



**SPECIFICATION FOR UHF LINK
RADIO EQUIPMENT**

OCTOBER 2006.

Revision 3.00

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DOCUMENT AUTHORISATION

FUNCTION	NAME	TITLE & DIVISION	SIGNATURE	DATE
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I DISTRIBUTION

Once updated, a copy of the latest revision will be published in the document management system in use. E-mail to this effect will be sent to the relevant personnel or heads of department

II DOCUMENT CHANGE HISTORY

ISSUE NO.	DATE ISSUED	ISSUED BY	HISTORY DESCRIPTION
1.00	August 2005	Transmission Engineering	New document
2.00	October 2006	Transmission Engineering	Converted to ISO 900 Standard

III CHANGES SINCE LAST REVISION

CLAUSES	DESCRIPTION
All clauses	Converted to ISO standard
	Additions/changes and upgrades to the existing specifications to allow the unit to be more universal

IV ABBREVIATIONS, ACRONYMS AND DEFINITIONS

ABBREVIATIONS AND ACRONYMS	DESCRIPTION
FM	Frequency Modulation
CD	Compact Disk
Hz	Hertz
ISO	International Standards Organization
LED	Light Emitting Diode
DC	Direct Current
dB(W)	decibel relative to Watts
AC	Alternating Current
dB	decibel
dB(C)	decibel relative to the carrier
kHz	Kilohertz
MHz	Megahertz
Pd	Power density
RF	Radio Frequency
SANS	South African National Standard
SWVR	Standing Wave Ratio
Tx	Transmit
UHF	Ultra High Frequency

V RELEVANT DOCUMENTATION

DOCUMENT NO.	DESCRIPTION	LOCATION
ISO 9000	Quality Management Systems	External
BS 3939 Graphic symbol for Electrical Power	Telecommunications and Electronic Diagrams	External
SPC-00846	Two-Way Mobile Radio communication Equipment (Old number SCEH-54)	Document Control Centre
SANS 10313	Protection of dwelling houses against lightning. External	External
SANS 61643-1	Surge arrestors for low voltage distribution systems.	External
SPC-00851	Old specification No. SCEH-59 Document	Control Centre

1. SCOPE

This specification covers the requirements of Transnet Freight Rail for the supply of a radio repeater station, operating in the UHF frequency band with 12, 5 kHz channel spacing. The radio would be used to link several radio repeaters to provide wide area radio coverage.

2. COMPLIANCE

- 2.1 Tenderers must submit their main offers in terms of this specification, and must indicate in their document of "COMPLIANCE" to this specification whether their offer is fully in COMPLIANCE with this specification or not. Where additional information must be furnished by the tenderer, this may be given on a separate sheet attached to the statement of COMPLIANCE, with the page and paragraph number of the additional information given together with a "YES" or "NO" in the COMPLIANCE" column of this specification; which will then form the STATEMENT OF COMPLIANCE.
- 2.2 Offers, which include deviations of a minor nature, not departing greatly from the specification, will be considered at the discretion of Transnet Freight Rail
- 2.3 Tenderers may offer alternatives for consideration. Alternative offers are to be reflected on a separate schedule and the following particulars are to be provided
- 2.3.1 A fully detailed technical description in English explaining the functioning of the individual components, the operation of the items of equipment as well as the procedure to be followed in clearing faults and maintenance.
- 2.3.2 Drawings and brochures supporting the offer.
- 2.3.3 Details of deviations from the specifications of Transnet.
- 2.3.4 The values of imported and local components of complete items are to be stated separately.

3. SERVICE CONDITIONS

- 3.1 The equipment must be suitable for continuous operation under the following conditions:
- Altitude: 0 to 1 800 metres above sea level.
 - Ambient temperatures: Minus 10 °C to plus 60 °C
 - Air pollution: Heavily saline laden industrial and locomotive fumes
 - Relative humidity: As high as 95%.
 - Lightning: Severe
- 3.2 All component parts, including wiring, etc. must be manufactured and processed to ensure reliable operation under continuous operation.

