THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
345 E. 47 St., New York, N.Y. 10017

85-JPGC-APC-5

Economical, Innovative Methods of Straightening ESP Collector Plates So As to Achieve Alignment for the Purposes of Improving Particulate Control and Performance

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ABSTRACT

There are more than 1800 electrostatic precipitators installed in power plants across the nation. Many of these discharge more particulate matter into the atmosphere than they should. One of the typical reasons for degradation of precipitator performance and reliability is poor electrode clearances, often caused by collector plate distortion. Economical and innovative solutions to this problem are required. This paper will discuss several techniques currently being used to straighten warped collector plates in electrostatic precipitators. Each method will be addressed in terms of its benefits and detriments to the precipitator, as well as its physical practicality.

PROBLEM DESCRIPTION

Collector plate distortion presents a number of obstacles to good precipitator performance. The most obvious is erratic electrode clearances. The proper function of a precipitator depends on the existence of a specific clearance between discharge electrodes and the collector plates. In a high efficiency ESP, it is necessary that these clearances be uniform throughout a given electrical field.

The minimum clearance between the electrodes and plates is often referred to as the "spark gap". To realize design performance, the spark gap must remain within the design tolerance. Should the spark gap become shorter, for instance, due to a warped collector plate, a spark will occur at a lower voltage than otherwise thus causing the entire field to function at a lower voltage. In addition, this will typically result in a higher spark rate and less "on time" for that electrical field. The effect is the same as if the precipitator were reduced in size.

Should electrode clearances become excessively close, performance will drop off sharply, and reliability will be reduced as well. This condition is normally anticipated with a spark gap of 75% of optimum or less (3-3/8 in. for 9 in. plate spacing) but will vary depending on numerous factors. For example, a weighted wire unit with adequately sized weights and a state of the art anti-sway system will function efficiently with closer than expected clearances due to reduced electrode movement. If widespread collector plate damage has occurred with numerous electrode clearances of less than 75% of design, sparking will be localized to the close clearance areas rather than random. A high electrode failure rate will typically result. Electrode movement, such as sway or whip, becomes extremely critical. Fields in such condition are often operated at high spark rates in an attempt to balance performance with reliability. In a weighted wire unit, electrode failure is a particularly serious problem, as a fallen wire can ground more than one field. The loss of two or three fields in succession can cause dust overload of the subsequent fields, allowing a large volume of flue gas to essentially escape treatment. As a temporary measure, the decision is often made to remove large quantities of wires in order to increase the minimum spark gap to a more acceptable level. The precipitator is effectively reduced in size, but the reliability is restored. Many rigid frame designs offer no opportunity for this compromise, as close clearances cannot be eliminated by simple wire removal. Indeed, the discharge electrode frame or mast is subject to distortion in the same manner as the collector plate. Collector plate dis-

Presented at the Jt. ASME/IEEE Power Generation Conference
Milwaukee, Wisconsin — October 20-24, 1985

tortion can be severe, with the typical minimum electrode clearance at 50% of design or less. The author has observed and photographed collector plates in a number of precipitators warped so badly as to be in physical contact with each other. However, collector plates in this condition have been successfully repaired as described later in this paper.

FIG. 1 COLLECTOR PLATE DISTORTION

Besides causing poor electrode clearances, collector plate distortion can be seen to reduce precipitator performance in a number of other areas. Severe plate warpage can result in distorted gas distribution within a precipitator. Warped plates can act as flow diverters, and may even direct flue gas into hoppers. Hopper sneakage is the worst form of bypassing in that the flue gas not only escapes treatment over a given area, but also re-entrains ash which has already been collected. A gas distribution test at the inlet and outlet of the precipitator will normally not uncover this condition.

