HIL–Tech
LTD

2119 Devon Rd.
Oakville
Ontario L6J 5L9
Canada

Tel: [001] 905 849 6134
FAX: [001] 905 842 7418
Eml: hil-tech@cogeco.ca
Web: www.ledline.net

Suggested Installation Guidelines for Retrofitting LEDline® LED Guidance Lighting into Concrete Pads or Asphalt. September 2024.

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All LEDline® products must be installed by a HIL-Tech qualified installer or the LEDline® Limited Warranty is void. Please contact HIL-Tech for the nearest installer.

To be HIL-Tech qualified installers, installers must have installed at least one project under the supervision of HIL-Tech and their workers must receive a HIL-Tech Certification. **Please contact HIL-Tech Ltd. for further details.**

If there is not a locally qualified installer, then, for validation of the Limited Warranty, a person from HIL-Tech Ltd. must be present to ensure the correct installation.

Applicability:

These *Retrofitting Installation Guidelines* apply to any light strip products forming part of the LEDline® family of products, (collectively, LEDline® products).

For installing LEDline® into poured concrete, please contact HIL-Tech Ltd. for further information.

The installation methods and techniques documented in these guidelines are general and should apply in most retrofit situations. However, it is not uncommon for the detailed layout of an LEDline® system or certain aspects of an installation to have unique requirements at a particular situation or location. Accordingly, we recommend that HIL- Tech engineers review all layout and installation plans before installation and preferably, before ordering an LEDline® system.

As the LEDline® changes, the installation procedure may also change, so be sure to have the latest installation procedures.

These Installation Guidelines relate only to situations where the LEDline® is to be installed within and slightly below a paved surface (e.g., on a concrete or asphalt road). However, it should be noted, that LEDline® is also used on barriers, signage, and other structures, to highlight them in any weather, improving road safety or structure aesthetics.

Vancouver International De-icing Pad: Jan. 2010 picture date, with modern semi-directional yellow (12 x LED) LEDline®. Installed Fall 2009, the LEDline® there has NEVER been turned off, so as of September 2023 has been on 24/07 and successfully working there for some 14 years and counting

About LEDline®:

LEDline® is a lit guidance lighting system, which increases road/airport safety, guidance, and efficiency. The linear array of encapsulated light emitting diodes ("LEDs") provides for a high intensity lit safety guidance line. (Note: All LEDline® units are daylight visible, however, for maximum in-pavement visibility in sunlight, the 12 x LED systems, particularly the semi-directional 12 x LED LEDlineSunDV^{TM} units should be used for most in-pavement sunlight visibility situations).

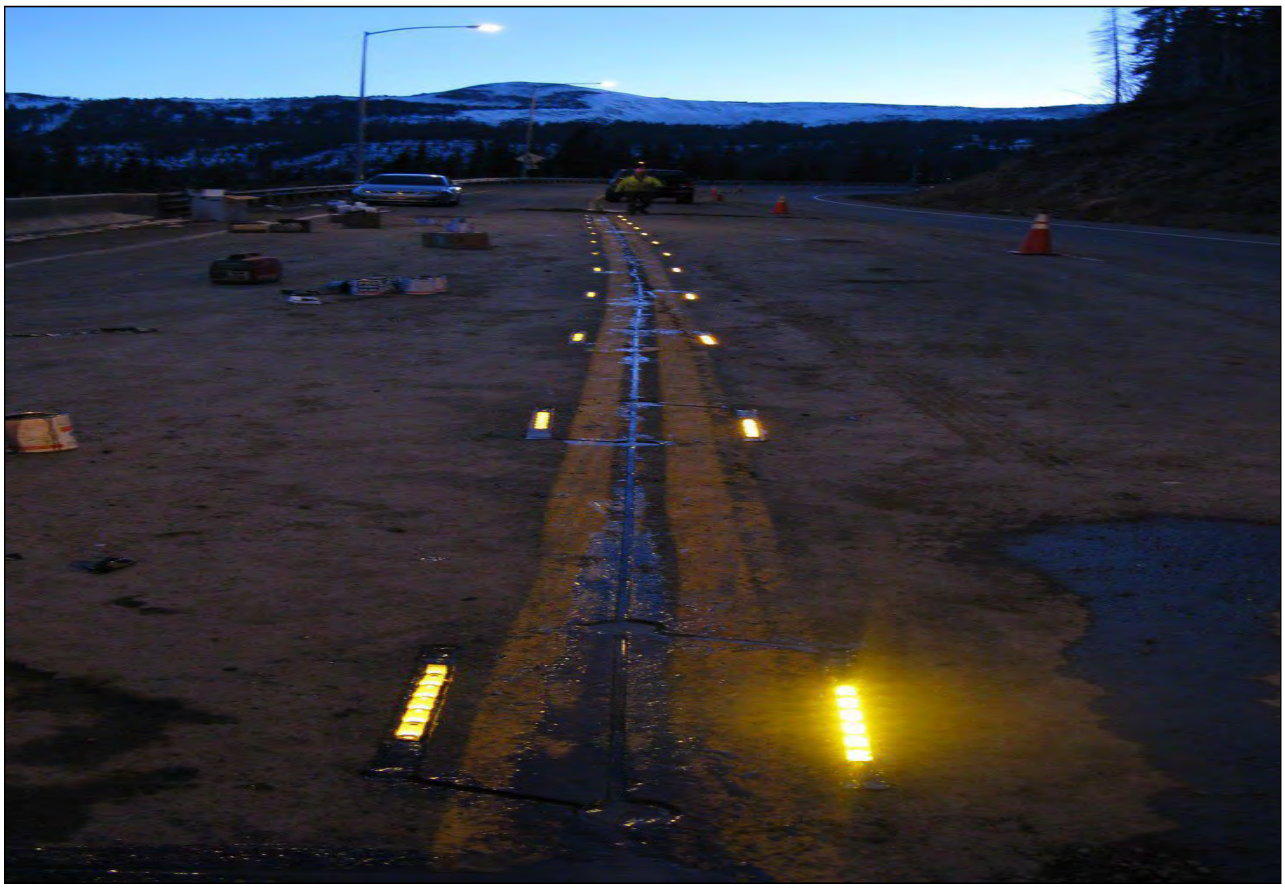
The embedded LEDs are mounted on a printed circuit board embedded within a solid clear plastic matrix that is connected to a set of Power Supply (BUSS) wires.

Unlike painted or reflective markings, LEDline® melts snow without any additional heating elements so is visible in most weathers, including heavy fog, (where it is seen far earlier than any reflector markings), heavy rains, snow whiteouts, and dust storms.

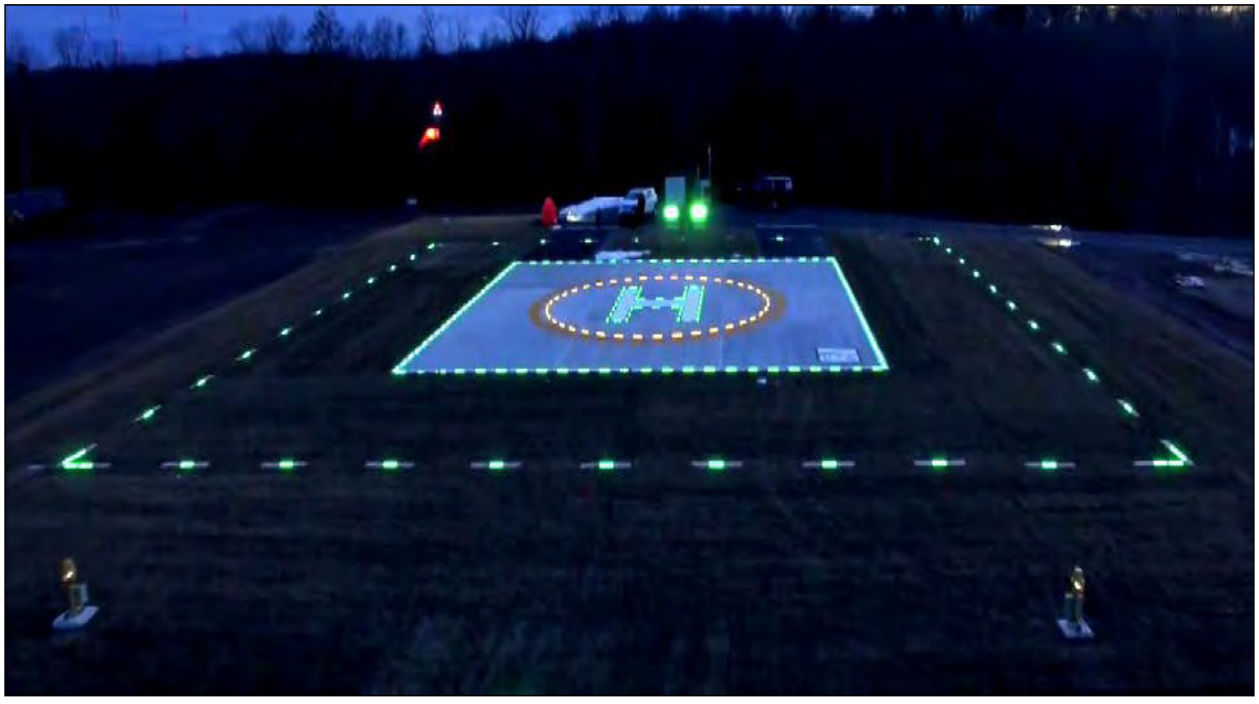
- ***For Airports:***

Above at Anchorage International; (incandescent bulbed, giving more heat than light), standard green FAA Taxiway lights (left) and old-style yellow 6 x LED LEDlineDVTM semi-directional lamps (right), both seen in identical deep snow conditions. Both melt snow and both are equally visible and effective. (**Note: HIL-Tech now has 12 x embedded LEDs, so are much brighter and melt more snow**).

- ***For Roads:***



- ***For Helipads:*** **Picture, Copyright Mr. Bruce Lomasky USA Helipad.**



There Are Five Basic Types of LEDline®:

For evening and nighttime visible systems, LEDline® can come with 6 x embedded LEDs;

- LEDlineDV™ is a semi-directional system aiming most of its light towards the viewer and
- LEDlineHB™ is an omni-directional system with similar light visibility from all directions.

For the brightest sunlight-visible applications, LEDline® comes with 12 x embedded LEDs;

- LEDlineSunDV™ is a semi-directional system (the brightest in sunlight situations) and
- LEDlineSunHB™ is the brightest omni-directional system.

Custom LEDline® systems are available, such as unique hybrid LEDlineSunDV™, with 6 x LEDs in an omni-directional position, and 6 x LEDs in a semi-directional position with their embedded optical system focusing the light towards the driver. Other custom LEDline® systems can be created, so please ensure that these installation guidelines apply to any customized systems by contacting us at.
HIL-Tech Ltd.

The "**HB**" designation means; High Brightness and that the embedded LEDs are omni-directional, whilst the "**DV**" designation stands for directional visibility, having the unique proprietary precision optical system embedded in with the LEDs, focusing most of the light at low angles towards the viewers.

The "**Sun**" designation means that the units are visible in sunlight. Again, whilst all LEDline® units are visible in sunlight those designated with the "**Sun**" are recommended for all sunlight applications.

All LEDline® components are fully encapsulated in a durable, clear, weather-resistant, UV-resistant, solid clear matrix. As such, they are submersible, (previous iterations tested to 300m (1000ft) seawater depth); are corrosion resistant; are extremely tough; highly chemically resistant; solid, so not easily compressible, (will take the weight of 747 / A380 aircraft); could be explosion proof (need to be certified); and are specifically engineered to withstand the challenges of a variety of extremely harsh environments.

Most in-pavement applications have the induction power supply low powered series circuit, except when the in-pavement LEDline® units need to move, as in applications like wrong way onto freeways where lit moving arrows move from the freeway towards a normal road.

The standard induction-powered and connected in-pavement type of installation has; the Induction Power Supply; a Mounting Plate, which is inset into the pavement; the linear LEDline® Lamp units; and a non-contact, not hardwired, Induction Power Pick-up connection system. This induction-powered connection system is connected to the surface-mounted LED lamps via a waterproof IP69K quick disconnect connector. This IP69K disconnect connector to the LEDline® lamps is the highest IP electrical connector system available, so any maintenance or changing out a lamp from the Mounting Plate is easy. (**Please Note:** If needed for deep-sea use, custom, much deeper, high-pressure certified connectors are available).

For highlighting barriers, structures, signs, and other special applications, LEDline® is usually specified with a Direct Current (VDC) configuration with HIL-Tech's Power Equalizer Boards which limit power to the lamps so the first and last lamps on the VDC circuit are as equally bright and line voltage drop is minimized. Again, the lamps come with the IP69K connector. For this configuration, there is also the optional computer special effects package. This allows for individual LEDline® lamp

computer control, so that each lit individual LEDline® segment can be controlled as to sequencing, movement, as well as dimming/brightness.

Standard LEDline® units have a nominal illuminated length of 415mm (16.3"), within a Mounting Plate "U" channel of 625mm (24.6") long, with a nominal width of 48mm (1.9") and a nominal depth of 30mm (1.2"). (**Note:** For in-pavement letters and numbers, custom LEDline® units can be made that are half this size, contact HIL-Tech Ltd. for details).

Longer custom linear units can be 115cm (47") long can be made. HIL-Tech can manufacture individual point source lamps, but its major production is in linear sources either omni or semi-directional or combination optical units, able to provide light in all directions from zero degrees. Please contact HIL-Tech for details.

All light units are available in a wide variety of LED colors plus infrared (IR) and Ultraviolet (UV). (Please consult the LEDline® Technical Specifications for a list of currently available standard colors).

Linear LEDline® meets the needs of the transportation industry by enhancing the visibility of pavement markings, barriers, signs, obstacles, etc. in all conditions, particularly when motorists and pilots find visibility a challenge, so the lamps improve safety and guidance.

When illuminated, the LEDline® system is seen; in sunlight; at night; at dusk; under intense rain; in the wash of headlamps; and in snow depths of 200mm (8") or more, **since, when on, it glows under the snow and melts snow. (Note: LEDline® is the only LED lamp that melts snow without requiring additional heating elements.** Therefore, in melting snow, it is self-cleaning).

It is excellent for guidance in; fog; snow whiteouts; and dust storms; and is visible in broad daylight/sunlight when used on barriers or the poles signs, or directly facing the viewer in in-pavement applications, especially when the 12 x LED LEDlineSunDV^{TM} system is used.

For in-pavement applications, **LEDline® units are always embedded slightly below the pavement surface**, this is good engineering practice as well as avoiding snowplows, so they are not damaged.

LEDline® is easily attached to any structure to highlight its presence. The Mounting Plate "U" channel comes with standard screw holes at its edges or holes can be drilled through it, to provide the necessary places for screw attachments.

Rule of Thumb of the Time for a Retrofit Installation: Provided temperatures are reasonable and the weather is dry, as per the glue manufacturer's suggestions, LEDline® is easily and quickly installed. (Note: HIL-Tech has seen an electrical contractor, with no previous experience in installing LEDline®, with one saw cut machine and a crew of five (5) install some 188 LEDline® units with their power supplies in about 5 days = 200 hours of work). Access, such as being able to work only at night, etc., can slow installations, as does rain, and cold freezing temperatures, all of which prevent the glues from adhering and curing. Provided the right conditions are available for the selected glue, LEDline® is often installed in days not weeks.

Energy Efficient, Long-Lasting, and Chemically Resistant: The use of LEDs as the light source ensures that the LEDline® system is energy efficient, long-lasting, and requires minimal

maintenance. Since the encapsulating material was formulated to be tough and resistant to a variety of chemicals (e.g., jet fuel, de-icing fluids, etc.) as well as other contaminants in the transportation industry, LEDline® may be deployed in a host of outdoor, industrial, or resource-industry environments. It is also suitable for a variety of indoor and commercial uses including being used for aesthetic structure outlining purposes, and as previously mentioned, if required, may be surface mounted on vertical surfaces.

***Waterproof Submersible Connector*:** LEDline® comes with a quick disconnect, locking, screw together, nickel-plated brass, waterproof, IP69K connector. Other than deep-sea high-pressure electrical connectors, **IP69K is the highest IP-protected type of electrical connection available**.

In the IP69K picture above, please note the black gasket with the locking mechanism, a key item to be noticed and used to maintain the waterproofness of the IP69K connection. And when the service loop is created tape around this connection and the created service loop to hold it in place.

Note: The IP69K wires are very thin so can be easily kinked and/or broken, so great care should be taken when connecting the IP69K connectors to the LEDline® units.

Ensure that the connectors are not damaged when installed into the Mounting Plate's IP69K cavity. When the 3M Gel is introduced, the 3M Gel acts as a barrier to moisture and corrosion and stops the unit from being moved and rattled as traffic travels over it, so must always be used.

Lastly, once connected to the LEDline® lamp within their Mounting Plate, the IP69K connectors should never, ever be used to carry the connected LEDline® and its Mounting Plate weight as this might damage, kink, or break the small wires inside the connector. Therefore, always handle these connectors with great care.

IP69K = Protected against ingress of dust and high temperature and close-range high pressure, high-temperature spray downs, so it is submersible. These connectors are used in case it becomes necessary to replace a LEDline® lamp to easily connect a new lamp to the buried-in glue difficult-to-access induction power pick-up connectors and power distribution cables.

General Power and Power Supply Considerations: For in-pavement applications, LEDline® products usually operate on a low-powered constant current series circuit, although other custom power supplies are available. In areas where mains power is problematic or when safety considerations require it to be always lit, LEDline® may have a battery or other backups to remain lit during power blackouts.

The LEDline® Master Controller/s with its Power Module/s generates a low-power induction series circuit lighting system that has non-contact non-hardwired IP69K induction power pickups to get power to the slightly below-the-pavement surface LEDline® units. These power supplies are connected to surge-protected standard mains power.

HIL-Tech Power Supplies; there are;

- induction power supplies and induction power connector systems, which are used for in-pavement applications.

- VDC power supplies are normally used when LEDline® is attached to buildings, barriers, or any other structures. (**Note:** For VDC-powered LEDline® units, HIL-Tech had Power Equalizers which ensure that the last unit is as bright as the first, eliminating VDC power line energy drops and keeping the last lamp as bright as the first).

- transformers for airfield series circuits, when LEDline® is to be powered from the standard airfield series circuits. (**Note:** Because of the high-powered series circuit and Constant Current Regulator/s (CCR) voltage surges designed to bypass any short circuits in the airfield series circuit, as with all / any other LED lamps, the required LED protections against these high voltage spikes and surges negates most of the usual LED energy savings benefits and attributes).

- alternative renewable power sources such as solar power, wind generators, or fuel cells (all with batteries), can be used when mains power is not available. (**Please Note**: In remote areas, such as mountains or northern areas where renewable solar/wind energy is used but their batteries might need help to recharge, these renewable sources can themselves be backed up with propane-powered generators which kick in when there is insufficient solar / wind to charge the batteries).

Induction Non-contact, Non-hardwired Power Supply: With HIL-Tech's induction power supplies and their non-contact, not hardwired connector systems, the voltage in the BUSS wires varies depending on the total wire distance run and the number of and types of LEDline® modules connected to the system. The constant current power module provides a known controlled low constant current of 10Amps into the main power BUSS wires, whilst the low voltage floats to accommodate the power draw until the maximum voltage of the circuit is achieved. This allows for several individual LEDline® units to be connected (linked) together to create continuous or dashed illuminated lines of considerable length, (up to the maximum power rating of the power supply 600W), without any degradation of brightness at the far end of a run.

As a "Rule of Thumb," each connected LEDline® unit adds approximately 1V to the voltage in the BUSS wires over and above a minimum 12V for minimum loaded condition with a factory pre-set **minimum load** on a Power Module = 10 units. For example, a system with 10 x connected units would expect approximately (12V + 10V) = 22V in the BUSS wires. The voltage in the BUSS wires will vary up or down depending on the total wire run distance installed; the total number of units connected; the color of the LEDs; and the impedance within the power distribution wire.

CAUTION: When testing an Induction Power Module controller, there must be a minimum load on the circuit. With the induction system, one cannot just light up one or two units alone.

CAUTION: Older, before 2007, Master Controllers with older Power Modules, do not use the Power Module with less than 20 x connected LEDline® units or the power control board will be damaged. (If in doubt, please contact HIL-Tech Ltd). Today's modern units automatically adjust to the number of LEDline® units on a circuit, however, they still need a minimum load to be self-calibrating, whilst the older controllers need manual adjustment**.**

CAUTION: Always disconnect the power supply system when working with any LEDline®.

