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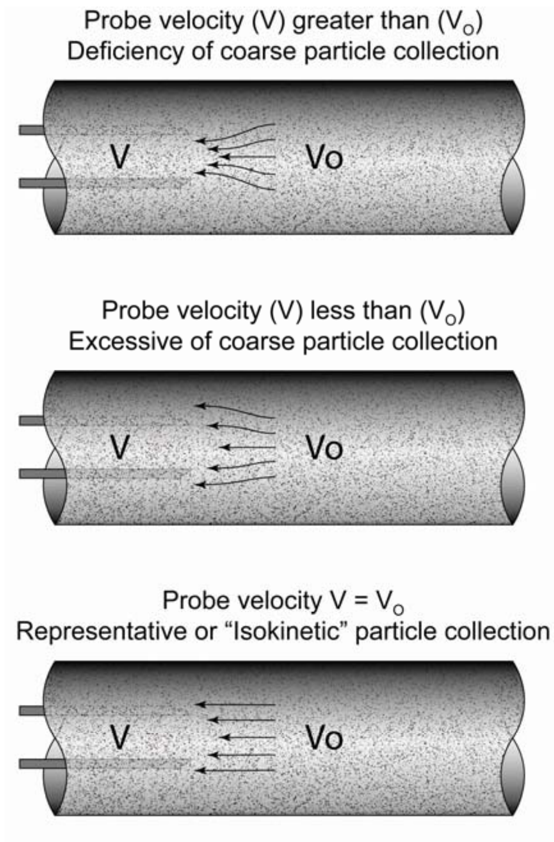
ISOKINETIC FLYASH SAMPLE COLLECTION AND ANALYSIS

A flyash sample is said to be collected "Isokinetically" when the velocity of the dust laden gas flow entering the flyash probe collection nozzle is equal to the velocity of the gas flow in the duct. It is extremely critical velocities be equal if a representative sample of ash is to be collected. If sampling velocity is lower than duct velocity (sub-isokinetic), the collected sample will be skewed with a higher percentage of coarse particles. If the collection velocities are higher than duct velocities (super-isokinetic), a disproportionately high quantity of fine particles will be collected. Figure 1 illustrates the effect of sub-isokinetic and super-isokinetic sampling.

Figure 1 - Isokinetic Sampling opposed to Non-Isokinetic Sampling

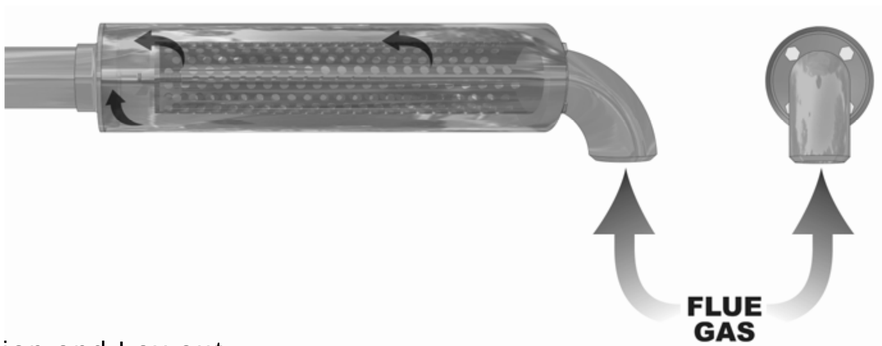


Flyash Loss on Ignition (L.O.I.) or unburned Carbon level is indicative of combustion efficiency. For this reason, an "in-situ" flyash sample is frequently extracted for diagnostic or quantitative reasons. Two types of duct inserted flyash samplers are utilized to collect flyash samples; these are High Volume Samplers and Isokinetic Samplers. The High Volume Sampler is expedient and simple, and is usually used for diagnostic purposes or periodic monitoring of flyash L.O.I. The High Volume Sampler collects a larger bulk sample than the Isokinetic Sampler, allowing shorter collection time. Additionally, its simplicity requires little training or expertise of persons performing the test. In some cases, a more accurate sample must be collected for contractual specification, compliance with flyash sale restrictions or dust loading. In these cases, an Isokinetic Sampler must be utilized.

