A DATALOGGER AND REMOTE CONTROL FOR HYBRID POWER SYSTEMS

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ABSTRACT

Remote hybrid power systems, including renewable power sources, are for long term safe operation, depending on the correspondence between the actual powers of nature on site and the estimations made when designing the system. Two options are available to secure safe operation, either costly oversizing or long term monitoring for later corrections.

The alternative of long term monitoring of remote hybrid power systems will be discussed in this paper.

An equipment for this purpose will be described. Also two years of experience of the datalogger monitoring two hybrid power systems will be presented.

INTRODUCTION

A datalogger installed at a remote site is a valuable equipment, a kind of binocular, making it possible to follow the performance of a remote primary power plant. It can also control and supervise other equipment installed at the site.
The main task for the datalogger is to make possible a detailed analysis of the energy production and performance of a remote hybrid power plant with solar, wind and diesel power installed. Such a monitoring need to be done on a long term basis covering one year or more.

An analysis is of interest to verify the dimensioning made during the planning of the site. The dimensioning is based on estimations and calculations. The real outcome might differ according to local circumstances on the site. To cope with these circumstances, oversizing in battery, solar and wind generator capacities has been practiced. With a datalogger in a system, the dimensioning can be made more precise, and after an analysis of the power plant's energy production, a correction of battery size and/or power generation capacity can be done to secure long term safe operation. The datalogger equipment might then be removed to another site to collect data for a new analysis.

During the analysis made with the help of the datalogger, a continuous supervision of the power system functions can be performed.

Fig. 1 The CERRO NEGRITO REPEATER, located 4500 m above see level in Argentine has a complete ERIGEN hybrid power system and a data logger installed.

Other tasks for a datalogger installed on a permanent basis are remote control and supervision of other installed equipment. The datalogger creates a great potential for preventive maintenance and fault analysis in situations of malfunction.

By the use of dataloggers, an improved art and deeper understanding of solar and wind systems dimensioning can be learned. A tighter and more precise dimensioning can be practised in order to save investment maintenance costs. This is of course even more important for bigger power plant systems.

To make the energy production analysis, the datalogger needs to be called once a day for collection of the lates 24-hour values.

The ERIGEN Datalogger for primary power plants is a call-up computer unit for collection and mean value calculation of meteorological parameters, (wind speed, wind direction, temperature etc) and data from wind plants for solar/wind and diesel power, see fig. 1. Also, supervision- and control-facilities are included, not only for equipment with direct connection to the power systems. In case of malfunctions and alarms the datalogger itself calls up the operation and maintenance center.

