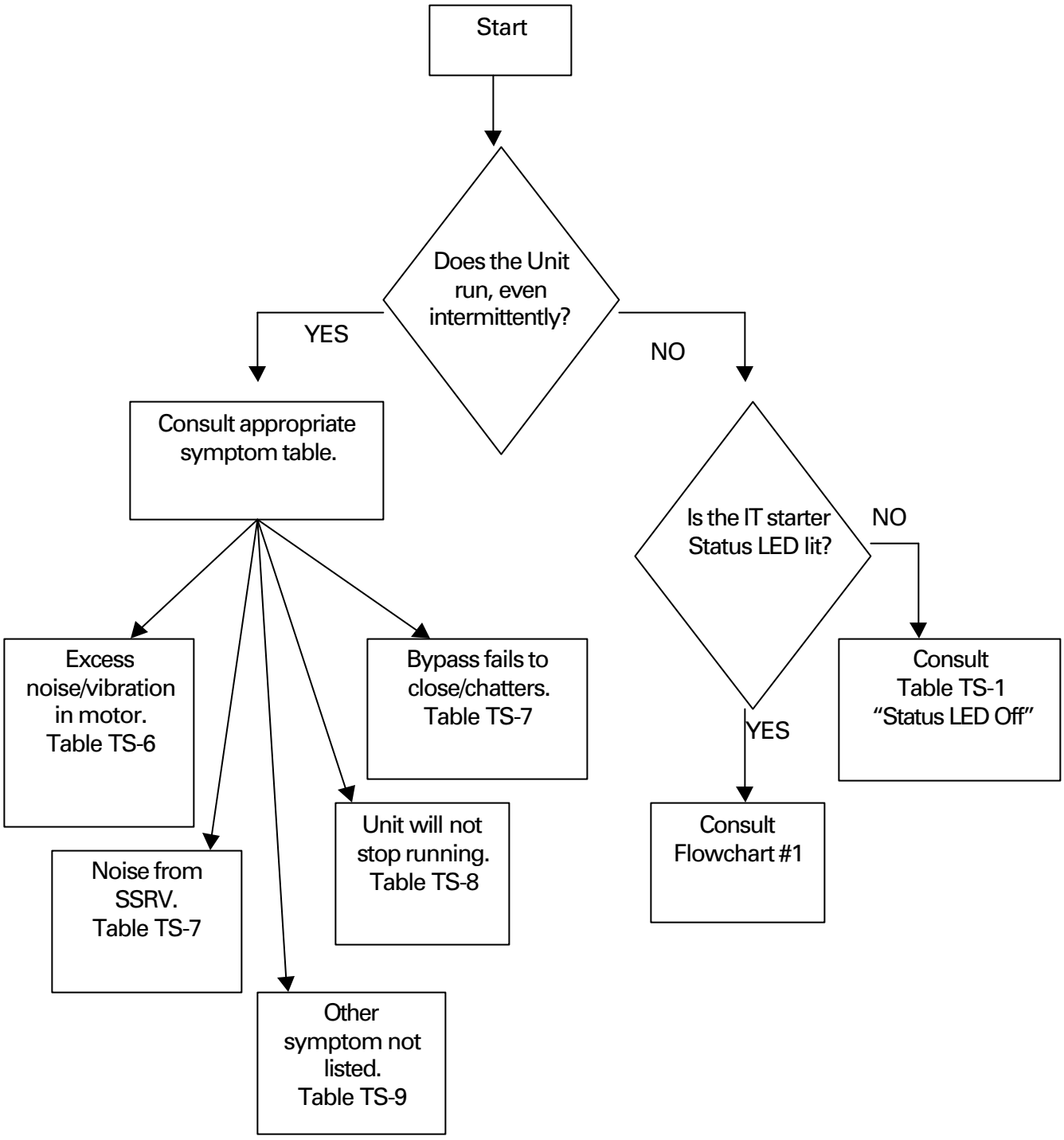

Start
Does the Unit run, even intermittently?
YES
NO
Consult appropriate symptom table.
Is the IT starter Status LED lit?
NO
YES
Excess noise/vibration in motor. Table TS-6
Bypass fails to close/chatters. Table TS-7
Consult Table TS-1 "Status LED Off"
Unit will not stop running. Table TS-8
Consult Flowchart #1
Noise from SSRV. Table TS-7
Other symptom not listed. Table TS-9

