

Reporting the Quality of Communications in Underground Mines

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Effective communication is critical in a mine emergency. The transmission of information so that the recipient understands what the sender intends can mean the difference between life and death. As work progresses on developing improved mine communication systems a means for comparative evaluation of various systems is needed.

While the modes of communications being reviewed are predominately wireless two-way voice there are also those working on seismic systems that involve detection of sonic pulses. A system of reporting on the effectiveness that addresses multiple modes would benefit those comparing the results of testing. It is proposed that testing adopt the American Radio Relay League's (ARRL) Signal strength, Interference, Overall quality (SIO) reporting system which is commonly used by amateur radio operators and shortwave listeners to describe reception quality.

Accepted Reception Reporting Systems

The RST (Readability-Strength-Tone) system of reporting goes back to 1934. The S-meter name was derived from the S in RST. A reading between S1 and S9, on a well-calibrated meter can provide a reasonable indication of signal strength that parallels the original RST system.

The RST system as updated in 1995 (<http://www.arrl.org/FandES/field/forms/fsd220.pdf>)

Readability:

1. Unreadable.
2. Barely readable, occasional words distinguishable.
3. Readable with considerable difficulty.
4. Readable with practically no difficulty.
5. Perfectly readable.

Signal Strength:

1. Faint signals, barely perceptible.
2. Very weak signals.
3. Weak signals.
4. Fair signals.
5. Fairly good signals.
6. Good signals.
7. Moderately strong signals.
8. Strong signals.
9. Extremely strong signals.

Tone:

1. Sixty cycle a.c. or less, very rough and broad.
2. Very rough a.c., very harsh and broad.
3. Rough a.c. tone, rectified but not filtered.
4. Rough note, some trace of filtering.
5. Filtered rectified a.c. but strongly ripple-modulated.
6. Filtered tone, definite trace of ripple modulation.
7. Near pure tone, trace of ripple modulation.
8. Near perfect tone, slight trace of modulation.
9. Perfect tone, no trace of ripple or modulation of any kind.

The above reporting system is used on both Morris code and voice, leaving out the "tone" report on voice.

An ARRL standard group on digital voice standards for radio and internet are currently revisiting the subject. They are attempting to develop an automated measurement technique that ultimately relates to the opinions of listeners. The widely accepted rating system is called mean opinion score (MOS). The MOS system asks listeners to rate voice quality on a scale 0-5. Non-integer scores like 3.8 are possible. A score of 5 means that voice quality is unimpaired; a score of 0 means the voice signal is not understandable and is unusable. The system takes into account all means of degradation and does not place any constraints on how the listeners judge impairment. Audio engineers have used it for at least 10 years and a large body of MOS-rated audio samples exists in the public domain. A collection of papers on the subject can be found at <http://www2.arrl.org/tis/info/digivoice.html>.

Mean opinion scoring definitions:

MOS	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying
0	Unusable	Total

The United Nations provides its personnel with the following standards (<http://www.reliefweb.int/telecoms/training/unhccradio.html>) for describing the quality of radio communication:

Readability

Clear	Excellent quality
Readable	Good quality, no difficulty in reading you
Distorted	I have problems reading you
With Interference	I have problems reading you due to interference
Not Readable	I can hear that you are transmitting but cannot read you at all

Signal Strength

Loud	Your signal is strong
Good	Your signal is good
Weak	I can hear you but with difficulty
Very Weak	I can hear you but with great difficulty
Nothing Heard	I cannot hear you at all

An additional approach is the SINPO report (Signal, Interference, Noise, Propagation, Overall) is mainly used by SWLs (Short-Wave Listeners) and describes the quality of a radio communication with a five digit number.

This report is more accurate than the RST that is very often just 59 and therefore doesn't really reflect the quality of the received signal. SINPO reports are very appreciated by broadcast station for the quality of the feedback information.

In this report all digits are from 1 (worse) to 5 (best) according to the following table:

Signal	Interference	Noise	Propagation	Overall
Strength of the signal received.	Interference from other stations.	Presence of atmospheric or other noise.	Fading characteristics of the signal.	How well the information is understandable.
1 Barely audible	1 Extreme	1 Extreme	1 Extreme	1 Barely
2 Poor	2 Severe	2 Severe	2 Severe	2 Poor
3 Fair	3 Moderate	3 Moderate	3 Moderate	3 Fair
4 Good	4 Slight	4 Slight	4 Slight	4 Good
5 Excellent	5 None	5 None	5 None	5 Excellent

The SIO report (Signal strength, Interference, Overall quality) is a simplified version of the SINPO report that is sometimes used.

Some literature promotes SINPO as the best code for reception reporting; however, many listeners cannot accurately rate Propagation and cannot distinguish between man-made Interference and Natural atmospheric noise. Most professional monitoring stations use a simpler code. The following table shows how Interference, Natural Noise and Propagation are combined into a single Interference rating. The SIO code is based on the SINPO code yet is much simpler to create.

Signal Strength	Interference of any type	Overall Quality
5-Excellent	5-No interference	5-Excellent
4-Good	4-Very slight	4-Good
3-Fair	3-Moderate	3-Fair
2-Poor	2-Heavy	2-Poor
1-Useless	1-Extreme	1-Unusable

It is suggested that this approach, SIO, is the best for the purpose of comparing the performance of underground communication products.