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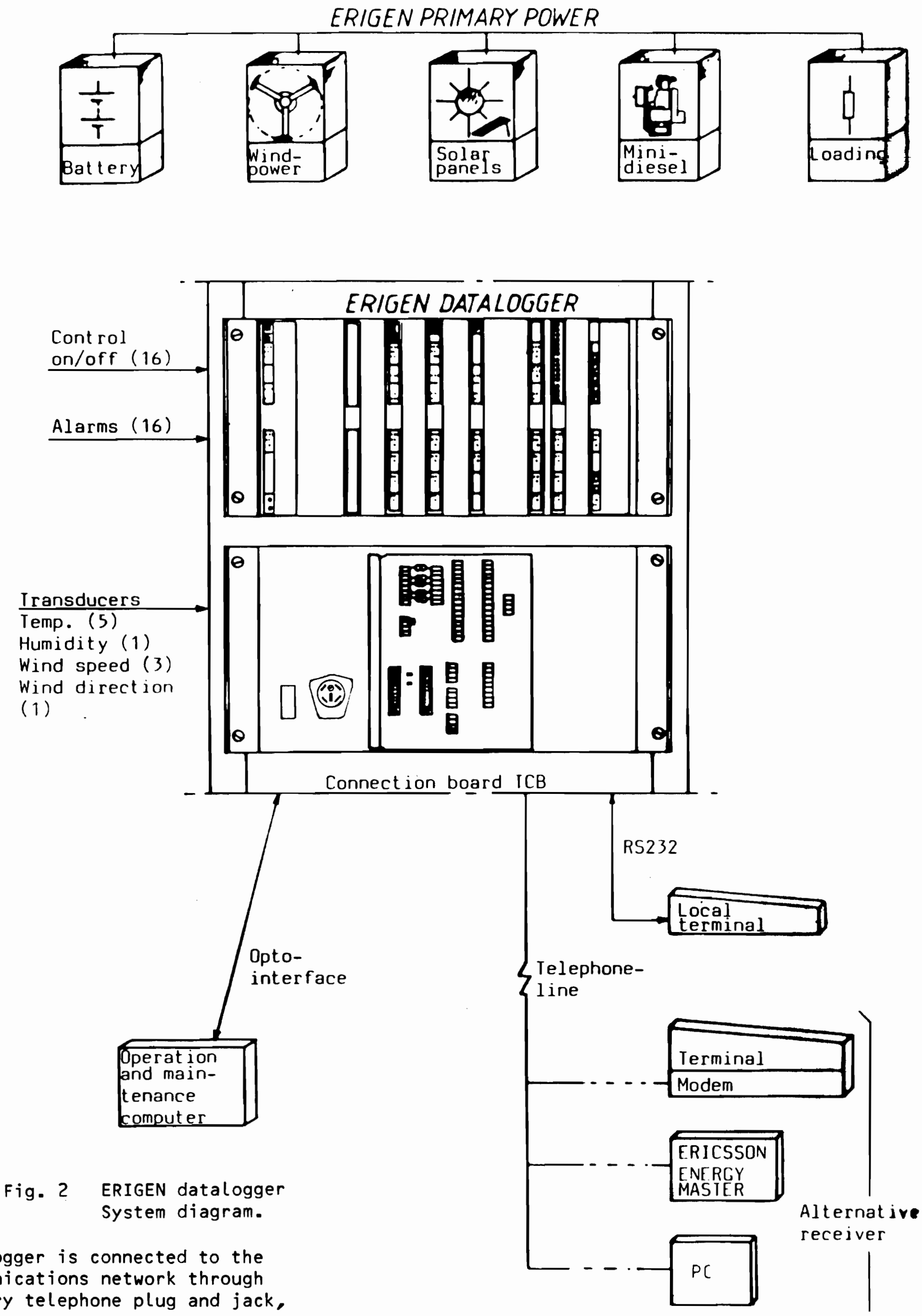

Fig. 2 ERIGEN datalogger System diagram.

The datalogger is connected to the telecommunications network through an ordinary telephone plug and jack, see fig 2.

DATA VARIABLES

There are three types of data variables collected and available in the datalogger system.

- Meteorological data
- Power and energy data and other data related to the power supply system
- Alarm and status indications

Each meteorological variable is presented with a momentary value, an average value for one minute, one for 24 hours, and a minimum and a maximum value. Three wind speeds, one wind direction, five temperatures and one humidity value can be measured. See fig 3, example of data printout.

The power system's data are given in momentary value, average values for one minute and for 24 hours. The data available are shown in the data print out.

The alarm indications are divided into wind system alarms, diesel status codes, solar and other system alarms. Also, there is an indication for the status of the 16 command relays.

Updating of variables is done by command from a terminal. The afterwards printed values are related to the time of the latest updating. The datalogger can also be programmed to execute this updating at preprogrammed times around the clock. Printouts from these occations are then available for reading the day after. The average 24 hours-value

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SHW FLIST                               ERIGEN DATALOGGER SJ-JÄMNVALLEN
-XP/JOO-

TIME        87 03 20 08 48 44
START TIME  87 02 09 12 45 00

**METEOROLOGICAL DATA**                 MINVALUE    MOMVALUE    AVERAGE     AVERAGE     MAXVALUE
                                        24 HRS      SAMPLE      MINUTE      24 HRS      24 HRS

-WINDSPEED-(0-4 OM/S)
    WS1------------------------- 0.00        0.00        0.00        5.55 E-6    0.160
    WS2------------------------- 1.28        5.44        5.95        4.68        11.2
    WS3------------------------- 0.00        0.00        0.00        0.00        0.00

-WIND DIRECTION-(-N 360-+N 360 DI6.)
    WD1------------------------- 0.00        0.00        0.00        0.00        0.00

