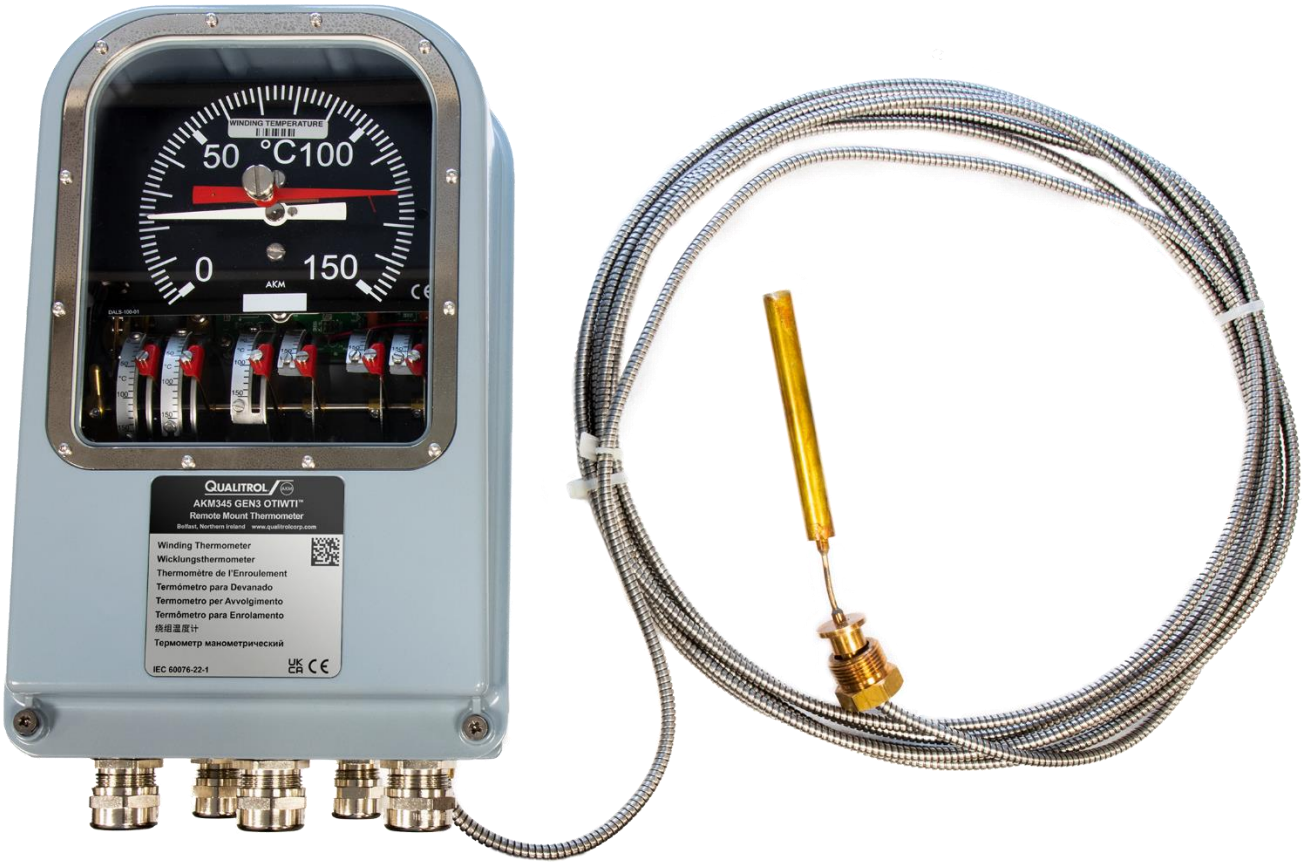
QUALITROL AKM345 GEN3 OTIWTI™

OTIWTI™ AKM Type 34 Oil Temperature Indicator

OTIWTI™ AKM Type 35 Winding Temperature Indicator

Document ID: 40-08847-00-Rev001



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About Qualitrol®

QUALITROL® manufactures substation and transformer monitoring and protection devices used by electric utilities and OEM manufacturing companies. It is the global leader in sales and installations of transformer asset protection equipment, fault recorders, and fault locators. Established in 1945, QUALITROL® produces different types of products on demand, customized to meet unique requirements.

Table of Contents

1. List of Abbreviations/Acronyms

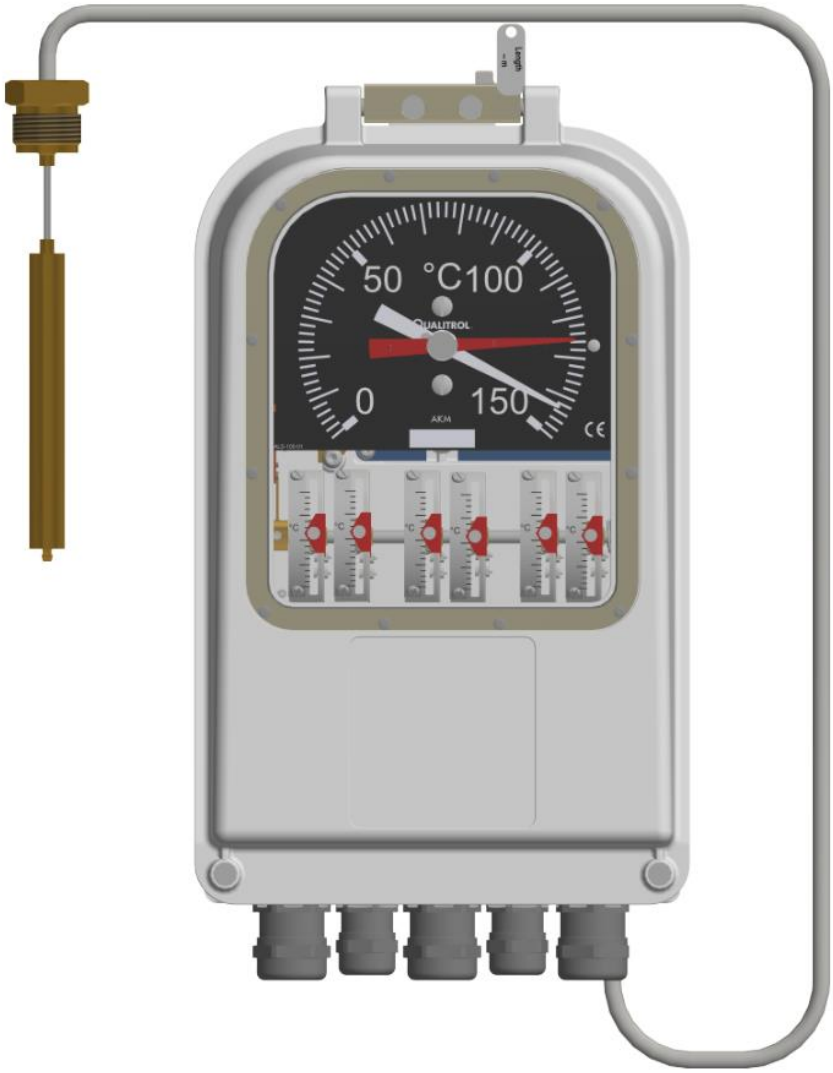
Abbreviation/Acronym	Expansion
AKM345	Qualitrol Product Family of Oil and Winding Temperature Indicators
GEN3	Third Generation Product
OTI	Oil Temperature Indicator
WTI	Winding Temperature Indicator
MBO	Magnetic Blow-Out Contact
WHS	Winding Hottest Spot
OTIWTI	Qualitrol Trademarked Oil and Winding Temperature Indicators

2. Introduction

2.1 QUALITROL AKM345 GEN3 OTIWTI™

The Qualitrol AKM345 GEN3 OTIWTI™ is the future of oil and winding temperature indication for transformers of all classes. The GEN3 is a world class, robust, feature packed temperature indicator designed and manufactured for long and trouble-free operation in all conditions.

The AKM345 GEN3 OTIWTI™ is a remote mount, bellows style, temperature indicator used on transformers for indicating Oil Temperature (OTI) or Winding Temperature (WTI). The AKM345 is used for activating cooling equipment, alarming on temperature, and electronically transmitting temperature readings.



2.2 Operation

The AKM345 operates using a bellows type technology. A temperature probe is installed in a pocket/well located in the transformer wall or cover. The probe is connected to a sealed system capillary filled with oil that is then connected to the bellows system in the enclosure of the unit. As the temperature of the oil in the probe increases, the oil expands also expanding the bellows and as a result driving the dial of the unit along with switches and remote outputs.

On WTI units, the load current from the bushing CT can be brought directly into the enclosure of the AKM345 to be used for simulating winding temperature. Winding temperature is simulated from a heater located in the bellows of the unit providing accurate and reliable gradient indication.

