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February 16, 2010

Dave Fox
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Re: Doris North Incinerator Stack Testing

Dear Mr. Fox,

Please find attached to this letter a memorandum describing the recent stack test performed on the Doris North Incinerator. Please review ahead of our conference call scheduled for 4PM Mountain Time on February 19, 2010.

Should you have any questions or concerns regarding this memorandum, please do not hesitate to contact me at Chris.Hanks@Newmont.com.

Sincerely,

Christopher C. Hanks

Digitally signed by Christopher C. Hanks
DN: cn=Christopher C. Hanks, o=Hope Bay Mining Company, ou=Environment and Social Responsiblity, email=chris.hanks@newmont.com, c=US
Date: 2010.02.16 14:20:44 -07'00'

Chris Hanks
Director Environmental and Social Responsibility
Hope Bay Mining Ltd.

Memorandum

DATE: February 3, 2010

Refer to File: MEMO - BMPs for Doris Incinerator-revised 3 Feb 2010.doc

TO: Bill Patterson, Environmental Compliance Manager

FROM: Dan Jarratt, P.Eng.

CC: Dr. Deborah Muggli, project # 1009-004 file

SUBJECT: Doris North Gold Mine Project – Doris Camp Incinerator: Summary of September 2009 Emissions (Dioxin/Furan and Mercury) Testing Conditions and Best Management Practices

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The following incinerator stack emissions monitoring requirements are outlined in the Doris North Gold Mine Project Certificate (NIRB No. 003, issued September 15, 2006): under Section 4.0, Item 30.

> *Commentary: NIRB expects that Canada Wide Standards for Dioxins and Furans and the Canada Wide Standards for Mercury will apply and should be followed including stack testing of incinerators.*

An incinerator stack emissions testing program was implemented in late September and early October 2009 to collect samples for dioxin, furan and mercury. This is the first time that the incinerator stack emissions were tested and the objective was to establish a baseline by which future improvements can be measured against. The samples were analyzed at an accredited laboratory. The resulting concentrations of the sampled parameters were compared with the Canada Wide Standards (CWS) for Dioxins and Furans and the CWS for Mercury (CWS 2001). The CWS were developed by the Canadian Council for Ministers of the Environment (CCME). Testing of dioxin, furan and mercury emissions followed Environment Canada – Environmental Protection Service (EC-EPS 1989) standard methods.

The Doris incinerator stack emissions monitoring results indicated that there were no exceedances for the mercury emissions; however, the dioxin and furan emissions exceeded the Canada Wide Standards. The average mercury emissions were 1.0 micrograms per reference cubic meter (µg/Rm^3) at 11% O_2, compared to the CWS guideline of 20 µg/Rm^3 at 11% O_2. The average dioxin/furan emissions were 2,170 picograms per reference cubic meter (pg/Rm^3) at 11% O_2, compared to the CWS guideline of 80 pg/Rm^3 at 11% O_2. The combined toxicity of all 29 dioxins is called the "TEQ" (for Toxic Equivalency). The dioxin and furan concentrations are reported in International Toxic Equivalents (I-TEQ) where a reference cubic meter is measured at 25°C and 101.3 kPa. In addition, it is standard practice to provide the dioxin and furan concentrations at 11% oxygen (O_2).

The purpose of this memorandum is to put the 2009 stack emissions testing results into perspective by:

- Determining the appropriateness of the incinerator technology selected for operation at the site;
- Comparing the 2009 results with results from similar units and the manufacturer's performance estimates (if available);
- Summarizing the incinerator operating conditions for the first round of testing;
- Listing the potential reasons why the test failed for dioxin/furan;
- Identifying opportunities to improve the incinerator operations and performance;
- Presenting the available Environment Canada best management practices (BMPs) for incinerator operations to reduce air emissions for dioxin/furan and mercury;
- Proposing an implementation schedule for an adaptive management system for segregating waste, blending for temperature control, removal of plastics, etc.; and
- Proposing a commitment for future testing after the BMPs have been implemented to measure improvements.

Appropriateness of the Doris Camp Incinerator Technology

The Doris camp incinerator appears to be an appropriate design for the size of the camp due to its designed capacity for incinerating waste, 100 kg per hour. The Doris incinerator is a batch type incinerator that matches the volume of waste produced by the Doris North camp. The camp does not appear to produce a sufficient volume of waste to support a continuous incineration process.

