ZED Tunnel Guidance Ltd

Unit 1, Russell House, Molesey Road,
Walton-on-Thames, Surrey, KT12 3PJ, UK.

Telephone: +44 (0)1932 251 440 Email: sales@zed-tg.co.uk
Fax: +44 (0)1932 244 971 Website: http://www.zed-tg.co.uk

THE GLOBAL COORDINATE SYSTEM, ZED 261

The Global Coordinate System or ZED 261, represents the next level of complexity compared to the Minimised Basic and Basic systems for guiding Tunnel Boring Machine (TBM). Wholly designed and manufactured by ZED, for use on more complex tunnel alignments that may include small radius curves in one or two dimensions, vertically & horizontally.

In the systems simplest configuration, the principle of operation is based on using a standard tunnelling laser as a reference, which is mounted in a manner that permits the best line of sight to a target unit positioned on the TBM. From the original Client supplied survey data for the project, the designed tunnel alignment is defined within a global frame of reference as 3 coordinates, typically a Northing (Y), Easting (X) and Level (Z), called the DTA table or file, and is downloaded into the system. The laser position and the angles associated with the beams direction are required for system entry, together with the distance along the tunnel drive or chainage.

Due to the more sophisticated mathematical approach used by the system, the entry level configuration described here can be enhanced with a much wider range of options & upgrades, tailoring the offered equipment to meet the demands made by more demanding project requirements.

The system 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 made 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.

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, including :-
  - TBM position shown as offsets and in global coordinates, in two planes, parallel to each other and perpendicular to the machines axis, from the designed tunnel axis.
  - Display of TBM orientation relative to the designed tunnel axis and to the vertical or gravity.
  - Display of drive / chainage and bored tunnel length.
  - Pre program coordinates or chainage of key milestones along the designed alignment to forewarn TBM Operator & other relevant underground personnel.
- 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

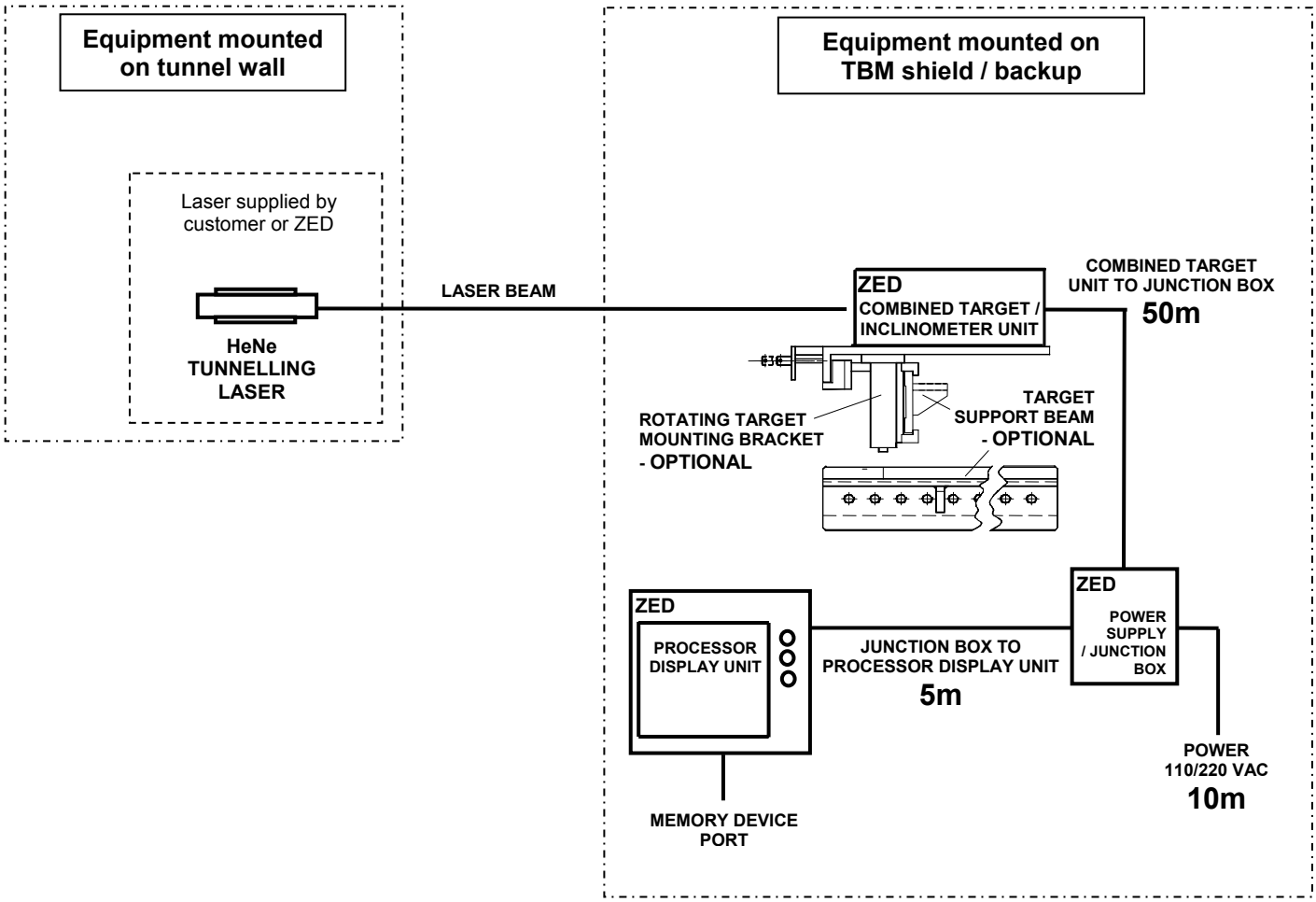
- Power Supply Unit and cable interconnection point.
- Has a robust and reliable supply that requires minimal power and is tolerant to variations in the supply ±15% of nominal.

Interconnection cables

In detail, the Global Coordinate or 261 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 or offset of the TBM shield axis from a designed tunnel axis. This calculation is based on the system monitoring the deviation of the machine from a laser beam reference, mounted at a fixed point on the tunnel wall, monitoring the Roll & Lookup (pitch) to gravity and the distance of the TBM along the pre-programmed alignment, the DTA. The DTA table is currently limited to 20,000 points or sets of coordinates in a simple ASCII format.

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.

Additional survey data required :-

- The global coordinates of the lasers position in the same frame of reference as the DTA file
- Of the laser beam :-
  - The horizontal (Bearing or Azimuth) angle referenced to North in a clockwise direction
  - The vertical (Elevation) angle referenced to the vertical.

As tunnelling progresses the machine operator manually enters a value which represents how far along the tunnel alignment, from the first point in the DTA file, the TBM has progressed, termed Drive. This can be entered directly in metres or determined indirectly by inputting the number of rings built or shoves / pushes made. If Drive, is entered manually, then the system will require periodic calibration to ensure the calculated value is the same as the real, surveyed, distance along the alignment.

Once the machines position has been calculated, the TBM's position is displayed 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 of it. The separation of the two planes, Prediction Distance, is a user settable parameter. Additionally, the 3 principle, angular attitudes of the TBM's axis with respect to the designed tunnel axis are also displayed.

On more complex tunnel alignments, using the Global Co-ordinate System can dramatically reduce the downtime and the workload of the surveyor and machine operator, particularly with regards to the determination of the global position of a new laser station and the two angles associated with it, as the station follows the TBM along the excavation.

Options :-

A wide range of upgrades & options are available with this system, please refer to the separate document 'Upgrades & Options'.