FEDERAL REFERENCE METHOD 5
Nozzle Size Selection Worksheet

Note: *The most commonly used equation for estimating isokinetic sampling nozzle diameter is the following (assumes that moisture fraction at dry gas meter equals zero.):*

$$D_{n(est)} = \sqrt{\frac{0.03575\, Q_m\, P_m}{T_m\, C_p\, (1 - B_{ws})} \sqrt{\frac{T_s\, M_s}{P_s\, \Delta p_{avg}}}}$$

Source Name ________________________________ **Date** ____________

Facility ________________________________ **Calculated by** __________

INPUT DATA

Barometric Pressure (in. Hg) = P_{bar} = ____________

Stack Static Pressure (in. H_2O) = P_g = ____________

Stack Gas Pressure (in. Hg)

$$P_s = P_{bar} + \frac{P_g}{13.6}$$

$$P_s = (\quad) + \frac{(\quad)}{13.6}$$ = P_s = ____________

Dry Gas Molecular Weight (lb/lb-mole) = M_d = ____________

assume 30.0 for combustion of coal, oil or gas
assign 29.0 if mostly air
assign 28.0 if mostly purge nitrogen
or use preliminary Orsat or Fyrite data

Stack Gas Moisture (fraction) = B_{ws} = ____________

use preliminary moisture data
use wet bulb/dry bulb if < 212°F
BE CAREFUL: fraction B_{ws} = %H_2O/100

Wet Gas Molecular Weight (lb/lb-mole)

$$M_s = M_d\,(1 - B_{ws}) + 18.0\,(B_{ws})$$

$$M_s = (\quad)(1 - (\quad)) + 18.0(\quad)$$ = M_s = ____________

Stack Gas Temperature (°R) = T_s = ____________

°F + 460 = °R

Pitot Tube Coefficient = C_p = ____________

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(continued)

Average Velocity Head (in. H_2O) = Δp_{avg} = ________________

v = calculation of inside square root term

$$v = \sqrt{\frac{T_s\, M_s}{P_s\, \Delta p_{avg}}}$$

$$v = \sqrt{\frac{(\quad)\,x\,(\quad)}{(\quad)\,x\,(\quad)}}$$ = v = ________________

Sampling Flow Rate (cfm) = Q_m = ________________
assume 0.75 cfm

Dry Gas Meter Temperature (°R) = T_m = ________________
use ambient temp + 25°F + 460 = °R

Dry Gas Meter Pressure (in. Hg) = P_m = ________________
use P_{bar} **+ ($\Delta H_@$)/13.6**

CALCULATION OF NOZZLE SIZE

Estimated Nozzle Diameter (inches) = $D_{n(est)}$ = ________________

$$D_{n(est)} = \sqrt{\frac{0.03575\, Q_m\, P_m\, V}{T_m\, C_p\, (1 - B_{ws})}}$$

$$D_{n(est)} = \sqrt{\frac{0.03575\ x\,(\quad)\,x\,(\quad)\,x\,(\quad)}{(\quad)\,x\,(\quad)\,x\,(1-(\quad))}}$$ = ________________

Actual Nozzle Diameter Chosen (inches) = D_n = ________________

K-FACTOR CALCULATION

ΔH = Isokinetic Rate Orifice Pressure Differential **ΔH = K x Δp**

$$K = \frac{\Delta H}{\Delta p} = 846.72\, D_n^4\, \Delta H_@\, C_p^2\, (1 - B_{ws})^2\, \frac{M_d\, T_m\, P_s}{M_s\, T_s\, P_m}$$

$$K = \frac{\Delta H}{\Delta p} = 846.72\, (\quad)^4\, (\quad)\, (\quad)^2\, (1-(\quad))^2\, \frac{(\ )(\ )(\ )}{(\ )(\ )(\ )}$$ = ________________

Nozzle Size Selection Worksheet
(continued)

CHECK CALCULATIONS FOR SUFFICIENT SAMPLE VOLUME AND ISOKINETIC RATE 90-110%

Stack Gas Velocity (ft/sec) = v_s = ________________
from preliminary velocity run
convert to ft/min **v_s x 60 sec/min** = $v_{s(fpm)}$ = ________________

Estimated Sampling Time (minutes) = θ = ________________

multiply number of traverse points by minutes/point = _________**total min.**

CALCULATION OF ACTUAL SAMPLING RATE

$Q_{m(std)}$ = Actual Sampling Rate (dscm)

$$Q_{m(std)} = \frac{100(1-B_{ws})P_s\, v_{s(fpm)}\, D_n^2}{1039\, T_s}$$

$$Q_{m(std)} = \frac{100(1-(\quad))(\quad)(\quad)(\quad)^2}{1039(\quad)}$$ = ________________

$V_{m(std)}$ = Total Gas Sample Volume to be Collected (dscf)

$$V_{m(std)} = Q_{m(std)} \text{ x } \theta$$ = ________________

Based on applicable regulations for this source:

Will there be sufficient sample volume (dscf)? ☐ **yes** ☐ **no**

Will there be sufficient sampling time (minutes)? ☐ **yes** ☐ **no**

Check Intermediate Isokinetic Sampling Rate

$$\%I_i = \frac{100\, T_s\, V_{m(std)}\, P_{std}}{60\, T_{std}\, v_s\, \theta\, A_n\, P_s\, (1-B_{ws})}$$

$$= \frac{K_4\, T_s\, V_{m(std)}}{P_s\, v_s\, A_n\, \theta(1-B_{ws})}$$

Where K_4 = 0.09450

$$\%I_i = \frac{0.09450(\quad)(\quad)(\quad)}{(\quad)(\quad)(\quad)(\quad)(1-(\quad))}$$ = ________________

Nozzle Size Selection Worksheet
(continued)

Check Final Isokinetic Sampling Rate

$$\%I_f = \frac{100\,T_{s(avg)}\left[K_3\,V_{lc} + \left(\frac{V_{m(tot)}}{T_{m(avg)}}\right)\left(P_{bar} + \frac{\Delta H}{13.6}\right)\right]}{60\,\theta\,v_{s(avg)}\,P_s\,A_s}$$

Where $K_3 = 0.00269$

$$A_s = \left(\frac{\pi}{144}\right)\left(\frac{D^2_{n(act)}}{4}\right)$$

$$\%I_f = \frac{100(\quad)\left[(0.00269)(\quad) + \left(\frac{(\quad)}{(\quad)}\right)\left((\quad) + \frac{(\quad)}{13.6}\right)\right]}{60\,(\quad)(\quad)(\quad)(\quad)} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$