DEMINE
Decreasing the Impact of Abandoned Mines

DELIVERABLE B2.2.

Design and specification the METP

Public summary

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Summary

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1. Introduction

This task consisted in designing the Mining Effluent Treatment Plant (METP) based on the process diagram developed during task B2.1, the data collected during Action B1 and the assessment of the test site requirements. The work involved specifying all the relevant hardware identified in the P&ID and producing a detailed 3D drawing of the plant that included all key items.

The 3D drafting work enabled the plant design to be assessed and reviewed in virtual format before committing to physical fabrication, this way rendering fabrication a more efficient and risk-less task. The detail drawings are key reference documents for the design and fabrication of the METP but also for future operation and maintenance.

The modularisation of the technology presented some design challenges, such has grouping hardware into discreet, standardised, units (e.g. 'Control module', 'EC module', 'Process module', etc…). However, having achieved this, it provided substantial advantages from both process and manufacturing perspectives (e.g. versatility and standardisation).

Three key benefits result from this approach:

- Broad scope of application – both EC and Membrane filtration are applicable to a wide range of contaminants, the combination broadens the scope further.
- Versatility – the modular design enables simple reconfiguration and scaling of the plant to suit site requirements.
- Enhanced performance – the techniques complement each other's performance, resulting in higher output quality.

Alongside the design of the plant itself (i.e. the hardware), ran the development of the process philosophy to manage the plant and the software to run it. This work consisted in establishing how the process is required to operate and breaking it down into sets of well-defined tasks that can be managed by software. A key element of this work is setting out the input and output signal requirements (I/O schedule) that the PLC (Programmable Logic Controller) must manage so all tasks are carried out in a controlled way and system performance can be monitored.

The table below summarises the information (i.e. input and output signals) generated by the different sensors and hardware in the plant and managed by the PLC software.

These are classed into 'Digital' and 'Analogue' signals regarding the nature of the signal (i.e. binary or continuous), and 'Input' or 'Output' regarding origin (i.e. received or sent by the PLC). Despite also being a digital input signal 'Valve' position were categorised independently as it suited design of the control unit.

Various motors (e.g. pumps, compressor, fan…) are used across the plant to perform a range of tasks, and these are also listed as require management.

	DI	DO	Valve	AI	AO	MBus	AC motors
Control panel module	13	12	0	0	0	5	12
Cell module 1	12	2	8	2	0	0	0
Cell module 2	12	2	8	2	0	0	0
Mixing module	9	0	2	2	0	0	0
Process Module	10	0	2	5	0	1	0
UF module	16	0	13	6	0	0	0
NF module	16	0	13	6	0	0	0
	88	16	46	23	0	6	12

Table 1: Summary table of signals generated by hardware and sensors on the MET.

2. Plant description

The treatment process applied in the project combines two technologies (Membrane Filtration with Electro-Coagulation), designed into modular units that can be configured in manner of arrangements to suit application/site requirements.

The 'Plant modules' are entities comprising key hardware grouped in such a way that each module is a discreet standardised unit that is always manufactured to the same specification despite the configuration of any given plant. Physically, each module consists of a metallic frame/structure of set height, supporting an arrangement of reactors, sensors, pumps, motors, tanks, pipework and valves. These frames are mounted on castors/wheels for ease of handling and built in technical aluminium profile for light weight, chemical resistance and versatility.

Any given METP is assembled by physically locking the required sequence of modules to each other and connecting them ('plug-and-play') hydraulically and electronically (power and communications).

Each 'Plant module' has a local process control station (the 'outstation') that monitors and controls every powered/automated piece of hardware on the respective 'Plant module'. In turn, each 'outstation' (i.e. each 'Plant Module') communicates with the central process control (the PLC) in the 'Control module', that manages the plant as a whole.

Due to the way the plant software and communications were designed, the 'Control module' can manage any combination and number (up to a limit) of 'Plant modules' without requiring any alteration of the software or hardware. Presently 6 different types of 'Plant Modules' have been designed:

- Control module – central control station that communicates with each individual module and manages the process as a whole. Also carries out tasks of data collection and remote access.
- Process module – unit containing general process hardware such has process pump, compressor, flow, temperature, pH, pressure sensors and 'Clean-in-Place' unit.
- EC module – unit containing Electro-Coagulation reactors and ancillary pipework and valves.
- Mixing module – unit containing mixing stage carrying homogenisation of processed effluent post EC treatment

- Micro Filtration module – unit containing an array of micro-filtration (UF) membranes and ancillary pipework, valves and pumps.
- Nano Filtration module - unit containing array of nano-filtration (NF) membranes and ancillary pipework, valves and pumps.

