Foundation Fieldbus End Users Council Australia Inc.

P.O. Box Z5546 Perth

AUSTRALIA 6831

SPECIFICATION AND IMPLEMENTATION OF A FIELDBUS PROJECT

Phil Eastwood

Lead Instrument Engineer - WorleyParsons

Abstract The presentation is based on our experience on implementing a Foundation Fieldbus based control system on an offshore “Not Normally Manned” gas platform in the North West Shelf of Australia, from the detailed design phase of the project through to fabrication site commissioning.

The project has been conducted based on the client’s project philosophy of developing a set of FF standards for specification of field devices, host and integration of data to the upstream asset management system which may be universally applied to future projects.

The following key subject areas shall be covered.

- System Architecture and Control Philosophy
- Segment Risk Management
- Host PCS Fieldbus Requirements
- Field Device Selection and Configuration Requirements
- FISCO Specification and Certification
- 3rd Party Vendor Supplied Equipment
- FF Documentation Requirements
- Factory Inspection and Testing Requirements
- Installation and Site Integration Requirements
- Asset Management Integration

Keywords: Fieldbus, Design, Specifications

1. Network Communications and Scheduling

1.1 Network Topology

Connection of individual instruments shall be via spurs from the IS trunk, 'Daisy-chain' connections and the use of more than one wire per terminal shall NOT be permitted for serviceability and reliability reasons.

The architecture shall consist of groups of field devices individually cabled to local junction boxes, using a single twisted pair cable per device.

Up to 12 devices may be electrically connected in parallel inside the junction box to form a FF "segment". The number of devices on a segment shall conform to the requirements of the segment risk management philosophy.

From each JB, a single pair "home-run" cable will run back to the PCS in the facility Equipment Room.

The topology is shown in Figure 1.1 below.

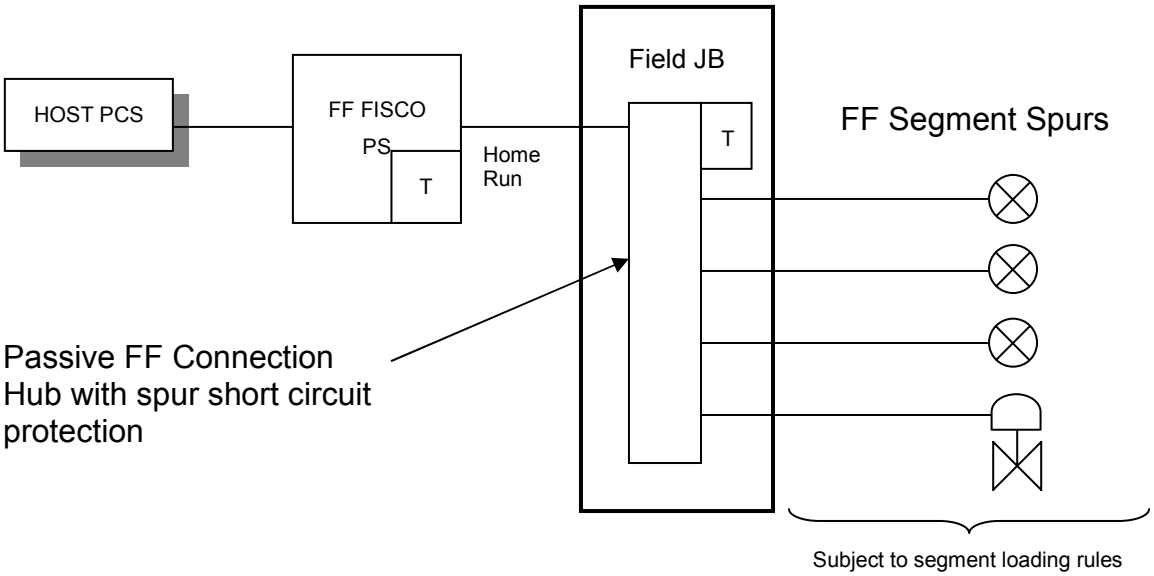

Figure 1.1 Typical "H1" Segment

1.2 Fieldbus Network Redundancy

Foundation Fieldbus does not support redundant field networks at the H1 level. Redundancy can be provided for the Link Active Scheduler (see below) and for the host control system Field Interface Modules.

1.3 Link Active Scheduler

The Link Master (LM) and Backup Link Active Scheduler (LAS) for each segment shall reside in the control system in redundant FIM's. Each segment shall be

configured for automatic fail-over to the Back-up LAS in the event of Link Master failure.

The failure strategy between master LAS and primary/secondary backup LAS shall ensure there is only one active LAS on the segment at any given time. The backup LAS shall automatically take charge of the segment. The FF segments shall be designed to “Fail Operational”.

The PCS shall support an on line ability to monitor and adjust LAS parameters.

1.4 Segment Execution Time

The default max execution time for all segments shall be limited to 1 sec. The required execution times for each segment shall be subject to review during detail design to ensure the segment performance satisfies the process control functional requirements of each loop.

Where loops are identified that require a faster response time than the default value of 1 sec, the following segment design guidelines shall be followed:

- For segments with monitor only measurements, limit segment to 12 devices.
- For loops requiring 1-second execution time, limit segment to 8 devices.
- For loops requiring 0.5-second execution time, limit segment to 4 - 8 devices.
- For loops requiring 0.25-second execution time, limit segment to $\leq$ 3 devices with a maximum of one (1) final control element.