Table TS – 1
"Status LED Off"

Symptom and Indication	Possible Problem	Possible Solution
No indication on the unit or on the CIM.	Loss of 24-vdc control power	Check control wiring
		Verify 24-vdc power from power supply
		Check power supply fuse/breaker
	Failed CIM	Disconnect the CIM. If the Status LED lights, replace the CIM. If not, the control board may be defective.
	Failed control board	Contact service or parts
No status light, but CIM is powered.	Failed LED indication	Reset the unit, verify operation
		Cycle the 24-vdc power to the unit.

Table TS-2
"Status LED Green"

Symptom and Indication	Possible Problem	Possible Solution
Status LED is green, but no indication on the CIM.	Line power fault	Check wiring connection on load and line side.
		Check line power breakers/fuses
		Verify 24-vdc power is available for terminals P and 1 on the starter.

Table TS-3
"Fault Shown on CIM"

Symptom and indication	Possible Problem	Possible Solution
SS or over temp LED is lit on CIM.	High temperature – see flash codes	Allow unit to cool down with 24-vdc applied to + and -.
		Verify operation of unit cooling fans.
		Clear any restrictions to airflow.
	Possible hardware failure – see flash codes	If code 32 is indicated, check actual motor start time vs. the "Tr" setting. Tr should not be set more than 2 or 3 seconds longer than the actual motor start time.
		Contact technical assistance
PH LOSS LED is lit on the CIM.	One or more line voltages missing or is low.	Verify that proper line voltage is present and that no other equipment was affected.
		Confirm the line power connections are correct and tight.
		Check line power fuses, circuit breakers, and disconnects.
		Press the reset button below the CIM to clear the fault.
	Phase voltages or currents unbalanced	Check same solutions for phase loss.
		Confirm the motor current is acceptably balanced when the line voltage is balanced. If not, investigate system/motor.
		If line voltage is balanced but load voltage is not, check bypass. Contact technical assistance.
		Check load connections at starter and at motor terminal box.
OVLD TRIP LED is lit on the CIM. (Thermal overload trip, the Trane unit controls should trigger before the IT starter).	Motor is overloaded.	Check motor for load problems.
	FLA not set to motor ratings.	The IT starter uses the highest RLA value of "D" for Trane applications.
	Trip class not set properly.	The IT starter uses the highest trip class of "30" for Trane applications.
	Fault exists in memory.	Press the reset button below the CIM to clear the fault. If the fault remains, allow the system to cool and try again.
	Failed current sensor	Contact technical assistance.

Starter Fault Flash Codes sent to the CIM
To obtain the fault flash codes from the CIM, press and hold the reset button (located below the CIM) down or apply 24-vdc to terminal 4. All LEDs on the CIM will flash in a sequence that will define the faults that are present. Count the number of times all the LEDs on the CIM flash.

For example, if you see three flashes, and then two more flashes after a short pause, the flash code is 32.

The CIM can provide multiple flash codes if more than one error condition has caused a stop. Once you see the same flash codes repeated you will have seen all of the flash codes for the error conditions that caused the stop.

For example, if you see three flashes, a pause, then two flashes, a pause, then four flashes, a pause, then one flash, the flash codes are 32 and 41. If you then see three flashes, a pause, then two flashes, you are seeing the first code again. This means you have seen all of the flash codes for this stop. You may release the reset button or remove the 24-vdc from terminal 4.

