



File 455-10-13

Occupational Health Division,
Environmental Health Centre,
Ottawa 3, Ontario.

December 7, 1970.

Mr. S. Homalos,
Indian Affairs and Northern
Development Department,
Room 1350,
Centennial Tower,
400 Laurier Ave. W.,
Ottawa 4, Ontario.

Dear Steve:

Stack Sampling Procedure at Giant
Yellowknife Mines Limited.

You asked for a complete description of the sampling procedure and subsequent calculations that we used to determine the efficiency with which Giant was collecting arsenic from its roaster gases. We used equipment bought from Western Precipitation Inc. (now called Precipitation Division of Joy Manufacturing Company); the equipment sampling method and calculations are all described in their Bulletin 40-50 entitled, "Methods for Determination of Velocity, Volume, Dust and Moist Content of Gases". A copy of the latest edition (7th) is enclosed for you to send to Giant. In the following, description of references to page numbers, tables, figures and equations relate to this bulletin. To make it easier to follow the description, I have attached a page of nomenclature.

Summary of method

Using the method of equal areas illustrated in figure 2, (page 11), we selected 12 measuring points along one diameter of the stack. The sampling ports on the other diameter at right angles to the first had corroded and could not be opened. We determined the gas velocity at each of the 12 points, then sampled for ten minutes at each of these same points using the same sampling filter for the whole test. The rate of sampling at each point was adjusted so that the velocity of the gas entering the sampling

Mr. S. Komalos.

December 7, 1970.

nozzle was the same as the previously determined velocity of the stack gas at that point (isokinetic sampling). The filter was then taken back to our laboratory in Ottawa where "a", the total weight of arsenic in the sample, was determined chemically. Daily operating data supplied by Giant enabled us to calculate "TA", the total weight, in tons, of arsenic going to the cleaning plant (Cottrell + Haghouse) on each day that we took samples.

From T_v , V_t (total volume of gas sampled in cubic feet converted to flue conditions) $V_{s,avg}$ (average velocity of gas in the stack in feet per minute) and A (stack area in square feet), we calculated the percent loss of arsenic to the atmosphere. Collection efficiency = $100\% - \%$ loss.

Velocity determination

The stack gas contained considerable dust which would have plugged the static holes in a standard pitot tube. We therefore used a Type S double pitot tube (figure 5, page 14) which was made for us in the Giant shops. The overall length required was about 13 ft. - 9ft. inside stack diameter, 3 ft. stack wall thickness plus a few inches projection of the sampling port outside the stack wall.

The stack was said to have an inside diameter of 107". Sample station locations were, therefore, read directly from table 1, (page 34), using the figures for a 108" diameter stack, and marked on the pitot tube. Velocity pressures at each station were read on an inclined draft gauge and the corresponding velocities of flue gas then calculated by equation 4, (page 6), using a value of 0.85 as the correction factor, k_s , for the double pitot tube. For V_s in feet per minute, the equation became: -

$$\begin{aligned} V_{s, fpm} &= 2.90 \times 60 \times 0.85 \sqrt{hT_s} \\ &= 147.9 \sqrt{hT_s}. \end{aligned}$$

where h is the velocity pressure in inches of water and T_s is the stack gas temperature in degrees Rankine. At the end of the traverse the 12 values were averaged to give $V_{s,avg}$.

Usually we found that the average of the six velocity measurements made on one side of the stack center differed appreciably from the average

Dr. E. H. H. H.

December 7, 1970.

of the six velocity measurements made on the other side of center. The following are results from tests done in 1960: -

Sample no.	Date	Average fpm		
		Stations 1-6	Stations 7-12	Difference
1	10 July, 1960	877	1003	126
2	10 " "	901	1073	172
3	11 " "	784	969	185
4	11 " "	941	1141	200
5	12 " "	911	1054	143
6	12 " "	883	959	76
7	12 " "	905	1026	121
8	13 " "	945	1053	108
9	13 " "	907	1001	94

Station 1 was nearest the sampling point; Station 12 was furthest. Readings taken at the stack center were not used in calculating the averages.

There was considerable fluctuation in the draft gauge reading at any one point requiring a lengthy observation before a reasonable average value could be estimated. The complete velocity traverse usually took an hour or more. A complete sampling traverse then took a further two hours, during which time the velocities in the stack might have changed, which would have invalidated our calculations for isokinetic sampling conditions. We therefore made two improvements in technique. To improve the accuracy of estimation of the velocity pressure, we replaced the draft gauge with a calibrated differential pressure meter and fed the output of the meter to a recorder. To reduce the time lag between measuring the velocity at a station and taking a sample at that station, we put the sampling probe and the pitot tube into the stack together, with the pitot tube pushed in one station further than the sampling probe. With the sampling probe operating at station 2, for instance, the pitot tube was put at station 3 and the velocity

Mr. S. Homan.

December 7, 1970.

pressure readings recorded for two to three minutes. These were averaged visually and the velocity calculated; the volume flow rate through the sampling probe nozzle that was necessary to produce isokinetic conditions was then calculated and the corresponding setting for the orifice meter determined (see under Sampling Procedure). After exactly ten minutes sampling at station 2, the probe was pushed to station 3 and the orifice meter adjusted to the previously determined setting. The pitot tube was pushed to station 4 and the whole process repeated. The time lag between determining velocity at a station and sampling at the same station was thus reduced to ten minutes.