The switches can be used for cooling control and alarming. The remote outputs can be used to transfer data to a local or remote monitoring system.

2.3 Calibration Check

Each AKM345 instrument is factory calibrated and no further calibration is required.

If the calibration of the AKM345 needs to be verified, please follow the below procedure:

- Place the probe in bath of boiling water (100°C) or a calibrated oil bath set to 100°C
  - note, the minimum volume of water or oil should be 5 liters!
- Stir the contents of the oil/water bath to ensure even temperature distribution and check that the temperature of the bath is 100°C (check with a calibrated thermometer)
- Read the temperature on the device thermometer after 15 minutes
  If the difference between the temperature indicated by the AKM345 unit and the temperature of the bath is greater than 5°C we recommend contacting Qualitrol for further assistance

2.4 Winding Simulation

The AKM345 GEN3 OTIWTI™ has a method to simulate the temperature of a winding by indirect measurement called thermal image. This is a frequently used simulation method that senses top oil temperature and biases the thermometer reading proportional to transformer load to indicate winding temperature.

On WTI units, the load current from the bushing CT can be brought directly into the enclosure of the AKM345 to be used for this method of simulating winding temperature. Winding temperature is simulated from a heater located in the bellows of the unit providing accurate and reliable gradient indication.

On the AKM345 a matching resistance is used to adjust the current needed by the heating element to provide the required winding hottest spot (WHS) temperature gradient delivering a parallel path to divert part of the total current. There are 3 internal matching resistance models (TD50, TD76, and TD50/5) and 2 external matching resistance models (AKM 44674 and AKM 44678).

2.5 Switches

The AKM345 GEN3 OTIWTI™ can be equipped with 2, 4, or 6 Form C contact switches. These switches can be used for alarming and control of cooling equipment.

Each switch is independently adjustable across the dial range. Switching accuracy is ±3% of the dial range.

As an option, the switches can be specified for high DC current applications or with gold contacts for intrinsic environments.

More information is available in section 6 of this manual.

2.6 Remote Output

The AKM345 GEN3 OTIWTI™ can be equipped with various remote outputs for connecting to a SCADA or monitoring system.

Powered outputs include a 4-20mA, 2 x 4-20mA, or 4-20mA & 0-5VDC, outputs. These outputs are scaled evenly across the specified dial range.

An additional non-powered output is available as a Pt100 resistance signal. The Pt100 signal will correspond to the temperature as per the Pt100 resistance curve.

More information is available in section 5.3.5 and wiring recommendations are available in section 8.

2.7 MODBUS

The AKM345 GEN3 OTIWTI™ can be specified to include RS-485 Modbus communication.

Modbus communication can only be specified with a powered remote output.

Further information is available in section 8 of this manual.

3. Specifications

3.1 Environmental

Storage Temperature	-50°C to 80°C
Ambient Operating Temperature	-40°C to 70°C; Optional for -60°C
Enclosure protection	IP66
General Requirements	Per IEC 60076-22-1, section 7.8
Overvoltage category, Pollution degree, Class	Category III, Pollution degree 2, Insulation Class 1

3.2 Electrical

Dielectric Isolation- SWITCHES	2000Vac to Ground for 60 seconds
Standard Switch Rating (<250V ac)	15A; resistive or <7ms inductive
Standard Switch Rating (125V dc)	0.75A resistive/ 0.4A <7ms inductive
Standard Switch Rating (250V dc)	0.3A resistive/ 0.2A <7ms inductive
MBO Switch Rating (125V ac/dc)	10A resistive/ 6A <7ms inductive
MBO Switch Rating (250V ac/dc)	3A resistive/ 1.5A <7ms inductive
Gold (dry circuit) Switch Rating (125V dc)	0.1A resistive
Switch terminal wire size; torque	1.5 to 4mm sq; 0.8 N-m (6-8 in-lbf)

3.3 Mechanical

Dial and switch accuracy	For T > 0 deg: +/- 2% of Full-Scale Range
Seismic; switch stability	Per IEC 60068-3-3; Level II
Vibration; switch stability	Per IEC 60721-3-4; Class 4M4
Shock; switch stability	Per IEC 60721-3-4; Vertical axis, Type 1

3.4 SCADA

4 - 20 mA output signal	Maximum 500 Ohms load
0 – 5 V output signal	Minimum 10k Ohm load
24 Volt Power Consumption	Maximum current < 0.25 Amp.
Dielectric Isolation: 4-20mA, 0-5V, PT100, Modbus port	500 Vac to Ground for 60 seconds
Optional Power Supply: Voltage / frequency; rated	100 – 240 Vac 50/60 Hz, or 125 – 250 Vdc
Optional Power Supply: Voltage operating range	Per EN 60255-1; 80 to 110% of rated
Optional Power Supply: Dielectric Isolation-MAINS port	2000 Vac to Ground for 60 seconds
Optional Power Supply: fusing	Internal 5 x 20 mm; T2A; 250V
Optional Power Supply; environmental	IP20
EMC immunity	Per EN 61000-6-5; Substation category, interface 4 Per IEEE C37.90.1,2,3
EMC emissions	Per EN55011; Class A
Terminal wiring: SCADA	0.5 – 1.5mm sq (16-20 AWG)

4. Safety

4.1 General Warnings

⚠ Operation outside of the intended use shall not be the responsibility of Qualitrol.

⚠ Refer to the installation manual for mounting details, and adjustment of the switches.

⚠ DO NOT APPLY HEAT TO THE THERMOMETER SENSOR BULB AT TEMPERATURES WHICH EXCEED THE MAXIMUM RANGE OF THE DIAL.

4.2 Capillary Routing

The capillary tube used on the AKM345 GEN3 is made from a soft copper to allow easy routing of the capillary. If the capillary is kinked or crushed, the unit will be damaged.

To prevent kinking the capillary we recommend a minimum bend radius of 38mm [1.5”].

4.3 Switch Wiring

Warning

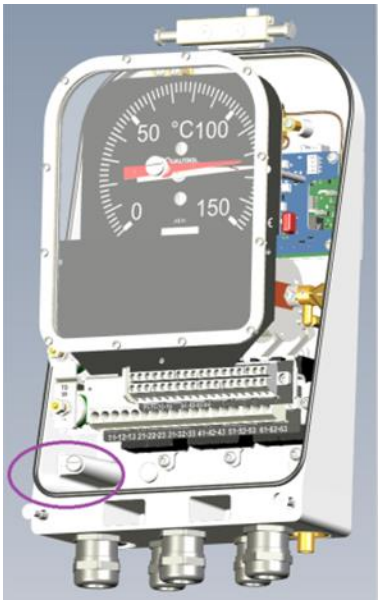
Cabling or wires to the terminal strip must be rated to at least 80°C. For installations that are switching voltages higher than 24V, the AKM345 GEN3 must be grounded to the transformer or control cabinet using 1.5mm^2-4mm^2 copper wire (16AWG-10AWG), with a ring terminal, and 5mm screw to the grounding spot provided.

Bonding must be made before and whenever the unit is energized.

4.4 Electrical Connection

Warning

- Make sure to ground the unit according to local regulations.
- Remote output signal connections must be made with shielded cabling.
- All user supplied wiring shall be rated at 80°C or higher.
- Do not disconnect protective grounding while unit is energized.
- Do not exceed 250V above ground for any switch or mains connection.



Grounding Terminal

4.5 Power Connection

- Mains GROUND wiring to housing is shown as above in **Grounding Terminal** figure above, “Neutral” may be above ground potential.
- User shall supply a 5 or 10A double pole (or double fuse) time delay overcurrent protector at the MAINS source.

4.6 4-20 mA Current Loop

- The 4-20mA current loop is scaled across the dial range.
- Attach the shield wire ONLY at the left/bottom printed circuit hold down screw using a ring or fork terminal. Single point shield attach/grounding shall be made.

4.7 0-5 Volt Signal

- The 0-5 V dc output is scaled across the dial range.

5. Installation

- Before installation check for possible damage from transport or handling.
- Do not carry the instrument by the capillary. Do not twist the capillary when unwinding it or bend too sharply. The minimum bend radius is 38mm [1.5”].
- Clamp it along its entire length at approximately 400 mm intervals. Excess capillary can be wound in a spiral with min diameter 100 mm.
- For oil filled wells/pockets, be sure to leave 15% excess volume after probe is inserted for thermal expansion.
- The non-vibration mountings included must be used to prevent mechanical wear caused by transformer vibrations.

