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INTEROPERABILITE DES EQUIPEMENTS INTELLIGENTS DE TERRAIN SUR UN BUS OUVERT : DES TESTS EN LABORATOIRE AUX APPLICATIONS SUR SITE

INTEROPERABILITY OF SMART FIELD DEVICES ON AN OPEN FIELDBUS : FROM LABORATORY TESTS TO ON-SITE APPLICATIONS

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SYNTHÈSE :

Cette note présente un essai effectué dans les laboratoires d'études et recherches d'EDF sur les instruments intelligents de terrain (capteurs, modules d'entrées/sorties, transmetteurs), fonctionnant sur le bus de terrain WorldFIP. La plate-forme de test mettait en œuvre un système de contrôle et d'acquisition de données (SCADA) sur le bus de terrain, avec équipements de terrain et outils logiciels du commerce.

Cet essai a permis aux équipes d'EDF d'aborder le problème de l'interopérabilité des équipements intelligents de terrain et de préparer la transition prochaine de la technologie de mesure analogique au tout numérique, par une évaluation des nouveaux services et des meilleures performances offerts. Des architectures possibles pour le contrôle-commande et les essais sur site ont été identifiées.

Une première application à une boucle de débitmétrie est en cours de mise en service. Elle emploie un système numérique de contrôle-commande (SNCC) à base de bus de terrain WorldFIP, avec des multiplexeurs FIP/HART, des équipements intelligents (capteurs et actionneurs) FIP et HART, et un système de supervision.

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EXECUTIVE SUMMARY :

The paper presents a field trial held in EDF's R&D laboratories concerning smart field instruments (sensors, I/O modules, transmitters) operating on the WorldFIP fieldbus. The trial put into operation a supervisory control and data acquisition (SCADA) system on the fieldbus with available industrial field devices and software tools.

The field trial enables EDF's teams to address the interoperability issue regarding smart field devices and to prepare the forthcoming step from analog to fully digital measurement technology by evaluating new services and higher performances provided. Possible architectures for process control and on-site testing purposes have been identified.

A first application for a flowmetering rig is under way. It implements a WorldFIP fieldbus based DCS with FIP/HART multiplexers, FIP and HART smart devices (sensors and actuators) and a field management system.

Interoperability of Smart Field Devices on an Open Fieldbus : from Laboratory Tests to On-Site Applications

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INTRODUCTION

Electricité de France (EDF), the French Electricity Utility and the world's largest operator of nuclear power plants, has always been very concerned by the recent emergence of fieldbus and intelligent field devices. These new technologies impact both short lived on-site monitoring and testing systems and process control systems for which standardized solutions with availability warranted on a long term basis are required [1]. But the fieldbus race is far from the end despite manufacturers' and users' joint efforts to get united behind a single fieldbus [2]. For process industry users faced with an innovative and often unproven technology, the smart instrumentation and the associated fieldbus choices thus look like a gamble [3]. However the digital instrumentation spreading is ineluctable and users have now to prepare themselves (from designers to operators) to get mature with the technology and its concepts, independently of standard evolution.

This paper presents a user's way to prepare this measurement technology forthcoming step and particularly focuses on on-site testing purposes as the on-site testing activity appears to be one of the first potential application domains for fieldbus and smart sensors in EDF.

EDF BACKGROUND

In a nuclear power plant, testing may concern the steam generator, the turbo-pump, the exchanger or any other component of the primary or secondary circuit and may aim at establishing a performance evaluation or precise characterization of the component. The tests practically consist in acquiring data on the selected plant component thanks to a specific instrumentation that is independent from the control instrumentation and only installed for the test duration. The technical staff in charge of on-site testing traditionally uses analog instrumentation, consisting in analog sensors, with point-to-point connections to concentrators (i.e. multiplexers where the analog signal is converted to digital format), scanners and workstations for data acquisition, processing and storage as shown in figure 1.