The incinerator operated at Hope Bay, Doris Camp is a Westland Incinerator, Model CY 100 CA-D-O two-stage incinerator. The incinerator is a dual chamber, starved air, oxygen controlled incineration system. The unit is designed to process 100 kg of waste per hour and uses diesel fuel as the auxiliary fuel. The incinerator utilizes primary and secondary combustion chambers and is equipped with a six-meter (nominal) refractory lined stack. According to the manufacturer similar incinerators are used in the Northwest Territories and Nunavut at remote camps. There is no tracking system in place to monitor the types of camp waste that are being incinerated.

Similarly, there is currently no tracking system in place at the Doris incinerator to monitor the weight (kg) of the waste that is processed each year. According to the CWS, waste incinerators with annual throughput of less than 26 tonnes per year (t/y) must make a "determined effort" to achieve a stack concentration below 80 pg/I-TEQ/Rm^3 for dioxin and furan. Achieving this standard becomes mandatory when the annual throughput exceeds 26 tonnes per year. CWS define "determined effort" as, the ongoing review of opportunities for reductions and implementation of in-plant changes and/or emissions control upgrades that are technically and economically feasible and which confer on-going reductions in emissions (CCME 2001). With the initial Doris incinerator baseline emissions testing program and the application of the best management practices and a follow up emissions testing program that will be implemented during 2010 (see below) the Doris North project owners are making a "determined effort" to comply with the CWS.

A ball park estimate of the maximum volume of waste processed by the Doris incinerator is 44 tonnes per year. This is based on an estimate of the weight of the waste incinerated during the late September early September 2009 emissions testing campaign (i.e., 20 kg per batch X 6 batches per day X 365 days of operation per year).

2009 Results Compared to Results from Similar Units and the Manufacturer's Performance Estimates

Unfortunately neither the manufacturer nor Environment Canada has dioxin and furan emissions data available for small batch incinerators similar to the Doris camp incinerator. The manufacturer, Westland Environmental Services (Edmonton, AB) has supplied medical waste incinerators to several municipalities in Nunavut and the Northwest Territories. However, all the medical waste incinerators include a scrubber because plastics are part of their normal waste stream. The Doris camp incinerator does not have a scrubber so no direct comparison can be made. In an email to the author on November 20, 2009 Mr. Al Lanfranco indicated that his firm has tested several of the medical waste incinerators in the Northwest Territories and Nunavut and they all struggle to meet the CWS for dioxin and furan even though they have scrubbers. Several of the biomedical incinerators have been shut down because they have not been in compliance with the CWS for dioxin and furan emissions and they are located in populated areas.

Under the authority of the Canadian Environmental Protection Act (CEPA 1999) Environment Canada lists various air emissions through the National Pollutant Release Inventory (NPRI) system. Any incinerators incinerating greater than 26 tonnes of non-hazardous solid waste per year must report emissions of dioxin, furans, hexachlorobenzene, and mercury under the NPRI. For more information, please see www.ec.gc.ca/inrp-npri/.

No facilities in Nunavut were required to report their dioxin and furan emissions to the NPRI system in 2008. Interestingly, the three diamond mines in the Northwest Territories (Snap Lake, Ekati and Diavik) reported no dioxin and furan emissions in 2008 and we believe that each of these operations incinerates their camp waste. The Ekati facility has a domestic waste segregation program that separates batteries, aerosol cans and recyclable drinking containers from the other waste that reports to the incinerator. The current waste segregation program at the Doris North camp separates the following items from the waste that reports to the incinerator: aerosol cans, used batteries, fluorescent light bulbs, chemicals, waste oil and fuel and painted or preserved/treated wood waste.

Incinerator Operating Conditions for the First Round of Testing

A set of specific operating conditions were recommended by the incinerator manufacturer and were implemented during the 2009 emissions testing campaign. Prior to waste introduction, the secondary chamber was pre-heated to approximately 900°C, and the primary chamber was pre-heated to 650°C. Once the primary and secondary chambers reached the set-point operating temperatures, waste was manually introduced to the primary chamber via the main charge door. Approximately 10 to 15 kg of waste comprised of one wet and one dry bag of "waste" were loaded at about 90 to 110 minute intervals. Incineration of the waste proceeded until the next waste charging sequence occurred. In general, the system was allowed to stabilize for about ten to fifteen minutes prior to the start of the stack emissions sampling.

Maintenance of the Doris incinerator has been an ongoing issue. During the first incinerator stack emissions testing campaign the secondary burner for the Doris incinerator was cycling on and off on a regular basis. The secondary burner would operate for 4 to 5 minutes and then shut off for approximately 1 minute. As a result the stack gas temperatures were not consistent during the collection of the samples.