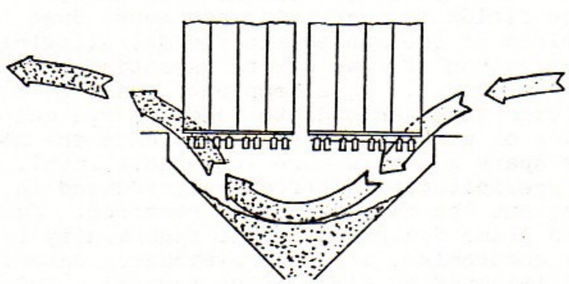

FIG. 2 HOPPER SNEAKAGE

Collector plate warpage adjacent to precipitator walls and structure can result in large openings at leading edge anti-sneak baffles. Under this condition, flue gas is allowed to bypass the treatment area by travelling along walls and between fields. It should be pointed out that a 2% sneakage rate will place a 98% cap on ESP efficiency. Should the distortion occur at a trailing edge anti-sneak baffle, flow through the adjacent gas path may induce a flow through the resulting opening. In some cases, this can result in a flow which will draw ash directly from the hopper. Such induced sneakage has been observed during practical air flow tests in the field.

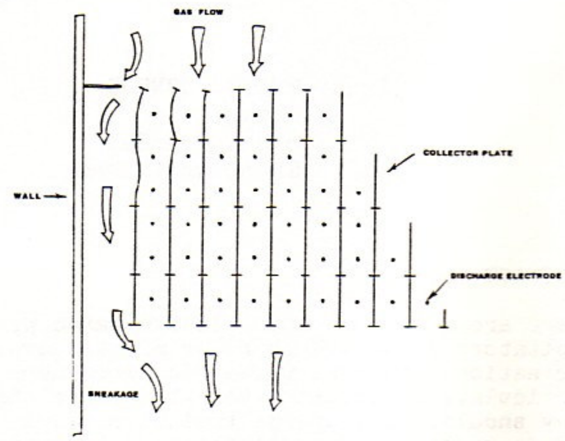

FIG. 3 TYPICAL SNEAKAGE

Another area of concern is the detrimental effect on collector plate rapping. A severely warped collector plate can dampen transmission of acceleration to its far corners. Of even greater interest is rapper loss due to the resulting non-uniform cross section of the plate. To illustrate, picture two collector plates: one in its original straight condition, one with a large simple bow along its entire length. Ideally, the straight collector plate is properly rapped, separating the ash layer from the surface cleanly under the shearing effect. Due to gravitational force, the ash then slides along the plate surface, within the dead air space created by the stiffener baffle of the collector plate. The ash is thus protected from re-entrainment into the gas stream until reaching the hopper. The stiffener baffle looses its effect in the case of the bowed collector plate. On the prominent side of the bow, the ash moves along the plate surface until reaching the lower elevations. At this point, the slope of the collector plate cross section is reversed. The ash can then fall directly into the gas stream and be re-entrained into the system. It should be noted that this problem is exacerbated by low adhesion of ash to the plate surface due to the relatively lower strength of the electrical field associated with warped collector plates in a given area. On the reverse side of the same bowed collector plate, re-entrainment can begin immediately at the upper elevations. Occasionally, if the plate is rapped from the top, ash can form excessive buildups at the lower elevations due to the altered cross section of the collector plate, as well as the associated degradation of transmission of rapper acceleration. On the other hand, relatively clean plates may result due to poor adhesion and excessive re-entrainment, thus masking the condition during routine inspection. In the case of a modern ESP with relatively tall collector plates, rapper loss can account for a large percentage of total emissions.

PROBLEM CAUSES:

Collector plate distortion is most typically caused be a rapid or excessive change in temperature within the precipitator. Often such an occurrence is traced to a process upset at the front end of the steam generating unit. Loss-on-ignition, commonly referred to as "carbon carry-over", has been responsible for numerous precipitator fires and explosions leading to warped collector plates. Some of these catastrophes have occurred as a result of operating problems related to a conversion from high sulphur to low sulphur fuels as mandated by regulatory agencies. It has proven difficult to properly control the burning of certain low sulphur coals in some boilers. During an inspection of such a unit, it is not unusual to observe carbon clinging to the collector plates at the outlet end of the precipitator. Ash accumulation may take on a "salt and pepper" appearance. The condition may not be fully diagnosed by analysis of hopper samples, as much of the carbon is carried directly up the stack. A few units have unusual design or operating problems. In such a unit, one can often find combustibles on surfaces throughout the precipitator. Another typical source of carbon within the precipitator has been traced to improper boiler start-up techniques. In this case, carbon may be observed as stratified layers within the ash accumulation on collector plates or discharge electrodes. In addition, insulators may be found to be oil coated. It should be noted that once collector plate distortion has begun, the condition of the plates will often degrade further over time.

