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### **13 INSTRUMENTATION AND MONITORING (WHEREEVER APPLICABLE)**

#### **13.1 SCOPE OF WORK**


##### **13.1.1 GENERAL**

- i) Contractor shall supply, install, calibrate, test, survey and maintain instrumentation in the weir, in the foundation, in the underground structures or elsewhere as specified in this Chapter or as directed by the Project Manager. He shall supply and install all ancillary measuring equipment and construct terminal structures, protective surrounds for instruments, excavate pits and trenches, drill holes, install pipes and fittings, and cast concrete where required.
- ii) The number and location of the instruments may be altered by the Project Manager during the construction period, according to the requirements.

##### **13.1.2 MEASURING DEVICES AND STRUCTURES**

- a) Optical convergence measuring equipment.
- b) Load cells
- ii) All instruments and accessories shall be suitable for operation at the project site. All steel parts shall be of hot dip galvanised steel, long-term protected against corrosion or of stainless steel of first quality.
- iii) The Contract Documents give only the numbers, general type, and general arrangement of the instruments to be supplied by the Contractor.
- iv) All instrumentation operating on electrical or hydraulic systems shall be accompanied by individual test certificates, and shall be tested in the presence of the Project Manager prior to installation, unless specifically stated otherwise.
- v) All instruments shall be installed to the lines and elevations shown on the Construction Drawings or as established by the Project Manager as the work progresses during construction.

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- vi) The installation of instruments may interfere with the overall construction progress. Contractor shall make provision for such interferences in his construction planning. He will not be entitled to any compensation or extension of the Time for Completion by reason of any such delays, including repair and replacement of weiraged instruments.
- vii) No materials shall be purchased prior to Project Manager's approval. However, approval by the Project Manager of the Contractor's proposals and drawings or data shall not relieve the Contractor from his sole responsibility to meet all the requirements under this Contract.

### **13.2 SUBMITTALS**

- i) Contractor shall submit with his bid general information on the instrumentation he proposes to install, as brand and type including additional equipment, read out units or probes which may be necessary for the instruments he proposes to use.
- ii) Within 112 days after the day of receipt of the Notice to Commence, the Contractor shall submit details of the instruments proposed for the installation. These shall be consistent with the general information on the instrumentation submitted by the Contractor with his Tender as well as with any modifications subsequently agreed to by the Project Manager and the Contractor, and shall include:
  - a) Detailed description of all instrumentation, cabling and accessories including any ancillary measuring equipment he proposes to install,
  - b) Evidence of the successful performance of the instrumentation proposed for installation,
  - c) Manufacturer's instructions for the installation, testing and operation of the instruments,
  - d) Details of the layout of all equipment and accessories to be installed in each switchbox and terminal structure,
  - e) Details of the terminal structures, concrete surrounds, recesses in concrete structures, etc. proposed for the installation of instrumentation and switchboxes.

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- iii) Not less than 28 days before the anticipated date of installing any instrumentation, the Contractor shall submit details of construction procedures to be employed in the weir placing operations in the vicinity of the instrument installation, and the programmed sequence of events for this work including details of all labour, construction plant and materials to be used.
- iv) During the execution of the Works, the Contractor shall submit any further details regarding the instrumentation required by the Project Manager. The Contractor shall prepare surveys and furnish "as-built" drawings for all installed instruments.


### **13.3 SKILLED PERSONNEL**

- i) The whole of the instrumentation work shall be carried out under the direct supervision of a senior supervisor, approved by the Project Manager, and employed by the Contractor who is well experienced in all types of instrumentation and installation work and who understands the purpose and function of all instruments being installed.
- ii) Installation and calibration of the measuring instruments shall be carried out by skilled technicians, acceptable to the Project Manager, well experienced and who have a thorough understanding of the purpose and function of the particular instruments being installed.

### **13.4 INSTALLATION**

- i) Contractor shall install and calibrate all instrumentation conforming to the suppliers instructions and shall, where necessary, expose all partially installed instruments, cables and tubes to continue their installation, including carrying out all survey work required to locate such instruments. Contractor shall tag all cables and tubes with identification tags approved by the Project Manager to provide continuous identification.
- ii) Instrumentation shall be installed and calibrated in the presence of the Project Manager, and when he considers it desirable, instruments shall be installed only during daylight hours. At all times, Contractor shall ensure that

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adequate lighting is available, whether by natural or artificial means, to ensure proper execution of the work.

- iii) Cables and tubes shall be installed in the maximum lengths practicable. Splicing and coupling shall be performed in accordance with the manufacturer's recommendations. Calibration readings shall be taken prior to and immediately after splicing. Open ends of all incomplete lines of tubing and casing shall be kept plugged or sealed and Contractor shall at all times during installation keep the insides of casings and tubes free from foreign matter. Cables and tubes shall be protected from mechanical weirage.
- iv) The instrumentation shall be put in operation at the earliest practicable period during construction in order to obtain information pertaining to the performance of the structures.