For collection of an Isokinetic flyash sample, we have found the ICT "Isokinetic Flyash" probe to be a reliable, efficient means of accomplishing this goal. The Isokinetic Flyash probe uses a three-hole "Fecheimer" head to measure velocity head and an "in-line" calibrated square-edged orifice to maintain the required sampling velocities. The Isokinetic Dust (Flyash) Sampler is illustrated by Figure 2 on the following page. A High Volume Flyash Sampler is also illustrated by Figure 3 on the following page.

Figure 2 - The ICT Isokinetic Flyash Type Dust Sampler

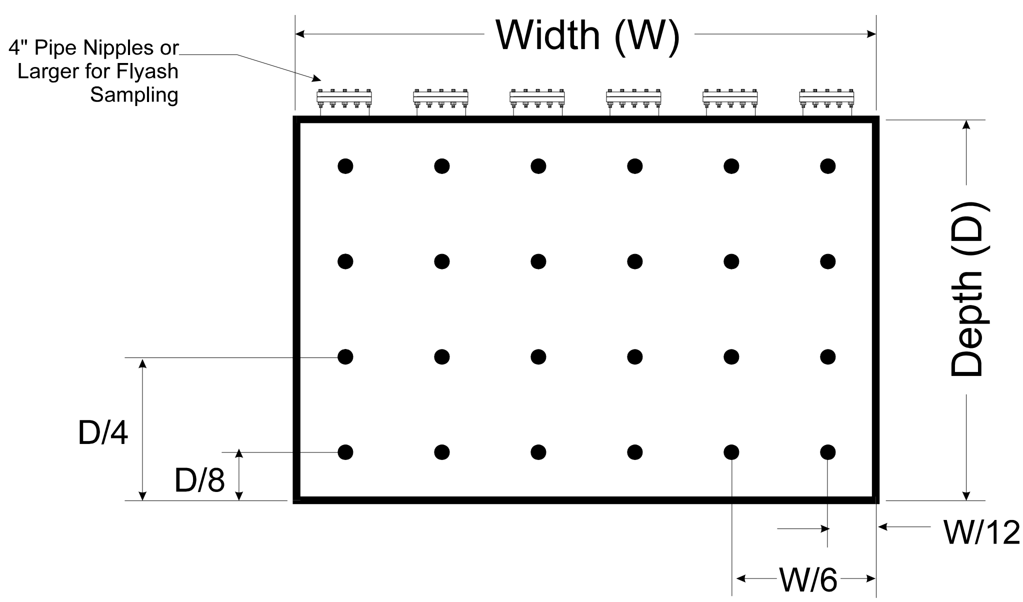
Figure 3 - Flue inserted High Volume Flyash Sampler



