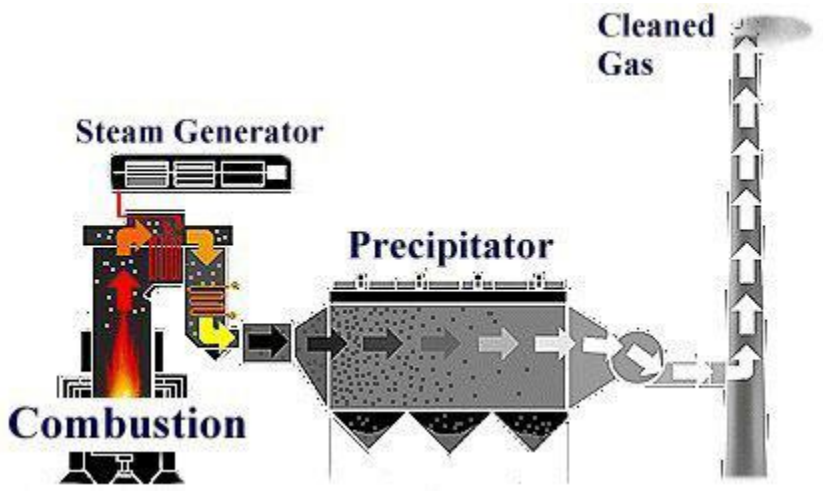
allied environmental technologies, inc.

Intermittent & Pulse & Pulse Energization of Electrostatic Precipitators

A Compendium



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Intermittent Energization of Electrostatic Precipitators

FOREWORD

Flue Gas Conditioning (FGC) was developed as one of the most efficient ways to control the fly ash resistivity and particulate properties. Nevertheless, alternate approaches to minimize the effect of reverse ionization (back corona) were developed in attempt to conquer the latter electrically. By energizing the electrode system using a discontinuous mode, such that time is allowed for the charge alike collector to dissipate the effect is minimized. This discontinuous energization mode can either be achieved by superimposing a short duration high voltage pulse periodically on a reduced DC precipitation voltage or by controlling the thyristor firing to produce an intermittent energization regime.

In addition, while most operating precipitators use full wave high voltage rectification for energization purposes, there is, particularly for larger installations, a requirement to minimize energy consumption. This can be achieved by an intermittent energization approach (IE), where the thyristor firing is held off for specific periods based on feedback from an opacity meter or a specific operating instructions. The use of intermittent energization in this case, where periodic flashover assists in maintaining the emission areas fully effective, overcomes the possible deterioration in electrical operation and hence performance synonymous with the earlier system of reducing the operating voltage in order to effect power savings. This IE approach can also be beneficial in the case of back corona arising with high resistivity fly ash, when the time interval between successive current pulses enables charge to dissipate through the dust layer, rather than allowing a voltage to build up on the surface.

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1.0 BASICS OF INTERMITTENT ENERGIZATION

Intermittent energization (IE) is a system introduced, with the dual purpose of saving energy and improving the collection efficiency of precipitators when handling high resistivity dusts. This energization form is also known under other trade names like energy control [3], semi-pulse [4], Variopuls [5], etc. IE operation emerged as a cheaper alternative to pulse energization that had been developed and used commercially in the solution of high resistivity dust problems.

1.1 BASIC PRINCIPLES OF INTERMITTENT ENERGIZATION.

Intermittent energization is obtained with the same electrical equipment as employed in traditional full wave power supplies. The difference resides in the automatic voltage control equipment, which has the capability of suppressing a certain number of half-cycles of the primary current delivered to the transformer by the AC supply.

The suppression is obtained by not firing the phase control thyristors in the respective half-cycles or alternatively, by using a firing angle of 180°. The principle of operation is illustrated for a 50 Hz rectified supply by the waveforms shown in Figure 1-1. This example shows six half-cycles of the line frequency and indicates the case where two out of three current pulses are suppressed. Figure 1-1[a] shows the primary current in relation to the supply voltage. The corresponding waveforms of the precipitator voltage and current are shown in Figure 1-1[b], where these waveforms were obtained with a firing angle corresponding to 3 ms after the zero crossing of the line voltage.

The waveforms in Figure 1-1 show the following advantages compared with DC energization for the same firing angle as in Figure 1-2:

(a) The peak value of the precipitator voltage is higher.

(b) The minimum (trough) value of the precipitator voltage is lower.

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(c) Due to the suppression of two current pulses, the mean and the RMS values of the precipitator current are significantly reduced.

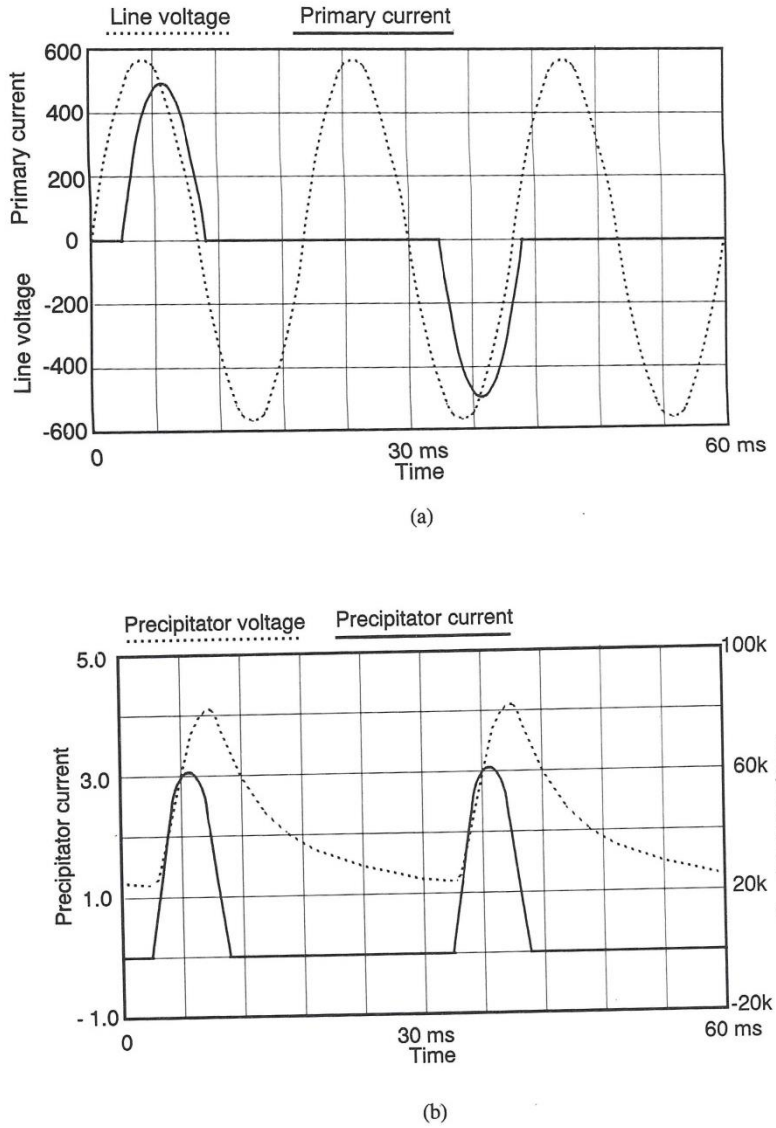


Figure 1-1. Typical Waveforms with Intermittent Energization (Firing Angle of 54° (3 ms)). Two out of Three Pulses Suppressed (D=3)

