BIEWER LUMBER™

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Biewer Sawmill Inc.
Malfunction Abatement Plan
Start-Up, Shut Down, and Malfunction Plan
SRN – N1722
Permit Number – 286-05

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Abatement Plan

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Biewer Sawmill Inc.
Malfunction Abatement Plan
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1.0 General

The purpose of this plan is to outline procedures of operation that Biewer Sawmill will enact to operate and maintain two Wellon's storage silos and one 40,000lb/hr Wellon's wood fired boiler with ESP installed at 6251 West Gerwoude Drive, McBain, MI 49657 under permit number 286-05, SRN – N1722. Boiler will produce steam for heating the facility and dry kiln operation. Procedures set forth by manufacturer, Wellon's Inc., will be utilized to ensure proper operation, maintenance and monitoring during normal operation of boiler to minimize emissions to be in compliance with permit number 286-05.

2.0 Operating Theory

2.1 Fuel Supply / Silo System

Biewer Sawmill produces sawdust, bark, wood chips and dry planer mill shavings in excess of what the boiler can consume to ensure a constant supply of clean fuel, fuel reclaim system allows an option to purchase outside wood chips in event a shortage were to develop. Green fuel is conveyed to storage silos to contain fuel for the boiler. Each silo has roughly a 36 hour supply of fuel at normal burn rates. In event of silo malfunction, an emergency feed auger was installed on fuel infeed conveyor to boiler to further ensure boiler avoids upset condition.

2.2 40,000lb/hr Wood Fired Boiler

Boiler will be staffed 24/7 during all operations. Operators will monitor boiler to ensure water chemistry and performance stay at an optimal level. Operators will be required to keep a daily log and notify plant manager and manufacturer of any circumstances that may deviate from normal operation so that acceptable performance can be maintained. Boiler is computer controlled to monitor entire system and is equipped with modem and telephone lines in event that the manufacturer needs to access the system to assist during a malfunction or perform preventive maintenance to software. In addition, Biewer Sawmill will

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utilize two existing natural gas fired boilers as back up in event wood boiler cannot be operated in compliance with permit 286-05

2.3 Electrostatic Precipitator (ESP)

Exhaust gases exiting boiler pass trough the multiple cone collector where particulate falls out before preceding to ESP. The ESP is a series of collecting plates that are positively charged to collect negatively charged particulate. The collector plates are broken into tow zones, a primary and secondary zone each on separate controllers which are monitored in control room. As particulate collects on plates rappers strike plates at intervals to remove particulate which is augered out to a hopper. Stack temperatures of 250 – 330 degrees must be maintained to ensure proper operation of ESP.

2.4 Start – Up / Shut – Down and Excessive emissions

Start Up and Shut Down process: Please refer to section M – 197

Following the Startup / Shut down process will assist in limiting the amount of excess emission from the boiler during that time.

Excessive emission: Please refer to section M – 432. In this section we will cover how to check the fire, fuel mixture and exhaust system pressures to determine the cause of excessive emissions. The system is also equipped with a digital read out of current emissions volumes as well as a system to record emission and calculate a 7min average emissions rate. Operators will document the current emissions on the hour every hour. If there is an issue with excessive emissions the operator will follow protocols later described in the binder. All operators are trained on what to do if we are excessive in emissions.

Example 1: Fuel mix – Type of fuel being burned and moisture content of the fuel. Fuel Mix will be checked to verify the type of fuel we are currently mixing. If the current fuel mix is not acceptable the employee will adjust the system to maintain proper mix.

Example 2: If a high-pressure situation occurs in the Multi-cone, the system will have to be shut down and cleaned to maintain proper air flow. A high reading tells the operator there is a plug in the system that needs to be removed. The

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reading is checked on a daily basis and reported to the General manager in a daily production report.

Example 3: Using the sight glass on the East side of the boiler, the operator can look at the "Burn" or color of the fire. If the color of the fire is not adequate, the fuel mix or pile height can be checked to maintain a proper "Burn" inside the cell. Too much fuel will cause excess emissions or not enough fuel can cause excessive emissions.

3.0 Operational Procedures / Preventative Maintenance

3.1 Silos / Fuel Handling System

3.2 Wellon's Cell Furnace

3.3 Electrostatic Precipitator

3.4 Recommended Spare Parts

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3.0

Operational Procedures / Preventative Maintenance

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3.1

Silos / Fuel Handling System

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FUEL HANDLING SYSTEM OPERATION

The fuel handling equipment that delivers fuel to the energy system can be divided into two (2) separate operating systems, the Fuel Receiving System and the Fuel Storage and Delivery System.

I. FUEL STORAGE AND DELIVERY SYSTEM

A. The Fuel Storage System consists of two (2) A30-30 dry fuel storage bin, capable of holding 150 units. This storage capacity gives a fuel reserve of about 40 hours with the furnace system operating at full capacity.

