Confidential

File Note

October 5, 1995

Re: Roaster Stack Air Dispersion Mechanical Feasibility Study

This study has been completed by Dillon Engineers in Yellowknife. The report will form part of the basis for discussions proceeding during the 4th quarter 1995, with GNWT and Environment Canada, regarding development of emission regulations for SO_2 and arsenic.

Dave

David Anthony
Manager - Environmental Services
NWT Division

cc Sadek El-Alfy
Larry Connell
John Stard

FAX - 7 pages

DILLON
Consulting Engineers • Planners
Environmental Scientists

Our File: 95-3018-01

September 19, 1995

Royal Oak Mines
Giant Mine Site
P.O. Bag 3000
YELLOWKNIFE, Northwest Territories
X1A 2M2

Attention: Mr. D. Anthony

Roaster Stack Air Dispersion
Mechanical Feasibility Study

Dear Mr. Anthony:

Dillon Engineering is pleased to submit our findings for the Roaster Stack Air Dispersion Mechanical Feasibility Study. This work is a follow-up to the Air Dispersion Modelling report that was completed by Dillon in March 1995 for Royal Oak Mines.

Background

The scope of work for the mechanical feasibility study, as outlined in our letter proposal dated August 1, 1995, included the following items:

- Complete a feasibility assessment of making hardware changes to the roasting gas exhaust ventilation system stack discharge parameters of stack height, exit gas temperature, and exit gas velocity.
- Order of magnitude cost estimates for changes in each of the three stack discharge parameters.
- Identify alternative bag types that will reduce arsenic emissions in the baghouse.

The results of this study will be used to complete further air dispersion modelling. The remaining sections of this report outline our findings.

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Discussion

Increased Stack Height

Sensitivity analysis during the air dispersion modelling assignment indicated that increases in stack height have a very positive effect on dispersion of SO_2 from the stack. The sensitivity analysis showed that doubling the stack height to 300 feet resulted in a 40 to 45 percent reduction in SO_2 ground-level concentrations.

Custodis-Cottrell, a well-known chimney fabrication company, was contacted and options were discussed for increasing the height of the existing stack, which is a 150-foot-high, 9-foot-diameter brick structure constructed in 1955 by the Taylor Engineering Construction Company of Toronto. The two basic options that exist are to extend the existing stack and to construct a brand new stack.

The amount of extension that can be installed on the existing stack is dictated by the capability of the existing stack foundation to withstand the increased deadload and overturning moments from the extension. Based on their experience, Custodis-Cottrell recommends a maximum extension of 30 to 35 feet to the existing stack, bringing the overall stack height to approximately 180 feet. Steel construction is recommended for this extension as it is easier to construct and will add less weight to the overall foundation load than if the extension were of brick construction. An order of magnitude cost to design, supply, and install a 30 foot stack extension is $100,000.

If greater overall stack heights are required, a new stack is required. Order of magnitude costs for a new 200 foot stack and foundation are in the range of $500,000 to $700,000, according to Custodis-Cottrell. A 300 foot stack would be in the range of $1.25 million to $1.5 million. Construction costs are quoted FOB Yellowknife. Costs are based on an insulated steel stack, complete with liner and concrete foundation. The stack would typically consist of a number of straight sections of stack separated by cones that would reduce in diameter as the stack got higher. A height of 300 feet is at the limit for a reasonably priced installed steel stack.

Costs for stacks greater than 300 feet in height rapidly escalate due to the requirement for different types of materials and construction methods. Mr. John Nolan of Custodis-Cottrell advised that a 350-foot-high stack was installed at Inco in Sudbury and it consisted of a 50-foot-high concrete pedestal and a 300-foot-high steel stack. Order of magnitude costs to provide something similar or higher (400 feet) for Royal Oak Mines would be in the range of $2.0 million to $2.5 million.

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Operating and maintenance costs associated with either an extension to the existing stack or a brand new stack would change very little. Although there would be a nominal increase in fan motor horsepower to overcome the increased friction loss within the stack extension or new stack, it is believed that this could be accommodated within the normal range of operation for the existing stack discharge fan motor.

Increased Exit Gas Temperature

The exhaust gas temperature at the stack discharge fan and stack is currently maintained at 230°F. This is the maximum temperature that can be maintained in the baghouse that will allow precipitation of arsenic trioxide and not result in damage to the bags themselves, which have a maximum temperature rating of 260°F.

Sensitivity analysis during the air dispersion modelling assignment indicated that increases in exit gas temperature have a very positive effect on dispersion of SO_2 from the stack. The sensitivity analysis showed that the greater the temperature increase of the exhaust gases, the greater the reduction in SO_2 ground-level concentrations. Incremental temperature increases of 50°F, 100°F, 150°F, and 200°F were reviewed, and it was found that a 50 to 60 percent reduction in SO_2 ground-level concentration could be achieved in the summer months, for a 200°F temperature increase. Temperature increases of 150°F, 100°F, and 50°F had a correspondingly lesser impact on reducing SO_2 ground-level concentrations.

For the purpose of this mechanical feasibility study, the maximum temperature increase of 200°F was used for equipment requirements and sizing. The basic approach for increasing the exit gas temperature is to provide a propane-fired heater in the ductwork downstream of the baghouse and upstream of the existing stack discharge fan. The duct heater would be sized to provide a temperature increase of 200°F, raising the exhaust gas exit temperature to approximately 430°F. From discussions with fan manufacturers, operating in the temperature range of 430 to 450°F is reasonable and can be accomplished without significant changes in the materials or construction of the fan unit.