Function block execution frequencies shall be compatible with both system loading and process control objectives.

The macrocycle shall have a minimum of 60% unscheduled (***free*** asynchronous) time.

1.5 Segment Scheduling

The order of execution shall be automatically determined based on the connections between function blocks on the Fieldbus segment. Calculation of “free” asynchronous time shall be based on the time required for the communications and the block execution time.

The vendor’s configuration software shall manage and maintain minimum (60%) unscheduled time; this shall be subject to verification at the FAT/SAT.

2. Foundation Fieldbus Segment Risk Management

The risk assessment ranking for each segment shall be documented on a FF Risk Assessment Sheet. Topology design shall minimize single points of failure. The following valve criticality rating and segment loading method shall be used. The valve and associated measurement criticality shall be defined for loading of Fieldbus segments.

FF segments shall be classified into one of three criticality ratings, based on the resultant consequence of a device or segment failure on the operational status of the facility.

The following ratings shall be assigned to each valve and segment.

2.1 Level 1 Segment and Final Control Element

Failure of a Level 1 segment or valve will result in an immediate system trip, causing a shutdown of the process resulting in loss of production. Normal Valve failure mode shall be used for this classification.

Design Restrictions:

Level 1 valves and their associated measurement device (transmitter) shall reside on networks that are only used for Level 1 control. The segment may have one Level 1 Valve and associated Transmitter.

Host interface cards and field devices for all Level 1 loops shall be independently tested for interoperability. Upgrades should be done during planned plant maintenance shutdown windows if necessary. The segment drawing shall show the criticality rating and shall prominently display that no additional devices shall be loaded on this segment.

2.2 Level 2 Segment and Final Control Element

Failure of a Level 2 segment or valve will not result in any short-term risk of process unit shutdown or operating losses. Level 2 valves can go to their fail position without requiring immediate operator action.

Design Restrictions:

Level 2 valves can reside on cards or segments with up to one other level 2 valve, Networks containing Level 2 control may use products from multiple (approved) vendors including Level 3 measurement only devices. The devices and interface cards shall be kept at compatible revision levels for the lifetime of the network. Upgrades may be done online. The network/segment drawing shall show the criticality rating.

2.3 Level 3 Segments – No Control

Level 3 devices are measurement only devices that shall not be used for control or interlocking applications.

Design Restrictions:

Level 3 devices can reside on segments with up to the maximum number of devices based on network design bandwidth and physical limitations. The devices and interface cards shall be kept at compatible revision levels for the lifetime of the network. Upgrades may be done online. The segment drawing shall show the criticality rating.

2.4 Single Loop PID Control

For single PID control where possible, all function blocks that make up that control loop must reside on the same segment.

2.5 Cascade Loop PID Control

For cascade control (if identified during detail design), primary and secondary loops may reside on the same segment if the segment is classified as a Level 2 segment.

Where the segment is classified as a Level 1 segment, the primary and secondary loop field devices and function blocks must reside on separate segments.

2.6 Summary of Allocation of FF Devices to Segments

The following summarises the restrictions to be applied when allocating FF devices to segments:

- No more than 1 control valve shall be connected to any Level 1 segment.
- No more than 2 control valves shall be connected to any Level 2 segment.
- No more than 8 FF devices in total shall be connected to a Level 2 segment which has any control valves connected to it.
- No more than 12 FF devices in total shall be connected to a Level 3 monitoring-only segment.
- No more than 6 DVC’s shall be connected to any segment. This is to limit segment loading.
- No cable run from a field J/B to a FF device shall exceed 60m in length.

These segment loading rules shall be applied to both I.S and non-I.S. installations, to ensure commonality of design.

3. PCS Requirements

The PCS shall comply with the following technical requirements associated with Foundation Fieldbus system design.

3.1 PCS Interoperability

The PCS host systems shall have completed the Host Interoperability Support Test (HIST) as witnessed by Fieldbus Foundation staff and based on HIST Procedures Document FF-569.

A letter of conformance to the Host Interoperability System Test shall be provided to verify test completion and feature support.

The PCS revision level shall be backwards compatible with older FF instrument revisions that satisfy Interoperability Test Kit (ITK), revision 4.01 or later.

3.2 Link Active Scheduler

The Link Master and back-up LAS shall reside in the redundant FIM configuration. Failure of primary FIM shall result in bump-less transfer to the back-up FIM and automatic initiation of the backup LAS.

3.3 Host System PCS Functionality

The host system functionality should be designed to integrate the features of FOUNDATION Fieldbus as follows:

- Automatic node addressing.
- Interoperability.
- Direct configuration of devices using standard DDL.
- Direct integration of FF device operating, maintenance and diagnostic data.
- Tuning parameters, modes, alarms and quality of data.
- Field devices should be configurable while the host system is operating without shutting down the network.
- The host system should have the capability to add and fully configure new field devices to an existing network/segment (i.e. Device Tag/Placeholder) without affecting the operational status of existing devices on the network not directly affected by the change in configuration.
- The host system should be provided with device capability files.