Note: See Wellons Posi-Flo storage bin bulletin for description and operation.

B. The Fuel Delivery System consists of a series of drag chain conveyors and augers that transport the fuel from the storage bin feedout section into the furnace. The process energy needs of the new installation require one (1) boiler with a furnace system consisting of one (1) cell which receives fuel from a metering bin/cell feedscrew combination. The metering bin receives fuel from the storage bin feedout section and contains two (2) augers driven by a variable speed motor, that discharge into a constant speed cell feed screw that delivers the fuel into the cell.

1. Electrical Controls

All on/off/auto/maint controls for the fuel storage and delivery system are located in the control room where a computerized programmable logic controller (PLC) controls the functioning of the system. The control logic is a simple progressive interlock arrangement that allows each conveyor/auger in the system to start only after all succeeding conveyors/augers are running. This system has an "auto/maint" mode for supplying fuel to the metering bin upon demand. An optical level switch, which is mounted on the metering bin, will detect a low fuel level, and will start the delivery system that supplies material to the metering bin and will operate until the fuel demand of the metering bin is satisfied. The "auto" mode interlocks the fuel delivery system to the heater/furnace safety "master control" system. An adjustable timer is part of the supply auger control circuit, and if the delivery system operates for a period of time longer than the timer's setting, a "fuel trouble" alarm is activated.. The metering bin delivers fuel to the cell feed screw located above the cell chute.

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WELLONS POSI-FLO STORAGE BIN WITH RATCHET AGITATOR DRIVE

I. GENERAL

The Wellons Posi-Flo storage bin consists of: an upper silo storage section; a lower cone shaped storage/delivery section; a powered agitator assembly; and a powered material removal (feedout) section located at the bottom. This design ensures that a dependable outflow of material is always available to the process system.

NOTE: Storage bins may be classified as a confined space and subject to the facilities confined space and lock-out/tag-out procedures

II. PARTICLE SIZE

This storage bin will operate with best results if the particle size of the material to be stored or processed through the bin does not exceed 3" in any one direction with the average size of 3/4" or less. When greater sized particles or stringy, long fibrous material get into the bin, the feeding down process is hampered and additional attention to operation may be necessary. Otherwise, the operation of the storage bin is fully automatic in delivering material to the process system.

III. DESCRIPTION

A. MATERIAL STORAGE

The storage part of the bin consists of two (2) components: 1) the silo section which has a negative-slope design that virtually eliminates the possibility of side wall hang-up, and delivers material by gravity to; 2) the cone section which delivers material by gravity and agitator operation to the feedout section of the storage bin.

B. AGITATOR

The agitator is a tube with digging rakes arranged to produce an augering effect as it both turns on its axis and moves around the inside circumference of the cone. The function of the agitator is to prevent fuel bridging and to maintain a downward flow of material to the feedout section at the bottom of the bin's cone section. The agitator is turned through a universal joint by a gear reducer drive, and pulled around the inside circumference of the cone section and through the stored material by an air powered ratchet drive.

C. AGITATOR RATCHET DRIVE

The ratchet drive is made up of two (2) air cylinders, located 180° apart on the circumference of the storage bin. Limit switches mounted on each cylinder activate air solenoid valves which cause the air cylinders to extend and retract. During the extension part of the cycle, the cylinders move a chain, which is attached to the top of the agitator, around the cone section of the bin. This extension/retraction cycle is continuous as long as the ratchet drive is energized. For normal (forward) operation, the agitator turns in a clockwise direction and is pulled by the ratchet chain in a counter clockwise direction around the cone as viewed from the top. For reverse operation, the agitator turns in a counter clockwise direction and the ratchet drive does not operate.

WARNING: RELIEVE ALL PNEUMATIC AND MECHANICAL STORED ENERGY BEFORE SERVICING EQUIPMENT.

D. FUEL REMOVAL SECTION

This section, which is also called the feedout bin, is located at the bottom of the storage bin and contains two (2) feedout augers. The augers remove the material at the bottom of the cone and deliver it to a conveyor system for transport to the process. The fuel removal section also contains the motor/gear drives for the agitator and feedout augers.

IV. OPERATING LOGIC

With the feedout augers and agitator selector switches in the "ON" position, the storage bin (silo) is in automatic operation and will feed out material upon demand of the take-away conveying system. The agitator and feedout auger drives are electrically interlocked to prevent operation of the agitator without having the feedout augers running, which avoids compaction of the material at the bottom of the cone section. A level switch is located in the discharge area of the feedout section to stop the augers if material is not being removed fast enough by the conveyor system.