-TEMPERATURE-(-40-+80 CENTIGRADES)
    TE1------------------------- 27.5        27.5        27.6        31.3        30.1
    TE2------------------------- 11.5        11.5        11.5        12.7        12.5
    TE3------------------------- 11.5        11.5        11.7        11.9        12.5
    TE4------------------------- -5.44       -4.64       -4.66       -3.87       -3.68
    TE5------------------------- 24.3        24.3        24.3        25.8        25.3

-HUMIDITY-(0-100 RH%)
    HU1------------------------- 7.60        10.4        13.8        13.5        20.8

**POWER SYSTEM DATA**

-WIND POWER PLANT-
    GENERATOR FREQUENCY (HZ)-                71.1        71.1        73.6
        -CURRENT-(AMPS)---------             3.62        4.41        2.25
   FEED- -POWER-(WATTS)---------             190         231         117
        -ENERGY -(WH)-----------
        -TOT.ENERGY -(WH)-------             6.95 E4

-SOLAR POWER PLANT-
         -CURRENT-(AMPS)--------             0.160       0.141       0.135
   FEED- -POWER-(WATTS)---------             8.41        7.37         .98
         -ENERGY -(WH)----------                                     168
         -TOT.ENERGY -(WH)------             3.30 E4

-DIESEL POWER PLANT-
    OPER.TIME-(HOURS)-----------             154
    STARTS-(NUMBER)-------------             13.0
        -CURRENT-(AMPS)---------             0.00        0.00        0.00
    FEED- -POWER-(WATTS)--------             0.00        0.00        0.00
        -ENERGY -(WH)-----------                                     0.00

     DIESEL STATUS CODE--------- 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
     (BINARY)

-BATTERY-
    BATTERY VOLTAGE (VOLTS)-----             52.6        52.4        50.2
    DISCHARGED C AP.-(AH)-------             84.5

-POWER CONSUMPTION-
        -CURRENT-(AMPS)---------             1.97        1.99        1.93
  LOAD- -POWER-(WATTS)----------             103         104         99.0
        -ENERGY -(WH)-----------                                     2380
        -TOT.ENERGY -(WH)-------             6.14 E4

-ALARMS                          16          12          08          04          01
    (A=ALARM,X=NO ALARM)
     WIND (AL16-AL01)----------- X-X-X-X-X-X-X-X-X-X-A-X-A-X-X-X-X-
     SYSTEM (AL16-AL01)---------                -NO ALARMS-
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Fig. 3   Example of data printout.

is always valid for the day before. The maximum and minimum values refer to the period from midnight to the time for updating. The total energy values (such as totally produced wind energy) are calculated from the time the system was last started. The time of start shall for this reason always be registered.

SUPERVISION

The available data produced by the datalogger can be used to supervise and check the power plant performance.

The nominal functioning of the wind generator can be checked by comparing the wind speed with the generator's frequency and delivered power to the system.

The solar generator power is measured with a shunt in the same way as the wind generator power. To each regulator, the connected solar panels are divided into two parts. To analyse the good functioning of the solar generator, each regulator compares the two parts reciprocally. If an abnormal deviation in current between the two parts occurs, an alarm is issued to the data logger and the faulty part of the solar array can be identified. The measured total power value can also be used to check the normal function.

The minidiesel control which like the wind power control also is micro computer based, sends information to the datalogger about total running hours, number of start attempts, discharged battery capacity and status code. The status codes give information about conditions causing start and stop and different failure reasons. (The measuring of current, power and energy from the mini diesel has not yet been developed). Together with the possibility of remote start and stop of the diesel set, these available data give a good possibility to supervise the diesel generator's performance.

Voltage and discharged capacity of the battery give information about its state of charge.

With the possibility of measuring five different temperatures, the station shelter can be supervised by measuring the temperature outside, in the diesel room and radio room and in different racks.

Except for the remote control and supervision of the power plant, the datalogger also can be used to supervise and control for example radio and transmission equipment. The analog parts in the datalogger can also be used for measuring on other transducers, if needed. Command and alarm channels are available.

