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THE FIELDBUS CHALLENGE
@
CHH TASMAN, NEW ZEALAND

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Abstract:

The challenge wasn't just to deliver on the promise to reduce running and maintenance costs; the challenge was to combine existing 4-20mA technologies with Foundation Fieldbus technology and to make it work.

The Lime Kilns and the Causticising Plant are two plants that operate within a Kraft Pulp Mill process where joint operation interaction and plant stability are critical. The Lime Kilns at CHH Tasman have been subjected to partial upgrades over the years but were still predominantly controlled by a Bailey Infi90 DCS system while the Causticising Plant was operated from panel mounted controllers, recorders and displays. Motor stop/starts for both plants were push-button based and operated from a control panel. Motor control, interlocks and permissives were handled via Motor Control Centres with Allen Bradley 5 Series PLC's communicating with the Bailey DCS via a Data Highway + local area network.

The real challenge was to replace the electrical and instrument field equipment and transfer total control to a Smar System302 Foundation Fieldbus hardware/software platform complete with a new iFix SCADA server while retaining the Bailey DCS control for the Kilns, retaining the Allen Bradley PLC's for motor control and… …making it all work!

Keywords
Foundation Fieldbus, High Speed Ethernet HSE, Interoperability

1 INTRODUCTION

1.1 What?

I remember listening to Mark Stormer's presentation at last year's 'Jump Aboard' and thinking "…. I wish I had heard this 12 months ago". Hopefully this paper will have the same impact on some unsuspecting engineer about to embark on the implementation of a Foundation Fieldbus system of his own.

The project commenced October 2001 and was completed October 2002. The system consists of dual redundant Smar Fieldbus DFI302 processors and Intellution iFix SCADA servers interconnected with high speed Ethernet (HSE). The field network was split into four H1 Foundation Fieldbus segments containing a total of 38 Fieldbus devices.

The field instrumentation was predominantly from the Smar 302 range with one Rosemount Conductivity Fieldbus device. A total of 38 4-20mA devices were connected to the Fieldbus networks via Smar Current to Fieldbus converters (IF302s). Smar remote I/O modules (DC302) were used for hard wired discrete interlocks to motors and drives. HSE was used as the system backbone integrating data servers and operator interfaces. The Bailey operator interfaces were replaced and the graphics and tag database were replaced with an iFix SCADA server.

This project was split into 3 smaller projects:

- The DCS upgrade of the Lime Kilns
- The MCC replacement for Lime Kilns and Causticising Plant
- The implementation of Foundation fieldbus for Causticising Plant control.

This paper will focus on the last phase, the implementation of Foundation fieldbus for Causticising Plant control.

1.2 Why?

Raja Lokuketagoda, the mill E&I Engineer, had been following the developments of Foundation Fieldbus technology for some time. The Foundation Fieldbus End Users Council New Zealand held regular seminars on Foundation Fieldbus technology and its developments. After following the Foundation Fieldbus developments over a period of months, Raja was enthusiastic to propose the introduction of this technology to the CHH Tasman Pulp Mill and to benefit from the upgrade to digital control. An increase in plant availability and a reduction in process variability were anticipated as a result of the implementation of a digital Foundation Fieldbus control system.

1.3 The Paper

In this paper, we will be journeying through each stage of our project detailing our methodology, sharing our experiences and stopping along the way to highlight some of our trials and tribulations in implementing a control system upgrade using Foundation Fieldbus.

2 THE PLANT

The Lime Kilns and the Causticising Plant are two plants that operate within a Kraft Pulp Mill process where joint operation interaction and plant stability are critical. The loss of the Causticising Plant has the potential to interrupt pulp production both upstream and downstream of this plant. Loss of production is measured in lost tonnes of pulp production per day and has a fluctuating cost of anywhere between NZ$300,000 to NZ$400,000 for any 24hr period.

Keeping plant downtime to a minimum was a pre-requisite for the project and the installation and commissioning had to take place during short 4-hour shuts. This was to add extra pressure when it came to commissioning time and dictated the constructability and commissioning phases of the project.

We were fortunate not to have to worry about hazardous area requirements and limiting the number of Fieldbus devices per network due to power limitations was not something we had to worry about.

2.1 Pulp Mill Block Diagram

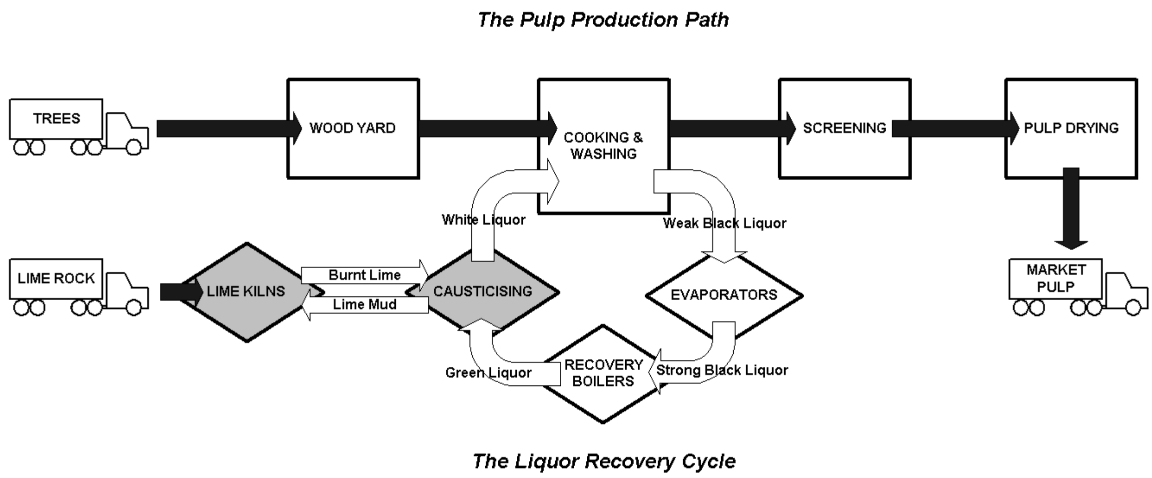

Figure 1 - Pulp Mill Block Diagram

3 THE PROJECT

3.1 The Original System

3.1.1 The Lime Kilns

The Lime Kilns had a mixture of existing Bailey Infi90 DCS control and panel mounted controllers. The majority of the motors were already on PLC control with a small number still on control panel operation. Field instrumentation was a mixture of pneumatic and 4-20mA equipment. As a large portion of this plant was already on DCS control, it was decided that the existing Bailey DCS would remain. The existing Bailey DCS network would be connected to the new iFix SCADA servers. This project would upgrade the pneumatic equipment with analogue 4-20mA devices.

Figure 2 - View of Lime Kiln No.2

3.1.2 The Causticising Plant

The Causticising Plant had largely panel mounted single loop controllers with local panel indication and recording. Field instrumentation was a mixture of old pneumatic devices and analogue 4-20mA devices. Existing motor control was a mixture of PLC and control panel operation. This was the plant where we were to introduce Fieldbus field devices and a Fieldbus distributed control system. The majority of 4-20mA sensors were large in-line type such as magflow meters and density meters. Due to financial constraints, the decision was made to retain these devices and run the signals to the Fieldbus system via Current to Fieldbus converters. Fieldbus versions of these devices were not yet readily available either. Variable speed drives had been controlled with outputs from panel mounted controllers. It was decided to connect these devices to the Fieldbus system via Fieldbus to Current devices.