Firmware revisions of Fieldbus devices should not impact upgrades to the host system software and vice-versa

3.4 Host Maintenance and Diagnostics

The host shall be capable of commissioning, setup, and maintaining all FF devices. This function shall be integrated into the host and available from the host engineering workstation. The following functions shall be supported:

- Report of electrical and bandwidth load on all busses.
- Error counters for all busses.
- A schedule (time chart) report for H1 networks/segments.
- An online reconciling function to allow change management when replacing field devices.
- Ability to report, alarm, and acknowledge all device alarms.
- Add a new FF device to a network/ segment. Add a future FF device to a network/segment through use of placeholder templates.
- Move FF devices from/between offline, spare, standby, commissioned, and mismatch states and manage all address changes transparently. Manual address changes shall not be required.
- Simple and complex commissioning functions including transmitter range changes, zeroing, and control valve positioner setup.
- Support for DD methods and menus (wizards) for all maintenance functions to walk technicians through the necessary maintenance procedures.
- Provide specific maintenance displays, organized in a logical manner, for all FF devices using specified language descriptors and definitions with access to all parameters.
- Ability to mirror existing FF device configuration (all FBs and parameters) onto a new FF device to allow quick device replacements.
- Display of commissioning and maintenance screens shall be possible from the operator/ engineering workstation.

As a minimum, diagnostic capabilities shall report critical failures of devices. Diagnostics shall be reported to the Host via FF Alarms and Alerts. Polling schemes for diagnostics are not acceptable. Diagnostics shall be reflected in data quality to the operator and control loop, as well as through separate diagnostic alarms intended for maintenance.

3.5 Fieldbus Network Interface Redundancy

The PCS will incorporate redundant FIMs for each segment. The redundancy strategy shall ensure a bump-less transfer between all primary and secondary components that form the FF network.

Both primary and secondary FIM shall be time synchronised so that when a new primary FIM takes over as acting link master it shall also become acting time publisher on the segment.

Failure of a FIM and subsequent switchover between primary and secondary shall result only in producing system event alarms on the PCS.

3.6 Fieldbus Control Philosophy

All control algorithms shall be resident and configured within the Host PCS.

The recommendation to not implement control in the field device has been based on the following potential issues involved with this technique:

1. Not all devices come with all Function Blocks installed as standard. This means that although one make of pressure transmitter (for instance) may have a PID function block, not every manufacturer will include that as standard, unless specifically requested. A situation could, therefore, arise where there is no immediate replacement device, therefore defeating most of the object in standardising on Foundation Fieldbus.

2. The PCS manufacturer's PID controller contains more features than the generic PID function blocks which are provided in FF field devices.

3. To carry out PID control in FF field devices, the transmitter and the control valve must be physically connected to the same FF segment. In an I.S. FF implementation, the number of devices on a segment, and the cable lengths, are limited. This restricts the possibilities for field PID control.

4. When possible the system and network/segment design shall endeavour to place the transmitter and final control devices on the same network/segment.

5. FF field devices only require to be supplied with a limited subset of the possible function blocks which instrument vendors offer. This helps to limit costs (depending on the particular vendor's pricing structure).

It is a requirement of this philosophy that, in the event of a communications failure between the PCS and the H1 segment, that the devices in the segment continue to operate. Also, in the event of functional failure of the Link Master (LM) Link Active Scheduler, that control passes to a backup Link Active Scheduler (LAS) to maintain segment communication, and therefore functionality.

3.7 Advanced Diagnostics & Asset Management System

The facility shall incorporate a computer-based asset management system & maintenance software solution having the capability to manage and protect the assets, maximizing the effectiveness of plant operations by utilising the additional device condition monitoring and performance data supplied by FF. The asset management system shall be separate, from the PCS operator/ engineering workstations, and shall be used to manage and display real-time and historical diagnostic & maintenance information. However, it may not replace commissioning and maintenance functions integrated into the PCS as described above. The asset management system should include the measurement, management and regulation of the equipment running in the plant, not just the process.

The asset management system shall include but not be limited to the following features / benefits:

- Remote diagnostics of Foundation Fieldbus supplied data.
- Provide for a separate asset management workstation to allow device diagnostics separate from operating functions.
- Streamline routine maintenance tasks such as loop checkout, configuration and calibration.
- Establish a predictive maintenance capability with reliable diagnostics, to allow maintenance before failure.
- Automatic documentation of diagnostics and maintenance activities.
- The FIM shall provide pass-through capability to transfer non-control data to field device asset management applications.

3.8 Software Configuration

FF Software Revision

All FF software shall be the most recent revision that is applicable to the system hardware at the time of the hardware freeze date as defined in the contract or purchase order. The system shall allow for upgrading of system software on all redundant modules of the system without the necessity of shutting down the process, without losing the operator interface, and without the loss of access to any control function. Application software shall not require modifications in order to be able to run under new releases of the system operating software. Any new release of system software shall be backward compatible with files created using the previous software releases.

Host Software Configuration Tool

The FF host shall have a configuration tool capable of online and off-line configuration. The configuration tool shall have multi-user and multi-instance capability.