For Daylight Visible LEDline® Systems: For in-pavement or barriers/structures, the 12 x LED embedded systems, omni-directional LEDlineSunHB™, or semi-directional LEDlineSunDV™ should be used and specified for sunlight visibility applications. If 12 x LEDs are being powered, (obviously twice the number of LEDs compared to the 6 x LED systems), in rough terms, this will tend to halve the number of LEDline® units that can be powered from a single Power Module. To be sure about a specific length of power circuit powering a specific number of LEDline® units, please contact HIL-Tech Ltd for the distances and/or number of 12 x LED, LEDlineSunDV™, or LEDlineSunHB™ units that can be powered on a single circuit with a single Power Module.

For extra-long power line circuits, a specialized booster circuit may be specified. This is used for very long wire runs and/or extending the number of LEDline® units that can be powered from a single Power Module. Please contact HIL-Tech Ltd for details.

Glue Installation, Weather Considerations: HIL-Tech does not specify any glues since most authorities have specific requirements for glues in their area as these have been tested for in-pavement applications for their local environments.

In general, most glues prefer dry conditions at optimum temperatures (above 5°C (40°F)) to set. However, whatever glue is chosen, **its manufacturers' requirements must be followed to the letter.** This results in the best seal of the in-pavement LEDline® and the installed electrical connections within the pavement in a particular local to prevent water from accessing the groove over time. (**Note:** Since LEDline®, its induction connectors, and its power supply lines are all waterproof and submersible, the reason to use the right glue for the environment is to prevent water damage to the pavement over time).

Some adhesives/sealers are tolerant of wet conditions and can cure and seal in these relatively cold temperatures, although cure times will usually be slower in these conditions. Again, please closely follow the authority's glue specifications AND the specific optimal glue curing conditions, curing times, and specifications from the chosen glue manufacturer's instructions. Any deviations from the glue manufacturer specifications, for the curing conditions and the required curing times, may cause damage to the installed LEDline® units from vehicles prematurely traveling on the units that are not properly stuck down, this would nullify any of HIL-Tech's LEDline® Limited Warranty.

Visibility Considerations: Designers and engineers should be aware that lit marking visibility/conspicuity depends not only on brightness but also on the contrast ratio between the lit marking and its background. (Its lit area luminance is also important). For contrast, lit white or yellow on

a black background will normally show in any ambient light, whilst lit white on a white background will be much less conspicuous unless, of course, it is dark or nighttime. Similarly, lit signs or visual aids will be far more visible at night (a high contrast time) compared to daylight. LEDline® with 12 x embedded LEDs is visible in sunlight and many other light and nighttime conditions, so please contact HIL-Tech Ltd for details and recommendations.

Snowplow Safe, Installation, and Layout Considerations for Enhancing Visibility: All LEDline® units that are driven over, must be placed into a groove slightly below the pavement. This is especially so in winter areas to prevent damage occurring to the product by snowplow impacts.

(**Note: The picture above of many snowplows snowplowing LEDline®,** was taken from a video, so its quality is not the best. To see the video, go to www.ledline.net).

***A Unit's Installation Should Always Be Uniform*:** To achieve this, all in-pavement LEDline® units come with four (4) x adjustment screws at the 4 x corners of a Mounting Plate "U" channel.

Before installing any glue into the groove, the completed LEDline® unit and its Mounting Plate with the cured 3M Gel, should always be positioned in the middle of the open saw cut, and have its set screws adjusted within the open groove at this appointed place. Each of the four (4) adjustment screws must be individually adjusted for that position to achieve the right depth, camber, slope, and aspect ratio that the road surface exhibits. And, whilst mimicking the road attributes, the LEDline® must always be placed 2mm – 4mm (1/6" – 1/8") slightly below the pavement surface.

To achieve a uniform depth, some contractors have fabricated specific "T Bar" metal or plastic measuring tools that span the groove's width as well as fit into the groove's depth to easily achieve the uniform pavement depth for all installed LEDline® units. Again, for a uniform display, it is important that all units are set up at the same depth and each end is slightly below the pavement and has NOT been "rolled" to the left or right when installed. Therefore, setting the right depth on the lamps for each

lamp position, with the 4 x corner set screws is important!

Again, all units should always be slightly below the pavement surface, and this is especially true in snowplow areas. **Under no circumstances should any part of the LEDline® be proud of or above the pavement surface so that it can be impacted by a snowplow blade!** Any such units positioned like this should be repositioned if the glue has not cured or, if it has, be reinstalled so that snowplows cannot touch it.

For units that are above the grade, the unit should be re-installed. Any unit that can be impacted by a snowplow blade is not covered by the HIL-Tech Limited Warranty. (**Note:** A brick resting on the road and passing over the LEDline® installation is a quick way of determining if a unit is installed too high).

For too deeply installed LEDline® units, they should be raised if the glue has not set and reinstalled, or the pavement around the LEDline® can be ground down and lowered.

Visibility of The Markings: Once the background conspicuity is solved, care should be taken to design the lamps to be seen and optimized for their purpose. In-pavement applications such as roads or airfields, are where distance visibility and viewing are important. Therefore, special care should be taken to make sure that all units are positioned at least 200mm (8”) away from the leading edge of the groove the lamps are being placed in so that the lip of the groove does not block any of the low angled light exiting towards the distant viewer.

All LEDline® units should be installed the same way with the same; height, slightly below the surface; at a set distance from the groove’s front; aligned with the road’s slope or camber, etc.; so that their appearance is always uniform. (Again, the lamps should be in the same position within the groove, with the same aspect ratio, and the same spacing away from the front edge of the groove, or the units may not have a uniform brightness or appearance and look uneven).

Aspect Ratio: Aspect ratio means that the position of the LEDline®, its direction, its depth, its camber (left / right ratio), and the positioning of the LEDline® within the cut groove, should be the same for every LEDline® unit in the circuit **unless there is a specific reason not to do this, (more later)**.

This way, the appearance is the same for every unit, whether they are in a line or put parallel to each other as at a pedestrian crossing.

Again, to be clear, in this application, each unit is in line with and parallel to the other at the specified separation distance. This way, a horizontal lit line is created with directional LED light focused towards the viewer, and the full length of each LEDline® unit and its light is available for long-distance low angle viewing. Here there are only two options available, for nighttime viewing only, the LEDlineDV™ (6 x LEDs), or for 24-hour viewing, the much brighter LEDlineSunDV™ (12 x LEDs) are available.

Longitudinal Markings: **From a distance, longitudinal markings are ALWAYS more visible than horizontal markings.** LEDline® shows best when used to replace or enhance pavement markings that run longitudinally, (i.e., parallel with the road like road lane lines). As previously mentioned, when installed longitudinally LEDline® products have the full length of the installed product for the light to exit and be seen by the distanced viewer, whilst a horizontally installed product has only the much smaller LEDline® width, the surface area of the cross-section of the product to be viewed from a distance.

Physics dictates that the further away one views anything, especially within a pavement, the lower the viewing angle will become. Therefore, with horizontally installed LEDline® with a much-reduced

surface area being visible, when viewed from long distances, the foreshortening effects and the low angles will only allow a fraction of the light's surface area to be visible. As with the horizontal white painted stop bars at traffic lights, which are deliberately widened to try to counteract this aspect ratio visibility loss, if the units are to be used this way and are to be "visible", additional LEDline® units should be installed parallel to the line (with appropriate spacing between them), to widen the visible horizontal area of light available.

Again, for distance viewing, the preference is always to take advantage of the LEDline®'s linearity and install them lengthwise, parallel with the traffic direction, so the distance viewing is enhanced. Have the LEDline® units placed longitudinally and space them relatively close together across the road (not closer than 30cm (12") and create the horizontal lit line this way, so a maximum lit surface area will be available for viewing from a distance.

(**Note:** The viewers will see the spacing between the lit sections. However, they will also see that these lit sections cross the section of the taxiway where the painted stop bar is located, so will understand, and get a much earlier warning of this stop bar area).

Horizontal Markings: If LEDline® units are intended to enhance the horizontal pavement markings, such that they will be installed across (i.e., perpendicular to the direction of travel), planners should be aware that unless specific countermeasures are taken, such as widening the lit line width with additional LEDline® units, as above, that the distance-foreshortening effects will significantly reduce the intended visibility of the LEDline®.

In addition, in these circumstances, installation depth considerations become **VERY IMPORTANT** for the LEDline®'s visibility for such horizontal installations. This is because, the deeper the unit is installed within a groove, the more the sides of the horizontal groove cut off what little **low-angled light is emanating toward the intended viewer.** This further reduces the visible area of light from a distance.

(**Note:** The deepening of the installation for LEDline® can be deliberate and useful and can, when one does not intend the light to be viewed from a distance in that particular direction but does want the light's linearity to be seen in their linear directions). Here, the **LEDline® units are deliberately installed deeper than usual,** so the edge of the grooves are used to deliberately cut off the light, reducing its distance visibility in the side direction, so that the LEDline® is only able to be seen once the viewer is close, almost right on top of it.

For Horizontal Distance Viewing of A Lit Line, It Is Recommended That:

- planners decide on the desired distance visibility of the marking and consult HIL- Tech engineers for advice as to the best layout and product selection to achieve their requirements;
- that a minimum of two tracks of LEDline® be placed side by side with a suitable gap between them. This increases the width of the visible lit line's light emitting area, thus increasing its distance visibility;
- all lit horizontal line-markings should be created by individual LEDline® units being installed parallel to the road direction, with appropriate spacing. For pavement markings, this usage style is the most visible from a distance.

Pedestrian Crossing / Crosswalk Safety: At night, lighting up anyone on a crosswalk is key to improving crosswalk safety. As trialed by FHWA at Virginia Tech., from the pictures below, the semi-directional LEDlineDV™ units were placed on either side of the crosswalk facing across the crosswalk, lighting up anyone in the crosswalk whilst facing oncoming traffic. When lit, particularly at night, pedestrians are highlighted from all sides of the crosswalk.

(**Note:** These directional lighting units are deliberately placed on opposite sides of a crosswalk, facing toward the pedestrians' and the approaching vehicles on the other side of the crosswalk. Therefore, at night, anyone stepping between the lights is fully highlighted from all directions and should be easily seen by approaching drivers who will understand that the crosswalk is in use).

The nighttime Crosswalk Pictures below illustrate, how LEDline® highlights and lights up people from a distance, even when they have dark clothes on. (From the FHWA Study Video, Copyright Dr. Ron Gibbons Virginia Tech.);

LEDline® Comes with Mounting Plate "U" Channel and Waterproof and Submersible, Top of the Line IP69K Electrical Quick Disconnect Connector:

For all in-pavement applications, for ease of installation and ease of future maintenance/replacement, each LEDline® unit comes with an aluminum Mounting Plate "U" channel and IP69K waterproof induction power pickup connector. Here, the LEDline® must be connected to its IP69K connector within its Mounting Plate and the induction power pickup must have a direct burial wire running through it.

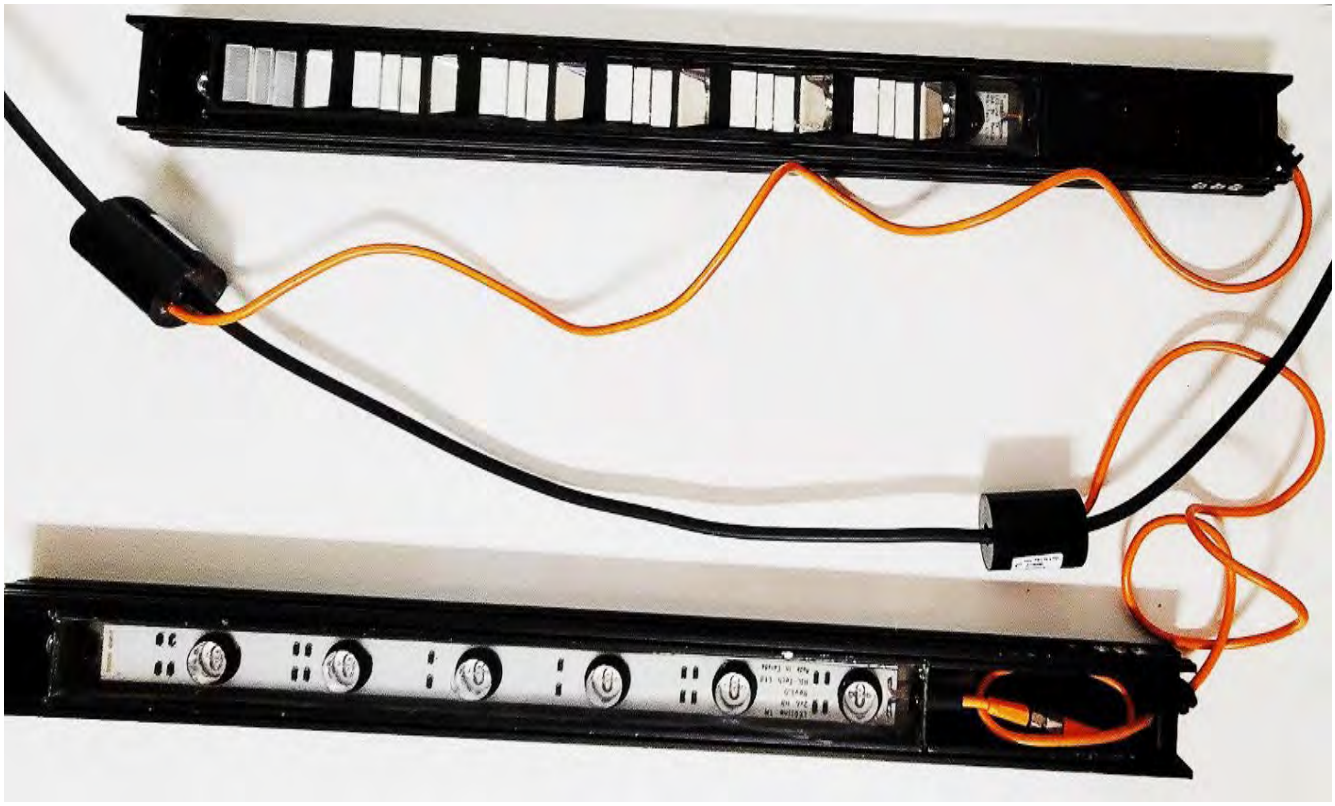
The reason for the Mounting Plate "U" channel is to hold the LEDline® within the shallow groove, so that access for long-term maintenance to the LEDline® lamp is easy. Once glued in place, the waterproof connector for the induction power pickup and Mounting Plate "U" channel will permanently stay in the groove yet still allow for any maintenance and, if necessary, for a new LEDline® unit to be installed. Such installations require a cut groove in the pavement for the LEDline®/Mounting Plate "U" channel of some 60mm (2.4") wide x 45mm (1.7") deep x some 96cm (38") long. (See drawing HT-6851; HT-6852; HT-6853). The direct burial power line wire can be installed at any depth. **However, it must never be installed at any depth less than 55mm (2") deep**. Again, it can be installed much deeper but must never be installed less than 55mm (2") deep.

Within the Mounting Plate "U" channel, the LEDline® is locked in place at one end with an attached bolt nut and two (2) hold-down bars on either side of it all along the LEDline® lamp's length locking in both ends. These lockdown bars are connected to the other end's lockdown screws. Therefore, via these same two lockdown bars, which slide into the IP69K's cover, they keep everything secure.

(**Note:** For added security, the nut holding down the system can be changed and specified to ones that are easily tightened but need specialized tools to unscrew. Please contact HIL-Tech for details).

Standard LEDline® units have a nominal illuminated length of 415mm (16.3"), within a Mounting Plate "U" channel of 625mm (24.6") long, with a nominal width of 48mm (1.9") and a nominal depth of 30mm (1.2").

Below are Semi and Omni-directional units connected to the direct burial wire by their non-contact, non-hardwired, completely submersible induction power pickups. (**Note:** the opened Omni-directional unit illustrates **the needed service loop is a requirement for all LEDline® units being installed in the pavement**).



The Mounting Plate "U" channel has four (4) x adjustable screw holes at each end for #8/32 gauge for M4 metric adjustment screws. These are sent with the units and need to be mounted into the Mounting Plate, 4 x screws for each unit, one at each corner in their appropriate holes. (**Note:** They are used in setting the LEDline® at the right depth and camber within the pre-cut groove and are always glued in place).

(**Note:** Before any glue is used, each LEDline® unit must be tried within its groove, and the 4 x set screws adjusted for that particular groove. Once the screws are set, the LEDline® unit can be removed from the groove to allow glue to be added. Once added, the power line and induction connector around its distribution wire are pushed down into the glue. This is then followed by the fully loaded Mounting Plate with its LEDline® unit and IP69K connection within the cured 3M Gel. The power lines, induction power pickup, and Mounting Plate are all sequentially pushed down into the glue and are installed within the groove, then weighted down with a brick and left for the glue to cure.

The complete LEDlineDV™ or sunlight visible LEDlineSunDV™ and Mounting Plate "U" channel unit, are carefully installed together, slightly below the pavement surface. (**Note: The completed LEDline® installation should always be slightly below the road surface.** Moreover, every unit should be installed in the same way within the groove, at the same distance from the groove front, a minimum of 16cm (6") away from the groove's front, with the same aspect ratios, so that they all have the same appearance when lit.

The LEDline® direct burial power line circuit is always installed in a grove with **a minimum depth of 55mm (2.2”). It can always be deeper, but never shallower)!**

General Preparation and Equipment: To ensure proper installation and to receive the HIL-Tech Ltd. standard One (1) year or extended years LEDline® Limited Warranty; LEDline® must only be installed by HIL-Tech Ltd. approved/certified workers and contractors. Contact HIL-Tech for the nearest certified workers and contractors.

If no HIL-Tech Ltd. approved/certified workers and contractors are available; a representative of HIL-Tech Ltd. must be present when;

- the LEDline® units are being put together with their IP69K connector/induction power pickups, t 4 x pavement leveling screws, and their 3M Gel is being built /put together.
- When the prebuilt LEDline® is to be installed into the pavement. Any in-pavement installation s must be verified and installed by a HIL-Tech Ltd. approved/certified workers and contractors, or a representative of HIL-Tech Ltd. must always be present when the installation is taking place. **Please contact HIL-Tech for details.**

The Standard One Year HIL-Tech Ltd. Limited Warranty and No Liability declaration is on Page 65 and Page 66.

(Please Note: Up to an additional three (3) years of added Limited Warranty for the LEDline® product, above and beyond the standard one (1) year, may be purchased at the time of acquisition).

Some Suggested Installation Equipment: For Installing LEDline ® into Either Asphalt or Concrete, in Normal Summertime Conditions.

THIS IS NOT A COMPLETE LIST.

Amounts will vary depending on the size of the Job:

For new concrete installations, grooving, grinding, or saw cutting is unnecessary since forms and spacers can be inset into the quick-setting concrete to create the necessary grooves for the LEDline® installation. Contact HIL-Tech Ltd for details.

Whatever the process, LEDline® is always installed some 2mm - 4mm (1/16” - 1/8”) below the pavement surface so snowplows cannot touch it.