3.1.3 Causticising & Kiln Motor Control Centres (MCCs)

The Causticising & Kiln Motor Control Centres were replaced as part of this project. The existing MCCs were in varying states of upgrade. This project would replace the Lime Kiln and Causticising MCCs. All motor control would be transferred to Allen Bradley 5 Series PLC operation.

3.1.4 The Operator Interface

The Operator Interfaces were to be replaced as part of this project. Existing Bailey HMI's on the Lime Kilns were to be removed. The graphics were to be redrawn and new PC clients supplied. The Causticising Plant was to have graphics generated from scratch and also be supplied with new PC clients.

As you can see, this project was split into 3 smaller projects:

- The DCS upgrade of the Lime Kilns
- The MCC replacement for Lime Kilns and Causticising Plant
- The implementation of Foundation fieldbus for Causticising Plant control.

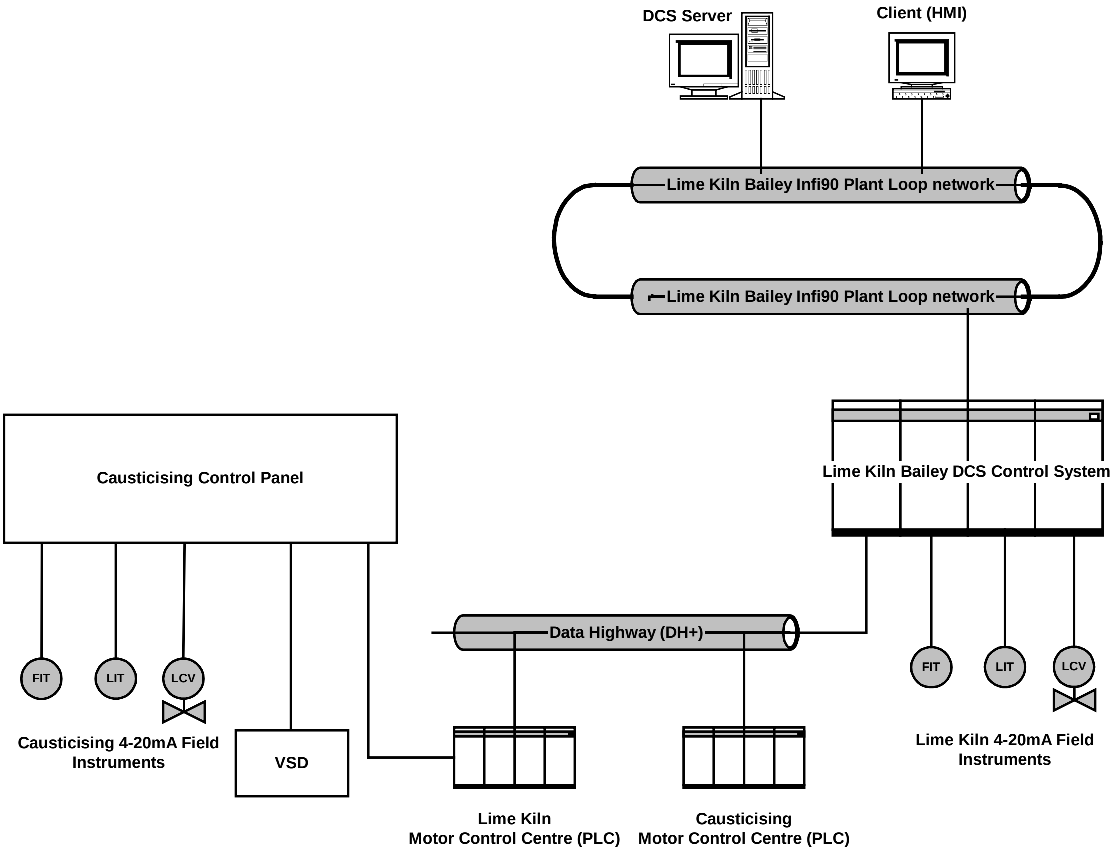

Figure 3 - The '*Before*' Shot

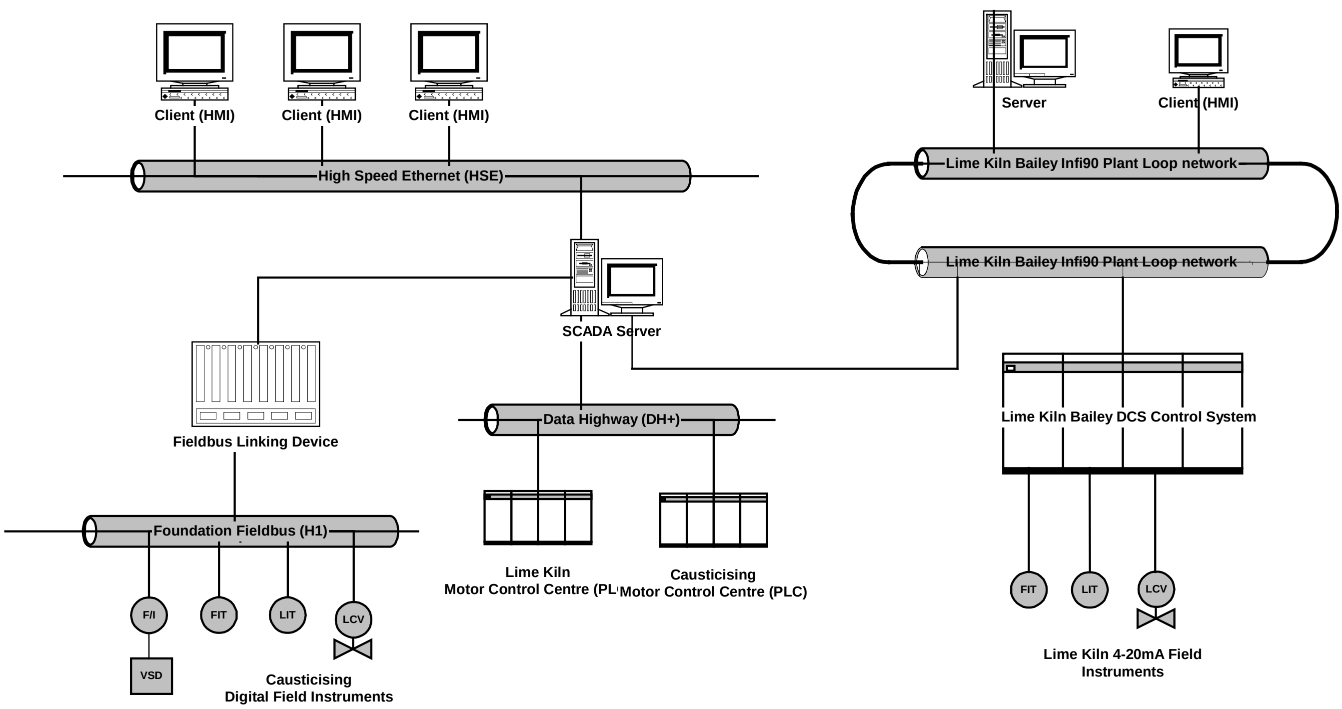

Figure 4 - The '*After*' Shot

This paper will focus on the last phase, the implementation of Foundation fieldbus for Causticising Plant control.

3.2 Concept Design

Several key questions needed to be asked before we could embark on selecting a suitable product and vendor

3.2.1 Do we retain our existing design philosophies and engineering procedures?

Our existing design philosophies and engineering procedures were well defined and both our engineering and maintenance staff and our engineering contractors were very familiar with our current practices and thoughts.