Capabilities

The host shall be capable of configuring all FF function blocks and parameters and support of Device Description (DD) services and Common File Format (CFF) specification as detailed below:

- Soft simulating and testing any and all FF control strategies.
- Importing non-native, bulk configuration data for developing configuration of larger project databases.
- Simple or complex online FF control strategy creation or modification.

- Transparently managing the macrocycle schedule including maintaining minimum unscheduled acyclic time (60%).
- Coordinating integration of custom FF function block execution times.
- Providing alerts and messages for FF configuration error.
- Partial or incremental downloads to target function blocks and link schedulers without interrupting the operating network/segment strategies.

For the Project the Host Vendor shall utilise the DD and CFF files from the PCS device file library for all available instruments. This is to ensure that interface issues identified by the PCS Vendor during in house testing of 3rd party field device Vendor supplied DD/CFF files are avoided.

Where a field device is selected for the project that has not previously been tested by the PCS, then the field device in question shall be forwarded by the Company to the PCS Vendor for in-house testing prior to the FAT to mitigate against potential DD/CFF compatibility issues.

3.9 Alarms & Alerts

The PCS shall be capable of supporting the multiple alarm priorities provided by the FF standard. The PCS Vendor shall define in the DFDS the allocation of alarm & alert priorities proposed for each device type employed on FF segments for approval of the WEL Technical Integrity.

This philosophy shall define the management of the following FF data:

- Device Status Alarms.
- Device Status Alerts.
- Device Status Trends.

All such status alarms shall also be transmitted to the Asset Management based maintenance and conditioning monitoring system for assessment by maintenance personnel.

Field devices generate alerts, due to miscommunication, misoperation (diagnostics) or failure, the PCS shall support display and logging/archiving of device alerts. Alerts are important for system integrity and are needed in order to take full advantage of diagnostic capabilities in field devices to notify users of various status conditions of a device.

3.10 Node Addressing & Naming Conventions

Each Foundation Fieldbus node shall be assigned a unique Node Address. Each Fieldbus device shall have a unique physical device tag and corresponding network address.

The Host shall allocate node addresses in the range 0-255 in accordance with the FF standard. They shall reserve low numbers for overhead and host interfaces, and a group above that for live field devices, and some higher numbers for spares. Addresses used by FF shall be in accordance with the following ranges:

- 0-15 shall be reserved.
- 6–247 shall be available for permanent devices.
- 248–251 shall be available for devices with no permanent address such as new devices or decommissioned devices.
- 252–255 shall be available for temporary devices, such as handhelds.

Third-party systems or configuration tools connected through a communications interface to an H1 network shall not be used to.

- Interrupt the operation of any device within the system.
- Change device address.
- Affect link schedule.

4. Device Selection

4.1 Fieldbus Registration

All devices, including 3rd Party packaged equipment must, as a minimum, satisfy the requirements of the Fieldbus registration laboratory. In the case of the Fieldbus Foundation, this is the FF “check mark” logo and listing on the approved devices list maintained on their web site (http://www.fieldbus.org/). This verifies interoperability of devices.

4.2 Support for Foundation Fieldbus Functionality

All Fieldbus instruments should support Methods to allow automation of online procedures (such as calibration) from the host control system.

All FF devices selected shall comply with the following requirements:

- Tested by the Fieldbus Foundation to the Interoperability Test Kit ITK4.6 or later as a minimum. (Note: It is preferred that FF instruments have been tested to the latest ITK5.0 Test Kit).
- Tested and proved compatible with Project control system.
- Peak Inrush Current (0-500 μs) not exceeding 20mA.
- Quiescent current as low as possible.
- Minimum lift-off voltage not more than 9V.
- Capable of instantiable function blocks.

- Incorporate Analogue Input (AI), Analogue Output (AO), Discrete Input (DI), or Discrete Output (DO) blocks as appropriate though each device shall have at least ***one*** defined Function Block.
- Include a Sensor Diagnostic function.

4.3 Field Device Power

Field Devices shall be capable of satisfying the following minimum requirements in regard to power supply:

- Fieldbus devices shall be powered from the host PCS the segment (bus).
- Fieldbus device's communication signal shall be polarity insensitive.
- Fieldbus devices shall be designed to operate normally at voltages of 9–32 VDC.

Circuit analysis shall be carried out for each Fieldbus segment to determine the operating voltage at each device. The 9 VDC specified is a minimum, the segment design should ensure that a margin of at least 4 V (i.e. a minimum of 13 VDC) be maintained at all field devices connected to the segment.

5. Fieldbus Intrinsically Safe Concept - FISCO

5.1 Introduction to Fieldbus Intrinsically Safe Concept

FF segment design for devices situated in hazardous areas shall be based on Fieldbus Intrinsically Safe Concept (FISCO) protection techniques, FF installations in non-hazardous areas are not required to utilise any hazardous area protection techniques.

FISCO defines special requirements for an intrinsically safe Fieldbus system with a physical layer according to IEC 61158-2: 2000.

The FISCO Technical Standard (IEC 60079-27:2005) results in the following key benefits:

- Simple safety assessment. The safety documentation is reduced to a list of devices, and new devices can be added without re-evaluating the safety case.
- Elimination of cable parameter calculations provided the cable complies with a minimum requirement for resistance, capacitance and inductance per unit length.
- Higher levels of available current for the field wiring (than for ENTITY), permitting more field devices to be connected onto the hazardous area trunk.