A rapid drop in temperature can cause similar results as the aforementioned overheating conditions. For instance, boiler economizer tube leaks have been linked to collector plate distortion in hot side precipitators. Severe damage from this source has been observed to result in the destruction of structural members, as well as collector surface. in the case of a rigid frame design, the discharge electrode system, of course, will also suffer damage.

Of course, another typical cause of collector plate warpage is a high hopper ash condition. High ash can stress the collector plates during operation, resulting in permanent warpage and buckling. A high ash condition will aggravate the damage caused by carbon carry-over and the resultant hopper fires. Damage is frequently traced to this source, indicating the importance of a reliable high level alarm system.

Collector plate bowing has also been linked to improperly designed or installed plate spacer hardware at the top, bottom or sides of the plate. The bottom side spacer retaining bar usually interfaces with the precipitator structure in some manner to maintain the plate section in a particular position in space. If this hardware is designed in a manner which binds the plate section to the structure, the plates adjacent to that structure can be expected to bow. It should be appreciated that the collector plates will expand prior to the precipitator structure which may be shielded from the gas flow and thus momentarily shielded from heat. This becomes a matter of concern during a fast start-up of a unit with a hot side precipitator. As has been observed on some hot side precipitators, the last three plates adjacent to an outside wall are either warped or are broken free from the bottom side spacer bar.

Many precipitators have suffered from major structural distortion problems. In a hot side precipitator, the structural problems can be chronic. The structural condition can result in collector plate warpage in a variety of ways. The collector plate support beams or support anvils at the top of the precipitator may distort, causing the entire plate section to twist. A vertical column may deflect, forcing several plates in a section to bow. A warped vertical column may force an anti-sneak baffle into a collector plate. A distorted level strut or catwalk may contact the plates. In all such cases, the collector plate is forced into a bowed condition through an outside force. The distortion may or may not become a permanent condition of the collector plate.

Collector plates can warp and bow due to mishandling during installation. One erection practice, sometimes utilized in the industry, is to install warped or otherwise damaged collector plates adjacent to casing walls in order to avoid a close clearance to the wires. Crimping, as well as localized heating, described later in this paper, have been widely used in an attempt to correct fabrication inadequacies and mishandling. Plates abused in this way often distort in service. In addition, the precipitator may have been erected in an out-of-plumb condition, thus inducing widespread collector plate distortion.

Certain collector plates tend to be more conducive to distortion than others. The trend in weighted wire ESP designs has been to smaller plate stiffener baffles. The smaller baffle provides less rigidity over the length of the plate, and less resistence to distortion. Many rigid frame designs utilize long narrow collector surfaces commonly referred to as "strip plates". These plates typically provide an extremely small stiffener baffle integral with the plate. Thus, a plate can be made simply by passing the metal plate through a roll former. The degree of bow in the original plate depends on the accurate adjustment of the rolls. It is not unusual for large numbers of such plates to be bowed in their original condition.

FIG. 4 "STRIP PLATE" DISTORTION

In light of modern collector plate design and the large sizes currently installed in a high efficiency ESP, some degree of collector plate distortion should actually be anticipated. It seems almost unreasonable to expect such an insubstantial structure to maintain a straight cross section to close tolerances without adequate support. In addition, one should note the hostile environment to which they are subjected. Once damage has occurred, the choices are to accept the loss on precipitator performance, replace the damaged components, or repair the damage. The major methods of repair, both successful and unsuccessful, are discussed in the following section.

METHODS OF REPAIR

Many interesting attempts have been made to straighten warped collector plates. Plates have been removed from a precipitator, bent over a sawhorse, and reinstalled. One attempt, known to have been made, involved the use of automobile inner tubes to separate collector plates which had collapsed toward each other. The author has inspected serious collector plate damage which resulted from an attempt to straighten bowed plates by manhandling with scaffold lumber. In hindsight, many such repairs appear totally inappropriate. However, it should be pointed out that many plant engineers have been faced with the problem of precipitator internal damage and the punitive reductions imposed upon generating capacity due to poor precipitator performance. Until recently, reliable, permanent repairs were not readily available.