4. SCHEDULE OF REQUIREMENTS

- 4.1 Where only equipment in terms of this specification is required by Transnet Freight Rail, a SCHEDULE OF REQUIREMENTS will accompany this specification. Where a system, including other equipment, is to be supplied, a main specification will be included in the tender document together with a Schedule of Requirements for all the equipment.
- 4.2 The equipment required is listed in the Schedule of Requirements. The equipment must comply with the details therein, in addition to the requirements of the relevant clauses of this specification.
- 4.3 The tenderers statement of compliance as per clause 2 must also cover the relevant clause of the SCHEDULE OF REQUIREMENTS.

5. LINK RADIO

5.1 General Requirements

- 5.1.1 The radio link equipment must comprise of a transmitter, receiver, associated electronic equipment, internal duplexer and 4-wire E&M 600 ohm audio interface
- 5.1.2 The equipment must be designed and rated for continuous transmission duty.
- 5.1.3 An engineering panel must be provided for local control and testing of the Link Radio. Facilities to key the transmitter and monitor received audio must be included. A monitor loudspeaker with volume control must be provided. A handset with a dynamic microphone must be provided as part of the engineering panel for speech transmission from the link radio.
- 5.1.4 Pre-emphasis of 6 dB per octave must be used in the transmitter with de-emphasis in the receiver. Provision must be made to switch to flat frequency response.
- 5.1.5 The equipment must be suitable for operating in frequency bands using 12, 5 kHz channel spacing.
- 5.1.6 The equipment must be supplied complete for operation in the frequency band specified in the SCHEDULE OF REQUIREMENTS.
- 5.1.7 The link radio must be a full duplex radio. When simplex or half duplex operation is required, it would be as indicated in the SCHEDULE OF REQUIREMENTS.
- 5.1.8 The equipment must be 19" rack mountable. Tenderers must submit alternative sizes offered.

- 5.1.9 The successful tenderer will be advised of the actual frequencies once the order has been placed.
- 5.1.10 The Link Radio must be suitable for transmitting and receiving on a single antenna.
- 5.1.11 The equipment must be able to operate in the following DC voltage ranges without degrading the performance. The operating voltage and negative or positive earth of the equipment shall be as indicated in the Schedule of Requirements.

- For a 12 volt system: Nominal operating voltage 13, 8 volt.
- Operating range 10, 8 volt to 15, 6 volt.
- For a 24 volt system: Nominal operating voltage 27, 6 volt.
- Operating range 21, 6 volt to 30, 5 volt.
- For a 48 volt system: Nominal operating voltage 53, 5 volt.
- Operating range 43, 2 volt to 56, 8 volt.

5.1.12 Tenderers must guarantee that there will be no cross-coupling or any other degradation in radio equipment performance due to a common battery and charger combination being used to supply the link radio.

5.1.13 The equipment must be of fully solid-state design.

5.1.14 Tenderers are to submit their recommendations for earthing of the equipment.

5.1.15 All the miscellaneous items such as plugs, connectors and cables, necessary for a complete installation, must be supplied with the equipment.

5.1.16 The RF switching bandwidth of the equipment offered must be 10 MHz without degradation in transmitter or receiver performance. The tenderer must state the degradation in receiver sensitivity, transmitter power and any other parameter for switching between channels, 10 MHz apart.

5.1.17 The transmitter circuitry must incorporate protective devices to protect the output circuitry when the transmitter is operated with the antenna open circuit or, short-circuit, or for any excessive VOLTAGE, STANDING WAVE RATIO on the antenna feeder cable.

