



Ti Thermal Imaging LTD

Unit 8, Weybridge Business Centre, 66 York Road, Weybridge, Surrey, KT13 9DY

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RISK MANAGEMENT SOLAR PANEL THERMOGRAPHIC INSPECTION FOR:

**WHILTON MILL KART TRACK
C/O POWERSUN LTD**

LOCATION:

**WHILTON LOCKS
NEAR DAVENTRY
NORTHAMPTONSHIRE
NN11 2NH**

DATE:

14/09/12

TI JOB NO.

TI-16074



Report generated by Ti Thermal Imaging LTD.

Company Registered in England: 04450573 VAT No. 828 6288 87





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Introduction to your Ti Thermal Imaging LTD risk management thermographic inspection

This solar panel visual and thermographic inspection has been carried out using a Flir P/T-series camera with data input onto a purpose built tablet PC platform for instantaneous results and report generation. A Webmanager houses all data that is permanently accessible over the internet allowing the user to track and monitor problems and their repair status.

Solar Panels should register an even temperature across their entire surface. Areas with an elevated temperature can equate to faulty cells because their energy is not being converted and sent to the inverters correctly and therefore it is often released as heat. This enables the identity of faulty panels to be found and pinpointed quickly using an infrared camera. The survey can be carried out in all conditions although for best results a sunny clear day enables easier image interpretation. Clouds can manifest themselves as areas of elevated temperature so it is important for correct image interpretation to be executed.

This is a guide which should help you to fully understand how the inspection was performed and how the results were achieved

- The framework to this inspection can either be generated onsite during the inspection, building the list during the survey or a list exported to MS Excel can be imported into the tablet PC to provide comprehensive information such as item locations, tag numbers, work orders etc.
- Images are captured of all online items and a record is kept of temperature data to enable a trending programme to begin. Subsequent inspections will see the addition of a new image for each inspection so that temperatures can be monitored.
- Baseline images and anomalous pieces of equipment have been recorded as one of three types of inspection:
 - T/D Electrical – This covers transmission, distribution and instrumentation
 - Mechanical – This covers all mechanical/moving/rotary equipment
 - Visual – This covers all visual findings only
- All component baseline images are taken under normal load conditions.
- Panels have been removed where safe and possible to do so and where covered by the Permit To Work system. In addition load readings have been captured using a clamp meter only where covered by the Permit to Work system and where safe to do so. In some cases load readings have not been taken so these are left as blank intentionally so that the normalised graph will function correctly. If a 0 value is inserted then a fictitious reading will be obtained. An explanation of the Normalization graph is listed later.
- A complete inventory will be built of the equipment giving Test Status at the time of the inspection allowing transparency to the inspection and what occurred with each piece of equipment. These Test Status include:

TBT	To Be Tested	These appear in bold on the thermographers tablet to identify which items are still to be tested
TESTED	TESTED	Marked as Tested once images and faults have been documented
NTLO	Not Tested Locked Out	Selected if the item could not be opened safely
NTNL	Not Tested No Load	Selected if the item was offline at the time of inspection and could not be started
NTNA	Not Tested Not Available	Selected if the item is no longer available
NTNS	Not Tested Not Specified	Selected if an item is found to be unspecified
NTUR	Not Tested Under Repair	Selected if an item is currently under a repair procedure
NSFI	Not Scheduled For Inspection	Selected if an item is not due or needed to be tested
NTTC	Not Tested Time Constraint	Selected if the inspection has not been allocated enough time or access problems have cause it to overrun.



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- Each piece of equipment has been allocated a priority to operation taken from the following non-changeable list:

CTO	Critical To Operation
ETO	Essential to Operation
NON	Non-Essential To Operation
UNC	Unclassified

- Emissivity is the value in which an object emits it's infra-red radiation and is also directly proportional to it's reflectivity. For example if an item had 0.9 emissivity then it's reflectivity would be 0.1. This inspection uses an emissivity set to 0.96 because this value is found to be suitable when assessing the temperatures of most electrical components due to them usually being housed in plastic or rubber which has a similar emissivity value. Emissivity is only changed were absolutely necessary. An example of this would be copper busbar with no electrical tape/labels attached.
- Anomalous components are assessed in one of two ways.
 - With the use of Reference components operating under similar conditions: These would include using line/load sides or different phases with similar load patterns to compare an anomalous component with another which has a more normal temperature gradient.
 - The use of load correction formulas which results in the following value:
 - Estimated fault component temp at full load (°C) – This estimates the temperature that the component would be running at if it was loaded at 100%. This value has been arrived at using a formula correction using anomalous and ambient temperatures, measured and maximum load.
- The value of 75°C has been taken from the British Standard BS7671 (*.*). This value is the recommended cable temperatures of between 65-85C at full load.
- Using this value it is possible to use a fault rating system to grade the severity of the fault. The following fault ratings and colour coding have been used:

