

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

FIELDBUS DESIGN, INSTALLATION, OPERATION & MAINTENANCE

PTS 32.30.10.10
July 2008



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This new PTS **32.30.10.10** - Fieldbus Design, Installation, Operation & Maintenance has been developed with the objective to specify the minimum and fit-for-purpose, requirements of a Fieldbus System.

This PTS also includes PETRONAS Lessons Learnt and PETRONAS Best Practice for the subject matter in the Fieldbus Design, Installation, Operation & Maintenance

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PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

The right to use PTS rests with three categories of users:

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorized to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

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1 INTRODUCTION

1.1 SCOPE

This PTS specifies the requirements for the design, installation, operation and maintenance of Fieldbus installation. This PTS shall be used for new projects and existing installations, where Fieldbus system is being implemented. The objective is to specify the minimum and fit-for-purpose, requirements of a Fieldbus system

This PTS is developed together with the Technical Professionals and experienced Fieldbus users of Skill Group 14. The Custodian of this PTS shall be consulted for any deviation from these PTS.

Do NOT use Fieldbus for any Process Shutdown System

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS group and to contractors and manufacturers/suppliers nominated by them.

All publications referred to are listed in Section 10.

1.3 DEFINITIONS

1.3.1 General Definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor or the Plant Owner.

The **Plant Owner** is the PETRONAS instrumentation party responsible for the operation and maintenance of the equipment, who in turn, is responsible to the plant management.

The **Principal** is the PETRONAS party which initiates the project (new or revamp) and ultimately pays for its design and construction. The Principal will generally specify the technical requirements.

The **Custodian** is the originator and technical owner of these PTS.

The word **Shall** indicate a requirement.

The word **Should** indicate a recommendation.

1.3.2 Technical Definitions

Application Layer

The Application Layer is a layer in the communication stack containing the object dictionary

Bus

A bus is an interconnected network of devices. A larger bus can be formed by multiple segments connected through repeaters. A bus typically has a single segment. Therefore the terms “bus” and “segment” are often used interchangeably although there is a difference.

Fieldbus Coupler

A coupler is an optional physical specialized wiring block between a trunk and spur to the devices.

Cycle

The scanning of inputs, execution of algorithms and transmission of output values to devices.

Data Link Layer

The Data Link Layer (DLL) controls transmission of messages onto the Fieldbus, and manages access to the Fieldbus through the Link Active Scheduler (LAS). The DLL is defined in IEC 61158 and ISA S50. It includes Publisher/Subscriber, Client/Server and Report Distribution Services.

Deterministic

The ability to calculate maximum worst-case delay when delivering a message between any two nodes in a network. Any network protocol that depends on random delays to resolve mastership is non-deterministic.

Device Description

A Device Description (DD) provides an extended description of each object in the Device and includes information needed for a control system or host to understand the meaning of data in the device

FISCO

Fieldbus Intrinsic Safe Concept. Allows more power to an IS segment for approved FISCO devices, allowing for more devices per IS segment. FISCO eliminates the requirement of calculating entity parameters of capacitance and inductance when designing networks.

Flexible Function Block

A Flexible Function Block (FFB) is similar to a Standard FB, except that an application specific algorithm created by a programming tool determines the function of the block, the order and definition of the block parameters, and the time required to execute the block. Flexible Function Blocks (FFBs) are typically used for control of discrete processes and for hybrid (batch) processes. A Programmable Logic Controller (PLC) can be modeled as a Flexible Function Block device.

Function Block

A Standard Function Block (FB) is built into Fieldbus devices as needed to achieve the desired control functionality. Automation functions provided by Standard FBs include Analog Input (AI), Analog Output (AO) and Proportional/Integral/Derivative (PID) control. There can be many types of FBs in a device. The order and definition of Standard FB parameters are fixed and defined by the specifications.

Gateway

A Gateway translates another protocol to Fieldbus, for example HART to Fieldbus or Modbus to Fieldbus.

Link

A Link is the logical medium by which devices are interconnected. It spans one or more physical segments interconnected by bus Repeaters or Couplers. All of the devices on a link share a common schedule which is administered by that link's current LAS.