When material is requested from the storage bin by the conveyor system, a time delay is started before the feedout augers are started. Once the feedout augers start, the silo agitator is allowed to start in its forward mode. The agitator will continue it's forward mode as long as there is a request for fuel or a fuel jam has not been sensed by the agitator over current relay. Only when the agitator is operating in the forward mode is the ratchet drive control air solenoid energized, supplying air to the cylinders, which ratchet the agitator around the circumference of the bin. When the agitator is called upon to operate continuously to meet the fuel demand, a timed "cleaning" cycle is initiated which periodically interrupts the forward mode and reverses the agitator for a short timed period. When material is not required, the feedout augers stop, which starts a silo agitator reverse run timed "cleaning" cycle. When this reverse run timed cycle has completed, the silo agitator will stop.

If a material jam is sensed by the agitator over current relay, the agitator and ratchet drive will stop their rotation for a timed stop, then the agitator only will begin a timed reverse rotation. At the end of the timed reverse rotation cycle, the agitator will stop for a timed stop period then go back to the forward operation mode which allows the ratchet drive to operate. If the material has not broken loose, the over current relay will start the reverse cycle again. If, during the reverse agitator rotation, a jam is also sensed, the agitator will stop for a timed period, then go back to a forward rotation. This alternating forward-reverse action will continue until the agitator jamming is relieved and material free flows once again to the bottom of the cone section.

If it becomes necessary to operate the silo agitator manually, turn the "SILO AGITATOR" selector switch to "MAINT" position. This enables the silo agitator jog selector switch, which is located near the feedout section. The silo agitator jog selector switch can be turned to "FORWARD" or "REVERSE" to operate the silo agitator manually for forward or reverse rotation. The silo agitator switch is spring returned to the off position from both forward and reverse. When the selection switch is in the "MAINT" position, the ratchet drive does not operate.

V. START-UP AND OPERATION

Before any material is placed in the bin, the following must be checked:

A. Lubrication - Universal joint, feedout auger bearings, agitator drive bearings, agitator wheel bearing, ratchet drive parts, chain race liners, air cylinder lubricators, ratchet drive chain, and roller chain.

B. Oil level - All gear reducers.

C. Electrical - Check motor starters to see that heaters are proper for motor current rating. Bump motors for rotation and ensure no drive belt or chain interference.

D. Agitator - The forward direction should rotate the agitator tube in a clockwise direction when observing from the top end. This tends to move the material in a downward direction and the agitator will start up and normally operate in this mode. The reverse direction rotates the agitator tube in a counter clockwise direction and creates a slight lift effect to the cutting action; however, material still tends to flow down, but at a lesser rate than the forward direction. See Table No. 1 in Section V, Paragraph F for the correct air pressure setting to operate the agitator ratchet drive. The flow restriction valves that control the speed of the air cylinder's retraction stroke should be set for very slow cylinder operation (the retraction stroke should take about a three (3) second time interval). Run the agitator ratchet drive only enough to check clearances and to seat and adjust the ratchet chain. When operating the agitator for the first time, follow the wheel assembly all the way around to ensure that the teeth clear the cone section and that the wheel assembly and agitator top shaft clear the sloped gussets on each main column head. Check to ensure that no agitator teeth interfere with feedout screw flights.

E. Feedout augers - Before allowing any material to contact the augers, be sure the rotation is correct. Normally, right-hand screws are used, in which case rotation will be counter-clockwise when viewing screws from the drive end. If any doubt that proper rotation exists, throw a small container of material into the augers to ensure that the material will move in proper direction.

F. Air Powered Ratchet Agitator Drive - The air pressure at which the ratchet drive cylinders operate controls the rate of agitator movement around the circumference of the cone. Normally, use the lowest air pressure that will cause the agitator to dig into the stored material. Should the feed down rate be too slow, then the air pressure can be increased up to the maximum (shown in the following table). The air pressure should be adjusted so that the agitator does not supply more material to the feedout screws than they can discharge; otherwise, material compaction can occur at the bottom of the agitator.

TABLE NO. 1

Bin Size	* Maximum Air Pressure Allowable
A-30	90 psi
A-24	90 psi
A-21	90 psi
A-19	70 psi
A-17	70 psi
A-13	70 psi

* Measured at zero flow conditions.

Note: Too much air pressure can cause damage to the agitator.

G. Ratchet Chain Lubrication - This is very important and should be performed once a week. Both the upper and lower chain race liners around the entire circumference of the track need to be lubricated. Spraying a light oil or dry type lubricant on the liners will keep dust buildup to a minimum. Application of a heavy oil or grease should be avoided. The ratchet chain tightness is also important. If its too tight, the force available to drive the agitator into the stored material is reduced; if too loose, the slack chain will jam in the chain races. If the chain is properly tensioned, there should be approximately a 1/4" gap between the chain and the chain race at the following places: Immediately ahead of the two (2) ratchet prawls or immediately behind the trailing chain link attachment to the agitator wheel assembly. Tensioning should be done with the agitator restrained from moving and full force of the two (2) air cylinders applied to the chain.

H. Level Sensing Switches - Check all material level sensing devises to ensure proper mechanical and electrical operation.