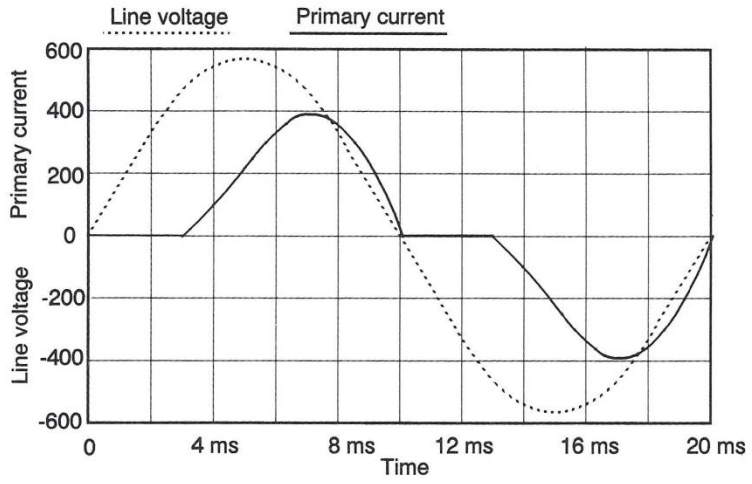
As a consequence, the following can be established:

(a) The **Mean Value** of the precipitator voltage is lower;

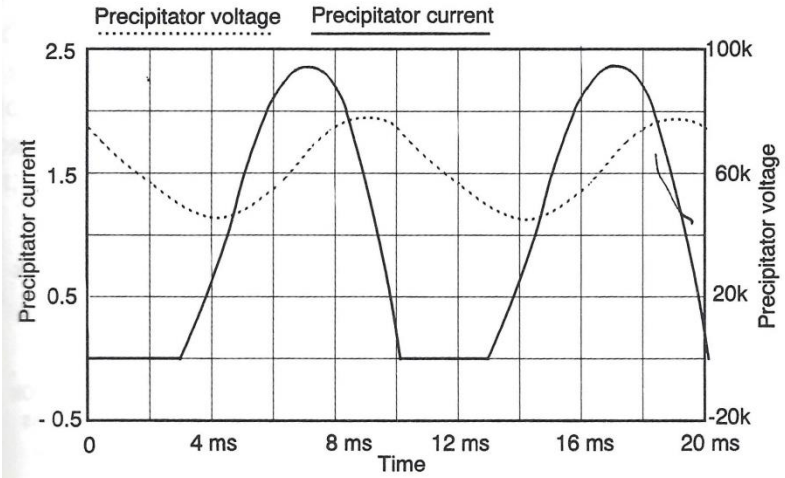
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(b) The **Corona Power** delivered to a particular bus section of a precipitator is lower;

(c) The **Power Consumption** is lower.



(a)



(b)

Figure 1-2. Voltage and Current Waveforms with DC Energization (Firing Angle of 54° (3 ms))

With intermittent energization, since the current to the precipitator is discontinuous, the operation is specified in terms of the Degree of Intermittence or D, which is derived by dividing the number of half-cycles included in one energization duty cycle by the number of current puls-

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es in this time interval. In the example shown in Figure 1-1 the energization cycle is three, so the degree of intermittence D is 3. In another example of IE, where the thyristors are fired once and then kept blocked for the next ten half-cycles, then the degree of intermittence D would be 11.

The degree of intermittence is also expressed by other names, for example, the '**Charge Ratio®**', which is defined as the number of current pulses in one duty cycle divided by the number of half-cycles included in the energization cycle. For instance, the Charge Ratio®, in Figure 1-1 is ⅓, that is, the waveform comprises one current pulse out of every three. This means that the Charge Ratio® is basically the reciprocal of the degree of intermittence (D).

The waveforms for IE presented in Figure 1-1 and Table 1, (Courtesy FLS Miljö a/s), presents a direct comparison of the electrical operation between intermittent energization, with a 3 ms firing angle, in comparison with conventional DC energization.

Table 1. Current And Voltages With Intermittent Energization, Ie, Compared To Values Obtained with DC Energization.

Energization form		IE	(DC)
Primary current	$I_{p\,rms}$(A)	172	(223)
Precipitator current	$I_{o\,rms}$(mA)	1080	(1400)
	$I_{o\,peak}$(mA)	3100	(2350)
	$I_{o\,mean}$(mA)	476	(1030)
Precipitator voltage	$V_{o\,peak}$(kV)	82	(78)
	$V_{o\,mean}$(kV)	41	(61)
	$V_{o\,min}$(kV)	24	(46)

1.2 Comparison of IE with Traditional DC energization

The impact of these changes on operating conditions are examined in greater detail in the following sections:

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1.2.1 Voltage Levels.

i. The **Peak Voltage** is higher because the area under the current pulse is greater. As this area corresponds to the electric charge Q_p delivered to the precipitator section, the larger the value of Q_p, the higher the peak voltage since the precipitator load has an inherent capacitive component.

ii. Because of the longer time interval between successive current pulses, i.e. without receiving electrical charge, the precipitator discharges towards the corona onset voltage, resulting in a lower **Minimum Voltage** value.

iii. The **Mean Voltage** is proportional to the area under the precipitator voltage in one energization duty cycle (in this example: three half-cycles of the line frequency). Because of the lower minimum voltage the mean voltage value also reduces.

1.2.2 Current Levels.

The **Mean Value** of the precipitator current is reduced due to the suppression of a number of current pulses, where the suppression is typically expressed as the 'degree of intermittence' D. If it is assumed the area under the current pulse is the same for both IE and DC energization, and the mean current obtained with DC energization is $I_{DC,}$ then the mean current obtained with intermittent energization I_{IE} can be expressed as

$$I_{IE} = \frac{I_{DC}}{D} \quad (1)$$

The area under the current pulses with intermittent energization, may sometimes be higher than that from conventional energization by a factor k (Figure 1-1). Then, the mean current is given by: -

$$I_{IE} = k\frac{I_{DC}}{D} \quad (2)$$

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Where k may vary between 1 and 1.5 and in the example shown in Table 1, k is 1.39.