Table TS-4
"Flash Codes"

Code	Fault	Possible Cause
11	Thermal Overload	See Table TS-3
12	Motor Stall	NA (not used by Trane)
13	Motor Jam	NA (not used by Trane)
14	Phase Sequence ACB	NA (not used by Trane)
15	Pole Over-temperature	See Table TS-3
16	SCR Failed to Fire	Loose connection or defective unit
21	115v Power Supply Low	Weak control power or defective unit
22	Phase Loss	See Table TS-3
23	By-pass Dropout	Weak control power or defective unit
24	SCR Contactor Overcurrent	Load amps excessive
25	Phase Imbalance	See Table TS-3
26	Non-volatile Memory Error	Internal control board fault
31	Zero Voltage Cross Failure	Control power applied out of sequence or PFCCs on motor
32	Shorted SCR, Phase Loss, Load Disconnect	See Table TS-3
33	Serial Communications Lost	Internal control board fault
34	SCR Instantaneous Over-current	Current exceeded start ratings during the starting or stopping mode
41	24-vdc Power Supply Low	Improper 24-vdc supply or weak control power
42	Timer System Fault	Internal control board fault
43	Watchdog Reset Occurred	External electrical noise or internal control board fault
44	PLL (DSP)	Internal control board fault
45	Illegal Address	Internal control board fault

Table TS-5
"Fault Not Shown on CIM"

Symptom Indication	Possible Problem	Possible Solution
Status LED is lit, but no indication on the CIM.	No communication with the CIM.	Verify connection between starter and CIM. Press the reset button on the starter, all LEDs on the CIM should light.
	Sensor Failure.	Cycle the 24-vdc power to the unit. Allow unit to reset.
	Bypass opened during run.	Press the reset button to reset the fault.
		Weak 24-vdc power supply. Verify that the 24- vdc power supply output rating is large enough to close the bypass contacts with a minimum output rating of 250 watts for 0.15 seconds.

Table TS-6
"Excessive Noise and Vibration in Motor"

Symptom indication	Possible Problem	Possible Solution
Motor vibration during start-up.	Load fluctuations.	Check load conditions.
	Misapplication.	Ramp time set too low for application.
		Torque set too low for application.
	Load voltage or current is unbalanced, but line voltage is balanced.	Check line and load connections at the starter, and at the motor terminal box.
	Hardware failure.	Contact technical assistance.
Motor vibration during normal run.	Load fluctuations.	Check load conditions.
		Check motor connections.

Table TS-7
"Noise from Starter - Bypass Fails to Close/Chatters"

Symptom Indication	Possible Problem	Possible Solution
Audible noise from IT starter.	Bypass contact chatter.	Check 24-vdc control power to IT starter.
		Verify 24-vdc power supply meets power inrush requirements of 250 watts for 0.15 seconds.
	Loose connections.	Remove power from unit, check all connections.
	Loose mountings.	Remove power from unit, check all mounting hardware.

Table TS-8
"Unit Will Not Stop"

Symptom Indication	Possible Problem	Possible Solution
Motor will not shut off.	Control wiring is incorrect.	Verify 24-vdc is removed from the P terminal when stop is desired.
		Verify no stray strands of 24-vdc power are connected to the P terminal.
	Bypass fails to open.	Open disconnect. Remove all power from unit and check continuity of poles.
	Shorted SCR.	Open disconnect. Remove all power from unit and check continuity of poles.

Table TS-9

Symptom Indication	Possible Problem	Possible Solution
Motor short circuited.	Winding fault.	Identify and correct motor fault.
		Verify all power connections are secure.
		Verify no shorts exist in cabling or motor terminal box.
Motor starts too slowly.	Incorrect setting.	Increase torque or current limit setting.
		Decrease ramp time.
Motor starts too quickly.	Incorrect setting.	Increase ramp time.
		Decrease torque or current limit setting.

Removing the Controller Interface Module (CIM):
Note that the IT starter, with the CIM attached, is installed up side down in the Trane starter panel.

1. To remove the CIM, release the catch lever located in the cover just below the center of the CIM. Move the latch away from the CIM.
2. Disconnect the communication cable from the bottom of the CIM assembly by pressing the lever to unlatch the communication plug.
3. Re-install the CIM in the reverse sequence.
   Note: The edge of the CIM opposite of the latch must be inserted into the cover first, prior to snapping the CIM into the latch.

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