Some apparent collector plate distortion is merely the result of external factors. As described earlier in this paper, a structural member may bear on a plate, causing it to deflect. A plate section can often be found to be improperly secured or otherwise bound to the precipitator structure. Retaining bars are often improperly installed or damaged. The plate suspension system, or indeed the entire precipitator, can be out of plumb. Once the condition is recognized, the appropriate steps can be taken. Most often, once the external factor is eliminated, the collector plate will return to a straight condition. If the plates maintain the distortion, alternate straightening methods are required.

Several methods of repair have been devised which impose a localized stress upon the collector plate in an attempt to return the plate to a straight condition without removal from the precipitator. One mechanical method which has been widely applied is known in the industry as "crimping". Under this technique, a simple tool is used to form a small bend on the stiffener baffle on one side of the collector plate. Thus crimped, one side of the baffle is effectively shorter than in the uncrimped condition. Therefore, by crimping the collector plate at chosen locations, the plate is brought into alignment. The required tools are simple, and several variations have been devised. The technique has been used to straighten new collector plates which were installed in a warped condition, as well as to straighten plates damaged in service. One variation of the crimping technique, peening, has been routinely used to straighten strip plates in rigid frame precipitators during installation. Crimping techniques, however, are falling from favor in the industry due to negative operational experience. Once crimped, a collector plate looses much of its structural rigidity. The plate is then more conducive to distortion than prior to repair. Collector plates repaired in this manner tend to further distort, and it has proven necessary, in a number of precipitators, to perform widespread crimping as a routine outage item. During inspection of such a unit, it is not unusual to find numerous collector plates which bear the mark of repeated straightening attempts. At this point, the plates often can no longer be brought into satisfactory alignment using internal stress techniques. In addition, plates have been observed to return to the previous bowed condition or to "oil can" almost immediately after straightening by this method. The continued distortion of collector plates after crimping has become a matter of concern in precipitators repaired in this manner.

Another method of collector plate repair, generally employed throughout the industry, is known as "heat straightening". A torch is used to heat the surface of the plate at chosen locations to change the shape of the plate in an attempt to bring the plate into satisfactory alignment. The plate is, in effect, intentionally warped and buckled in a way intended to counteract the existing warpage. Torch heating of one side of the collector plate while alternately water quenching the opposite side of the plate is a logical extension of the same technique. Like mechanical crimping, heating has been used in the industry to straighten new collector plates which had been installed in a warped condition, as well as to repair collector plates warped in service. On the negative side, the results entirely depend upon the skill of the tradesmen directly performing the repair. It is not unusual to find areas of extremely close electrode to plate clearances after the conclusion of such a repair. In addition, such heating of the collector plates destroys the original cold-rolled condition of the steel and imposes local stresses of an unknown nature within the plate. Once repaired in this manner, a collector plate will often distort more dramatically than the condition before repair. Such plates typically can be observed during inspection as bent and buckled. For example, a plate observed with a simple bow prior to repair may show complex warpage after heat straightening and subsequent operation. Like mechanical crimping, heat-straightened plates have also been observed to return to a bowed condition or to "oil can" almost immediately after repair. The continued distortion of collector plates after heat-straightening can result in a serious operational problem in a modern ESP.

Some success has been noted by a process of cutting and repairing of the collector plate stiffener members. Under this method, the collector plate stiffener baffle and/or the plate bottom support component is cut at one or several locations. Often then the plate will hang plumb and straight due to its own weight. The cuts are then repaired with patches and welding. In order as not to cause close point to point electrode clearances, cuts must be located and patches designed for maximum separation from the discharge electrode system. In addition, welding must be held to a minimum to reduce the introduction of localized stresses and consequential plate buckling during operation. The process tends to be extremely labor intensive but can be an appropriate repair in certain instances, for example, repair of one isolated and sharply bent collector plate.

The most successful repair techniques devised to date involve the use of spacer devices to positively maintain the proper distance between collector plates. These spacers have taken a variety of forms depending upon many factors. The most significant benefit observed from the spacer concept is the support of the collector plate against distortion.

Typical precipitator design provides a means of maintaining the proper spacing between collector plates at all four corners of the plate section. Many weighted wire designs have added one or more elevations of retaining bars or "intermediate side spacer bars" to the leading and trailing edges of the plates. Some designs include additional "centerline spacer bars" at the top and bottom of collector plate sections.