Link Active Scheduler

A Link Active Scheduler (LAS) is a deterministic, centralized bus scheduler that maintains a list of transmission times for all data buffers in all devices that need to be cyclically transmitted. Only one Link Master (LM) device on a Fieldbus Link can be functioning as that link's LAS.

Link Master

A Link Master (LM) is any device containing Link Active Scheduler (LAS) functionality that can control communications on a Fieldbus Link. There must be at least one LM on a Link; one of those LM devices will be elected to serve as LAS.

Link Object

A Link Object contains information to link Function Block (FB) Input/ Output (I/O) parameters in the same device and between different devices. The Link Object links directly to a Virtual Communications Relationship (VCR).

Object Dictionary

An Object Dictionary (OD) contains all Function Block (FB), Resource Block (RB) and Transducer Block (TB) parameters used in a device. Through these parameters, the blocks may be accessed over the Fieldbus network.

Physical Layer

The Physical Layer receives messages from the Communications Stack and converts the messages into physical signals on the Fieldbus transmission medium, and vice versa.

Repeater

Repeater is an active, bus-powered or non-bus-powered device used to extend the range over which signals can be correctly transmitted and received for a given medium. A maximum of four Repeaters can be used between any two devices on Fieldbus network. Repeaters connect segments together to form larger networks.

Resource Block

A Resource Block (RB) describes characteristics of the Fieldbus device such as the device name manufacturer and serial number. There is only one Resource Block (RB) in a device.

Segment

A segment represents a cable and device installed between a pair of terminators. Segments can be linked by Repeaters to form a fresh signal and elongate the Fieldbus.

Splice

A Splice is a Spur measuring less than 1m in length.

Spur

A Spur is a branch cable connecting to the device to the Trunk.

Terminator

A Terminator is a shunt that converts transmitted current signal to a voltage signal. It is placed at or near each end of a transmission line. Only two Terminators shall be used on a segment.

Topology

Topology refers to the shape and design of the Fieldbus network (for example, tree, bus, daisy chain, point-to-point, chicken foot, etc.).

Transducer Block

A Transducer Block (TB) decouples Function Blocks (FBs) from the local I/O functions required to read sensors and command output hardware. Transducer Blocks (TBs) contain information such as calibration data and sensor type. There is usually one TB channel for each input or output of a FB.

Transmitter

A Transmitter is an active Fieldbus device containing circuitry which applies a digital signal on the bus.

Trunk

A Trunk is the main cable-between the control system and the devices in the field.

User Application

A User Application is based on “blocks”, including Resource Blocks (RBs), Function Blocks (FBs) and Transducer Blocks (TBs), which represent different types of application functions.

User Layer

The User Layer provides scheduling of Function Blocks (FBs), as well as Device Descriptions (DDs) which allow the host to communicate with devices without the need for custom programming.

Virtual Communication Relationship

Configured application layer channels that provide for the transfer of data between applications.

1.4 ABBREVIATIONS

Abbreviations	Description
AI	Analog Input
AO	Analog Output
BPS	Bulk Power Supply
CAPEX	Capital Expenditure
CCR	Central Control Room
C/S	Client/Server
CCF	Common File Format
DCS	Distributed Control System/Digital Control System
DI	Discrete Input
DD	Device Description
DLL	Data Link Layer
DO	Discrete Output
EDDL	Enhanced Device Description Language
ESD	Emergency Shut Down
FAR	Field Auxiliary Room
FAS	Fieldbus Access Sub layer
FB	Function Block
FF	FOUNDATION Fieldbus
FFB	Flexible Function Block
FFPS	FOUNDATION Fieldbus Power Supply
F&G	Fire And Gas
HIST	Host Interoperability Support Testing
HMI	Human Machine Interface
HSE	High Speed Ethernet
IEC	International Electro Technical Commission
I/O	Input Output
IPS	Instrument Protective Function
IS	Intrinsic Safety