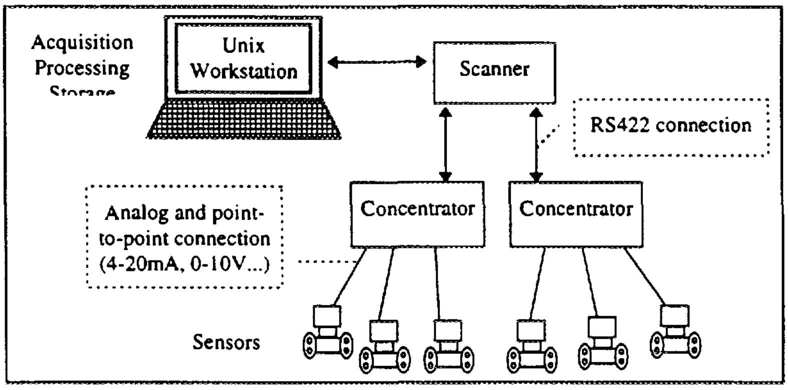

Figure 1. Today's architecture for on-site testing in EDF power plants

To evaluate the impact of the smart sensor and fieldbus technology on today's architectures and to prepare tomorrow's solutions for measurement and automation, EDF has organized a field trial in its R&D Division laboratories.

THE FIELD TRIAL

Rig description

The field trial is supported by a water flowmetering rig including a circulation pump, a heat exchanger, a pressurizer and two tanks as shown in figure 2. The rig is usually used by the R&D staff to reproduce power plant circuit specific configurations and to study the influence of special characteristics such as bends, double bends or headers on flowmeters. It is controlled by a conventional control system, analog and point-to-point sensors and actuators.

Architecture description

The rig has been fitted out with a fieldbus and smart sensors, that come in redundancy with existing control instrumentation. The measurements are measurements of temperature, absolute, relative and differential pressures, level and flow which are the most widely used measurements in power plants.

The chosen fieldbus is WorldFIP which is an open protocol, non-proprietary and well adapted for real time applications. About fifteen connecting points are mounted on the cable to connect transmitters, I/O modules, interface boards and PCs to the fieldbus as indicated in figure 3.

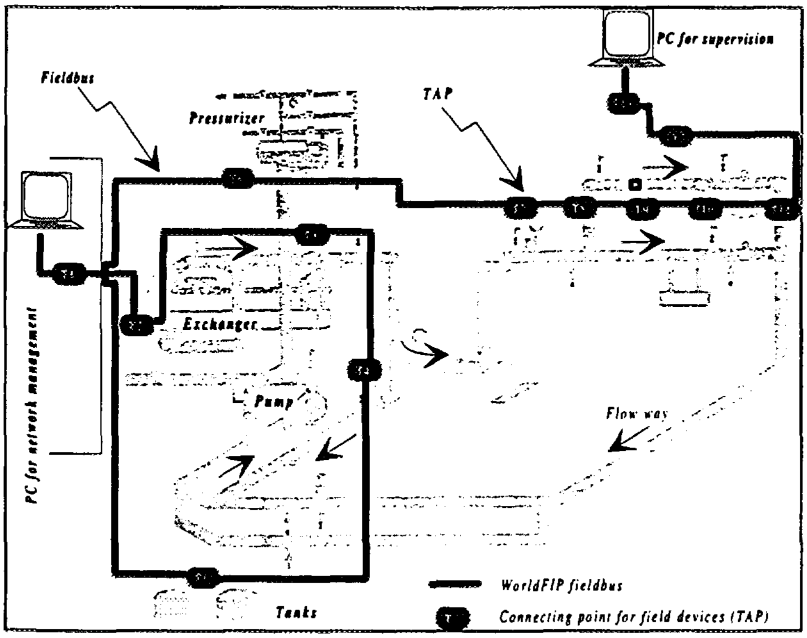

Figure 2. The rig architecture

The used hardware is briefly described hereafter.

Field devices

Pressure sensors retained for the application are Honeywell and Rosemount sensors. These sensors do not provide a digital exit compatible with the WorldFIP protocol. This point is relevant to the larger problem of the communication between networked smart sensors and actuators which is underlined in [4]. To face the problem, some interfaces are used :

- "DE/FIP" interfaces for Honeywell sensors,
- "HART/FIP" interfaces for Rosemount sensors.

DE/FIP interface converts the DE (Digital Enhanced) signal to a WorldFIP format and enables to exploit both the 4-20 mA signal and digital data (alternately). This interface is used on absolute, relative and differential transmitters (see figure 4).

HART/FIP interface converts the HART signal to a WorldFIP format and enables to exploit the superimposed data on the 4-20 mA (simultaneously). This interface is used on differential pressure transmitters (see figure 4).