Occasionally, collector plates can be successfully straightened by the installation of additional side spacer bars at chosen locations. The addition of such spacers is also used concurrently with more sophisticated spacer techniques described later in this paper. Good spacer design calls for the use of cold-rolled material with provision for a loose attachment to each collector plate in order to maintain separation for the rapping of each plate. Alternately, spacers can be designed to firmly attach a group of collector plates together within a given anvil section, with a loose link connection between anvil sections. In this way, the rapper accelerations can be better transmitted to the extremities of the plate section without dispersal into adjacent anvil sections. Spacer bars are typically secured to the collector plates by bolting or welding. A variety of other methods are used, including specialized tabs or notches in the spacer which capture the appropriate plate.

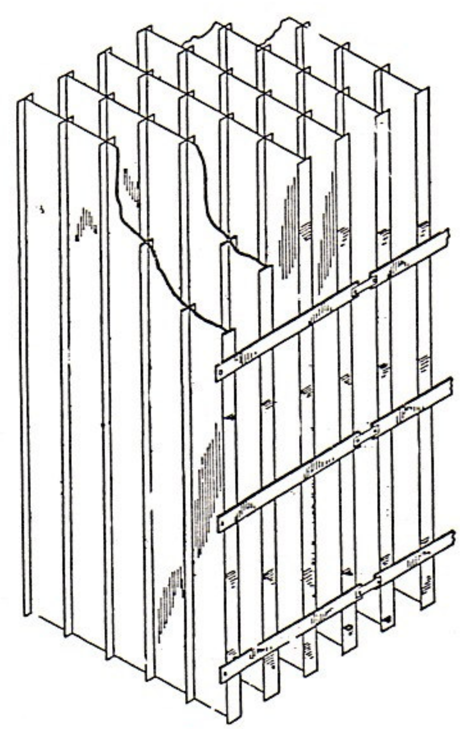

FIG. 5 SIDE SPACER BARS

Spacers and spacer attachments are typically located so as to maintain a clearance from the electrodes of 150% of the design spark gap. Mounting at a closer clearance usually necessitates the use of hardware having radiused edges. Close attention must be given to the method of attachment so as not to create sharp edges in close proximity to electrodes. In some cases, it may be necessary to physically relocate certain discharge electrodes to maintain adequate clearance to a spacer device.

Some precipitators, including one prominent rigid frame design, as well as a previous weighted wire design utilize a device known as the "middle alignment bar" to hold a set of strip plates in alignment. The middle alignment bar runs parallel to gas flow at the mid-point of the plates, secured to each narrow plate in a set, thus creating, in effect, one wide collector plate. In the case of the subject weighted wire design, the bar is made from a standard piece of flat stock, secured to the collector plates with pop rivets and connected to the intermediate side spacer with a pin. Much success has been achieved by a method which begins with the removal of the subject alignment bars, and all rivet hardware. Additional middle alignment bars are then installed at multiple elevations and secured to additional side spacers. The side spacers can then be used to position the middle alignment bars, and thus align the collector plates. The alignment bars are fabricated from cold-rolled steel and are provided with a radius along each edge. The result of the installation is to straighten the collector plates in place and eliminate all sharp edges adjacent to the discharge electrodes. This approach has proven successful in a number of units where its use is appropriate. In the case of severe warping, a modified form of the U-Bar spacer, discussed later in this paper, is installed at multiple elevations.

Modern collector plate spacer technology was developed several years prior to this writing in response to the perceived waste of material, time and financial resources associated with the removal and replacement of damaged components, particularly in weighted wire units. It was observed that a severely warped collector plate, once removed from the unit and placed on a flat surface awaiting removal for scrap, would often return to a straight condition under the force of its own weight. Thus, it was surmised, the component could have been saved given adequate support over the entire surface while in the precipitator. Accordingly, a concept was devised which would allow the internal stresses which were acting to distort one collector plate to be directed to provide the force needed to straighten another plate through the use of a transfer point. The cumulative effect of a sufficient number of transfer points could then maintain all collector plates within a given section in a straight condition. The transfer points took the form of a multiplicity of spacers attached to the collector plate stiffener baffle, extending between two adjacent collector plates. The spacer design was simplified into its current shape by a process of value analysis and has become generally known in the industry as the "U-Bar". The U-Bar has also been made in a variety of alternate configurations as required. Detailed information can be obtained by study of the subject patent 4,478,614.