5.1 Mounting the AKM345

5.1.1 Mounting the Enclosure

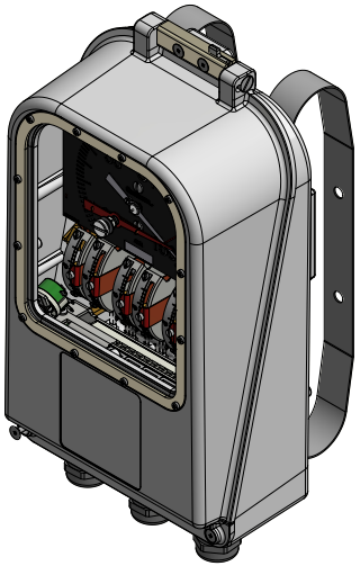
The enclosure of the AKM345 GEN3 can be specified with a standard mount, universal mount, or seismic mount.

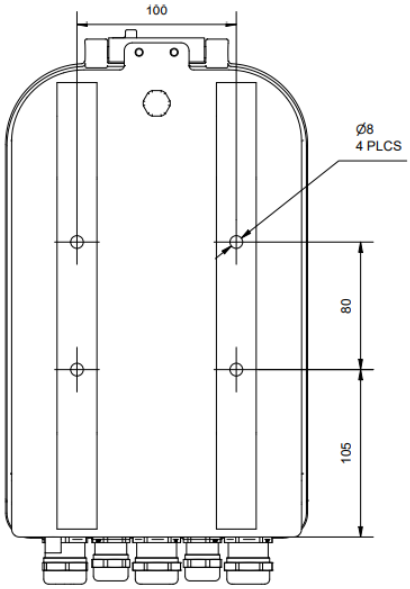
- For the standard and seismic mounts, mount the unit using all 4 of the holes given on the mounting brackets.
- For the universal mount, use at least 4 of the mounting holes given.

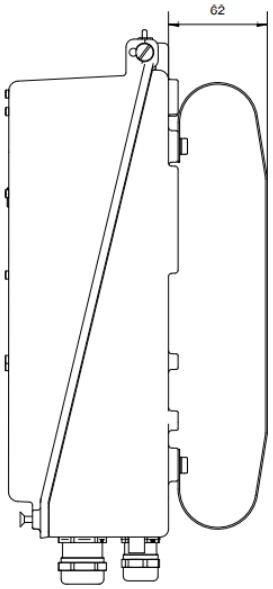
Do not modify the mounts in any way.

5.1.1.1 Mounting Styles and Dimensions

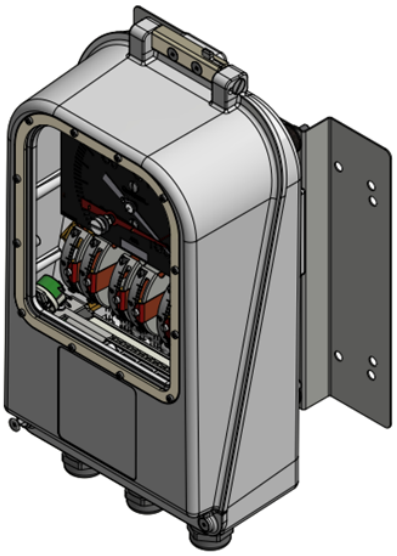
5.1.1.1.1 Standard Mount

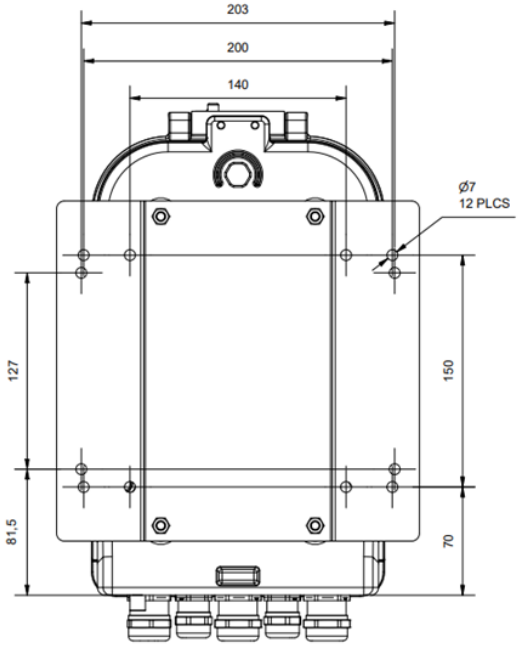


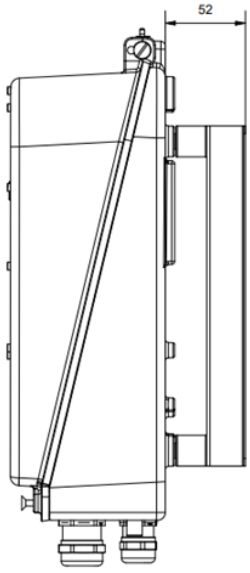




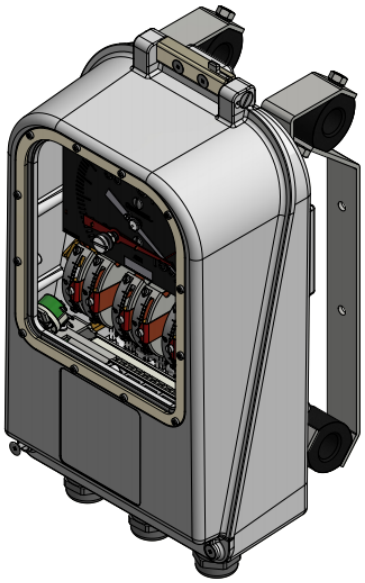
5.1.1.1.2 Universal Mount

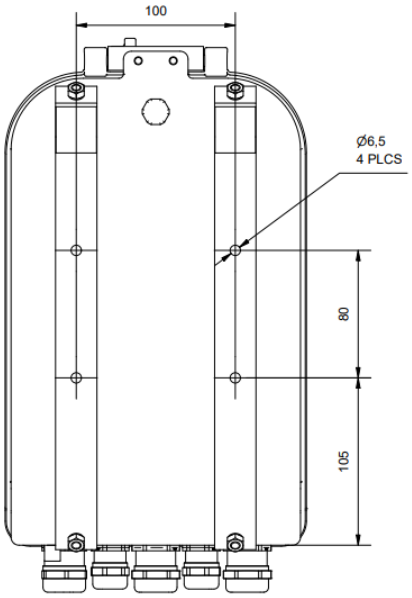


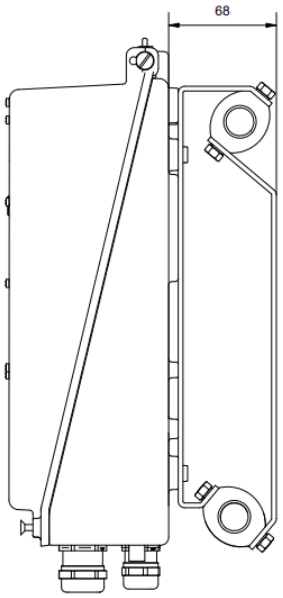




5.1.1.1.3 Seismic Mount







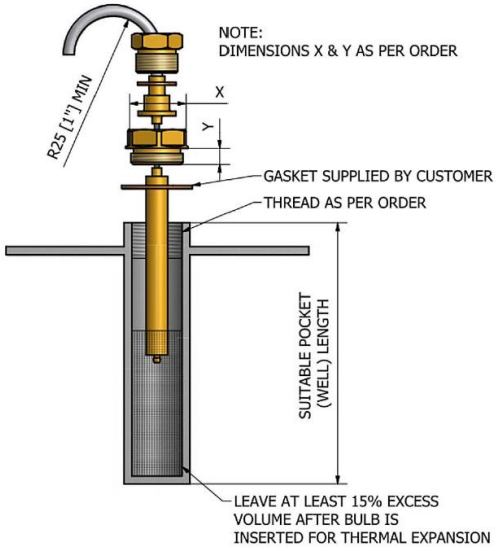
5.1.2 Installing the Probe

5.1.2.1 Pocket/Well Installation

The AKM345 GEN3 probe is designed to be installed in a pocket/well.

The pocket/well can be of dry-type or oil-filled.

