MANAGEMENT PLAN

PREVENTION AND MANAGEMENT OF BLAST GENERATED NOx

Tata Steel Minerals Canada Ltd.

Direct Shipping Ore Project

November 2015
# Table of Contents

1. **Purpose** .................................................................................................................................................. 1
2. **Scope** .................................................................................................................................................. 1
3. **Background** .......................................................................................................................................... 1
   3.1 Requirement for a Blast Generated NOx Management Strategy .................................................. 1
   3.2 Theory – NOx in Blast Fumes ........................................................................................................... 1
   3.3 Causes of NOx Gases in Blasting ...................................................................................................... 2
4. **Management Procedures** ...................................................................................................................... 3
   4.1 Blast Design by Explosives/Precursor Manufacturer/Supplier ..................................................... 3
   4.2 Pre-Blast Environmental Assessment ............................................................................................... 3
   4.3 Pre-Blast and Post-Blast Checklist .................................................................................................. 3
   4.4 Blast Log ............................................................................................................................................ 4
5. **Documentation and Retroaction** ............................................................................................................ 6
   5.1 Documentation .................................................................................................................................... 6
   5.2 Retroaction ....................................................................................................................................... 6

**Appendices**

- Appendix A  Blast Design Datasheet
- Appendix B  Pre-Blast Environmental Assessment List
- Appendix C  Pre-Blast / Post-Blast Checklist
- Appendix D  Blast Log
1. **Purpose**

This procedure outlines responsibilities and guidelines for manage and assist in the minimisation and management of blast fumes, in particular oxides of nitrogen (NOx) at the Direct Shipping Ore (DSO) Project operated by Tata Steel Minerals Canada Ltd., near Schefferville, QC.

2. **Scope**

Those involved in blasting operations need to be aware of the causes, risks and consequences of the oxide of nitrogen (NOx) gases that may emanate from their blasting activities. The aim of this Plan is to provide information and recommended guidelines to assist in the prevention and management of blast generated NOx gases from surface blasting operations. The Plan is specific to NOx gases and covers the following areas:

- the likely causes of NOx gases from blasting
- possible control measures to prevent or minimise blast generated NOx gases
- management of NOx gases from blasting should they occur

This document provides a mitigation strategy based on the Code of Practice for Prevention and Management of Blast Generated NOx Gases in Surface Blasting established by the Australian Explosives Industry and Safety Group (AEISG) (Edition 2, August 2011).¹

3. **Background**

3.1 **Requirement for a Blast Generated NOx Management Strategy**

Air quality studies conducted by TSMC in the context Environmental Impact Assessments for Provincial and Federal authorities show that air emissions (such as dust, NOx, CO and SO₂) generated during blasting events can negatively affect the air quality in the vicinity of the pits where blasting is conducted.

As part of an EIA submitted to the Canadian Environmental Assessment Agency (CEAA) in the fall of 2015 for the Howse Property Project (HPP), TSMC has committed to the development and implementation of a Plan for the prevention and management of blast generated NOx. This Plan will be put into effect when blasting at the HPP starts. This plan is applicable to blasting at the following pits: Howse, Fleming 7N and Timmins 3N. However, its application will be extended to other active pits as deemed necessary.

3.2 **Theory – NOx in Blast Fumes**

The group of gases known as Oxides of Nitrogen or NOx, of which the most common are nitric oxide (NO) and nitrogen dioxide (NO₂), are often found as by-products in the post-blast gases of ammonium nitrate-based explosives. Together, these gases are loosely referred to as “NOx”. Nitric oxide is invisible, but nitrogen dioxide ranges from yellow to dark red depending on the concentration and size of the gas cloud. These gases are pollutants. NOx from blasting constitutes only a small proportion of the total NOx emissions from human activities.

(primarily power generation and motor vehicles) and natural sources. However blasting produces a sudden localised release of gases with potentially high concentrations of NOx. Such gas emissions pose a health risk if people are exposed to them before the plumes can dissipate.

Despite a long history of blast-related NOx emissions, very few quantitative studies have been done under realistic field conditions. The underlying causes of high NOx are fuel-deficiency in the explosive or detonation reactions that do not continue to completion. There are many ways in which these conditions may arise.