Depending on the size of the installation and in no particular order;

- Glue; some sort of approved two-part epoxy style. (Please contact the contract owners, the DOTs, or Airports for their recommendation/requirements);
- Knee Pads and Rubber/latex gloves;
- Squeegee/s;
- Trowels;
- 75cm – 15cm (3”- 6”) wide Duct Tape to cover the edges of the cut grooves so that any glue spills do not make a mess;
- 3M Gel to seal in the IP69K connector when installing it into the Mounting Plate “U” channel cavity

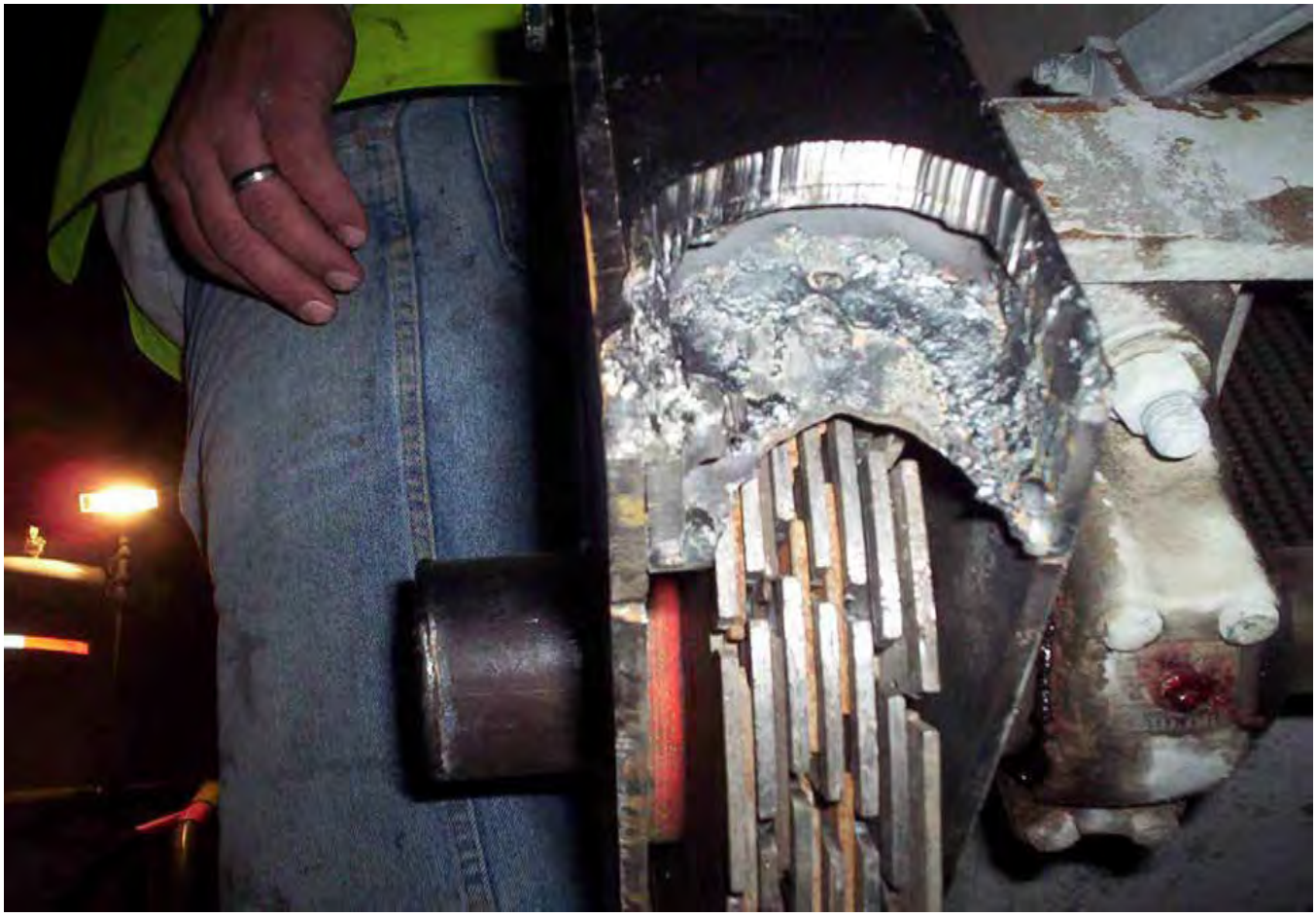
3M #8882 or equivalent;

- 1 – 2 saw cut machine/s with all necessary equipment (depending on the size of the job);
- Foam backer rods, to keep the wires in the grooves until the glue has cured;
- Bricks to hold down the LEDline® so it does not float once it is installed into the glue;
- Have 55mm (2.2”) tape, to cover the surface of the LEDline® before installation, so that when installed, any glue spills will not make a mess of the LEDline® lens surface. (**Note**: This tape must not be removed from the LEDline® surface lens until the glue is set (Do not use painters’ tape as it is too easily torn and if left on for a lengthy period is difficult to remove and leaves a residue that has to be cleaned);
- 1 x 12mm (0.5”) wide saw cut blade to create **the min. 55mm (2.2”) deep groove** for the LEDline® power line circuit with 2 lines within the groove. Alternatively, if two (2) separate power lines (4 x wires) are to run within the groove, a 25.4mm (1”) wide blade can be used to cut the 24mm (1”) wide by a minimum 55mm (2.2”) deep groove. The greater the number of circuits the wider or deeper must be the groove.

- A 24mm (1”) wide blade for up to two separate power lines (total of 4 x wires). With these compound saw-cut blades, the groove can be cut with a single plunge cut pass, minimizing saw cut time.

  Note: If more than one pair of power lines are using the cut groove make sure that the groove is both wide enough and deep enough to accommodate them and make sure that the grooves are at least a minimum of 55mm (2.2”) deep from the pavement surface).

- 1 x 60mm (2.4”) wide blade to cut min. 45mm (1.8”) deep x by some 965mm (38”) long groove in concrete or asphalt for the LEDline® lights. These wide Mounting Plate and LEDline® grooves can be routed/ground out or saw cut with a compound blade made up of a few blades with spacers. Multiple blades with spacers can make the 60mm (2.4”) wide cut with one pass for the Mounting Plate and LEDline® lamps.



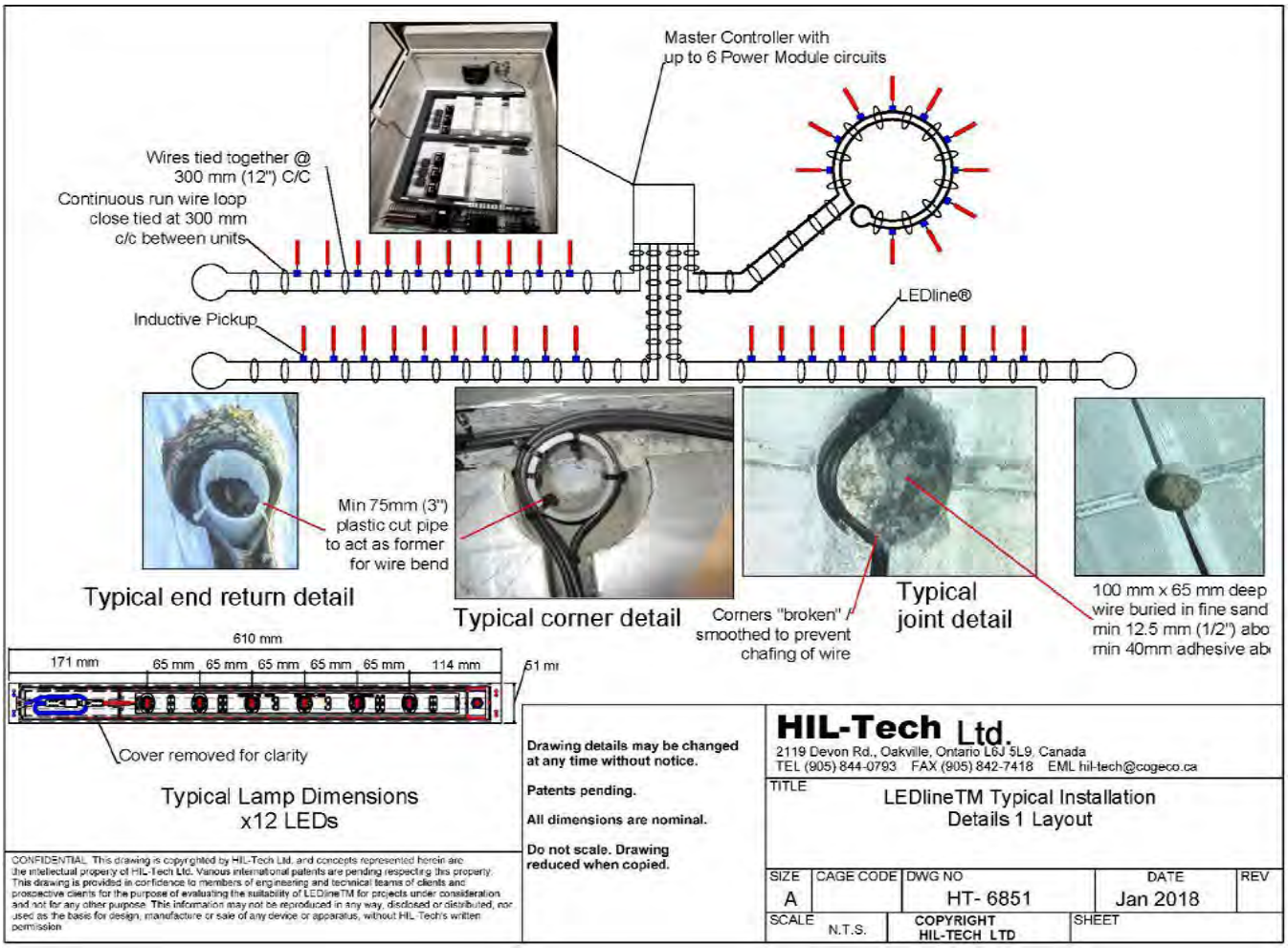
- Chalk and a tape measure, to mark the road where the wire and the LEDline® are to be installed;
- Electric drill (Phillips's head) for the Mounting Plate screw adjustments with a 6mm (¼”) drill to make a hole in the LEDline® connector cavity top for the 3M Gel to be applied. (**Note:** if the harness is fabricated offsite, the hole and 3M Gel should already have been applied);
- All nighttime applications will require good lighting to check the quality of the installation and to see that the color of the glue is consistent when installing the LEDline®;
- (Note: It is easier and quicker to have a compound blade of the desired width than to try to use multiple saw cuts to create the necessary width).
- Direct Burial Wire: Suggested Type; RWU #8 or XPL USE-2. Again, using #8 (USA) RWU
- gauge wire (= #35 metric wire gauge). Max O.D. of wire and insulation must be 7.9mm (0.31”) with a stranded copper area of approx. 11 mm^2 (0.01705sq”), all suitable for direct burial, according to local codes.
- There must be sufficient wire to complete all wire run distances from the Power Supply/s out to the furthest distance of a particular run then back again, (not forgetting to add in the amount to reach the power supply). The doubled wire run length must be sufficient to create a complete

unbroken loop over the entire distance;

- Create a 2mm (0.16”) deep “depth key” of metal or plastic, so that the LEDline® can be measured within the groove and properly set to the right depth below the road’s surface;
- One generator to test the LEDline® Master Controller and circuits;
- Pressure washing equipment to clean any new saw cut grooves or reclean and open saw cuts previously left open from an earlier time;
- Propane and heating wand/s to quickly dry out open saw cuts should they get wet;
- Vacuums to suck out any debris in the open grooves before immediate LEDline® installation;
- Sand or similar material, as per the client's requirements, to fill in and help protect any open grooves from traffic might be needed depending on how long the contractors are allowed to work. Consult local weather conditions at the time of installation and DOTs or airports for their preferred material to temporarily protect open grooves between LEDline® installations;
- Optional plastic sheeting strips and sand to cover/hold down plastic over any open saw cuts to minimize rain delays;
- For concrete slabs, where the power line crosses an expansion joint between slabs, a 100 mm (4”) diameter x minimum 55mm (2.2”) deep hole should be drilled/cored so that it spans the expansion grooves between the separate slabs. This is to house a loop of wire to accommodate different slab movements. Once the wire loop is installed, sand should be placed on top of the wire loop to allow for its movement, then glue should be used on top of the sand to seal it all in and prevent water from accessing this place.
- **Weather Considerations:** Make sure that the weather will support installation; temperature; humidity; wetness etc. should be checked and these considerations considered to make allowances for the adhesive’s setting times. (i.e., Normally, colder temperatures and wet conditions will slow the glue’s setting times, whilst very hot conditions will tend to speed up the setting times). Please read and follow the adhesive manufacturer’s specific installation specifications.

Fig. 2. Crossing Concrete Pad Expansion Joints with The LEDline® Direct Burial Power Line: Below a 100mm (4”) diameter cut hole, created across an expansion joint, allows for a wire service loop to be made, to move with the different slabs. Similar arrangements are made for any expansion joints.

A LEDline® Circuit Schematic:



Off-Site Preparation: *Installers have done this, however, as with any pre-preparations,* ***if the people preparing the LEDline® have not done this before and have not been approved by HIL-Tech, they must have someone present who has****. This is because, when not sealed in glue in the pavement, the IP69K connection system if mishandled, is easily damaged. Please contact HIL-Tech for instructions and authorized HIL-Tech installers in your area.*

To speed up on-site installation, the LEDline®, the Mounting Plate "U" channel, the 4 x screws, and Induction Power Pickup **with their service loop within the IP69K connector housing and the cured 3M Gel to seal in the IP69K quick disconnect, can all be done and be pre-connected off-site.**

(**Note**: The 3M Gel is to prevent moisture from accessing the IP69K screw-together nuts causing corrosion and it has proven successful at preventing the movement of the LEDline® lamp unit within its Mounting Plate, and once installed, prevents movement and rattling from vehicles traveling over it). All this can be prepared off-site and everything once the 3M Gel has cured, be fully connected, and sealed against moisture and available for onsite installation, **provided a HIL-Tech authorized installer is present**. (See General Preparations Page.17).

- When constructing the LEDline® lamp; a HIL-Tech trained and approved contactor or HIL-Tech itself must always be present when these units are being pre-assembled off-site.

- The Mounting Plate should be disassembled to allow the installation of the LEDline® lamp and IP69K connector with its Induction Power Pickup.

- The 4 x depth adjustment screws should be added to the empty Mounting Plate.

- The IP69K Induction power pickup should then be connected to the LEDline® lamp by screwing the two nuts together until they both click. When being attached to the LEDline® lamp unit, the handling of the IP69K wire must be carefully done and its wire NOT kinked or bent;

- A service loop needs to be created within the IP69K cavity. When creating the service loop within the IP69K cavity, it too must be carefully done to avoid any damage to the IP69K wire. (Note: The assembled LEDline® is heavy and the IP69K wires are fairly fragile when not held in place by their glue within their pavement groove, so when everything is being connected, great care must be taken to not stress these wires.

- The grommet holding in the service loop must be properly inserted to prevent glue from getting into the cavity when the unit is installed into the pavement. (Note: This check can be done, before the 3M gel is installed, by carefully pushing in the exterior IP69K connector wire into the IP69K cavity unit until there is slight resistance).

- If a hole in the IP69K cover plate is not present create one by drilling a 6.35mm (¼”) hole in its middle.

- The LEDline® lamp and Mounting Plate are then assembled with the cover over the IP69K cavity installed.

- Once the LEDline® lamp is fully assembled within the Mounting Plate and the service loop within the IP69K cavity is again checked. Placed on a flat area, 3M gel should be poured into the IP69K cavity via a small hole in the IP69K cavity cover. (Note: if this is not there, drill one The 3M gel must be left to cure before the assembled unit is carefully packed for transport to site.

- Do NOT attach the assembled off-site units to the direct burial power distribution wires. This is a prime area when mishandling can occur and the IP69K connector wires be bent, kinked, and broken, thus damaging the LEDline® lamp unit. (Note: Such damage or partial damage to the small wires is difficult to detect and may only show up after the lamp is installed. Thus, if all LEDs within a lamp fail at once, either before they are installed or after they are installed in the pavement, almost 100% of the time is because some or all of the small wires in the IP69K were damaged during the fabrication.

- The IP69K connector is the best connector available. Because of the LEDline®'s lamp's minimal power requirements, only small wires are needed for the connector. When loose and not within their installed positions within the pavement, these fine wires are easily kinked or broken. (Of course, once installed, they are unlikely to be stressed so this is not an issue once they are within the pavement, buried in glue).

- Again, these broken or kinked wires are difficult if not impossible to see as the damage usually occurs within the sealed LEDline® units, so it is hidden. Indeed, if only some of the wires are broken, the lamp may still light so one has difficulty telling if any of the wires are broken or not. However, over time, (depending on how many of these fine wires have been broken), the broken wires may begin to arc, and this may cause heat and burning of the connector and loss of power. If this happens, because there is no power to the LEDs, all the LEDs suddenly will not light. Clear symptoms of this are having all LEDs within an LEDline® unit either not light or all LEDs suddenly fail at once).

- Having all 6 or 12 x LEDs within an LEDline® unit fail at once is always a highly unlikely form of failure, as all the LEDs are effectively independently powered. Therefore, such types of failure are unlikely to be HIL-Tech's fault. Therefore, with all such failures, when returned under HIL-Tech's Limited Warranty, they will be tested. If when tested and powered up the LEDs all light, the LEDline® unit will NOT be replaced under HIL-Tech's Limited Warranty as the damage was done by others. However, if when powered up they stay off and unlit, the unit will qualify to be replaced.
- In addition, if mishandled before the 3M Gel curing, or even after it has cured, the service loop within the IP69K cavity can be accidentally eliminated by having the combined weight of the lamp and Mounting Plate pulling on the wire and pulling the service loop out of the 3M sealed IP69K cavity. This may go unnoticed until the service loop is needed. Therefore, because the small wires within the IP69K connector cord can be easily bent, kinked, pulled out, or broken, NEVER, EVER CARRY THE HEAVY LEDline® UNIT ALONE BY ITS IP69K CONNECTOR).

- Clear duct tape or equivalent must be placed over the LEDline® lens, preferably across the whole Mounting Plate surface, to keep it clean during installation. (Note: Paper-backed tape is not recommended as if left on too long; it is difficult to remove; it breaks easily; and leaves its glue on the lens surface which then has to be cleaned off once the LEDline® is installed).

- Once the units have been put together, before their installation each unit must be carefully stored so that there is no stress on the long exterior IP69K connector cord and Induction Power Pickup connector.

- For contractors new to LEDline®'s installation, a HIL-Tech trained and approved contractor or HIL-Tech itself must always be present to give advice when these elements are being put together. The advice will be on the best way to build/complete the off-site LEDline® lamps and their induction connectors, and then the best way to carefully transport them to the site. (Note: Again, any third-party damage done here is

NOT HIL- Tech's fault so is NOT covered under HIL-Tech's Limited Warranty replacement, so please make sure you have a HIL-Tech-approved contractor of HIL-Tech present when this is done).

- In addition, a HIL-Tech trained and approved contactor or HIL-Tech itself must always be present when these units are installed into the pavement.

Basic Good Practice:

For retrofits, there are two (2) types of grooves needed for LEDline®'s installation, one for the power line/s and the other for the LEDline® lamps and their Mounting Plates.

Make sure that the saw cuts for the LEDline® / Mounting Plate "U" channel unit and the wire power lines between the units are to the correct depths and widths. Where the LEDline® lamp unit is located, the groove **should be a minimum depth of 45mm (1.8") deep** x 60mm (2.4") wide and some 965mm (38") long.

Where the (hopefully) **uncut** direct burial wire power line is installed, **the groove can be much deeper as the standard IP69K connector has sufficient length to accommodate most depths, but it should never be less than the minimum depth of + 55mm (2.2") deep. (Note:** Non-standard longer IP69K connectors can be ordered, contact HIL-Tech for details).

The width of this power line grove is dependent on the number of wires it is carrying. However, with only two direct burial wires, it should only be some 12mm (1/2") wide.

- If more than one circuit is to be installed within the groove, then the groove can be both wider and deeper, but never shallower than 55mm (2.2") deep.

- If wire grooves are crossing each other or there is another circuit's lamp supposed to be installed over the wire circuit, move the circuit, lamp, or both, so that this does not directly happen. Lamps should only be installed over one circuit. (Contact HIL-Tech if you have any questions.)

- **The Preferred Installation Procedure:** Is that the LEDline® units be placed on top of the deeper, narrow power line groove. Router or plunge cut the grooves for the power lines, then, where the LEDline® units are to go, on top of the wire groove, create the 60mm (2.3") wide groove x 45mm (1.8") deep groove for the Mounting Plate, LEDline® and Induction Power Pickup Connector. This way, the LEDline® groove has the power line groove running below it. See HIL-Tech Ltd drawings for details HT-6354 and HT-6355.

  (**Note;** LEDline® is always installed slightly below the pavement and if a separate hole for the induction connector is being created, it must be some 100mm (4") in diameter and a minimum +55mm (+2.2") deep. See HIL-Tech Ltd drawings for details HT-6354 and HT-6355).

- An alternate installation method is to have the narrower power line groove parallel to but slightly away from the wider LEDline® lamp grooves by about 300mm (12"). See HIL-Tech Ltd drawings for details HT-6938 page. 49).

- For inline centerline asphalt installations, try to make sure that any LEDline® installation is at least 200mm (8") away from the nearest asphalt cold rolled join, or this will become a weak section in the

asphalt and with time, the asphalt may start to break down.

- For correct glue adhesion, all saw cuts must be clean, clear of grease and debris; clear of moisture, and dry. ("White Glove" Test; pressure wash after the saw cut to free it of debris or saw-cut sludge and, if necessary, dry it with a propane wand, then test again with the "white glove").

