REPORT **DAS-ASYS2024-013-RPT**

USER REQUIREMENT SPECIFICATION

Wind Tunnel Facility Upgrade: MSWT Test Article Controller Data Acquisition System Upgrade

by

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Change Control No	Date	Name	Description
This page will only be updated starting from: Rev 2			

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ABBREVIATIONS

ADC	Analog-to-Digital Converter
CSIR	Council for Science and Industrial Research
DAC	Digital-to-Analog Converter
DAQ	Data Acquisition System
DEC	Digital Equipment Corporation
EMI	Electro-Magnetic Interference
FFPS	Flow Field Probe System
GPIB	General Purpose Interface Bus
HMI	Human Machine Interface
HP	Hewlett-Packard
I/O	Input/Output
JB	Junction Box
MSWT	Medium Speed Wind Tunnel
MMS	Main Model Support
OEM	Original Equipment Manufacturer
PDP	Programmable Data Processor
PGA	Programmable Gain Amplifier
RTD	Resistance Temperature Detection
SCSI-2	Small Computer System Interface
SWS	Side Wall Support
TAC	Test Article Controller
TCP/IP	Transmissions Control Protocol/Internet Protocol
TEC	Tunnel Environment Controller
TOE	Test Operations Executive
URS	User Requirement Specification
USA	United State of America

1 Scope of Project

1.1 Background

The CSIR's Medium Speed Wind Tunnel (MSWT) utilises an obsolete NEFF data acquisition system as part of the test article controller (TAC) processor which is approaching end of life. The NEFF system in question is the 620 series system package that primarily functions as the main data acquisition platform for test critical signals and control necessary signals.

Due to the availability of spares and the closure of NEFF Instruments Corporation in 2009, the NEFF has been flagged as requiring an in place replacement for the continued operation of the tunnel. This is the primary motivation for the replacement of the NEFF system as well as including several upgrades to the data acquisition suite with modernised designs and systems.

1.2 Purpose of Document

The user requirement specification (URS) document is directed explicitly to replace the current MSWT TAC NEFF system 620 DAQ with equivalent or better modern hardware and software. These specifications include the sample rates, resolution, bandwidth and channel count per input/output type.

All the necessary and sufficient requirements for logistics, safety, test and evaluation, acceptance testing, maintenance and coding standards are documented here.

1.3 Exclusions

The transducer network currently installed in the MSWT and sub-systems (see Section 1.4.) will remain in place and not be included in the system to be decommissioned and replaced. The existing transducers will be integrated into the selected replacement system with the necessary interfaces. Please reference the original drawings 9259-P-0102 and 9259-P-0104.

The current tunnel environment controller (TEC) PDP-11/73 processor will remain in place which makes use of a separate NEFF system 620 which is utilised for data acquisition of tunnel critical signals for monitoring and control. Therefore the TEC DAQ in explicitly excluded from the scope of the URS and can be found in drawing 9259-P-0100 for reference.

1.4 Neighbouring sub-systems and interfaces

The MSWT TAC DAQ interfaces with several sub-systems and individua components in order to carry out all functions. The following sub-systems are listed from drawing 9259-P-0100:

- The current TAC HP 9000 C100 workstation will remain in place acting as the test model data acquisition control system.
- Expansion points for transducers installation will be carried over from current system.
- MMS and FFPS positioning feedback transducers and sub-systems responsible for positioning and control will be carried over as is.

2 Applicable and Reference Documents

2.1 Reference documents

Excel database containing comparisons between different manufacturer system configurations and components.

2.2 Annexure A

The following document shall serve as Annexure A:

MSWT TAC NEFF – Features and Specifications 2024 (Author: Daniël Ferreira, CSIR, Pretoria)

2.3 Reference Drawings

- 9259-P-0099 MSWT SYSTEM BLOCK DIAGRAM
- 9259-P-0100 CONTROL & DATA SYSTEM BLOCK DIAGRAM
- 9259-P-0102 TAC BLOCK DIAGRAM
- 9259-P-0104 DATA ACQUISITION SYSTEM CHANNEL ASSIGNMENTS TAC
- 9259-P-0182 DATA SYSTEM, DATA ANALYSIS, BALANCE CALIBRATIONS & PRESSURE MULTIPLEXER RACK LAYOUT

3 Existing System Overview

3.1 Definitions

Data Acquisition System (DAQ): The system responsible for the data acquisition for the test article controller system as well as the necessary control. This system is the primary focus of the URS and currently is the NEFF 620 series data acquisition system. The DAQ is made up of several components and interfaces required to convert the array of analogue input signals into digital formats for further processing. The primary function of a data acquisition system is to acquire signals, convert them into a format usuable by the system and carrying out control interfaces through analogue outputs and digital I/O. Additional important aspects of the DAQ is the resolution, sampling rate, bandwidth, amplification, filtering and conditioning necessary for specialised transducers. The current system makes use of a auto-calibration functionality.

