SIRIUS MINERALS PLC

Project Title / Facility Name:

North Yorkshire Polyhalite Project

Document Title:

BLASTING AND VIBRATION MANAGEMENT PLAN FOR RAF FYLINGDALES

NYMNPA

22/12/2017

Document Review Status

- [x] 1. Reviewed – Accepted – Work May Proceed — By: Robert Staniland
- [ ] 2. Reviewed – Accepted As Noted, Work May Proceed, Revise & Resubmit — On: 15 Dec 2017 16:43
- [ ] 3. Reviewed – Work May Not Proceed, Revise & Resubmit
- [ ] 4. For information only

	24-Nov-2017	Information	IFI			
B	24-Nov-2017	Review	IFR			
A	23-Aug-2017	Review	IFR			
Rev.	Revision Date (dd mmm yyyy)	Reason For Issue		Prepared by	Verified by	Approved by

Document ID:

40-VIB-GE-83-EN-PL-0001

Blasting and Vibration Management Plan for RAF Fylingdales, North Yorkshire - Polyhalite Project

SIRIUS MINERALS

Document No.
40-VIB-GE-83-EN-PL-0001

R17.9765/2/DW
Date of Report: 24 November 2017

QUALITY MANAGEMENT

Report Title:	Blasting and Vibration Management Plan for RAF Fylingdales, North Yorkshire Polyhalite Project
Client:	Sirius Minerals
Report Number:	R17.9765/2/DW
Issue Date:	24 November 2017

Prepared By:	**Checked By:**
Daniel Williams **Consultant**	**David Johnson** **Director**

Vibrock Limited
Shanakiel
Ilkeston Road, Heanor
Derbyshire, DE75 7DR

Web: www.vibrock.com

CONTENTS

APPENDIX

1.0 INTRODUCTION

1.1 The scheme is submitted for approval by the Mineral Planning Authority and the MOD in accordance with planning conditions 30, 31 and 32 of decision number NYM/2014/0676/MEIA detailed below:

1.2 30. A Blasting and Vibration Management Plan for RAF Fylingdales shall be submitted to the MPA for approval in consultation with the MOD, prior to commencement of activities with the potential to give rise to significant vibration arising from any underground works. Measures should include:

- Details of the specific actions that will be taken if the level of vibration at RAF Fylingdales due to the permitted development exceeds 0.023 mm/s;
- Details of the specific actions that will be taken if the stated vibration criteria are exceeded
- Technical changes to mining methods if the vibration levels in planning conditions are exceeded; and
- Communication of information to affected parties

The development shall thereafter be carried out in accordance with the approved Blasting and Vibration Management Plan.

31. Vibration monitoring equipment shall be installed, maintained and operated on or adjacent to RAF Fylingdales prior to the commencement of blasting, in accordance with the Blasting and Vibration Management Plan detailed plans of which shall be submitted to and approved by the MPA.

32. Ground vibration from construction/blasting shall not exceed a peak particle velocity of 0.025 mm/s in 95% of blasts as measured at RAF Fylingdales unless otherwise agreed in writing with the MPA in consultation and agreement with the MOD.

1.3 All development and production blasting shall be undertaken strictly in accordance with this approved scheme.

2.0 MONITORING INSTRUMENTATION AND SITING

2.1 The monitoring equipment to be installed at RAF Fylingdales would be the Syscom MR3000C, the technical specifications for the seismograph are displayed on pages 3 and 4. An option further to the specification would be enabled to detect vibration levels in the range 0.5 µm/s to 100 mm/s, in order to enable comparison to the site vibration criterion of 0.023 mm/s. The Instrumentation shall record ground vibration in terms of peak particle velocity in millimetres per second (mms^{-1}) in three mutually perpendicular planes of measurement.

2.2 The monitoring instrumentation shall hold a valid certificate of calibration. When the seismograph requires recalibrating this will be organised either during a period when blasting operations will not be conducted on site, or alternatively, if this is not possible a replacement seismograph will be installed to cover the time period required for recalibration.