Note: After the storage bin has been in service for two (2) weeks, a visual inspection should be made of all operating components to ensure that they are correctly aligned and working properly. At this time, retighten all shaft and bearing set collars.

WARNING: INSURE FACILITIES LOCK-OUT/TAG-OUT PROCEDURES ARE FOLLOWED WHEN PERFOMING MAINTENANCE ACTIVITIES.

VI. COMPACTION OF MATERIAL

Greater compaction occurs as moisture content and fiber length increases. For best operation, dormant storage should be avoided, or if it does occur, limit time to four or five days. As material is flowing in, material should be flowing out on some regular basis to reduce compaction rate and ensure continued automatic operation.

VII. FREEZING WEATHER

Subzero weather will cause freezing where high moisture content material contacts outer surfaces of silo and cone section. It is important to keep material moving through the bin when these conditions occur. When possible, the height of storage within the silo should be lowered to reduce vertical compacting forces. If the storage bin is located in an area where prolonged subzero weather is normal, the cone section should be enclosed at the column perimeter and heat added within this space to keep the material from freezing to the cone sheets. Should ice unavoidably form between cone sheets and material to the point where normal operating pressure of agitator will not cut free, a come-along can be attached to agitator upper end and the nearest column, adding pressure to teeth, shaving both ice and material down.

VIII. SHUTDOWN

For any prolonged shutdown period, thought should be given in advance to be sure material level is lowered to within the cone section. This ensures a reasonably smooth startup and minimized compaction.

IX. VIBRATOR

Important: Do not use vibrator on this storage bin as it only tends to increase compaction.

ZELLONS

SILO LUBRICATION CHART

GREASE	Twice Weekly	Weekly	Monthly
Feedout Bin Feedscrew Bearings (4)		X	
Universal Joint (1)		X	
Agitator Drive Chain Tightener Sprocket (2)		X	
Agitator Truck Bearing (1)		X	
Steel Flex Coupling			X
Feedout Screw Drive Wormgear Reducer Bearings & Seals (change Oil every 2500 hours)			X
Agitator Drive Workgear Reducer Bearings & Seals (change Oil every 2500 hours)			X
Motors	See Manufacturer's Lubrication Instructions		
Agitator Truck Wheel (2)		X	

OIL WITH BRUSH

	Twice Weekly	Weekly	Monthly
Drive Chains		X	

OIL WITH SQUIRT CAN OR SPRAY

	Twice Weekly	Weekly	Monthly
Chain Tightener Sprocket Arm Pivot Bolt (2)		X	
Cylinder Slide Assembly & Cam Rolls	X		
Polypropylene Race Linder		X	

PNEUMATIC LUBRICATOR - Fill as Required with 150 to 220 SSU Oil

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WEEKLY MAINTENANCE AND INSPECTION CHECK LIST

1. Check to keep ratchet chain tight, to prevent buckling and catching on the "C" section.
2. Drain water from the air filters.
3. Lubricate per the silo-lubricating chart.
4. Check air pressure to air cylinders. Air pressure should be __________ PSIG.
5. Check air cylinder assembly to ensure all air connections and mounting bolts are tight.
6. Inspect agitator frequently to ensure all digging teeth are in place and that no foreign materials are interfering with agitator operation.

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3.2

Wellon's Cell Furnace

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COMBUSTION PRINCIPLES AND THE WELLONS CELL FURNACE

PRINCIPLES OF COMBUSTION

Combustion is a term usually reserved for a chemical reaction, between a fuel and oxygen, that occurs with a release of heat and light. Normally, quicker rates of combustion are accompanied. by higher temperatures and brighter light. If the rate of combustion is carried to an extreme, it becomes an explosion. Combustion, as referred to in power generation, means a controlled chemical reaction involving any of the commercial fuels or waste products that will combine with oxygen to produce heat and light.

Fuel may be listed under three classifications: gaseous, liquid and solid. Gaseous fuels are the only ones that will burn with an open flame. Liquid and solid fuels must first be converted to the gaseous state before they will produce an open flame.

Gaseous fuels need little preparation before they are ready to burn. Carbon is the element that provides most of the energy in the combustion of commercial fuels, whether they are wood, coal, oil or gas. Gaseous fuels in their normal state have this carbon combined chemically with other elements. If the temperature is high enough, the carbon in the fuel will combine with the oxygen in the air. Before this chemical reaction is complete, it is necessary for the carbon to be released by the other elements with which it was formally combined. The exact sequence of events is unknown. However, we do know what conditions existed before the combustion process started, and we know what conditions exist when it is completed.

One atom of carbon joining to one atom of oxygen forms the chemical compound known as carbon monoxide. If the carbon atom joins two oxygen atoms, the chemical compound formed is known as carbon dioxide. Less than one-third of the chemical energy in the carbon is released when it becomes carbon monoxide. The remaining energy is released when the carbon monoxide finds the second oxygen atom and becomes carbon dioxide. If both atoms of oxygen are available when combustion takes place, the full heat value of the carbon will be released immediately. While getting all of the carbon atoms and oxygen atoms together so they can unite chemically may sound simple, it is actually a little more difficult.