In the absence of a single general cause or general solution, this Plan was developed by TSMC as an aid to identifying the local cause of NOx and as a prompt for possible ways to address those causes. It should be understood that, given the complexity of the problem and the inherent variability in the blasting environment, NOx events may still occur even after prevention and mitigating actions have been put in place. The Plan therefore include advice on managing blasts that could produce NOx gases.

3.3 Causes of NOx Gases in Blasting

The post-blast gases and fumes are generated as a result of the ammonium nitrate-based explosive detonation at the blast site. The factors that trigger the formation of the NOx are various but the following factors are among the main contributors in the generation of post-blast fumes during the mining process:

- Explosive formulation and quality assurance;
- Geological Conditions;
- Climate/seasonality;
- Blast design;
- Explosive product selection;
- Contamination of explosive in the blast-hole;
- On-bench practices.

Section 5 of the Code of Practice for Prevention and Management of Blast Generated NOx Gases in Surface Blasting should be consulted as an aid to identifying causes and mitigation measures.

As a result, the formation of the toxic fumes can be managed through some preventive controls considering the geological conditions during the design phase, designing an appropriate design for the blast, selecting an appropriate product formulation for the detonation, considering the weather condition during the time of loading; implementing on-bench practiced to minimise the potentials for water ingress into blasting area; minimising the contamination of explosives in blast holes.
4. **Management Procedures**

4.1 **Blast Design by Explosives/Precursor Manufacturer/Supplier**

The manufacturer and/or supplier of the precursors or bulk explosives must ensure products are formulated appropriately to prevent/minimise the generation of NOx gases during blasting. The products should be authorised, with quality control systems in place to ensure that the manufactured/supplied products meet specifications.

For each blast, a copy of the Blast Design datasheet must be forwarded to TSMC on-site Environmental team. An example “Blast Design” datasheet is provided in Appendix A of this Plan.

The explosives manufacturer/supplier must provide documentation for modification and alterations to explosive and/or precursor formulations. Documentation must be provided to TSMC on-site Environmental team and must cover the following aspects:

1. recording any modification/alteration and updating relevant authorisations, Technical Data Sheets, Material Safety Data Sheets, work procedures, and training programs as and where relevant;
2. ensuring changes continue to meet the requirements of this Code;

4.2 **Pre-Blast Environmental Assessment**

In collaboration with the blasting manager, TSMC on-site Environmental team will complete a Pre-Blast Environmental Assessment. A copy of the Pre-Blast Environmental Assessment list is provided in Appendix B.

The assessment covers 6 criteria:

- Explosive Formulation and Quality Assurance
- Geological conditions
- Blast Design
- Explosive product selection
- On bench practices
- Contamination of explosives in the blast hole

The assessment may be conducted days before a blasting event is scheduled.

4.3 **Pre-Blast and Post-Blast Checklist**

Appendix C contains an example of the Pre-Blast / Post-Blast checklist, currently in use at the site. The Pre-Blast / Post-Blast checklist

The following parameters will be added to the Pre-Blast section of the checklist:

a) Acknowledgement of the Environmental Assessment by the responsible for drilling and blasting
b) Meteorological conditions: wind speed, wind direction, temperature, precipitation
c) For pits located in the vicinity of the Workers’ camp (ex.: Howse, Fleming 7N, Timmins 3N), blasting must be conducted while the wind is NOT blowing in direction of the Workers’ camp

The following parameters will be added to the Post-Blast section of the checklist:
a) Visual Rating Scale: Assessment of the Post-Blast fume should using the AEISG visual NOx fume rating scale.
b) duration of any post-blast NOx gas event;
c) direction of movement of any post-blast NOx plume;
d) movement of any post-blast NOx gas plume relative to the established exclusion zone and any established management zone;
e) results/readings of any NOx monitoring equipment employed for the blast;
f) video results of blasts where relevant

4.4 Blast Log

Appendix D contains an example of the Blast Log used for recording blasting events. This information log will continue to be used at the site for all blasts.
### VISUAL NOX FUME RATING SCALE