In addition to the propane-fired heater, it is proposed that a new stack discharge fan also be installed and that both components be located in a new pre-engineered insulated metal building. The age of the existing stack discharge fan and doubts regarding its capability to handle the higher temperatures result in the decision to install a new fan rather than to try and modify and reuse the existing unit.

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The new fan and heater building (approximate dimensions 30 feet x 30 feet x 15 feet high) would be located in the same general vicinity as the existing fan building. Modifications would be required to the existing exhaust ductwork to tie in and feed to the new fan. Similarly, ductwork modifications would be required to connect the new fan discharge to the stack.

A larger propane supply system would also be required to feed the propane-fired air heater. In discussion with ICG Propane, the larger propane supply system would incorporate one 30,000 USG storage tank, pressurizing pumps, and vaporization and regulation equipment to provide the propane gas at sufficient volume and pressure to the air heater.

Order of magnitude costs for a system upgrade of this type is $525,000, roughly broken down as follows:

Stack discharge fan	$ 50,000
Duct air heater	75,000
Pre-engineered building (including heat and lights)	150,000
Ductwork changes	75,000
Propane supply system	25,000
Electrical and other	$150,000
TOTAL	**$525,000**

Additional operating costs to the mill for this system include the power for the new fan motor and the propane gas for the heater. Fan motor energy costs would likely be equivalent to the existing stack discharge fan it would replace. Use of a high-efficiency motor could result in an overall reduction in motor energy cost. Additional operating costs for propane are presented in the next paragraph.

Based on discussions with BCF Associates of Toronto, the new heater would have a 10 million BTU input, and at the current propane cost to the Mine of 19.1 cents per litre, propane operating costs would be $80 per hour of heater operation. If the roaster operates 75 percent of the time, propane costs would amount to $525,000 annually based on 8,760 hours per year.

If the temperature increase was reduced to 50°F, 100°F, or 150°F, the equipment and capital costs would not change significantly. However, operating costs for the propane fuel would change because the cost for fuel is directly related to the desired temperature increase. Operating costs for different temperature rises follow.

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Temperature Increase Above 230°F	Annual Propane Costs
50°F	$131,000
100°F	$262,000
150°F	$393,000
200°F	$525,000

Increased Exit Gas Velocity

The existing exit gas velocity from the 9-foot-diameter stack is roughly 9 feet per second (fps) based on 35,000 cfm currently being discharged up the stack. The relationship between flow rate and velocity is as follows:

Flow rate, cfm = stack area, ft^2 x velocity, fpm
where area = 0.785 x dia^2

This exit velocity is considerably less than the recommended guideline values of 50 to 60 fps, which are required to ensure the exit gas stream has sufficient momentum to carry it into the atmosphere and achieve optimum dispersion.

The scope of work for this mechanical feasibility study was to increase the exit gas velocity either by increasing the stack air flow rate or by reducing the stack diameter.

However, the sensitivity analysis of the original air dispersion modelling study showed that increases in exit gas velocity resulted in no reduction in SO_2 ground-level concentrations and the report concluded that "the plume rise is buoyancy flux dominated." Mr. Ron Hillburn, who performed the original air dispersion modelling, indicated that momentum (i.e., velocity) changes are not effective in achieving greater dispersion in this case because the plume is constrained by the upper layer of free-flowing atmosphere, which is a meteorological condition of the Yellowknife area. Based on his knowledge of dispersion and modelling, he stated that pursuing options for increasing the exit gas velocity from the stack would not be beneficial in this case. He recommended that increased stack height and increased exit gas temperature should be focussed upon to achieve greater dispersion of the exhaust gases. Based on this recommendation, no options were investigated for increasing the exit gas velocity.

Alternative Bag Types for Baghouse

The existing bag type used in the baghouse is not effective in capturing all the arsenic trioxide that precipitates in this equipment, according to mill personnel responsible for the operation and maintenance of the baghouse.

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The existing bags, which are supplied by Crosible Filtration Ltd., are fabricated from Drelon fabric, and are 5 inches diameter and 127 inches long. The approximate cost per bag is $20.00, expected bag life is one to two years, and delivery from the supplier is three to four weeks.

Mr. Phil Golding of Crosible Filtration Ltd. advised that Drelon fabric bags are the best choice of the acid-resistant materials, considering cost, bag life, and availability. Other acid-resistant materials that could also be used include Teflon and Ryton. Both materials will give marginally better bag life of approximately three years, but at five to six times the cost of Drelon. Availability of Teflon and Ryton is more limited, with typical delivery time from suppliers of 10 to 12 weeks.

Conclusion

This report presents options and order of magnitude cost estimates for changes in the stack discharge parameters of stack height and exit gas temperature of the roaster exhaust ventilation system at Royal Oak Giant Mine. Options for increasing exit gas velocity were not investigated based on recommendations of the air dispersion modelling expert. As well, alternative bag types were identified for use in the baghouse.

We trust this report addresses the objectives outlined in the scope of work for this assignment. We have enjoyed working with Royal Oak Mines on this project and look forward to serving you again in the future.

Yours truly,

M. M. DILLON LIMITED

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