In this situation the mean current is reduced by a factor k/D. (Assuming that the primary current pulse has a similar waveform in both cases, then the RMS value is reduced by a factor equal to k divided by √D).

Summarizing there are two aspects where IE can be considered inferior to DC energization, these are:

(i) The higher form factor of the primary current, and

(ii) Potential saturation of the transformer magnetic core.

The relationship between the RMS and mean precipitator current values in Table 1 clearly indicates that with IE, the form factor is higher than that obtained with DC energization. This results in a corresponding higher form factor for the primary current, which is equivalent to a higher harmonic content. Also, because of the pause interval in primary current flow with intermittent energization, the change in the magnetic induction (″B), is reduced, resulting in a reduced and inferior transformer core saturation. This situation can be minimized in the design using different approaches such as: -.

a. Using a larger transformer core.
b. Using a core with higher remanence and low eddy losses.
c. Firing a smaller auxiliary current pulse before the main one.
d. Installing a larger linear series reactor to modify the waveform.

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2.0 COLLECTION EFFICIENCY EVALUATION,

Since IE operation reduces the corona power supplied to the precipitator, and although this will result in an energy saving, it poses the question as to how does this reduction in corona power influence the collection efficiency of the precipitator? The normal way to evaluate the effect of IE on performance is to measure the collection efficiency obtained with intermittent energization and compare it to that obtained with conventional DC energization. From these figures it is then possible to calculate the respective effective migration velocities and hence performance factor H, which is defined as:

$$H = \frac{\omega_{IE}}{\omega_{DC}} \qquad (3)$$

Where:

- ω_{IE} is the migration velocity obtained with intermittent energization and
- ω_{DC} is the migration velocity obtained with DC energization.

Since the required collection surface is inversely proportional to the migration velocity for a given collection efficiency, if under IE operation the enhancement factor (H) is greater than 1, then this is the factor by which the collection surface of a DC energized precipitator would need to be increased to produce the same collection efficiency as that measured with intermittent energization.

2.1 OPERATION UNDER LOW RESISTIVITY (NORMAL) DUST CONDITIONS.

The application of intermittent energization to any precipitator because of the thyristor hold off periods invariably results in a **lower** precipitator **Mean Voltage** and **Mean Curre**nt, which means a lower specific power is available for precipitation. With low resistivity fly ash,

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without back corona being present, this reduction in specific corona power leads to a lower collection efficiency and therefore a reduced effective migration velocity.

This situation is illustrated in Figure 2-1, where dust emission is plotted as a function of the specific corona power density Pc/A for both DC and intermittent energization having intermittence factor, D of 3. The precipitator relating to this figure collected fly ash from a boiler fired with a coal blend producing an ash, which did not exhibit resistivity problems. In this situation, operation under IE results, in a lower performance and therefore IE is not advantageous for this application since H is less than 1.

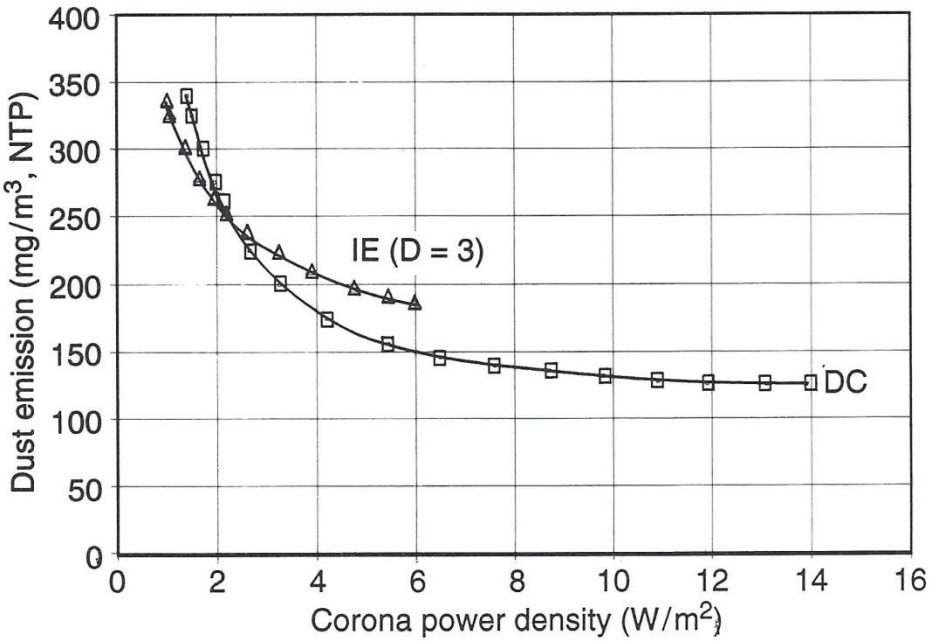


Figure 2-1. Stack Emission as a Function of the Corona Power with DC and IE for Low Resistivity Fly Ash Conditions

As indicated earlier, if an installation, handling a low resistivity fly ash, produces an emission lower than that specified, either because of a change in the fuels' sulfur level or ash content, the application of IE can result in a significant decrease in power while accepting a slightly lower efficiency. Reductions of up to 90 % in consumed power have been recorded

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[6,7], without potential electrical deterioration as would result from simply decreasing the operating voltage levels.

2.2 Operation with some Back Corona Exhibited.

In Figure 2-2, similar curves are presented for a precipitator collecting fly ash from a boiler fired with coal, which produces a fly ash resulting in a limited degree of back-corona. From these results it will be noted that both forms of energization produce very similar minimum dust emissions and hence the enhancement factor is equal to 1. Therefore if a higher dust emission can be considered as acceptable (>40mg/m^3 NTP), then IE results in a better performance for a similar specific power consumption.

