Main Index

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New Networked Fiscal Metering System for the Phillips Ekofisk Complex

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CONTENTS :

0. INTRODUCTION

The paper describes the architecture and functionality of the metering system supplied by **Holta & Håland A/S** (H&H) to replace the existing measurement computer system on Ekofisk 2/4-T and 2/4-Golf. The replacement Measurement Computer System consist of **Daniel Industries** (DUK) Micro 5000 flow computers, performing data gathering and calculations, and the Supervisory Computer System supplied by **Eurotherm Process Automation** (EPA) performing reporting and logging functions.

The paper describes the fundamental requirements and the final system architecture and relates some of the unforeseen problems encountered in implementing a large and complex integrated metering system.

The system integrates field instrumentation such as smart transmitters and individual stream computers into a wide area networked supervisory system with distributed databases. Use of fault tolerant configurations throughout ensures high availability of functionality and data.

The need to maintain accuracy, data integrity and security, network access protection, and on-line maintenance of fiscal data are key features of the system.

H&H have delivered one system which is in operation at Statoil Kårstø (a simplified version of the Ekofisk system), and a system for the Ekofisk complex which now are undergoing final testing.

The following important requirements have been achieved in our system:

- High availability (99.996)
  By use of dual redundancy
- High accuracy
- Scalability
  Start small grow large
- Remote operation
  Unmanned platforms
- Real time applications in Supervisory system.
- Flow Computer with fast sample rate. All I/O within 1 second.
- Oil flow calculation cycle less than 2 seconds
- Gas flow calculation cycle less than 4 seconds.

1. CLIENT REQUIREMENTS

- Flow Measurement at Ekofisk 2/4-T and 2/4G.
- Available Requirements: Overall time availability of 99.996%
- Best available accuracy, using SMART transmitters where appropriate. (pressure, d/p, temp).
- State of the art technology, but using as much standard (proven) software as possible.
- Expandable system, capable of accommodating the total requirements of the Greater Ekofisk complex in the longer term, but maintaining speed performance as system expanded.
- Ability to perform remote monitoring, control and maintenance (from on-shore facilities, and other platforms)
- Act as slave for communication of measurement data to telemetry computer (TCS).
- Display of local oil and gas densitometer, pressure and temperature values..
- Maintain storage for two months of hourly reports for each meter and station.
- Printing of metering reports and system alarms.
- Provide VDU graphic trending display.

The following improvements to client requirements were achieved

- Flow Computers with fast sample rate. All I/O within 1 second.
- Oil flow calculations with cycle less than 2 seconds.
- Gas flow calculations with cycle less than 4 seconds.
- Fast real time response at the Supervisory System (typically 1 to 2 secs).

2 SYSTEM OVERVIEW

The system architecture and functionality has been developed and evolved to meet the latest NPD regulations, and the stringent operational, maintenance and integrity requirements of Phillips for the major Ekofisk refurbishment programme.

The Ekofisk 2/4T metering stations and the number of associated flow computers is as follows:

- Oil: 12 streams + 4 future
- Prover: 1 duty and 1 standby prover computer
- Gas: 28 streams + 8 future
- Flare Gas: 6 streams
- Test Separator: 2 streams

The Ekofisk 2/4G metering stations and the number of associated flow computers is as follows:

- Oil: 3 Streamers + 1 future)
- Prover: 1 flow computer.
- Gas: 4 Streams + 1 future.

A total of 72 flow computers serving 69 metering streams.

The total metering system integrates the specialist functions of Daniels Fiscal Metering Subsystems (Micro 5000) into an EPA Network 6000 Automation System (Maxi-Vis Supervisory system). The resultant system combines the advanced features of the Micro 5000 flow computers with the large system environment of Network 6000.

Maxi-Vis Supervisory system

Maxi-Vis IV Supervisory Systems are assembled from a base set of well proven hardware and software packages. The mix of base software packages defines the general functionality. To this is added special metering application package.

The system is based on a 'Metering Database' package, which is a standard industry package addressing the off-shore Oil and Gas Fiscal Metering Application. The mix of standard DEC hardware and a well proven base package for fiscal metering provided the user with a flexible and expandable system.

Data from the front end subsystems is regularly scanned into the central Maxi-Vis IV database system. The structure of the system is designed to provide a throughput of data into the database such as to achieve a currency of 1-2 seconds on each data value.

Access to this database can be achieved from different terminals either directly linked to the Maxi-Vis IV (e.g. Operator Workstation) or remotely (e.g. On-Shore Computing Workstation).