Air is composed of twenty-one percent oxygen, and seventy-eight percent nitrogen by volume. The other one percent consists of a number of different gases that do not help but are ignored. Nitrogen will not support combustion. It is an inert gas the furnace could do without. Each carbon atom has to bump a lot of nitrogen atoms out of the way before it can find a couple of oxygen atoms. If the carbon atoms and the combustion air can be forced into a rolling turbulence, each carbon atom has a much better chance of combining with a couple of oxygen atoms. For this reason, turbulent mixing of fuel and air is considered essential for good combustion.

An ordinary candle will provide an excellent demonstration of the principles of combustion. A lighted match can be brought near the tip of the wick and removed with nothing happening. There is no gas and thus no combustion. If the match is brought closer to the wick and then removed, it is possible to melt the wax on the tip of the wick and still not have combustion. By holding the match near the tip of the wick, it is possible to melt and increase the temperature of the wax until a gas is formed. As soon as gas starts to form, the heat from the match will decompose it. Carbon is released to join oxygen in the air. When combustion starts, the heat released will keep the process continuing.

The flame does not flash down the wick because the fuel is not prepared for combustion. Melting of the wax and changing it to a gas occurs as the flame slowly advances down the wick. This relationship between changing the solid wax to a liquid, then to a gas, followed by ignition, must be maintained or the combustion process will stop.

A candle flame has three basic zones in it. The lower part of the flame surrounds the wick and is almost clear. A match stick can be viewed through this part of the flame quite easily. The reason for this is, the gas released from the melted wax has formed an envelope and does not have air for combustion. That part of the wick inside the envelope does not burn. There is a little burning at the surface of the envelope, where the gas is in contact with the air. However, there is no forced mixing and combustion is retarded. The ideal quantity of air for best combustion is also the smallest quantity that will burn all of the carbon in the gas with no oxygen residual. In actual practice, it is difficult to obtain ideal conditions. A little surplus air with turbulent mixing is required to burn all of the carbon.

The second zone in the candle flame is directly above the wick. A match stick can be viewed through this part of the flame but not as distinctly. The gas from the envelope is rising and mixing with the air. The mixing is not thorough and only partial combustion takes place. Carbon in the gas, formerly associated chemically with other elements, begins to break away as free carbon. The free carbon glows to incandescence, making the flame visible. A microscopic envelope of carbon monoxide forms around the glowing particle. The air stream wipes it away and exposes the glowing particle to additional oxygen. This continues until the particle is consumed or until it is cooled below the combustion temperature.

This introduces another requirement for combustion, temperature above the ignition point. Combustible material has some minimum temperature for ignition.

The third zone in the candle flame is at the top. Mixing is improved. Carbon monoxide from the lower zone is completing its combustion to carbon dioxide. The gas envelope is breaking down completely and releasing the carbon as flowing particles. A match stick is not visible through the flame. Energy is being released at a greater rate, the temperature is higher and combustion is progressing beautifully.

The particles of carbon, glowing with the heat being released as their atoms combine with atoms of oxygen, produce the visible flame. This sequence of events did not happen instantaneously. It required time for completion. And, this introduces another requirement for combustion: time enough must be provided in a zone that is hot enough or combustion will be incomplete.

The principles of combustion, as explained here, cover all commercial fuels. If a fuel happens to be a gas, it has a head start over solid and liquid fuel because those steps necessary to convert solid and liquid fuels to a gas are not required.

This discussion of combustion principles is far from complete. It does, however, provide the necessary foundation for the following discussion. The two principal elements in any commercial fuel are carbon and hydrogen. Hydrogen actually has more energy in it than carbon on a per pound basis. However, the amount of hydrogen in wood fuel is small and is not mentioned further in this discussion.

WOOD COMBUSTION PRINCIPLES

Wood waste in the form of hogged fuel, sawdust, planer shavings, sanderdust and bark constitute the bulk of the fuel used in the wood industry. The combustion of these fuels follows the principles previously outlined.

The flame from a burning splinter of dry wood has some of the characteristics of the candle flame. Gases being distilled from the wood form a clear zone at the base of the flame. These gases decompose under the action of the heat of the flame. Carbon is released and ignition takes place. The second zone of the candle flame is not as pronounced in the wood flame. The third zone, in which the combustion is completed, is of about the same appearance.

Dry wood is composed approximately of 75 percent by weight of volatile material, 23 percent by weight fixed carbon, and 2 percent ash. These figures vary according to the species of tree, where it grew and how it was stored. Trees stored in ocean bays will absorb some salt water. When the tree dries out, the salt will stay in the wood and change the percentage figures given above. Different reference books list different values also.