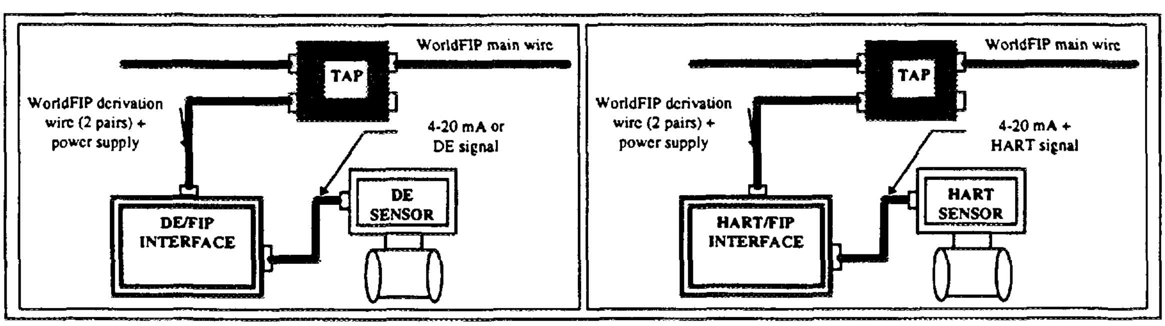

Figure 4. DE/FIP and HART/FIP interfaces

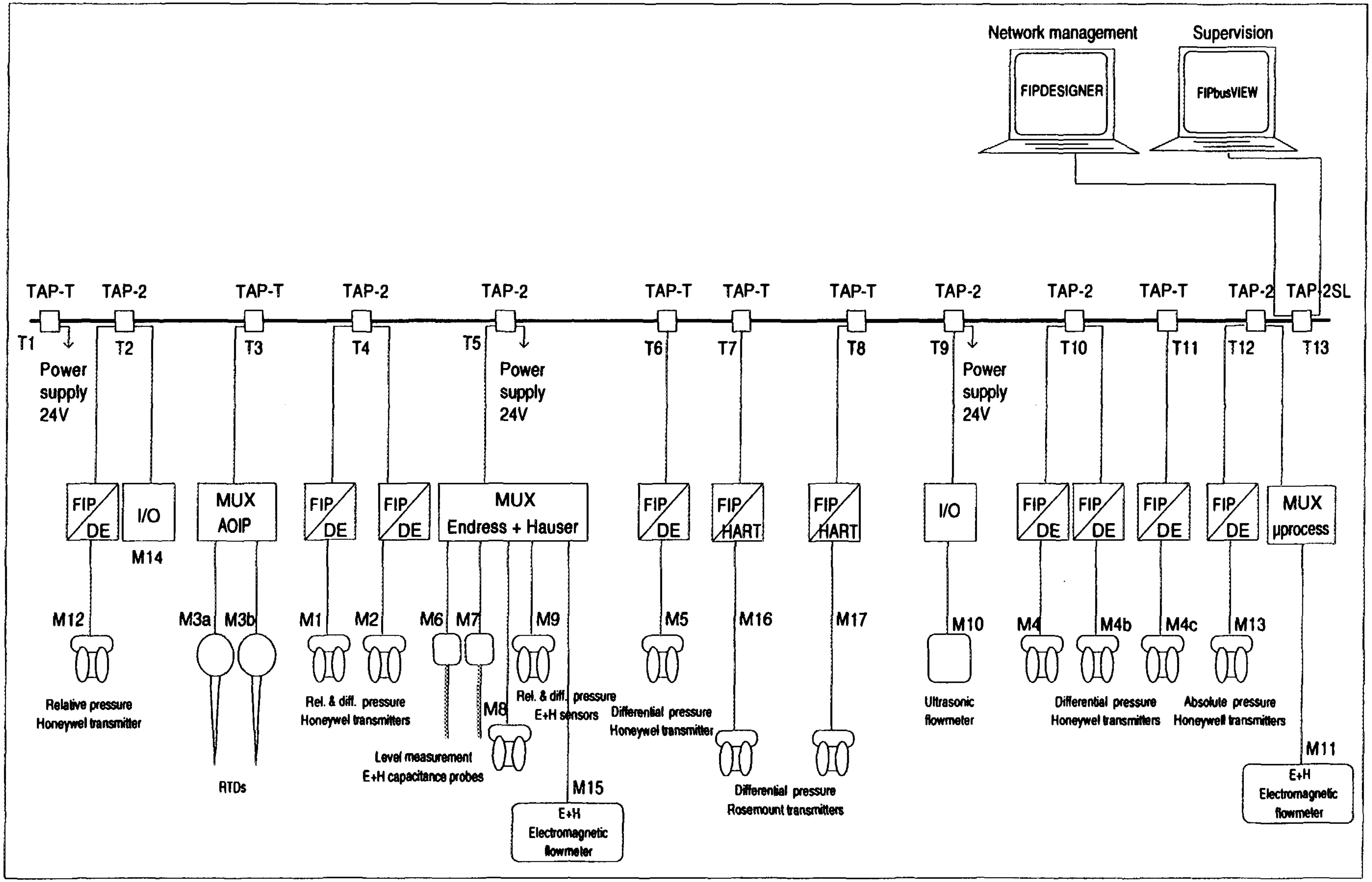

Figure 3. Field trial architecture

Temperature measurements are made with RTDs that are connected to the fieldbus through a WorldFIP I/O module (CIFIP from AOIP or MUFIP from Microprocess).

Flow, level and some pressure measurements are made with Endress&Hauser Rackbus system which enables to connect together up to 64 Endress&Hauser sensors. A gateway interfaces the system to the WorldFIP fieldbus.

Software tools for network management and application supervision

A PC equipped with a WorldFIP board (from CEGELEC) is in charge of the network management. A software tool (FIPDESIGNER from HLP Technologies) allows the user to build and control the communication. Another software tool is dedicated to the application supervision and data acquisition (FIPbusVIEW from HLP Technologies). It operates under a LabVIEW environment such as indicated in figure 5.