Fault Ratings	minor	Important	Serious	Critical
Temp above ref temp or above 75°C	0-7	8-15	16-32	33+

- This value of 75°C is also used as a threshold temperature for the captured baseline images. In certain circumstances, this value has either been increased to 100°C or decreased to 50°C. The value has been increased to 100°C where the thermographer deems this a more appropriate value due to an elevated cubicle ambient or where components are tightly arranged together causing uplift in operating temperature. The value has been decreased to 50°C where the thermographer deems this a more appropriate value due to panel covers not being able to be removed and only the surface of the component can be seen and not the actual connections. In certain circumstances where SP2 Reference temperature cannot be suitably obtained, the value has been set from the BS Ref of 75°C as the SP2 reference temp.
- The normalization graph simulates temperature at 0, 50% and 100% load and is designed to assist the prediction of component operating temperature where a reference component has been used. According to Ohms law $P=I^2R$ but the graph is designed as a quick glance tool to assist in viewing the potential that a problem may become.
- Where anomalous components are found, a knowledge base library is used to house specific statements that ensure synergy between inspections for faults, root causes and recommended remedial actions.
- Formulas:**

Normalization Graph	$P=I^2R$ where P=Power, I=Current, R=Resistance
T load corrected	Let $(T_m - T_{amb}) = Trise$; $I_{meas} / I_{full} = LF$ (Load factor) Then: $T_{corr} = (((1/LF)^{1.68} + (1/LF)^{1.46})/2) * Trise + T_{amb}$



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Report pages:

The combined report contains the following pages:

NB Page numbers have been left in for additional ID purposes. Page numbers run in sequence beginning at #1 for each section but do not run in sequence for the whole combined report.

1. Cover Page for TD Electrical: This is a summary report which offers the amount of problems found and their severity grade. It is for a complete site overview.
2. List of all open problems: This is the full list of equipment found with problems and includes their locations and tag numbers
3. Inspection Inventory: This is a full inventory of equipment inspected, their ID numbers and their test status.
4. Documentation pages: These pages include the details of all anomalies found for individual pieces of equipment.
5. Cost Benefit Analysis: This lists the possible cost benefits of finding the faults before they have failed and estimates how much cost has been saved by predicting a failure before it happens. These values are deliberately very conservative and loss of production has not been taken into account.

The Webmanager contains all of the above reports and lists problems, cost benefits and baseline trends in easy to source locations. To view your current and previous inspections, please logon to your personal Webmanager using your username and password already supplied. If you do not have this please contact Ti on 0845 4586315.

<http://193.228.155.40/inspectrend> or www.thermalimaging.co.uk then 'Login to Webmanager' tab

Webmanager tutorial snapshot:

Navigate to the area you need using one of the 6 tabs at the top of the screen:

REP'S/ELECTRICIANS ENTER CORRECTIVE WORKORDERS INTO WEBMANAGER HERE	Overview	Summary listing all problems active or closed with severity grade.
	Inspection	Select site and then hit search to reveal historical list of inspections. Select 'more' next to the inspection that you want to see further details of. At the bottom is a 'reports' button that highlights in red, hit this to reveal a list of your reports. Your combined report will be prefixed by 1_ to ensure it the very first report.
	Inventory	Select site and then hit search to reveal a full inventory of surveyed equipment, test status, priority to site operation and last inspected date.
	Problems	Select site and then hit search to reveal a list of all open/closed problems found with severity grade, repair status and date found. Attach a work order here for remedial action and view the problem in its own individual report page.
	Cost Benefit	Select site and then hit search to reveal the savings you have made by having this inspection carried out. Typical ratio is spend £1 and save £4.
	Baseline	Select site and then hit search to reveal baseline trend data for all equipment surveyed. Here you can view individual trend reports for each piece of equipment where the latest IR/DC images are displayed with a historical temperature graph for baseline temp/current insp. Temp and threshold temp.



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