The system includes operator colour graphic workstations, allowing access via preformatted displays, mimics and spreadsheets to the real-time database. Trending and alarm features are also available as standard at this terminal. Alarm and event messages, database change messages and reports are stored on disk and printed on dedicated hard copy printers. The operator interface is simplified by the use of a dedicated operators keyboard in conjunction with a trackerball. The operators workstation is also used by the engineer (via key protected access) to configure the Maxi-Vis system on-line via standard EPA software packages.

Micro 5000 flow computer

The flow computers are Daniel Industries µ5000 flow computers. They each calculate stream totals, stream flow rates and press, temp, d/p density based on the data gathered from each stream input point. The flow computers each monitor the stream to which they are dedicated. A prover flow computer is provided to carry out proving functions for each of the oil streams.

The µ5000 flow computer is a microprocessor based instrument capable of measuring field signals representing flow and process conditions. The µ5000 flow computer can measure flow represented by signals from primary devices such as turbine meters, PD meters, differential pressure transmitters, and with inputs representing process conditions such as, pressure, temperature, and density, can perform corrected flow and totalisation in accordance with recognised standards such as AGA 3, (API 2530), ISO 5167, AGA 5, AGA 7, AGA 8, API 1101, API 2534, and API 2540.

All the electronics required to monitor and measure these signals are located on a single circuit card. Each µ5000 flow computer can therefore carry out full metering, alarming, control and reporting on single metering stream. Multiple stream metering is also possible only limited by the input and output capability of the instrument.

3. SYSTEM ARCHITECTURE

3.1 Supervisory System

Network 6000 is the generic term for an EPA Integrated Automation System. These systems have a number of characteristics incorporated in the fundamental system design, each of which is important to the successful implementation of a modern Automation System. These are:-

- Predictable real-time performance.

- Open Architecture

- High Availability Configurations

Use of a combination of Fault Tolerant (dual redundant) configurations and distribution of function at a low level.

A Network 6000 System consists of 4 primary logical elements:

- Maxi-Vis Database Servers
- Networked Operator Stations
- Primary Plant Subsystems
- Foreign Database Servers

The Maxi-Vis database server is responsible for updating its database with current data, servicing external database access requests using structured interface routines, and providing a computing platform to run other supervisory functions.

The server communicates with the Primary Plant Subsystems (fiscal flow computers, general process I/O, continuous control elements etc.), using optimised proprietary protocols. By partitioning the communications into a number of segments, each controlled by a dedicated communications processor resident in the server chassis, the server is able to maintain an update rate of 1 to 2 sec. for all primary dynamic data.

Larger systems may be accommodated by adding extra standalone Maxi-Vis Real-time Database Servers. In this case communication between data base computers is handled by an extensive set of Distributed Database interface routines that allow the user to define the types and speed of data exchange (this includes display and file data transfer).

Foreign Device Database Servers can communicate with Maxi-Vis Servers using the same Distributed Database interface routines, or can use an optional package (Distributed Database Network Interface) that imposes strict access protection mechanisms on the device accessing the Maxi-Vis Database. Either method can use DECNet, TCP/IP or other custom protocols.

Maxi-Vis functionality

A brief description of each function follows.

Stream Metering Operations
Operator and Engineer operations are provided for metering runs and stations using a combination of real-time spreadsheets and mimic displays. Extensive use is made of the display hierarchy configuration facilities to provide Operators and Engineers with access to information and facilities in a logical and efficient manner. Integrated into the Operator facilities is the production of hourly, daily and on demand reports.

Meter Proving Operations
Meter proving operations are integrated into the Oil station Operator and Engineer interface using a combination of real-time spreadsheets and mimic displays.

A tape streamer allows archiving of trend data for long term storage and is also used to backup the files on the system disk.

Oil/Gas Densitometer Surveillance
Oil and Gas density surveillance spreadsheets show for each run the density figure used in the flow calculations. An override spreadsheet allows the Operator to choose between measured, calculated or manually entered values.

Sampler
Pulsed digital outputs, proportional to station flow, are provided for sampler systems. Parameters are configured via a spreadsheet.

Real Input Overrides
Spreadsheets are provided to allow the Engineer to override values used by the flow computers.

Information Security
Security of information is ensured by providing:

- Four levels of Operator/Engineer access.
- Read only and read/write privileges to workstations.
- Restricted network access via account passwords.

Information Integrity
The integrity of information is maintained by:

- File/Program/Spreadsheet version numbers.
- Master/Standby Measurement Computer System.

- Duty/Standby flow computer interface.

Time Synchronisation
The system is designed to centralise all date and time stamping for Fiscal reports at the Supervisory Database Computer.