Technical specifications

Data acquisition

Principle	4th order delta-sigma ADC per channel
Resolution	24 bit
Sampling-rate	50, 100, 200, 400, 500, 800, 1'000, 2'000 sps, others on request
Number of channels	3
Channel to channel skew	None – simultaneous sampling on all channels
Dynamic range	Typ. 130dB@250, 127dB@500 sps
Data Filter	FIR & IIR digital filters
Trigger Filter	Digital IIR filter: 0.5 - 15 Hz band-pass (Strong Motion Applications) Others on request

Trigger and de-trigger

Principle	Level trigger or STA/LTA or combined
Trigger voting logic	Predefined AND or OR combinations, individual channel votes
Level trigger	0.003 to 100% full scale
STA / LTA (Strong Motion)	STA: 0,1 to 25s, LTA: 1 to 250s, Ratio: 0,1 to 25.
Smart Trigger / De-Trigger	Automatic adjustment of trigger level

Microprocessor

Recording principle	Event recording (time history), continuous time recording or manually triggered
Header	Contains status information at time of trigger and event summary
Pre-event recording	1 - 30 seconds (in 1 sec steps)
Post-event recording	1 - 100 seconds (in 1 sec steps)
Max. recording time	Event recording: unlimited
Non volatile Memory	Internal and flash and removable SD card

Alarm triggers principle	Multiple level triggers with various notification options (individually settable for each axis)
Range	0.1 % to 100% full scale

Precision timing

System Clock	1 ppm, this clock is disciplined by GPS, NTP

Data / user interface

Intelligent Alerting	System initiates communications or sends text message (SMS) or e-mail when an event is detected
Web Interface	Easy to use command & control through embedded web server
FTP	Built-in FTP client to push data to an FTP-server

Display

3 LED	Run, Recording, Warning/Error
LCD-Display	Status information, important settings.

Wireless Communication

WiFi	IEEE 802.11b/g/n compliant
Mobile Network (option)	Multi-Band UMTS / HSDPA / WCDMA / GSM / GPRS / EDGE

Power Supply

Supply Voltage	9 - 13.5VDC or 48V PoE
Power Consumption (W/O wireless communication)	2 W (velocitymeter) 3 W (accelerometer)

I/O and Connectors

Type	Metallic self-latching push-pull connectors with positioning key (LEMO)
Power	Metallic connector with protective GND
GPS	Connector for external GPS
LAN / PoE	Communication with PC or network - Ethernet 100BaseT

Sensors (Internal)

Triaxial Velocitymeter

Type	Velocity sensor with linearized frequency response A3HV 315/1 (triaxial) (according to DIN 45669)
Principle	Geophone
Measuring range full scale	± 100 mm/s
Frequency range	1 - 350 Hz (linear ±10% frequency response)
Case-to-coil motion	4 mm p-p
Dynamic range	> 130 dB
Linearity / Phase	According to DIN 45669 (class 1)
Cross axis sensitivity	According to DIN 45669 (<5%)

Triaxial Accelerometer

Principle	The sensing element is an analog force feedback accelerometer featuring a variable capacitance, silicon bulk-micro machined acceleration sensor (MEMS) and a custom low-power mixed-signal integrated circuit (ASIC). The MEMS/ASIC custom design forms a DC coupled analog servo accelerometer.
Hysteresis	None
Dynamic range (100 Hz BW)	typ. 100 dB (±4g)
Noise (10 to 1000 Hz)	typ. 7 $\mu g_{rms}/\sqrt{Hz}$
Frequency response	0 - 600 Hz
Measuring range	±4 g
Orientation	Triaxial, horizontal (floor) mounting or vertical (wall mounting)
Self test	Test-pulse

Dimensions

Housing	Aluminum, 120 x 180 x 100 mm
Weight	1.5 kg
Protection degree	IP 65 (splash-proof)

Regulation

Electrical Safety	In compliance with IEC 61010
EMI/RFI	In compliance with EN 61000
Environmental	Shock: 30 g/11 ms half-sine Heat: -20° up to +70°C Humidity: up to 100% RH Vibration: up to 5 g (operating)
Conformity	CE

Ordering Information (please refer to last page)