### **13.5 CARE OF INSTRUMENTATION**

- i) Contractor shall protect all instruments and connections from weirage and displacement during the progress of the work. If weirage or displacement of the instruments or connections occurs during the progress of the work, they shall be repaired or replaced immediately by the Contractor.
- ii) Contractor shall be fully responsible for the maintenance and repair of all instrumentation for the duration of the contract period.

### **13.6 READING INSTRUMENTS**

- i) An initial set of readings on all instruments installed at any particular elevation will be taken immediately after their installation, and the Contractor shall not place fill over the instruments or tubes or cables at this location until these readings have been taken.
- ii) Contractor, after consultation with the Project Manager, shall program his work and make all necessary arrangements to allow the reading of instruments as soon as possible after their installation. Such arrangements shall include, where necessary, the provision of temporary read out points.

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- iii) During construction, the Contractor shall read the instruments once a week or as directed by the Project Manager. Contractor shall inform the Project Manager when reading of instruments will take place.

### **13.7 ELECTRICAL INSTRUMENTS**

#### **13.7.1 GENERAL**

- i) Electrical instruments shall be of vibrating wire type or approved equivalent.
- ii) The instruments shall be provided with over voltage surge arrester to protect the gauges against weirage.
- iii) Where applicable, a suitable thermistor shall also be incorporated in the sensor for temperature sensing and for temperature-zero reading correlation.
- iv) Electrical instruments shall have stainless steel outer casings and hermetically sealed by welding with a vacuum or inert gas inside it.


#### **13.7.2 LOAD CELLS**

- i) Load cells are required to measure and monitor loads of rock bolts and anchors.
- ii) The capacities of the load cells shall be 100 and 500 kN and they shall be suitable for 25 mm to 40 mm rock bolts and anchors.
- iii) The cells shall have the following characteristics:
  - a) Over load capacity 150% of FS
  - b) Accuracy  $\pm 0.5\%$  of FS
  - c) Resolution 0.1% of FS

### **13.8 CONVERGENCE MEASUREMENT**

- i) Convergence measurement shall be performed in underground excavation works to determine the absolute displacement of measuring points placed around the excavation perimeter. The measurement shall be performed by

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the Contractor in the presence of the Project Manager with equipment supplied by the Contractor.


- ii) The measuring points shall consist of plastic reflectors of the GEODATA Bireflex type produced by GEODATA Messtechnik GmbH, Hans Kudlichstrasse 28, A-8700 LEOBEN, Austria or similar approved manufacturer and mounted on a treaded bar grouted into predrilled hole.
- iii) The absolute position of the reflectors shall be measured in 3-dimensional space by a electronic coaxial theodolite equipped with distance measuring facility and data logging. Accuracy of the distance measurement shall be  $\pm 1$  mm and the directional measurement  $\pm 1$  mgon.
- iv) The convergence bolts shall be installed directly behind the face within the heading zone immediately after the installation of supports. Five bolts per measurement cross section shall be installed at a spacing of 25 m or as directed by the Project Manager. At the beginning, the measurement shall be carried out daily. Later, weekly readings shall be taken for several months up to the cessation of any movement but latest when the placing of the concrete lining commences.
- v) The measurements shall be logged directly into a suitable data module (PCMCIA card or similar) and shall be stored on a suitable computer station and evaluated by the Contractor with appropriate software such as DEADELUS from GEODATA or a suitable approved equivalent. The Contractor shall supply the Project Manager with the required hardware and software to enable him to independently check the data.

### **13.9 MEASUREMENT AND PAYMENT**

#### **13.9.1 GENERAL**

- i) Unless otherwise specified, the Unit Prices for instrumentation entered in the Bill of Quantities shall include the supply, installation, calibration, testing, surveying, repairing and maintaining of all instruments, ancillary and read out equipment, including protective steel covers, switchboxes, a nominal

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length cable for each instrument, tubes and tube protections, required to perform the specified measurements.

- ii) The Unit Prices shall also include for forming all necessary recesses in concrete, all necessary trench and pit excavation, foundation preparation, temporary and permanent protection of instruments and ancillary equipment by surrounding with selected material or by other approved method, and maintaining easy access to all readout points.
- iii) Contractor shall include in his Unit Prices any additional readout equipments, which may be necessary for reading the instruments he proposes to use.
- iv) The Unit Prices shall also include for the regular reading of the instruments and reports during construction.

#### 13.9.2 CONVERGENCE MEASUREMENTS

- i) Measurement and payment will be made on per running meter of tunnel where convergence has been monitored.
- ii) All cost related to installation of measuring points, equipment, all survey, measurement, evaluation and monitoring of the points is deemed to be included in the unit prices for convergence measurement.

End of Chapter

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