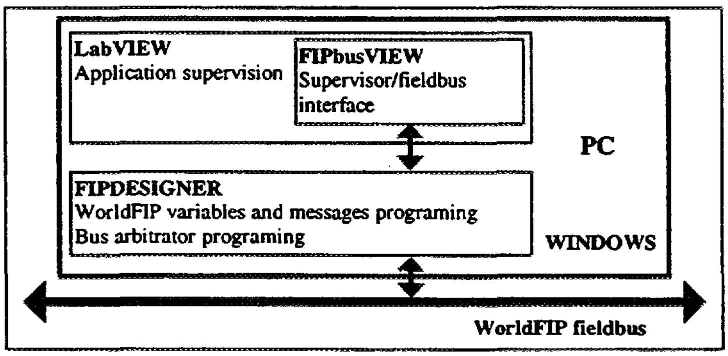

Figure 5. Software tools for network management and supervision

FIPbusVIEW offers a library of virtual instruments (so called "VI") to read/write WorldFIP variables or messages and to build virtual instruments to interface any type of field devices connected to the fieldbus. From the PC, one can analyse any data of the devices and visualizes it in real time through graphical user interfaces (GUI) such as shown in figure 6.

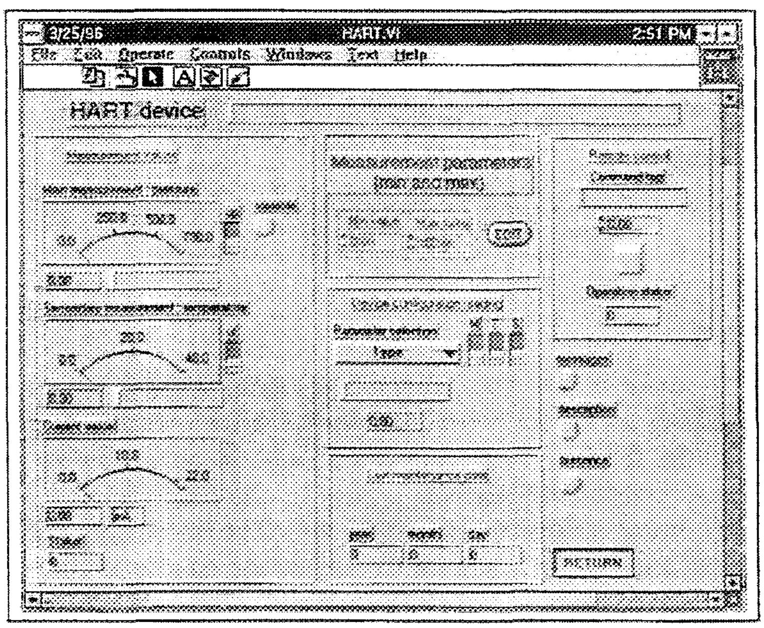

Figure 6. Graphical user interface for supervision

The VIs act as drivers regarding the device connection and integration in the application. These drivers derive from a generic VI which has to be slightly modified and adapted for each particular device (see figure 7).

