

DATA QUALITY CONTROL FLAGS

LINDSAY PENDER

29 June 2000

Specification

All quality control flags are to be unsigned integer numbers in the range 0 to 255. Where appropriate, the flags are to be stored as unsigned byte length values. Each byte length QC flag is subdivided into 3 fields. These fields are defined as follows:

Data State (bits 6 & 7)

The data state describes the overall status of the data without concern about the type of error, and the type of correction process performed on the data, if any. If the QC is unknown, the person loading data must determine the data state, i.e. unknown QC does not necessarily imply no QC.

Data State	Numeric value	Description
0	0	Data is good
1	64	Data is suspect
2	128	Data is bad
3	192	No QC

Operation type (bits 4 & 5)

The operation type describes the type of operation performed on the data to enable it to be classified with the given data state.

Operation	Numeric value	Description
0	0	No operation – data used as is.
1	16	Data has been interpolated to replace bad values.
2	32	Data has been averaged or otherwise filtered.
3	48	Data has been manually adjusted.

Error type (bits 0 & 3)

The error type describes the type of data error detected which resulted in the given data state and subsequent operation on the data.

Error type	Numeric value	Description
0	0	No error – data is good, or if no QC, error is unknown.
1	1	Hardware error.
2	2	Software error.
3	3	Operator error.
4	4	Error flagged by hardware.
5	5	Error flagged by processor.
6	6	Analytical error.
7	7	Recording anomaly, e.g. transcription error.
8	8	Data stream corrupted, e.g. communications fault.
9	9	Data out of range.
10	10	Anomalous spike, e.g. data spikes.
11	11	Preliminary processing (calibration) only.
12	12	Unprocessed (uncalibrated) or processing error.
13	13	No data – data missing for unknown reason.
14	14	Timing error.
15	15	User defined – user must provide adequate description.

Numeric interpretation

The complete flag for a given data element is the sum of the numeric values of the 3 fields. To unpack a flag, the user can either use a lookup table, or perform the following manipulations:

Arithmetic method	Bit manipulation method
<p><i>To unpack a flag:</i></p> $\text{state} = \text{int}(\text{flag} / 64)$ $\text{op} = \text{int}((\text{flag} - \text{state} * 64) / 16)$ $\text{error} = \text{flag} - \text{state} * 64 - \text{op} * 16$ <p><i>To pack a flag:</i></p> $\text{flag} = \text{state} * 64 + \text{op} * 16 + \text{error}$	<p><i>To unpack a flag:</i></p> $\text{state} = \text{flag} \gg 6$ $\text{op} = (\text{flag} \& 0x30) \gg 4$ $\text{error} = \text{flag} \& 0x0f$ <p><i>To pack a flag:</i></p> $\text{flag} = (\text{state} \ll 6) \& (\text{op} \ll 4) \& \text{error}$

On some systems and file formats, eg. netCDF, it is not possible to store unsigned byte values. In this case, flags greater than 127 are stored as negative numbers. To convert them to unsigned integers, add 256.

If a user is only interested in the state flag, the following can be used to interpret flags:

State	Unsigned Byte	Signed Byte
Good	$0 \leq \text{flag} \leq 63$	$0 \leq \text{flag} \leq 63$
Suspect	$64 \leq \text{flag} \leq 127$	$64 \leq \text{flag} \leq 127$
Bad	$128 \leq \text{flag} \leq 191$	$-128 \leq \text{flag} \leq -65$
No QC	$192 \leq \text{flag} \leq 255$	$-64 \leq \text{flag} \leq -1$