FISCO leads to easier planning, application and documentation of intrinsically safe bus circuits. In addition, higher supply current is permitted on the intrinsically safe bus than with conventional ENTITY circuits.

5.2 Electrical Power for Fieldbus Devices

The FISCO concept dictates there is only one source of possible energy into the flammable atmosphere, which is the power supply (Associated apparatus). All other devices and accessory equipment must not put energy onto the bus.

For Fieldbus systems conforming to the FISCO model, the power supply may be category Ex ia, or Ex ib,

As FISCO has been selected, redundant segment power supply conditioners shall not be provided.

Individual bus segment power supplies shall be protected against over-current due to short circuits on the cable. Current-limiting devices shall be used in preference to fuses, with each field device being connected to the segment via a current limiter.

5.3 FISCO Power Supply/Conditioner

The preference is that the FF design shall be based on the MTL FISCO 9121-IS power supply/conditioner which satisfies the FISCO requirements detailed below.

The requirements for FISCO power supplies are defined in IEC 60079-27 2005.

The maximum output voltage, Uo, shall be not greater than 17.5 V under the fault conditions specified in IEC 60079-11 or less than 14 V under normal operation.

For Fieldbus use, power supplies shall meet the criteria and performance specified in IEC61158-2. This entails the use of a power supply capable of communicating the necessary signals on top of the 9 - 32 Vdc which shall be available at each device connected to the segment.

The power supply shall be in compliance with the requirements of document “Fieldbus Power Supply Test Specification” FF-831.

The power supply shall be constructed in accordance with IEC 60079-11.

Galvanically Isolated & Shunt Zener Diode Barriers

IEC 60079 – 27 permits the use of either galvanically isolated or conventional shunt zener diode circuitry for I.S. protection in a FISCO power supply. The preference is to employ galvanic isolation in FISCO Power supply/conditioners.

5.4 Bus Powered Devices

The system design shall normally be based on bus powered segment architecture. This means that the only source of electrical power allowable on the segment is the Fieldbus itself.

Separately Powered Devices

All Fieldbus segment design shall normally be based on bus powered segment topology. The use of separately powered Fieldbus devices shall be avoided if possible. Where a requirement for a separately powered Fieldbus device is identified the design shall conform to the following separately powered device restrictions.

These device types have one or more sources of electrical power in addition to the power supplied from the fieldbus itself. Examples of such a device are a coriolis meter where the application circuitry requires higher levels of power than can be obtained from an I.S. fieldbus, or a battery powered hand-held unit. These types of equipment, and their power supplies, could utilise another form of explosion protection, but the bus terminals must remain passive, i.e. the terminals shall not be a source of energy to the system except for a leakage current not greater than 50 µA. The bus terminals must be galvanically isolated from the additional sources of electrical power.

5.5 Interconnecting Device Couplers, Component and Enclosures

FISCO Device Couplers

The FISCO segment design shall incorporate field JB / DIN rail mounted device couplers, which are passive hubs for connection of FF networks which allow the IS trunk to be carried through the block and individual instruments to be spur connected to the IS trunk. MEGABLOCKS minimise hand wiring and allow individual devices to be added/removed from the segment without disrupting network communications.

The preference is that the FF design shall be based on the MTL-RELCOM MEGABLOCK Models FF245/251. Where the Vendor proposes the use of a different device coupler it shall be subject to the approval of the WEL Technical Integrity.

When the enclosure is mounted in the hazardous area, the enclosure must meet the requirements of ‘simple apparatus’. The enclosure materials shall comply with the requirements of IEC 60079-0, which specifies the ‘General Requirements’ of apparatus used in hazardous areas.

The MEGABLOCK device coupler selected (Models F252/F245) contain integrated SpurGuard device port, short circuit protection that minimizes susceptibility to single point failures.

Fieldbus Terminator

The PCS FIM shall contain a permanently connected terminator which defines one end of the I.S trunk. The field end of the I.S. trunk shall also include a terminator suitable for installation in a hazardous area, which connects in the field junction box to the MEGABLOCK at the furthest end of the segment cable.

The preference is that the FF design shall be based on the MTL-RELCOM Model FCS-FBT1-IS line terminator.

Any terminator that is part of the hazardous area circuit shall be formally certified since it includes a resistive-capacitive circuit.

Surge Protection

Surge protection shall not normally be specified as a standard requirement for segment design.

The requirement for surge protection on FF segments shall be reviewed on a segment by segment basis during detailed design dependant on the proximity and exposure of segment devices and cable runs to potential sources of EMF. This shall be considered as part of the design of the segment cable layouts and junction box locations to minimise as far as is practical potential sources.

Where surge protection is deemed necessary the FF design shall be based on the MTL Surge Technologies Model TP32 which is certified for FISCO applications.

5.6 FISCO System Cables

System cables for FISCO must comply with the functional requirements of the IEC 61158-2 standard and with the safety requirements of IEC 60079-27: 2005.

The IEC 61158-2 standard states that a twisted pair cable with overall shield is used as transmission medium for the Fieldbus, transmitting the communication together with the supply for bus powered field devices.