To satisfy the overall time Synchronisation (and data currency) requirements of ± 1 sec., the following system design criteria are observed:-

a) Each stream micro will recalculate the primary flow algorithms and update its local database at a frequency of approximately 1Hz.

All Primary Flow data are updated each second.

b) The Maxi-Vis will update all primary flow data into its real-time database at a frequency of 1Hz. Thus, primary flow data held within the Maxi-Vis real-time database will have a time currency of ± 1 sec.

c) Reports will be formed by taken a snap shot of the set of core data (within say 100 msec. of the specified time of day), and copying into a static scratchpad area of the database.

(Note:- the size and structure of this scratchpad area is user definable via the database configuration tools).

Once placed into scratchpad, the data (formed as a consistent set in time) is then available for the spreadsheet processes to operate on.

d) As a backup the Daniels flow computers will hold the latest value for each of the following stream flow totals - hourly total, daily total, weekly total.

e) The time of day clock within the master and standby Maxi-Vis systems will be maintained to within 1 sec. of the time received from the EPA system.

Alarm and Event Processing
The standard alarm and event processing system providing extensive functionality and flexibility.

Long Term Data Storage and Access
Historic trend data is transferred to tape for later recall.

Daniels Micro 5000 Flow Computer Interface

- Implemented via front end processors.
- All parameters down loaded from the MCS.
- All parameters read back after down load and compared with master files.
- Data down loaded to both duty and standby computers.
- Parameters scanned every one second.

Smart Transmitter Interface

Read only interface to smart transmitters for calibration purposes.

Telemetry System Interface

- Handles both send and receive requests.

3.2 Flow Computer system.

The system is configured with one µ 5000 flow computer dedicated to each metering line. The input signals are segregated into signal type. These are distributed to the appropriate flow computers. Signal conversion is carried out on each flow computer termination module.

The oil stations have a PLC monitoring the valve interlock for proving. This carries out interlocking functions.

Each metering run are supplied with one computer per line, each monitoring the following signals :

- Turbine meter:
  Dual Pulse Inputs : optically isolated.
  0 - 2.000 Hz, Integrity Monitoring to ISO 6551 Level A or B
  optional on each input channel

- Densitometer:
  Frequency Inputs : optically isolated.
  5 - 10,000 Hz, 650 nano-seconds resolution. Accuracy : Typically
  0.0013% of reading.

- Flow Control valve:
  Analogue feedback signal
  4 - 20 mA, 16 bits resolution ± 0,02% of full scale accuracy.

- Control valve position:
  Status Inputs

- Prover Detector Switch Status Inputs

- RS485 link to the smart transmitter interface. Temperature, pressure, diff. pressure, process values

- Flow Control valve:
  Analogue Control Outputs :
  4 - 20mA, 12 bits resolution ± 0.1% accuracy, 100 msec update.

- RTD Inputs:
  4 Wire. 100 ohms PRT to IEC 751 Class A, ± 0.1% accuracy (of reading)

- Valve:
  Control Outputs

Each flow computer has the following communications links : -

- Link to dual supervisory computer system (Dual RS 422 Link)
- Link to prover flow computer (RS 422 Link)
- Link to the neighbouring flow computer providing standby metering (RS 422 Link)
- Link to the neighbouring flow computer that this flow computer is supplying standby metering for (RS 422 Link)
- Link to the smart transmitter interface for the standby process signals (RS 485 Link)

Each flow computer receives the signals as detailed above and uses the values measured from the transmitter outputs to calculate flow rates and flow totals. The calculated values and data gathered from each transmitter are available for the supervisory computer and can be accessed at each computer using the hand held keypad. In addition to the signals received and supplied, as detailed above, each flow computer provides monitoring and controlling for the neighbouring flow computer.

<u>Proof Control</u>
The system is configured with two micro 5000 flow computers providing common proof control for all oil stations. The two flow computers are arranged in a primary/standby arrangement, with proof control only possible from the primary flow computer. A switch is provided to enable selection of the primary and standby flow computers. The switch will enable the operator to select which flow computer is the primary. The standby flow computer will become the primary after a switch over and the primary flow computer shall control the valves. A single RS 422 communication link is provided between the stream flow computers and the prover flow computers. The primary prover flow computer acts as the master with the other flow computers on the communication link.

4. PROBLEMS ENCOUNTERED

Size and complexity of system caused some implementation problems. The system has proved to be more complex than any of the participating Companies originally envisaged.

Creating a secure multi-user environment with sufficient levels of protection, particularly in relation to remote network access and partitioning data access and executive access.