<table>
<thead>
<tr>
<th>Level</th>
<th>Typical Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 0</strong></td>
<td>No NOx gas</td>
</tr>
<tr>
<td><strong>Level 1</strong></td>
<td>Slight NOx gas</td>
</tr>
<tr>
<td>1A</td>
<td>Localised</td>
</tr>
<tr>
<td>1B</td>
<td>Medium</td>
</tr>
<tr>
<td>1C</td>
<td>Extensive</td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td>Minor yellow/orange gas</td>
</tr>
<tr>
<td>2A</td>
<td>Localised</td>
</tr>
<tr>
<td>2B</td>
<td>Medium</td>
</tr>
<tr>
<td>2C</td>
<td>Extensive</td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td>Orange gas</td>
</tr>
<tr>
<td>3A</td>
<td>Localised</td>
</tr>
<tr>
<td>3B</td>
<td>Medium</td>
</tr>
<tr>
<td>3C</td>
<td>Extensive</td>
</tr>
<tr>
<td><strong>Level 4</strong></td>
<td>Orange/red gas</td>
</tr>
<tr>
<td>4A</td>
<td>Localised</td>
</tr>
<tr>
<td>4B</td>
<td>Medium</td>
</tr>
<tr>
<td>4C</td>
<td>Extensive</td>
</tr>
<tr>
<td><strong>Level 5</strong></td>
<td>Red/purple gas</td>
</tr>
<tr>
<td>5A</td>
<td>Localised</td>
</tr>
<tr>
<td>5B</td>
<td>Medium</td>
</tr>
<tr>
<td>5C</td>
<td>Extensive</td>
</tr>
</tbody>
</table>

Assessing the amount of NOx gases produced from a blast will depend on the distance the observer is from the blast and the prevailing weather conditions. The intensity of the NOx gases produced in a blast should be measured on a simple scale from 0 to 5 based on the table above. The extent of the NOx gases also needs to be assessed and this should be done on a simple scale from A to C where:

- **A** = Localised (ie NOx Gases localised across only a few blast holes)
- **B** = Medium (ie NOx Gases from up to 50% of blast holes in the shot)
- **C** = Extensive (ie Extensive generation of NOx Gases across the whole blast)

Pantone colour numbers have been included in the following Field Colour Chart to ensure colours will be produced correctly thereby ensuring a reasonable level of standardisation in reporting NOx gas events across the blasting industry.

<table>
<thead>
<tr>
<th>Level</th>
<th>Colour</th>
<th>Pantone Number</th>
<th>Pantone Number</th>
<th>Pantone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 0</strong></td>
<td></td>
<td><strong>0</strong></td>
<td><strong>1C</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>No NOx gas</td>
<td>Warm Grey 1C</td>
<td>(RGB 244, 222, 217)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 1</strong></td>
<td></td>
<td><strong>1</strong></td>
<td><strong>155C</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Slight NOx gas</td>
<td>Pantone 155C</td>
<td>(RGB 244, 219, 170)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td></td>
<td><strong>2</strong></td>
<td><strong>157C</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Minor yellow/orange gas</td>
<td>Pantone 157C</td>
<td>(RGB 237, 160, 79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td></td>
<td><strong>3</strong></td>
<td><strong>158C</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Orange gas</td>
<td>Pantone 158C</td>
<td>(RGB 232, 117, 17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 4</strong></td>
<td></td>
<td><strong>4</strong></td>
<td><strong>1525C</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Orange/red gas</td>
<td>Pantone 1525C</td>
<td>(RGB 181, 84, 0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 5</strong></td>
<td></td>
<td><strong>5</strong></td>
<td><strong>161C</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Red/purple gases</td>
<td>Pantone 161C</td>
<td>(RGB 99, 58, 17)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Documentation and Retroaction

5.1 Documentation

For each blast, the following documents will be reviewed and filed by TSMC on-site environmental team:

a) Blast Design by blasting company or responsible
b) Pre-Blast Environmental Assessment
c) Pre-Blast and Post-Blast Checklist
d) Blast Log

5.2 Retroaction

Any reported significant NOx event or trends should be investigated to minimize the potential for ongoing generation of NOx gases and to mitigate the potential impacts of any such event. Such investigation should involve the explosives manufacturer and/or supplier.