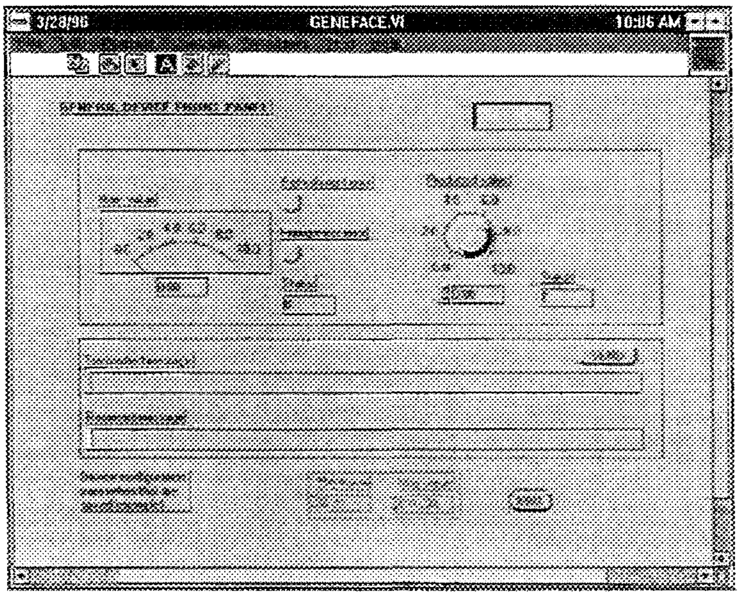

Figure 7. Generic VI front panel

This mechanism enables the user to insure the interoperability of hardware from various manufacturers with a minimum time (few hours are requested for the development of the corresponding VI when the integration of a new device is requested).

The SCADA system carries out the supervision of both process and field devices. Measurement values are reported on a front panel. Alarms are generated on threshold overload and from device auto-diagnosis (i.e. test results on hardware components) and communication status. The device configuration is possible through the supervisor ; device configuration parameters may be read and modified from the supervisor at any time thanks to the message service provided by WorldFIP that keeps time in the communication cycle for maintenance or configuration needs. Finally, the supervisor offers interactive front panels to display the configuration data the user is interested in (principal and secondary measurements, configuration parameters, communication status, global device state, etc.) (see figure 6).

FIELD TRIAL FEED BACK

Feasibility demonstration

The field trial very first result is the feasibility demonstration of a supervisory control and data acquisition system (SCADA) on an open fieldbus with available and industrial products. With a 1 Mbit/s fieldbus speed, all the field devices (between 15 and 20 according to the configuration under test) are read (i.e. the measurement they deliver is read by the fieldbus) in a time cycle inferior to 15 ms which exceeds the PC dating accuracy (around 50 ms). The interesting point is the idea it gives of what could be the practical admissible scanning frequency for on-site testing applications which may require up to 500 measurement points.

Product evaluation

The field trial allowed the evaluation of available smart field devices from various manufacturers. Performances, services and "intelligence" of the devices have been analyzed and expertise and advises can now be given for the choice of devices for future applications. Routines built up for testing have been capitalized in systematic procedures for future smart field device evaluation, ranging from metrological performances to processing and communication capabilities. More precisely, a dozen procedures have been written down on the basis of [5]. They regard the device characteristics listed in table 1.

Measurement function	- static metrology - dynamic metrology - signal processing capability - environmental parameter influence
Configuration function	- device parameter configuration - maintenance data access
Validation function	- autodiagnosis capability - history and logbook capability
Communication function	- physical connection to the fieldbus - physical addressing - communication optimization - communication reliability

Table 1. Smart field device evaluation procedures

Interoperability problem approach

The interoperability problem has been addressed practically from the user's point of view. Even working with an open non-proprietary fieldbus, the plug-and-play concept revealed to be a myth as manufacturers provide products with proprietary format variables. The use of a software library under LabVIEW allows to address the problem with the duplication of a generic device driver that has to be adapted to any particular device (i.e. "cut-and-paste" mechanism).

Technician training

The field trial is one of the first projects where smart instrumentation and fieldbus were brought into operation in EDF's R&D Division laboratories. This trial was and still is a adequate platform to train technicians to new technologies including digital instrumentation, smart field devices and fieldbus. Technicians who practiced on the trial now have the know-how to go and manage on-site testing in power stations using smart sensors and fieldbus.