Failure mode detection and recovery.

Understanding and agreeing precise functional requirements, and translating these into an agreed implementation.

Time and complexity of integrated and FAT testing

e.g. large quantity of complex real time spreadsheets
failure mode testing
network testing.

5. FUTURE POTENTIAL

Experience gained has established the overall design principles for a Fiscal metering system integrated into a comprehensive network environment.

With current computing technology, these principles can be readily applied to small system applications, but ensuring that the system can be expanded as required in the future. For example, a single workstation combining the functions of database and user interface can be used to supervise a few fiscal stream computers in the knowledge that the basic architecture will support expansion into a larger integrated environment if required.

6. ILLUSTRATIONS

- PPCON Ekofisk System overviews
- Unique features
- Operator overviews

PPCON Ekofisk System overview

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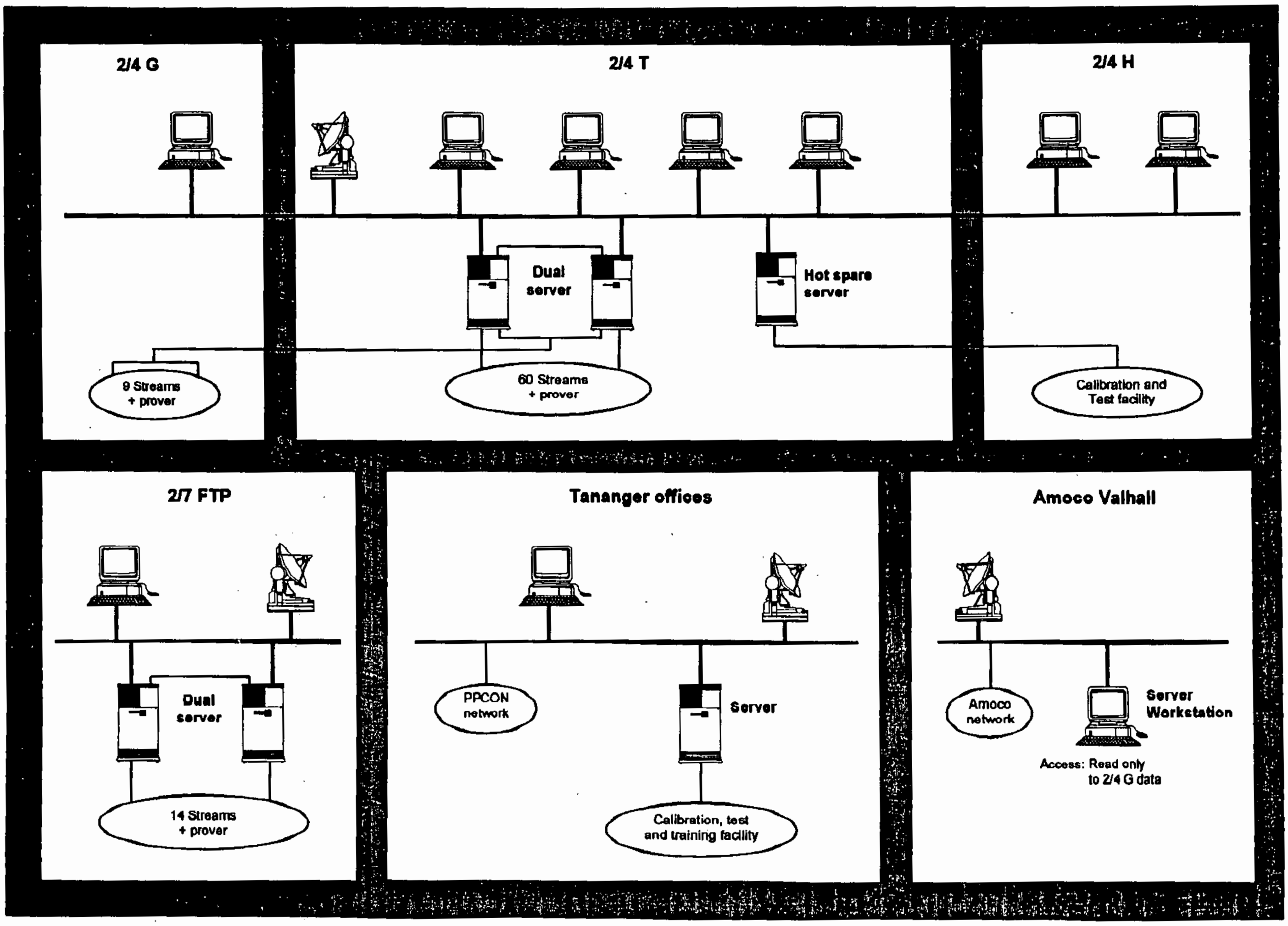