The Erigen datalogger's hardware is prepared for connection to Ericsson's EnergyMaster R (EEM) for control and supervision of telecom power plants. In this case EEM calls up, collects the data and stores it in the central monitor.

DATALOGGER HARDWARE

The datalogger consists of two units: a 19" magazine and a transducer and telephone line connection unit. See fig. 4. The magazines' circuit boards are interconnected both by a wiring side in the back of the magazine and cables plugged to the front of the boards.

The cables from the other equipment are front connected. The datalogger has an internal power converter for 48 V/24 V with ±12 V and 5 V output.

The power consumption is 14 W when in operation. The unit can be set in standby consuming only 0,2 W. It can be woken up when called upon by a normal ringing signal.

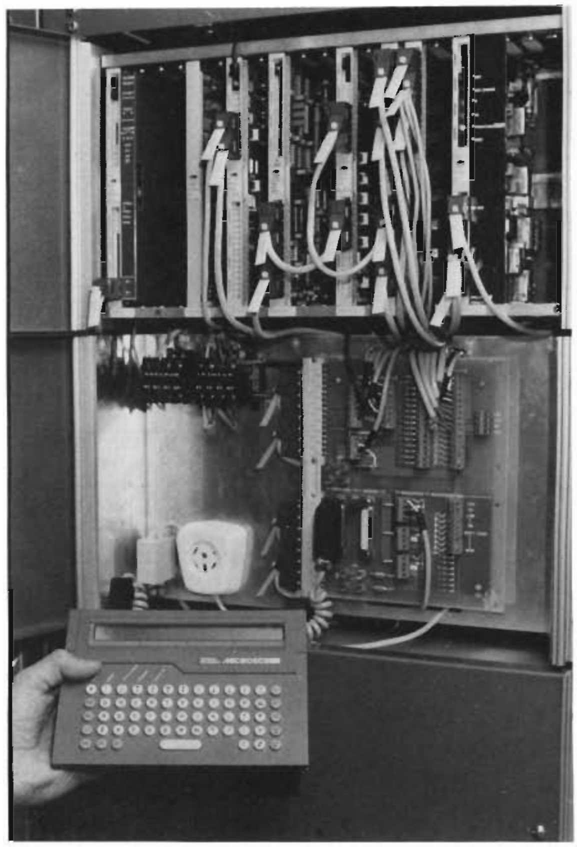

Fig. 4 Picture of the ERIGEN datalogger, interface and handterminal.

Except the power supply converter and the modem, there are six circuit boards forming the datalogger computer. These can be divided into two parts: one micro computer part and one interface part.

There are three circuit boards forming the micro computer of the datalogger.

- Main processor board (MCB)
- Communication processor (COB)
- Memory board (MEM) (with maximum 64 KB ROM or RWM).

The MCB is the CPU of the datalogger. It has an 8-bit processor and executes the collection and all different data processing and forms the protocol. The synchronization is external and comes from the COB. The COB executes the data transmission between datalogger/windpower-solar power control and between the datalogger /diesel control. An external computer can collect data from the system via an OPTO interface. An RS-232/V24 interface is used for terminal communication, locally and remotely via a telephone line. See fig. 2.

The interface part of the datalogger consists of the following circuit boards.

- Control interface (CIB)
- Transducer interface (TIB)
- Relay board (REB)

The CIB's main task is to convert analog signals into digital ones. It receives analog signals from the TIB and sends them further to the MCB in digital form.

The TIB has an analog and a digital part. The analog part contains converters for windspeed, temperature and humidity, adapting them to the analog parts of the CIB. The digital part consists of latching circuits for wind direction, alarm inputs, relay control outputs and command inputs.

The REB has 16 relays with cable connections to the board front. The relays' states are shown by LEDs at the front.

The TCB is mounted in a separate 19" rack unit to be installed below the datalogger magazine. The transducer cables are screwed up on this board. There are also contacts with RS-232 interface for the connection of the hand terminal and data modem. The TCB and TIB are wired front to front by cable and plug.

The modem is mounted in the magazine and is set up for 300/300 band speed rate. It has its own DC/DC converter. All connections, indications and switches are at the board front. The interface follows CCITT's recommendation for V24 and V28.

