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THE BASIC SYSTEM, ZED 26

The Basic System or ZED 26, is a Tunnel Boring Machine (TBM) guidance system which is designed and manufactured by ZED, for use on straight or simple designed tunnel alignments that may include large radius curves. The principle of operation is based on a standard tunnelling laser mounted parallel to the designed axis. Curves are negotiated by the TBM operator manually inputting into the system, a series of offsets pre-calculated before each shove.

The equipment consists of an intelligent or active target unit which includes an integral dual-axis inclinometer in one robust and compact enclosure, called the Combined Target Unit (CTU). Measured parameters are transmitted every five seconds to the Processor Display Unit (PDU), which calculates machine position and orientation, then displays the data graphically to the Operator. The tunnel surveyor is responsible for the entry of all initial system setup parameters and ongoing adjustments and checks during excavation.

The communications link between the CTU and PDU can be either RS422 or Z format to provide backwards compatibility with older systems; for the former, the link is limited to approximately 1Km whilst the latter is up to 100m.

Various options exist to upgrade the system, permitting use on more demanding and complex projects.

The primary system components are :-

Combined Target Unit, CTU

Operating features include :-

- Laser based – calibrated with laser power set at 0.5mW and 2.0mW, but will operate below 0.5mW and up to approximately 5.0mW, without loss of accuracy.
- Measurements made by the unit :-
  - Optically determines the X & Y coordinate of the incoming laser beam on the front glass screen. Also the angle of incidence between the unit and the laser, to determine the Lead or Tendency.
  - Mechanically measures the Roll and Lookup (Pitch) of the unit, to gravity, with an integral dual axis inclinometer.

- A built-in laser power sensor constantly monitors the beam, with the values displayed by the PDU together with a comprehensive set of diagnostics and error reporting
- Autoranging sensitivity feature responds to varying laser power levels due to the separation distance between target and laser and the quality of the tunnel air i.e. amount of dust and water vapour present. Extends the use of the target with a wide range of laser powers
- Passive measurement using opto-electronic sensors, and with the inclinometer transducer have no moving parts, reducing the effects of vibration and improving reliability and the units robustness
- Inherently more rugged by using surface mount technology for the electronics
- Error / self test warning lights within unit but visible through the front glass screen
- Packaged within a milled aluminium case with two parts, box & lid, to IP65. No welded joints. Anodised finish.
- Powered from the PDU with over voltage protection
- Internal electronics protected against induced currents from electrical static discharge.
- Includes a software damping module to reduce the effects of vibration
- Antivibration mountings also included

Processor Display Unit, PDU

Operating features include :-

- Presents guidance data to the TBM Operator via a comprehensive set of graphical and numerical displays
- Packaged within a milled aluminium case with two parts, box & lid, to IP65. No welded joints
- A toughened glass, touch screen is used to operate and communicate with the unit. If conditions permit, a mouse can be used, if preferred

- Uses low power, embedded PC technology providing greater processing power and memory, permitting a wide suite of upgrades to be offered, as software options which are cheaper and simple to implement.
- Inherently more rugged by using surface mount technology for the electronics
- Fully sealed no need for cooling or ventilation
- Powered from the Junction Box but contains over-voltage protection circuitry
- Internal electronics protected against induced currents from electrical static discharge.
- ZED software is fully Windows compatible and is tailored for use with the latest embedded operating systems and associated displays, providing enhanced stability i.e. during power loss, and preventing the typical errors encountered with the standard desktop computer
- Protected / uninterruptible power supplies are not required.
- Fully backwards compatible permitting present customers to replace their older system processing unit, the Control Unit