Components: Components are the smallest practicable divisions making up a sub-system of the DAQ.

3.2 Description: MSWT TAC Computational System Hardware

3.2.1 TAC Overview

The system that interfaces directly with the DAQ is the test article controller, which is responsible for data management and control relating to the model, test section and other test-dependent activities.

3.2.2 TAC Hardware and Communication

The original TAC controller was a PDP-11/73 processor. The current TAC controller is a HP 9000 C100 workstation, which communicates with the existing NEFF 620 series via a SCSI-2 link.

However, the HP 9000 is obsolete and shall be replaced by a new TAC controller pc selected by the CSIR (MSWT).

It is preferred that the replacement TAC controller pc will communicate with the new DAQ via a high-speed non-proprietary bus standard (e.g SCSI, Ethernet or GPIB)

3.2.3 TAC Neighbouring Systems

Systems that are adjacent to the TAC are the six FFPS stepper motor controllers, the two MMS stepper motor controllers and the side wall support stepper motor controller. Drawing 9259-P-0100 shows the neighbouring systems and how they interact with the NEFF.

3.2.4 TAC Functions

The TAC is primarily responsible for performing the following functions:

a) Acquiring raw test article data

b) Pre-processing and converting raw data to first-level engineering parameters

c) Controlling test article parameters (6-FFPS, 2-MMS, 1-SWS)

d) Monitoring autonomous capability for controls system and monitoring data parameters
e) Monitoring status and health of critical parameters

3.3 Description: Existing NEFF 620 Series

3.3.1 DAQ Overview

The NEFF 620 series data acquisition is the collective name given to a family of data acquisition modules installed in a 600 series chassis to form the system utilised by the TAC. The result of this family of modules or components allows for user freedom to configure the system to the desired role. The sub-systems utilised to make up the TAC DAQ are as follows:

Sub-System	Function
100 Series	ADC and Amplification
300 Series	Signal Conditioning
500 Series	Measurement and Control I/O Logic

Table 1: NEFF 620 series sub-systems used in the MSWT TAC DAQ

These principal sub-systems are configurable as follows: with different input cards in the case of the 100 Series, and with different signal conditioning cards in the case of the 300 Series, thereby handling a variety of transducer types. In this manner, the DAQ is configurable to accommodate any combination of transducers a customer may need to gather data from his test model during a wind tunnel test.

The next sections describe these principal sub-systems in greater accuracy.

3.3.2 300 Series Signal Conditioner

The Series 300 signal conditioner is a data acquisition sub-system that conditions signal transducers for measurement by analogue subsystems. This sub-system was selected for the MSWT TAC because each channel can be easily configured for a particular transducer type including strain gauge, thermocouple and RTD.

The Series 300 has the following functionality:

- Constant voltage excitation for bridge transducers.
- Constant current excitation for RTD’s and potentiometers.
- Programmable voltage calibration.
- Accommodates one, two, and four-arm bridges.
- Bridge, RTD and thermocouple calibration.

A four-channel input conditioning plug-in card (Neff Part No 620350) is the basic component of the 300 Series signal conditioner, providing excitation power, relays and calibration circuits for each of four channels. Each input conditioning card accepts four mode cards, one for each channel, that configure the input conditioning and calibration circuits for operation for a particular type of transducer.

Table 2 below lists the standard mode cards currently used in the MSWT TAC DAQ.

Neff Part Number	Description
620360	Strain Gauge Mode Card (One, Two, or Four-Arm Bridges)
620361	RTD/Potentiometer Mode Card
620362	Thermocouple Mode Card

Table 2: 300 Series Mode Cards used in the MSWT TAC DAQ

Refer to Annexure A for detailed specifications and performance characteristics of each of these components.

Additional 64-channel input assemblies equipped with the required complement of four-channel input conditioning and mode cards can expand the 300 Series capacity up to 2048 channels. The MSWT TAC DAQ does not use additional input assemblies, using only the base 64 channels.

3.3.3 100 Series Amplifier/Multiplexer

The 100 series amplifier/multiplexer is an amplifier-per-channel model featuring high-speed sampling at 50 kHz, programmable gain and individual filter frequency selection per channel.