IT	Information Technology
ITC	Individual Twisted Cable
ITK	Interoperability Test Kit
LAS	Link Active Schedule
LM	Link Master
MAI	Multi Analog Input
MAO	Multi Analog Output
ML	Manual Loader
MOV	Motor Operated Valve
MV	Manipulated Variable (Controller Output)
NM	Network Management
OD	Object Dictionary
OPEX	Operational Expenditure
PCS	Process Control System
PAS	Process Automation System
P/S	Publish/Subscribe
PD	Proportional/Derivative Control
PID	Proportional /Integral /Derivative Control
PV	Process Variable
PLC	Programmable Logic Controller
RA	Ratio
RB	Resource Block
SIL	Safety Integrity Level
SM	System Management
SP	Set Point
SS	Safety Systems
TB	Transducer Block
TCoO	Total Cost of Ownership
TPE	Thermo Plastic Elastomer
VCR	Virtual Communication Resource

2 GENERAL

To ensure standardization across the PETRONAS Group of companies, based on the most prevalent use across the oil majors and based on capability building across the Group, the FOUNDATION Fieldbus shall be the only Fieldbus technology approved for use in the Group for process instrumentation and control applications.

2.1 SYSTEM PHILOSOPHY

All instrumentation devices used in the Fieldbus system shall be approved by the Fieldbus Foundation and shall have the checkmark symbol, as follows:



Approved devices can be found on the Fieldbus Foundation website:
<http://www.Fieldbus.org/>

The FOUNDATION Fieldbus device shall be at least ITK 4.6 compliant, which allows for on-line firmware upgrades. It is recommended that the selected ITK version shall remain unchanged thorough-out the project phase, until commissioning and one (1) year operation, to avoid discrepancies in the various devices installed in the network.

FOUNDATION Fieldbus (hereinafter known as Fieldbus) devices shall be capable of supporting incremental device description (DD) for extra functionality and/or software revisions in device memory. The internal software of the Fieldbus instruments shall be configured by the manufacturer to include at least the serial number, tag name and process service description.

The Fieldbus devices shall not be polarity sensitive. Older Fieldbus devices were polarity sensitive and, if connected incorrectly, will not work. These older devices shall be progressively replaced.

The field devices shall generally be 2-wire bus powered from the host system. The bus-powered Fieldbus devices typically require 10-30 mA current and shall be between 9 to 32 VDC. It is recommended that a margin of at least 1VDC be maintained at the field end of the bus i.e. at least 10VDC. Any segment that is designed to operate below 15 VDC shall carry a warning on additional loads in the segment documentation. The minimum segment voltage shall be shown on the network/segment documentation.

Devices that require external power, e.g. 4-wire devices, shall have their power isolated from the Fieldbus signal. Bus-powered, 2-wire devices are the recommended standard.

Devices should strive for minimum power consumption.

The fields devices shall be provided with a maximum of 60 mA current limiting short-circuit protection. For practical purposes, this means that all field devices shall draw no more than 50 mA, since approximately 10 mA will be needed to activate the short-circuit protection circuitry.

The Fieldbus equipment shall be designed to withstand vibration forces of up to 1.0 g over the range of 5 to 100 Hz, and for a 5 msec duration a vibration force of 4.0 g over the same range. Networks, Data, I/O highways are required to have an approved type of electrical isolation at the point of connection to the Host System hardware, Fieldbus junction box, and the field.

All Fieldbus devices shall be certified by an internationally recognized testing laboratory, and labeled for the Hazardous Area classification where they will be installed.

The Fieldbus system shall only be used for purposes of monitoring and/or control. The Fieldbus system shall NOT be used for safety shutdown purposes.

The overall Fieldbus system design should be well under-stood before the network and individual segment design is started. The P&ID's, Instrument Location drawings and Plot Plans are needed to effectively design Fieldbus segments.

Prior to defining Fieldbus segments, the process control strategy and philosophy shall be complete, the P&IDs available, and instruments selected with locations determined. This is a necessary condition to allow for the design of control in the field, which requires all devices for the loop to be part of the same network/segment.