Test Tap Location and Lay-out

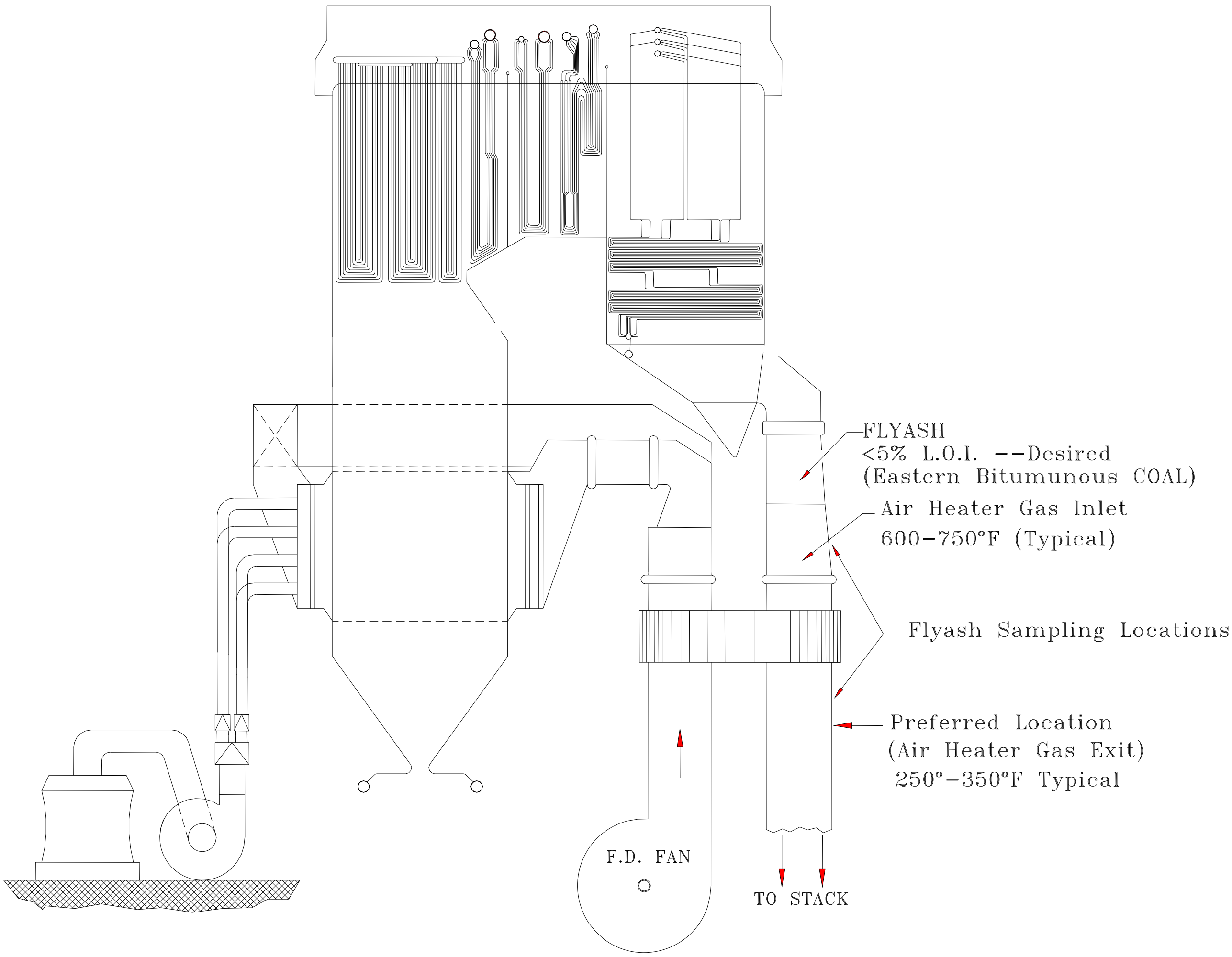
According to the ASME Test Code PTC 38 “Determining the Concentration of Particulate Matter in a Gas Stream”, test tap layout should ideally be such that sampling access ports and traverse points are selected to permit sampling in zones of equal areas. The traverse grid should facilitate at least one traverse point for every 9ft². For example: a 12’ × 36’ duct with a cross-sectional area of 432ft² will require a minimum of (48) traverse points. The traverse grid should be located in a straight run of ductwork (constant cross-sectional area), preferably a vertical run, in order to minimize stratification of the medium. In addition, the traverse grid should be located a minimum of eight (8) duct diameters downstream and two (2) duct diameters upstream from the nearest flow disturbance. Since these criteria are often impossible to meet, test taps are generally located in the “best possible” location. This is acceptable if all parties involved in the testing agree. Adequacy of probe access, lighting, power facilities, etc. should also be considered when choosing a location.

Figure 4 - Example of Equal Area Sampling Grid



Flyash samples are typically collected at the air pre-heater's gas inlet or gas outlet ducting. The air heater gas outlet is usually the preferred sampling location due to lower gas temperatures making probe handling easier. Stratification in ash is also less prominent at the air heater gas outlet due to the homogenization effect of the air heater's basket type heating surface. The Isokinetic Flyash flyash sampler's head is 3" in diameter and will require test ports of 4" pipe or larger. Figure 5 illustrates typical locations for collecting a flyash sample.