The fault tree (see Section 6 Code of Practice for Prevention and Management of Blast Generated NOx Gases in Surface Blasting) should assist any investigation and ensure all relevant factors are considered and adequately addressed. The results of any investigation of post-blast NOx gases should then be factored into the site specific procedures to minimize their production and to mitigate impacts.
Appendix A

Blast Design Datasheet

Example Datasheet Currently in Use. To Be Amended As Per This Plan.
Appendix B

Pre-Blast Environmental Assessment List
Pre-Blast Environmental Assessment  
TSMC DSO - SCHEFFERVILLE

<table>
<thead>
<tr>
<th>Blast #:</th>
<th>Scheduled Blast Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit ID:</td>
<td></td>
</tr>
<tr>
<td>Assessed by:</td>
<td>Assessment Date:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment Criteria</th>
<th>Likelihood</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PB 1: Explosive Formulation and Quality Assurance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explosive product incorrectly formulated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explosives product change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate mixing of raw materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery system metering incorrectly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery system settings for explosive product delivery overridden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explosive precursors not manufactured to specification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precursor degradation during transport and storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw material changes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| <strong>PB 2: Geological conditions</strong>                                                     |             |       |
| Lack of relief in weak/soft strata                                                  |             |       |
| Inadequate confinement in soft ground                                               |             |       |</p>
<table>
<thead>
<tr>
<th>Explosive product seeping into cracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic water in holes</td>
</tr>
<tr>
<td>Moisture in clay</td>
</tr>
<tr>
<td>Blast hole wall deterioration between drilling and loading e.g. cracks, voids, hole contraction</td>
</tr>
<tr>
<td>Chemistry of rock type e.g. limestone</td>
</tr>
<tr>
<td>Other:</td>
</tr>
</tbody>
</table>

**PB 3: Blast Design**

- Explosive desensitisation due to the blast hole depth
- Inappropriate priming and/or placement
- Mismatch of explosives and rock type
- Inter-hole explosive desensitisation
- Intra-hole explosive desensitisation in decked blast holes
- Initiation of significant explosive quantities in a single blast event
- Other:

**PB 4: Explosive product selection**

- Non water-resistant explosive products loaded into wet or dewatered holes
- Excessive energy in weak/soft strata desensitising adjacent explosive product columns
- Primer of insufficient strength to initiate explosive column
- Desensitisation of explosive column from in-hole cord initiation
- Inappropriate explosive product for application
- Other:

**PB 5: On bench practices**

- Hole condition incorrectly identified
<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast not drilled as per plan</td>
</tr>
<tr>
<td>Dewatering of holes diverts water into holes previously loaded with dry hole explosive products</td>
</tr>
<tr>
<td>Blast not loaded as per blast plan</td>
</tr>
<tr>
<td>Other:</td>
</tr>
</tbody>
</table>

**PB 6: Contamination of explosives in the blast hole**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosive product mixes with mud/sediment at bottom of hole.</td>
</tr>
<tr>
<td>Interaction of explosive product with drilling muds.</td>
</tr>
<tr>
<td>Penetration of stemming material into top of explosive column (fluid/pumpable explosive products only)</td>
</tr>
<tr>
<td>Water entrainment in explosive product</td>
</tr>
<tr>
<td>Moisture in ground attacking explosive product</td>
</tr>
<tr>
<td>Contamination of explosives column by drill cuttings during loading</td>
</tr>
<tr>
<td>Rainfall on a sleeping shot.</td>
</tr>
<tr>
<td>Other:</td>
</tr>
</tbody>
</table>
Appendix C

Pre-Blast / Post-Blast Checklist

Example checklist Currently in Use. To Be Amended As Per This Plan.
## Pre-Blast Checklist / Liste à Cocher Avant-Sautage

**Date:** May 3/15  
**Project:** Good Wood Quarry  
**General Contractor / Entrepreneur Général:** Grey Rock  
**Blaster-in-charge / Boutefeu en charge:** Roderick Lords