A hand terminal is used on site for data collection testing and trouble shooting.

The temperature transducer is a temperature sensitive current generator of solid state type. It measures temperatures between -40 and + 80°C. The humidity transducer is a polymer thin film capacitor that measures a relative humidity of 0-100 %.
The wind speed and wind direction transducer are of opto couple type. The wind speed is proportional to a pulse frequency of 4 pulses per m/s wind speed.

Wind direction is given by a 7-bit Gray code. This is read by the datalogger digitally and presented as a number 0-360°*n.

n is a positive or negative number. The number is positive if the direction passes 0° clockwise and negative in the opposite direction.

THE DATALOGGER PROGRAM

There are three major program parts included in the datalogger. All of them are real time programs.

- The main program executes all scanning operations, calculations and presentations. The program PROMs are located at the main processor board (MCB) and the memory board (MEM).

- The communication program administrates the communication routines between the system's different units. Its program PROM is located at the communication processor board (COB).

- The modem program executes the connection of the telephone line. The program PROM is located in the modem (MOD).

The main program is divided into a number of blocks which in turn consists of a number of subroutines with their specific tasks, see fig 5. The diagram shows schematically the program structure. After an initiation of an input/output device, the process awaits an interrupt. The clock gives interrupts every second. When an interrupt occurs, all analog and digital values are scanned. The clock is updated and checks time scheduled functions. After these operations, the process proceeds to calculation routines in order to calculate the mean values, max and min values power and energy values etc. These calculations can be rather extensive and time consuming. Therefore new interrupts are allowed before end of calculation.

Each second, data is transmitted in both directions via COB to and from the wind and diesel control systems.

The operation system receives signs from terminal and moves sign after sign into the command tree. When a full command has been written, an order of execution is given to the routines in question.

The main program has a volume of 20 KB PROM and is written in macro assembler. It has been structurized so that changes easily can be made. This is especially important when customers' demands for new facilities shall be implemented.

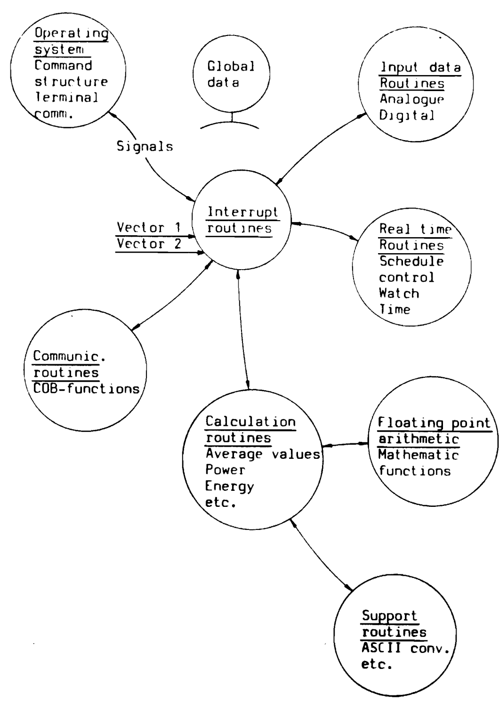

Fig. 5 ERIGEN datalogger program structure.

Fig. 6 The ERIGEN powered lighthouse.

Fig. 8 The ERIGEN powered radio repeater for the Swedish Railways.

FIELD EXPERIENCE

The first Erigen datalogger was installed in 1984, to monitor a wind and minidiesel hybrid power system, installed at a lighthouse some 15 km off shore in the Baltic, south of Sweden. See fig. 6. It has been of great value for the evaluation and understanding of this hybrid power system's performance and behaviour. The reason is that the lighthouse can only be reached by helicopter, and analyzing and trouble shooting on site can only be made during a short time, because of the uncomfortable working conditions. Also, which is of great importance, the course of events to be observed in a hybrid power