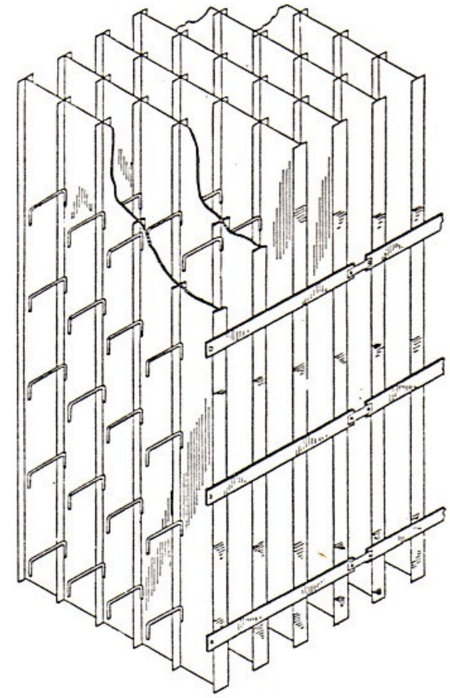

FIG. 6 TYPICAL U-BAR SPACERS

Several factors were considered to be desirable in the development of the U-Bar spacer. The spacer is designed using a rounded cross section of sufficient diameter to preclude the chance of spark-over from an adjacent discharge electrode. No sharp edges are used. In addition, the specific diameter was chosen in light of strength requirements and weight considerations. The spacer is installed adjacent to the collector plate stiffener baffle both to provide an adequate surface for the mounting of the spacer and to separate the device as much as possible from the discharge electrode system, generally between 125% and 150% of the design spark gap. The spacer is secured to the collector plate stiffener baffle by welding or other means. To maintain the separation between individual collector plates for purposes of rapping, the spacer is typically secured to one collector plate and allowed to abutt the adjacent plate. Also for rapper isolation, the spacer is fabricated of a slightly shorter length than would otherwise be chosen to hold the collector plates in an ideally spaced relationship. The resulting "gap" is varied depending upon the requirements of the individual precipitator. The ideal quantity of spacers per collector plate was determined through field testing. The process has proven to be an economical and effective technique for the repair of warped collector plates and has been widely used since its development for both routine and major repairs in weighted wire precipitator designs of several manufacturers.

The U-Bar spacer has also been effectively used to stabilize collector plates against subsequent distortion. Accordingly, the U-Bar system has been installed throughout entire precipitators at a number of locations. Thus, all collector plates were properly supported and held in alignment regardless of forces later acting to distort the plates. This approach has proven successful and has become a viable alternative to component replacement. Recently U-Bar spacers have been installed on new collector plates at two generating units to prevent plate distortion by anticipated process upsets. For these projects, a special mounting device was designed and registered under U.S. Letters of Patent number 4,519,818. The new device allowed the spacers to be mounted in a "retracted mode" in shop conditions during collector plate fabrication. The collector plates were then stored and installed in the normal manner. After erection, the U-Bar spacers were opened to the "extended mode", to become operational as collector plate supports. An added benefit of the spacer installation on new collector plates was the resulting ability to provide electrode alignments to closer tolerances than would otherwise have been normally practical to achieve.

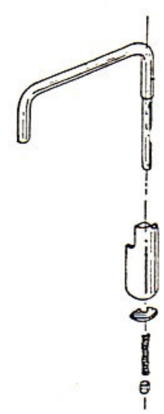

FIG. 7 MOVEABLE U-BAR SPACER

It was surmised, in the natural course of development, that a less labor intensive U-Bar installation could be achieved in a number of weighted wire precipitator designs through a simple modification of the spacer device. A new spacer was fabricated to provide two or more U-Bar type spacers connected together to form one longer assembly generally referred to as the "Ladder Bar". The new assembly could then be inserted between two adjacent collector plates, using the stiffener baffle as a guide, thus eliminating many of the practical problems of difficult access. The potential for an extremely economical method of repair to collector plate distortion was obvious. The device was proven in field installation to have several advantages over the conventional U-Bar system. Many variations on the concept have been demonstrated. The use of two or more spacers connected together to form a large assembly was registered under U.S. Letters of Patent number 4,479,813.