Guide lines

In addition to technician training, one of the important field trial results lies in the working out of guide lines for designing, installing and operating digital instrumentation on a fieldbus. Technical documents have been written out to whom one can now refer for every phase of an instrumentation life cycle, from specification to installation and commissioning in the plant. This warrants to meet traceability objectives which is of prime necessity in nuclear power plant operation.

PROSPECTS

One of EDF's R&D Division next projects is the building of a new flowmetering rig. The object of the rig is to meter liquid flow (water) from $5m^3/h$ to $1100m^3/h$ in order to evaluate and calibrate flowmeters (ultrasonic, magnetic, vortex, venturi tube, orifice plate, etc.) with high accuracy ; the final aim is to be certified by the French National Board for Accreditation (COFRAC) for liquid industrial flowmetering.

On the basis of the previously described field trial feed back, the chosen technical solution for the process control is a WorldFIP based DCS (distributed control system). The DCS zero level will integrate WorldFIP devices and HART/FIP interfaces to make possible the use of HART based field devices (actuators and sensors). All of the field device digital data may be exploited, from auxiliary measurements to configuration parameters. This choice warrants the possibility of using of a large range of field devices as HART has become a *de-facto* standard for the field communication.

The architecture for this new DCS flowmetering rig is detailed in figure 8.

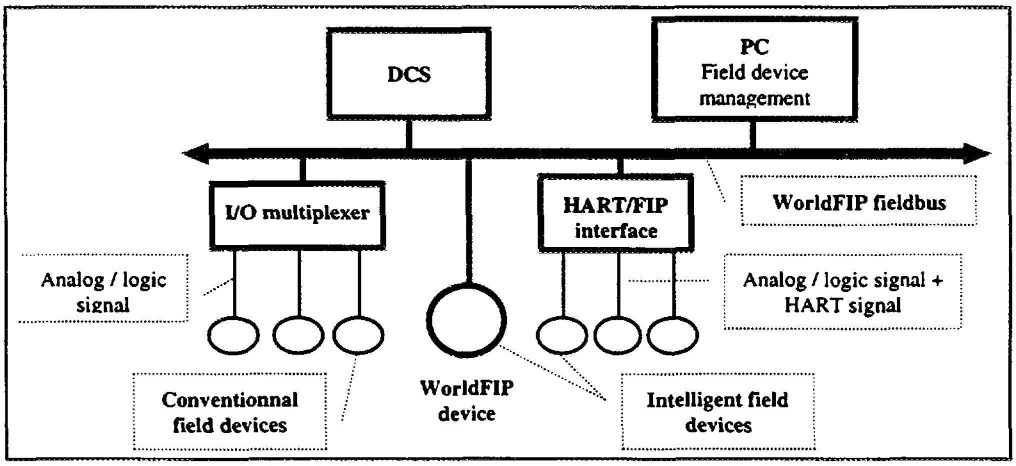

Figure 8. Flowmetering rig DCS

In the near future, the discussed architectures will be adapted for on-site monitoring and testing in power plants. Special attention will have then to be paid to requirements on the field device number and the acquisition frequency (typically 500 sensors with a one-to-ten hertz scanning frequency).

CONCLUSION

The presented field trial held in EDF's laboratories put smart field devices and fieldbus into operation. Assembling of available off-the-shelf products revealed to be possible provided that dedicated (SW or HW) interfaces are used to ensure a minimal level of interoperability. As main results, the technology was evaluated, the technical staff has been trained and got mature with the use of intelligent instrumentation, and procedures and guide lines were written down to answer to traceability concerns. These three factors (technology evaluation, technician training and procedure writing out) pave the way for future industrial applications in EDF power plants.

REFERENCES

[1] F. Beaudouin, J.M. Favennec, M. Piguet, "Intelligent transmitters for process control - What, how, when, how much? A users' point of view", ISA 94, October 1994.

[2] R. H. Caro, "The SP50 perspective : Fieldbus, ATM, Ethernet", Intech, October 1994.

[3] D. Roeder, "Fieldbus handicap hurdles", C&I, August 1995.

[4] J. Bryzek, R. Grace, K. Lee, P. Madan, J. Warrior, S. Woods, "Common communication interfaces for networked smart sensors and actuators", Sensors, September 1995.

[5] CIAME, Méthode d'évaluation des capteurs intelligents, May 1992.