A control implementation strategy guideline shall be created for all Fieldbus projects and approved by the Principal or Plant Owner. The guideline shall define the typical control strategies, with control modules, function blocks and all parameter configurations defined. This guideline shall set the function block and control module philosophy for the current and future Fieldbus projects at the particular facility. As part of the guideline, a narrative shall be provided for each typical function block and control modules to describe in detail the parameter settings and subsequent blocks/module operation. Included shall be narrative discussion on parameter configuration and operation for signal status, bad value determination, failure mode switching, initiation feature, anti-reset windup feature, etc. The guideline shall highlight any differences in configuration or operation between the FOUNDATION Fieldbus and conventional 4-20mA control strategies, if a mixture of FOUNDATION Fieldbus and conventional control strategies are used. This shall form the basis for configuration of the devices and control system behavior during Abnormal Situation and is critical for the safe and reliable operation of the facility. The control system vendor shall produce configuration options and defaults for the specific host system wide settings, configuration strategies, devices and asset management software. The Principal or Plant Owner shall approve all configuration options and defaults. A typical example of default settings for a control loop can be :-

- Loop mode shall default to manual for Bad PV, condition is alarmed and indicated by graphics and faceplate colour change and blanked out data indication.
- Loop mode shall ignore Questionable PV, condition is not alarmed but is indicated by graphics and faceplate colour change.

All personnel executing design, projects, installation, testing, commissioning, technical operation and maintenance shall have undergone certified training by any approved party. The certified training shall be for a minimum of two (2) weeks, covering both theoretical aspects and practical training on FOUNDATION Fieldbus.

2.2 DEVICE DIAGNOSTICS

Device integration and diagnostics shall be based on FOUNDATION Fieldbus approved technologies, such as, EDDL technologies. The device diagnostics shall be able to provide key information on the ability of the device to measure and/or control the process, including, but not limited to, basic device failure diagnostics and advanced diagnostics.

2.2.1 Basic Diagnostics

Basic diagnostics are the device failure diagnostics that shall be viewable from any process control host. They help determine common problems with the device, communication path and host. Diagnostics that indicate device failure should force the loop to the required safe failure mode, as per the control narrative, with appropriate warnings and alerts as per Section 5.5.

2.2.2 Advanced Diagnostics

Advanced diagnostics includes full device diagnostics that is determined without removing the device from the network. Advanced diagnostics is available as on-line and off-line.

2.2.3 Online Advanced Diagnostics

Online diagnostics perform their functions while the device is performing its normal process function and provides the capability to alert in real time if a problem needs attention. This function is a primary benefit of FOUNDATION Fieldbus and should be supported by all devices installed in the facility.

2.2.4 Offline Advanced Diagnostics

Offline diagnostics have limited benefits, as it requires the device to be taken out of normal operation.