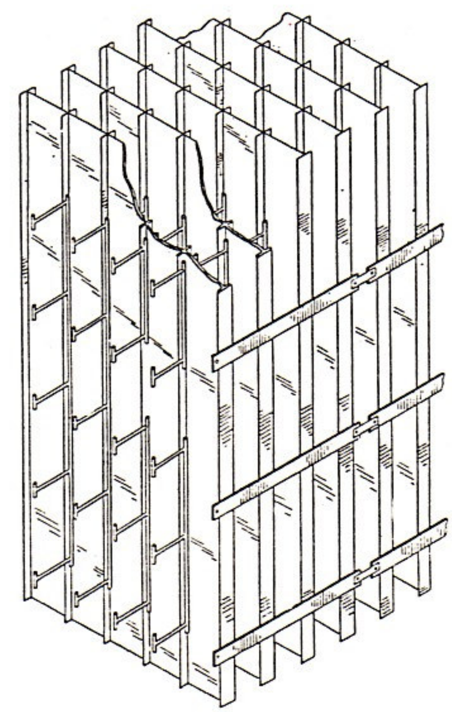

FIG. 8 LADDER BAR INSTALLATION

The early ladder bar designs consist of two or three U-Bar type spacers connected together by one or more vertical members. These could be secured to the plate by welding or other means at the ends of the assembly. Subsequent ladder bar designs are constructed from separate modules which link together within the precipitator, thus forming a large ladder assembly. The modular concept allows the formation of ladders along the entire length of the collector plate regardless of the size of the plate or the available access to the precipitator. Thus, each component of the ladder is designed to loosely engage with the collector plate stiffeners of two adjacent plates. In this way, the spacer bars are positively retained in place while each collector plate remains in isolation for rapping purposes. The ladder holds the collector plates in straight alignment by use of the integral U-Bar type spacers. In addition, the overall assembly is securely held from a top suspension where it is attached to the plate by welding or other means. Thus, the entire assembly will tend to remain in a straight and plumb condition due

to its own weight. When required, the assembly can be placed under tension to straighten a severely bowed collector plate. In addition, a rigid connection can be used between spacers, thus providing structural integrity across the entire length of the assembly.
The ladder bars can be loaded into the precipitator from the top or bottom of the collector plates using relatively unskilled labor. Little or no welding is required, discharge electrode removal is unnecessary, and collector plates do not have to be cut loose or moved. The need for elaborate scaffolding installation is eliminated. The assembly can readily be removed from the precipitator at a later date if required. The result is an effective and reliable method of permanent collector plate repair which can be easily accomplished during a short outage using available in-house or contract personnel.
The technique has been successfully used in a number of precipitators at the time of this writing. The modular ladder bar currently is designed for use on a particular type of collector plate common to many precipitator designs. Research and development is continuing, and it appears obvious that with simple hardware changes, the concept can be made available to a wider variety of precipitator designs.