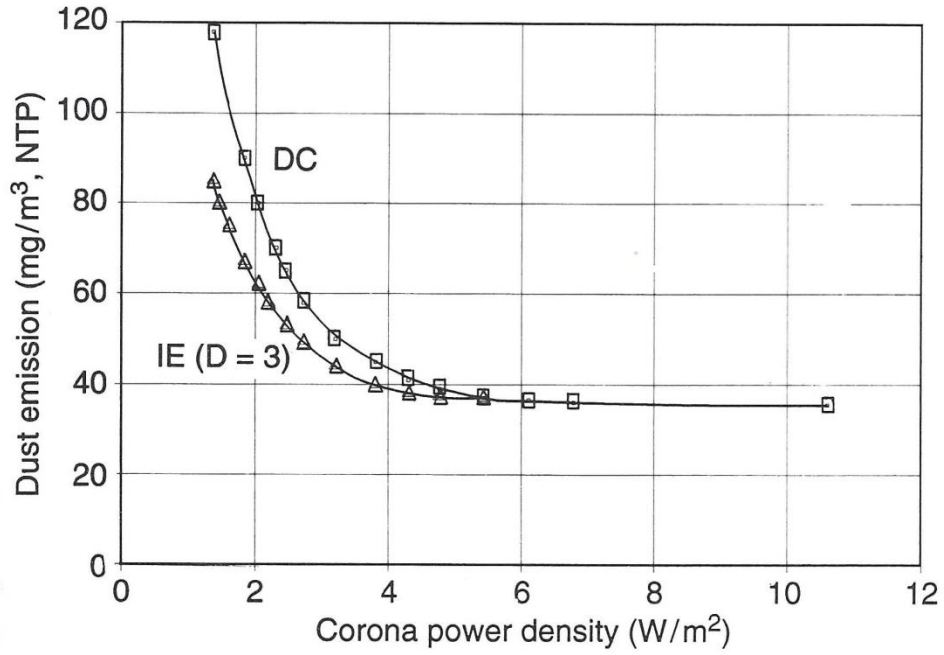


Figure 2-2. Comparison of Emissions for both Forms of Energisation with Limited Back Corona Present

2.3 Operation Under Conditions Of Severe Back Corona.

In Figure 2-3, dust emissions are again plotted as a function of the specific power input for both DC and intermittent energization having an intermittence of 7 for fly ash arising from a

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boiler firing a low sulfur coal, which resulted in a fly ash producing severe back-corona in the precipitator. In this instance it can be seen that operation with IE is clearly better than DC energization, since it results in a lower dust emission and hence an enhanced performance factor H > 1 together with a lower specific power consumption.

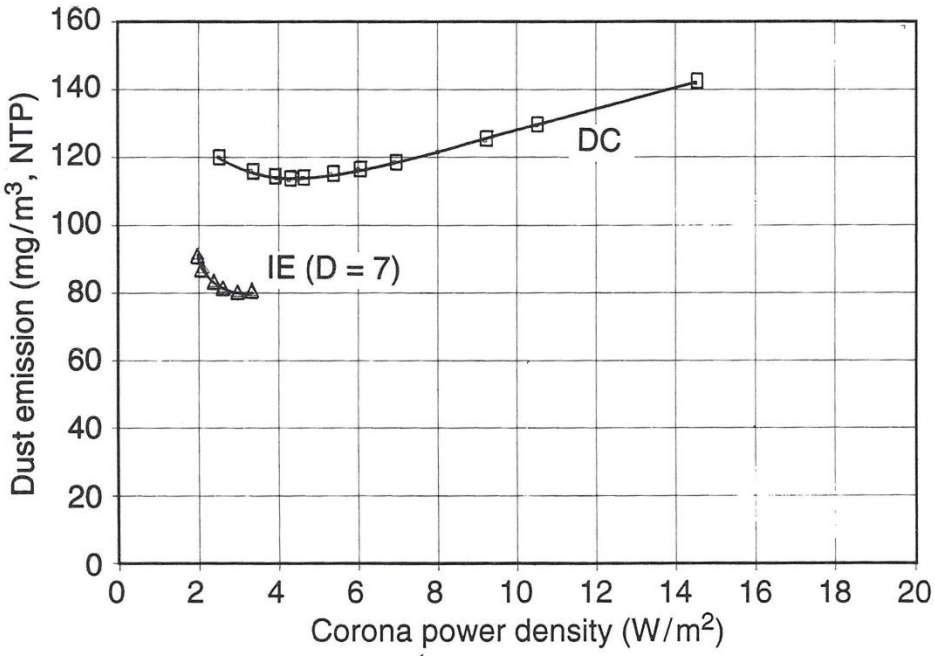


Figure 2-3. Comparison of Emissions for both Forms of Energisation with Severe Back Corona Present

From this data operation under intermittent energization in general terms, can be summarized as follows:

- ✓ ***Intermittent energization always results in lower power consumption, but it does not always produce the highest collection efficiency.***
- ✓ ***The performance with intermittent energization is very closely related to the resistivity of the collected dust.***
- ✓ ***With low resistivity fly ash, the performance with IE is inferior to DC energization, since it results in a lower precipitator efficiency.***

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- ✓ ***For medium resistivity fly ashes, operation under IE is as good as DC energization and sometimes better.***
- ✓ ***In the case of high resistivity fly ashes, operation under IE is superior to DC energization.***

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3.0 PULSE ENERGIZATION

Another approach, initially developed as an alternative to chemical flue gas conditioning for improving the performance precipitators handling high resistivity fly ash, is pulse energization. Energization using a pulsing technique was specifically developed to improve the collection of 'difficult' high resistivity particles, which results in reverse ionization in terms of precipitator operation. The energization basically consists of applying a very short duration high voltage pulse superimposed on a reduced 'base voltage' (Figure 3-1).

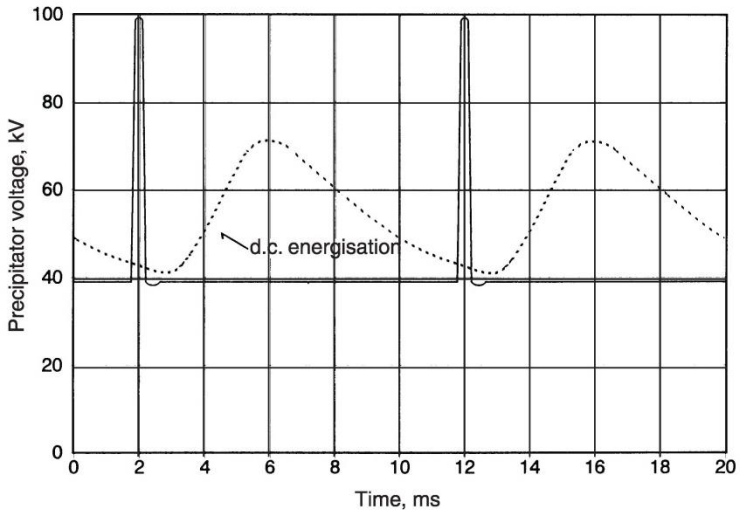


Figure 3-1. Typical Waveform Comparison Obtained with Pulse and D.C. Energization

Generally, improvement in the precipitator performance is closely related to the resistivity of the collected dust. This improvement is normally expressed by the enhancement factor

$$H = \frac{\omega_{kP}}{\omega_{kDC}}$$

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where ω_{kP} is the migration velocity obtained with pulse energizations and ω_{kdc} is the migration velocity obtained with D.C. energization. The enhancement factor *H* obtained with very high resistivity dusts increases to around 2 (Figure 3-2).