Junction Box, JB

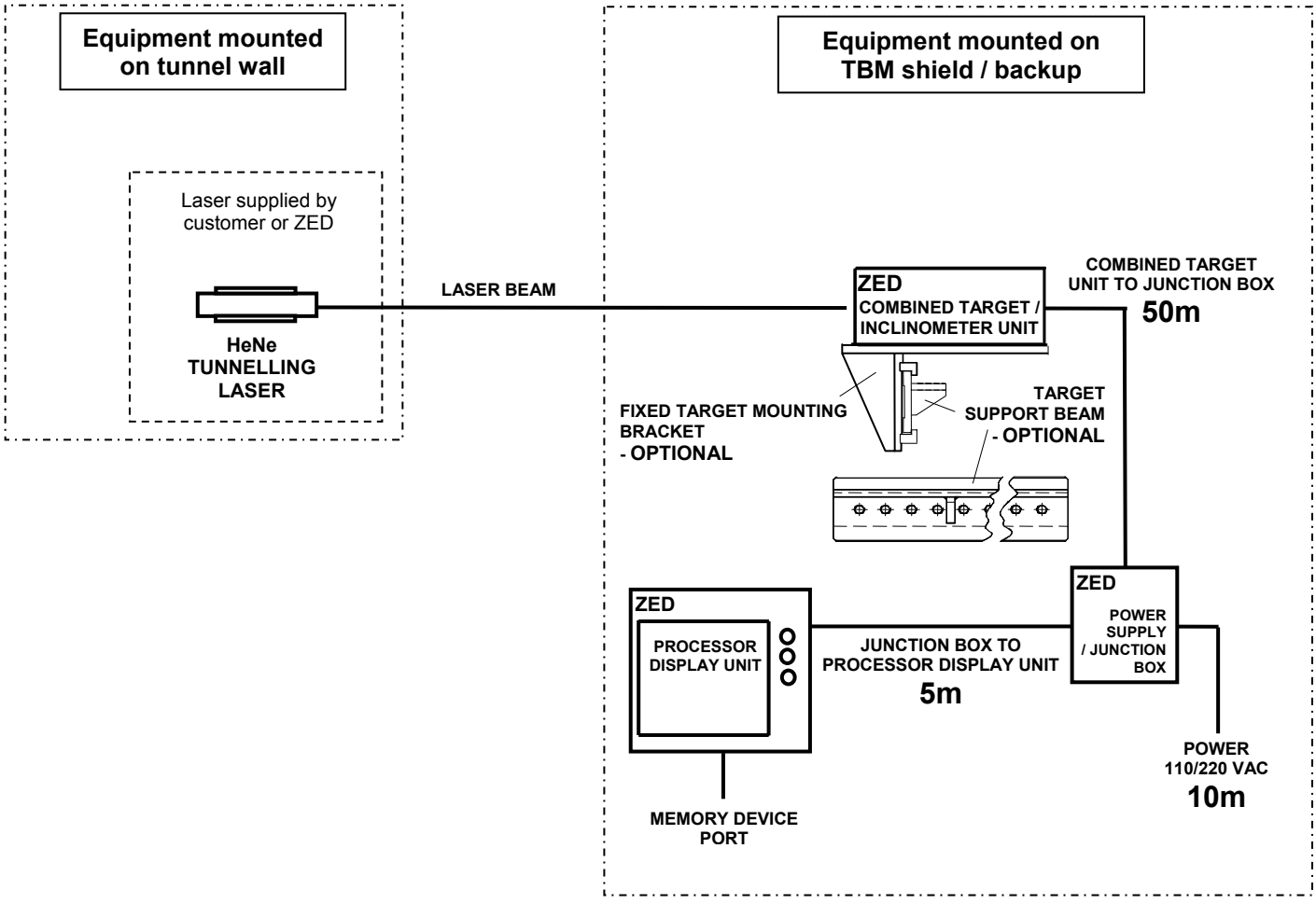
- Power Supply Unit and cable interconnection point.
- Has a robust and reliable supply that requires minimal power and is tolerant to variations in the supply ±15% of nominal.

Interconnection cables

In detail, the Basic or ZED 26 system comprises :-

- x1, Combined Target Unit
- x1, Processor Display Unit
- x1, Junction Box
- x1, Toolbox, containing :-
  - Laser Power Meter
  - Tools
  - Fuses
  - Test connector
  - USB Mouse
  - User Manual
  - CD containing drawings & user manual
- x1, Set of interconnecting cables, comprising with standard lengths :-
  - x1, Combined Target Unit to Junction Box @ 50m
  - x1, Junction Box to Processor Display Unit @ 5m
  - x1, Junction Box power cable 110 / 220 VAC @ 10m

System interconnection :-



Note :- **The laser is <u>not</u> normally included with the system, however, a suitable tunnelling laser can be supplied by ZED, if required.**

Principle of Operation

The equipment calculates and displays the position of the machine from a designed tunnel axis. This calculation is based on the system monitoring the deviation of the TBM from a laser beam reference, mounted at a fixed point on the tunnel wall, parallel to the designed axis, and the machines roll & pitch (Lookup) to gravity. The Combined Target Unit is placed on the machine such that its three principle axes are parallel to the same axes of the machine. Slight variations are removed by entering correction values into the system during setup / installation. The following data is also required, for system entry :-

- The $\mathbf{X_T}$ (horizontal) and $\mathbf{Y_T}$ (vertical) co-ordinates of the centre of the Combined Target Unit with respect to the TBM's longitudinal axis.
- The $\mathbf{X_B}$ (horizontal) and $\mathbf{Y_B}$ (vertical) co-ordinates of the laser beam with respect to the designed tunnel axis.
- Tunnel grade in mm / 10m

On straight drives, with the laser illuminating the target unit, the system displays the machines position as an offset in millimetres, in two planes parallel to the glass screen of the target. Present Position is the offset of the TBM's axis from the designed axis in the plane of the target unit glass screen and Predicted Position, the offset of the machines axis in a plane parallel to the Present Position but set at the head of the machine or just in front. The separation of the two planes is a user settable parameter, Prediction Distance. Additionally, the 3 principle, angular attitudes of the TBM's axis with respect to the designed tunnel axis are also displayed.