The 75 percent volatile material in dry wood forms the gases that produce the open flame. This has been discussed. The 23 percent fixed carbon has not been discussed.

Fixed carbon will not break down into a gas when it is heated. Therefore, it will not burn with an open flame. There are several examples of the combustion of fixed carbon that could be given. Two of the most widely observed examples are the burning of barbecue briquettes and the glowing coals of a campfire.

The combustion rate of the two examples given is very slow. Heat from the coal expands the air above the fuel bed and causes it to rise. This action draws in a fresh air supply which moves across the coals and provides the necessary oxygen for combustion.

If the coals are on a grate so the air can move through them, the combustion rate will increase and the temperature of the fire will go up. In the case of a blacksmith's forge, the air is forced through the fuel bed at high velocity. Combustion is extremely rapid and the temperature may climb to a blinding white heat.

A flame may appear over the coals in the air blast. The flame is composed of microscopic particles of glowing coals that have been wiped off of the fuel bed. It is not a flame resulting from the combustion of volatile gas.

Fixed carbon releases its energy in the same manner that the carbon in a gaseous fuel does. The gas decomposes under the action of heat and sets the carbon free. This free carbon and the fixed carbon both may be converted to carbon monoxide burning to carbon dioxide. The carbon monoxide results from the lack of sufficient combustion air in direct contact with the coals.

Green wood follows the same combustion principles that have been discussed for dry wood. However, the physical laws governing the generation of steam also apply.

Moisture content of green wood varies with the species and growing conditions. Under certain conditions, a cubic foot of green wood will contain more water than dry wood on a weight basis. Water boils at 212°F. at sea level. This temperature is not sufficiently high to drive off any volatile gases from the wood. Therefore, the first heat directed to a particle of green wood will be used in driving off the water. After the water has been evaporated, additional heat will raise the temperature of the wood and drive off the volatile gases which then can be ignited.

WELLONS CELL TYPE FURNACE

The Wellons cell is a vertical pile burning furnace designed for complete combustion of wet or dry solid fuels. Fuel is continuously augured into the side of a high temperature refractory tube forming a small pile on water cooled grates below, while heated combustion air is simultaneously introduced to four (4) separately controlled zones:

Primary (undergrate) air, which can represent up to 30% of the total combustion air when burning wet fuels, enters through the hearth grates, drying the fuel and providing air for the gasification process and burning of fixed carbon.

Secondary (wind box) air, represents the remaining combustion air requirement and is staged through three (3) separately controlled zones. The major portion of the secondary air enters the cell tangentially through multiple staged holes in a refractory tube, with a wall temperature of about 2000°F, for combustion of the fuel volatiles. Additional staging is accomplished in the lower part of the cell by controlling the percentage of secondary air that is supplied to the vertical side grates.

Burning gases leave the cell and enter a large combustion zone designed to allow time for completion of the combustion process in temperatures of 1400° to 1700°F. This zone, consisting of both refractory and heat transfer tubing elements, absorbs the radiant energy from the burning gases and allows any char carry-over from the cells to fall into a high temperature dropout zone for completing combustion.

The Wellons cell furnace system's unique firing process not only maximizes efficiency through complete combustion and precise air control, but also provides positive benefits to the elimination of pollutants.

Particulate

Since char carry-over from the furnace system is almost nil, it eliminates any requirements for reinjection, and avoids the need of high efficiency (and energy consuming) collection devices on the stack. Ash and dirt in the fuel are deposited on the grates as the pile burns. Most particles caught in suspension are thrown against the cell walls by the cyclonic air movement. With a surface temperature of about 2000°F., non-combustible particles melt and run down the cell wall. The slag is then chilled by the water-cooled side grates and easily removed during the grate cleaning process. By collecting the particulate within the furnace, low stack emission levels are achieved without addressing their high energy-consuming cleaning equipment.

Nitrogen Oxides (NO_x)

Nitrogen fixation, or oxidation of nitrogen in the air, primarily occurs at temperatures above 2500°F., which is beyond those encountered in the Wellons furnace. Nitrogen fixation can therefore be neglected as a source of NO_x . Oxidation of nitrogen compounds in the fuel can occur, but are minimized by good control of excess air, mixing of air and gases in staged levels, and short dwell periods of combustion gases in the high temperature cell, yet allowing time for firing to completion in a relatively low temperature secondary combustion chamber.