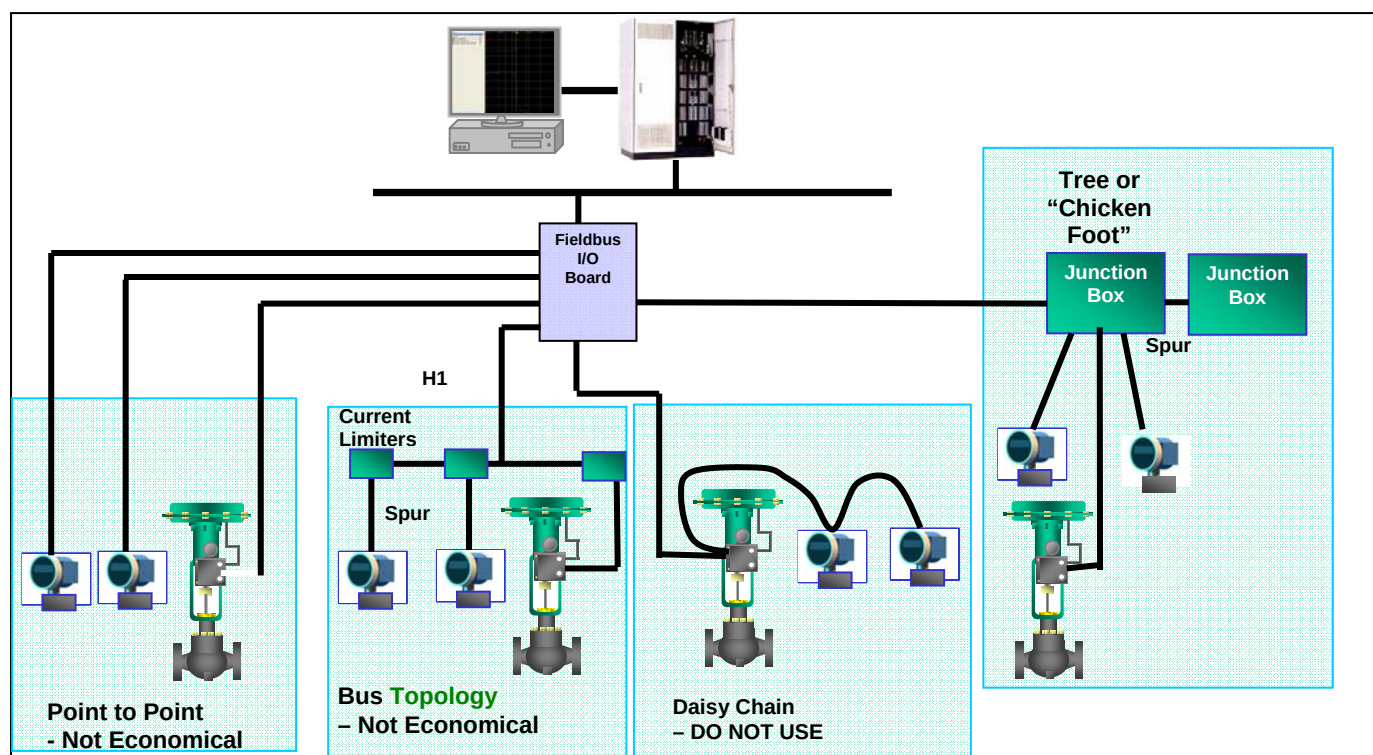
3 SEGMENT DESIGN GUIDELINES

3.1 FIELDBUS TOPOLOGY

Components of Fieldbus segments or networks can be connected together in various topologies. The topology selected is usually driven by the physical device location in order to reduce installation costs. Hence, control narratives and plot plans are used in addition to P&IDs and instrument indexes in the design of a Fieldbus segment.

Spur connections shall be connected to current-limiting connections to the bus to provide short-circuit protection, and to provide the ability to work on field devices without a hot work permit. This current limiting connection should provide an intrinsically safe connection to the field device.

There are several possible topologies for connecting the Fieldbus instrumentation in a system, as follows:-



Topologies where devices cannot be added or removed from a network/segment without disruption to other devices in the same network/segment shall not be used, such as Daisy Chain topologies. Only the Tree or "Chicken foot" topology shall be used for Fieldbus system that is used for control purposes.

3.1.1 Point-to-Point Topology

This topology consists of a network having only two devices. The network could be entirely in the field (e.g. a transmitter and valve, with no connection beyond the two) or it could be a field device connected to a host system for control or monitoring.

Point-to-point topology should not be used due to uneconomical reasons.

3.1.2 Tree Topology (Chicken Foot)

This topology consists of a single Fieldbus segment connected to a common junction box to form a network. It is practical if the devices on the same segment are well separated but in the general area of the junction box. When using this topology, the maximum spur lengths must be considered. Maximum spur lengths are discussed in Section 3.6.3.

This topology also allows maximum flexibility when configuring and assigning devices to networks/segments.

3.1.3 Bus Topology

This topology consists of Fieldbus devices that are connected to a trunk through a length of cable called a spur. This technology is technically acceptable but is not generally a good economic choice.

3.2 BULK POWER SUPPLIES

The 24VDC bulk power supply unit, supplying the Fieldbus system, shall be redundant. Two separate, independent, power circuits should provide the source power to the bulk power supply unit. The bulk power supply unit should be fed from redundant UPS power or have battery back-up supply for 30 minutes. The bulk power supplies shall have the necessary failure alarms. The negative leg of the bulk power supply unit should be grounded. The bulk power supply unit may be either dedicated solely to the Fieldbus network or shared between the Fieldbus network and the conventional 4-20mA instrumentation.