Basic functionality of the 100 Series is as follows:

- Throughput Rates: 50 kHz (10 kHz for normal operation in the MSWT TAC DAQ)
- Full scale input: ±5 mV to ±10 V
- Resolution: 15 bit plus sign resolution

The Series 100 amplifier/multiplexer chassis has 16 available card slots; each can house four channel amplifier cards. Up to three expansion chassis can be added, bringing maximum system capacity up to 256 channels. The MSWT TAC DAQ does not use expansion chassis, using only the base 64 channels.

Neff produces a range of amplifier cards for the 100 Series amplifier/multiplexer, depending on required ranges and gains. Table 3 below lists the 100 Series amplifier cards in use in the MSWT TAC DAQ.

Neff Part Number	Amplifier Card Functionality
620050	For low-level signals ranging from ±5 mV to ± 1V
620055	Same as 620050 but with an individual sample and hold for each channel
620060	For low-level signals ranging from ±25 mV to ±10 V

Table 3: 100 Series Amplifier Cards in the MSWT TAC DAQ

The 100 Series in use at the MSWT TAC DAQ also has an option to buffer analogue outputs (Neff Part No 620040) plus a 64-channel calibration assembly (Neff Part No 620080) which allows the user to switch channel input, by energizing a relay, from the analogue input to an external, user supplied calibration voltage source.

Refer to Annexure A for detailed performance specifications of the 100 Series amplifier/multiplexer subsystem and its components.

3.3.4 500 Series Measurement & Control I/O System

The 500 series subsystem provides communication between the controlling computer and other members of the 620 series family, including analogue systems and analogue or digital I/O function cards.

The 500 series has a serial data link that can control the operation of up to eight remote systems.

It has the following features and functionality:

- Links I/O functions to computer.
- Versatile computer I/O.
- Plug-in function cards.
- Easy expansion.
- Local or remote data acquisition.

Table 4 below lists the I/O function cards that plug into the 500 Series in use in the MSWT TAC DAQ

Neff Part Number	Description
620530	32-Bit TTL Output
620561	32-Bit Isolated DC Sense

Table 4: 500 Series I/O function cards in the MSWT TAC DAQ

The 32-Bit TTL output card transfers TTL data from the 500 series bus to a peripheral device. The 32-bit isolated DC sense card monitors contact closures or other types of event lines and generates interrupt requests to the computer.

Refer to Annexure A for detailed performance specifications of the Series 500 Measurement & Control I/O system and its components.

3.3.5 Programmable Calibration Voltage Source

The TAC NEFF 620 series 500 series sub-system includes a programmable calibration voltage source in the form of an integrated EDC voltage standard model 501J, which supplies a precise voltage source for automatic calibration.

Refer to Annexure A for detailed functional and performance specifications of the EDC voltage standard model 501J.

4 Functional Requirements of New System

4.1.1 General Description

The CSIR requires that the replacement system to be fully configurable and integrate with the existing tunnel architecture. The existing sensor network should be able to integrate with the new system as well as additional transducer and sensory equipment that may be added to the tunnel suite. The new data acquisition system should allow for further expansion if required and host a wide range of transducers suitable for future wind tunnel technologies.

4.1.2 Functional Requirements

4.1.2.1 Platform and Data Communication

It is required that the replacement data acquisition system interfaces directly with a computer network (the TAC Section 3.2.2 refers). A custom communications protocol between the two is acceptable, but preferably via a high-speed non-proprietary computer bus standard (eg. Ethernet, etc) since future maintainability of the system is an important requirement and throughput of high sampled data sets. Most modern data acquisition platforms support DMA which should be considered during the contracting stage. The existing architecture does make use of existing GPIB interfaces which will require some conversion to the new communication interfaces used by the new data acquisition system.

4.1.2.2 Chassis Specifications

The system should be configured to operate within a 19-inch chassis which is mountable in the standard 19-inch server rack configuration. The installation of additional support hardware, connection interfaces and control interfaces will be handled external to the chassis. The chassis platform selected should support a high throughput and operational bandwidth which does not limit the data rate of the installed modules and restrict system performance. The selected chassis platform should be a modular platform that allows for multiple varying configurations. The chassis platform must support a timing and synchronization functionality to allow for the scaling of the system with time to maintain system performance across chassis platforms.

- The minimum internal bus bandwidth performance specification should be same or greater than 10 GB/s.
- Accommodate the card modules required from the attached specifications to allow for a one chassis type platform.
- High channel count support in the 19-inch chassis format.