- There are always concerns about getting excess glue onto the groove's pavement edge. To prevent this, most contractors elect to cover the edges with a 10cm (4") wide duct tape or equivalent, so that once the glue is set and the tape is removed, the installation looks clean and neat.
- Remember to cover the top of each LEDline® unit and its Mounting Plate with tape before gluing in the LEDline® units, so any spilled glue cannot get to it and its surface lens is kept clean. DO NOT REMOVE THIS TAPE UNIT THE GLUE IS SET. If the harness with its LEDline® units is being constructed on-site next to the grooves they are to be installed in, **remember the need for the service loops for the IP69K connector**, create them in the Mounting Plate IP69K cavity and once created, make sure the grommet is secure so that the wires cannot be pulled out or the #M Gel exit. Also, remember how thin the IP69K connector wire is so take care not to kink or break it. (**Note:** Provided extreme care is taken, this is often more efficiently done off-site, ahead of time. When connecting the induction power pick-up IP69K connectors to their lamps there, it is useful to use the 3M Gel within the Mounting Plate units to hold everything together. The hardened 3M Gel is also helpful when transporting the units to the site as it holds everything in place.

- If the harness has not been pre-done, then for maximum efficiency, whilst the saw cuts are being created, others should create the LEDline® harness by the side of the grooves. This is done by pulling sufficient wire to run from the Master Controller to the end of a circuit and back again to the Master Controller. **IF POSSIBLE, IT IS RECOMMENDED THAT THERE BE NO BREAKS OR SPLICES IN THE WIRE.** (More on this is available on pages 21 to 36 below).
  All lamps must be pretested and lit before their installation into the glue. A final test should be conducted once the lamps are residing next to their final inset grooves before being placed into glue within their grooves. Any defective IP69K connectors causing lamps to flicker or not light should be replaced.

- Once installed, light up the lamps again and replace any that show any signs or issues.

On-Site Installation:

Wiring The LEDline® Together in The Field to Form a Harness: The handling of the LEDline® is key. Make sure that when handling the LEDline®, its Mounting plate, and IP69K connector, extra care is taken not to carry or hang the completed unit/s via its / their IP69K connector wire. The IP69K connector wire is very thin and easily kinked or broken. Any damage done to the unit at this stage is NOT covered by HIL-Tech's Limited Warranty.

Pull sufficient direct burial power line to reach from the Master Controller location out to the farthest end of a circuit and then back again to the Master Controller, leaving enough spare cable to easily connect the circuit to its Power Module.

Lay out the main power supply wiring (BUSS wires) beside the groove and, individually supporting the LEDline® / Mounting Plate "U" channel section, carefully move/slide the CT along a wire to approximate the installed lamp position. Repeat this for each lamp. Again, ensure that the BUSS wire runs from the position of the Master Controller through each of the induction CT connector holes to the end of the entire lit feature-length and then back again to the Master Controller area, preferably without a break in the wire.

Only one wire goes through the inductive power connectors (CTs), preferably it is the lowest one in the groove for the wires. (This is easily accomplished when everything is in place and the wires and CT are all tie-wrapped together).

The induction CTs will allow a North American #8-gauge RWU#8 or USA type XPL-USE2 direct burial wire, (stranded copper area approx. 11mm2 or (0.01705sq in.), with a cable diameter, including wire cladding of not more than 8 mm (0.31”) to be able to go through the induction power pickup CT central hole.

Make sure that the end of the circuit loop back towards the Master Controller location is large enough not to kink or break over time by having the wire go around a non-corrodible 75mm (3”) plastic pipe or similar wire guide. (If necessary, ensure that the end of a circuit has a slightly wider/ deeper section to accommodate this pipe and loop size). (Please see the enclosed picture on page 38).

Once the LEDline® sections are positioned along the length of the “outgoing” wire, in their designated areas, ensure that both the “outgoing” and the “return” wires are taped / tie-wrapped together at 300mm (12”) intervals or less to form a single wire harness with the main power wires fixed nearby along its entire length.

When going from the Master Controller to the side of the road where the light units start, if you are using a conduit, make sure to have a large enough conduit so that the taped-together wires can be easily pulled through. Again, if for some reason one cannot pull the taped-together wires through a conduit, have sufficient extra wire length available so that once the separate wires are pulled through the conduit, they can then be twisted together to ensure that the wire sections within the conduit always remain in close contact with each other. Any wire going through a conduit should have a wider conduit and be pre-taped or twisted together.

If an LEDline® unit and its IP69K connector wire and CT are all to go through a conduit, then the conduit must be wide enough to easily do this with no sharp turns. The IP69K connector wire cannot be stressed so they must all be taped or tied together so they do not move and can be safely pulled through the conduit without damage.

The direct burial power line wires must be in continuous contact with each other along their whole length, except where one of the wires passes through the induction CT power pick-up connector. Each of the direct burial power lines must also be taped or tie-wrapped on either side of the induction power collectors (CTs). Again, any feed wires going through a conduit should be twisted together and when exiting or entering the Master Controller must also be tie-wrapped or taped together up to where they are electrically attached to the Power Module. This is necessary, as it reduces the impedance levels and prevents the wires from giving off electromagnetic emissions (EM), since the two wires in contact with each other cancel out each other’s EM.

Saw Cuts: The concrete slab or asphalt is routed out or saw-cut or along the line where the LEDline® is to be installed. Do not drive over open saw cuts, especially asphalt saw cuts, since vehicle weight can cause damage to the open saw cut edges!
Measure and mark with chalk where the circuit and lamps are to go. The “narrow” groove or saw cut for the power wire (for one circuit with only two wires, some 12mm (½") wide x and a minimum of +55mm (+2.2") deep, is routed out or cut where the circuit should go, then, usually, the “wider cut” for the

LEDline® units and their induction power pickup connectors made on top of the “narrow” groove at each light position.

It is recommended that the "wider cut", grooved, routed out, or plunge saw-cuts for the Mounting Plate “U” channel and LEDline® units are made after the narrow wire power line grooves/cuts. These should be to a width of 60 mm (2.4”) wide and some 45mm (1.8”) deep. The length of the grooved, routed out or plunge saw-cuts should be around 965mm (38”) so that there is plenty of room to position the LEDline® unit at least 200mm (8”) away from the front of the groove so that low angled light is not blocked by the front edge of the groove.

To Avoid Future Milling Machines: For roads, where the connecting groove or saw-cut is made from the end of the LEDline® feature across to a Master Controller and a Power Module, to avoid future milling machines when the road is resurfaced, the depth of this saw cut to the Master Controller can be much deeper than usual. Here, it is not uncommon to have this depth some 100mm -160mm (4” - 6”) deep or more below where the surface of the pavement is normally replaced. The width of this saw cut is also dependent on how many circuits are returning to the Master Controller at that point, and so is dependent on the number of circuits it is to hold. However, where the LEDline® lamp / Mounting Plate is to be installed, whilst the grooves for the wire can be much deeper (minimum depth 55mm (2.2) deep,) the grooves for the Mounting Plates should only be about 45mm (1.8”) deep.

Avoid Sharp-Edged Wire Direction Changes in Grooves: Any groove or saw cut for the power line wire that changes the direction of the wire must have a radius to prevent the wire from being cut or breaking on a sharp corner when it shrinks in cold or expands in warm weather. Wire/s within all grooves should be loose, not tight, so that when it shrinks in cold weather it will not be damaged. If multiple lines from different circuits are all being fed back across the road, either bury them much deeper or stagger each groove line across the road, leaving plenty of asphalt between them so as not to create a weakened area in the road.

As above, saw cuts back to the Master Controller must allow for wire expansion/contraction so must have gentle radius / angled curves. To avoid possible breaks, remove any sharp edges around these curves, and allow space so that the wire does not contact any sharp edges, as it contracts or expands. Again, to allow for expansion and contraction, do not pull and install the wires tightly within the groove/s, they should be loose.

All grooves or saw cuts must be pressure cleaned and dried immediately after routing or cutting and then dried again, just before the glue is applied. This will remove any mortar “slurry” created during the grooving /cutting process. This is especially true when saw-cutting concrete, as dust fragments mix with the lubricating water causing weak bonding areas. All this must be removed before it dries and sets, or the glue will not bond properly. (Note: If after running your finger/s along the inside surface of an open groove (white glove test), there is still a residue, then the groove must be cleaned again.) Remember open grooves will accumulate dirt, dust, grease, and debris and may need to be cleaned again if left open for a few hours.

All debris must be removed and blown out of the grooves before, first, the glue and then the direct burial wire, induction connectors, and the LEDline® are installed on top of the glue. Have sufficient glue to be able to push all of these down into the glue, eliminating all air pockets and future water collection places, which, with freeze-thaw conditions, inevitably cause asphalt and concrete issues.

For a professional site appearance after saw cutting and cleaning, duct tape the edges of the grooves to prevent getting glue on them when the LEDline® is installed.

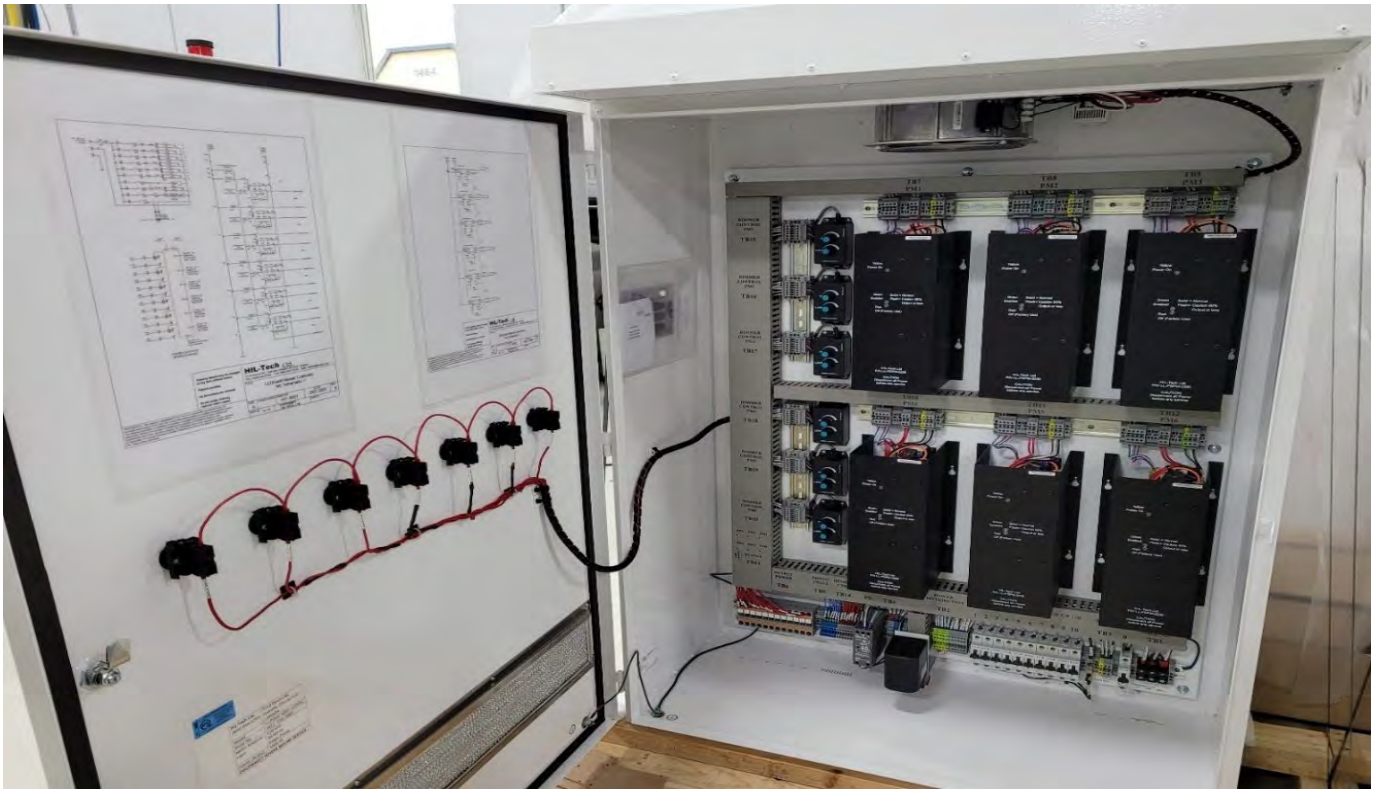
Make sure that any installation is at least 200mm (8”) or more away from the nearest asphalt cold-rolled join or this will become a weak section in the asphalt and with time, the asphalt may start to break down.

Hopefully, all bus wires in circuits should be composed of a single length of wire without a break. For very long runs where a joint must be made, to allow easy future access to that joint should it deteriorate in the future, it is advised to carefully record and memorialize the area where the splice break is done.

Electrical Considerations: For the induction connected/powered LEDline®, the Master Controller contains a pulse modulation power module that provides a constant current power of low voltage to the LEDline® light units. Each 12 x LED unit receives some 700mA at around twenty volts. (This is a series circuit where voltages vary and float whilst the amperage is kept constant).

Master Controller: There is a separate installation and activation manual for this which is available from HIL-Tech Ltd. (All Master Controllers must be connected and protected via power surge protectors.

Master Controller With a Maximum 6 x Power Modules



Each Master Controller can contain up to six (6) x Power Modules inside a (NEMA) rated (3R) weatherproof cabinet of; Height 992.5mm (39.1”) x width 558.8mm (22.0”) x depth 479mm (18.9”). (**Note:** For crosswalks, there are Master Controllers with a single Power Module which are much, much smaller, and narrower).

The Master Controller must be installed at a suitable location, as close to the LEDline® installation as possible, but far enough away from any possibility of vehicle contact. (See the separate Master Controller Installation Guideline). (**Note: Each Power Module separately controls its own LEDline® circuit).**

Wires: Pairs of #8 (USA) BUSS (= #35 metric wire gauge MAX O.D. of wire and insulation 7.8 mm (0.3")) suitable for direct burial, according to local codes, (suggested Type RWU #8 or XPL USE-2), are run inside the saw-cuts (See drawing HT-6257), or inside a conduit, from an individual Power Module to the start of the LEDline® feature. Again, all the wire runs to and from any circuit should not be spliced but should be a single continuous wire run and they should always be tied together.

The LEDline® Master Controller is rated 90 - 240VAC universal input 50 / 60 Hz input (please see power supply spec. sheet). Different variations are available for series circuits at airports or if the LEDline® is to be powered directly from a legacy CCR series circuit then LEDline®'s electronic regulator and an isolation transformer must be used.

Wire Distance: Suggested Type RWU #8 or XPL USE-2. Again, using #8 (USA) RWU gauge wire (= #35 metric wire gauge MAX O.D. of insulation 7.9mm (0.31") or stranded copper area approx. 11 mm^2), all suitable for direct burial according to local codes. For a circuit, measure off the complete wire run distance, (not forgetting to add in the amount to reach the power supply) and then double this distance to have sufficient wire to create a complete unbroken loop over the entire distance. i.e., If the distance is 100m, (328ft) plus another 10m (32ft) to cross the road to the power supply, then the wire loop distance needed would be 220m (722ft).

(Please Note: The induction power system with its non-contact CT power pickup connectors has been specifically developed to avoid creating any possible areas where corrosion can happen to the buried, inaccessible, non-contact, CT electrical connections and wire. Therefore, to avoid corrosion, each wire run should start and end at a particular Power Module and, if possible, NOT be spliced).

SPLICING OF THE BURRIED INDUCTION POWER LINE IS NOT RECOMMENDED, as any splice can become a weak spot allowing corrosion to start. **DO NOT SPLICE** without local DOT or other authorization and always use their approved procedures for splicing in-pavement direct burial lines.

If because of the DOT or other authorized requirements, or because other possible restrictions occur, **splices should be limited**. ***To minimize their number;*** connect the LEDline® units to their IP69K connectors and 3M Gel elsewhere off-site so they are immediately available on-site to slide onto the wires and be installed once the grooves are cut, cleaned, and dried. **Beware, off-site connection/production must be supervised by people with experience of this as the IP69K connectors are delicate and easily broken;**

- ***speed up the saw-cutting of the in-pavement grooves by doubling the number of working saw-cut machines on site;***
- ***have two clean-up crews available to quickly clean and artificially dry the grooves;***

- ***have DOT-approved glues that will quickly cure in cold temperatures;***

- ***if low temperatures cause delays in the setting of the glue around the LEDline®, if possible, delay the time traffic is allowed onto the road;***

- ***pre-cut the grooves in the pavement and have them filled in with DOT-approved media like sand or other media, to support the grooves during the traffic operations, so that traffic can travel over them without damaging the grooves. Then, at night, when the installation resumes, the media can be quickly removed and the grooves quickly cleaned and dried ready for the pre-harnessed LEDline® to be installed;***

- ***have other operations in place to minimize the time it takes to install the LEDline®, but always ensure that the installation is done carefully so the IP69K wires are NOT broken;***

- ***ensure that traffic is not allowed onto the installation BEFORE the glue is cured.***

LEDline® Unit Installation:

If the Mounting Plate "U" channels have been shipped separately to the LEDline®, mount the LEDline® units into the Mounting Plate "U" channel. The connector between the LEDline® unit and the induction power pickup connector should be carefully made within the IP69K connector housing and should always have a service loop.

Afterward, the plastic grommet should be closed, and the hole blocked and sealed with 3M #8882 Gel or equivalent to prevent glue from entering the IP69K housing section when installing the LEDline® and to prevent moisture around the screw together IP69K connector, which can make it difficult to later unscrew if that is needed.

(Note: The Mounting Plate is open to the elements and is not designed to be watertight. As such, the 3M Gel takes up space in the IP69K cavity preventing water/ice/ debris from getting in there, keeping the IP69K connection buried, hopefully preventing the nickel-plated chrome connector from getting corroded thus making it difficult to undo. It also stabilizes the service loop during transportation/installation and helps to prevent the LEDline® lamp from rattling (moving) within its Mounting Plate when driven over by traffic. Such rattling is to be avoided since damage to the Mounting Plate can occur with this movement. Any rattling units should always have the 3M Gel replaced).

Retro-fit Installation into Concrete Slabs or Asphalt via Saw Cut:

Installing the LEDline®: For the LEDline® Limited Warranty to be valid, only certified HIL-Tech qualified electricians should install LEDline®. If there are no locally certified electricians with such experience, then a representative from HIL-Tech must be present on the job site to ensure the correct installation for the Limited Warranty is valid.

Pre-installation Preparation of the LEDline®: Before going to the installation site, the LEDline® can be prepared and everything, other than the wire, can be connected so that installation will proceed very quickly. **(However, great care must be taken here not to kink or break the small, fine IP69K wires and if you are NOT AN APPROVED HIL-Tech INSTALLER, this should be supervised by people who know how to do this);**

Preparation of the LEDline®, Mounting Plate "U" channel, Induction Power Pickup, and 3M Gel: Once the LEDline® has been received from HIL-Tech Ltd., open the box containing the LEDline® / Mounting Plate "U" channel and the induction power pickups to prepare it. The idea here is to have everything ready and the lamp unit pre-connected to speed up site installation. **(Again, great care must be taken here and if you are NOT AN APPROVED HIL-Tech INSTALLER, this should be supervised by people who know how to do this);**

- Install the four adjustment screws that control the depth of the exterior Mounting Plate "U" channel. The four (4) x 10-32 x 0.75" – 1" machine screws need to be screwed into the four (4) x appropriate holes. All four (4) are accessed from the top of the Mounting Plate "U" channel. Just screw them in so that they are secure. (These screws adjust the LEDline® to the right depth, slope, and camber within the onsite cut grooves, so will need final adjustment before the LEDline® can be installed and glued into its position there).

- Undo the nut holding down the LEDline® slide out and open the IP69K connector box.

- Connect the induction power pick-up to the LEDline® within the box. (**Note: Make sure that the red or black "O" ring is intact and present before the two (2) parts of the IP69K connector are tightly screwed together until they lock together so are then joined and watertight).**

- Block the wire exit hole from the IP69K housing so the glue cannot enter this box from the outside by tightening or pushing in the plastic grommet /nut around the wire of the induction power pick-up connector. This should be done after the service loop is established within the IP69K cavity.

- With the service loop, install the IP69K connector into the Mounting Plate "U" channel box to the LEDline® lamp. (**If you are putting in the 3M Gel here rather than later, again, make sure that the end where the induction power pickup enters the box is completely sealed so the 3M Gel will not leak out before it is set**).