Contemplating the fact that no one really likes any sort of change we decided to retain as much of the appearance and maintainability as was practical. Visible items such as the marshalling of field cabling; installation of terminals and use of field junction boxes for instrumentation was to remain. The location of Fieldbus Linking Devices would be in the same equipment room as the Bailey DCS equipment. Redundancy was also to remain at the server and controller module level as is currently engineered into our Bailey DCS system.

Interlocking was to remain hard-wired between our existing PLC's and the new Fieldbus system.

3.2.2 What topology would best suit us?

We looked at both the Daisy Chain and Chicken Foot topologies and quickly determined that Chicken Foot would best suit our requirements. Chicken foot topology was also schematically very similar to our current practice of marshalling up to 24 devices in a field junction box. Daisy chain was dismissed due the impracticality of running what would essentially have to be a ring main of signal cabling to be able to accommodate integrity of the devices on each network.

3.2.3 Do we want to replace all our 4-20mA field equipment?

A significant proportion of our existing 4-20mA field equipment consisted of expensive 'in-line' magflow meters and conductivity meters. These were spread across both the Kiln and Causticising Plant. Following inspection, these items were found to be in good condition and to replace them would not have been cost effective. Lime Kiln 4-20mA hardware not currently connected to the DCS was to be wired back to the existing Bailey DCS. Causticising Plant 4-20mA equipment was to be added to the Fieldbus network via Current to Fieldbus converters.

Figure 5 - Smar 3 Channel Current to Fieldbus Converter

3.2.4 Do we try to utilise existing field cabling?

Existing field cabling and marshalling was reviewed and initial thoughts were that this could be utilised. Although this could have potentially saved some money it would have meant having the Fieldbus processors in a location dictated by the end of a cable rather than in a location that was more practically and environmentally suited. The final decision, although this was made following the award of the contract, was to run new cabling for all Fieldbus devices and new cabling for each of the four Fieldbus segments back to the Fieldbus Linking Device.

3.2.5 Do we need redundancy in our control system servers and processors?

The existing site policy is to have redundancy at the controller level and server level in our Bailey DCS systems. The DCS processors currently operate on a Primary and Backup principle. This to allow the addition to or modification of the DCS configuration without plant interruption. This system also provides a high level of integrity within the automated control of our plants. It was decided that the same principal should be applied to our Foundation fieldbus system. Redundancy at the Fieldbus Linking Device and at the SCADA Server was to be engineered into the system.

3.2.6 Do we need redundancy in the field?

Redundancy at field level is something that is currently not engineered into our control and electrical loops. It was not thought necessary to introduce redundancy at field level. However redundancy was built into the 'trunk' cabling from the field Fieldbus marshalling boxes to the processors by having a spare pair of unterminated cables should these be needed.

3.2.7 How do we handle our interlocking?

It is our current site policy that interlocks and permissives must be hard-wired and not transferred over our control system network. This is largely due to reliability issues that we have experienced in the past with the Data highway to Bailey interface cards (KF2 cards). These cards provide a DH+ to RS232 conversion to allow our Bailey DCS network to talk to our Allen Bradley Data Highway network.

As we really did not know much about foundation fieldbus and its integrity we decided to stick with hard wiring of interlocks and permissives.

3.2.8 Do we replace our Bailey DCS for the Lime Kilns?

Varying proportions of the Lime Kilns were already connected to the Bailey DCS. The remaining Lime Kiln control was implemented on panel mounted controllers. The cost involved in re-writing the configuration, including some complex advanced control, would not have been cost effective (not to mention the disruption in implementation and commissioning). The Bailey DCS would remain in control of the Lime Kilns.

TIP TIME

Involve your Operations and Maintenance Personnel

The co-operation from the operators and plant management is essential to the success of any project. Buy-in from operations early on was necessary with regards to the new graphics, trending and alarm management. Having these people involved from the start gave them some ownership and involvement in the decision making. The net result of this involvement was plant access co-operation during installation and commissioning and a positive attitude in the adoption of a new control system.

Buy in from maintenance from as early as the concept stage was also crucial to the project success. Their life as an instrument technician was never to be the same again. Out of all of the problems faced throughout the duration of this project, the biggest underestimation was to fully appreciate the impact on the day to day maintenance team. Current maintenance practices and theories were to be turned on their heads. Without the early involvement of these people the acceptance of this technology would not have been an easy task.

3.3 System Selection

Now that we had the basis of a design concept, it was time to select a suitable vendor and Foundation Fieldbus system. An initial survey determined the availability of suitable systems. Vendors and agents were asked to register their interest with regard to the supply of a turnkey package for the supply, engineering, design, configuration, installation and commissioning of a Foundation Fieldbus system, new MCC's and associated control room and field hardware. It was decided at an early stage to outsource all engineering/design, supply, installation and commissioning to one supplier.

Although the primary focus was on Foundation Fieldbus, at this stage of the process, we were concentrating on a vendor that could supply all components, all engineering, installation, and commissioning of the Causticising Foundation Fieldbus system, the Kiln DCS system, and the Causticising and Kiln MCC replacements.

The Foundation Fieldbus proposals were examined and key items such as system architecture, redundancy proposals, and proposal for digital instrumentation, high-speed ethernet capabilities, previous Foundation Fieldbus experience, and Foundation Fieldbus reference lists were reviewed. Due to the relatively small installed base reference sites were difficult to find so at this stage we were still reliant on vendor knowledge and information.

A selection panel was established to choose the final vendor. After much discussion, the final vendor was selected and the contract awarded.

TIP TIME

<u>Points to note at the time of system selection</u>

- Insist on reference sites and speak to end users of equipment being proposed
- Compare functionality between your existing equipment and the equipment being proposed.
- Functionality you take for granted may not be available in you new system.
- Make sure that you are aware how all the new diagnostic information is going to be presented to the user. And what they are going to do with it.
- What extra purchases are necessary that you wouldn't have to consider with 4-20mA systems
- Take time to visit a site where similar systems have been installed
- Treat new technology upgrades and implementation as separate projects. Give them the attention they deserve

3.4 System Design

3.4.1 System Redundancy

Our system contains two Smar DFI302 Fieldbus Linking Devices, which act as interfaces between the Fieldbus H1 segments and the high-speed ethernet network that the iFix SCADA servers sit on. The Fieldbus Linking Devices work in a hot-standby redundant mode where only one of the two is actively performing the function of the Link Active Scheduler (LAS). In the event that the active Fieldbus Linking Device stops working the other Fieldbus Linking Device will take over this role of LAS.

Each Fieldbus Linking Device is connected to a specific server in the same way that the current Bailey DCS operates. The iFix OPC client has been configured to source its data via a single Fieldbus Linking Device only. This is to separate the Fieldbus traffic from the SCADA display and trending data. Each SCADA server is fitted with two ethernet network cards. One for the direct connection to the Linking Device and one to connect the server to the HMI clients.

When the primary Fieldbus Linking Device and iFix SCADA server combination failure occurs the iFix clients (HMIs) swap over and obtain their data from the backup iFix SCADA server and Fieldbus Linking Device combination. The redundant paths on the HSE side of the Linking Device are always available. When the primary SCADA server fails, the HMI clients take their data from the backup server.

Figure 6 - The DFI Panel and 'Onlooker'

3.4.2 Communication between the iFix SCADA server and the Bailey DCS

The Bailey DCS operates on a mill wide proprietary ethernet network. The Lime Kiln instrumentation and control was to remain on this network whilst the HMI operator interface was to be transferred to the new iFix SCADA server.

It was possible to physically connect the Bailey network directly to the new iFix SCADA servers via the COM port of the server PC.