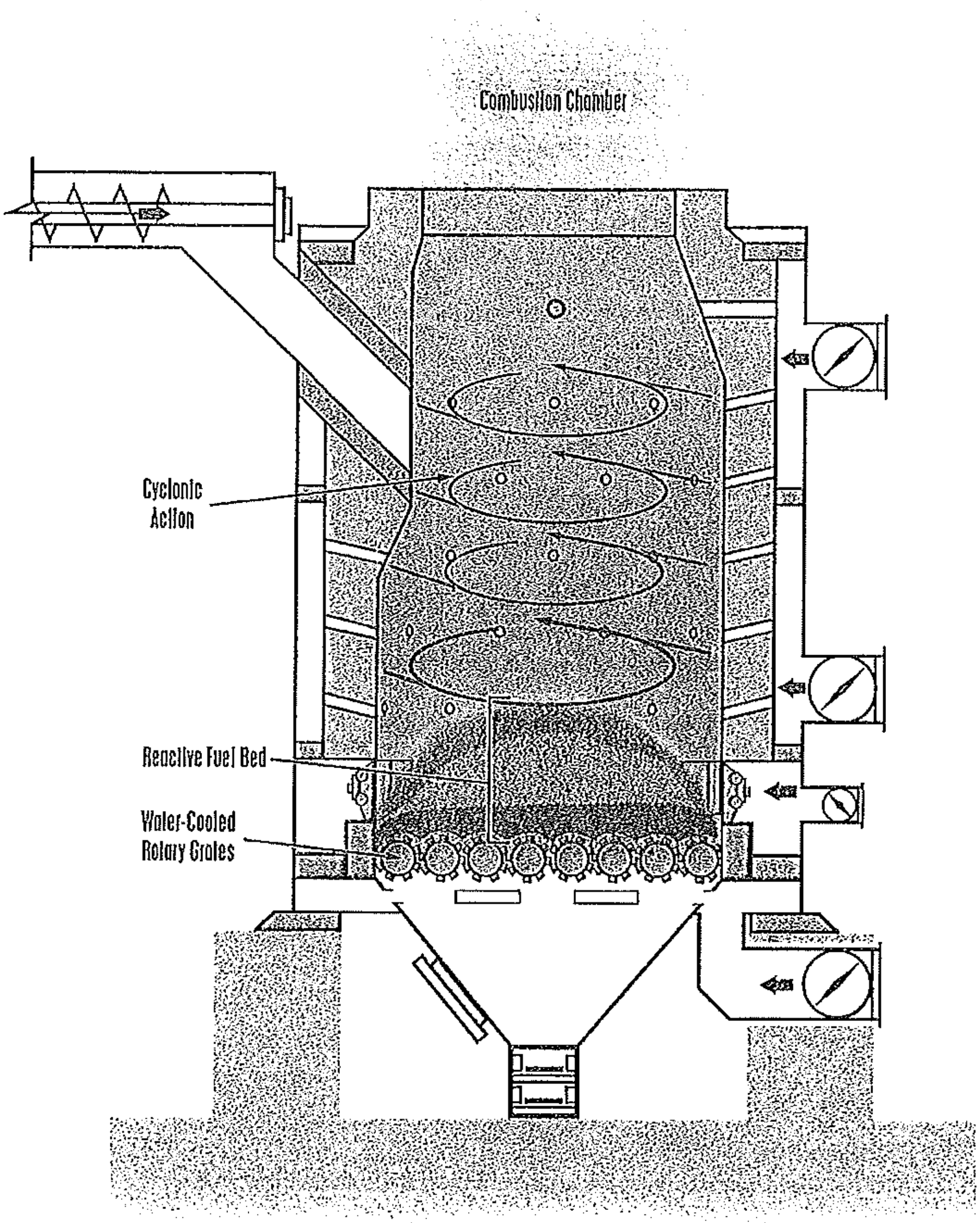
Carbon Monoxide (CO)

Precise control, combined with good distribution of mixing of air with the volatile gases, again yields complete combustion of carbon monoxide and reduced emission levels of negligible amounts.

Volatile Organic Compounds (VOC)

Hydrocarbons are allowed both time and temperature in the cell and secondary combustion chamber to completely burn. Even at reduced firing rates, hydrocarbons are eliminated as high temperatures are maintained in the cell.