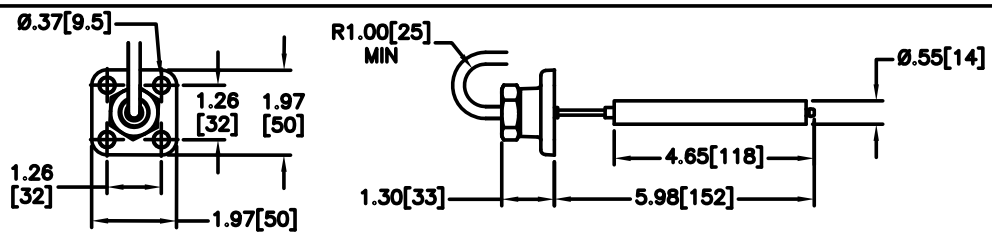
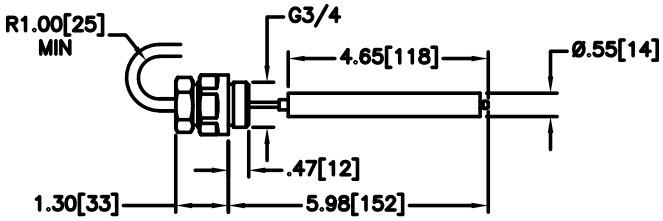
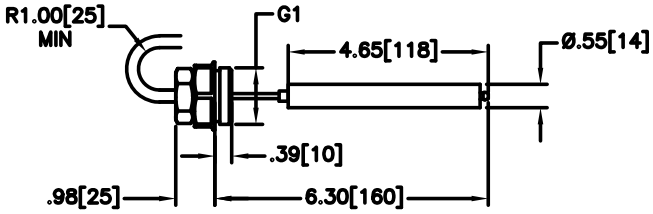
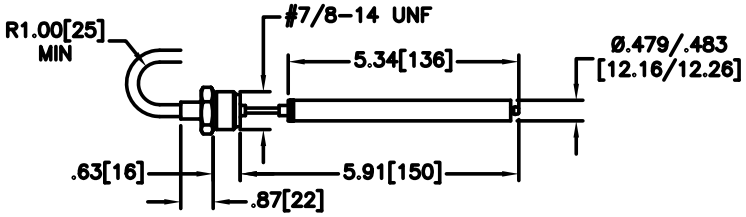
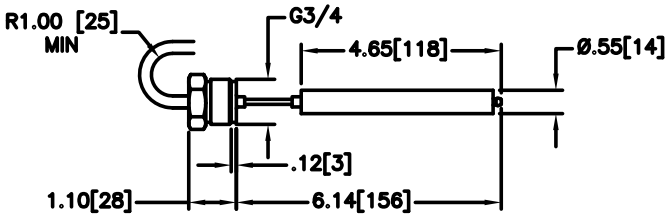
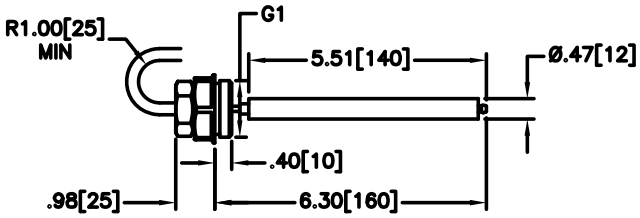
NOTE: If using an oil filled well, be sure to leave 15% excess volume after probe is inserted for thermal expansion. Failure to do so can result in damage to the probe or pocket/well.



Probe Installation Example

5.1.2.2 Probe Types

PROBE TYPES

11	
12	
15	
16	
18	
19	

5.2 Front Cover

The AKM345 GEN3 features a new cover design that allows for the cover to be propped open or removed for ease of access and installation.

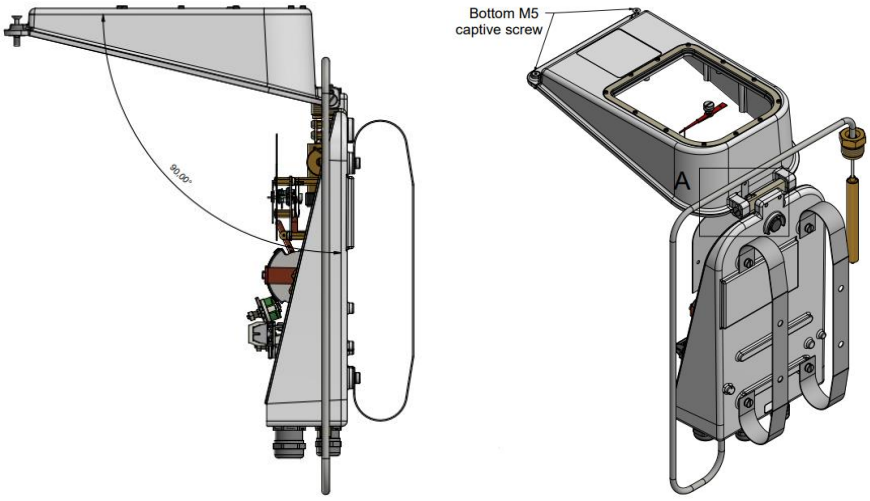
The cover should not need to be removed unless the unit is being mounted in a cabinet or under a rain/sun shield.

5.2.1 Opening and propping

Perform the following steps to open and prop open the front cover:

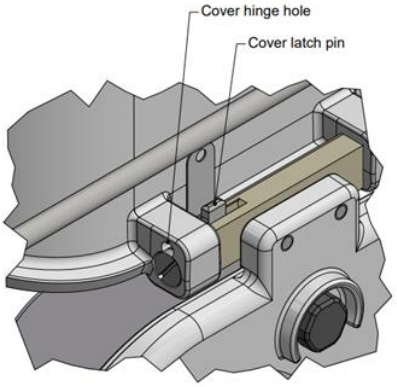
Step 1) Loosen the two bottom M5 captive screws to release the lid from the enclosure base. DO NOT remove the screws from the lid.

Step 2) Open the lid to the 90° position.



AKM345 GEN3 with Cover Open

Step 3) Slide the cover latch pin into the cover hinge hole to secure it in the open position.



AKM345 GEN3 Hinge

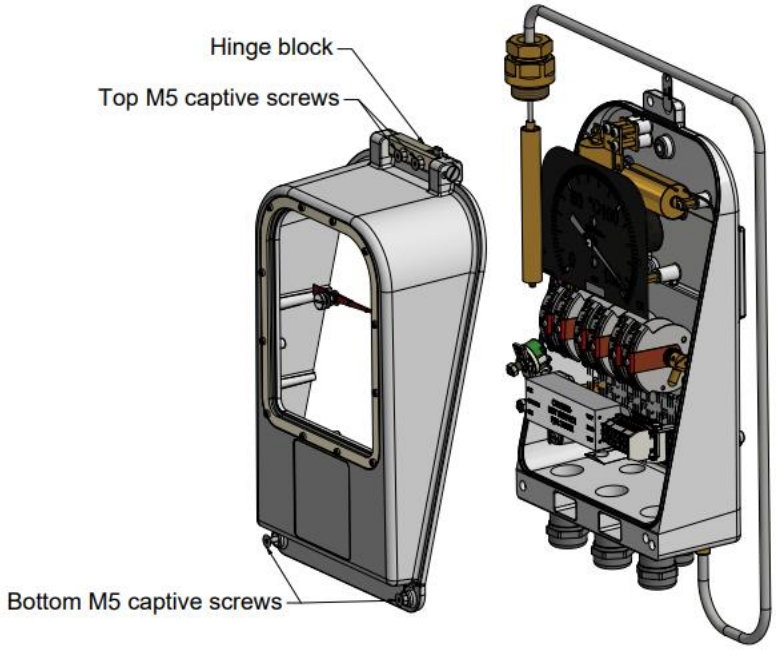
5.2.2 Cover Removal

To remove the front cover, perform the following instructions:

Step 1) Loosen two of the top M5 captive screws. DO NOT remove screws from hinge.

Step 2) While holding the lid, loosen two of the bottom M5 captive screws to release the lid from the enclosure base. Again, DO NOT remove screws from the lid.

Step 3) Lid assembly can now be fully removed.



AKM345 GEN3 with Cover Removed

5.3 Electrical Connection

5.3.1 Cable Glands

The unit can be specified to come equipped with cable glands as required, with all cable glands fitted, or with blanking plugs instead of cable glands.

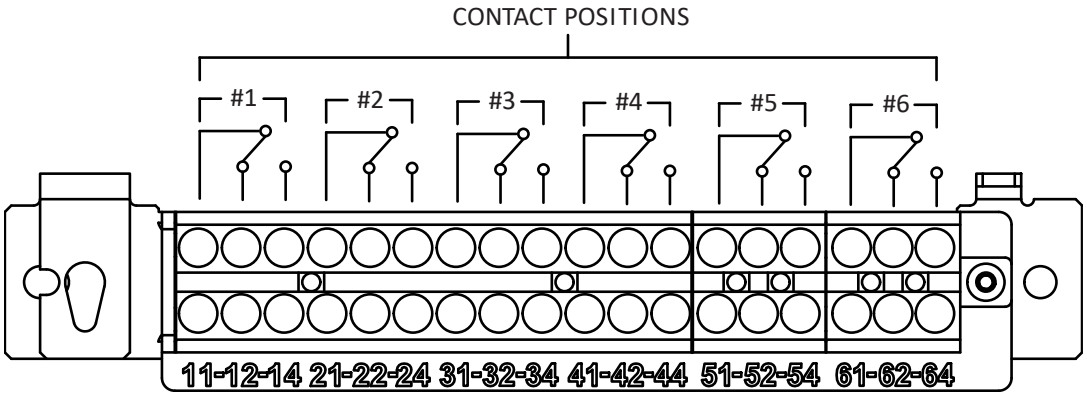
When specified with cable glands as required, the unit will be provided with M20 and M25 cable glands as needed for the other features specified. i.e., # of switches, remote outputs, etc. and blanking plugs in unused positions.