Before the stack emissions testing began for dioxin and furan the manufacturer of the Doris camp incinerator (Westland Incinerators, Edmonton, AB) recommended that the temperature in the secondary chamber be maintained above 850°C. Generally the stack gas temperatures were at or above 850°C for run #1, however during the second traverse the stack gas temperature dropped to approximately 650°C during two of the twenty four sample points. The stack gas temperatures for run #2 were more variable. During the first traverse there were 2 sample points with a stack gas temperature below 650°C. During the second traverse there were 6 sample points below 800°C. The stack gas temperatures for run #3 were all near 850°C or higher.

Other than the problems with the secondary burner there were no other operational issues observed during the 2009 stack emissions sampling program.

<u>Potential Reasons why the Doris Incinerator Failed the 2009 Dioxin and Furan Tests</u>

The most likely cause of the high dioxin and furan emissions during the 2009 stack testing program was the secondary burner cycling on and off. Research into dioxin emissions from combustion sources has generally shown that dioxin is formed in two manners. The first mechanism is known as the "Precursor mechanism" where there is incomplete combustion and dioxin is formed by reactions of chlorine and organic aromatic compounds. The second mechanism is known as "DeNovo Synthesis", where dioxin formation reactions occur post-combustion, in the air pollution control systems at temperatures between 200 and 450 °C.

One possible indicator of dioxin generation is carbon monoxide (CO). CO is present as a product of incomplete combustion, and can often predict emissions of elevated dioxin. In this case, the technicians were able to measure CO levels, and found that on occasion the instantaneous CO concentration was greater than 500 ppm. A well tuned incinerator with a properly functioning secondary combustion chamber usually emits CO at 0 to 10 ppm (perhaps slightly higher with diesel firing) (Al Lanfranco 2009).

Because of the occasional high CO spikes, it is possible that the dioxin formation mechanism at Doris Camp is predominantly by precursor formation. DeNovo formation seems unlikely due to the high secondary temperatures maintained throughout the sampling periods.

Summary of Incinerator Best Management Practices (BMPs)

The best management practices (BMPs) aimed at demonstrating a determined effort to reduce dioxin and furan levels from the Doris incinerator (and limiting the annual waste throughput to a level below the 26 tonne threshold) are described below.

The CWS for Dioxins and Furans proposes the following pollution prevention strategies (CCME 2001):

- waste diversion initiatives to minimize the generation of wastes destined for disposal (waste reduction, material reuse options);
- waste segregation initiatives aimed at materials with greater potential to generate emissions of dioxins and furans or other air pollutants of concern (e.g., mercury, other heavy metals) and aimed at diverting those wastes to recycling or other non-incineration disposal options;
- combustion control strategies to optimize performance of existing combustors at destroying pollutants of concern; and
- use of alternative disposal or treatment technologies (e.g., anaerobic digestion of wastes with material recovery and combustion of biogas).

In a review of the CWS Standards for Dioxins and Furans in 2007 (Chandler 2007) a series of recommendations were made by the Dioxins and Furans Incineration CWS Review Group regarding batch incinerators in remote locations. These recommendations suggest that:

- The company/department should take appropriate measures to ensure good operation and provide adequate records of such operation;
- The company/department should only use incinerators that are equipped with monitoring equipment (temperature probes, differential pressure meters and auxiliary fuel flow) to ensure that proper operation is maintained. The monitoring equipment should be connected to a computer which will continuously log the data recorded;
- All installations should install weigh scales to record the weight of each load charged to the incinerator to prevent over loading;
- All data from these systems should be available to inspectors;
- The computerized data acquisition equipment should be integrated with all the operating controls of the incinerator in a manner that would facilitate remote access to the data to enable the manufacturer to assist the operator with trouble shooting the operation;
- Operators should be trained, either through an appropriate site specific training program or through a certification program provided by a qualified body;
- Operators should be instructed to distinguish between broad categories of waste, in terms of their calorific value, and be given clear instructions on how much from each category is suitable for charging to the primary chamber for a given batch; and

- All facilities should be required to file, with the appropriate regulatory authority, their annual waste throughput data. This filing should include details on the quantity and disposition of residues discharged from the facility.

Environment Canada (EC) has released an overview document outlining its six-step process for batch waste incineration on its website. The entire technical document was to be released on the EC website in fall 2009; however the document summarized below (EC 2009) was accessed through the Mackenzie Valley Review Board website. The steps are appropriate for incinerators handling batch loads from 50 to 3,000 kg/batch. The six steps are outlined below; for more specifics see the document cited in the references.