The iFix SCADA server talks to the Bailey DCS via an OPC server, OPsCon. OPsCon is a proprietary piece of software purpose built to allow Bailey DCS and Intellution (iFix) data communications. OPsCon permits 1:1 tag mapping between the Bailey and the iFix SCADA. This allows the existing Bailey tag data for a particular loop to be sent to iFix in one piece of data. The Bailey tag database could then be accessed for graphic information and control via the iFix system.

OPsCon had been developed primarily for end users wanting to upgrade the SCADA/top end of their control system whilst retaining their existing DCS control system

3.4.3 Communication between the iFix SCADA server and the Allen Bradley PLC

The motor control logic was to remain in the Allen Bradley PLC. A gateway was required from the new iFix SCADA servers into the existing Data Highway PLC networks. A proprietary Allen Bradley communications card (KT card) was fitted to each of the new SCADA servers permitting a connection for the Data Highway + network. Stop/start operations etc. can now be transferred from the HMI to the PLC via this network. Alarms generated at the PLC can now be transferred to the HMI via this network.

Interlocks remain hard-wired and are connected to the PLC via a Smar Fieldbus remote I/O module (DC302).

3.4.4 Communication between Fieldbus and the Variable Speed Drives

As part of this project several variable speed drives who's setpoint signal used to be generated from a 4-20mA output from a single loop panel mounted controller were modified to receive a control signal from the Fieldbus system.

Fieldbus to current converters were used to provide this interface. Signal isolators (I/Is) were fitted to the 4-20mA signals from the Fieldbus to current converters. This was to isolate any potential for ground loop problems.

3.4.5 System Documentation

Our existing control system drawing standards were reviewed with respect to reducing the number of typical drawings produced for a project. The CHH Tasman drawing standard for instrument loop diagrams is one loop per A3 drawing.

Could the number of drawings be reduced? The answer was potentially yes as the only detail to appear on the loop diagram was the physical connection to the field device termination box. The segment 'trunk' cabling was to be detailed on a system block cable diagram.

After a great deal of thought, it was decided to retain the current drawing practice with one device per drawing. This would give some 'familiarity' to the maintenance team with respect to the documentation. This would also allow us to detail in full; our field powered devices such as magflow transmitters and conductivity transmitters. Trying to add signal isolators, 115VAC power supply details etc. to a drawing containing 8 – 13 other loops would not have been practical.

3.4.6 Hardwired Interlocking from Fieldbus to PLC

Options considered were:

3.4.6.1 On-board discrete I/O

The original proposal from the system supplier was to hard wire interlocks and permissives from the Fieldbus controller to the PLC using discrete I/O fitted to an extended Fieldbus Linking Device backplane. This original concept was fine until the problems became apparent with updates following the addition or modification to the discrete logic. As this I/O was part of the Fieldbus Linking Device a full download was required after each modification or addition. As a full download needs a plant shut to safely action this was not a preferred option.

This option would have permitted hard-wired interlocking for our safety interlocks but was not an acceptable method of implementing discrete I/O.

I believe that Smar has addressed this and that partial downloads to the linking device can now be achieved.

3.4.6.2 Modbus communication

A Modbus serial communication port is available as part of the Fieldbus Linking Device. Our site standard PLC communication protocol is Allen Bradley Data Highway +. In order to utilise Modbus, a third party protocol converter would have been necessary.

Permissives such as high or low-level alarms could be generated fieldbus function blocks and communicated to the PLC via Modbus. This would mean that we would be using our data highways to carry all interlocks and permissives. Using this method would compromise our safety interlocking policy by having safety interlocks actioned across a data network. Using this method for interlocking was not a preferred option.

Disadvantages of this option are also as per the on board discrete I/O. The Fieldbus Linking Device would need to be updated following new configuration or configuration changes.

3.4.6.3 Use the iFix SCADA server and tag database for interlocking

The HMI server tag database is capable of being configured to generate alarms and interlocks. These interlocks could be communicated to the PLC Data Highway via a proprietary communications card fitted to the server PC. This would allow the PLC Data Highway to be plugged directly into the server PC.

Once again this would mean that we would be using our data highways to carry interlocks and permissives. As a mill wide policy, interlocking is not permitted over the data highway. Using this method for interlocking was not a preferred option.

3.4.6.4 The provision of a Fieldbus discrete I/O module

Smar were developing a Fieldbus remote I/O module that would connect directly onto the H1 side of the Fieldbus network. The only problem was that these units were not yet commercially available. We made the decision to purchase these remote I/O modules and wait for them to become available. Smar fast tracked their development and five of these devices were delivered to CHH Tasman when available. Loop commissioning was split into two phases. Loops without interlocking could be commissioned now. Loops with interlocking would have to wait until these devices were available and tested.

The DC302 remote I/O modules connect to the network on the H1 side and provide discrete I/O for devices connected onto the same H1 segment. These devices have function block capability, which permits configuration to be implemented with only having to perform a ‘partial download’ on completion. Each of our H1 segments was fitted with one of the DC302s. We have had no problems with these items since their installation.

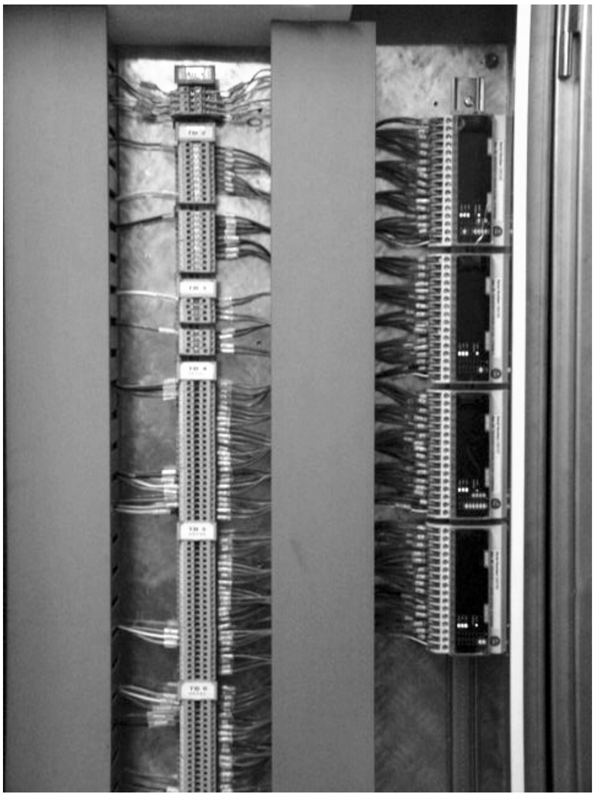

Figure 7 - Smar Foundation Fieldbus Remote I/O & Termination Panel

3.4.7 The Use of Spur Guards

A Spur Guard is a current-limiting device that provides short circuit protection to the Fieldbus segment. By attaching a Spur Guard at each point where a field transmitter attaches to the segment, the Fieldbus network is isolated from individual device failures.

Because transmitters on a Fieldbus network share a single cable run, a failure or short of any individual device has the potential to interrupt data communication across the entire segment. Such events can occur due to accidents or even during routine instrument maintenance.

As we became aware of these devices, Relcom were contacted to discuss the feasibility of retrofitting these devices to our Fieldbus loops. This was not going to be easy due to the type and configuration of terminals used in our boxes. Relcom's Australian agents, MTL came up with a prototype spur guard that had been modified to enable it to be screwed into a terminal block. Once again, due to our terminal arrangement this still was not possible to retrofit without some major panel rework. After talking to various Foundation Fieldbus gurus, it was not thought necessary to retrofit our fieldbus junction boxes with spur guards at this stage. If this became an issue at a later date, then this would be reviewed. Our system has been running without spur guards for over a year although the Smar Fieldbus power supply modules do contain protection against short circuits in the field. We have not experience any problems to date.