Figure 5 - Typical locations for collection of a flyash sample



Necessary Equipment

Item	Quantity	Description
1.	1	“Isokinetic Flyash” Flyash Sampler Head w/sampling nozzle. Sampler Head should have a calibrated nozzle and orifice coefficient.
2.	1	3/4” standard pipe threaded on both ends, suitable in length for traversing the depth of the duct
3.	5	Lengths of 1/4” X .035” stainless steel tubing to connect to the probe head. The length of the tubing should be slightly longer than that of the pipe.
4.	1	Magnahelic gage panel or suitable substitution of two inclined manometers capable of measuring a velocity head and maintaining an orifice differential simultaneously. A Dual Scale incline may also be used. In addition, two “U - tube” manometers will also be necessary for measurement of “null” balance and gas flow static pressures.
5.	1	Temperature measurement assembly including: one (1) type “K” chrome-alumel thermocouple of sufficient length to attach to the probe, one (1) type “K” lead wire of sufficient length, and one (1) potentiometer.
6.	1	One set of five (5) strands of tygon tubing (or similar) with an overall length at least 10’ to 12’ longer than the total length of the sampling probe assembly. Each of the strands should be clearly marked on each end for identification. Several strands of loose tubing along with a couple of tees for the tubing will also be necessary.
7.	1	One aspirator assembly with 1” X 1” X ¾” jet pump.
8.	1	Length of ½” or ¾” air line sufficient to connect the air supply to the probe. The air line should have a needle valve (or similar) for accurate control of the aspirating air flow rate.
9.	1	One box of Gelman fiberglass filter paper, Type AE, 8” X 10” sheets, will be required.
10.	1	One box of storage bags for collection of the ash following each test.
11.	1	Stopwatch
12.	Several	Gaskets for the nozzle assembly; it will be necessary to have at least three of each style of gasket for the nozzle assembly of the sampler.

Assembly of the Probe and Test Equipment

The first step in the procedure is to assemble the probe and connect all necessary sensing lines. The ¾" pipe is first threaded into the welded coupling on the "Isokinetic Flyash" Sampler Head on the end closest to the calibrated orifice. All threaded junctions should be effectively sealed by using Teflon tape or an acceptable substitute on the threads. Once this is accomplished, the stainless steel tubing can be connected to the fittings on the sampler head. The stainless steel tubing should be numbered (1) through (5) and connected accordingly:

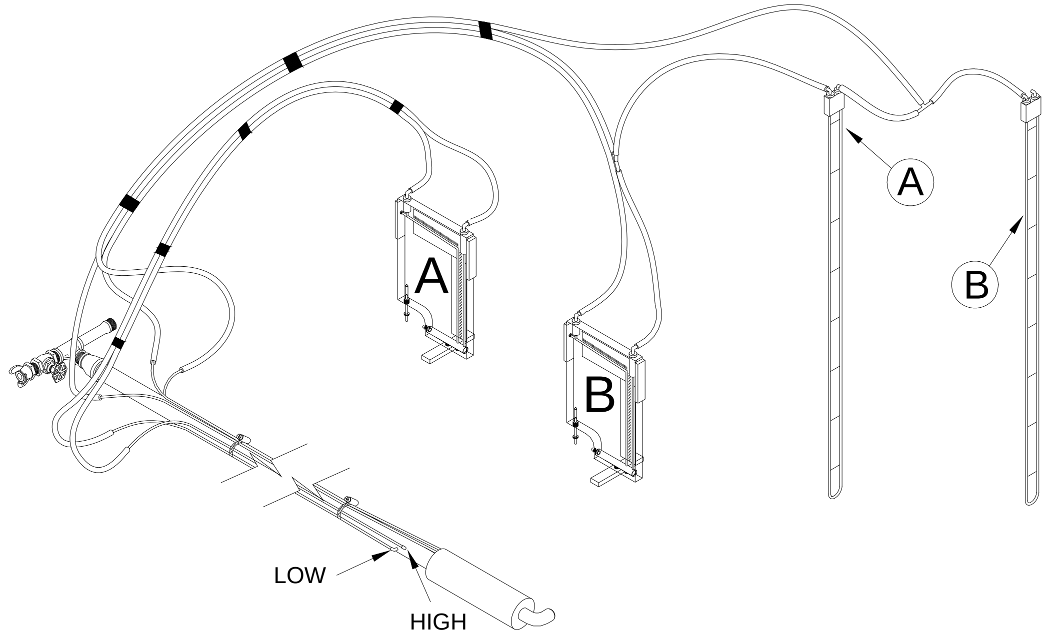
No. 1 Connect to the sensing line exiting the impact hole (center hole of the three "Fecheimer" holes).