Step 1 – Understand Your Waste Stream

EC suggests the completion of a waste audit to:

- Determine the quantity of waste generated in the various parts of an operation;
- Characterize the waste from each type of operation; and
- Examine the waste stream to determine what opportunities exist for reducing the quantity of waste generated; reusing materials; and recycling as much as possible before considering disposal.

Step 2 - Select the Appropriate Incinerator (or Evaluate the Existing System)

As part of this step, EC recommends facilities with existing incinerators; owners/operators reassess the suitability of the existing system to manage the current waste stream.

- At facilities incinerating more than 26 tonnes of waste per year, dual chamber controlled air incinerators are the recommended configuration. These systems are capable of incinerating a wide range of wastes and, when properly maintained and operated, will achieve emissions of dioxins and furans below the level of the CWS. These systems should be equipped with a large secondary chamber sized to provide a residence time of at least one second at a temperature higher than 1000°C, to ensure complete combustion and minimize dioxin and furan emissions. During the late September early October 2009 Doris incinerator emissions baseline testing program the stack gas temperatures were rarely above 900°C.
- For facilities incinerating less than 26 tonnes of waste per year, EC again suggests "determined efforts" as defined in the CWS for dioxins and furans should be undertaken. Should circumstances restrict the ability to use a dual-chamber incinerator with a large secondary chamber, a single chamber incinerator with an afterburner should be used. It should be noted that such systems are less likely to be able to meet the emission standards than dual chamber incinerators.
- It is also noted that if the unit is unlikely to process 26 tonnes of waste per year, and a smaller secondary chamber is chosen, additional care must be taken in ensuring the correct types of wastes and volume of material are charged to the primary chamber. This will reduce the possibility of high dioxin and furan emissions.

Step 3 - Properly Equip and Install the Incinerator

EC suggests the following when considering the incinerator system:

- The system should be equipped with a scale to measure the weight of all materials charged to the incinerator and a computerized process control and data acquisition system to store operating data from the incinerator.
- Operational data should be collected and stored, at a minimum, every minute that the system is operating. The intent is to be able to summarize operating parameters during start-up, operation and cool-down for every cycle. The parameters suggested for continuous monitoring are temperature, differential pressure in the primary chamber, auxiliary burner operation, fan amperage, and the status of the system interlocks. From this information, operating procedures can be adjusted to improve performance. Provisions should be made for the manufacturers to be able to remotely access and review the operating data for trouble shooting purposes.
- Stacks should be properly designed to ensure that emissions can freely disperse in the atmosphere and not be re-entrained into fresh air intakes on nearby buildings.
- It is highly recommended that batch incinerators not be equipped with heat recovery devices.
- Air pollution control systems are not recommended for batch waste incineration systems to control dioxin and furan emissions. Stack gases should be released directly to the atmosphere at temperatures higher than 700°C to reduce the chances of the inadvertent formation of dioxin and furan through the de novo synthesis process.
- If it is necessary to introduce additional waste to the incinerator during the burn cycle, the incinerator should be equipped with a ram charge system to limit the disruption of combustion in the primary chamber during the waste charging process. The feasibility of applying this mitigation to the Doris incinerator is limited due to the cost of a ram charge system and the relatively small amount of waste processed. Based on the first round of emissions testing the estimated weight of waste burned every 3 hours was 20 kg.

Step 4 – Operate the Incinerator for Optimal Combustion

Since air pollution control systems are not recommended, operating the incinerator for optimal combustion is the most efficient means of reducing dioxin and furan concentrations. EC suggests:

- Wastes received at the incinerator building should be separated according to their heating value characteristics: wet or low-energy wastes (e.g. food waste); mixed wastes with average energy values; and other materials with high energy values, such as oily waste materials. To facilitate this separation, all waste should be collected in transparent bags. To further assist with separation, wastes could be collected in coloured-coded bags.