- 5.1.18 The link radio must be provided with standard multipin sockets and plugs for the easy interconnection of control consoles, carrier circuits, batteries and any other devices stated in the SCHEDULE OF REQUIREMENTS.
- 5.1.19 Tenderers must state the DC current consumption at the nominal operating voltage of all equipment offered under transmit, receive and stand-by conditions.
- 5.1.20 The parameters for the transmitter, receiver, talk through signal level and duplexer must be measured according to Standard SPC-01274.
- 5.2 The parameters for the transmitter, receiver, talk through signal level and duplexer must be measured according to Standard SPC-01274.
- 5.3 Transmitter**
- 5.3.1 The Transmitter RF power output must be adjustable. The adjustable range must be as indicated in the SCHEDULE OF REQUIREMENTS.
- 5.3.2 The conducted spurious emissions must not exceed a level of operating = -36 dBm; standby -57 dBm
- 5.3.3 When provision must be made for an audio input (from external interfaced equipment) to the transmitter, the audio frequency response, measured at the transmit must be within -1 to +3 dB of a true 6 dB per octave pre-emphasis characteristic between 300 and 3 000 Hz (reference level 0 dB at 1 000 Hz).
- 5.3.4 The audio frequency harmonic distortion must be less than 2% at a modulating frequency of 1 000 Hz and a modulation factor of 60% of maximum rated system deviation.
- 5.3.5 The FM hum and noise ratio must be greater than 34 dB.
- 5.3.6 The frequency deviation corresponding to 100% modulation at 1 000 Hz, must approach but not exceed 2, 5 kHz.
- 5.3.7 The transmitter circuitry must incorporate protective devices to protect the output circuitry when the transmitter is operated with the antenna open circuit or, short-circuit, or for any excessive voltage, standing wave ratio on the antenna feeder cable.
- 5.3.8 The measured and calculated AM hum and noise level must be less than -34 dB.
- 5.3.9 The carrier frequency error must not be greater than 1, 0 kHz.

- 5.3.10 The power measured at the adjacent channels must be < -70 dBc .
- 5.3.11 The intermodulation attenuation must be $=40$ Db

5.4 Receiver

- 5.4.1 The minimum usable sensitivity for a 12 dB Sinad ratio must be -116 dBm (Pd) or better, without the duplexer.
- 5.4.2 The receiver must be provided with an electronic squelch control the sensitivity of which must be adjustable via the front panel. The hysteresis of the opening and closing threshold levels must not be greater than 3 dB
- 5.4.3 The following parameters must be measured according Standard SPC-01274.

5.5 The following parameters must be measured according Standard SPC-01274.

- 5.5.1 The adjacent channel selectivity and desensitisation ratio must be greater than 70 dB
 - 5.5.1.1 The spurious response attenuation must not be less than 75 dB
 - 5.5.1.2 The intermodulation spurious response attenuation must be not less than 70 dB for a wanted input signal of a level equivalent to usable sensitivity.

- 5.5.2 The audio power output into the built-in monitor loudspeaker must be at least 2 watts at less than 5% total harmonic distortion
- 5.5.3 When provision must be made for an audio output (to external interfaced equipment) from the receiver, the audio frequency response must be within ± 3 dB of true 6 dB per octave de-emphasis characteristic from 300 Hz to 3 000 Hz is applied to the receiver. It will be stated in the Schedule of Requirements if an audio output is required.
- 5.5.4 The frequency stability must be at least $\pm 0, 0005\%$ over the temperature range of -10 °C to $+60$ °C (reference temperature $+25$ °C).
- 5.5.5 The modulation acceptance bandwidth must not be less than 3, 75 kHz
- 5.5.6 The signal to hum and noise ratio must be at least 60 dB in the case of a squelched receiver, and 39 dB in the case of an unsquelched receiver.
- 5.5.7 Tenderers must state what protection will be provided, and what maximum signals the receiver will be protected against without damage.
- 5.5.8 The selectivity of the receiver must not degrade when a high RF signal, in the operating band is applied to the receiver. This must apply for signal levels up to -70 dBm .
- 5.5.9 The co-channel rejection ratio must not exceed 12 dB