1. Inspect immediate and surrounding area for structures and roads leading into the affected area.  
2. Inspect the zone imédiate et environnement pour les structures et les routes menant à la zone touchée.  
3. Ensure local area for any hazards or dangerous conditions / Inspectez la zone de travail pour tous les dangers ou des conditions dangereuses.  
4. Conduct tailgate meeting - Review all hazards, safety equipment required and job descriptions. / Effectuez une réunion sur chantier - Examinez tous les dangers, l'équipement de sécurité requis et les procédures de travail.  
5. Ensure locates for utilities are completed / Assurez-vous de localiser les services.  
6. Review blast design and adjust according to site conditions as required before loading. / Revoyez la conception du tir et ajustez selon les conditions du site avant le chargement au besoin.  
7. Ensure required blast protection is in place / Assurez-vous que le contrôle des projections nécessaire est en place i.e.: bell covering, protective measures for structures, blast mats, collarts control. / C'est-à-dire : couvre-fits, des mesures de protection pour les structures, matelas, contrôle des collets.  
8. Notify owner, general contractor and local residents of the blasts / Avertissez le propriétaire, le maître d'ouvrage et les habitants des炸药。  
9. Ensure the guarding procedures are reviewed, including the following: / Assurez-vous que les procédures d'évacuation sont examinées, y compris ce qui suit:  
   - Confirm guard locations and assign guards as per blast area plan / Confirmez la zone d'évacuation et attribuez des gardiens selon la zone sur le plan.  
   - Check radios for group communication / Vérifiez les radios pour la communication de groupe.  
   - Review clearing procedure and site specific guarding procedure with all personnel / Revoyez la procédure d'évacuation et les zones de garde avec l'ensemble du personnel.  
10. Program and install seismographs at nearest structure / Programmez et installez des sismographes où la structure la plus proche.  
11. Check blast area and remove all equipment and materials / Vérifiez que tous les équipements et matériaux à l'intérieur de la zone d'évacuation soient enlevés.  

## Post-Blast Checklist / Liste à Cocher Après-Sautage

1. Review blast area / Révisez la zone dynamitée.  
   - Visually and physically confirm blast has completely fired / Visuellement et physiquement confirmez que le sautage a bien détoné.  
   - (If misfire occurred, refer to Accident Prevention Program) / (Si sautage raté, reportez-vous au programme de prévention des accidents).  
2. Investigate surroundings for possible damage / Vérifiez les alentours si dommage causé.  
3. Retrieve seismographs / Récupérez les sismographes.  
4. Ensure before leaving site all materials and explosives have been picked up / Assurez-vous avant de quitter les lieux tous les matériaux et des explosifs ont été ramassés.  

*****Note: Abandoning explosives is a criminal offence*** / ***Remarque: L'abandon d'explosifs est une infraction pénale***

1. Ensure all explosives counted and properly stored with amount returned on bill of lading / Assurez-vous que tous les explosifs stockés balance avec le montant utilisé.  
2. Return blast report completed to office / Retournez le rapport de sautage complété au bureau.  
3. Return video to office / Retournez le vidéo au bureau.  
4. Wildlife and environment survey conducted / Enquête de l'environnement et de la faune mené.

**Comments / Commentaires**

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Blaster-in-charge / Signature Boutefeu en charge:
Appendix D

Blast Log

Example Datasheet Currently in Use.
BLAST LOG

DATE: Sunday May 3rd
TIME: 
CONTRACT / JOB #: XLC-730-06a
LOCATION: Kinvar, Vic

DESIGN:
BLASTER: Randall Fraser
SIGNATURE: 
EXPLOSIVES:
TYPE/BLEND:  
1) Emulsion 90/10  
2) Dyno Tnt 200/G  
3)  
NO. OF DELAYS:  
MAX. LOAD PER DELAY: 
HOLES PER SERIES: 
POWDER FACTOR: 
LOADING:
COLLAR: 2.4m - 3.0m
COLUMN LOAD: Bulk emulsion
TOE LOAD: Dyno Tnt 200/G
SUBGRADE: 

DIMENSIONS:
1) Width: 1.8m
2) Length: 24m
3) Depth: 9m

LOADING:
COLLAR: 2.4m - 3.0m
COLUMN LOAD: Bulk emulsion
TOE LOAD: Dyno Tnt 200/G
SUBGRADE: 

PRE BLAST DESIGN:
NOTES / REMARKS: 
HAZARDS & DISTANCE: 
IS THERE A GARDING PLAN & PROCEDURE?: YES NO
ARE GARDENS IN PLACE?: YES NO
WAS THERE A CUT SHEET PROVIDED BY THE DRILLER?: YES NO

POST BLAST REPORT:
FLYROCK DAMAGE: 
MISFIRE: YES NO
SEISMIC DATA: 
WIND DIRECTION VELOCITY: 
ATMOSPHERIC CONDITIONS: 
BULK USED?: YES NO
BULK TRUCK NUMBER'S: 
BULK TRUCK DRIVER: Tim Silva