Cable shall be of Type A and specifically certified and coloured coded for FISCO. Using cable certified for FISCO, the safety of the overall FISCO system can be easily demonstrated.

In general, however, the cable type selected for this service shall have the following properties:

- Blue outer sheath to indicate I.S. circuit.
- Twisted pair style with screen (Type A).
- Armoured cable should be used to provide mechanical protection.

Segregation between wires carrying I.S. circuits and other cables within equipment racks or cubicles is required. In accordance with normal good engineering practice, segregation shall be adopted to run the two cable types in separate, clearly labelled cable ducts.

System Cable Parameters

The parameters of cables for FISCO applications are given in Tables 5.6.1 and 5.6.2 below. Where the cable parameters are not known, they may be determined in accordance with the Annex C of IEC60079-14.

Table 5.6.1 Cable Parameters in Accordance with IEC 60079 – 27.

DESCRIPTOR	**GAS GROUP 11B**	**GAS GROUP 11C**
Cable length including trunk length and total length of all spurs	5.000 m max.	1.200 m max
Cable length spur	60 m max.	
Loop resistance Rc	15 to 150 Ω/km	
Loop inductance Lc	0,4 to 1 mH/km	
Loop Capacitance Cc	80 to 200 nF/km	

Table 5.6.2 Type of Cables in accordance with IEC 61158-2.

DESCRIPTOR	**TYPE A**	**TYPE B**
Cable design	Twisted pair, individual shield	Multiple twisted pair, overall shield
Maximum conductor cross section(nominal)	0,8 mm²(AWG 18)	0,32 mm²(AWG 22)
Loop resistance (DC)	44 Ω/km	112 Ω/km
Impedance (31,25 kHz)	100 Ω ± 20 %	100 Ω ± 30 %
Attenuation (39 kHz)	3 dB/km	5 dB/km
Capacitive asymmetry	2 nF/km	2 nF/km
Max. propagation delay change (7,9 to 39 kHz)	1,7 µs/km	Not specified
Min. shield coverage	90 %	Not specified
Recommended extent of network (including spurs]	5.000 m	1.200 m

Although IEC 61158-2 permits different cable types to be mixed in one network segment, mixing of cable types is not recommended.

5.7 Certifying Equipment for Installation in Hazardous Areas

All components of the Fieldbus segment shall be appropriately marked as certified by the approved certifying authority (SAA, IEC, or CE).The certification mark (which should appear on all segment products) indicates that the product conforms to all the relevant standards and directives.

Copies of all FISCO certificates and Category 3 documents of conformity shall be provided by the Vendor and retained by the project in either paper or electronic format.

Dual Certified ENTITY & FISCO Devices

The use of dual certified field devices shall be avoided due to the potential for miss-management of interoperability and compatibility issues during the lifecycle of the segment involved. Where a particular instrument is identified for a given application that is only available in dual certified mode, the contractor shall seek the approval of the project on a case by case basis for each application.

5.8 FISCO Junction Box Construction and Layout

Junction boxes shall be suitable for installation in a Zone 1 Gas Group IIA T3 area with a minimum protection rating of IP66.

The Junction Box configuration shall be designed in accordance with the project drawings and will be supplied with device couplers installed.

The JB size and layout is based around segments with a maximum of 12 devices.

5.9 FISCO Specific Installation Requirements

Field devices will be connected to the Fieldbus trunk using spurs, so that the removal of an individual device does not interrupt the operation of the whole system. Additional wiring components will therefore be required. These shall take the form of passive device couplers specifically designed for FISCO applications.

Wiring devices often contain only passive components or other components with well-defined parameters such as terminals plugs, sockets and switches. These devices may be considered to be ‘simple apparatus’, as defined in AS/IEC60079-11 and they do not need to be certified or marked.

Earthing and Shielding - FISCO

The IEC 61158-2 Standard requires that the Fieldbus is operated in a balanced mode with respect to earth or ground. The Manufacturer of the Fieldbus devices should ensure that this balance is within the limits defined in the standard. Neither conductor of the Fieldbus cable should be connected to earth or ground.

The IEC code of practice IEC 60079-14 proposes that single point earthing is the preferred technique, because of the need to avoid ill-defined circulating currents, which may be incendive. It does however permit the use of small decoupling capacitors to reduce the high frequency problem.

It is recommended that the installation should be earth the screens at one point. In the unlikely event that there are interference problems then if possible they should be remedied by using decoupling capacitors.

6. Documentation

An integrated design and documentation system is recommended for initial design and for maintenance support of Fieldbus installations. The system should include a database with import and export provisions, design calculations for the project support, and a CAD system that can use data in the project database. FOUNDATION Fieldbus system design requires the same documentation as conventional control system designs. However, some documents must be altered for FOUNDATION Fieldbus architecture. Documentation alterations, additions and deletions required for FF use are defined below.

FF System Network Drawing

The PCS vendor shall supply a network topology diagram indicating how all the networks, controllers, communication highways, data historians and operator interfaces are interconnected. This drawing is to be functional in its representation of how each system connects to the others and does not include devices on individual network/segments though it should indicate where or on what unit operation each of these segments is installed.