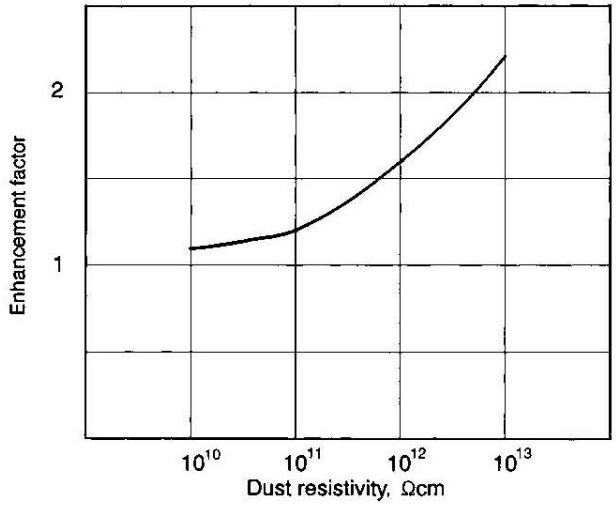


Figure 3-2. Enhancement Factor Obtained with Pulse Energization Compared to D.C. Energization as a Function of the Dust Resistivity.

The application of pulse energization is not restricted to new precipitators and can be a very effective solution for improving the performance of existing precipitators having resistivity problems. In this case, it is important to bear in mind that the mechanical condition of the precipitator has to be good. This means effective rapping of the discharge and collecting electrodes, good gas distribution, good electrode alignment, etc., otherwise the expected enhancement factor will not be obtained.

In practice it has been found that if a precipitator installation is collecting a high resistivity fly ash contaminated by a high carbon carryover, then since effective precipitation of the carbon particles requires a high current density, this directly conflicts with the need for a low current density to eliminate back corona arising from the high resistivity ash. ***Hence the result of pulsing under this situation is a higher stack emission because of carbon slippage; therefore, a full analysis of the fly ash is necessary prior to making the decision to install pulsers***. (This is contrary to the Dual FGC…)

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Summarizing, pulse energization is normally ideal for precipitators collecting high resistivity dusts. The improved precipitator performance in the collection of medium and high resistivity dust, compared with traditional D.C. energization and IE, results from the combined effect of (a) better particle charging, (b) higher collecting field strength, (c) better current distribution and (d) improved current control capability.

The enhancement factor H, obtained with pulse energizations, is mainly the result of the application of high pulse amplitude creating an intense ionic cloud and improved collector current distribution. Therefore, the mechanical condition of the precipitator has to be good for the collection of fly ash and the concentration of low resistivity particles, e.g. unburnt coal, has to be low; otherwise the expected performance enhancement will not be achieved

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4.0 BASIC AVC CONTROL PRINCIPLES

Under ideal operating conditions, the firing angle of the thyristors could be controlled manually, but in practice this is virtually impossible. Most of the processes, which use electrostatic precipitators for particulate control, are subject to both slow and fast changes in the inlet operating conditions, e.g. the gas flow, gas temperature, gas humidity, fuel mix, raw material, etc. which can rapidly alter. In order to keep the collection efficiency as high as possible under difficult conditions, more powerful and sophisticated control units are continuously being developed and applied.

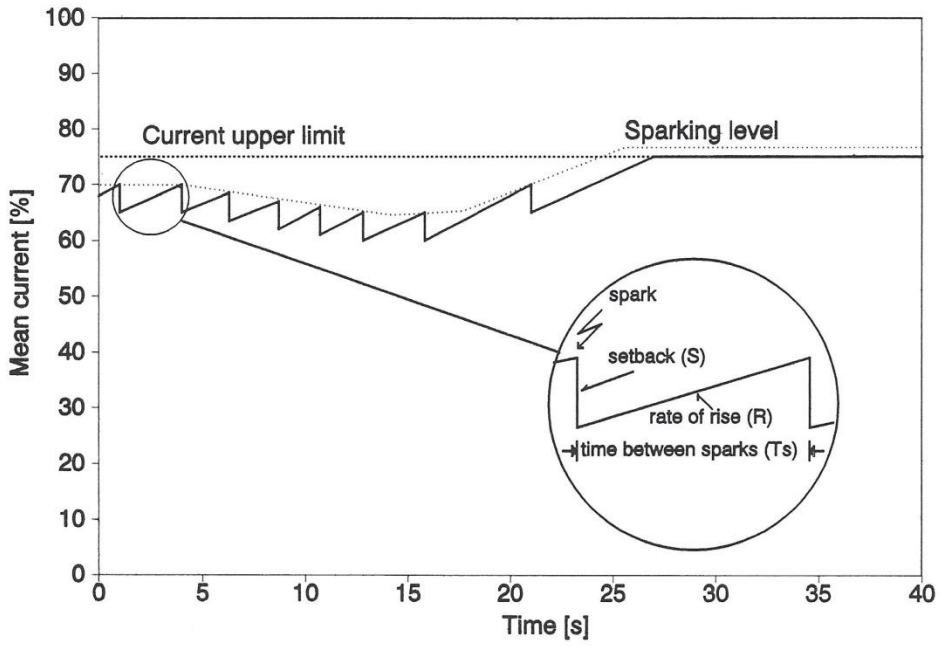


Figure 4-1. Basic Control Strategy Utilizing the Precipitator Mean Current

Most control units are now based on microprocessors and peripheral circuitry, which offer very powerful performance because of their inherent memory and computing capabilities. Generally the programming is such that any chosen reference signal varies as a function of time, according to the control strategy.

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An example of this basic control principle is illustrated in Figure 4-1, where, the mean precipitator current is increased linearly at a rate of rise R, until a spark occurs or an upper limit is reached. R is normally expressed in %/min where 100 % corresponds to the rated mean secondary current of the TR set.

In this example if one assumes the sparking level changes in the way shown, that is, it is fairly consistent at the beginning, then reduces, remaining low during a short period of time before increasing again. When a spark occurs, the current is automatically reduced by a constant setback value S, where, S has an absolute value expressed as a percentage of the rated current e.g. (5%). If one assumes a constant sparking level, the spark rate SPR can be expressed as the reciprocal value of the time interval between successive sparks.