- Once the connector within the Mounting Plate "U" channel box is properly installed, replace the LEDline® by inserting it back into the Mounting Plate "U" channel, locking it down with a tightened nut, then install the 3M Gel into the IP69K service loop in the connector box and wait until it has gelled. (**Note:** Provided the Mounting Plate is clean when first mixed, like water, the 3M Gel should penetrate from the IP69K cavity out and under the LEDline® lamp to a distance of about 10cm - 15cm (4" - 6") or so before setting. This is normal).

- Once the 3M Gel has set, top up the 3M Gel in the cavity to block up the hole in the cavity top.

- With clear tape, cover the surface of the LEDline® and Mounting Plate edge, to prevent any **future glue from getting onto it or the Mounting Plate**. (The LEDline® needs to have its face covered

with tape to prevent any glue from getting on it when it is being installed. It helps to have tape slightly wider than the lens so that once it is in its Mounting Plate the tape can seal over the whole surface of the LEDline® lamp and Mounting Plate keeping everything clean from the glue.)

- Place the induction connected ready to install LEDline®, Mounting Plate "U" channel, and induction power pick-ups, carefully into a box to take to site. Treat like eggs and gently handle each unit one at a time, making sure that the connected induction connector does not dangle free to catch on anything. **Do NOT carry the LEDline®/Mounting Plate unit by the induction connector as the thin wire connecting the two can be easily bent, kinked, broken, or partially broken**. (Being partially broken is the worst case as it still allows enough power to light the lamp, however, over time, some of the internal kinked broken wires might start to arc causing heat the connector to burn and the lamp unit to have all its LEDs fail at once). If the IP69K wires at this stage are damaged, the induction power pickup IP69K cord must be replaced.

  (Note: Such failures often cause the whole of the LEDline®'s 12 x LEDs or 6 x LEDs to fail altogether. If this occurs and HIL-Tech then tests and finds that the LEDs work, then, such type of failure is NOT COVERED BY HIL-TECH'S LIMITED WARRANTY because the broken internal wire within the IP69K connector which is not providing power to the unit, was broken by others).

Preparing the Installation Grooves on Site for the LEDline® And the BUSS Wires:

For a clean road surface on either side of the LEDline®, before its installation, duct tape or something similar can used to protect the surface of the road from glue overfills and spills, keeping everything neat.

(Note: A series of weights or bricks will be needed to ensure that once the LEDline® unit is installed into the glue it does not float and so remains in position. Of course, once the LEDline® cannot move in the glue, these weights can be removed and used over again).

Creating The Harness and Installing the Lamp on Site: Keep in mind that it is useful, before any installation into the pavement, to have the completed LEDline® units energized and tested so, if needed, any changes are easily accomplished. (This is why a portable generator and an LEDline® Power Module be brought to the site).

Again, handling is key and none of the units should ever be picked up, carried, or moved to its position on the pavement via its IP69K connector.

Creating The Harness on Site;

The top of all the LEDline® units must be pre-covered with tape to keep them clean during the glue-down process. Always leave this tape on until the installation is complete, and the glue is dry.

Whilst the saw cutting for the lamps is proceeding, the direct burial loop of BUSS wires should be roughly laid out alongside where they are to be installed.

- The LEDline® and their Mounting Plates are then connected up to an IP69K connector and a service loop within the IP69K cavity is then created. All LEDline® units need a service loop. Before the grommet is tightened within its position, the service loop can be created and pushed gently down into

the CT's cavity. The tightening of the Mounting Plate's gromet is to prevent loss of the service loop with handling the completed unit and to prevent the 3M Gel from leaking out when it is installed. It also helps prevent the groove's glue from accessing this cavity when everything is pushed down into a bed of glue in the pavement.

- The IP69K induction connector is then threaded onto one of the direct burial lines. The supported LEDline® units within their Mounting Plates are carefully slid along the BUSS wire until they approximate and parallel to the positions where they are to be installed.

- The BUSS wires between the sections are then taped tightly together every 300mm (12") intervals (or less) all along their entire length, (except where one of the looped wires is threaded through the LEDline® CT connector and here tape/tie wraps can be used to hold everything securely together to the wire harness for the glue to cover).

- At the induction connector (CT), the direct burial wire intersects the CT connector one going through the unit, so the wires here are then taped or tie-wrapped together on either side to the CT to prevent the power line wires and CT from moving.

- If the "lamps" are to be built beside their cut grooves, the most secure method is to slide only the induction CTs along the wire to each position and only then connect the Mounting Plate, lamp, and induction CTs at the roadside, besides their positions. If the road is flat and there is time, once the service loop is checked by gently pushing the CT wire into the Mounting Plate cavity, the resistance will confirm the service loop, so the 3M Gel can then be poured into the Mounting Plate CT cavity and left to cure.

  (Note: If the *LEDline® lamp has been pre-assembled elsewhere, with its LEDline® lamp, Mounting Plate "U"* channels, induction CT connectors, and 3M Gel; carefully slide each the fully assembled unit with their induction CTs along the wire and have a unit left at each position. Note: Care should be taken when handling the CTs, especially when the CTs are connected to their lamps and Mounting Plates as the combination "lamps" are heavy and the wires within the CTs are very small and easily kinked and/or broken).

- Again, **Once a line is in position and fully connected up, the system should be energized as a final trial of the lit LEDline® units before they are glued in**. Any issues that are found can then be easily dealt with.

- For those that have not yet installed the 3M Gel into the Mounting Plate IP69K cavity, before the Mounting Plate is in position in the groove, always **ensure that the service loop, within the IP69K Mounting Plate cavity is still present and has not come out during the handling or transportation to site. Again, to test it, provided one is careful not to bend or kink the wires, gently push the IP69K connector wire into the covered IP69K cavity. If the service loop is present, there should be some resistance**. After this test, lay the Mounting Plate flat introduce the watery 3M Gel into the IP69K cavity and await its curing. (**Note:** Cure times are dependent on temperatures see the 3M Gel instructions).

- The overall positioning of the LEDline® may need to be slightly adjusted to avoid any individual LEDline® unit being positioned across a concrete joint or asphalt-to-bridge joint. Typically, all expansion joints are crossed by using the flexible BUSS wires coiled within a standard wire detail.

Again, all LEDline® sections should be at least 200mm (8”) away from any cold rolled join of asphalt.

On-Site: Preparing the Installation Grooves for the LEDline® and the BUSS Wires: For a clean road surface after LEDline®'s installation, once the road groves have been cut and cleaned, use duct tape or something similar on either side of the grooves to protect the surface of the road from glue overfills and spills, thus keeping everything neat.

(Note: A series of weights or bricks will be needed to ensure that once the LEDline® unit is installed into the glue it has no air pockets for water access, and it does not float and remains in its position, slightly below the road’s surface. Of course, once the glue is set, these weights are removed and used again elsewhere).

***Select the Master Controller Site/s*:** The Master Controller/s power supplies should be located off to the side of the road, close to it but far enough away from it so that traffic cannot by accident hit it.

Installation of the LEDline® can proceed in parallel. Whilst the grooves are being cut, another set of people can be pulling the wire from the Master Controller for each of the circuits and be preparing the wire harness, the LEDline®, and its Mounting Plate “U” channel, ready for installation into the cut groove.

Sometimes the harness can be prepared off-site. However, since this requires extra care not to damage the IP69K connector cords, this must be supervised by a HIL-Tech-approved contractor or by HIL-Tech itself. If extra care is not taken, such damage is easily done if the Mounting Plates with their LEDline® lamps are carried/swung by their IP69K connector cords. **Such damage is NOT covered by HIL-Tech’s Limited Warranty.**

Routing out or Saw Cutting the Grooves:

- First measure, chalk out on the pavement surface, exactly where the power line and the LEDline® and its Mounting Plate “U” channel are to go. (If you are using the alternate (not preferred) side cut and induction power connector hole, then allow for at least 200mm – 275mm (8” - 10”) between the LEDline® saw cut and the power supply distribution wire. (HT-6355 and HT-6354) **(Note: The wire depths are minimums and if required, the induction wire can be installed much deeper).**

- Using a router, grinder, or saw cut machine, where they are required, groove or cut out the power distribution wire groove. Do the same for where the LEDline® units are to be placed. Please see the suggested installation details. (HT-6355 and HT-6354). If using the alternate (not preferred) side cut and induction power connector hole, Cut the diagonal grooves and mill out the 102mm (4”) diameter x +55mm (2.2”) deep induction power pick-up space, where the induction connector meets the power distribution wire. See DOT drawings or HIL-Tech drawings (HT-6355 and HT-6354)

- **High-Pressure Clean:** Once the grooves are “cut,” they must be thoroughly cleaned so that the left-over slurry/material does not dry or cake onto the bottom or sides of the groove, forming weak areas for the glue to adhere to. **Cleaning must be done immediately after the saw cutting with a high-pressure water spray**.

(Note: If the grooves remain open for more than a few hours they may need to be cleaned again prior to the LEDline® installation, since dirt, grease, and dust from passing traffic may have gotten into them again. Always check to see if they are clean (white glove test) and if they are not clean, clean them again).

- **ALL GROOVES OR SAW CUTS MUST BE DRY and CLEAN BEFORE INSTALLING GLUE INTO THEM**. (**Note:** Once the grooves are done, **do not drive any vehicles over the open grooves,** especially on new asphalt edges, as the edges of the saw cuts/grooves can break down and any glue will not have a solid edge to stick to).

- **Working in Parallel on Site: One Group Creates the Saw-cut grooves, Whilst Another Makes the Wire Harness:** As the grooves are being measured and cut, another group can pull the direct burial wire from the Master Controller location along the side of the road/circuit for the full circuit length and then back again to the Master Controller. There should be no breaks in the wire. In addition, there should always be sufficient wire length pulled, so that when the wires are taped together or are twisted together in a conduit, there is always enough wire left over to easily connect to the Master Controller and the circuit's Power Module.

- **Always check to ensure that there is sufficient wire to complete the required circuit.**

- Pull sufficient wire so that there are no breaks to complete a single circuit and thread the LEDline®/induction power pick up onto the outgoing wire, laying each LEDline® unit opposite its cut groove position. (See the specifics here pages 27 -28).

- Once the wire for a circuit is pulled, the LEDline® induction power pickups can be installed onto the outgoing wire, by sliding them and the pre-attached and gel-filled Mounting Plate "U" channel boxes along the wire. (It makes no difference whether they are installed on the wire going away from the Master Controller or the one returning to the Master Controller.) The induction power pickup connectors can be individually slid along the wire until they are roughly in the position they will be installed into the road. The two wires can now be tied together every 300mm (12") so that they make up a single harness with the LEDline®, Mounting Plate "U" channel, and Induction power pickups.

  If this has not been pre-done in the shop, remove the LEDline® insert from the Mounting Plate "U" channel top box plate of the Mounting Plate "U" channel following the previous guidelines, pages 16 – 18 and 27 - 28 on connecting the induction power pick-ups with the LEDline® via the connect. (See enclosed drawing (HT-6355 and HT-6354) and LEDline® Locking Connector picture). Please ensure that there are 150mm (6") long service loops present within the Mounting Plate IP69K cavity).

- Individually, thread the induction connectors and LEDline® units onto the BUSS wire circuit.

- Test all the LEDline® units once they have been installed on the wire harness before installing them into the glue, as an induction power pick-up connector wire might have been damaged when installed or in transit, so might need to be replaced.

- Place a 75mm (3") diameter piece of cut plastic pipe at the end of the circuit/s and tie wrap them together. This is to allow for a smooth return of the power distribution wire circuit at the end of the

circuit, thus preventing any kinking / breaking over time. (Page 39 picture).

- Tie wrap the direct burial wire together every 300mm (12”) to reduce the circuit impedance starting from the furthest end away from the Master Controller, (where the wire bends back to return to the Master Controller). Make sure that each induction pickup connector is tie-rapped on each side of the induction connector to the power line circuit and that the induction power pickup is preferable on the bottom wire of the circuit.

- For efficiency, whilst the grooves are being cut, cleaned, and then dried, the completed harness fabrication can be laid out near and alongside the grooves where the LEDline® units are supposed to be installed.

  (Note: If you have not installed the 3M Gel and the surface is flat, do so NOW. First, ensure that there is still a service loop then tighten the grommet around the IP69K wire so that the exit hole from the LEDline®/induction power pick-up is covered. Pour in the 3M Gel and this and the cured 3M Gel then ensures that the glue cannot enter the IP69K connector area when the LEDline® fixture is pushed into the glue for its final resting place).

Installing the LEDline® Into the Pre-cut Grooves: General Preparation Reminder as per page 17 - 21: Some possible helpful equipment to have when installing LEDline®. **(Note: Depending on the installation, these suggestions may not necessarily be a complete list, and quantities will vary depending on the size of the job):**

- Plastic gloves;
- knee pads;
- Philips’s small type screwdriver (cross-type for #8 machine screws);
- 75mm – 100mm (3”– 4”) or more wide duct tape for keeping the road grooves clean from glue spills;
- 50mm (2”) wide clear tape or duct tape to cover the LEDline® lenses and the cracks on either side of the lenses, to protect them from the glue as they are installed.

  (Note: After being on for a long time, painter tape gets very hard to remove, easily tares and leaves a residue on the LEDline® lens which has to be cleaned, so it is preferable to use another type of clear tape);
- tape measure;
- chalk;
- glue;
- backing rod to hold the power lines in the groove whilst the glue sets;
- depending on the glue type, perhaps buckets for the glue mixing?
- small watering can help when filling up the small grooves around the Mounting Plates with glue. (**Note:** All LEDline® units in their Mounting Plates, the induction connectors, and the power lines, should always be pushed into a bed of glue in the groove so no airgaps develop, and the Mounting Plates are held by the glue from underneath and their sides);
- all LEDline® units should be installed slightly below the road surface. As such, some sort of weight will be needed to hold down the LEDline® within the glue so it does not float and end up above the road surface.
- many paint stirring sticks to mix the glue and push the power lines etc. into the bed of glue within the grooves.

Setting the Correct LEDline® Height, Depth, and Angle within the Groove: It is also good engineering practice to always set the LEDline® below the pavement surface. In areas with winter snow, the only way that LEDline® survives snowplows is to completely avoid them. Therefore, it is important to always set the LEDline® unit slightly below the surface of the road.

(**Note:** Even though the LEDline® is installed slightly below the pavement surface, provided the LEDline® is left on, it is self-cleaning as it melts holes in snow depths of some 18cm (7") deep, so the light should not be obscured by snow).

To achieve the right depth for the LEDline® light unit within the groove, make sure that the Mounting Plate groove is at least a minimum of 45mm (1.8") deep. (**Note:** The groove for the power distribution circuit can be deeper but must be a minimum of +55mm (2.2") deep).

The "front" of the LEDline® is the leading edge of the LEDline® facing the oncoming traffic, which must be set at a "standard distance" away from the leading edge of the groove, (minimum 200mm (8")), so that the low angled light (vital for being viewed from a distance), is not physically blocked by the end edge of the groove. Mark where the "front" of the LEDline® is to be within the groove, making sure that this is consistent for all the installed LEDline® units.

Again, the LEDline® should always be below the pavement surface, especially in areas where snowplows operate. No part of the LEDline® should be able to be in contact with snowplow blades. (Contact HIL-Tech for any guidance).

Once the grooves for the LEDline® and Mounting Plate "U" channel have been cut, cleaned, and are dry, each LEDline® / Mounting Plate "U" channel unit, should be tested within and adjusted to its designated groove. Its four (4) mounting screws should be adjusted to position the LEDline® unit to the right depth, aspect ratio, road slope and camber (side slope), etc. These screws do not have to be fully screwed down, as they are just adjustment screws, so their heights will vary depending on the groove's depth. Once the glue is set these screws help hold the LEDline® down within the groove.

Using the four (4) x #8 machine screws on the Mounting Plate "U" channel, adjust the screws within the LEDline® groove position until it is at the right depth within the groove and the LEDline® is slightly below the pavement surface at the right camber, pitch, etc. to the road surface. Then remove the light unit, lay it by the groove, then move to the next light unit, and repeat the operation.

(**Note**: To standardize the LEDline® surface lens depth to the road surface, many contractors have made a simple metal or plastic depth gauge key guide for the installation and keep the LEDline® some 2mm - 4mm (1/16" - 1/8") below the road surface. This helps to quickly standardize the LEDline® lens face to the surface of the road. Others have simply had a brick to slide over and along the groove/installation to make sure that no part of the LEDline® lens is above the road surface).

Always introduce the glue into the groove first of all, so that there is a bed of glue, before pushing power lines and induction connector then the LEDline® / Mounting Plate "U" channel down into the glue to its per-determined position. Provided they have been properly calibrated, the four (4) x Mounting Plate "U" channel screws will maintain the LEDline® unit at the right depth (slightly below the pavement) and the right angle, camber, and pitch. If they do not, adjust the screws before the glue sets).

All four (4) screws are accessed from the top of the Mounting Plate "U" channel**. NO screws should be sticking up above the surface of the glue once it is installed**. Once the glue is installed and the unit is still too high, so the screws have not been positioned properly, the mounting screws should be immediately recalibrated. **As no pavement is level, once the LEDline® is installed into the glue, make sure that the entire length of the LEDline® is slightly below the pavement surface.**

Again, all LEDline® must be installed slightly below 2mm -4mm (1/16" – 1/8") below the pavement surface so snowplows cannot contact them as well as being set at a minimum of 150mm – 200mm (6"- 8") away from the front of the groove.

If, due to a road's camber the LEDline® unit is to be installed on a ridge line in the road, then extra care should be taken to ensure that the LEDline® unit is slightly below the road surface. On a ride line, even mounting the LEDline® units slightly below the pavement may not be deep enough to avoid the plows, since the snowplow blade will be resting on the ridge / LEDline® as it moves along the ridge crest. In these circumstances, if possible, it is better to move the LEDline® away from the ridge line. If it cannot be moved, then recess the LEDline® by an additional 2 mm (1/16"). It is especially important that no snowplow blade can reach the LEDline®, so please ensure that the unit is at the required depth.

(**Note:** Despite being slightly below the pavement, if LEDline® is set back away from the groove front some 150mm – 200mm (6" – 8"), even below the pavement surface, the low angled light from the LEDline® can still exit towards the viewer so the LEDline® will remain visible from distances).

For those wanting even lower angled light facing the viewer, via the four corner screws, it is possible to make the back end of the semi-directional LEDline®, (where the power comes in), slightly higher than the front. All of the units are still slightly below the pavement, but the unit is slightly angled down, slightly deeper at the front. However, make sure all of the lamps are still slightly below the road surface.

At the end of the circuit, support the power wire loop with a 38mm deep section from a 75mm plastic pipe. Install the section in a 100mm deep, 75mm wide hole. And, as per the picture below, tape or tie-wrap the power line wire to the pipe so that the two cannot separate and bury them in glue. This is to maintain the loop over time so that the power line does not kink and break.

Within any groove; never, ever tighten/pull tight the wire run harness, but always install it in a loose configuration. Make sure that the wires are taped or tie-wrapped together, every 300mm (12”), and allow some slack, for expansion and contraction, especially when going around bends. (**Note: Within all grooves, all sharp corners should be removed and/or rounded before the wire’s installation, so the corners cause no issues over time).**

It is critical to have the right depth for the power line wire run between the LEDline® units. **The minimum required depth is 55mm (2.2”).** They can be much deeper than 55mm (2.2”) however, any installation of these wires in less than 55mm (2.2”) in depth is unacceptable and will void any product Limited Warranty. The depth required where the LEDline® is installed is a minimum of 45mm (1.8”).

Too shallow installations cause nothing but trouble. If the power distribution wires are too close to the road surface, they will expand in summer heat work their way onto the road surface, and be damaged or broken by traffic. Again, any such installation is the installer’s responsibility and will void the HIL-Tech Ltd. Limited Warranty.

Always tape the edges of the saw cuts with duct tape to keep the road and installation clean.

Choosing the Glue**: (Please Note**: HIL-Tech Ltd does not recommend or take any responsibility for the selection or use of glues. Many authorities have glues specified for their local weather conditions, so it is the installer’s responsibility to consult with the buyers and select the glue. In all cases, the glue manufacturer’s instructions must be followed to the letter)!

The ideal glue will harden quickly in moist conditions and once cured will remain flexible (not brittle) even in cold temperatures so it can expand and contract with the weather temperatures, sticking to the asphalt or concrete edge so as not to allow any water ingress, at any time.