4.1.2.3 Controller Module

The controller module of the DAQ system should be able to offer state-of-the-art communication interfaces for data transmission and allow for integration with the surrounding systems. The specific specifications of the controller module will be handled at the contracting stage.

4.1.2.4 Sampling Modes and Sampling Rates

The replacement DAQ must be capable of sampling data at various sampling rates ideal for modern wind tunnel testing. A minimum sampling rate per channel with a real-time throughput of data is 1 kHz to be transferred to a computer network within a 10 µs delay from the point of acquisition to it being accessible on the network for display and processing. The current NEFF system makes use of sample and hold sampling methods, thus the recommendation to move to simulations sampling methodology to have high throughput, low loss, acquisition of all signals. It is important to note that the sampling rate is only applicable to certain channels and sensor types due to operational importance during wind tunnel testing and will be specified moving forward in the document and specifications. The new system will be required to be able to acquire data continuously.

4.1.2.5 Channel Counts

At a minimum, the replacement system shall have the following channels:

- 32 channels analogue strain gauge channels at 24-bit resolution.
- 64 voltage analogue input channels (± 25 mV range to ± 10 V range) at 24-bit resolution.
- 32 TTL output channels.
- 32 isolated DC input channels.
- 16 analogue output channels.
- 32 digital input channels.
- Dedicated RTD cards of 8 total channels.

The final quantity of channels shall be chosen at the contracting stage.

4.1.2.6 Transducer Types

At a minimum, the replacement system shall be configurable to signal condition inputs to the following types of transducers:

- Strain Gauges (Full, Half and Quarter)
- Potentiometers
- Thermocouple
- Differential Voltage
- RTD

4.1.2.7 Strain gauge Channel Specifications

The strain gauge channels are critical to wind tunnel testing and are the core focus of the detailed specifications of the various channels. The following specifications serve as a guideline to the definition of the desired standard that the wind tunnel balance signals will be acquired by. At a minimum, the replacement system should be able to achieve the following for the strain gauge channels:

- Channel resolution: 24-bit resolution with resolution upscaling.
- Channel count per card will become a factor in cost vs performance which will be covered at the contracting stage.

- Type of ADC: Sigma-Delta or performance equivalent.
- Input ranges (This acts as a common range experienced and can be altered at the contracting stage):
  - ± 25 mV/V measurable range per channel or lower (This does vary depending on excitation voltage and carrier frequency amplifier requirements)
- Sampling rate:
  - Sampling rate of 10 kS/s per channel.
- Gain selection:
  - Programmable selection preferred.

The specifications for the strain gauge acquisition can be found in the following table.

Table 5-Strain Gauge channel specifications

Specification:	Strain Gauge Acquisition
Resolution (For acquisition)	24
Channels Required (Total not single card) (1 to 1 replacement)	32 [0]
Sampling Rate for card (Rough match to NEFF) [Higher better]	>50 kS/s
Sampling Rate per channel [Higher better]	>10 kS/s
Acquisition method [Fixed for performance]	Simultaneous
Accuracy Class (Lower is better)	0.05
Absolute Accuracy	Absolute accuracy heavily relies on mode and Vex
(Reading*Gain Error + Offset Error + Noise Uncertainty)	
Noise Uncertainty	3.4 - 40.5 µV/V
(3*Random Noise/√(#Samples))	
Selection (Gain, Voltage level, filters)	Programmable
Input Range (Assuming 350 Ω operation with 5 V excitation)	±25 mV, ±100 mV
Bridge Completion Supported	Quarter, Half, Full
Bridge Resistive Supported	120, 350, 1 kΩ
Excitation Ranges	1 - 10 V
Common Mode	-
Interrupt Capability (Poll rate)	-

Common Mode Voltage	± 10 V
Common Mode Rejection	120 dB
Filter Type	FIR, Butterworth or Bessel
Cut-off Range (Additional range is ideal)	2 - 2 kHz + wideband

4.1.2.8 Voltage Input Channel Specification

The voltage channels are critical to wind tunnel testing and are the core focus of the detailed specifications of the various channels. The following specifications serve as a guideline to the definition of the desired standard that the wind tunnel voltage signals will be acquired by. At a minimum, the replacement system should be able to achieve the following for the voltage channels:

- Channel resolution: 24-bit resolution with resolution upscaling.
- Channel count per card will become a factor in cost vs performance which will be covered at the contracting stage.
- Type of ADC: Sigma-Delta or performance equivalent.
- Input ranges (This acts as a common range experienced and can be altered at the contracting stage):
    - ± 25 mV/V measurable range per channel or lower (This does vary depending on excitation voltage and carrier frequency amplifier requirements)
- Sampling rate:
    - Sampling rate of 10 kS/s per channel.
- Gain selection:
    - Programmable selection preferred.