From the zoomed area in Figure 4-1, it can be seen that the rate of rise is determined by:

$$R = \frac{S}{T_S} \text{ (\%/min)} \tag{4}$$

Then and the spark rate expressed by:

$$SPR = \frac{1}{T_S} = \frac{R}{S} \text{ sparks/min} \tag{5}$$

Equation [5] indicates that a high sparking rate can be obtained with a high rate of rise R and a small setback S the controlled variable. Conversely, a low rate of rise and a large setback produce a low spark rate. In the example shown in Figure 4-1, the rate of rise R = 100%/min and the setback S = 5%; then the spark rate, at a stable sparking level, will be around 20 sparks/min. When the controlled variable reaches the upper limit the spark rate becomes zero.

The parameters R and S or S and SPR are normally programmed as settings in all control units. S is used as an absolute or relative value. The way these parameters are used and set by the specialists of the precipitator suppliers is different, each advocating their system as having the best control strategy. Often this is based on tradition, for the processes where the control units are normally used or are associated with particular characteristics of their precipitator design.

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With respect to the basic control strategy as shown in Figure 4-1, in order to maintain a high corona power level during varying inlet conditions, the rate of rise R has to be large, the setback S has to be as small as possible and the spark rate SPR has to be high. There is, however, an upper limit for the spark rate, above which the collection efficiency starts falling because of 'precipitation time' lost during voltage recovery following a flashover. Moreover, too high a spark rate may be detrimental to the life of the internal parts of the precipitator and the high voltage equipment.

One of the important objectives in a modern control unit is to obtain a fast recovery of the precipitator voltage after a spark; in this way it is possible to maximize the voltage-time integral and maintain high collection efficiency. A fast voltage recovery is only obtained if:

(a) Unnecessary turn-off time intervals of the control thyristors are avoided. (This turn-off time is also referred to as the 'deionization time', 'quench time', etc.), and

(b) The voltage is quickly raised to the highest possible level within a few half-cycles of the line frequency.

It is also imperative to perform this voltage recovery without a new spark arising; i.e. 'multiple sparking' should be avoided. Voltage recovery is, however, closely related to spark detection, so this aspect will be briefly examined in the following sections.

Generally, sparks are automatically classified by most controllers, into two main types according to their intensities, e.g.

a. light sparking (or spitting) - where the precipitator instantaneous voltage rapidly recovers to a certain level within a very short time period and

b. severe sparking (or arcing) - where the precipitator instantaneous voltage remains low for a significant period of time before recovering.

Figure 4-2, illustrates the two types of sparks and the level of voltage recovery achievable by a good modern control unit. This also shows that even in the case of a severe spark, the volt-

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age can be rapidly raised to a high level, without the utilisation of turn-off time and without the occurrence of multiple sparking.

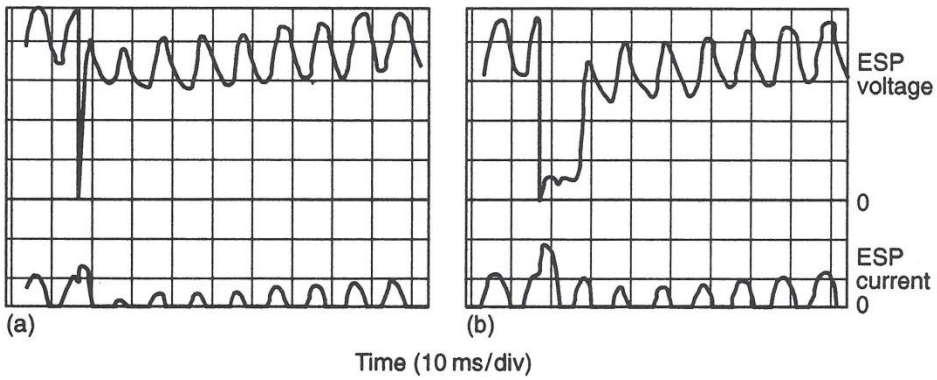


Figure 4-2. Classification of Sparks According to their Intensity. Light Sparking (a) and (b) Severe Spark (Short Circuit)

The question of whether or not to utilize a thyristor turn-off time to control sparking is one of the less understood problems in automatic voltage control techniques. There are some manufacturers of modern control units who recommend in their user manuals the use of a turn-off time in order to avoid the occurrence of arcs in the precipitator, while others do not.

A fast voltage recovery is also closely related to the method of detection used, in the past, the primary values and the precipitator current have been used, but the use of the instantaneous precipitator voltage has proven to be superior for controlling the voltage recovery. The problem of recovering the precipitator voltage within a few half-cycles of the supply frequency without introducing a specific turn-off time is complex. One of the difficulties is to know how much the instantaneous voltage can be raised without the re-occurrence of sparking, i.e. the determination of the "aimed level", and the next, to find the predetermined value of the thyristor firing angle, which will provide this "aimed level".

This problem and its solution are illustrated by means of the curves presented in ure 4-3. Figure 4-3 (B), shows the typical variation of the mean voltage as a function of the firing angle during DC normal operation, while curve (A), shows the attainable peak voltage in the

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first half-cycle after the spark. Experience has shown that the aimed level can be represented by the curve B, without causing multiple sparking, and at the same time producing an acceptable precipitator voltage level. Sometimes a higher aimed or target level might be used, but the probability of sparking in the recovery period would be quite high.