When specified with all cable glands fitted, the unit will be provided with 2 x M20 glands and 3 x M25 glands.

5.3.2 Switches

Wiring the switches on the AKM345 GEN3 is as follows:

- The first digit of each terminal number designates the switch number.
- The second digit of each terminal number designates the contact position.
    - 1 = common
    - 2 = normally closed
    - 4 = normally open



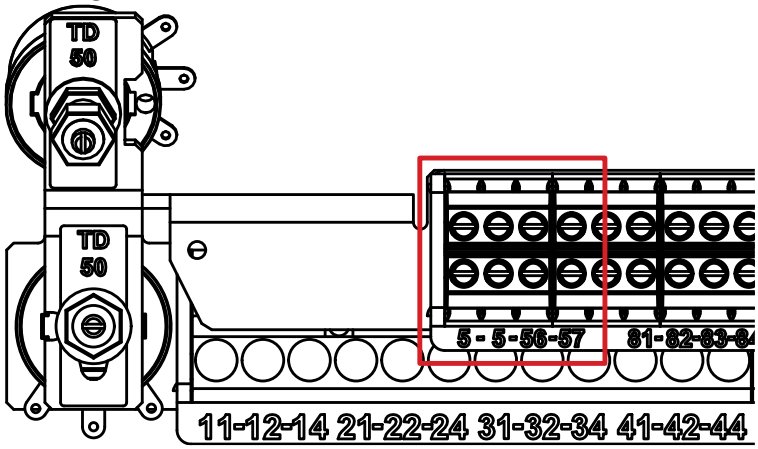
Switch Wiring Example

5.3.3 Matching Resistance

To utilize the internal matching resistance of the AKM345 GEN3, you must connect your bushing CT directly to the unit.

The CT input for the AKM345 GEN3 is designated on the terminal blocks as follows:

- 5-5 = primary matching resistance (applicable to TD50, TD76, and TD50(5A))
- 56-57 = secondary matching resistance (applicable to TD50(X2) and TD76(X2))
- **NOTE:** terminal block arrangement may differ depending on other options selected, but terminal designation will remain the same



Matching Resistance Wiring Example

5.3.4 Power

In some configurations, the AKM345 GEN3 will require a power input for the remote indication or Modbus communication.

The power inputs will be identified with a “+” and “-“ for positive and negative respectively.

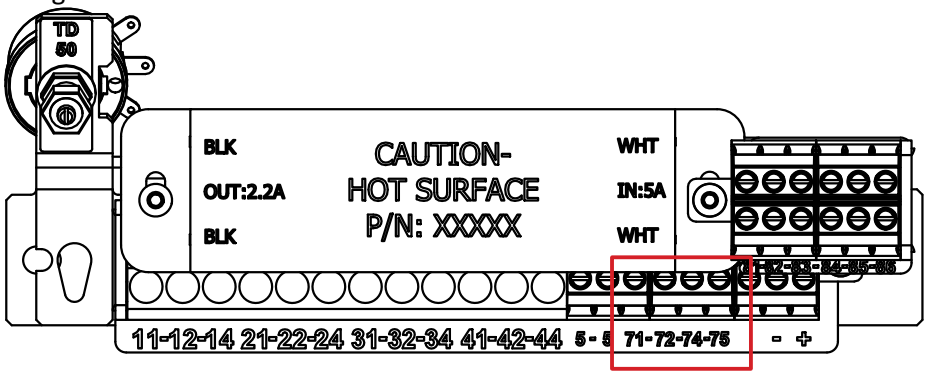
The input power requirement is 24VDC.

5.3.5 Remote Output

The AKM345 GEN3 can be equipped with powered outputs: 4-20mA, 2 x 4-20mA, or 4-20mA & 0-5VDC. These outputs are scaled evenly across the specified dial range.

The wiring for these remote outputs is designated as follows:

- 71 = Output Return
- 72 = Output 1
- 73 = Not Used
- 74 = Output 2
- 75 = Output Screen
- **NOTE:** terminal block arrangement may differ depending on other options selected, but terminal designation will remain the same

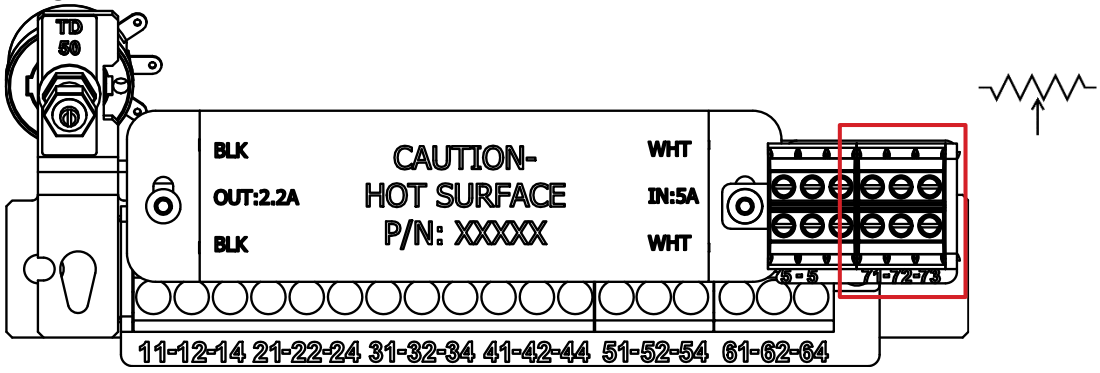


Powered Remote Output Wiring Example

An additional non-powered output is available as a Pt100 resistance signal. The Pt100 signal will correspond to the temperature as per the Pt100 resistance curve.

The wiring for the Pt100 output is designated as follows:

- 71 = R2
- 72 = R1
- 73 = R3
- **NOTE:** terminal block arrangement may differ depending on other options selected, but terminal designation will remain the same



Pt100 Output Wiring Example

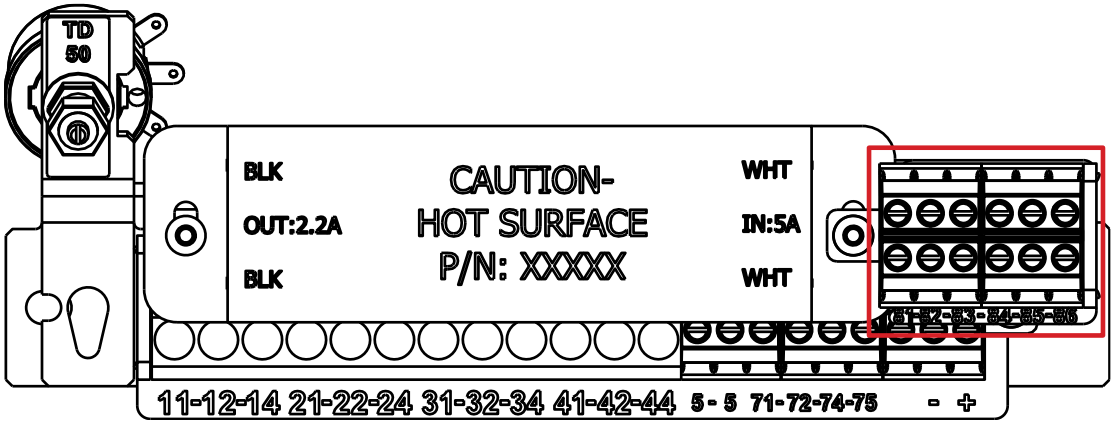
5.3.6 Modbus

The AKM345 GEN3 can be specified to include RS-485 Modbus communication.

Modbus communication can only be specified with a powered remote output. Further information is available in section 9 of this manual.

The wiring for the RS-485 Modbus is designated as follows:

- 81 = RxTx Ground
- 82 = TX+
- 83 = TX-
- 84 = RX+
- 85 = RX-
- 86 = RxTx Screen
- **NOTE:** terminal block arrangement may differ depending on other options selected, but terminal designation will remain the same



RS-485 Modbus Wiring Example

6. Switch Setting

The AKM345 GEN3 can be equipped with 2, 4, or 6 Form C contact switches. These switches can be used for alarming and control of cooling equipment.

Each switch is independently adjustable across the dial range. Switching accuracy is ±3% of the dial range. Switches are calibrated at the factory.