Given that a METP can operate in a range of configurations, for simplicity, the plant is described below in the configuration to be deployed at the Welsh site, Frongoch:

'Control module' => 'EC1 Module' => 'EC2 Module' => 'Mixing module' => 'Process Module' => 'Micro-Filtration Module'.

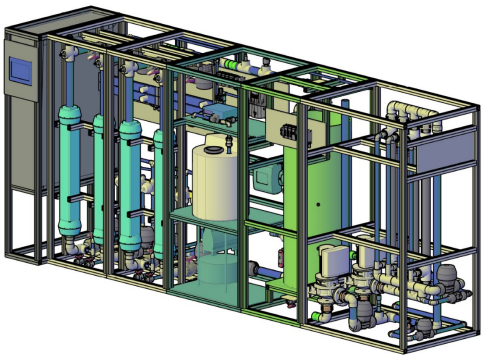

Figure 1: METP in configured for welsh site comprising Control module, EC module 1, EC module 2, Mixing module, Process module, Micro-filtration (UF) module.

The plant will be deployed in a standard 6 meter (20ft) shipping container (the 'Process container') along with a second container (the 'Support container') providing storage of ancillary equipment (e.g. generator, sludge tank), shelter and an onsite laboratory facility (for spot analysis and sample handling). The containers are to be sited next to each other to facilitate the required connections between METP and generator.

Despite the operational flow set out in action B.2.1. ($1m^3/h$), the plant has a hydraulic capability of up to $10m^3/h$. Presently, the objective is to demonstrate the ability of the plant to process the site's full discharge flow ($4.3m^3/h$).

3. Module description

3.1. Control module

The 'Control module' is the central control station for the METP where data from each individual module is processed and from where the operator manages the plant locally. It has general dimensions of 2025 mm X 755 mm X 1330 mm and contains two key elements: the main Control Panel and the Electro-Coagulation power supply.

The Control Panel comprises a Mitsubishi Programmable Logic Controller responsible for controlling and monitoring the system as a whole, alongside a communication and data logging unit that enables remote access to the plant (e.g. via internet) and also stores all process data for backup.

Plant operation is carried via a touchscreen interface mounted on the side of the control panel enclosure. Through the touchscreen the operator can access all the parameters of the plant, process data and start stop the system.

The EC power supply powering the EC reactors is a unit that comes with an expansion slot for doubling of capacity should it be required/desired.

3.2. EC module

The 'EC Module' is the unit containing the electrochemical reactors (the 'EC cells') that perform Electro-Coagulation of the contaminants. It has general dimensions of 2025mm X 755mm X 970mm and comprises 2 EC reactors along with ancillary pipework (ABS) and automated valves EC reactors of varying sizes and capacities can be fitted to suit process requirements.

3.3. Mixing module

The 'Mixing module' is the unit receiving the effluent post EC and ensures homogenisation of the electrochemically treated flow. It comprises the mixing stage along with and array of sensors and the local control outstation.

3.4. Process module

The 'Process Module' provides general process capability such as process flow, compressed air and various process metrics of the incoming effluent (e.g. flow, pressure, temperature, pH, conductivity). It has general dimensions 2025mm X 945mm X 970mm and comprises key process hardware: the process pump air compressor, flow meter, pressure sensor, pH, conductivity and temperature.

3.5. Microfiltration (UF) module

The 'Micro-Filtration (UF) module' physically separates coagulated contaminants from the effluent (through fine filtration) whilst simultaneously concentrating the sludge to a high degree of solids content. It has general dimensions 2025mm x 3920mm x 720mm and comprises an array of membranes and ancillary pipework (ABS), automated valves and filtration pumps.

Because in this configuration the UF module is the final process step, along with a flow meter for measurement of final discharged flow, it also includes sensors for metrics of final effluent quality, pH, conductivity and temperature.

The produced sludge will be collected in a storage tank in the 'Support container' and will be regularly taken off site for characterisation and further processing. The treated effluent will be discharged back into the receiving stream and regularly sampled for record keeping.