The specifications for the analog voltage acquisition can be found in the following table.

Table 6-Voltage Input channel specifications

Specification:	**Voltage Acquisition**
Resolution (For acquisition)	24
Channels Required (Total not single card) (1 to 1 replacement)	64 [64]
Sampling Rate for card (Rough match to NEFF) [Higher better]	>50 kS/s
Sampling Rate per channel [Higher better]	>10 kS/s
Acquisition method [Fixed for performance]	Simultaneous
Accuracy Class (Lower is better)	0.05
Absolute Accuracy	4362 µV

(Reading*Gain Error + Offset Error + Noise Uncertainty)	(Equation for reference)
Noise Uncertainty	19.6 µVrms (10 V)
(3*Random Noise/√(#Samples))	(Equation for reference)
Selection (Gain, Voltage level, filters)	Programmable
Input Range (Assuming 350 Ω operation with 5 V excitation)	±100 mV, ±10 V
Bridge Completion Supported	-
Bridge Resistive Supported	-
Excitation Ranges	-
Common Mode	-
Interrupt Capability (Poll rate)	-
Common Mode Voltage	± 10 V
Common Mode Rejection	120 dB
Filter Type	FIR, Butterworth or Bessel
Cut-off Range (Additional range is ideal)	2 - 2 kHz + wideband

4.1.2.9 Voltage Output channel specification

The voltage output channels are an addition to the existing system to add additional functionality to the TAC DAQ platform. The following specifications serve as a guideline to the definition of the desired standard that the wind tunnel will make use of the voltage output channels. At a minimum, the replacement system should be able to achieve the following for the voltage channels:

- Channel resolution: 16-bit resolution.
- Channel count per card will become a factor in cost vs performance which will be covered at the contracting stage.
- Output range: ± 120 VDC
- Sampling rate:
  - Sampling rate of 50 kS/s per channel.

4.1.2.10 RTD Channel Specifications

The RTD channels are critical to wind tunnel testing and are the core focus of the detailed specifications of the RTD channels. The following specifications serve as a guideline to the definition of the desired standard that the wind tunnel RTDs will be acquired by. At a minimum, the replacement system should be able to achieve the following for the voltage channels:

- Channel resolution: 24-bit resolution with resolution upscaling.
- Channel count per card will become a factor in cost vs performance which will be covered at the contracting stage.

- Type of ADC: Sigma-Delta or performance equivalent.
- Input ranges (This acts as a common range experienced and can be altered at the contracting stage):
    - 5 – 50 mA for PT100.
- Sampling rate:
    - Sampling rate of 100 S/s per channel.

The specifications for the analog voltage acquisition can be found in the following table.

Table 7-RTD channel specifications

Specification:	RTD
Resolution (For acquisition)	24
Channels Required (Total not single card) (1 to 1 replacement)	8 [4]
Sampling Rate for card (Rough match to NEFF) [Higher better]	-
Sampling Rate per channel [Higher better]	100 S/s
Acquisition method [Fixed for performance]	Simultaneous
Accuracy Class (Lower is better)	0.05
Absolute Accuracy	-
(Reading*Gain Error + Offset Error + Noise Uncertainty)	-
Noise Uncertainty	-
(3*Random Noise/√(#Samples))	-
Selection (Gain, Voltage level, filters)	Programmable
Input Range (Assuming 350 Ω operation with 5 V excitation)	5-50 mA for PT100
Bridge Completion Supported	-
Bridge Resistive Supported	-
Excitation Ranges	-
Common Mode	-
Interrupt Capability (Poll rate)	-
Common Mode Voltage	10 VDC
Common Mode Rejection	120 dB
Filter Type	FIR, Butterworth or Bessel
Cut-off Range (Additional range is ideal)	1 - 500 Hz + Wideband

4.1.2.11 Digital Input Channel Specifications

The digital input channels are critical to wind tunnel testing and are used for certain control and monitoring applications. The following specifications serve as a guideline to the definition of the desired standard that the wind tunnel digital input channel signals. At a minimum, the replacement system should be able to achieve the following for the digital input channels:

- Channel resolution: 2x 16-bit word resolution.
- Channel count per card will become a factor in cost vs performance which will be covered at the contracting stage.
- Type of ADC: Sigma-Delta or performance equivalent.
- Input ranges: Digital logic (0 – 5 V)
- Sampling rate:
  - Sampling rate of 1 kS/s per channel.
- Common Mode rejection: 1000 V

The specifications for the digital input acquisition can be found in the following table.