The typical adhesive should be an epoxy or other style of glue, which meets the above ideal and should be mixed at the time of installation using a static mixing nozzle of the right length and size or be hand mixed. (Again, please refer to the glue manufacturer’s instructions for nozzle sizes and glue set times, since the latter is usually temperature and wet weather-dependent). The glue manufacturer’s instructions for mixing and the glue’s application in temperatures or wet/moist conditions MUST be followed at all times.

For flat road surfaces, the usual Department of Transportation-approved self-leveling glue for ground loop applications should be fine. For slopes, the usual Department of Transportation’s firmer “stay put” glue should work.

Some glues are more tolerant of damp conditions, again, local Departments of Transportation or other organizations know their local weather conditions so have usually pre-approved glues for these conditions.

(Please Note: HIL-Tech Ltd does not recommend or take any responsibility for the selection or use of glues. Whatever the local Department of Transportation or airport’s glue preference/selection, the selected glue manufacturer’s instructions must be followed to the letter)!

Glues:
Make sure the glue is approved by the client.

Make sure that the chosen glue will function in the expected weather conditions, installation temperatures, moisture, etc.

Once everything is positioned for installation and the depths of the LEDline® / Mounting Plate "U" channel have been set using the four (4) **leveling** screws, electrically test the length of the feature LEDline® line again **before** its installation into the glue to ensure everything is working.

Installing the Glue and LEDline®: Make sure that there is sufficient glue available for the project. On **flat-level** areas, self-leveling glue can be used. On grades use the two (2) x part epoxy style or other glue that stays where it is placed, this way the glue can be deliberately placed and squeezed and smoothed into place. Whatever the glue, always quickly clean off any excess.

Again, the glue should **always be installed first into a section of a groove** and then the wire; induction power pickups; LEDline® fixtures**,** etc., be sequentially pushed down into the glue. This ensures that there are no air pockets left to potentially fill with water and then with **freeze/thaw** conditions, expand causing damage to the groove or the LEDline® by lifting it so that it may be damaged by **snowplows** or traffic.

A little experiment will determine how much glue is necessary before the LEDline® or distribution wire is pushed down into it. Again, the process must avoid having trapped air, causing voids for water to get into. (It is helpful to have pre-sealed the edges of the saw cuts with duct tape, so that any excess glue can cure on it rather than the road).

Make sure that the wires in the groove are taped or tie-wrapped together every 300mm (12"). Once placed into the glue in the groove, do NOT pull them tight, but allow some slack for summer/winter expansion and contraction in the grooves.

Any wires crossing an expansion joint should have a 100mm (4") diameter by 75mm (3") deep hole cut into the pavement and have a standard wire loop bent into the hole to allow for any expansion or pavement movement.

Ensure that the grooves are very clean and ready for glue.

For a clean project look, use 75mm (3") – 100mm (4") duct tape, and tape the edges of the cut grooves so any spilled glue will not affect the road surface.

If possible, load the induction connectors onto the bottom power line in the circuit, so that they are attached to the bottom wire, and have the maximum amount of glue around and on top of them. Do not tighten the wire run harness in the groove since it must be able to shrink and expand in cold and hot temperatures without breaking, but everything should be buried within the glue.

For installations where the power line is located below the lamps, usually starting at the end of the circuit, (the farthest point away from the Master Controller), apply the glue for the buried wire for a small linear section, then sequentially pick up and push down the tied together wire harness, the

induction connector, and then the Mounting Plate/lamp into the glue. The glue should flow up and around the LEDline® wire and lamp sections. Then, if needed, add enough glue into the grooves, so that when installed, the wire, the induction connectors, and the LEDline® will be buried, with only the surface of the LEDline® showing slightly below the pavement.

By installing the glue first and then pushing the LEDline® into it, the LEDline® and Mounting Plate "U" channel should displace the glue so that it rises on either side of the Mounting Plate, forming a slight meniscus at the level of the road. This is to ensure a watertight seal so that no air voids will form within it. Infill any areas that need more glue but do not glue in the lamps within their Mounting Plate.

Clean off any excess or spilled glue areas, especially any glue obscuring the taped LEDline® top. At this time, the LEDline® should still have the tape on its surface so that no glue can get onto its surface or between the lamp and Mounting plate and the edge of the grooves should still have their tape protecting the surface of the road there.

LEDline® is always installed some 2mm - 4mm (1/16" - 1/8") below the pavement surface so snowplows cannot touch it. If necessary, make up a tool to check this level quickly and easily.

Again, starting at the furthest end of the wire circuit and working towards the Master Controller / Power module/s, the wire harness and then the LEDline® units can be sequentially placed into their glue-filled grooves and pushed down until they contact the bottom of the groove to ensure the right harness/lamp groove fit is accomplished. This is achieved by having a bed of the properly mixed two-part adhesive ***pumped/placed*** into the bottom of the power lines and LEDline®'s groove to a pre-determined level (found by a small test with an actual saw-cut).

Again, depending on the circumstances, drawings**,** and circuits, the power line can be installed first into the glue, or its separate hole and groove, then the LEDline® can be subsequently placed into the grooves. (HT-6355 and HT- 6354)

Again, typically, the saw cuts are filled to about 25mm (1") below the top before the LEDline® and Mounting Plate "U" channel is installed into the glue. (Varying depths of ***the*** groove will alter this.)

The glue should hold the LEDline® and its Mounting Plate "U" channel with the four (4) adjustment screws and there should be no holes around it. If there are, fill up the holes with extra glue. (This is where a small watering can, to pore in glue, comes in handy). The waterproof connector is protected within the 3M Gel and its box within the LEDline® inset and has a plastic Sine plug, covering the wire hole leading out of the IP69K connector housing, so that when it is screwed tight, it will grip the wire preventing any glue from entering the connector housing.

Installing glue just before installing the LEDline® or the wire power lines means that the glue will contact both the bottom and sides of the cut groove and will flow around the installed wires and the LEDline® units eliminating any cavities. This means that there will be nowhere for water to penetrate, and the glue will have maximum adhesion to the groove and to the LEDline® Mounting Plate "U" channel.

The ***taped-together*** BUSS wires and LEDline® assembly (LEDline□, Mounting Plate "U" channel**,** and waterproof induction power ***pick-up*** connector) are sequentially pushed down into the sections of ***the***

glue bed within the saw-cut, as a single unit.

If possible, load the induction connectors onto the power line so that they are on the bottom wire, ***and*** have the maximum amount of glue on top of them.

After having been pushed down through a bed of glue, make sure that the wire power lines are installed towards the bottom of the groove loosely (not tightly pulled) so that they can move a little with road expansion and contraction.

A foam backer rod 150mm – 200mm (6”- 8”) long should be installed every 600mm (24”) on top of the wires to keep them within the groove until the glue cures.

Again, with LEDline® installations, units are always pushed down into the groove, until the Mounting Plate “U” channel***’s*** pre-adjusted support screws contact the bottom of the groove in their calibrated space and the LEDline® is at the right depth, slightly below the pavement surface.

If something has changed, so that the LEDline® is too high or low, immediately adjust it in place, by using the four (4) adjustment screws.

When pushed into the glue, the adhesive-sealer should squeeze up between the walls of the saw-cut and the side of the LEDline® units to in-fill the saw-cut edges to be paved surface. (Note: Again, make sure that the LEDline® is always slightly below the road surface so that snowplow blades cannot touch it).

Once the LEDline® units, power BUSS wires, and induction power pick-up connectors are all in their groove, and the LEDline® units weighted so as not to float in the glue, additional glue may be added to any area where the glue is below the norm to bring up the glue’s level to the top of the LEDline®’s / groove’s edge.

DO NOT *OVERFILL* AND REMOVE ANY SUCH OVERFILLS IMMEDIATELY BEFORE IT DRIES, ESPECIALLY ANY GLUE THAT GETS ONTO ANY uncovered LEDline® LENS, AS IT WILL OBSCURE THE LIGHT OUTPUT. Glue that gets between the LEDline® lamp and its Mounting Plate, (on the inside) should be immediately removed before it cures. Hopefully, the properly taped and sealed right across the top of the LEDline® unit will cover everything so will prevent this.

At this time, infill any missing glue before the original glue dries. (Note: The fixing times for the glues are temperature and wet ***weather dependent***. (Please see the glue manufacturer’s recommendations, the glue manufacturer’s instructions must always be followed as to the time to cure, based on temperature ***and/or*** humidity dampness)).

In normal summertime temperatures, with most two-part epoxy style glues, the glue / LEDline® units**,** etc. should be allowed to ***be*** set undisturbed for at least 2 – 4 hours (for approved quickset epoxies) before traffic is allowed over them. If the glue has not cured, under no circumstances should traffic be allowed to travel over the unstuck LEDline® as the LEDline® can move and the connection to the buried power lines be broken. HIL-Tech’s Limited Warranties are null and void if this occurs**.** (The glue manufacturer’s instructions for installation, cure times, etc., must always be followed).

Again, all LEDline® products must be installed **SLIGHTLY BELOW** the paved surface. In tropical climes, the product is also installed slightly below the pavement.

DO NOT REMOVE THE PROTECTIVE TAPE ON THE LEDline® LENS UNTIL THE GLUE IS PROPERLY DRIED.

Beware of Pavement Camber. As previously mentioned, in snowplow areas, if the pavement camber is causing a ridge in the road, install the LEDline® at the side of the ridge NOT on the APEX of the ridge. If the LEDline® units have to be installed on the apex, then, the LEDline® units must be installed some 4mm (1/8") below the road surface, so snowplow blades cannot touch them, (slightly lower at the leading front of the lamp compared to the back, with the adjustments being done with the supplied leveling screws).

The LEDline® should be at least 200mm (8") away from the leading edge of the groove. **Under no circumstances should the snowplow blade rest on or even be able to reach or touch any part of the LEDline® unit**. (As a test, place a brick or other straight edge firmly onto the road surface and move it over the leading edge of the LEDline®, if it catches, then that edge may need to be pushed down further into the glue, so adjust the four (4) adjustment screws and push the LEDline® down further into the glue.)

If for some reason the LEDline® unit is above the road surface, and the glue has cured, it and the glue must be removed, and everything reset so that the lamp is below / the surface.

At airport installations, or where it is not desirable to allow viewers to see any light from the side, (until one is right on top of the LEDline®), the units may be installed deeper below the surface to take advantage of the groove's sides ability to physically cut off low angle light from the side of the LEDline®. This way, visibility from the side is eliminated until one is right on top of the LEDline®. Experiment on-site in a groove that has no glue in it to achieve the correct depth, or, if in doubt, consult HIL-Tech Ltd.

- As before, the LEDline® must be below the pavement, but this is paramount for areas that use snowplows so that they cannot even touch the LEDline®. **Therefore, to ensure that the LEDline® is 2mm - 4mm (1/16" - 1/8") below the pavement surface, as a quick check, it is suggested that one make a tool to quickly measure this depth.**

  Depending on the glue, adequate weight/pressure must be applied to the LEDline® units so that they cannot float in the glue and will remain below the surface of the road until the glue is cured. If necessary, concrete blocks or bricks spanning across the groove can accomplish this and, if necessary, shims under the bricks can further ensure that the LEDline® is kept to the right depth.

- The glue must be in contact with the bottom of the Mounting Plate "U" channel / LEDline® unit, and cover over both of the ends of it, locking in the LEDline®, and must flow around and up the sides of the Mounting Plate and eventually be slightly below the surface, so that there are no voids for water to collect in.

- In addition, any gaps left beside the LEDline® units and the road edge, or where the induction connectors are submerged in glue, must be filled, and sealed to the surface of the pavement.

Preferably, infill any deficiencies before the glue dries, since many types of glue do not stick well to glue that is already dried.

- After the glue has set, (*this is temperature and moisture dependent*), there should be no gaps between the LEDline® and the groove wall. (Please see the glue manufacturer's recommendations for curing times). If there are any gaps, then infill again using the glue to the top of the saw-cut wall and allow for the glue to cure, which is always temperature and wet weather dependent, for this final application to cure.

- **Once the glue has set and there is no need for further applications of glue (all the edges between the Mounting Plate and edge of the pavement etc. are filled with glue) ONLY THEN** can the protective tape covering the top surface of the LEDline® and Mounting Plate be removed.

  (Note: Immediately scrape off or clean any glue that has accidentally gotten onto the LEDline® lens surface, since the surface must be clean and clear. And, if necessary, mechanically clean off the glue. (This will scratch the surface lens, but over time, the lens gets scratched up anyway)).

In Very Cold Winter Areas: Contact HIL-Tech for special precautions and installation instructions if LEDline® is to be installed in areas where temperatures can go below minus -30°C (minus - 22°F). If this is the case, then the Master Controller must have its internal heater set to prevent water condensation when the dew point is reached when the unit is off, so set to come on at around 10°C (50°F).

- No matter what its programming, the LEDline® units are temperature controlled so that they will automatically switch on if the temperature falls below -30°C. (-22°F), so that they keep themselves warm in extremely negative temperatures. Such settings are achieved within the Master Controller.

- Custom Adjustments to the Master Controller: Only HIL-Tech certified, qualified electricians can install LEDline® or adjust the Master Controller. If there are no locally certified electricians, then a representative from HIL-Tech must be present to ensure the correct installation for LEDline®'s Limited Warranty to be valid.

- Once the LEDline® pavement installation is complete, the LEDline® should be again energized and the custom adjustments at the Master Controller should be implemented (Please see the relevant Master Controller instructions and contact HIL-Tech Ltd.).

- Client-specific nighttime dimming requirements of the LEDline® should now be pre-programmed into the Master Controller. There is a low voltage 21 VDC circuit within the Master Controller, which accepts a photocell input so automatically dims the LEDline® units for nighttime applications. Both the high output and lower (nighttime) output light levels can be adjusted to suit clients' wishes. (Please see the Master Controller instructions).

- Once the glue has set, the site should then be cleaned and the duct tape around the cut grooves removed. **Again, do not remove the tape from the LEDline® before the glue is set.**

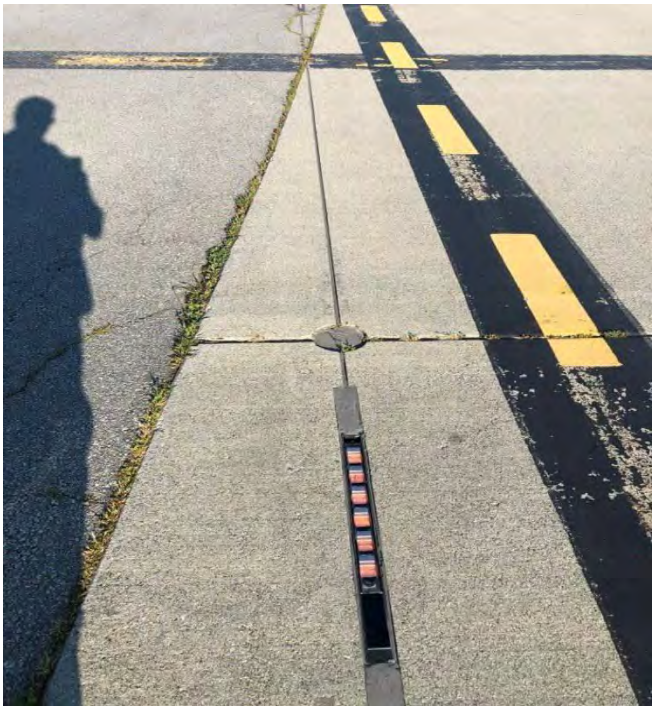
Once Installed: When lit, the LEDline® should be at a uniform height and position within the pavement and should look even and uniform along its entire length. Any units that do not should be immediately investigated and attended to.

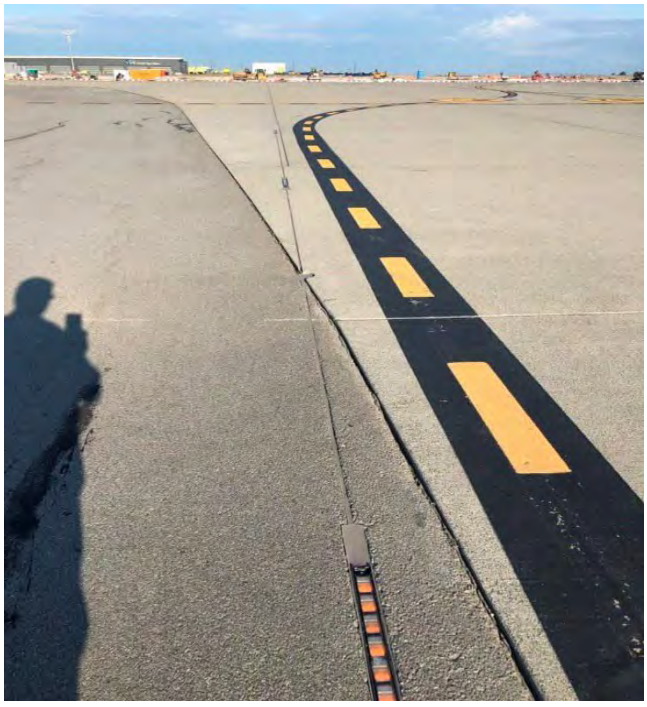
- If any units are too high, so that snowplows will touch them, then the LEDline® should be dug out and reset into the groove so that they are slightly below the pavement surface. **The HIL-Tech Limited Warranty will not apply to any units that a snowplow can touch.**

- If any units are too low, then grind down the pavement around them so that they can be seen, or if that remedy is not available, dig out the LEDline® and reset it.

There are many pictures of the oldest installation of modern style 12 x LEDs LEDline® from Vancouver International illustrating just how well LEDline® has done over the years in both concrete slabs and asphalt. Here there is no cracking or spalling of the pavement indeed the installation still looks good.

As of September 2023, Mr. Holtz confirmed that the LEDline® there are still left on 24/07 and that they were still working, which **as of September 2024 means that they have been lit for some +15 years and counting!!**





The two above pictures were taken on 30th October 2019 by Mr. Tim Holtz, Supervisor of Vancouver's Airfield Maintenance Engineers**. Key areas were photographed where the LEDline® power lines crossed expansion joints and/or exited concrete slabs or asphalt at acute angles, illustrating that if LEDline® would cause any spalling or cracking to occur, it would have done so. There were None!**

In the fall of 2019, the installation in Vancouver still looked good and there was no cracking or spalling of the concrete slabs despite being then installed for some 10 years with Vancouver's location issues.