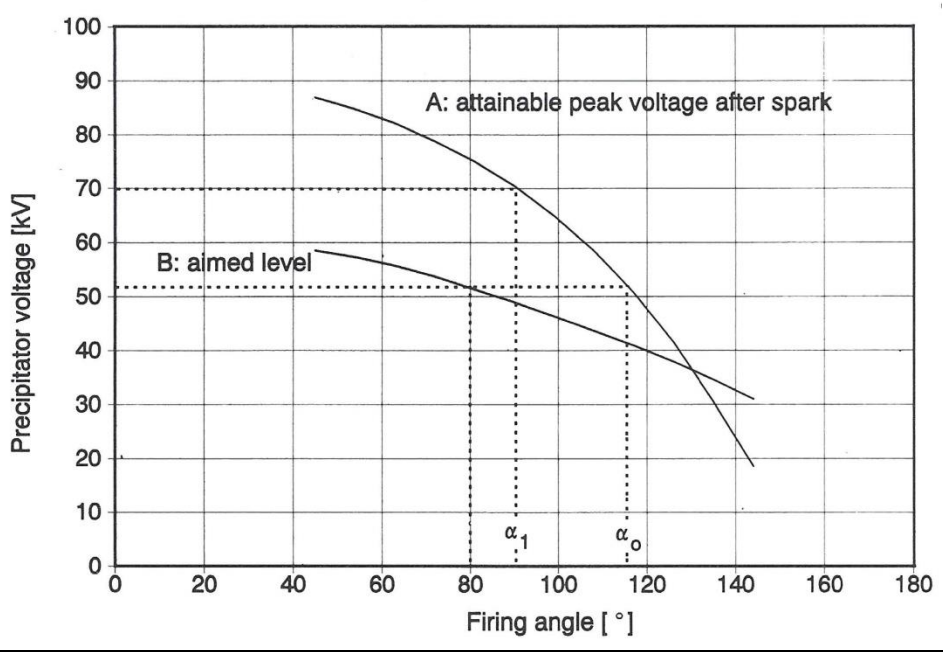


Figure 4-3. Control Principle for a Fast Voltage Recovery after Breakdown

The problem is possibly best illustrated by the following example, where it is assumed that the control unit is firing the thyristors at 80^o and the "aimed level" for voltage recovery of 52kV is shown by the dotted line. After a spark, the preset setback gives an increased firing angle, α_1, which will give a voltage level determined by the intersection of curve (A) and the firing angle (α_1) producing a voltage level of 70kV. However, this is obviously too high, compared with the "aimed target level", and will undoubtedly result in multiple sparking. The correct firing angle α_0 is determined by the intersection of the dotted line representing the aimed level and the curve (A).

At lower voltage levels, i.e, beyond the crossing of curves (A) and (B), the problem is reversed, if the closed loop control is not opened, the firing angle will be too high and results in too

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low a voltage level, accompanied with a slow voltage recovery. The recommended solution to this problem would be to:

(a) To store the curve (A) in the memory of the control unit;
(b) To open the control loop in case of spark and find the right firing angle according to the aimed level,
(c) To close the control loop and perform the required setback.
(d) To continue with the normal control strategy after the setback is performed.

To illustrate that a satisfactory voltage recovery can be obtained automatically, both at high and low current operation and without using turn-off times, the oscillograms shown in Figure 4-4 are included.

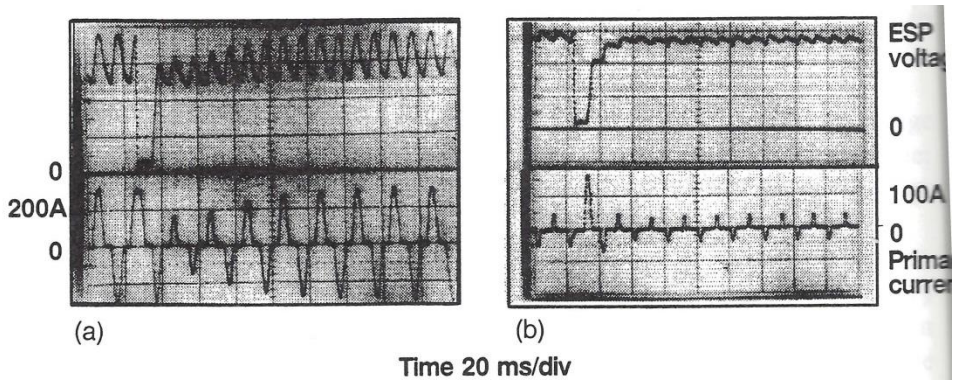


Figure 4-4. Oscillograms of Current Waveforms

Other important features obtained with this method of control also can be seen in ure 4-4:

(a) At higher current operation, the first pulse current used to raise the voltage to the aimed level, and the immediate following ones, are lower than the current pulses at normal operation.
(b) At low current operation, the current pulse used to raise the voltage is higher than at normal operation.

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5.0 BACK-CORONA DETECTION AND CORONA POWER CONTROL

The occurrence of back-corona in one or more precipitator sections has been normally determined by examining the corresponding V-I (Voltage-Current) curve. In the past, this curve was measured as a plot of the precipitator mean current vs. mean voltage. The criterion used for determination of back-corona was the slope of the V-I curve; if the slope was negative (falling kV), it indicated back-corona. But in the early 1980s it was considered that this method was not sensitive enough [1,8], and a better indication was obtained by using the V-I, where the mean current is plotted against the minimum value of the precipitator voltage, as illustrated in Figure 5-1.

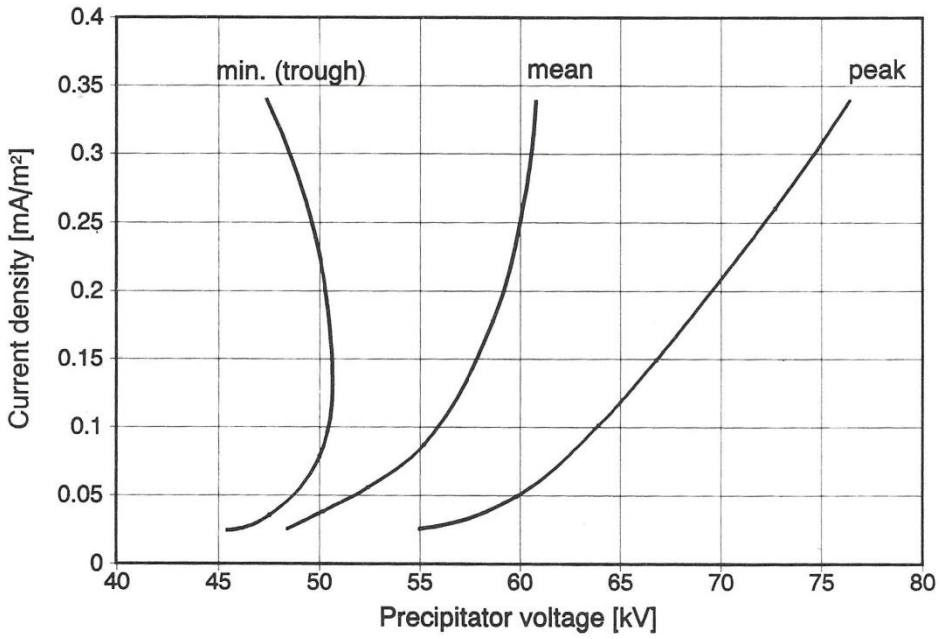


Figure 5-1. V-I Characteristics in the Case of Back Corona Conditions

This shows that the curve taken as a function of the minimum voltage changes slope at a relatively low current level, while the curve based on the mean voltage still has a positive slope.

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The curve based on peak voltage shows a positive slope, irrespective of the presence of back-corona.

Not all voltage control units include means of back-corona detection, but those, which have back-corona detection invariably, use the following control principles:

a. *The slope of I-V curve*. This corresponds to the method described above, where the minimum voltage of the precipitator is used. This method, however, has the disadvantage that the power levels have to be systematically reduced in order to find the actual inflexion point.

b. *Voltage waveform at sparking level*. This method is also based in the minimum value of the precipitator voltage and by comparing its value before and after a spark, the occurrence of back-corona can be determined. Back-corona exists if the minimum value after the spark is higher than the value before the spark. This situation is illustrated by the oscillograms shown in Figure 4-4.