Many thanks to Relcom and MTL Australia.

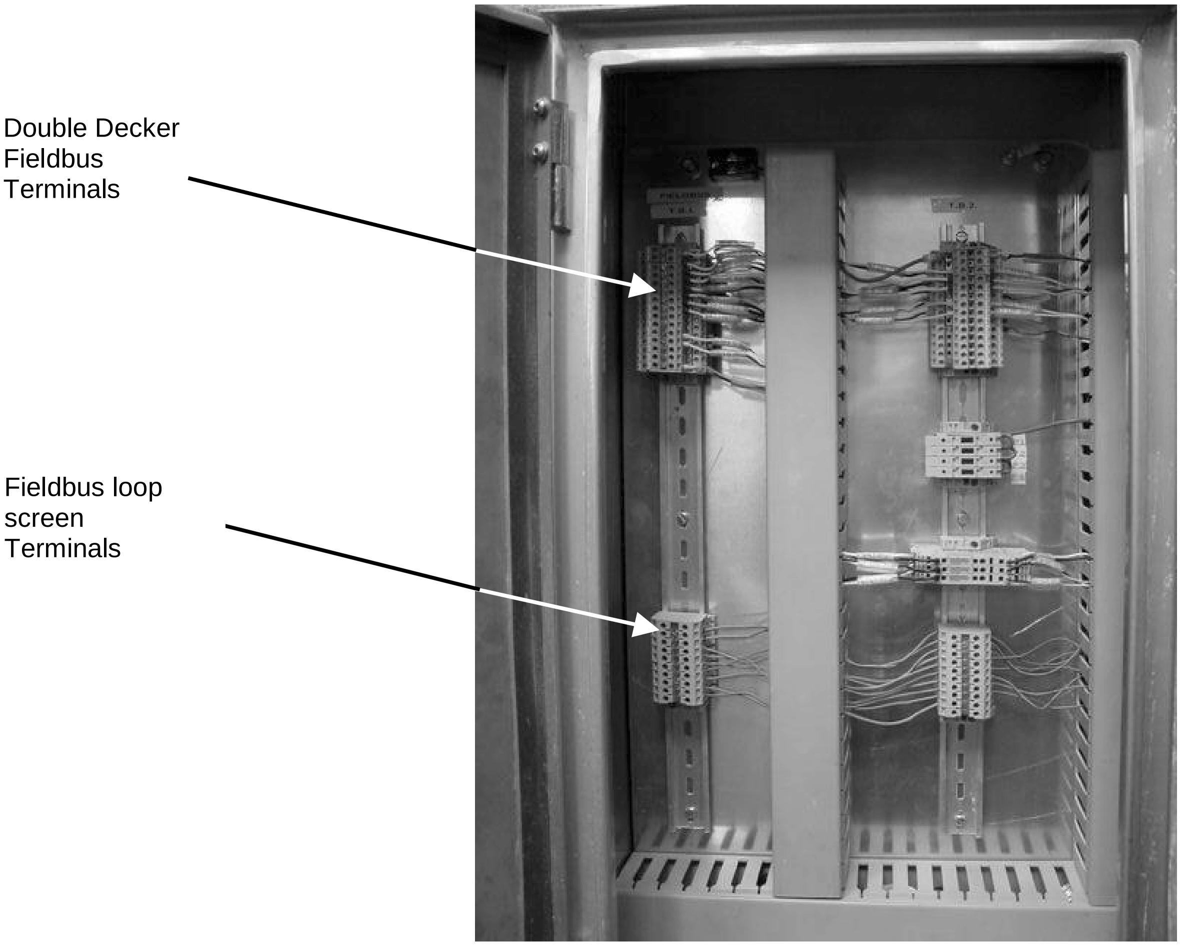

Figure 8 - Our own design of Fieldbus field termination box

3.4.8 Fieldbus Design Peer Review

As our fieldbus knowledge was VERY limited, we had decided at the early design stages to have an independent check carried out on our design concepts. Raja had met Ian Verhappen (Syncrude) previously at an End Users Council in New Zealand. Following initial contact, Ian offered to provide a review of our proposals and work to date. The feedback was very assuring and confirmed that we were on the right track. Items for consideration, suggested changes, etc. all proved very useful.

Many thanks to Ian Verhappen.

3.5 System Configuration

3.5.1 Fieldbus Configuration

As this was the first Foundation Fieldbus system in our mill, standards for configuration did not exist. We had agreed with the system integrator that the Smar proprietary configuration software was fine and that we would accept the standard strategy configuration. This could be reviewed following the completion of the programming and fine tuned if necessary.

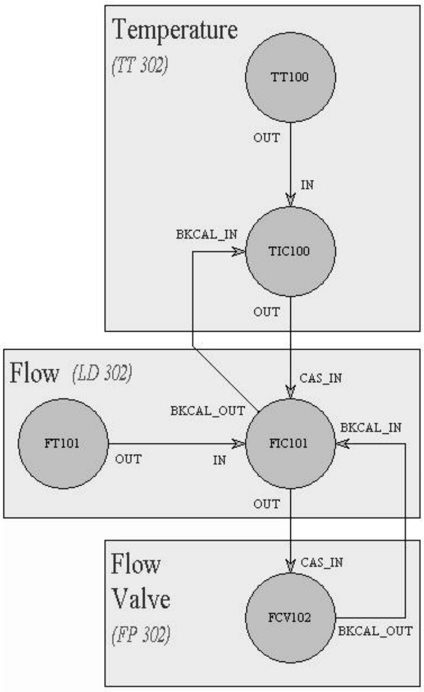

Figure 9 - Example of Syscon 302 Strategy

The generation of the configuration was straightforward and no operational problems have surfaced to date as a result of the strategy configuration. One drawback to the presentation of the strategy is the lack of block setting data such as PID settings, instrument ranges, alarm setpoint and other signal conditioning. Our Bailey strategy printouts are able to display both the strategy and the loop settings. It is possible to export this information from the Syscon 302 tag database into an excel or access format and this information is also available on line. Maybe this is something that could be developed by the system provider.

3.5.2 Latest version of firmware in field devices

Each Fieldbus device comes with preloaded upgradeable firmware. This firmware contains factory presets, diagnostic utilities etc. As the vendor develops additional utilities for each device new revisions of firmware become available. Although most vendors will tell you that the version of the 'firmware' will not stop the device from operating some utilities may not be available if the latest version is not loaded.

The latest version of firmware must be checked with the vendor at the time of order. The 'PC to device' firmware download tool should be procured with the instrumentation (treated like a hand held HART communicator). Check at the time of order if the firmware can be downloaded from your laptop or PC or only from a Download Tool.

It is recommended purchasing a spare firmware download tool. Should your firmware download device fail; there is no alternative method of downloading the correct version of firmware or upgrading with a new firmware release from the system vendor.

Check with your Fieldbus system vendor as to how they achieve their firmware downloads.

TIP TIME

Fieldbus Field Device Firmware

This parameter is new to most engineers and designers. Your maintenance records and instrument datasheets should be modified to give you the facility to record the version of firmware loaded in your device. The version of firmware should be common across a particular vendor range of Fieldbus device. When upgraded, the latest firmware should be made available for all devices.