Table 8-Digital Input channel specifications

Specification:	Digital Input
Resolution (For acquisition)	2x 16-bit word
Channels Required (Total not single card) (1 to 1 replacement)	32 [32]
Selection (Gain, Voltage level, filters)	Programmable
Input Range (Assuming 350 Ω operation with 5 V excitation)	0-5 V
Common Mode	1000 V
Interrupt Capability (Poll rate)	1 kHz

4.1.2.12 Calibration

It is a requirement that the replacement DAQ can be calibrated as a standalone system, using a secondary voltage/calibration standard. The MSWT currently utilises custom-written calibration software to calibrate the NEFF 620 series (which acts as an analogue-to-digital voltage converter) by applying a known voltage from the voltage standard to each signal channel in turn, and comparing the measured output.

The replacement system shall have similar auto-calibration functionality and use propriety software to achieve this.

The NEFF 620 series currently uses an EDC voltage standard model 501J, which is available for integration with the new system. Alternatively, a replacement voltage standard can be specified, on condition that the replacement voltage standard can be calibrated periodically by a SANAS accredited institution in South Africa.

4.1.2.13 Maintenance Software

The replacement system shall have self-diagnostic and maintenance software functionality.

4.1.3 Performance Requirements – Data Acquisition

The replacement system shall have data acquisition performance characteristics at least equivalent to the performance characteristics of the NEFF 620 series 100 series amplifier/multiplexer sub-system in terms of system gain, accuracy, stability, linearity, noise, resolution, and throughput rate.

Section 3.1.3 of Annexure A lists the quantitative values for these performance characteristics, as supplied by NEFF instrument corporation.

4.1.4 Performance Requirements – Signal Conditioning

The replacement system shall have signal conditioning performance characteristics at least equivalent to the performance characteristics of the NEFF 620 series 300 series signal conditioner sub-system in terms of output voltage, output current, output impedance, response time, line regulation, ripple and line stability.

Sections 3.16.3 and 3.16.4 of Annexure A lists the quantitative values for these performance characteristics, as supplied by Neff Instrument Corporation

4.1.5 Integration Requirements

4.1.5.1 General

The CSIR (MSWT) requires a turnkey solution, which includes the integration of all hardware and software into the MSWT with mutually agreed upon acceptance testing procedures, as well as the de-commissioning of the existing Neff 620 series.

4.1.5.2 Power cables:

Power cables are to be routed in a similar fashion as is current. If situated in the MSWT control room, use can be made of existing power cabling. Wiring shall conform to the applicable South African Bureau of Standards publication #SABS 0142. Supply power skirts in Consoles 20 and 21 are to remain as is currently implemented.

4.1.5.3 Electrical Workmanship

Wire, cable, conduit, and junction boxes shall conform to the applicable South African Bureau of Standards publication #SABS 0142.

4.1.5.4 Wiring Systems

Care shall be exercised while installing wires and cables so as not to damage conductors, insulation, or shielding. The ends of wires with integral insulation shall be stripped to expose the conductor. The conductor shall not have loose, cut, or nicked strands. The insulation shall not be torn or frayed. Stripping shall be accomplished with a suitable commercial stripping tool employing a method to control the depth of cut in relation to the wire size.

All cable shall be identified at each end with a cable number. Identification shall be made using heat shrinkable tubing with pre-typed number or stick-on labels covered by clear heat shrinkable tubing. Handwritten marks shall not be permitted. Cables shall be identified in all junction boxes. Where connections are made to numbered terminals on terminal strips, the identification shall consist of the terminal number, and strip numbers, for example: TB1-1. Where connections are made to numbered or lettered terminals on equipment, such as switches, relays, etc., the identification shall consist of the equipment number and terminal letter of number, for example: 2A-1. In the case of the short jumpers, both ends shall be identified by the one marker, for example: 2A-6/2A-2. Where connections are made to connectors on equipment, the connector end identification shall consist of the equipment number, for example: 2A.

Termination of all conductors on screw-type terminals shall be made with slotted tongue (spade) pre-insulated lugs (T & B forked type, insulated sleeve Sta-Kons) of the proper size for the wire and binding screw used. Lugs shall be securely crimped to the conductor using the tool and techniques recommended by the manufacture of the lugs. All conductors terminating in crimp-type terminals shall be properly tinned to prevent deformation of the strands of the conductor. All wiring in terminal boxes shall be neatly arranged using cable ties.