No. 2 Connect to one of the sensing lines exiting one of the "null" or static holes adjacent to the impact hole.

No. 3 Connect to the remaining sensing line exiting the remaining "null" or static hole adjacent to the impact hole.

No. 4 Connect to the fitting on the ¾" pipe exiting the sampler head located between the in-line orifice plate and the sampler head. This will become the "high" pressure side of the orifice differential.

No. 5 Connect to the fitting on the opposite side of the orifice, referred to as the "low" pressure side.



Once the steel tubing has been connected, a thermocouple of sufficient length can be positioned alongside of the tubing. Make sure that the tip of the thermocouple extends no closer than 3" from the "Fecheimer" holes on the sampler head. Hose clamps are then used to secure the tubing and thermocouple to the pipe. The aspirator assembly is then threaded onto the other end of the pipe. The aspirator is usually lined up with the impact hole on the "Fecheimer" head to provide a reference point once the probe is in the ductwork.

Place the needle valve "in-line" between the air supply line and the line connected to the probe.

The next step is to setup the inclined and U-tube manometers, taking special care to ensure that all valves are open, the inclines "leveled", and everything properly "zeroed". The sketch on the previous page illustrates a schematic of the proper "Tygon"™ tubing connections (shown without the full length of stainless steel tubing). Connect one end of one piece of "Tygon"™to the "high" side of the incline manometer labeled "A", and the other end to the "high" side (closest to the sampling head) orifice connection. Repeat for the low side. Incline manometer "A" should be hooked up to measure the Dp across the in-line orifice. Connect one common end of all three strands of the triple "Tygon"™ to one of each of the remaining tubes (2 null, 1 impact). Install a "tee" on the end of each of the tubes hooked up to the "null" fittings . Connect the remaining tube (impact) to the "high" side of incline manometer "B". Connect two pieces of tubing to each of the tees. The two pieces of "Tygon"™ on one of the tees should each be connected to separate u-tube manometers (A & B). The two other pieces of "Tygon"™ should be connected, one to the "low" side of incline manometer "B" , the other to one of the u-tube manometers. Once this is complete, leak check all sensing lines and subsequent “Tygon”™ tubing. The final step of the assembly is to load the filter paper into the perforated cylinder of the nozzle and insert the nozzle assembly into the sampling head.

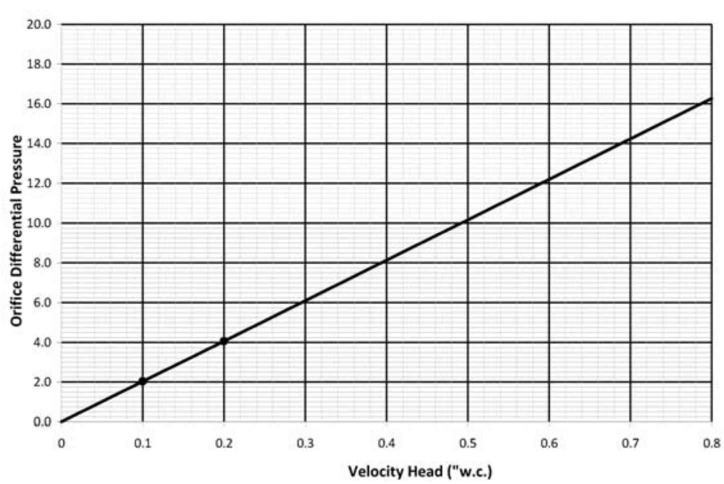
Carefully roll one sheet of filter paper lengthwise and insert it into the perforated cylinder of the nozzle assembly, making sure that no gaps are present between the bottom of the cylinder and the paper. The paper should fill the inside diameter of the cylinder fully and no tears on the paper should be evident. Install one of the small diameter gaskets between the mating surfaces of the perforated cylinder and the nozzle tip and secure these two pieces (now called the “nozzle assembly”). Insert the “nozzle assembly” into the “sampler head”, with a large diameter gasket positioned in between. Align the opening of the nozzle tip with the impact hole on the “sampler head” and secure with the bolts provided. Traverse points on the probe are to be marked according to PTC 38 for rectangular ducts if possible. Once this is complete, the probe is ready for use.