Measurement System	MR3000C with internal Velocitymeter MR3000C with internal Accelerometer
Power supply	External battery package with integrated AC/DC converter/charger External AC/DC converter
Mounting Platform	Mounting platform for MR3000C with levelling bubble
GPS timing	GPS receiver and antenna
Carrying case	For MR3000C and battery package

MR3000C with GPRS and mounting plate

Monitoring Location

2.3 As discussed at the meeting on 24 May 2017 between Sirius Minerals, Vibrock Limited and the MOD, at an earlier visit by Vibrock Limited to RAF Fylingdales on 5 June 2013 a suitable monitoring station was identified within building reference number 383/393. The advantages of this location are as follows:

- The building contains a mains power supply from which it is intended that the seismograph will operate,
- The building contains a solid concrete base upon which to site the seismograph,
- The building is currently unused. This will assist in establishing baseline vibration levels prior to the commencement of blasting operations and will minimise the reporting of localised vibration events,
- From a security perspective use of the identified building will minimise disturbance to RAF Fylingdales' personnel when access to the seismograph is required due to the location of the monitoring position adjacent to the site Police Station.

2.4 It is proposed by Sirius Minerals to establish the seismograph in advance of the shaft sinking operations in order that a suitable baseline from background vibration levels can be established.

3.0 BLAST VIBRATION MONITORING

Derivation of site specific regression line to enable the prediction and control of vibration levels

3.1 The first blasting exercise at the mine-head shall be deemed a test blast from which a site specific regression line shall be derived.

3.2 Seismographs in close proximity to the blast source will be established at known distances from the blast in addition to the seismograph located at RAF Fylingdales.

3.3 The accepted method of predicting peak particle velocity for any given situation is to use a scaling approach utilising separation distances and maximum instantaneous charge weights. This method allows the derivation of the site specific relationship between ground vibration level and separation distance from a blast.

3.4 Regression analysis of the test data will enable the calculation of allowable maximum instantaneous explosive charge weights per separation distance in order to attain the site vibration criterion.

3.5 Where it is predicted that the received levels of vibration will exceed the relevant criteria, the operator will have to reduce the maximum instantaneous explosive charge weight. One method of achieving such a reduction is to deck the explosives within the borehole. This technique splits the column of explosives in two, separated by inert material. If blasting is required at closer distances than that where double decking would be a successful strategy, other charge reduction methods would have to be employed. These could be more complex decking strategies or changes to the blast geometry and / or the use of smaller diameter boreholes.

Monitoring of Routine Construction and Production Blasting

3.6 A seismograph shall be installed at RAF Fylingdales in order that every construction and production blast associated with the development is monitored.

3.7 The location and depth of the blast shall be established prior to each event, in order to accurately measure the distance from the blast to RAF Fylingdales and to ensure that the appropriate maximum instantaneous explosive charge weight is utilised in the blast design.

3.8 The measurement of ground vibration shall be the maximum of three mutually perpendicular directions taken at the monitoring location.

3.9 A note of the prevailing weather conditions shall be taken for each blast.

3.10 Following a period of 12 months from the commencement of monitoring in accordance with this scheme, the Mineral Planning Authority, the MOD and the site operator shall review the monitoring procedures.

4.0 BLAST MONITORING RESULTS

4.1 On completion of each monitoring exercise, the following information will be recorded:

a) Date, time and location of vibration monitoring;

b) Peak particle velocity in each of the three planes of measurement (in mms^{-1});

c) Brief details of the blast monitored to include its location, number of holes, maximum instantaneous charge weight and total charge weight;

d) Weather details to include temperature, wind speed and direction, % cloud cover and details of any precipitation.

4.2 The results from the blast monitoring shall be retained for a period of two years and will be made available for inspection upon the request of the Mineral Planning Authority. The report format for the routine reporting of blast vibration levels is attached as Appendix 1.

4.3 In the event that a blast exceeds a peak particle velocity of 0.023 mms^{-1} the Mineral Planning Authority and nominated MOD personnel shall be notified immediately.

4.4 The seismograph has remote access capability, which dependent upon functionality, can be used to alert nominated personnel should the vibration criterion be exceeded. Should remote access functionality not be available, personnel trained in the use of the seismograph shall investigate the monitored level following each blast event.