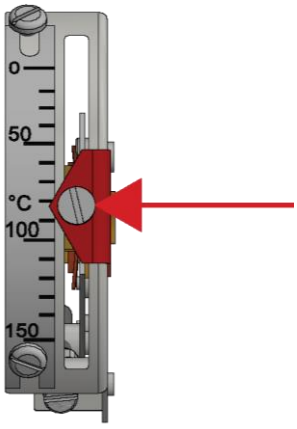
As an option, the switches can be specified for high DC current applications or with gold contacts for intrinsic environments.

Qualitrol does not recommend setting more than 2 switches at the same setpoint, as this can reduce device accuracy.

6.1 Switch Setpoint Adjustment

The procedure for adjusting each switch setpoint is as follows:

Step 1) Open the unit as noted in section 5.2.1
Step 2) Loosen the screw on the red pointer.



Switch Adjustment Locking Screw

Step 3) Hold the screw in position and rotate the scale drum until the red pointer indicates the desired contact point on the scale.
Step 4) Tighten the screw in this position.
Step 5) Check that contact is obtained by pulling downward on the tab to the right side of the switch stack so that the pointer of the temperature gauge moves towards the higher values on the scale. The tab shall never be pushed upward, this can cause the unit to be out of calibration. When checking the instrument, it must be placed in a vertical position.

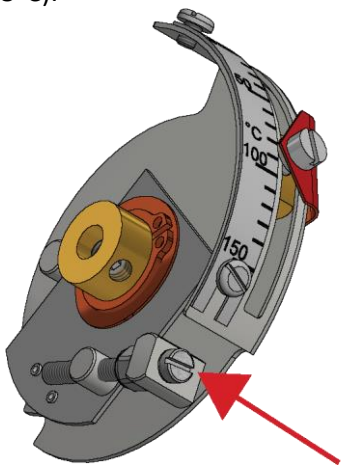
6.2 Adjustable Differential (option)

An option on the AKM345 GEN3 is to have adjustable switching differentials.

The procedure for adjusting the switching differential is as follows:

Step 1) Adjust the alarm set point as described above.

Step 2) Adjust the multi-turn adjusting screw located beneath the switch scale plate fully clockwise. At this point the differential will be set at 5°C. (When turned fully counterclockwise the differential is set at 25°C).



Step 3) Pull down the test lever (located on the right-hand side of the switch stack) slowly to verify correct alarm and differential setting. For example, if the alarm is set at 50°C and the adjusting screw is set fully anti-clockwise, the switch will energize at 50°C on rising temperature. It will de-energize on lowering temperature at 25°C.

⚠ **NOTE:** never force the test lever upwards

Step 4) Fine-tune the differential setting by gradually turning the adjusting screw.

7. Winding Temperature Simulation

The AKM345 GEN3 contains a method to simulate the temperature of a winding by indirect measurement referred to as thermal image. This is a frequently used simulation method that measures top oil temperature and biases the winding temperature indicator reading proportional to transformer load to indicate winding temperature.

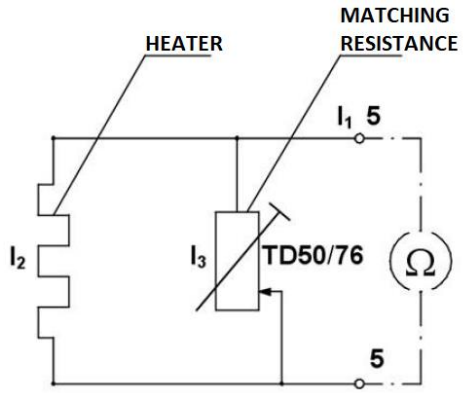
The AKM345 uses this method by utilizing the probe to measure top oil temperature, an internal heating element to provide the winding temperature bias, a matching resistance to adjust the current supplied to the heating element, and the current proportional to transformer load provided by the bushing current transformer (CT).

The matching resistance is used to adjust the current needed by the heating element to provide the required winding temperature gradient delivering a parallel path to divert part of the total current. There are 3 internal matching resistance models (TD50, TD76, and TD50/5) and 2 external matching resistance models (AKM 44674 and AKM 44678).

Internal Matching Resistance TD50, TD76, and TD50/5 Technical Data

	TD50	TD76	TD50/5 Amp
Max Cont. Input at 100% Load	2.2 A from CT	2.65 A from CT	5.0 A from CT
Adj. Range	0 - 80% of Input Current from CT	45 - 85% of Input Current from CT	0 - 35% of Input Current from CT
Insulation	2kV, 50Hz, 60s to Earth	2kV, 50Hz, 60s to Earth	2kV, 50Hz, 60s to Earth
I_3 Resistance	0 - 11Ω	1.75 - 13Ω	0 - 11Ω

AKM345 TD Adjusting Schematic



7.1 Adjusting the Internal Matching Resistance – TD50 & TD76

The procedure for adjusting the TD50 or TD76 internal matching resistance is as follows:

Step 1) Check or calculate the secondary current (I_s) in Amps from your bushing current transformer (BCT) at 100 % transformer load.

Step 2) Check the required winding hottest spot temperature gradient in °C.

a. **NOTE:** this should be available from the transformer manufacturer

Step 3) Use the below **Temperature Gradient Adjustment Graph** to determine the required parallel resistance of the heating element and the matching resistance TD50 or TD76 setting in Ohms using the CT current and temperature gradient as inputs to the graph. Take note of this value.

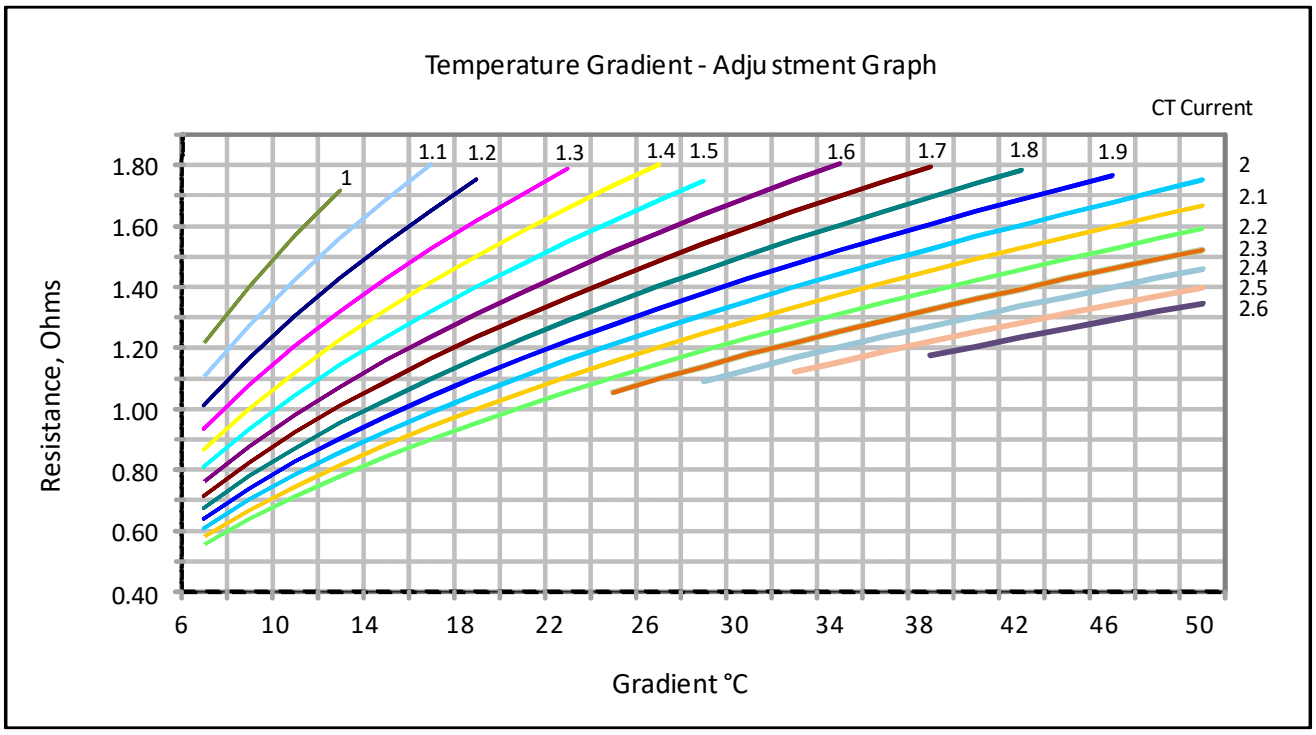
Step 4) Connect a multi meter, set to measure resistance, to terminals 5-5 inside the Winding Temperature Indicator (WTI)

Step 5) Loosen the lock nut on the TD50 or TD76 potentiometer and adjust the matching resistance until you reach the required resistance value

Step 6) Secure the lock nut on the matching resistance for this setting

Step 7) Check operation and make final adjustments if necessary

a. To check operation, keep cover fitted on the device and feed a constant and stable current to terminals 5-5 and wait 45 minutes before reading the winding temperature gradient.