3.5.3 Fieldbus Linking Device firmware version

With the Smar supplied System302 application software, there is an application called FBTools. FBTools is the user interface for getting the latest version of firmware into your Smar device. Upgrading the firmware in your Fieldbus Linking Device can be done from your engineering workstation or any client connected to the HSE network. The Fieldbus firmware download tool is not required for updating the Smar Fieldbus Linking Device.

It is advisable to have the latest version of firmware in your Fieldbus Linking Device. Any developments in facilities and enhancements to diagnostics etc. can only be accessed via the latest version of firmware. Once again, it is wise to keep a register of firmware revisions for your Fieldbus Linking Device. You may choose not to upgrade each time a new revision is released and to only upgrade when the enhancements benefit your particular installation.

3.6 System Installation

The completion of the Bailey DCS installation and replacement of the Kiln and Causticising MCC's were completed prior to the Fieldbus installation commencing. This meant that those efforts could be concentrated on the Fieldbus system, its installation, and any issues that might arise. We had a short shut window of 4 days in which we had to install the MCC's. Preparation for the Fieldbus installation could not take place during this period. This meant that the Fieldbus installation would have to be installed 'on the run'. Operations could make individual loops available as and when the process permitted. We had to work around this availability issue with much of the configuration and graphics being tested on the Bench Test Facility.

3.6.1 The Bench Test Facility (BTF)

It was decided at the concept stage of this project that a duplicate redundant Fieldbus test facility would be purchased. A PC (to act as a server) and dual redundant Fieldbus processors would be purchased to replicate the final installation in the plant. One of each Fieldbus device was also purchased as part of this set-up. Fieldbus development and configuration software would also reside on this system. This BTF initially served as a test and set up facility for the installation phase. This system was later utilised as part of the training program and now serves as a development and test rig. This development facility has proved invaluable in all aspects of this project. Future development and system optimisation could not take place without risk of plant trips and interruption if this facility did not exist.

TIP TIME

Fieldbus Test Facility Note

Although expensive (in the order of NZ$60,000), the success of this project and any future development was totally dependent on this facility. Bear in mind that none of the conventional analogue test equipment will work on Fieldbus digital technology. Training, development, and system configuration trouble shooting could not have successfully achieved without this set-up.

Include for this in your budget…!!

3.6.2 Partial downloads vs. Full Downloads

The Fieldbus systems vendor recommends that a full download be carried out after a device has been added to a segment. In practice, this is not practical as a full download can take up to 30 minutes and disables each Fieldbus segment for its duration. Links are severed between Fieldbus devices during a full download disabling controllability of all fieldbus loops for this period.

In practice, we were able to get a new device to communicate with the Fieldbus network with only a partial download. Following the partial download, a network update was necessary to schedule the communications and data transfer for the new device.

In reality we are not sure what other things happen 'behind the scenes' when a partial or full download is actioned. This is an issue that we need to resolve in the future.

3.6.3 Termination of 'spurs'

'Spur' cables were found to be a problem if terminated at the 'trunk' marshalling but not at the field device.

'Spurs' can be run but not terminated at the 'trunk' marshalling before the field device is installed and terminated. During maintenance or device change-out, disconnection at the marshalling box must be done first. Otherwise the 'loose' single pair from the Fieldbus Junction Box (JBF) will act as an antenna and pick up and transmit 'noise' throughout the segment. This will cause transmission errors for the remaining devices on this segment.

3.6.4 Spur length too long

A 'spur' cable run from a Fieldbus to current converter (FI302) to the termination point at the trunk marshalling was 130m. The FI302 provided a control signal to a variable speed drive. The long distance not only caused the device not to work but also had an affect on other devices on the same segment. The recommended maximum spur length is 100m. The FI302 was relocated to reduce the spur length and the problem with this particular output disappeared.

Ensure that your Fieldbus equipment specification and location, trunk design and spur design is within manufacturers Fieldbus installation requirements.

Calculations and system engineering are critical for each segment design. These calculations should form part of the as-built handover package for the Plant Engineer to keep up to date. System additions and deletions must be recorded on these spreadsheets.

TIP TIME

Segment design calculations

Segment design calculations become a very important part of your system design. These calculations will predict segment loading and identify power supply deficiencies. Trunk and spur length concerns are also identified as well as predicted attenuation problems. These calculation templates are available from most vendors and can be modified by the user to include their specific Fieldbus devices.

3.6.5 Proprietary trunk and spur connectors

To retain that 'familiar feel' of field junction boxes it was decided that we would engineer the Fieldbus Junction Boxes (JBF's) to contain Klippon terminals and panel wiring as per our Analogue 4-20mA junction boxes (JBI's). We had a mixture of 24VDC, Fieldbus signals, 4-20mA signals (inputs into current to Fieldbus converters) in these JBF's. Our 4-20mA instruments were a mixture of active and passive signals. As a consequence of our design and mixture of signals, during installation and subsequent maintenance, input channels on our Current to Fieldbus converters were blown. This also caused problems with the other remaining two channels on the converters.

As an amendment to the design, the JBF's were modified to contain signal isolators for the non-isolated outputs from the 'field powered' loops and fuses added to the 24VDC 'loop powered' 4-20mA loops. Maybe next time, proprietary Fieldbus connection blocks such as the Relcom 'Megablock' or the Turk Bus Stop "Junction Bricks " would be used. The use of such devices would need to be reviewed on a case by case basis.

3.7 System Commissioning

The system commissioning was split into three phases:

I. Indication loops
II. Control loops without interlocks
III. Control loops with interlocks

The Fieldbus system was commissioned initially with indication loops only. This allowed us to still run the plant from the existing control panel whilst gradually loading up the Fieldbus system by changing over devices.

This was just as well as our problems started to appear as we were adding our indication loops.

Our Fieldbus system problems started shortly after the commissioning of the indication loops. The new loops were dropping off scan on the primary server whilst reading OK on the backup server. To provide a temporary solution to this problem, we turned off one of the servers and ran for several weeks with one server only until this problem was resolved.

Two other system/networking issues caused us problems, which needed to be resolved before we had any chance of success of installing and commissioning our first batch of non-interlocked control loops.

TIP TIME

Soak test your system

Ensure that your newly installed Fieldbus system is checked out with non-critical loops.

Imagine the scenario:

'***Your plant is shut down, your old loops are decommissioned and you have reached the point of no return…'***

This is not the time to discover that you have problems you do not fully understand how to fix with your nice new control system.

Build up your networks slowly if possible. Problems do not always become apparent until you start to load up your networks.

3.7.1 Network Loading

The loading on the network was a major issue at the start of the commissioning. After our attempts to resolve this issue failed it was time to call in the big guns. Smar were contacted and a Smar applications engineer was with us within a few days. The Smar engineer ran system diagnostics with a yet to be released copy of Smar's Fieldbus Network analyser, FBView. The diagnostics revealed that the network traffic was particularly heavy on networks 1 and 3. Networks 2 and 4 seemed to be operating with expected network loads.

A new version of firmware for the Fieldbus Linking Device was loaded. One of the enhancements was an upgrade to the 'Multiple Variable Containers' (MVC) function. MVC's are data containers that hold all the data for a device. If the MVCs are disabled, the data will still get through but it will be sent through a block view. Each block has 4 views, which increases the communication overhead. If the MVC is enabled then one large block of data will be sent. At this time the MVC function was set to 'enable' on our system, which subsequently reduced the overhead on each of our networks. As a result the system became stable and commissioning of control loops was able to commence.

3.7.2 Optimisation of the OPC Client and the OPC Server

Following the addition of the control loops it became apparent that there were significant speed of response issues. At its worst, delays of up to 20-40 seconds were experienced between, for example, an operator asking for a control valve to open to the valve responding in the field.