All cables shall be terminated only at terminal blocks or directly on an end device. Splices in junction boxes, equipment enclosures, fittings, and conduits shall not be permitted.

For solder termination the wires shall be stripped to a length that will permit the wire to bottom in the solder pot and the end of the insulation shall clear the top of the solder pot by approximately 1.5mm. The conductor may be pre-tinned by dip solder technique. The insulation shall not be distorted because of the tinning operation. Termination of conductors on solder terminals and/or connectors shall use solder approximately 60 percent tin and 40 percent lead with a melting point approximately 180^{o}C. The use of lead-free solder is permitted provided the alloy used is not susceptible or prone to corrosion or oxidation. The type of solder used must be made known. Prior to soldering all surface impurities shall be cleaned from the soldered connections and electronic components by applying ethyl alcohol with a small stiff brush. All excessive rosin shall be cleaned from the soldered connection in the same manner. Equipment shall be free from all superfluous solder. Care shall be exercised not to allow cleaning solution to contact insulating materials. The parts to be joined shall be held together in such a manner that the parts shall not move in relation to each other during the soldering operation. The joint shall not be disturbed until the solder has solidified completely. For solder pot terminations, the pots shall be filled to a point even with the top without crevices, pits or bubbles. At the top, the solder shall not be drawn under the insulation by capillary action. Solder shall show the contour of the wire and terminal. Edges shall feather out on all surfaces. Only that area of the terminal which is closely associated with the wire shall be covered with solder. Joints with large beads, fillets, or excess solder will not be acceptable. Wires or parts showing burned, scorched, or frayed insulation will not be acceptable. Excessive heat shall be avoided when surface preheating is required. Solder shall be completed as soon as possible after heat is applied. Heat sinks to protect temperature sensitive components shall be used as required. Wire insulation shall not be embedded in the solder joint. Cold solder and rosin solder will not be acceptable. The CSIR (MSWT) will not permit the cooling of solder joints by quenching with liquids or blowing on joints. Soldering may not be used in lieu of crimped lugs.

4.1.5.5 Noise

The noise levels in the replacement system are to be no worse than the current noise levels.

4.1.5.6 Operational Environment

The CSIR (MSWT) envisages that the new system will be installed in the MSWT in a temperature-controlled room with a cooling capacity of 82 W on board per card and will be maintained at an operating temperature to accommodate for that amount of cooling. A section will be cornered off and create a controlled environment with its own HVAC unit responsible for cooling the environment. This system will be expected to run with minimal down time to ensure that the operating DAQ system is cooled to meet the supplier specifications. Alternative venues for installation shall be mutually agreed upon by the supplier and the CSIR (MSWT).

4.1.5.7 Power Supply

Electrical installation and power: power requirements within the capacity of the existing electrical supply in the MSWT control room.

4.1.5.8 Trunking and Concealment

All signal wiring shall be insulated and routed in such a manner such that it is concealed at all times. The necessary trunking shall be installed. The existing trunking may also be re-used. All signal wiring must be accessible for maintenance, troubleshooting and upgrades.

4.1.5.9 EMI

The EMI shall not exceed the current EMI levels in the system. The CSIR (MSWT) will not allow RF emission from equipment. EMI filter banks will be installed to support power lines and some high voltage channels of the DAQ system to reduce ambient noise and culprits are to be isolated with standard EMI reduction procedures.

4.1.6 Updating of Drawings

The MSWT drawings shall be updated and/or created with new cable schedules and routings required by the replacement system. This specifically includes the installation and connection of new terminal blocks.

5 HEALTH AND SAFETY

All operations shall adhere to government legislation. All testing shall be performed in a manner such that no damage can occur to equipment, or in such a controlled manner that systems can be prevented from being damaged.

6 ACCEPTANCE

6.1 Design acceptance

The design shall only be accepted after

- Appropriate design reviews (these design reviews are to be scheduled upon mutual agreement between the supplier and the CSIR(MSWT))
- Maintenance requirements review
- Supplier demonstration that the proposed system shall meet the requirements as specified in this URS

6.2 Product hardware acceptance

The system shall only be accepted after

- Design acceptance for which a mutually agreed acceptance test procedure shall be drawn up
- Manufacturing reviews if required
- Installation reviews
- Successful offline testing and performance.
- Successful tunnel running performance. A mutually acceptable acceptance test procedure shall be drawn up.
- Completion and delivery of documentation and drawings

7 Logistic Requirements

7.1 Installation

The timing of installation of the replacement system shall be mutually agreed upon. Due to the criticality of the system for the operations of the facility, strict schedules will be demanded. The installation of the system, including testing, shall thus be performed in one schedule slot.