For example, with CT current of 1.9 A and temperature gradient requirement of 30°C, resistance = 1.4 Ohm.

7.2 Using the Internal 5 Amp CT Option – TD50(5AMP)

7.2.1 Background

The AKM345 GEN3 TD50(5AMP) option allows for the input of up to 5 Amp winding temperature simulation current without the expense or additional wiring required by an external matching unit. It is available with up to 6 switches with some limitations on additional features. The 5 Amp option employs an internal CT which accepts 5 Amps at the primary and outputs 2.2 Amps at the secondary. The secondary current is in parallel with a standard TD50 matching resistance and heater. For temperature rise calculations please refer to the **Temperature Gradient Adjustment Graph** in section 7.1.

- Accuracy of 2.2A output at 5A input:
  - ±5% at 0 - 1.6Ω secondary load
  - ±10% at 1.6 - 1.8Ω secondary load
- Max continuous primary current: 6A
- Max primary current: 10A for 2 minutes

7.2.2 Setting the Matching Resistance

There are two methods of setting the matching resistance depending on the accuracy required. Use Method A for maximum ease of use and Method B for maximum accuracy.

7.2.2.1 Method A

Step 1) Calculate the Is in Amps from your BCT at 100 % transformer load. Use the Is from the BCT as an input to the internal CT in the OTIWTI™ AKM345 and calculate the output current using a ratio of 5 to 2.2 A
- Output current = Is (2.2/5)A

Step 2) Disconnect the white separable connector and using an ohmmeter at the "R" pins. Adjust the matching resistance to meet the target R5-5 value which will provide the desired heater current according to section 7.1 instructions using as an input the output current calculated above.

Step 3) Re-connect the white separable connector. After the matching resistance has been set and the white connector is re-mated, the winding simulation input current is wired to the terminal block at the 5-5 positions as shown in the **TD50(5AMP) Wiring Example** below.

7.2.2.2 Method B

Step 1) Calculate the Is in Amps from your BCT at 100 % transformer load. Use the Is from the BCT as an input to the internal CT in the OTIWTI™ AKM345 and calculate the output current using a ratio of 5A to 2.2A
a. Output current = Is (2.2/5)A

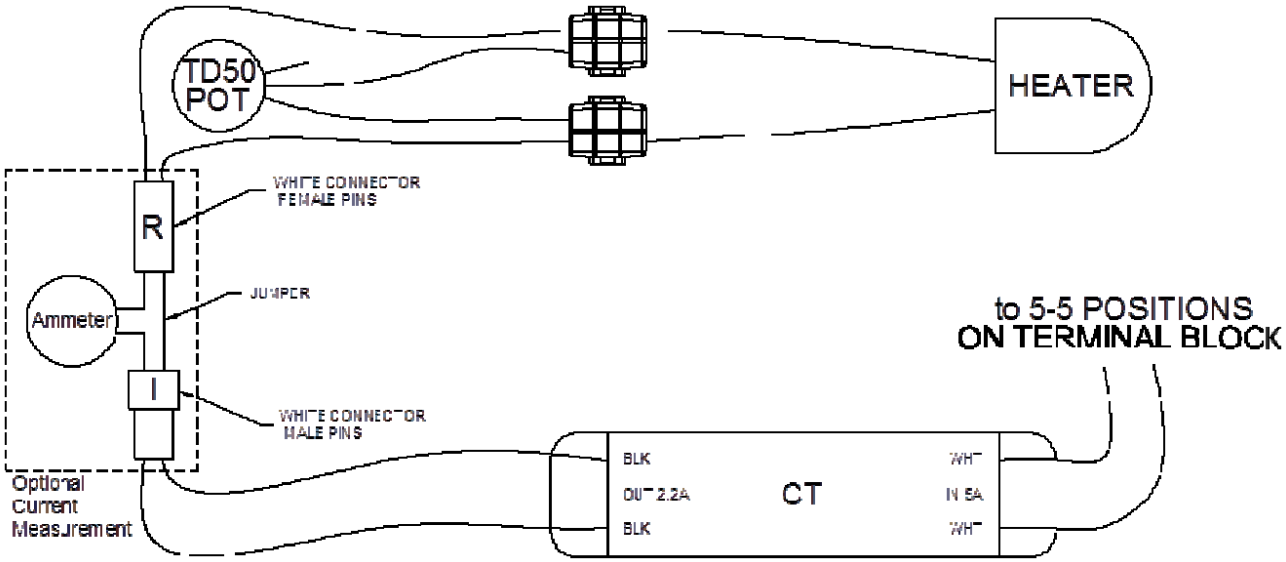
Step 2) Disconnect the white separable connector and using an ohmmeter at the “R” pins adjust (as above in 7.2.2.1 Step 2) the matching resistance to meet the target R5-5 value which will provide the desired heater current according to section 7.1 instructions using as an input the output current calculated above.

Step 3) Jumper between one pin of the "R" connector and one pin of the “I” connector, and connect an ammeter between the remaining two pins, as shown.

Step 4) Input the desired primary current at positions 5-5 on the terminal block and note the current flowing in the circuit. You now have the exact internal CT ratio of input to output current at secondary load. Disconnect the power before disconnecting the ammeter and jumper – the secondary leads must always be connected in-circuit or shorted when the CT is powered.

Step 5) Using the measured secondary current, re-calculate the desired R5-5 value which will provide the exact heater current necessary for the desired winding simulation. Using an ohmmeter at the “R” pins, adjust the matching resistance to meet this R5-5 value.

Step 6) Re-connect the white separable connector. After the matching resistance has been set and the white connector is re-mated, the winding simulation input current is wired to the terminal block at the 5-5 positions as shown in the **TD50(5AMP) Wiring Example** below.



TD50(5AMP) Wiring Example

7.3 Dual Gradient (option) – TD50(X2) & TD76(X2)

7.3.1 Background

The AKM345 GEN3 dual gradient option allows for setting two separate winding simulations in the same Winding Temperature Indicator (WTI).

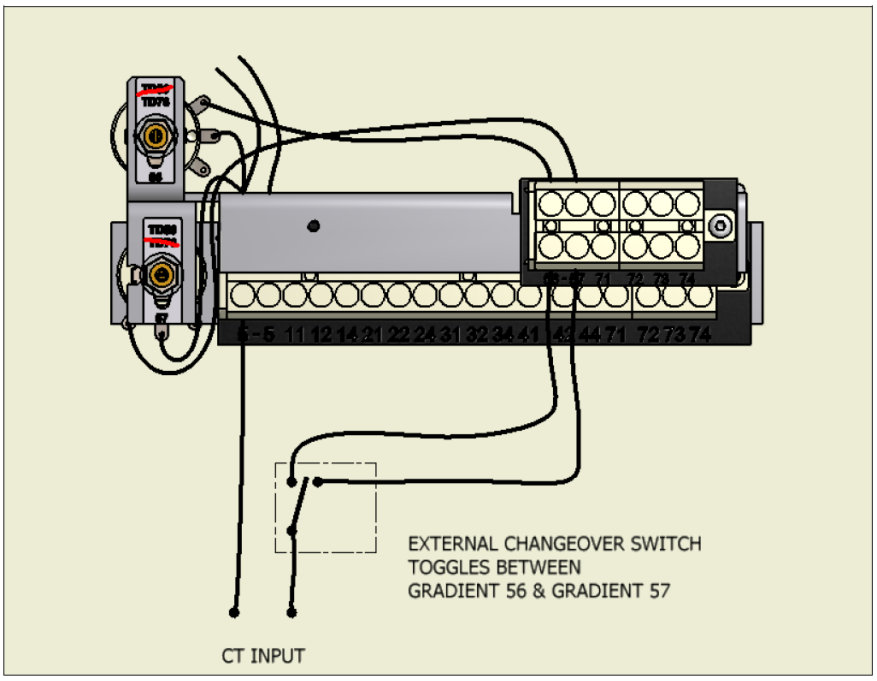
The CT input is provided with two independently adjustable potentiometers for determining the heater current. Switching between the heater currents is performed externally from the WTI.

7.3.2 Wiring Recommendations

The potentiometers are wired to the 56 and 57 terminal block positions. The CT input is wired to the 5-5 positions as shown.

- To activate the 56 gradient, place a jumper between the right 5-5 and 56 terminal block position.
- To activate the 57 gradient, place a jumper between the right 5-5 and 57 terminal block position.

An example of external switch wiring is shown below in **Guideline for Wiring Dual Gradient Option**.