With optimisation between the Smar OPC server and the SCADA OPC client this speed of response was reduced to 4 – 5 seconds on some loops. Other loops were unaffected with this tuning. The 20-40 second delay still exists on some loops.

It is thought that the speed of response can be further improved following the implementation of the latest version of Smar's OPC server. This is currently under review by both our system integrators and our SCADA server supplier.

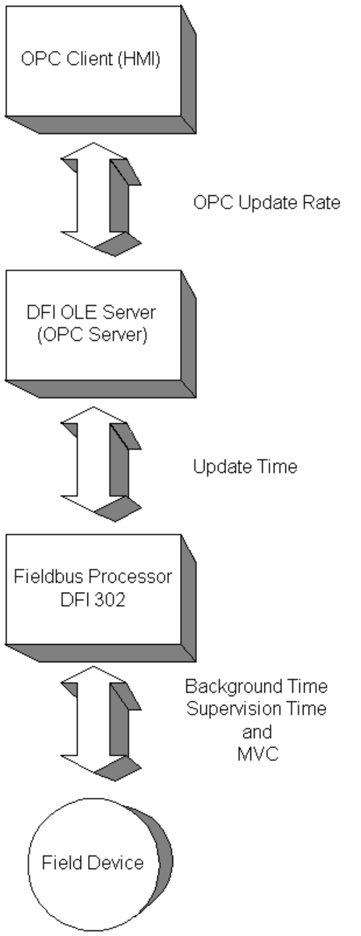

Figure 10 – Optimising Supervision

3.8 Post Commissioning Performance / Issues / Problems

Since the completion of the commissioning the Fieldbus system has been stable and plant control has been reliable. However, some long-term issues still need to be resolved. It is my opinion that this project is a successful one although this opinion is not shared by all.

I think that it is reasonable to say that lack of experience with Fieldbus technology can account for some of the problems. However, some limitations with the both the equipment and the technology are being identified as we try to push the system a little further. Smar have recently established a 'quick response' technical service. This has been of great assistance to us in recent times helping us further understand both our own limitations and the Fieldbus technology limitation.

The following section details some of the issues that we have experienced to date. Some of these issues are currently under review and remain unresolved.

3.8.1 Valve Positioners

Problems have been experienced with some of the more demanding control loops where valves have been retrofitted with Smar Fieldbus positioners.

- **Control Valve Cycling** - One valve in particular was cycling when switched to manual. The problem was diagnosed as mechanical and the vendor was informed. The vendor has since responded with a further development to the original positioner both mechanically and with enhanced firmware. Three of the new positioners have been reviewed for trial purposes. One has been fitted and we are currently waiting for our process optimising team to report on its performance.
- **No 'Auto-tune' Facility** – similar products have an 'auto tune' facility. This enables the instrument technician to set up some initial parameters with the press of a button. Without this facility, extensive field tuning is required.

Smar are releasing an asset management package called AssetView. We believe that there will be a device setup, which will permit positioner calibration from the engineering workstation or technician's laptop. We are currently talking to Smar regarding its release.

3.8.2 Instrument Tags Disappearing from the HMI's

This has been of concern for some time and currently remains unresolved. Tags have been intermittently dropping off the HMI. This results in the HMI displaying a series of question marks. Further investigation determined that these loops were not being scanned and not being updated, hence the display of question marks. This was happening on the primary server only. The tags appear to be fine when checked on the backup server.

Fortunately, links between control devices in the field remained intact. Plant control could be maintained although this meant that the operator was 'flying blind'.

Solutions to this problem are varied. A swap of servers followed by a network update can often reset the problem. At worst, the primary Fieldbus Linking Device needs to be switched off and restarted. The backup will take over as the primary processor.

This is currently under review.

3.8.3 Controller Faceplates 'Freezing'

Intermittent problems have been experienced with controller faceplates freezing. Two loops in particular have this problem. This has to be rectified by switching over to the backup server and performing a network update on the faulty server. This is still also under review.

Smar have requested a tag 'snapshot' using the Smar FBView Fieldbus network analyser. This analyser is an add-on to the Syscon302 software and we have had to purchase this package to provide Smar with the data required. We are still waiting for delivery of this package. Smar are unable to provide any further assistance on the tag disappearance or the freezing faceplates until they have analysed the data capture.

3.8.4 Connection to the Smar OLE Server

As part of the upgrade the process optimisation team were issued with proprietary OPC software and ethernet cards for their laptops. This would allow them to connect their loop tuning/process optimisation software (EnTech) to the Smar system. Problems with connectivity between this software and the Smar OLE server have prevented connection to date. This team is working through this problem.

3.8.5 Addition of New Devices

A new loop consisting of an Emerson (Rosemount) Fieldbus magflow transmitter and the retrofit of an existing control valve with a Metso (Neles) Fieldbus valve positioner was recently installed on the network.

The bench test facility was used to set up these new devices prior to the installation in the field. This is where our problems began.

The valve positioner would appear on the ‘live list’ but the magflow transmitter would not. After tests, including the running of an independent National Instrument Fieldbus configuration application, the magflow transmitter still would not appear on the ‘live list’.

The transmitter vendor was called and suggested changing some of the system settings. These settings were changed and the transmitter appeared on the ‘live list’.

- Slot timing
- Minimum Inter PDU Delay
- Max Response Delay

Although not tried, it was suspected that if this device had been installed on the ‘live’ server, it would have worked without any changes in settings. This issue is to be reviewed during the next ‘service’ visit by the system integrator.

The conclusion to this issue is that true interoperability between each vendor’s Fieldbus devices and hosts is not easily achievable.

3.8.6 Addition of ‘Extra’ Function bocks

During the recent installation of two non-Smar instruments it became apparent that the availability of function blocks in each type of device is not consistent from manufacturer to manufacturer. This has recently become an issue when a particular piece of ‘basic’ configuration was attempted within a Fieldbus device.
It was not possible to implement ‘basic’ strategy with the standard available FB’s in our new devices. It would have been possible to implement this at the Linking Device (DFI302) but this would result in a ‘full download’ each time FB’s were added as part of future configuration. This was not acceptable, as configuration modification should not be dependent on a plant shut condition to implement.

Due to the number of limitations and the inability to add additional function blocks to a particular device, mill wide engineering practices had to be compromised in order to facilitate this configuration. The SCADA tag database was used to implement this strategy.

3.8.7 Implementation of Advanced Control

One of the primary objectives of this project was to ‘lay a platform’ to allow the implementation of advanced control in the future. The implementation of advance control is possible in Fieldbus although only certain function blocks are capable of this level of tuning. Further research is required to determine the most practical solution to the implementation of advanced control. Proprietary advance control packages are commercially available. These should also be reviewed.

3.8.8 Network Update Problems

Following the installation of a new device and running of the network update, loops that were totally dissociated from the device we were commissioning were dropping ‘off scan’. This is an issue that is currently unresolved.
This may be linked to the fact that we are only performing a partial download when adding a new loop…watch this space!

3.8.9 System Expansion

With the Smar DFI302 Fieldbus Linking Device there are four H1 ports available. This has enabled us to run 4 Fieldbus segments around the plant. Our least populated segment contains 8 Fieldbus loops and our busiest contains 13 Fieldbus loops. We are getting too close to our maximum on the busiest segment. To run a new segment in the future we are going to have to either compromise on our redundancy at the Fieldbus Linking Device level, (which would enable us to run further four segments) or repeat out current installation, giving us up to eight segments.