Vancouver International is an excellent test for any in-pavement lamps including LEDline® since;

- **Vancouver averages some 500 or so earth tremors a year, which tests any installation;**
- **Vancouver has frequent winter freeze/thaw conditions, again, testing any installation;**
- **the LEDline® installation there, apart from the grass growing between the asphalt and concrete slabs, shows little signs of wear and tear and still looks like new).**
- **Vancouver has frequent winter snowplowing and ice removal brushing of the LEDline® lamps in winter;**
- **over many years, being installed in the de-icing pads, the LEDline® there has experienced many chemical sprays and soakings of highly aggressive/corrosive winter aircraft de-icing fluids like glycol and other chemicals;**
- **the LEDline® there has been left on since it was first installed back in the fall of 2009, so has been on and working 24/07 x 365 days for some +15 years, (September 2024) and is still in use today;**

IP69K Connector: Ifm M8 Male and Female Pico DC Cordsets and Field Wirable Connectors EVC141

Technical Specs – Cordsets (ifm)

Special feature: Free from silicone; Halogen-free; Gold-plated contacts; drag chain suitability;

Operating voltage: Without LED: 50 VAC / 60 VDC
Current rating: 3A
Protection Class 111
Protection rating: **IP69K = Protected against ingress of dust and high temperature and close-range high pressure.**
IP69K Test **Temperature spray downs**.
(On a rotating turntable, with a speed of 5 ±1 revolutions per minute, the test requires a spray 4"- 6" (101mm-152mm) from the product of 4 gallons/16 liters per minute with water pressure of between 1160-1450 psi, at a temperature of 176°F/80°C. The heat and spray must not cause damage. The IP69K rating is the highest protection available unless custom deep-sea connectors are required. **Please contact HIL-Tech for technical specs. on any required deep-sea connectors**).
Tightening torque: 0.3....0.5 Nm
Ambient temperature: -25°C +90 °C
Flex rating: > 5 million cycles
Material body: TPU housing,
Viton O-ring
Material coupling nut: Nickel-plated brass.
Cable: PUR, halogen-free, 24 AWG conductors, Ø 3.7 mm
Approvals: cULus, cRUus and RoHS standards

-

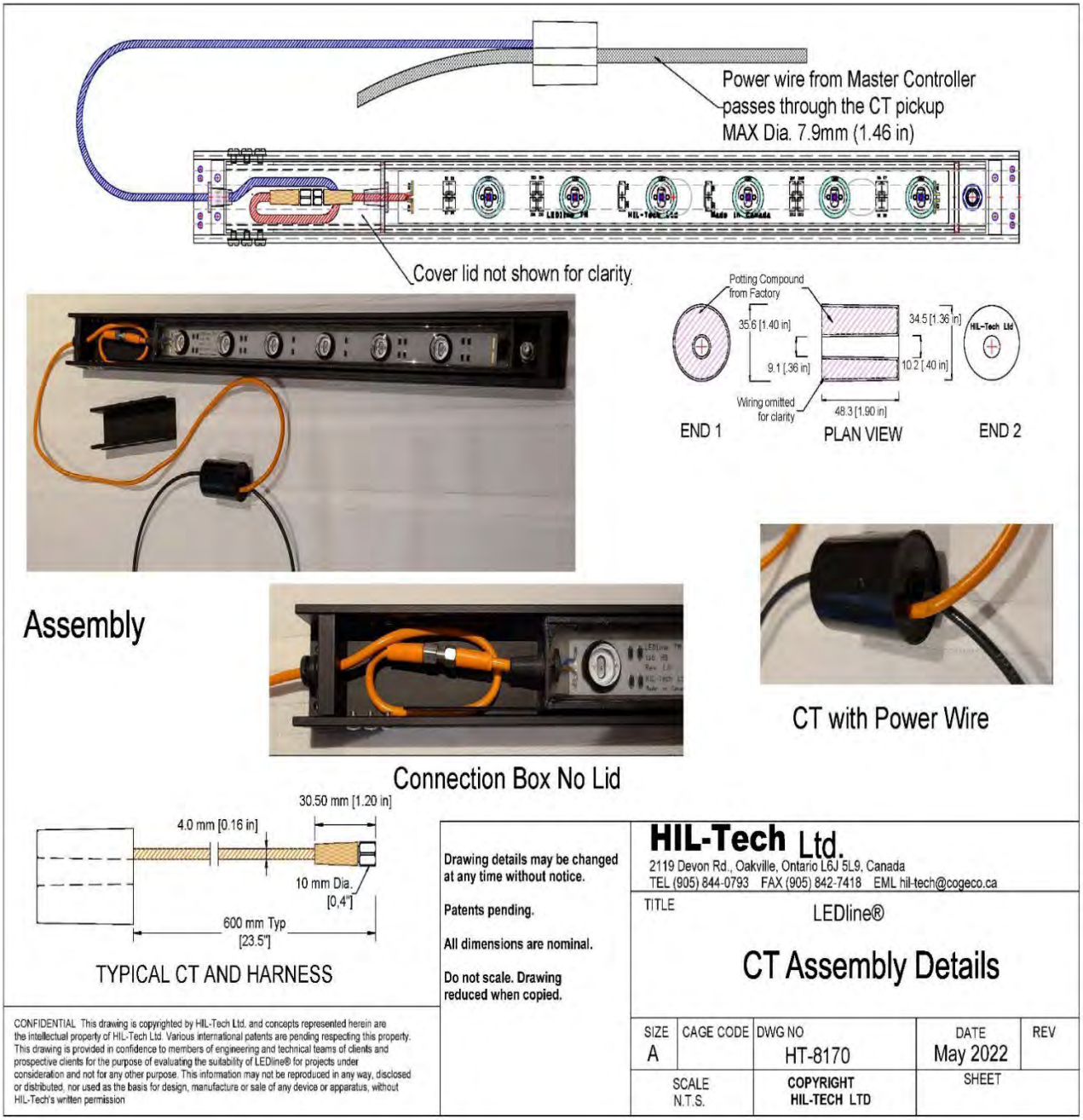
ifm TechnicalSpecs – Field Wirable Connectors
Operating voltage: **5**0 VAC / 60 VDC

-

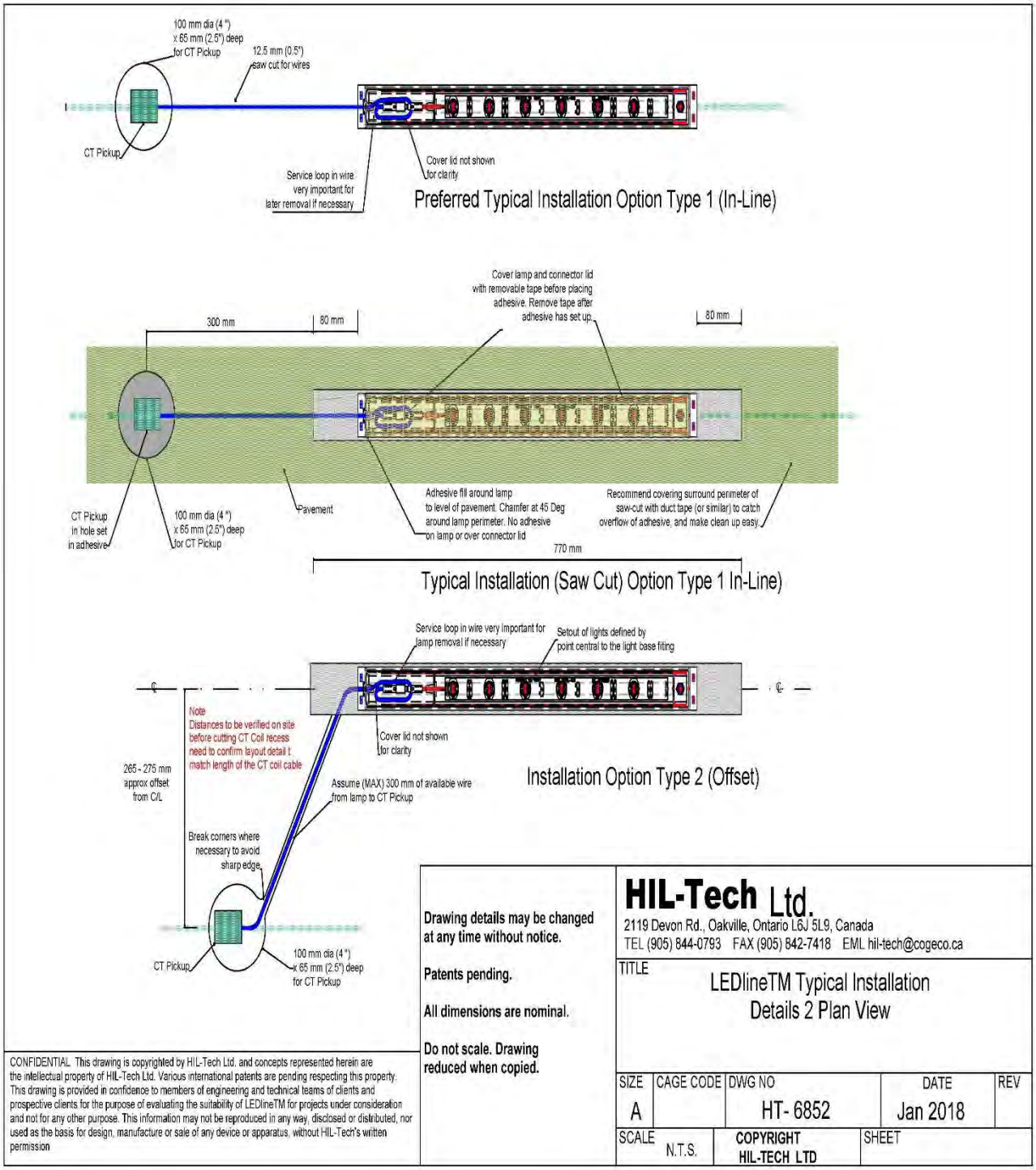
Protection rating: IP69K
Material body: Nickel-plated brass (L33600, L33601, E18216, E18218)
PA (L33602, L33603, E18217, E18219)
Material Coupling Nut: Nickel-plated brass.
Cord Set Features:

- Cordsets feature a "Lock-in-Place" coupling nut that resists high levels of shock and vibration.
- Cordsets offer high-flex PUR-jacketed cable rated for over 5 million flex cycles.
- A special insert design includes a mechanical end stop preventing damage to Viton O-ring from over-tightening.
- Cordsets are designed and tested to resist harsh conditions in industrial automation.

HT-6379 (Not to scale) Drawing of Induction Power Pick up Connector, (CT = Current Transformer and IP69K connector).

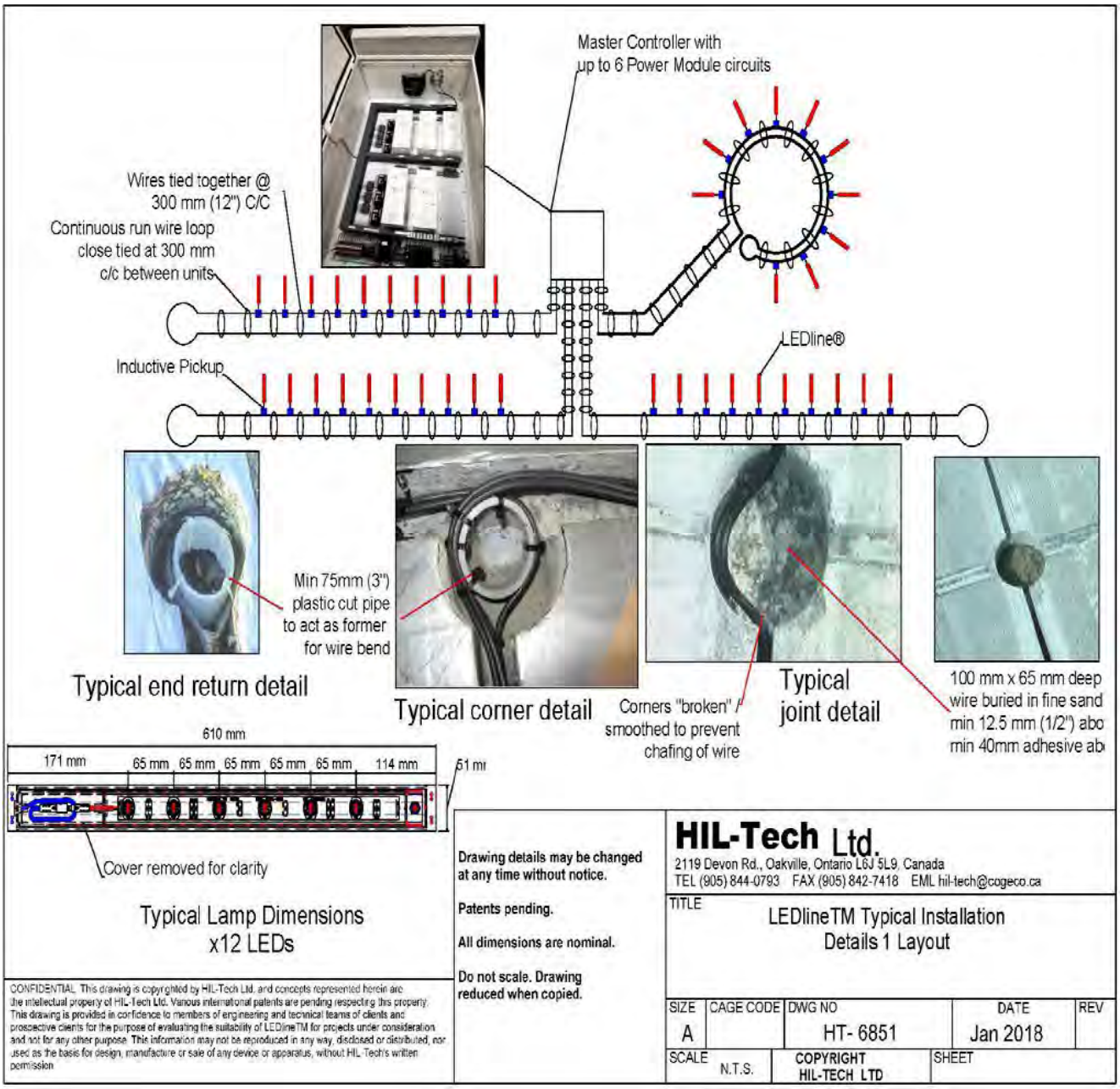


Typical Installation Sawcut Options
HT 6852 (not to Scale) Copyright HIL-Tech Ltd.



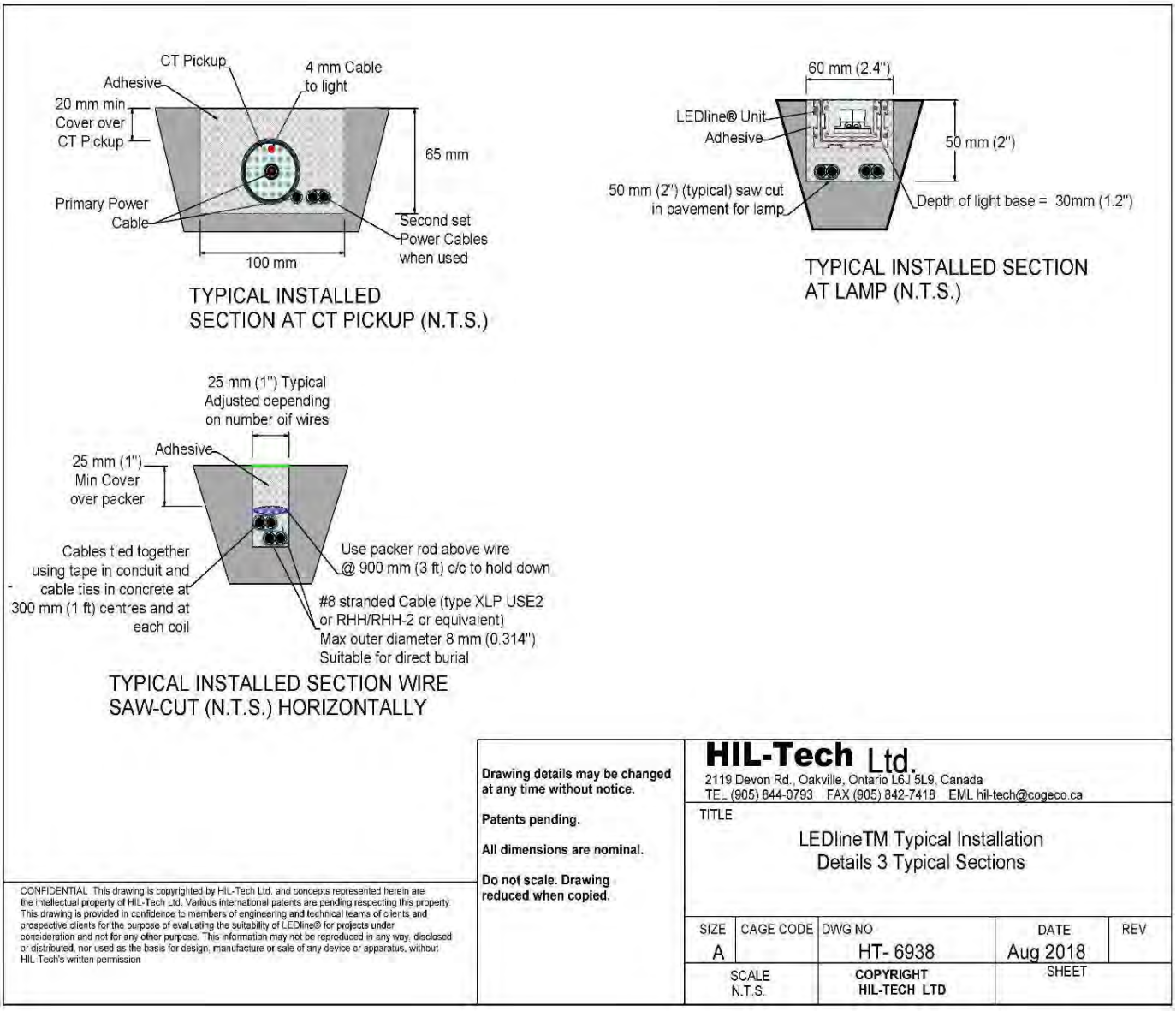
Below is an older style LEDline® installation illustrating how as per Page 49 above, the induction power cables, and induction power CT pick-up connectors can be placed in the middle of a no-passing line of lamps, separate from the lamps, which then run either side of the cable.

HT- 6851 Typical LEDline® Schematic of Induction Power Supply and Distribution Details (Not to scale). Copyright HIL-Tech Ltd.

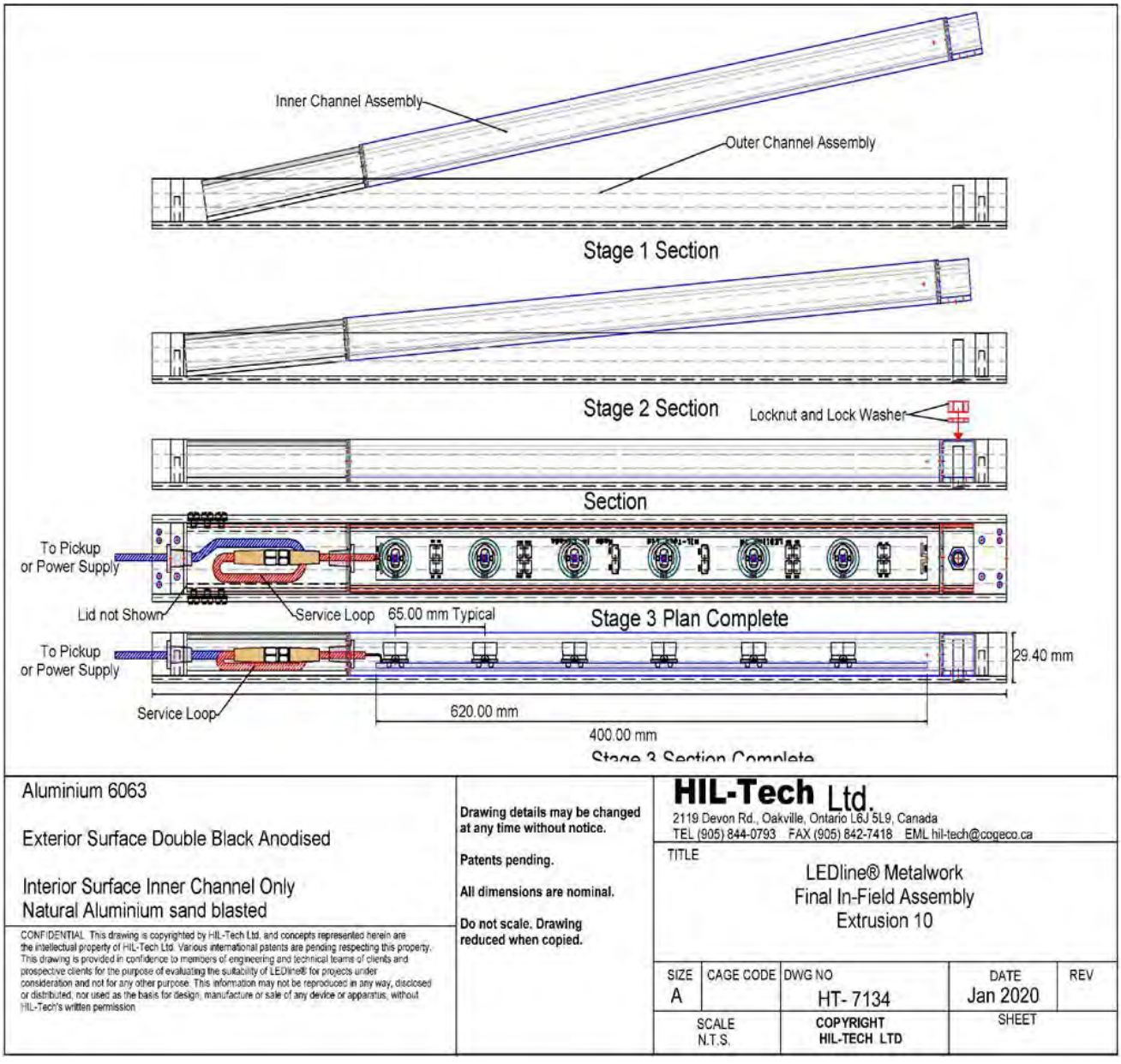


HT-6938 (Not to scale). LEDline® Typical Installation Section Details
Copyright HIL-Tech Ltd.

Below are typical saw cut depths for the induction power distribution direct burial wire with the unique induction power pickup connectors and the LEDline® lamps in their Mounting Plates.