5.6 Through Signals

- 5.6.1 Audio frequency response. The de-modulated audio level measured at the transmitter must not vary with more than 3,0 dB from a standard RF signal input with a constant modulation factor of 60% of maximum rated system deviation, at the receiver. The modulating frequency must be varied over the frequency range 300 Hz to 3 000 Hz. Standard RF input signal level is -60 dBm.
- 5.6.2 Modulation factor. The modulation factor measured at the transmitter must not vary with more than 0, 1 kHz from a standard RF signal input with a modulation factor varying from 20% to 100% of maximum rated system deviation, at the receiver. The modulating frequency must be 1 000 Hz. Standard RF input signal level is -60 dBm.

- 5.6.3 Response time. The transmit carrier voltage level must reach a value 6 dB below the steady-state value within 300 ms after the receiver received an RF signal which is 12 dB above the usable sensitivity level.

5.7 Antenna Duplexer

- 5.7.1 The repeater equipment must be supplied complete with internal antenna duplexer to obviate the use of two antennas
- 5.7.2 The duplexer must provide at least 80 dB isolation between transmitter output and receiver input to ensure that the receiver performance is not degraded when the equipment is operated in the duplex mode. The tenderer must submit response curves of the antenna duplexer offered and must state the insertion loss in the transmit and receive paths
- 5.7.3 The antenna duplexer must be capable of handling the transmitter radio frequency power output over a temperature range of -10 °C to +60 °C.
- 5.7.4 The VOLTAGE STANDING WAVE RATIO must not exceed 1, 5:1.
- 5.7.5 The insertion loss must not exceed 1, 2 dB in both the transmit and receive paths.
- 5.7.6 The tenderer must state the "drift" in the tuning, over the temperature range of -10 °C to +60 °C

5.8 4-Wire E&M Audio Interface

- 5.8.1 Audio In:

The Input level shall be -10 dBm referenced to a modulation factor of 60%.

- 5.8.2 Audio Out:

The Output level must be -10 dBm referenced to a modulation factor of 60%.

- 5.8.3 M-lead control signal:

Upon the Receiver squelch being activated (RX-gate), the link radio shall ensure that M-port is presented with an output state of "low" which could be used to control the external device interfaced to the link radio. The M-lead output state level or voltage must be as indicated in the SCHEDULE OF REQUIREMENTS.

- 5.8.4 E-lead control signal

When an input level state of "high" is presented at the E-lead port, the signal shall be used to key in the Transmitter. The E-lead input state level or voltage must be as indicated in the SCHEDULE OF REQUIREMENTS.

5.8.5 Provision must be made for allowing the E-lead and M-lead states to be swapped (e.g. selecting E-lead to be either "low" or "high" and M-lead to be either "low" or "high") Default states must be as indicated in the subclauses 5.8.3 and 5.8.4.

5.8.6 The interface connector shall be a RS232 DB15 Female connector.

6. QUALITY OF MATERIALS

- 6.1 Preference will be given to manufacturers who guarantee that they comply with the provisions of the code of practice for quality management systems as set out in ISO 9000.
- 6.2 Tenderers must note that the technical personnel of Transnet will carry out inspections to determine whether the code of practice has been adhered to
- 6.3 Tenderers must submit details of procedures they intend to adopt to comply with SO 9000.
- 6.4 Materials which may, under the influence of heat, light or pressure, decompose or liberate elements or compounds likely to corrode or affect other materials or cause electrolytic corrosion will not be acceptable.
- 6.5 Mounting screws, where used, must not be self-tapping. Bushes and threaded inserts must be used.
- 6.6 All covers, jacks, sockets etc. must be provided with adequate seals
- 6.7 Indication lamps must be rated for reliable long life and must be protected against surges where necessary. Pilot indicator lamps must be light emitting diode (LED) types.
- 6.8 Printed circuit boards must be of epoxy glass fibre laminate or better. Phenolic paper or bakelised paper boards are not acceptable.
- 6.9 Printed circuit boards must be properly washed and, if necessary, neutralised after the etching process so that no hygroscopic crystals remain in the board or printed wiring.
- 6.10 Printed circuit boards must be guaranteed not to promote or permit the growth of fungi under any conditions.