We do not anticipate any immediate problems. Additional fieldbus equipment has been added to the networks since our completion. We have not yet experienced any loading problems.

3.9 System Maintenance

The real ‘end user’ of Foundation Fieldbus technology is the tireless maintenance team that is left with a system to run and maintain long after the project team have been patted on the back and left for their next challenge. Every effort was made to provide the ongoing support, tools, and training to help these people through the months to come.

3.9.1 System Integrator Service Agreement

As ongoing support by the system integrator, a service contract has been established to include routine service visits to site. Although the maintenance department have been involved in each phase of this project a feeling of vulnerability still exists and to just to hand this system over and let them either sink or swim with its further optimisation, development, and maintenance would have been irresponsible.

As part of this service agreement, firmware updates will be implemented, as they become available. Phone and fax support is also available and bi-monthly site visits take place. This allows us to chip away at the knowledge gap, which, although is getting smaller, still exists. A visit to the Smar – Brazil is currently being planned (fourth quarter 02) to allow our maintenance team to establish personal contact with Smar's technical and development departments. Whilst in Brazil, visits to other Smar Fieldbus users will be planned and co-ordinated by Smar. This will allow us to benefit from both Smar’s technical expertise and similar end users experiences.

3.9.2 Test and development equipment

The life of an instrument technician was never to be the same again. You can forget all that you have learned about 4-20mA, you can throw away your multimeters and your hand held Hart configurator. You are about to maintain your plant with a laptop not your screwdriver.

3.9.2.1 Setup of fieldbus field devices

Our instrument maintenance department is set up in two groups, those that look after the individual plants and a dedicated control valve group that look after all valves at the mill. It was necessary to supply both departments with their own fieldbus test facility. Two PCMCIA to Fieldbus network cards were purchased and two version of Syscon302 were purchased to run on their laptops. This enabled field devices to be set up on the bench before being installed on the plant. It also enabled connection to the network to review existing configuration and set up.

AssetView - Smar AssetView is a software system for online network enabled asset management. Without the use of this package it would be difficult to utilise the diagnostics that are available from each fieldbus device. Smar claim that AssetView will provide a ‘friendlier’ user interface to enable the user to calibrate fieldbus instrumentation and setup control valves fitted with fieldbus positioners. This application is not yet commercially available although we are currently talking to Smar regarding a preview copy or beta copy.

3.9.2.2 Running Fieldbus diagnostics

FBView – Smar FBView provides the user with the messages that pass through the Fieldbus buses. FBView can capture, analyse and decode the messages, showing all of the information. The information reports the message type, the address of the device that sent the message, and the address of the receiver. It is also possible to decode the messages from each level of the Fieldbus protocol. The Smar engineer used a pre-released version of this software during their initial visit. This was used to assist in analysing the system traffic when speed and response problems were a major issue. FBView can run on a laptop and accesses the network via the Smar OLE server. FBView can also run on the server PC. We have recently placed an order for FBView and are waiting delivery.

3.9.3 Permits and Procedures

There are currently procedures and permits to work in place, which gives some degree of control over changes to the control strategies with in the Bailey DCS and Allen Bradley PLC system. These permits and procedures needed to be modified and in some cases new permits produced to control the update of both the Fieldbus tag database or the Fieldbus control strategies.

TIP TIME

Test and Maintenance Tools

Discuss with your system provider all your maintenance needs and specialist tools/software/hardware purchases necessary ***before*** you place your order. These can be expensive and would be of assistance during your commissioning phase of the project. Do not leave them until you hand over the project.

4 TRAINING

4.1 Installation and Commissioning Training

At the time of the project concept, general Fieldbus training was held for those who were going to be closely involved with the installation and maintenance. This was run by one of the lecturers from Waikato Polytechnic. This was intended to give the project team an insight into Fieldbus with a small amount of hands on experience.
This training was run over a period of 2 days

Streat Automation, our system integrators, provided more detailed training prior to the installation and commissioning phase of our project. This training was aimed at our technicians and project engineers.
This training was run over a period of 3 days and was run twice to catch all interested parties. The training was structured to include the following:

- Terminology
- System architecture
- IEC 61158-2 topologies (Fieldbus H1)
- H1 Power calculations
- H1 Network components
- H1 Intrinsic safety
- Commissioning and checkout
- Ethernet and IP topologies (Fieldbus HSE)
- Ethernet components
- IP configuration
- Strategy configuration
- Device configuration
- Network configuration
- OPC integration
- Maintenance schemes
- Calibration of Fieldbus devices
- Identification from workstation
- Diagnostics from workstation
- Troubleshooting from workstation
- Servicing from workstation
- Hands-on: SYSCON

4.2 Advanced Training

A site visit by our Fieldbus system vendors, Smar, initiated our second phase of maintenance and advance training. This was structured to include the following:

Maintenance –

- Replacing Instruments.
- Update and Assign Tag functions.
- Display Transducer block set-up.
- Valve tuning
- Getting fast information out of Fieldbus to tune PID's.

Advanced –

- DFI transducer block.
- Use of diagnostics tool - network analyser.
- Use of diagnostics blocks.
- iFix OPC PowerTool setup.
- Windows NT tasks and services, OLE/OPC servers etc.
- Taginfo.ini file and tag exporting.

4.3 Operator Training

The importance of keeping plant operators informed should not be underestimated. So often the operators are handed a new control system with little or no information. Operator training was held during the installation phase of our project. This was structured to include the following:

- An overview of the control system architecture.
- How does Fieldbus give us better control of our plant?
- New terminology.
- New features you will see in the control room.
- What do I need to do differently from what I do now?
- Troubleshooting.

4.4 Maintenance Training

A team of shift technicians cover out of hours maintenance at the Pulp Mill. These technicians are responsible for all plants within the mill. A training program was customised to accommodate their ad-hoc involvement in Fieldbus maintenance. Step-by-step manuals were written for each Fieldbus device to allow these shift technicians to replace a failed instrument out of hours. Hands-on training was then provided to give some familiarity to our new devices should it be required. This was structured to include the following:

- Checking and updating of firmware
- Removal and replacement of failed field device
- Working on the Fieldbus server
- Unloading and downloading to the new device

5 SUMMARY

"The challenge wasn't just to deliver on the promise to reduce running and maintenance costs; the challenge was to combine existing 4-20mA technologies with Foundation Fieldbus technology and to make it work…"

Did we achieve our goals and would we do it all again?

5.1 Have we reduced running costs?

There have been good improvements in production resulting in a much improved consistency of our product. There has been some reduction in consumables that we need to purchase such as Lime and chemicals. It is accepted that some of this can be attributed to the new system. Some of it can be attributed to other projects that that happened within the same plant areas. Notwithstanding our problems and issues, the performance of the new Fieldbus control system has been very good.

5.2 Have we reduced maintenance costs?

In terms of maintenance on things like Moor Mycros, panel recorders, old instrumentation then a definite yes!

On the down side, we have increased maintenance time as a result of increased change-out time. This will improve, as end users become further familiar with the Fieldbus technology and technology develops to make the changeout of a device a little simpler.

The purchase of an add-on asset management package should assist with the diagnostics and maintenance planning. This has yet to be tried and tested.

5.3 Were we on time and within budget

On time – No, after the delays in installation although our timeframe was flexible.

On budget - yes, after spending the entire contingency. Overspends largely on maintenance hardware, software and LOTS of training.

5.4 Would we do it all again?

The simple answer is yes (groan...)

The simple answer is yes…we would consider foundation fieldbus for future projects.

But first, we need to put our unresolved issues to bed.

6 ACKNOWLEDGMENTS

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