HT-7134 Channel Mount Assembly to Mounting Plate. (Not to scale).
Copyright HIL-Tech Ltd.



Please note the above configuration of the IP69K service loop above within the Mounting Plate IP69K cavity. There must always be a service loop here or the lamps become very difficult to maintain as they cannot be easily removed. **All returned lamps under the HIL-Tech Limited Warranty that have their wires pulled out of the LEDline® lamp void the HIL-Tech Limited Warranty as this demonstrates that there was an insufficient service loop when the lamp was originally installed, so was probably damaged at that time.**

Airports: **Below are examples of some older installations with old-style LEDline®, with only 6 x LEDs, being used for gate lead-in lines.**

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The Same Anchorage Lead in Lines; Day and Night.

Old Style 6 x LED Green LEDline® Taxiway Guidance, Through The Refueling Area at Anchorage.

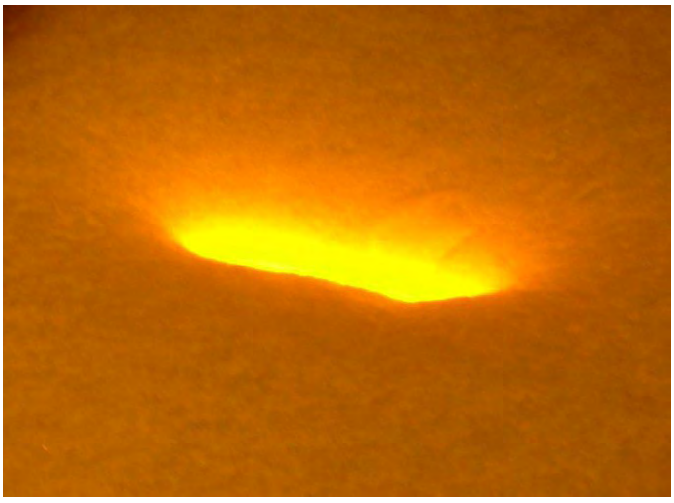
Green FAA Taxiway Lamps and Old Style Yellow 6 x LED LEDline® at Anchorage International In Identical Deep Snow Bad Weather Conditions.

Above, **on the left,** are standard green FAA / ICAO taxiway lights that at that time had standard incandescent bulbs, (more heat than light). **On the right** are old-style yellow 6 x LED semi-directional LEDlineDV™ in identical bad deep snow weather conditions. **Both are self-cleaning as they both melt snow**. The FAA lamps because of the incandescent bulb heat and the LEDline® LED lamps because they are designed to melt snow without any additional heating elements and only the heat from the LEDs.

Both are equally as effective as visual aids, although all pilots* preferred the linear LEDline® directional guidance compared to the point source FAA lamp guidance. (*Note: From the surveys done by the Chief Pilots of Alaska and Northwest Airlines of all their pilots stationed in Anchorage, 100% of their pilots preferred the LEDline® because of its linear directionality).

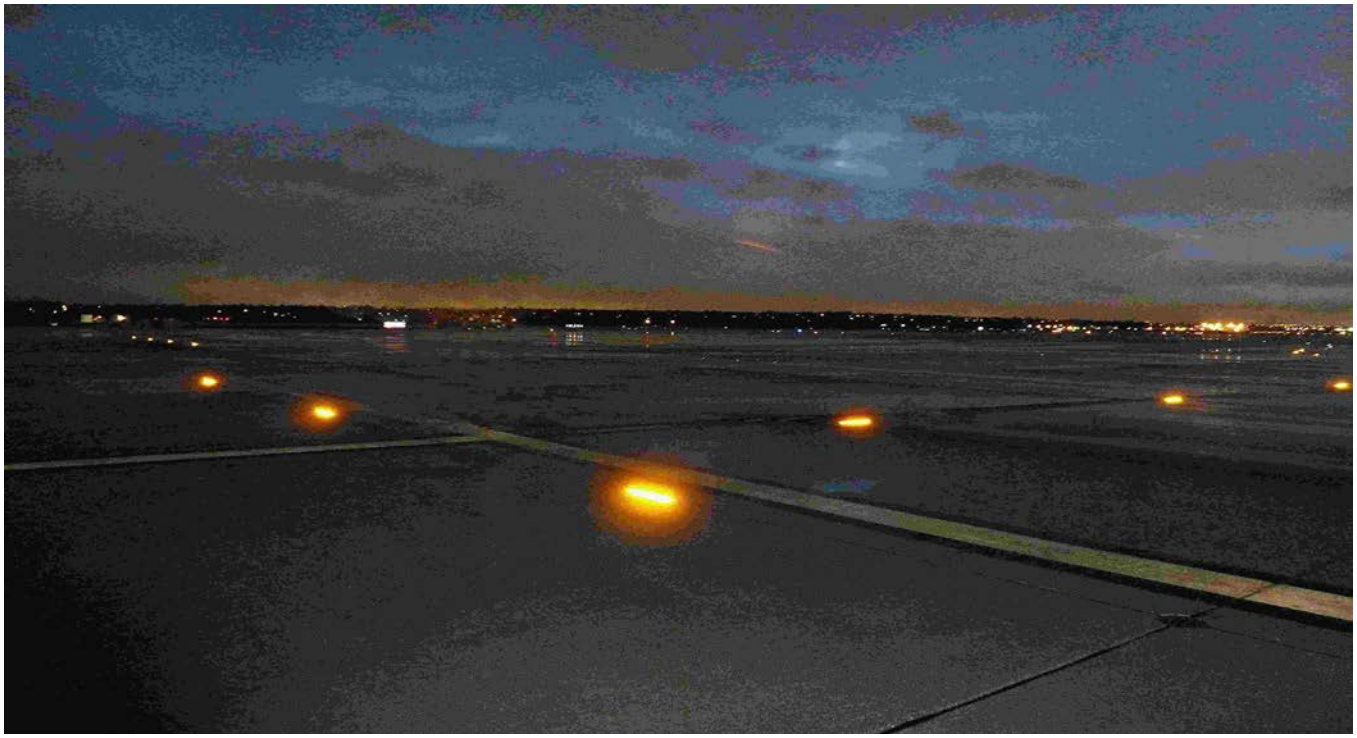
Green Taxiway LEDline® With 6 x LEDs VS. Standard Green FAA Taxiway Inset Visual Aids.

Pictures below are from the 3rd Party Alaska Snow Trials: The LEDline®, with only 6 x embedded LEDs melted holes snow without any extra heating elements. HIL-Tech now has modern LEDlineSun™ styles with 12 x LEDs, so the lamps are now twice as bright and create more heat to melt snow.

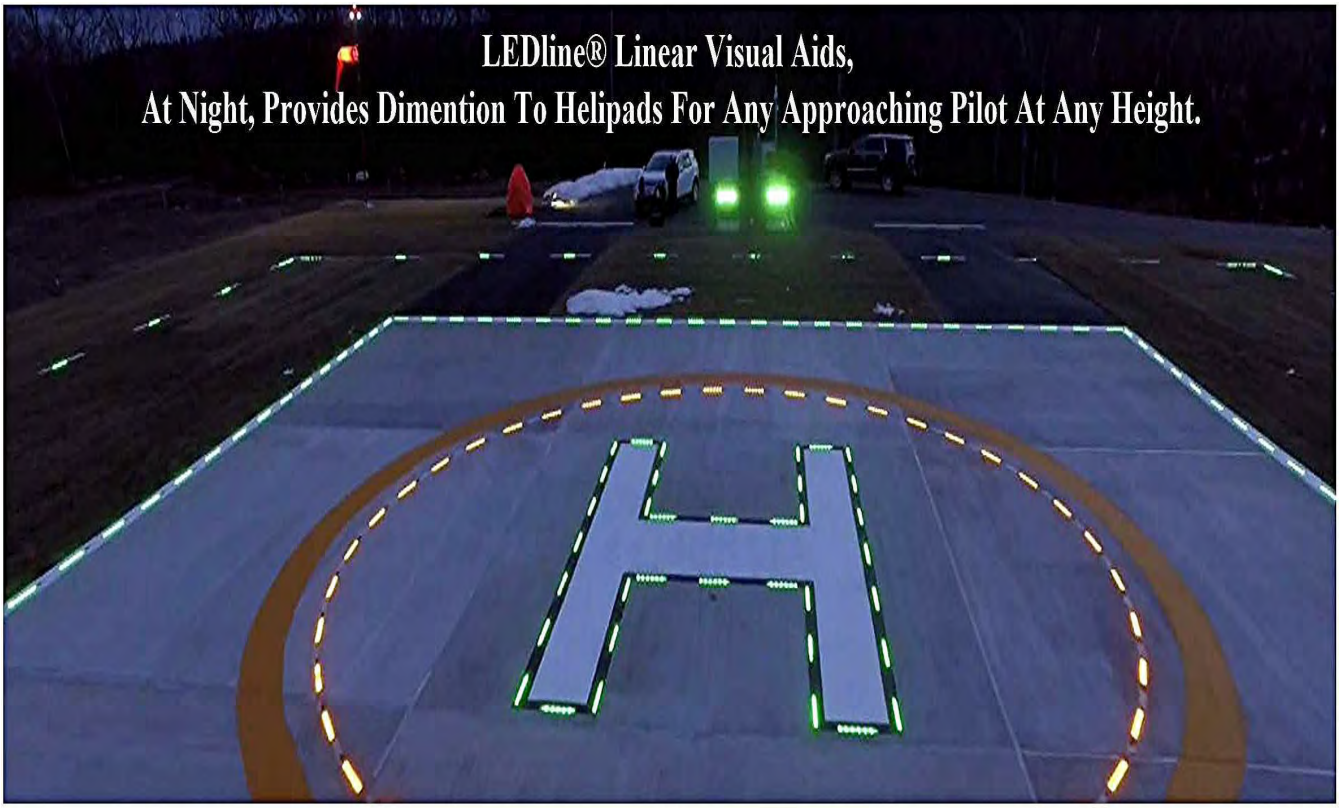


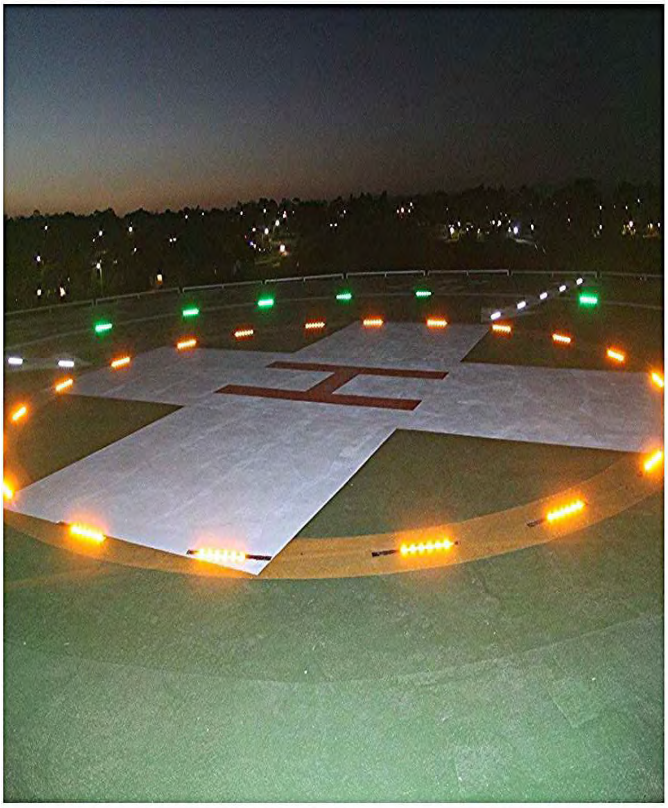
Airports:

Vancouver International De-icing Pad: Picture Jan. 2010 with modern semi-directional yellow (12 x LED) LEDline®. Installed Fall of 2009, the LEDline® there has **NEVER been turned off**, so as of September 2024 has been on 24/07 and successfully working there for some +15 years and counting.



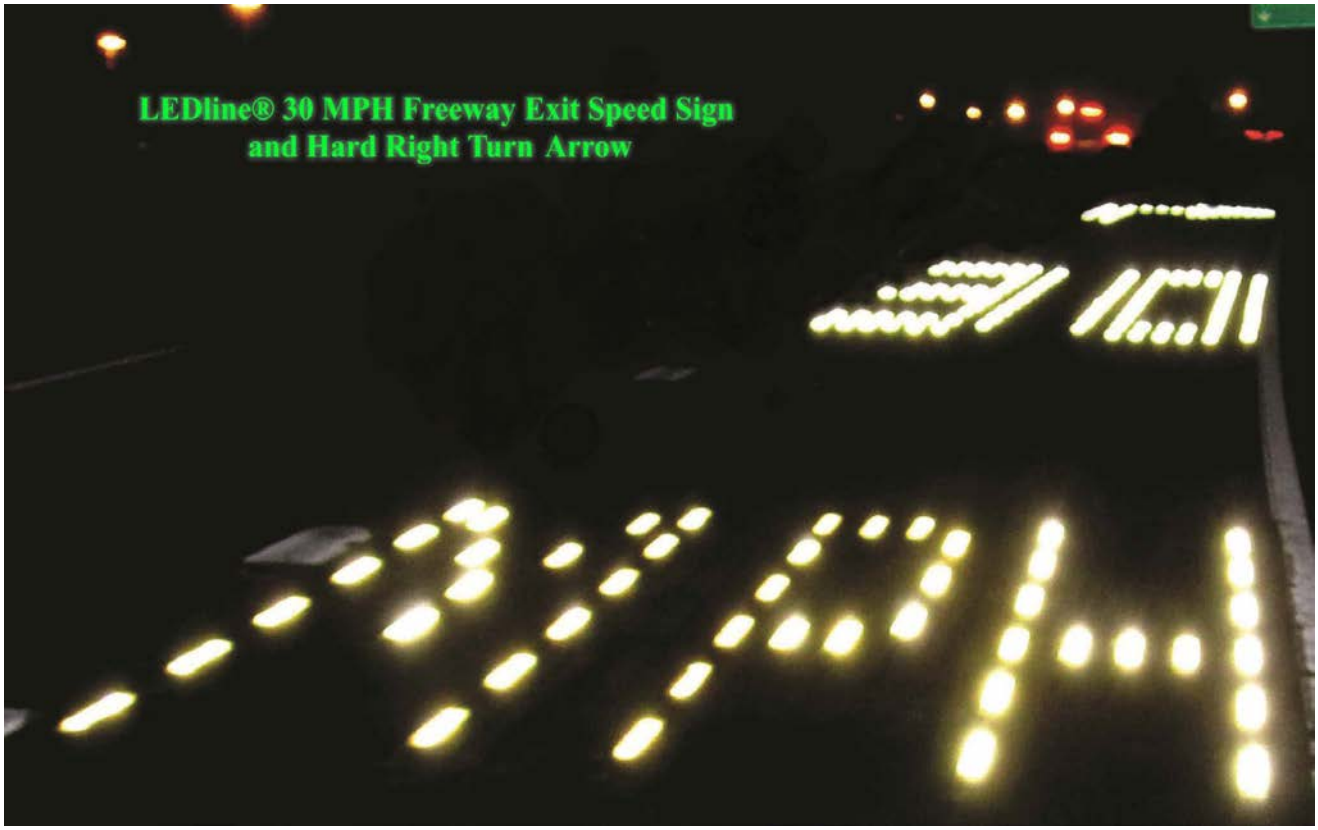
Helipads:


LEDline® Linear Visual Aids,
At Night, Provides Dimention To Helipads For Any Approaching Pilot At Any Height.



Tunnel and Road Applications

In-pavement LEDline® Freeway Exit Sign.



LEDline® Used for Crossover Lanes for Contraflow on the Chesapeake Bay Bridges

Troubleshooting LEDline® Units If The Units Aren't Uniform:

- If the lit LEDline® units do not look uniform, the problem might be that the LEDline® unit/s is/ are too high. In snowplow areas, this is a major issue and if left unresolved, will void the Limited Warranty as snowplows will damage them.

- If this is discovered after the glue has cured, depending on how high the units are, then the road around them should be lifted up with some suitable compound, and/or the LEDline® units should be removed and reset to their proper depth. Contact HIL-Tech about this to see if there are other suggestions.

- If the LEDline® unit/s is/are too close to the front end of the groove, (the edge closest to the oncoming traffic), so that the low-angled light is cut off from being viewed by drivers at long distances; a shallow groove ahead of the LEDline® should be made by removing a part of the road asphalt or concrete blocking the light. **Make sure** that the LEDline® unit/s are undamaged by the pavement grinding or removal.

- If the LEDline® is too deep, if possible, try to grind down the pavement around the LEDline®.

- If the glue has somehow covered the surface of the LEDline®, despite the tape, it should be mechanically removed, so that the surface is clean. This will scratch up and degrade the surface and if it has too much glue to do this, then replace the unit/s. (**Note:** Glue-covered LEDline® does not qualify for HIL-Tech's Limited Warranty)

- The main problem that often causes this, is that the covering tape on top of the LEDline® was removed before the glue properly cured; and/or traffic was allowed onto the LEDline® before the glue was fully cured so their tires spread it around).

  This will happen if:
  - the two-part epoxy style glue, hardener, and filler is not mixed properly according to the manufacturer's instructions so that the glue never or partially sets;
  - or if the weather and temperature have delayed the glue's curing;
  - or if the time allowed for the glue to sufficiently cure before allowing traffic onto the site is too short, so the wheels of vehicles have spread the wet glue onto the LEDline®.

All of these are avoidable, if they occur, it is the installer who is at fault.

The one sure thing to remember is ***DO NOT REMOVE THE PROTECTIVE TAPE FROM THE SURFACE OF THE LEDline® BEFORE THE GLUE HAS SUFFICIENTLY CURED.***

Removing/Replacing A LEDline® Unit;

Removing and replacing an LEDline® lamp unit within the Mounting Plate channel is simple.

- ***Unscrew the nut from the bolt holding in the LEDline® insert.***

- ***Using fingers or a tool, remove the insert by carefully lifting it out of the Mounting Plate and then lift and slide out the insert beyond the other ends 6 x hold-down screws, obviously breaking the 3M Gel suction. (Note: If by some chance there is no service loop within the IP69K cavity, be very careful when pulling out the LEDline® lamp. Normally, without a service loop, the wire is not long enough to remove the lamp, the puller will pull out the wire inside the lamp, so a new replacement lamp will then be needed. If this occurs, such a happenstance is not part of HIL-Tech's Limited Warranty and is NOT covered as it demonstrates faulty installation).***

To Replace A Lamp By Opening the IP69K Connector Box To Take Apart The IP69K Connector.

- ***Before installing the new lamp, make sure that the service loop is intact. If this is an issue and there is no service loop, the lamp will have to be carefully removed. Indeed, depending on the residual length of the wire, the lid of the IP69K cavity may have to be broken to access the IP69K connector without pulling out the wires from the LEDline® lamp. (If needed contact HIL-Tech for replacements as there are IP69K connectors and IP69K cavity top replacements).***

- ***Undo the two IP69K connector nuts. Then, reinstall a new LEDline® unit by connecting the new LEDline® male IP69K lamp connector to the female IP69K connector, make sure that the two nuts are turned tightly together and that there is a proper service loop, (tape it together) then replace everything and seal everything again with the 3M Gel. (Note: Make sure that the 3M Gel has cured before traffic is allowed back on the unit).***

- ***For the Mounting Plate's integrity, when replacing the LEDline® lamp insert within the Mounting Plate "U" channel, make sure that at the far end, (away from the nut and bolt), that the two hold-down bars are properly slotted into their slots so that they cannot be removed without undoing the nut and bolt.***

- ***Relace the insert, ensuring that the two hold-down bars are properly installed, and tighten down the nut onto the bolt.***

- ***Test the whole circuit again.***

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Extended Limited Warranty: Extended Limited Warranty of up to three (3) additional years, beyond the standard one (1) year Limited Warranty, can be purchased at the time of the purchase order, call for written details and prices**. * *Note: Unless HIL-Tech Ltd. has been paid in full for any delivered product and/or services; there is no product Limited Warranty.**

Caveats:

The information contained herein outlines only the preliminary general Installation Guidelines for LEDline® products and accessories. These Installation Guidelines are only intended to be of assistance to installers. They are of a general nature and do not necessarily apply to any specific installation. These Installation Guidelines may be changed at any time without notice. Installers are advised to check with HIL-Tech Ltd. to ensure they have the most current version of these suggested Installation Guidelines and should familiarize themselves with the most current version, before commencing any installation (see "No Liability").

No Liability:

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