7.2 Logistic support concept

This is client defined and customised. The intention is to minimise support, however.

7.3 Logistic support plan

This shall be defined by the CSIR (MSWT) and is not required to be met by the supplier.

7.4 Support

This shall be performed in conjunction with the supplier, their subcontractors and the CSIR (MSWT) on a mutually agreed upon basis.

7.5 Configuration management

All drawings, code and documents shall be identified with a mutually agreed identification system. Additionally it is required that the supplier (and their sub-contractors) implement a configuration management system for all work performed.

7.6 Documentation

All drawings, code and documentation shall be delivered to the CSIR (MSWT). For code in particular, the code shall be in such a form that upgrades can be easily performed, and control algorithms be replaced should this be required. The supplier shall update all existing drawings, with updates corresponding to the new system.

All setup parameters (such as control gains, jump switches etc) must be documented and made available as part of the operational documentation of the system.

Sufficient documentation (including software code) shall be delivered to the CSIR (MSWT)) in mutually acceptable formats for MSWT personnel to perform all maintenance (except as limited by off-the-shelf third party equipment) and for subsequent upgrades.

At minimum, the CSIR (MSWT) requires the following documentation:

- Updated wiring diagrams and numbering (i.e. updated MSWT drawings)
- Recommended maintenance schedules
- All system setup parameters
- Operators manual
- Programmers reference manuals

- Maintenance procedures
- All relevant work documentation sufficient for trouble shooting and re-creation of the system, should the documentation be accidentally destroyed at the supplier and any of its sub-contractors.
- Critical spares list (see below)

7.7 Spares

The supplier shall include a list of recommended critical spares required to ensure system availability as part of the submitted documentation. This documentation shall detail part numbers, current cost, lead-time, and whether the part is imported/locally available in South Africa. The CSIR (MSWT) and the supplier shall mutually agree to a suite of spares, which shall be delivered, with the system.

7.8 Personnel

Limited engineering and technician support will be available, though these will be at the discretion of the CSIR (MSWT).

7.9 Training

Those involved and responsible for the DAQ system will be trained on the operational use of the proposed system.

7.10 Training equipment

The supplier shall provide any training equipment for the training of the resposible personal as part of the deliverable.

8 Maintenance

The system shall be designed to require minimal maintenance. The only physical maintenance envisaged is routine external component dust removal in line with existing practices.

The system shall include maintenance software with self-diagnostic routines.

8.1.1 Long-term maintenance and obsolescence

When selecting the system, long term (10 years plus) maintenance and OEM support will be a decisive factor. A long-term maintenance plan to avoid obsolescence of any components shall be requested. A demonstrated track record of supporting existing product-lines over a long period shall also be requested.

9 Coding standards

The following coding standards must be adhered to:

- All files must contain a comment header that contain the following
    - File/Module name
    - Description (of the files contents/module)
    - Usage (how the file/module can be used by calling modules)
    - Remarks
    - Current version and date
    - Version history (including dates, reasons for changes and coder)
- It is preferable that a single operating system file be used for each module
- No specific language coding styles are mandated, except that the convention that is used is strictly abided by for all code. The supplier must define the coding convention for all programming languages used before any coding commences.

10 Progress Reviews

The following minimum progress reviews shall be held:

- Design review
- Installation review
- Documentation review

Additionally, the CSIR (MSWT) and the supplier shall define a mutually agreed upon review schedule.

11 General Conditions

All work performed by the supplier and it sub-contractors remains the property of the CSIR, except where mutually agreed upon. Destruction of any work relating to the system shall only be at the permission of the Facility Manager of the MSWT.

11.1 Warrantees

This shall be mutually agreed upon, though any warrantees as provided by sub-contractors or off-the-shelf equipment shall remain in force.

12 System Security

All work performed by the supplier and its sub-contractors shall remain confidential. Destruction of all work relating to this system as performed by the supplier and its sub-contractors shall be performed at the request of the CSIR (MSWT).

13 De-Commissioning

The procedure for the de-commissioning of existing NEFF 620 series components is to be considered, planned, approved and documented for final de-commissioning. It may be decided that the existing system remains installed and ready for an emergency event. This procedure is to be drawn up in conjunction with the CSIR (MSWT).