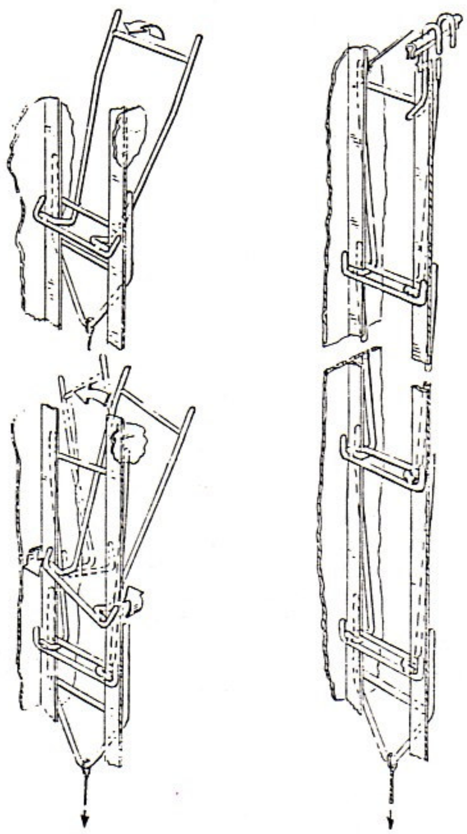

FIG. 9 MODULAR LADDER BAR

In November of 1984, work was concluded on a collector plate straightening experiment by this author in cooperation with a major utility. The project was begun in 1981 in response to the discovery of widespread collector plate distortion in a new precipitator. The distortion was noted prior to completion of erection and involved a large percentage of the collection surface within the precipitator with minimum discharge electrode to collector plate clearances of 25% of the design spark gap. The subject precipitator is of rigid frame design, utilizing the long, narrow collector plate type often referred to as the strip plate. Plate distortion took the form of simple bows and was traced to improper fabrication techniques. Accordingly, six collector plates were provided by the utility for the purpose of development of a new method of field repair. Existing spacer techniques were set aside in favor of a new concept which would not alter the original design of the precipitator. The concept was subsequently perfected in the form of a device which is referred to as the "Torque Bar". The device interfaces with one or both ends of the collector plate and is used to apply a moment of force to a collector plate to straighten the plate. The bar is then locked at the selected attitude to maintain the plate surface at the desired position. The torque bar thus becomes a permanent part of the precipitator assembly. Detailed information is available by study of U.S. Letters of Patent number 4,516,992.

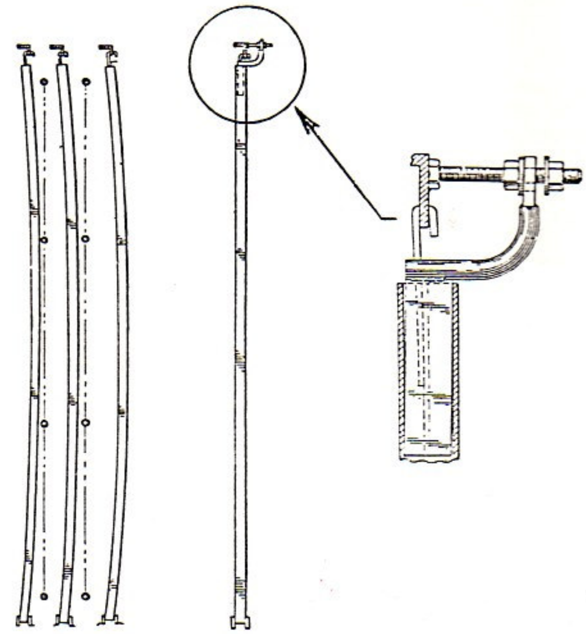

FIG. 10 TORQUE BAR INSTALLATION

In 1982, sample collector plates within the unit were successfully straightened in place to design tolerances using the torque bar technique. Rappers were activated and no ill effect could be noted on rapper function or effectiveness. Meanwhile, collector plates in other areas of the precipitator were straightened under manufacturers recommendations, using typical heating techniques. It should be noted that the heat repair has resulted in complex warpage as normally associated with the technique. In 1983, the subject test plates were inspected. No change could be noted. In addition, ash accumulation was light and similar to adjacent plates which were used as a control group. In 1984, the plates were again inspected, and again no change could be noted. Additional collector plates were straightened at this time with satisfactory results.

The project has resulted in the development of a radically new and effective method for the reclaimation of bowed collector plates of the variety commonly installed in rigid frame precipitators. Research and development continues, and it is anticipated that the technique will find application in a wider variety of designs.

CONCLUSION

Collector plate repair techniques have evolved in response to a need within the industry for a solution to the problem of frequent and widespread internal distortion within operating electrostatic precipitators. The punitive measures imposed by regulatory agencies in response to loss on ESP performance associated with such damage have resulted in the magnification of the importance of precipitator internal mechanical condition. Various methods of repair have been attempted, some with negative consequences to the precipitator. Several successful techniques have been developed which in many cases are preferable to component replacement. The repair of distorted collector plates is now considered to be a viable method of achieving improved particulate control and ESP performance. The devices utilized have reached the state of sophistication to be applicable for use during the erection of a new precipitator for the purposes of problem prevention. Research and development is continuing in this area.

ACKNOWLEDGEMENTS:

Credit is extended to the following for their assistance to the author in gathering information leading to this paper.

Robert B. Candelaria, Salt River Project
Raymond J. Horvatin, Commonwealth Edison Co.
Phillip Johnson, formerly Wisconsin Electric Power Company
Joseph Longo, Tampa Electric Co.
Frank V. Miholits, Commonwealth Edison Co.
Rodney F. Pierce, Commonwealth Edison Co.
William Sisk, Tennessee Valley Authority