- 6.11 Printed circuit boards must be fitted with robust plugs and sockets or another approved manner of connecting the boards reliably to the wiring. Edge connectors may be used provided that:
- 6.11.1 A suitable tolerance for the correct fitting of the board between guides and the wiring socket can be guaranteed
 - 6.11.2 Sufficient contact area is provided to guarantee reliable contact.
 - 6.11.3 Sufficient contact pressure is provided to ensure contact but not to remove precious metal from the contacts.
 - 6.11.4 In the final protective coating of the boards, no varnish or other protective material is permitted to cover the contacts.
 - 6.11.5 After 500 insertions and withdrawals, there must be no noticeable deterioration of the contacts of either the board or socket
- 6.12 All printed circuit board sockets, plugs or edge connectors must be gold plated or better.
- 6.13 Heavy components must not be mounted on printed wiring boards unless it can be guaranteed that the board will stand up to severe handling without fracturing with the components so mounted.
- 6.14 No unmarked and/or untested components may be used.
- 6.15 Only new components must be used.
- 6.16 All subassemblies and printed circuit boards must be permanently marked with an identification code.
- 6.17 Test points must be provided on all units, subunits and printed circuit boards for the measurement of all important circuit characteristics without the unsoldering of wires. Such test points must be clearly marked and identified in the equipment.
- 6.18 All wiring and terminations between subassemblies must be identified.
- 6.19 No printed circuit board must have terminations to points other than the edge of the printed circuit board.
- 6.20 No termination must have more than one conductor per solder joint.
- 6.21 Soldering direct to the chassis of any equipment will not be permitted. All chassis terminations must be made with soldering tags.
- 6.22 All pre-set variable controls must be clearly marked and readily identified in the equipment.

- 6.23 Terminations on printed circuit boards must not be made direct to the printed wiring. Where edge connectors are not used, termination to printed wiring must be made via terminal posts.
- 6.24 Where different metals are used in conjunction with each other, tenderers must explicitly guarantee that no electrolytic corrosion shall occur under operating conditions.
- 6.25 The equipment must be solid state throughout.
- 6.26 All components used must be types that can be readily obtained from local stocks.
- 6.27 The equipment must be built in such a manner that faulty modules can be easily and quickly detected, removed and replaced, but steps must be taken to minimise unnecessary movement of plug-in modules on a trial and error basis when locating faults.
- 6.28 Solid-state devices are to be so constructed that they may be easily tested for correct functioning without having to disturb wiring.
- 6.29 The number of component types must be kept to a minimum consistent with good design of the equipment.
- 6.30 Solid-state boards must be provided on a plug-in or other approved basis so that they can, when necessary, be readily removed for repairs.
- 6.31 Full details of the types of lamps and lenses offered must be furnished with the tender.
- 6.32 The functions of all controls, switches, etc. must be clearly engraved or otherwise permanently marked in English, or by means of approved symbols
- 6.33 All components must be suitably rated for the function they have to perform without interference to neighbouring material.
- 6.34 Resistors and restive components must not rise in temperature so that mounting boards or markings thereon are burnt or discoloured
- 6.35 Fuses must be rated to give adequate protection to the circuit served while rupturing prematurely
- 6.36 The equipment lay-out must be planned to facilitate fault clearance and maintenance.
- 6.37 All components must be clearly marked and must be capable of easy reference to circuit diagrams and handbooks to be supplied with the equipment
- 6.38 Equipment using plug-in modules must be fitted with guides for the insertion of modules. It must not be possible to incorrectly insert a module.