The bulk power supplies shall have overcurrent protection for each of its feed.

If the plant site already has an existing bulk power supply for conventional 4-20 mA instrumentation, this bulk power supply may be used to supply the Fieldbus power supply unit. The available spare capacity of the bulk power supplies shall be verified to meet the overall required demands. The Plant Owner shall approve, in writing, the use of the existing bulk power supply.

3.3 POWER CONDITIONER

Power conditioner is required for each Fieldbus network or segment to prevent the DC power supply from short circuiting the AC communication. The power conditioner shall be isolated, load sharing and output current limiting. The power conditioner shall be impedance matched to the Fieldbus signals. For control purposes, the power conditioner shall be redundant. Redundant power conditioners shall provide flawless transfer of power between one unit to the other. For monitoring purposes, redundant power conditioners are also recommended.

The power conditioners should be powered from the redundant bulk power supply units. The power conditioners units shall have alarms and diagnostics features.

3.4 TERMINATORS

Every Fieldbus segment shall have exactly two terminators. Terminators are necessary to prevent signal noise, arising from signal reflections, in event of wiring short or open circuit and convert transmitted current signal to a received voltage signal. The terminators are 1 μ F capacitor in series with a 100 Ω resistor. Self fabricated terminators shall not be used. Terminator that is located in the field shall be installed in a junction box. Terminators shall not be installed in the Fieldbus devices.

3.5 REPEATERS

Repeaters clean up the signal, by boosting it, re-timing it, and thereby improving the reliability of the Fieldbus network communications.

Repeaters replace one of the field devices in the network count, allowing the addition of the equivalent of an entire new segment by effectively splitting the network into a number of smaller segments. By adding a repeater, a new segment can be connected and terminators are required on each end of this new segment. Repeaters also provide the capability to increase the number of devices on a network to a maximum of 240 devices. However, note that the host system and network schedule limit will likely to be exceeded, before the physical maximum number of devices can be reached.

Some typical uses of repeaters would be :-

- a. If a segment (network) needs to extend further than the 1900 meter length constraint, then a repeater may be considered.
- b. A repeater can be used, with wire lengths of less than 1900 m, to improve the Fieldbus network robustness and reliability by boosting the communication signals.
- c. The most common use of repeaters is not to get longer distance, but to join IS segments together. Generally, an entity barrier only supports 3-4 devices and many barriers are required on a network to get loading of 16 devices per network.
- d. In the cases where it is economically justified, a repeater may be considered to extend the total segment length. This would typically be in cases where the H1 interface card cannot be located relatively close to the process (e.g. flare systems).

When Fieldbus repeaters are used, the overall design shall be reviewed and approved by the Principal engineer. When repeaters are used, the location of the repeaters shall be accessible. The Fieldbus repeaters shall be clearly marked on the Fieldbus network drawing.

3.5 JUNCTION BOXES

It is recommended that all trunk and spur connections in the field junction boxes, including pass-through trunk pairs without spurs, be terminated on Fieldbus couplers specifically designed and approved for Fieldbus networks. Inactive spare Fieldbus trunk pairs may be terminated on conventional terminal blocks. However, the use of conventional terminal blocks shall be documented, to enable future replacement, when the inactive pairs are re-activated, sometime in the future.

The design of the junction box shall include power isolation switches for maintenance of a section of the segment, without affecting the rest of the segment.

An alternate connection may be provided by weatherproof molded "bricks" that can be used without a junction box with factory molded plug connectors.

Conventional, 4-20mA, terminal blocks may be used but the wiring to all devices in the network shall be done via parallel connections.

If weatherproof molded “bricks” or conventional terminal blocks are used, the following requirements shall be met:-

- a. Two (2) dedicated connections for the Fieldbus homerun/trunk cable.
- b. Integral short-circuit protector for spur connections, where the maximum current to spur is limited by the area classification and current available to the network. The spur circuits shall have a non-incendive rating. The short-circuit protector can be connected to the terminating block at the homerun or main network cable.

