API RP-78 MWD, QAQC

Qualifying statement:

The Data User (DU) and Data Service Provider (DSP) shall have an agreed Standard Operating Procedures (SOP), which defines data delivery, calibration verification specifications and operational responsibilities. The DSP shall ensure that data, including equipment and system calibration data is documented, auditable, traceable and should be related to the MWD service error model. The MWD tool and data SOP shall include contingencies where out of specification data events are reported**.** **[APPENDIX DSRAPI RP78 or P7, or WITSML or OPERATORS EXAMPLES]**

# Error Model

## Directional survey tools and measurements shall be associated with an error model based on tool type, sensor performance, tool alignment, magnetic interference, local geomagnetic, gravity fields, depth accuracy and agreed SOP.

## Minimum pass/fail criteria (limits), Verification, and/or QA/QC tests shall be linked to the survey error model and agreed SOP.

## Directional Survey Records, (DSR) shall specify the error model terms and magnitudes and calibration reference report attached.

# Instrument Calibration

## Magnetic calibrations shall be performed in magnetically stable and controlled environment, and accelerometer calibrations shall be performed in a low vibration environment as per SOP.

## MWD tool calibration tolerance values should define tool error model MWD sensor fleet performance values reported at 3σ significance level. **[PK & RW Transfer of responsibility from DSP to (DU)]**

## DSP MWD tool calibration SOP shall include a step to assess that manufacturing and assembly calibration tolerance values are met. A secondary step should include a step to assess relative to actual MWD downhole tool field tool error model performance.

## Calibration temperature stations shall be sufficient to ensure instrument sensor performance over the specified operating temperature range, refer to 2.6 below

## Magnetic and accelerometer calibration results and calibration environment stability, and calibration verification parameters shall be recorded and retained for audit purposes

## DSP SOP shall include instrument calibration verifications that make use of measurements which exercise all sensors over at least 50% of their expected operating range and over the instrument operating temperature range, distributed as equally as possible across positive and negative signal polarities

# Instrument Verification

## Instrument verifications shall make use of measurements which exercise all sensors over at least 50% of their expected operating range, distributed as equally as possible across positive and negative signal polarities.

## Test limit values shall not exceed limits derived from the tool’s error model at a 2σ significance level.

## Failure of one or more tests shall cause the verification to be assessed as a failure.

## Instrument verifications shall be used to verify but not to change calibration parameters.

## Survey tools shall be sent for repair and/or re-calibration if verification fails.

## Verificationresultsshallbe recorded and retained for audit purposes

# Surface roll tests.

## Survey instruments shall pass horizontal roll tests each time an instrument returns from the field to the service base.

## Test limit values shall not exceed limits derived from the tool’s error model at a 3σ significance level.

## Survey tools shall have the Instrument Verification (3) repeated if surface roll tests fail.

## Survey data acquired with a tool that has subsequently failed Instrument Verification should be re-processed and re-analysed.

# Benchmark check shots.

## Benchmark survey stations shall be in regions free of external magnetic interference, such as from casing, and should avoid intervals of borehole curvature or inclinations below 6°.

## Check shots shall agree with benchmark shots, within a maximum tolerance consistent with the appropriate error models at a 3σ level.

## Check shots should be taken when a new survey tool or BHA configuration is used.

# Survey practices.

## Survey stations shall be taken at the planned survey frequency.

## Magnetometers shall be spaced sufficiently distant from magnetic BHA components in accordance with the error model assumptions.

## Surveys shall be associated with the same error model for anti-collision computations.

## Final magnetic survey deliverables shall include all surface location coordinates, datum, reference system, vertical datum, vertical reference, geomagnetic reference field values and their source, and north alignment. For each station include date, time, measured depth, raw survey data, any corrections applied, tool type and tool serial number.

# Magnetic Survey Station QC tests.

## The real time QC parameters at each magnetic survey station shall include, as a minimum, Total Gravity Field, Total Magnetic Field Intensity, Magnetic Dip Angle, and Temperature.

## Magnetic surveys should pass all QC tests at each station corresponding to the survey error model at a 3σ level.

## Over the course of a survey log, 90% of the surveys shall pass all QC tests at each station.

## Corrected surveys shall pass station QC tests appropriate for those corrections.

## Real-time surveys without QC tests shall not be used where a while-drilling HSE risk exists (e.g. collision risk, known shallow gas).

# Multi-Station Analysis and Correction (where used).

## Multi-station analysis programs shall determine maximum-likelihood values of error model terms and shall output these results to the user.

## Multi-station analysis programs should output an indicator of solution stability, such as a matrix condition number or an estimate of output azimuth uncertainty.

## A Multi-Station analysis report shall be provided that includes all raw input data, reference values used, survey sensor data, validation to the target error model, and any applied corrections with a definitive survey listing.

# Comparison with independent tools.

## When high levels of assurance are required, such as HSE risk, the strongest quality control test should use independent tools with few common error model terms, such as one MWD magnetic survey, and one wireline gyro survey.

## Agreement shall be defined using attitude angles or position coordinates within error model predictions at a 3σ level.

# In-Field Referencing.

## The geomagnetic uncertainty estimates of the IFR1 and IFR2 model reference values shall be equal to or smaller than the IFR error model’s geomagnetic uncertainty values.

## Station QC tests and Multi-station analysis should be used to verify the data meets the IFR error model uncertainty estimates.

# Inclination-only tools.

## Inclination-only survey tools shall only be run when complying with local regulations.

## Inclination-only tools shall not be used at hole inclinations above the inclination-only planning model’s specification.

## The real time QC parameters at each inclination-only survey station should include, as a minimum, Total Gravity Field, and Temperature.