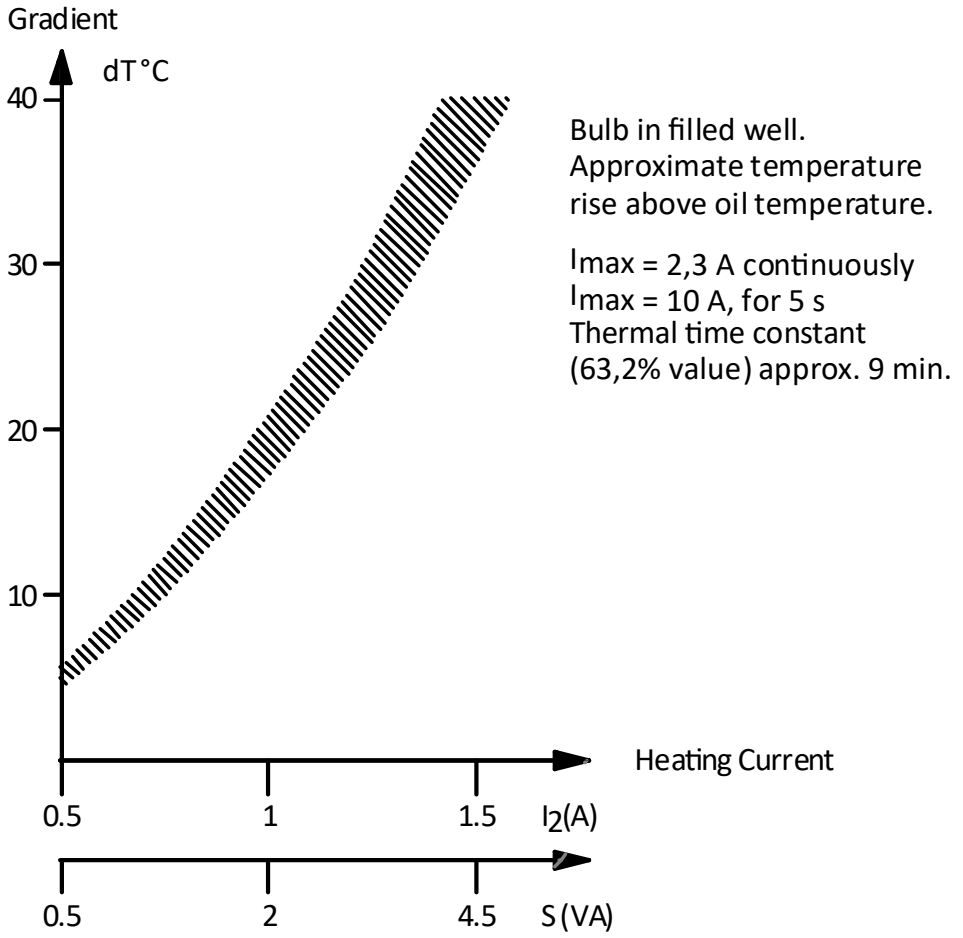
Guideline for Wiring Dual Gradient Option

7.4 External Matching Units

When an internal matching resistance is not specified, there is the option to use a 1A or 5A external matching resistance unit depending on the magnitude of the current from the bushing current transformer.

The 1A or 5A external matching resistance current output is connected to terminals 5-5 on the AKM345 GEN3.

Use the below **Guideline for Adjustment of Heating Current with External Matching Unit** to determine the magnitude of the current required by the heating element to provide the required winding temperature gradient in °C.



Oil temp. 30°C	Gradient °C for bulb type 11, 12, 15 and 18										
	10	12	14	16	18	20	22	24	26	28	30
	0.72	0.79	0.86	0.92	0.99	1.04	1.1	1.15	1.21	1.26	1.31
	Heating Current Amp. I2 ±5%										

8. MODBUS Communications (option)

The AKM345 GEN3 has an option to include RS-485 Modbus communication. This section describes how to implement and utilize the functions of the MODBUS protocol.

8.1 MODBUS Default Configurations

The default configuration for MODBUS is as follows:

- **Baud Rate** – 115200
- **Slave ID** – 1
- **Parity** – None
- **Start Bit** – 1

8.2 Event Reporting Over MODBUS

The AKM345 GEN3 has the following features to record and report events over MODBUS:

- The physical event buffers (device memory addresses) are mapped with MODBUS addresses, described in section 8.4 below.
- The device will store a maximum of 100 temperature-out-of-range events.
- Each event is comprised of 4 MODBUS registers.
- The event start Address is 30004.
- The client can read maximum 25 events in a single MODBUS query.
- The buffer size is limited to 100 event records – the device will overwrite the oldest event with the newest event in case of buffer overflow. Therefore, the events reported may not be in chronological order.
- The MODBUS client must not read incomplete events. It is required that all registers of an event be read in the same query.

8.3 MODBUS Register Map

8.3.1 MODBUS Registers

MODBUS Registers Range:

- Discrete Input registers start from address 10001.
- Input Registers start from address 30001.
- Holding registers start from address 40001.

Function Codes Supported:

- 02 – Read Input Status
- 03 – Read Holding Registers
- 04 – Read Input Registers
- 06 – Write Single Holding Register
- 16 – Write Multiple Holding Registers

8.3.2 Input Registers

Function Code: 04

Register	Operations (R/W)	Type	Notes
30001	R	16bit unsigned int	Alarm Count (Total alarms triggered till date)
30002, 30003	R	float	Transformer Temperature
30004	R	16bit unsigned int	Alarm Record 1 - Number and Type LSB: Alarm number (1 to 8) MSB: Alarm Type (0: Under Threshold Alarm, 1: Over Threshold Alarm)
30005	R	16bit unsigned int	Alarm Record 1 – Actual transformer temperature
30006, 30007	R	32bit unsigned int	Alarm Record 1 Trigger time (Epoch Time in UTC)
---	---	---	---
30512	R		Alarm Record 128 - Number and Type LSB: Alarm number (1 to 8) MSB: Alarm Type (0: Under Temp Alarm, 1: Over Temp Alarm)
30513	R		Alarm Record 128 – Actual transformer temperature
30514, 30515	R		Alarm Record 128 Trigger time
30516, 30517	R	float	Enclosure Temperature
30518	R	16bit unsigned int	Firmware version Bits 0-7: Firmware version minor increment Bits 8-11: Firmware version minor Bits 12-15: Firmware version major
30519	R	16bit unsigned int	Error Codes

8.3.3 Discrete Inputs

Function Code: 02

Register	Operations (R/W)	Type	Notes
10001	R	Discrete	Alarm 1 Status Value=1 if Alarm is ON Value=0 if Alarm is OFF

10002	R	Discrete	Alarm 2 Status Value=1 if Alarm is ON Value=0 if Alarm is OFF
---	---	---	---
10008	R	Discrete	Alarm 8 Status Value=1 if Alarm is ON Value=0 if Alarm is OFF

8.3.4 Holding Registers

Function Code: 03, 06, 16

Register	Operations (R/W)	Type	Notes
40001	N/A	16Bit unsigned int	Temperature dial selection Dial select value and temperature range: 1. 0 °C – 150°C 2. -20 °C– 130°C 3. 0 °C – 160°C 4. -20 °C– 140°C 5. 0 °C – 180°C
40002	R/W	16Bit unsigned int	Modbus Slave ID
40003	R/W	16Bit unsigned int	Modbus Parity
40004	R/W	32Bit unsigned int	Modbus baud rate LSB [Note: Device will set the new baud rate after the MSB register is written. Writing Only LSB register will not change the baud rate in the device.]
40005	R/W		Modbus baud rate MSB
40006	R/W	16Bit unsigned int	Alarm 1 Threshold
40007	R/W	16Bit unsigned int	Alarm 1 Type (0: Under threshold alarm, 1: Over threshold alarm)
---	---	---	---
40020	R/W	16Bit unsigned int	Alarm 8 Threshold [Note: It is recommended to set threshold and alarm type in the same Modbus query to avoid unnecessarily triggered alarms.]
40021	R/W	16Bit unsigned int	Alarm 8 Type (0: Under threshold alarm, 1: Over threshold alarm)
40022	R/W	32Bit unsigned int	System Time LSB
40023	R/W		System Time MSB

			[Note: Device will set the new system time after the MSB register is written. Writing Only LSB register will not change the system time in the device.]
40024	R/W	16Bit unsigned int	Reserved

8.3.5 MODBUS Notes

Special Transformer Temperature Values:

- The application will display the temperature value as 555°C if valid dial selection is not done.
- If the temperature value goes 2°C or more down below the dial lower range, the application will display temperature as -999°C.
- If the temperature value goes 2°C or more above the dial upper range, the application will display temperature as 999°C.

9. Troubleshooting

9.1 Matching Resistance

- Be sure to check the input current being used is steady.
- Be sure to check the proper resistance is set on the internal matching resistance.
- Be sure to wait 45 minutes before reading the winding temperature gradient.

9.2 Remote Outputs

- Ensure proper supply voltage is being used.
- Check wiring as wiring arrangement may differ depending on features.