4.5 The results of the blast vibration monitoring shall be reviewed with regression line updates and the blast design modified as required in order to comply with the site vibration criterion.

APPENDIX 1

Results of Blast Vibration Monitoring at RAF Fylingdales, North Yorkshire

SIRIUS MINERALS

R17.9769/1/DW
Date of Report: 24 November 2017

QUALITY MANAGEMENT

Report Title:	Results of Blast Vibration Monitoring at RAF Fylingdales, North Yorkshire
Client:	Sirius Minerals
Report Number:	R17.9769/1/DW
Issue Date:	24 November 2017

Prepared By:	**Checked By:**
Daniel Williams **Consultant**	**David Johnson** **Director**

Vibrock Limited
Shanakiel
Ilkeston Road, Heanor
Derbyshire, DE75 7DR

CONTENTS

TABLES

1.0 INTRODUCTION

1.1 In order to assess compliance with the blast vibration criterion detailed within permission reference NYM/2014/0676/MEIA, this report details the results of blast vibration monitoring conducted at RAF Fylingdales from the initiation of routine construction/operational blasting on XX.

1.2 This report gives the results of the blast vibration measurements as well as an assessment with respect to compliance with the relevant Planning Conditions.

2.0 BLAST VIBRATION CRITERIA

2.1 The relevant site planning conditions in relation to blast vibration are detailed below:

30. A Blasting and Vibration Management Plan for RAF Fylingdales shall be submitted to the MPA for Approval in consultation with the MOD, prior to commencement of activities with the potential to give rise to significant vibration arising from any underground works. Measures should include:

- Details of the specific actions that will be taken if the level of vibration at RAF Fylingdales due to the permitted development exceeds 0.023 mm/s;
- Details of the specific actions that will be taken if the stated vibration criteria are exceeded
- Technical Changes to mining methods if the vibration levels in planning conditions are exceeded; and
- Communication of information to affected parties

The development shall thereafter be carried out in accordance with the approved Blasting and Vibration Management Plan.

31. Vibration monitoring equipment shall be installed, maintained and operated on or adjacent to RAF Fylingdales prior to the commencement of blasting, in accordance with the Blasting and Vibration Management Plan, detailed plans of which shall be submitted to and approved by the MPA.

32. Ground vibration from construction/blasting shall not exceed a peak particle velocity of 0.025 mm/s in 95% of blasts as measured at RAF Fylingdales unless otherwise agreed in writing with the MPA in consultation and agreement with the MOD.

3.0 SURVEY DETAILS

3.1 Introduction

3.1.1 Levels of vibration were measured from a blast initiated at 00:00 on XX. The instrumentation utilised was the Syscom MR3000C as detailed within the Blast and Vibration Management Plan and monitored adjacent to the Police Station at RAF Fylingdales.

3.2 Survey Method

3.2.1 The following instrumentation was used for the measurements:-

Manufacturer	Description	Type
Syscom	Digital Seismograph	MR3000C

4.0 SURVEY RESULTS

4.1 Details of the blast monitored are shown in Table 1.

4.2 A summary of the results obtained is presented in Table 2.

5.0 DISCUSSION OF RESULTS

5.1 The blast details and vibration recordings from XX are presented in Tables 1 and 2 respectively.

5.2 The blast design employed on XX is typical of production/construction blasting at Sirius Minerals.

5.3 Table 2 gives the results of ground vibration monitoring on XX. The vibration level measured was XX mms^{-1}.

5.4 The result was below the planning condition vibration limit of 0.023 mms^{-1}.

INDEX TO TABLES

TABLE 1

Details of Blast at Sirius Minerals

Date:	
Time:	
Type of Blast:	
No. of Holes:	
Total Explosive Charge Weight (kg):	
Maximum Instantaneous Charge Weight (kg):	
Explosive Type:	

TABLE 2

Vibration Levels Monitored

Day/Date of Survey: Xxxxxx, XX XXXXXXX

Monitoring Position	Peak Particle Velocity (mms^{-1})		
	Long	Vert	Trans
Building Reference 383/393	<0.5	<0.5	<0.5