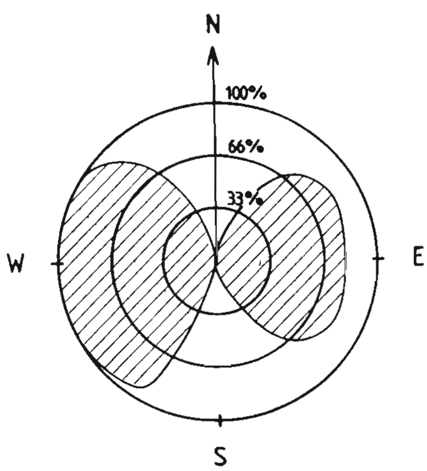

Fig. 7 Reduction factor diagram. Reduction caused by disturbance from tower as a function of wind direction. The turbine is mounted north of the tower.

plant takes place over periods of varying lengths from days to months, depending on weather conditions. One important condition that has been analysed in the lighthouse power system is how much the lighthouse tower reduces the wind power output by airflow disturbances for different wind directions. The power was reduced according to fig. 7. For the energy production, it is also important how the wind direction is distributed in percentage of time. The energy produced has been half of what is possible in an undisturbed airflow, as the wind directions have been evenly distributed.

At an other site, in northern Sweden, see fig. 8, the datalogger has been in operation since early 1986. From that site we have a one year energy production diagram, see fig. 9. The system observed is a complete Erigen solar wind and mini diesel power system with 8 solar modules, 350 W peak, and a wind generator, 950 W peak. The mini diesel generator, 1,5 kW, has contributed 17 % of the total energy produced. The solar and wind powers show a good complementary nature. However, during December and January, the wind contribution was less than expected.

The station was hit by lightning twice during the summer, and the datalogger went out of operation. That is the reason why no data is presented for July and August.

The datalogger has been of great value in the supervision and maintenance of the two stations.

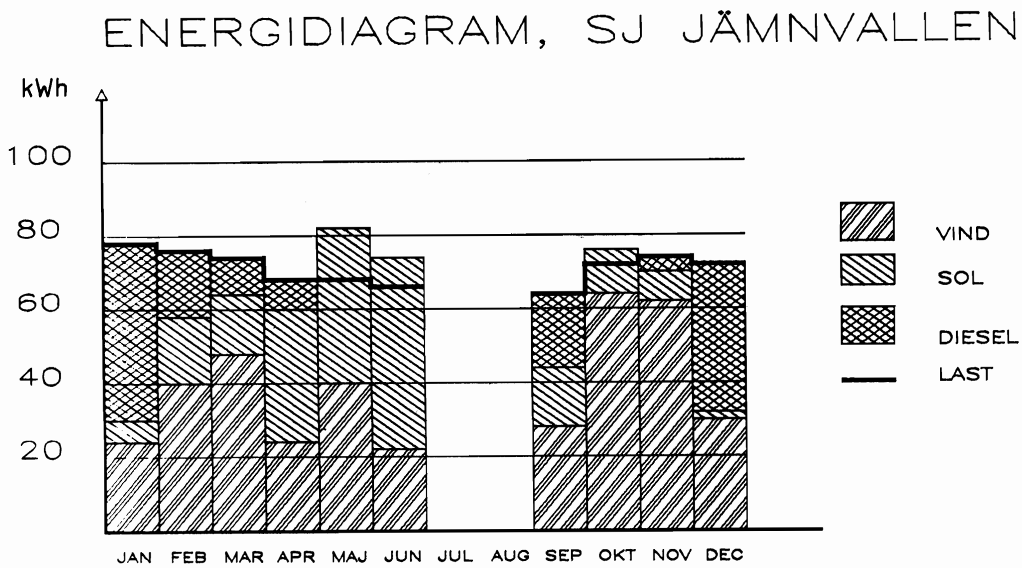

Fig. 9 An energy production diagram made from one year's data collection for the Swedish Railways' radio repeater.

FINAL REMARKS

The interest in data communication with telecom power plants has increased in recent years. This interest is even more justified with remote telecom equipment. This equipment is often difficult to maintain because of long distance travelling and uncomfortable working conditions on site. To verify the system's long term safe operation is therefore of great importance. For the same reason, preventive maintenance is vital. Both verification and preventive maintenance can be done with a datalogger.

When primary power generation is needed at remote sites, this type of power supply often becomes more expensive and complex than the equipment it supplies. It is therefore natural that the power supply system also comprises the station's supervision and control equipment.