Traverse Procedure

1. The first step in testing is to establish steady state conditions for the unit. All soot blowing should be completed prior to commencement of the testing. The unit will need to remain steady for the duration of the test (approximately 1 hour per duct sampling time will be required).
2. Turn on the air supply and regulate it to maintain approximately 4” w.c. of differential across the orifice (differential indicated on “Incline B”). This prevents the negative pressure inside the ductwork from damaging the filter once the probe is inserted into the duct. Insert the probe into the duct and position it on the mark providing the deepest depth. By starting at the deepest mark, the probe has some time to cool as it is worked out of the duct and is generally easier to handle when moving between ports.
3. At no time after the air has been turned on, should the tip of the nozzle come into contact with the ground or any other surface. The aspirating effect could pick up foreign matter that would contaminate the ash sample. With this in mind, the access ports should be cleaned prior to testing to remove any accumulations on the interior surfaces of the access ports.
4. Once the probe is positioned at the first mark, rotate the probe slowly from side to side until the “null” U-tube (U-tube 1) is balanced. This balance is usually no more than 20° off the centerline of the duct. Take care to ensure the sampling tip (and impact hole) is positioned into the flow as the probe is inserted (the direction of the aspirator tip will also help to give relative position and help to keep the probe directed into the flow). An erroneous “null” balance can be achieved with the probe head turned directly away from the flow.
5. Once the null is achieved, start the stopwatch. Sampling time for each point in the traverse duct will depend on the total number of points and the agreed upon “total” sampling time for each duct. Generally, one hour/duct is adequate time to collect enough sample for analysis.
6. Once the “null” position is established and held, record the velocity head reading off of incline “A”, the temperature from the potentiometer, and the static pressure off of “U-tube 2”. Using the velocity head recorded, it will be necessary to adjust the air supply to obtain an iso-kinetic sample. The formulas below will be utilized:

Iso-kinetic Flyash Sampling Probe

$\Delta P_{OR} = 20.33\ Vh_{Probe}$



Vh_{Probe}	Orifice ΔP
0	0
0.1	2.03
0.2	4.07
0.3	6.10
0.4	8.13
0.5	10.17
0.6	12.20
0.7	14.23
0.8	16.26

Note: Never turn off the aspirating airflow while the probe is inserted into the duct. The negative suction on balanced draft units is sufficient to pull all or a part of the sample out of the probe. The probe can be moved from port to port without adjusting the airflow.

7. After all points have been sampled, extract the probe and allow it to cool sufficiently before attempting to dismantle it. Remove the four bolts securing the nozzle assembly to the head. Make sure that you are in a relatively “draft-free” environment before dismantling the nozzle assembly. With the assembly vertical, remove the two nuts securing the nozzle tip and tap the nozzle as it is removed to shake off any accumulation. Dump the perforated cylinder contents into one of the bags (labeled with the test number, date, duct sampled, and time). Carefully remove the filter paper from the perforated cylinder, making sure not to tear the paper significantly. Lightly scrap the inside surface of the paper to loosen any ash accumulation that may have bonded to the paper and empty this into the bag. Reload the cylinder with filter paper, secure the nozzle tip to the cylinder, and replace the nozzle tip assembly in the probe head. The probe is then ready for the next test.

Collection of a dust/gas sample on an “Oil-fired” boiler

Flyash/dust sampling is often useful on “oil-fired” boilers since it provides relevant information on particulate emissions and emission pH levels. The collection of a dust/gas sample can be conducted either “isokinetically” as mentioned previously, or more often by simple volumetric means. With a volumetric sampler, there is no need to measure velocity heads, temperatures, maintain “null” balance, or vary aspirating airflow rates. The pressure at the inlet of the aspirator is simply set to 25 psi, the probe inserted, set to the first point, nozzle opening directed into the flow, and the stopwatch started. In either case, the preparation and many of the test procedures are much the same. The layout and number of traverse points is identical, and duration of sampling times is the same. For dust/gas sampling on “oil-fired” boilers, the duration of the sampling is increased to a minimum of two (2) hours for each duct sampled in order to collect enough sample.