Wiring Blocks with integral short-circuit protectors will prevent a fault (short-circuit) in the device or spur cable run from bringing the entire FF segment down. Typically an additional 10 mA load is added when this spur is short-circuited.

- c. Pluggable (removable) ‘trunk’ and ‘spur’ connectors.
- d. Indicators for each spur connection indicating when a spur is shorted and is in overcurrent mode.
- e. Indication when bus power is available.
- f. Electrical regulatory (e.g. CSA or FM) approved for Ex n; Class I, Division 2, Groups B, C, D or Zone 2, IIA, IIB, IIC.
- g. Wire capacity: 12-24 AWG.
- h. Temperature range: -45° to +70° C.
- i. DIN rail mounting (terminal blocks).
- j. Available in four (4) spur, six (6) spur and eight (8) spur configurations.

Where multi-pair trunk cables from the marshalling panel to the field are required (for large segment usages), the junction box for the multi-pair trunk cable shall comply with the PTS for conventional instrumentation.

3.6 CABLING

Individually shielded twisted pair overall screened cables shall be used for Fieldbus network cabling. Specially designed FOUNDATION Fieldbus cabling may be used, if the cost is justifiable.

The following are typical characteristics of FF cables as per IEC Physical Layer Standards:-

Wire Size	18 GA (0.8 mm ²)
Shield	90% coverage
Attenuation	3 db/km at 39kHz
Maximum Capacitance	150 pF/m
Characteristic Impedance	100 ohms +/- 20% at 31.25 kHz

The typical Fieldbus cable specifications are as follows :-

Type	Meters/Feet	Cable Size	Impedance Ohms	Resistivity	Attenuation (db/km)	Description
A	1900 / 6270	#18 AWG (0.8 mm ²)	100	22	3	Individual shielded pairs
B	1200 / 3960	#22 AWG (0.32 mm ²)	100	56	5	Multiple pairs with overall shield
C	400 / 1320	#26 AWG (0.13 mm ²)	Unknown	132	8	Multiple pairs with no shield
D	200 / 660	#16 AWG (1.25 mm ²)	Unknown	20	8	Multiconductor, no pairing

Cables for Fieldbus installation shall be labeled Type ITC (16 gauge) and shall be installed in trays or conduits. All cables shall be single or multiple twisted pair with individual shield for each pair (Types B, C and D cables shall not be used). Multi pair cables shall have an additional overall shield.

Fieldbus cables shall be unique in colour and shall be easily distinguished from conventional 4-20 mA cables. The cable differentiation can be at the cable ends, through the use of coloured cable lugs or coloured heat shrink markers.

To minimize cost for upgrading existing 4-20mA installations to Fieldbus, Fieldbus signals and 4-20mA signals may be run together in multiconductor cables provided each wire pair is individually shielded.

Cables shall have thermoplastic elastomer (TPE) flame-retardant insulation and comply with the colour conventions and polarities of the facilities. The cables shall be suitable for the electrical area classifications and suitable for outdoor use in cable trays. The cable jacket shall be flame-retardant polyvinyl chloride (PVC).

3.6.1 Distance Constraints

The maximum allowable segment length is 1900 meters (6232 ft) except where repeaters are installed, as specified in the ISA 50.02 Fieldbus Standard. The total segment length is calculated by adding the length of the main trunk line cable and all the spurs that extend from it.

Total Segment Length = Trunk + All Spurs

The total segment length is limited by the voltage drop and the signal quality (attenuation and distortion).

3.6.2 Trunk Cable

Either specially designed FOUNDATION Fieldbus cables, Type A or 18 AWG multi-pair, individually shielded cables shall be used for all trunk wiring. Runs parallel to high power (> 240 VAC) should be minimized, with adequate spacing and shielding.

A minimum of twenty percent (20%) spare pairs shall be provided for all multipair Fieldbus segment trunk cables, with a minimum of one spare pair. This sparing requirement covers trunk cable runs between marshalling racks and junction boxes, and between junction boxes.