This approach has the advantage that it does not need to reduce power levels, because sparking is used as the monitoring system. In the case of 'no sparking' conditions, a blocking period, where the thyristors are not fired, is used instead.

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6.0 SPECIFIC POWER CONTROL BY THE USE OF INTERMITTENT ENERGIZATION.

In the incidence of back-corona (i.e. in a case without the SO_3 FGC), in order to extinguish it and maximize performance, the corona power has to be reduced. As seen in the previous section there are two means to accomplish this:

i. To reduce the electric charge (Q_p) delivered to the precipitator, i.e. the area under a current pulse, by delaying the firing angle of the thyristors.

ii. To change to intermittent energization sequence and find the optimal degree of intermittence.

Plant personnel have traditionally performed this task manually, but over the last decade the tendency is to do it automatically.

The optimization of the degree of intermittence (D) can be performed, however, in combination with the automatic detection of back-corona. If during the detection back-corona is found, then D is increased, but if no back-corona is detected, D is reduced. The optimization of the electric charge delivered by each current pulse, Q_p, is difficult. One method employed is to maximize the minimum value of the precipitator voltage while remaining at the optimal degree of intermittence.

A combined method also exists for the optimization of D and Q_p [4]. Here D and Q_p are varied, so a variety of combinations of these two quantities are obtained. For each combination, a figure of merit is determined and the combination giving the best figure of merit is selected for control. An alternative method of determining the figure of merit is to compare the instantaneous voltage waveform with a reference voltage during the time interval when the corona discharge takes place, the reference voltage, for convenience, being set at the corona onset voltage V_o.

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This method is depicted in Figure 6-1. The figure of merit can be determined as the integral:

$$I = \int v_p(t) * (v_{p(t)} - V_{ref})dt$$

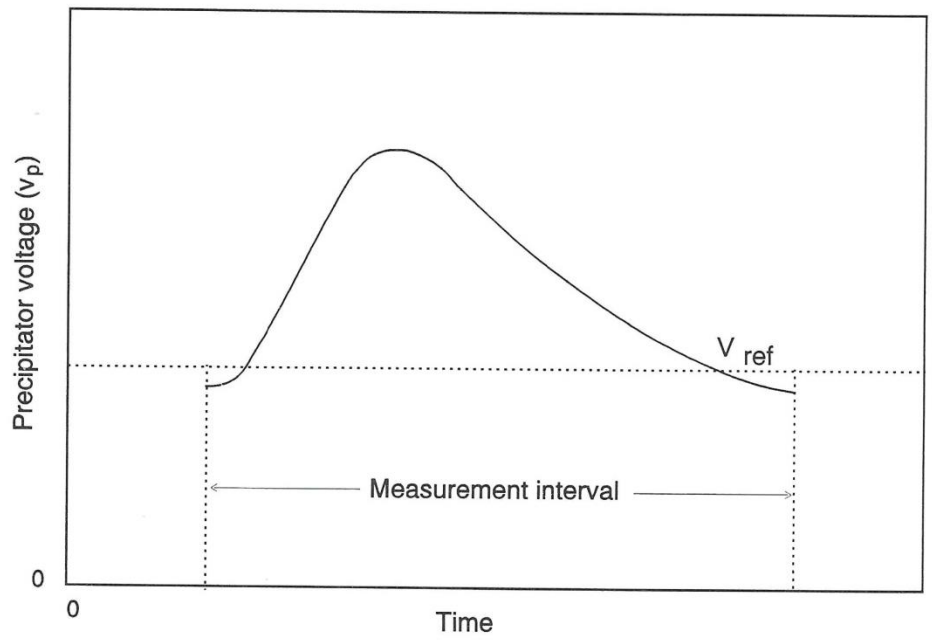


Figure 6-1. Determination of the Figure of Merit Based on a Comparison of the Precipitator Voltage with a Reference Voltage

In order to improve the above-mentioned tasks, some units also incorporate the **OPACITY (or ANY FEEDBACK-TYPE) SIGNAL** in the optimization of the corona power. However, this approach can never be 100% effective, as a particular control unit does not know if there has been a change in the settings of another control unit or a variation in the operating conditions of the precipitator. Therefore, the present tendency is to place this task in a "supervisory computer", which receives all the relevant process and stack emission signal information. With this data the computer can then optimize the settings of the individual control units accordingly.

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7.0 ADVANCED COMPUTER CONTROL FUNCTIONS

Among the features offered by a precipitator supervisory computer, one of the most important is an of an advanced control strategy including functions like optimization of:

i. The corona power
ii. The degree of intermittence (D)
iii. The charge delivered per current pulse (Q~)
iv. The spark rate and current setback, etc.
v. The rapping sequences, including optimization of the off-time between rapping of the collecting plates
vi. Synchronization between rapping of adjacent sections, programmable power-off rapping sequences, etc.
vii. Energy management and control.

A supervisory computer is able to fulfil these requirements in a satisfactory way because it is constantly receiving information about:

a. Process condition (gas temperature, flow, feed rate, 0_2, SO_2, etc.).
b. Stack opacity (dust emission).
c. Currents and voltages from the individual bus sections.
d. Status of TR sets, rappers, timers, parameters, etc.

Based on this data the supervisory computer can therefore optimize the relevant settings in each automatic control unit (AVC), such as,: -

i. The Degree of intermittence. (D).
ii. The Upper current limit (Q_0).
iii. The Spark rate SPR and voltage setback S.
iv. The Rapping off time, etc.

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These settings are changed at regular intervals, or when required, and their positive effect assessed by analyzing the opacity signal, while simultaneously checking that the process conditions have not changed by means of a trend analysis of their respective signals. These relevant settings cannot be optimized to the same degree by the AVCs operating as stand-alone units, i.e. only relying on the electrical mA and kV feedback signals.

For all these reasons, it is considered that a complete Energy Management System (EMS) architecture depicted in will become more and more accepted. The control room personnel will operate the precipitator from their monitor stations in the normal way but via a gateway communication with the precipitator supervisory computer running in the background. This computer will overtake and perform more and more advanced control and monitoring functions, like precipitator event and alarm indication and handling, fault diagnosis, etc. These features, complemented with precipitator start-up and shut-down automatic routines, will result in an intelligent and powerful supervisory computer control, thereby, relieving plant personnel from tedious work routines and will provide cost advantages because of power savings, easier and better maintenance, higher plant availability and a lower average dust emission.

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