Sampling Procedure

essentially, we used the equipment shown in Figure 6, (page 19), with a paper filter thimble holder, curved filtration tube and $\frac{1}{2}$ " diameter nozzle (Figure 9, page 20), instead of the aluminum thimble holder shown in Figure 8; instead of the vacuum pump shown, we used the vacuum line available in the sampling house. We did not weigh the paper thimble because we determined it (total weight of aerosols collected) by chemical analysis. The complete sampling probe was about 13 ft. long.

We would have preferred to move the filter holder at the end of the probe nearest the rubber hose so the filter would not have been subjected continuously to the stack temperature. However, a lot of dust would then have deposited in the probe before it reached the filter and would have had to be removed and added to the dust in the filter; this would have presented physical problems and introduced errors because it would be almost impossible to get all of the dust out of the pipe. Consequently, we used a short curved filtration tube (Figure 9, page 20) on the inlet side of the filter holder with the nozzle attached to the open end by a coupling; then we attached the necessary length of ordinary iron pipe to the outlet side of the thimble holder. The latter was thus inside the stack at all times.

The meter rate, Q_m , corr., required for isokinetic sampling was determined by use of equations 8, 9 and 10 (pages 6 and 7). The value of h_m (suction at the dry gas meter in inches of mercury) increased with increasing flow rate and with increasing pressure drop across the filter. The highest value we ever found was 1.4" hg; usually it was between 0.5 and 1.3". Consequently, we ignored the pressure correction term in equation 8. The resulting error in calculating Q_m , corr. was therefore about 2 to 5%.

Mr. C. Roulier.

December 7, 1970.

Our procedure was to sample at one station for exactly ten minutes, then push the probe to the next station and sample for exactly ten minutes and so on. We therefore had to be able to adjust the sampling flow rate quickly to the required rate, $Q_{corr.}$, for that station. We managed this by placing a home-made orifice meter in the sampling line between the dry gas meter and the valve on the suction line. We calibrated the orifice meter by plotting $Q_{corr.}$ against orifice meter gauge reading. The setting required to produce any value of $Q_{corr.}$ could then be read quickly from the curve. As soon as we had moved the probe to a new station and adjusted the orifice meter setting by means of its own control valve, we checked the volume rate of flow on the dry gas meter with a stop-watch. The calibration of the orifice meter sometimes changed with increasing pressure drop across the filter; if our check indicated an incorrect flow rate, we adjusted the orifice meter setting and rechecked. Usually we had this all done within two minutes of moving the probe. Then we took our pilot readings at the next station, etc. (as described under Velocity Determinations). Every five minutes, we recorded the orifice meter setting, stack temperature T_s , gas meter temperature T_m , vacuum at the gas meter V_m and the total volume indicated on the gas meter dial V_m . The T_s , T_m and V_m readings during the two-hour sampling run were averaged; barometric pressure was obtained from the local meteorological office at the airport; these values were then plugged into equations 9 and 13 (pages 6 and 7) to give V_t (total cubic feet of gas sampled converted to five conditions.)

From the Plant office, we got daily figures for -

- (a) Tons of roaster feed,
- (b) Percent As in feed,
- (c) Tons of As in feed,
- (d) Tons of calcine,
- (e) Percent As in calcine,
- (f) Tons of As in calcine.

The difference between (c) and (f) was A_s , the tons of As that went to the cleaning plant each day.

Mr. S. Morales.

December 7, 1970.

The cross-sectional area of the stack was 62.45 sq. ft. for
formula for percent loss of gas to the atmosphere times constant -

$$\text{loss} = \frac{24 \text{ hrs.} \times 60 \text{ min.} \times 60 \text{ sec.} \times \text{ft.}^3/\text{min.} \times 62.45 \text{ sq. ft.} \times 100}{\text{ft. cu. ft.} \times \text{lb. tons} \times 907,200 \text{ grains/lb.}}$$

$$= 9.913 \times \frac{\text{ft.}^3/\text{min.}}{\text{lb. tons}}$$

Sincerely,

J. L. Smith

J. L. Smith,
Industrial Engineer.

C.C. Mr. C. L. Ross
Mr. S. Morales 1019

Stamps

ABBREVIATIONS

	=	corrected in cubic feet.
P ₀	=	corrected factor for type of sample taken.
P ₁	=	velocity pressure in inches water.
P ₂	=	barometric pressure in inches of mercury.
P ₃	=	suction at dry gas meter in inches of mercury.
Q _{correct}	=	sampling rate in ft., corrected for the amount of vapor condensed from the sample stream.
T ₁	=	temperature at dry gas meter in degrees centigrade.
T ₂	=	stack gas temperature in degrees centigrade (°C. + 459°).
W	=	total weight, in tons, of arsenic (As) going to the cleaning plant (Cottrell plus sulphur).
V ₁	=	volume of gas sample as measured by the gas meter in cubic feet at meter conditions.
V ₂	=	stack velocity at any point, in feet per minute.
V ₂ avg	=	average stack velocity in feet per minute.
V ₃	=	total volume of gas sampled, in cubic feet, converted to like conditions.
W	=	total weight, in grams, of arsenic (As) in the sample.