FF Instrument Segment Diagrams

Traditional loop drawings shall be replaced with instrument segment diagrams (ISD) indicating all the devices on one wire pair on the same drawing.

Segment drawings shall include the following FF system details:

- The title block shall contain the "network name." The network name shall consist of the “Controller Name, Card Number and Port Number".
- The FF device segment address shall be shall be identified.

- All network connections inclusive of the H1 interface card, bulk power supply, FOUNDATION Fieldbus/FISCO power supply, through the field devices, terminations, junction boxes, and terminators.
- All segment and field device tagging. All spur cables shall be labelled with the instrument tag number.
- Terminator locations shall be clearly identified.

FF Control Strategy Documentation

The PCS configuration tool shall support printing and exporting to other applications copies of the function block diagrams for all FF segment control strategies as part of the configuration documentation.

FF Instrument Data Sheets

The Engineering Contractor shall complete applicable data sheet(s) as per a conventional instrument and in addition they are to complete the supplementary Fieldbus data sheet.

Foundation Fieldbus Instruments shall be specified with standard instrument specification sheets with the following line item additions:

- LAS capable (yes/no).
- Minimum Operating Voltage (VDC).
- Quiescent Current Draw (mA).
- Polarity Sensitive Termination (yes/no).
- DEV revision.
- DD revision level.
- CF revision.
- Channel number and Description, (e.g. Channel 1 - Sensor 1, Channel 2 - Body Temperature, Channel 3 - Sensor 2, etc.).
- Function Blocks Available, (e.g. AI_1, AI_2, PID_1, etc.).

FF Instrument Parameter Definition

FF field instrumentation requires that special attention is payed to identifying and defining the range of available parameters inherent in FF devices. This information is required in addition to that normally defined on the instrument data sheet.

In general FF device parameters are grouped into two broad categories.

- Basic
- Detailed

FF instruments may be supplied with either the standard factory default configuration for these parameters or ordered with custom configuration settings. For the Project all FF devices to be procured shall be reviewed and all FF device parameters defined as either requiring custom setting or factory standard default.

FF device Vendors shall be supplied with the custom parameter setting requirements for each device for configuration prior to shipment.

The FF device parameter configurations shall form part of the FF device documentation requirements and shall be defined during execute phase. The parameter definitions shall be supplied to the Host Vendor and verified as part of FAT via desk-top verification of the exported parameter listings.

The required parameter definitions shall also be incorporated within the site installation and commissioning instrumentation work-packs to assist in SAT and commissioning.

Safety Documentation for FISCO System

A benefit of the FISCO system is that no detailed analysis is necessary to ensure the safety of the system, and additions do not require a revaluation of the whole system. The gas group of the system is determined by the power supply and the temperature classification of each piece of apparatus by its certification (usually T4). The documentation is only a list of the connected apparatus. This is done electronically and can readily cross-refer to the certification documents of the apparatus. A further advantage of this system is that the inspection procedure is simplified to ensuring that the system is unchanged and undamaged.

An example of the safety documentation requirements for a typical FISCO system is given in Figure 5.1.1. The table and corresponding analysis should be done prior to installation.

Figure 5.1.1 Example Safety Documentation of FISCO System.

System Title: Typical Installation

Conclusion;

The safety document demonstrates that the FISCO system described satisfies the requirements of a IIC ib intrinsically safe system in which field devices mounted in a hazardous area all have a T4 temperature classification and can be used in the ambient temperature range -30^{o}C to +65^{o}C.

Remarks; The cable used for the IS trunk and spurs is General Cable type DO1A and has parameters compatible with the FISCO requirements, and has a usable temperature range of -30^{o}C to +65^{o}C

Item No.	Description	Manufacturer	Type No.	Classification	Cert. Number	Temperature Range
1	FISCO Supply	MTL	9121-IS	IIC [ib]	BAS02ATEX276	-40°C to +70°C
2	Connector block	Relcom	FCS-MB4-IS	Simple apparatus		-45°C to +70°C
3	Terminator	MTL	FBT1-IS	IIC ia T4	BASEEFA 02ATEX0042	-40°C to +70°C
4	Enclosure	Klippon	333OS	Simple apparatus		-40°C to +70°C
5	Temp. Transmitter	Emerson	6244	IIC ia T4	ABC02ATEX0034	-40°C to +70°C
6	Press Transmitter	Bars	888P	IIC ia T4	XYZ01ATEX3455	-40°C to +70°C
7	Flow Transmitter	Wave	3075F	IIC ia T4	QWE02ATEX876	-40°C to +70°C
8	Computer	Addo	FC200	IIC ia T4	WWW02ATEX0666	-40°C to +70°C
9	Valve Postioner	Fisher	VP5000	IIC ia T4	ZXC02ATEX3421	-35°C to +65°C

The rules for describing the safety of a FISCO system are listed below. There is no need to calculate maximum permitted cable lengths, provided the cable complies with the functional requirements of the IEC 61158-2 standard and with the safety requirements of IEC 60079-27: 2005.

7. Inspection and Testing Requirement

Factory witness tests (FWT) are traditionally done with systems and sub-systems, but not with field devices. It is not generally practical to test all field devices in a FAT, but a representative portion of each type of FF field devices to be used on should be included in the FWT.