- The operator should select waste from each category and mix it to achieve the manufacturer's specified input calorific value. Each bag should be weighed, its source should be noted, and the total weight of each category should be tallied before completing the loading. This information should be recorded by the computerized data acquisition equipment installed with the incinerator.
- Batch incinerator systems have limited charging capacity (both in terms of waste quantity and the calorific value of the waste charge). To assist the operator with the charging task, particularly for smaller incinerators, several batches could be weighed and placed in their own containers prior to loading the incinerator. The same weighing and logging procedures should be used for each batch and, once recorded, the batch can be charged when appropriate.
- When the incinerator is charged with the appropriate mix and quantity of waste, the operator should close the door, ensure all interlocks are engaged, and start the burn cycle. The operator should observe the burn for at least 15 minutes after ignition of the primary chamber burner to ensure the volatility of the waste charged is not creating too much gas for the secondary chamber to handle. The rate of combustion can be slowed by reducing the quantity of under-fired air. The primary chamber should be operated in the temperature range specified by the manufacturer (typically 500°C to 800°C). (For more information on controlling the temperature and other advice for operators, including a list of do's/Don'ts for incinerator operation, please see EC (2009).
- The burn cycle should not be interrupted by opening the charging door until after the burn is complete and the unit has cooled down. No additional waste should be added to the primary chamber unless the incinerator is equipped with an appropriate ram feed device.
- The operator should remove the ash from the previous burn cycle before reloading the incinerator. Any unburned materials found in the ash should be recharged to the primary chamber after the operator has cleaned the air ports, and before putting a fresh charge into the incinerator.
- Operators should be properly trained by the incinerator manufacturer. The training course should include, as a minimum, the following elements:
  - System safety including identification of hazards that the operator should recognize;
  - Waste characterisation and how waste composition can affect operation;
  - Loading limitations, including materials that should NOT be charged to the incinerator, and the allowable quantities of different types of wastes that can be charged;
  - Start-up procedures for the incinerator and the normal operation cycle;
  - Operation and adjustment of the incinerator to maximise performance;
  - Clean out procedures at the end of the cycle;
  - Troubleshooting procedures;

- Maintenance schedule; and
- Record keeping and reporting.

Step 5 - Safely Handle and Dispose of Incinerator Residues

EC warns that ash from the primary chamber of the incinerator can contain materials deleterious to the operator's health and the environment. It is recommended that:

- Operators should use personal protective equipment when handling this material. The material should be carefully removed from the hearth and placed in covered metal containers suitable for transporting the ash to an approved disposal site.
- The operator should weigh, and maintain records of, the quantity of ash produced.

Step 6 - Maintain Records and Report

In order to demonstrate the efforts that are made to ensure proper operation and maintenance of the incinerator, EC suggests the facility maintain records and prepare an annual report containing at least the following information:

- A list of all staff who have been trained to operate the incinerator; type of training conducted and by whom; dates of the training; dates of any refresher courses;
- All preventative maintenance activities undertaken on the equipment;
- Records of operation of the incinerator - in electronic format with full data backup;
- Summarized annual auxiliary fuel usage;
- A list of all shipments of incinerator residues, including the weight transported and disposed of by type if necessary, and the location of the disposal site;
- Results of any emissions measurements or any ash sampling data collected during the period;
- All raw data records from the operation of the incinerator should be retained for inspection by the appropriate authorities for the period designated by those authorities, or for at least 2 years; and
- It is important to note that any incinerators incinerating greater than 26 tonnes of non-hazardous solid waste per year must report emissions of dioxin, furans hexachlorobenzene, and mercury under the NPRI. For more information, please see www.ec.gc.ca/inrp-npri/.

Implementation Schedule for Adaptive Management Strategy for Incinerator BMPs

As demonstrated by the BMPs from CWS and EC for small waste incinerators the primary focus at the Doris Camp incinerator should be reducing and properly segregating waste products. In addition, the waste should be incinerated under optimal combustion conditions to limit the amount of dioxins and furans being emitted. Hence, the problems with the secondary chamber cycling on and off should be addressed. The secondary burner should be on all the time to ensure adequate mixing/turbulence and the temperature should be maintained above 850 or 900°C to promote complete combustion.

To determine whether or not the Doris incinerator processes greater than the CWS threshold of 26 tonnes per year a monitoring program should be implemented and the weight of waste incinerated each day should be recorded. If the incinerator were re-located inside of a building it may improve the combustion efficiency because the internal temperatures would be easier to maintain when the door is periodically opened and closed to allow a new batch of waste to be processed. A formal record keeping system for the operation and maintenance of the incinerator should be instituted. In addition a datalogger should be connected to the incinerator control system to track the temperature in the secondary chamber when waste is being incinerated.

The Doris camp incinerator is not designed to burn biosolids from the camp's sewage treatment plant so this waste stream should be removed. This will not necessarily reduce the dioxin/furan emissions but will reduce metals emissions.

Following consultation with government regulators on these issues it is recommended that an incinerator management plan be prepared at the end of Q2 2010 to provide the framework for implementing these adaptive management strategies. The recommendations listed above could be implemented by Q3 2010. A follow up stack testing campaign could be implemented in Q4 2010 to determine the effectiveness of these recommendations.

References

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