7. ACCEPTANCE TESTS

- 7.1** Transnet Freight Rail will conduct acceptance tests on the equipment. The equipment will not be accepted nor payment authorised until these tests have been completed and it has been confirmed that the equipment supplied is fully in accordance with the requirements of this specification and/or the stated claims of the tenderer as accepted by Transnet Freight Rail.
- 7.2 The successful tenderer must agree to rectify any defects at no cost to Transnet Freight Rail, where the equipment does not meet the tender requirements and/or the stated claims of compliance.

8. MAINTENANCE AND SERVICE

- 8.1 The tenderer must give full particulars of the maintenance, spare parts and service facilities which will be available in the Republic of South Africa. The names and addresses of the companies concerned must be furnished.
- 8.2 The tenderer must list the major centres where maintenance facilities can be provided and must state if repairs under guarantee can be undertaken at these centres.
- 8.3 Tenderers must state what provision will be made to ensure an adequate supply of locally available spare components for a period of 10 years after the order is placed.
- 8.4 Transnet will not consider tenders from tenderers who cannot provide an efficient spares and maintenance service. Tenderers must state whether they are prepared to agree to an inspection of their maintenance premises by the engineering personnel of Transnet Freight Rail

9. TECHNICAL HANDBOOKS

- 9.1** Technical handbooks must be clearly and professionally printed in English on quality paper. Photostat copies will not be acceptable unless it simulates professional printing quality and in colour where applicable.
- 9.2 The technical handbooks must be packed with the equipment.
- 9.3 Each set of handbooks must include the following:
- 9.3.1 Operating instructions.
 - 9.3.2 Complete maintenance instructions.

- 9.3.3 Complete and detailed alignment procedures in a proven and easy to follow order.
- 9.3.4 A detailed technical description of the equipment.
- 9.3.5 Complete circuit diagrams, drawings and photographs of the equipment. The photographs and drawings must clearly indicate component and module location in the equipment. All component numbers must be clearly indicated.
- 9.3.6 A list of parts, giving the values of all components, i.e. resistive, capacitive, inductive, integrated circuit and semi-conductor numbers for each schematic, drawing.
- 9.3.7 Detailed printed circuit board wiring diagrams showing component numbers and positions and the wiring itself. Multilayer board wiring must be shown to include all layers of printed wiring clearly and discernible.
- 9.3.8 Voltage levels, current values and test points, clearly indicated on circuit diagrams and printed circuit board layouts.
- 9.3.9 Complete circuit diagrams of all individual modules.
- 9.4 All symbols and notations used on drawings and circuit diagrams preferably comply with the requirements laid down in BS 3939. Where symbols and notations do not comply with these requirements, each drawing shall be accompanied by a legend clearly detailing BS 3939 equivalents.
- 9.5 No hand-written notes and numbers must appear in a handbook supplied by a tenderer. All writing must be of proper printed form.
- 9.6 Transnet Freight Rail reserves the right to reproduce in whole or in part, by any means whatsoever, any technical handbook or instruction manual supplied by the successful Contractor. Any such reproductions will be for the sole use of Transnet Freight Rail
- 9.7 A copy of the entire technical manual must be available on CD.

10. GENERAL

The tenderer must submit technical specification pamphlets and schematic diagrams covering the equipment offered. Photographs and complete drawings clearly displaying the external dimensions and physical appearance of the equipment must also be submitted with the tender.

11. ALARMS

11.1 Provision must be made for the monitoring of the following alarms:

- Transmitter alarms.
- 1 Tx VSWR alarm.
- 2 Tx Low Power alarm.
- Power Supply Alarms:

1 Mains failure.

2 Battery low (in the event of a power supply/battery charger).

3 Supply voltage low.

11.2 Alarms to be made available by means of polarity free closed contact.

12. POWER SUPPLY

Should the equipment be supplied with a mains power supply/charger, the battery charging circuit must be provided with load shed. The load-shed threshold must be adjustable.

END OF DOCUMENT