To create a curved tunnel alignment, two Offsets are entered into the system. These values represent the horizontal, **X**, and vertical, **Y**, deviations of the designed axis with respect to a theoretical straight line parallel to the laser beam. Note that in this instance, the parameters referred to above $\mathbf{X_B}$ and $\mathbf{Y_B}$ represent the values of the co-ordinates between the laser beam and this, new, theoretical line.

The Offsets can be calculated for either or both, the Present & Predicted Position, although normally the latter and are subtracted from the values determined by the system to give the correct position relative to the curved axis. Note that when based on the Predicted Position the displayed Present Position does not relate to the curved alignment but to the theoretical straight line.

By updating the Offsets manually, at an appropriate point, determined by the distance along the alignment, the machine operator can steer the TBM to maintain a Predicted Position as close to zero as possible and thus follow the designed axis. The Offsets must be continuously updated along the length of the curved section, usually before each successive push. The surveyor has the responsibility of calculating the Offsets and how often they need to be applied, which is dependent on the radius of the curve and the frequency of repositioning the laser. The overall effect of this technique is to develop a curved alignment by a series of steps, as defined by the Offsets.

Options :-

- **Installation & Commissioning :-**
  - Quick and straight forward installation onto the TBM.
  - Typically, 2 to 3 days, on-site training of survey staff is sufficient.
  - Development of close links with the site to encourage the speedy resolution of any problems, if they occur, once tunnelling starts.

- **Global Coordinate software upgrade**

  Suitable for more complex alignments where the axis is defined by a global coordinate reference system which is downloaded into the PDU as a DTA (Designed Tunnel Axis) file. Similarly, the laser station and the laser beam angles, horizontally & vertical, within the same frame of reference, are entered.

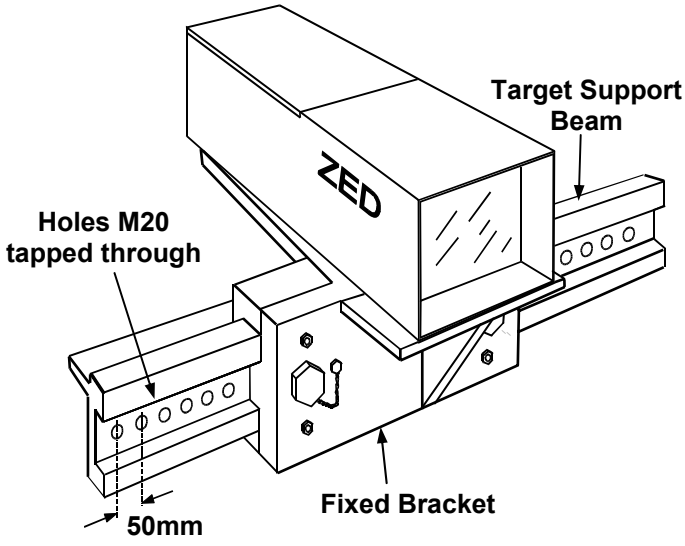
  Once this upgrade is made access to other more sophisticated hardware & software features and improvements then become available.

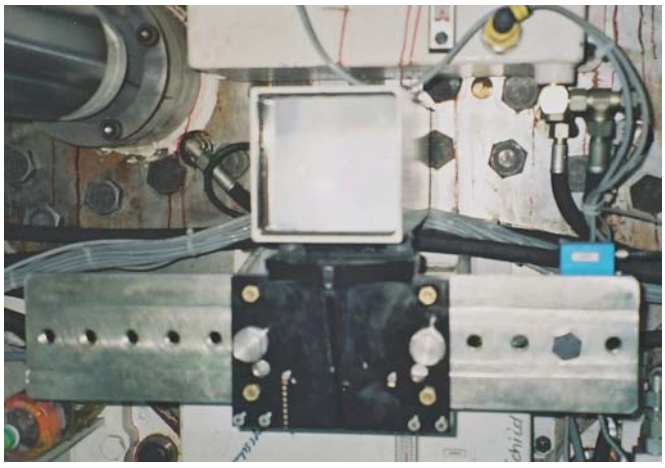
- **Data Logging**

  Data logging of all guidance & associated survey values within the PDU. Logging can be setup to trigger on time and / or a manual command from the PDU. The data is stored in a standard text / ASCII format, available for export into other software i.e. Microsoft Excel. A further option permits the transfer of the archive, manually via a flash memory device from the PDU to a PC, and with additional software from ZED, permits user selectable archive pages to be printed with a presentation, suitable for direct submission to, or inclusion within, reports to the Client.

- **Target Mounting Bracket**

  When a TBM excavates, typically, a horizontal curve, a mounting can be supplied by ZED that permits movement in the **Y** axis, in fixed steps, to help keep the laser on the units glass screen. If the unit were fixed rigidly to the TBM then moving the laser can be time consuming. The mechanical arrangement preserves the attitude of the target with respect to the machines axes as originally determined during the setup / installation phase.





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