One sheet of fiberglass filter paper (Gelman type AE) is place in a Ziploc “bag” and weighed. The filter paper is then removed, rolled lengthwise, and inserted in the filter canister of either an iso-kinetic or volumetric perforated cylinder. The cylinder is then attached to the nozzle tip and the entire nozzle tip assembly inserted into the probe head. The probe is then ready for use.

Once the sampling is complete, the assembly steps are reversed and the filter paper removed from the nozzle tip assembly and bagged. The filter paper, bag, and sample are then weighed and the difference between the initial and final weights is the amount of dust/gas sample collected. The analysis of the deposits on the filter paper is a means of obtaining a quick overview of combustion characteristics in the furnace. Differences in dust/gas loading between ducts can give a relative indication of combustion efficiencies between furnace left and right sides. In addition, a heavy black deposit of ash on the paper may indicate poor combustion characteristics at the burner front; usually a product of one or more of the following: poor secondary air balance, improper register settings, atomizer pressures, worn, damaged, or clogged oil gun tips, etc. Any of these possibilities would warrant further “specific” testing in order to pinpoint the problem.

Procedure for Sieving a Flyash Sample

Generally, the ash collected from each duct is divided into two samples. One sample, of approximately 5 grams, is set aside as the composite sample. The other sample is measured from the remaining ash. Ideally, a 10.0 gram sample is weighed and placed on a set of sieves (50, 100, and 200 mesh) to be shaken for 20 minutes. Graphing the fineness for the ash passing these particular meshes should produce a line very similar in slope and position to that graphed from an iso-kinetic coal fineness taken from the same unit. If it does not, it could indicate non-representative sampling of either coal or ash.

Once the finenesses have been calculated, the ash passing 200 mesh is to be burned for an L.O.I. (loss on ignition), along with the composite sample. The procedure for burning an ash sample will be discussed later. As a rule of thumb, L.O.I.’s for the ash passing 200 mesh should be no more than 2.0%. L.O.I.’s greater than 2% usually indicate a combustion problem; i.e. insufficient secondary air flow, secondary air imbalance, poor mixing at the burner front, etc.

PLACE 10 GRAMS OF ASH
ON STACKED 200 MESH PAN
AND SHAKE FOR 20 MINUTES

DETERMINE L.O.I. OF RESIDUE
ON 200 MESH SCREEN AND IN PAN

L.O.I. OF FINE ASH MUST
BE LESS THAN 2%*

*EASTERN BITUMINOUS COAL

Procedure for Burning a Flyash Sample for L.O.I. Determination

Equipment

- A small oven capable of maintaining temperatures between 300 - 1500 °F
- A set of ceramic crucibles for burning the ash
- A set of pincers or tongs for handling the crucibles
- A highly accurate scale(balance) for measuring the ash samples.
  The scale should have a readability of 0.1 mg with a repeatability of + 0.1 mg.

Label each of the crucibles. Then preheat the crucibles to 300 °F for approximately 15 minutes. Weigh each crucible while hot(Wc). Add one gram of the ash to be burned to the crucible as it remains on the scale and record the “sample and crucible” weight. Insert the crucible with the sample into the oven and leave it for 1 hour at between 300 - 500 °F. Remove the crucible with sample and reweigh and record it, comparing the weight to the initial weight. Any difference in the two is the amount of water driven off. Replace the crucible w/sample in the oven at 300 - 500 °F and leave it for 30 minutes. Remove, weigh, and record the crucible w/sample. Continue this process until the weight remains constant. RECORD THIS WEIGHT(WCSD). Replace the crucible w/sample in the oven and cook the sample at 1500 °F for three (3) hours. Remove, weigh, and record the crucible w/sample weight. Replace the crucible w/sample and cook at 1500 °F for 30 minutes. Remove, weigh, and record the crucible w/sample weight. Any difference indicates that there is still carbon present in the ash. Continue this procedure until the weight remains constant(WCSFW). Once the weight no longer changes, the flyash L.O.I. can be calculated using the following equation:

WCSD = Crucible w/sample (dried) weight
WCSFW = Crucible w/sample (final weight)
WC = Crucible weight

% Flyash L.O.I. = {[(WCSD - WC) - (WCSFW - WC) × 100]} ÷ WCSD