Operator overviews

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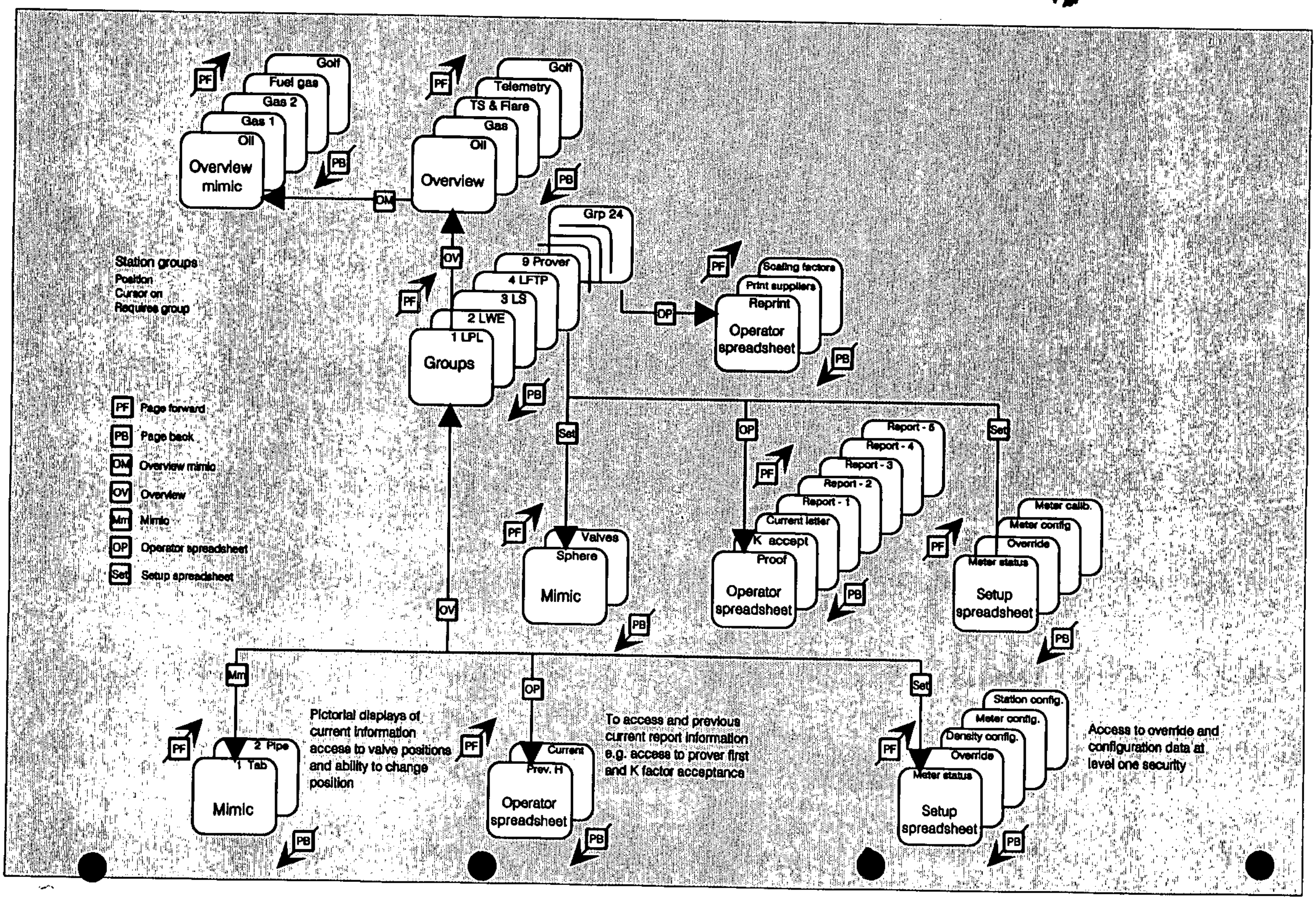

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Unique features

- High availability (99.996)
  - By use of dual redundancy
- High accuracy
- Scalability
  - Start small grow large
- Remote operation
  - Unmanned platforms
- Real time applications available in Supervisory system (SCADA, process control etc)
- Flow Computer with fast sample rate. All I/O within 1 seconds
- Oil flow calculation less than 2 seconds
- Gas flow calculation less than 4 seconds

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.