In addition to FWT, tests shall also be performed during Site Integration Tests (SIT). The remainder of the field devices, not tested during FWT shall be tested during Site Integration Tests.

Bench Test Facilities

The PCS Vendor should include in his scope of supply all necessary FF hardware and software to enable a standalone, offline bench test facility to enable the Company to carry out testing and calibration of FF devices in a workshop environment at the facility.

Specialised Test Equipment Requirements

As FF is a multi-drop communications and the following test equipment is recommended as a minimum for all phases of the project, from FAT through to ongoing operational maintenance requirements:

- Relcom, Inc. FBT-6 Fieldbus Communications Monitor.
- Oscilloscope (Differential Type with capture waveform capability).

No normal requirement for an oscilloscope unless the segment fault is very difficult to trace.

7.1 Installation and Site Integration Tests

Configuration of the field devices shall be carried out from the host system configuration software. This is in the interest of building the database as commissioning proceeds.

Procedures for commissioning of Fieldbus systems include:

- Cable, junction box, continuity, grounding, and insulation tests.
- Field device connection and signal analysis.
- Device download / Software checks.
- Bus monitor capture, Scope waveform capture.
- Field device (physical installation).
- Valve calibration.
- Loop tuning.

Network Installation

The advice of the Fieldbus Foundation based on feedback from previous/current projects that have implemented FF designs has identified that careful and correct installation and checking of the FF segment wiring, cabling and components is critical to the success of commissioning and ultimately the performance of the entire FF system when operational. Incorrect installation and testing of physical medium shall result in induced errors in the segment (some intermittent) that will affect commissioning efficiency and ultimately the reliability of the installed system.

Cable Tests

The following precautions shall be carried out before performing the cable checkout procedure:

Ensure that the field wiring is completed and properly terminated and that all field spurs (but not devices) are attached

Remove the Fieldbus network cable (+, -, and shield) at power conditioner terminal block connector locations; Remove only the connector to the field wiring; it is not necessary to remove the connector to the FIM. Removing the connector to the field wiring isolates the field wiring from the FIM and power supply, isolates the shield from ground, and enables measurement of the resistance and capacitance measurements in the checkout procedure.

The following checks shall then be carried out and the results documented:

Resistance Check

Measure resistance on the H1 segment conductors at the removed terminal block connector coming in from the field.

Table 7.1.1 Cable Resistance requirements.

RESISTANCE MEASURED FROM	EXPECTED RESULT
+ signal conductor to - signal conductor	open circuit > 50 KΩ1 (increasing)
+ signal conductor to drain/shield wire	>20 MΩ
- signal conductor to drain/shield wire	open circuit > 20 MΩ
+ signal conductor to instrument ground bar	open circuit > 20 MΩ
- signal conductor to instrument ground bar	open circuit > 20 MΩ
drain/shield wire to instrument ground bar	open circuit > 20 MΩ

Capacitance Check

Measure capacitance on the H1 segment conductors at the removed terminal block connector coming in from the field.

Table 7.1.2 Cable Capacitance requirements.

RESISTANCE MEASURED FROM	EXPECTED RESULT
+ signal conductor to - signal conductor	1 µF (0.80 to 1.20 µF acceptable) Note 2
+ signal conductor to drain/shield wire	< 300 nF
- signal conductor to drain/shield wire	< 300 nF
+ signal conductor to instrument ground bar	< 300 nF
- signal conductor to instrument ground bar	< 300 nF
drain/shield wire to instrument ground bar	< 300 nF

Note: A reading of < .5 µF indicates no terminator on the segment. A reading of a nominal 2 µF indicates a second terminator on the segment. The acceptable values assume that the power supply terminator is used as the second terminator and only one additional terminator is connected in the field. Otherwise, the expected result would be 2 µF.

DC Voltage Check

Reconnect the previously removed terminal block connectors to the power supply. Measure the DC voltage at the terminal block connector going to the field and confirm healthy supply.

Segment Test Procedure

Fieldbus segment wiring should be tested using a Fieldbus Wiring Monitor (Relcom, Inc. FBT-6 Fieldbus Monitor), and Oscilloscope which are used to test the voltage, signal levels and noise on the wiring.

The following tests shall be carried out in accordance with the Relcom documentation as a minimum:

- DC Carrier voltage test.
- LAS Function test.
- Average Noise test.

The tests shall be used to confirm that the segments satisfy the minimum requirements for FF listed in the tables below.

Table 7.1.3 LAS Probe Node Frame Function Test requirements.

SIGNAL LEVEL	**WIRE CONDITION**
800 mV or greater	Missing Terminator
350-700 mV	Good
150-350 mV	Marginal
150 or less	Will not work

Table 7.1.4 Average NOISE Test requirements.

NOISE LEVEL	**WIRE CONDITION**
25 mV or Less	Excellent
25-50 mV	Okay
50-100 mV	Marginal
100 mV or More	Poor

8. References

Document No.	Document Title
AG-140	Fieldbus Foundation: FF Application Guide 31,25 Kbit/s Wiring Guide
AG-163	Fieldbus Foundation: FF Application Guide 31,25 Kbit/s Intrinsically Safe Systems
AG-181	Fieldbus Foundation: Foundation Fieldbus System Engineering Guidelines