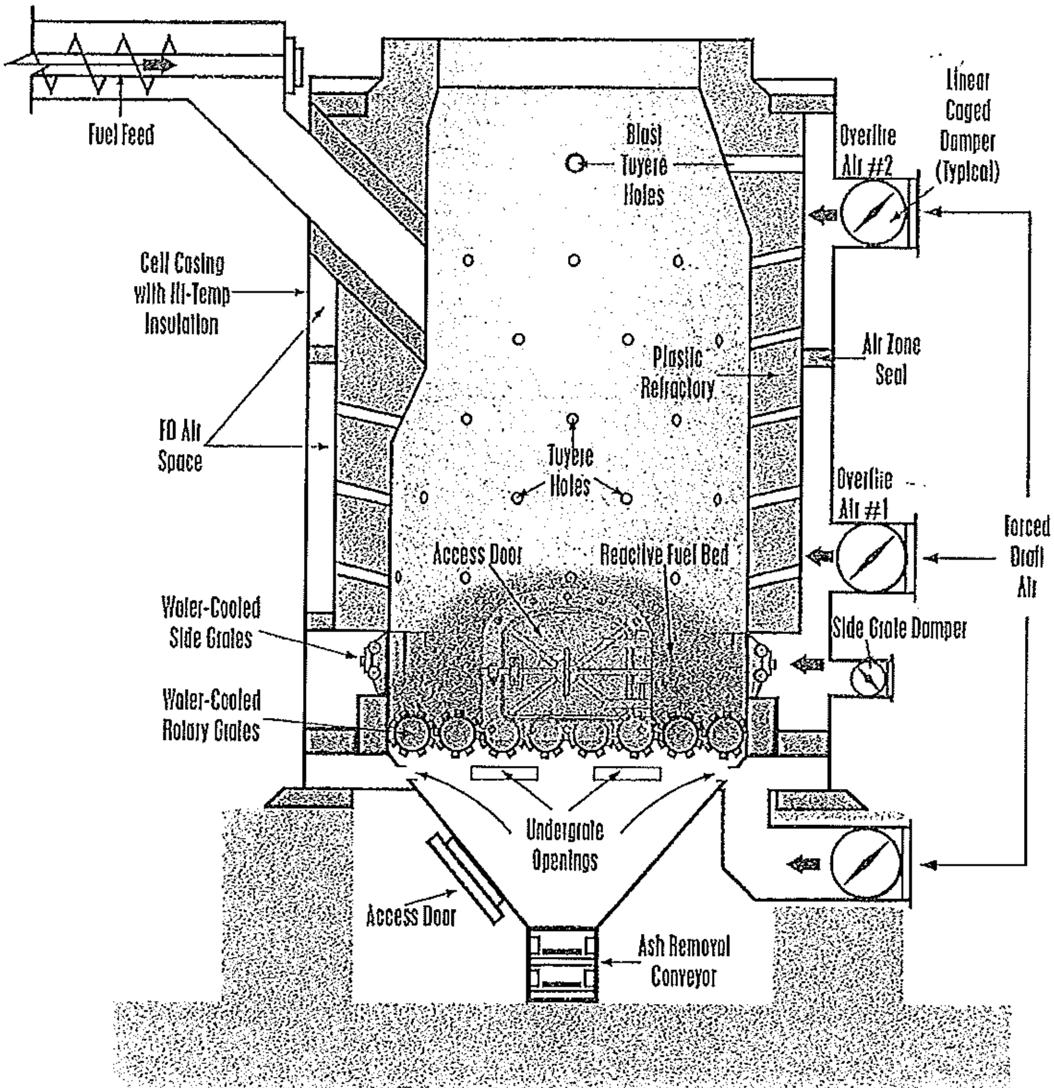
Response time to changing control signals is almost immediate as the rate of destructive distillation or wood gasification directly follows the forced draft air. The combustion air dampers are caged and ported for linear flow characteristics allowing a cell turndown ratio of 5:1 without upsetting the designed combustion parameters. The Wellons cell type furnace system keeps consistent firing results during normal changing demands as well as sustained steady state operation which normally occurs during a test.



Combustor Cell Gas Flow

WELLONS

F017-1004



Furnace Cell Cross Section - Rotary Grates

WELLONS F006-1202

ZELLONS

CELL FIRING PRINCIPLES

First, read the "principles of combustion" section in your operator's manual. With experience, you will learn the best way to operate your particular cells. Each cell will have a "personality" of its own. The ideal cell configuration is one that will keep the grates covered with fuel to a depth of 4'' to 6'' at the outer edge, have a fire with a light yellow color and provide the heat needed to supply the plant's needs. To achieve this, it takes a ratio of 1 lb. of fuel, 2 lbs. Of undergrate air and about 8 lbs. of overfire air. The fuel moisture content is best at 40% to 48%. As you can see, firing the cell correctly can be quite complicated, because of the number of variables. The bulk density and moisture content of the fuel will be the largest variable.

Normally, one turn of the metering bin augers per minute will provide enough fuel to produce 10,000 pounds of steam per hour in that cell with the fuel noted above. However, if the fuel is lighter than normal, or if it is drier, the fuel pile will diminish. If the fuel is dry enough, or light enough, the fuel pile might disappear all together.

The action of the flame is a good indicator of the correct fuel pile size. If the flame is a light yellow color and the flame is moving somewhat horizontally, the adjustments are reasonable correct. If the flame is a bright white, the fuel is too dry! If the flame is a burnt orange to dull yellow, the fuel is too wet, or the cell is still cold. If the flame moves vertically, the fuel pile is too small.

If the fuel pile plugs the sight-glass, the fuel pile is too large. The fuel pile height is somewhat predicated by the type of fuel. Sawdust has a lower slump angle than bark. Bark will pile higher than sawdust.

Dirty grates cause the fuel pile to increase in size, because of the undergrate air cannot reach the fuel pile to burn it. Excessive moisture will cause the fuel pile size to increase. The wet fuel burns slower because it has to dry out before it can burn. This takes additional time. (Notice the fuel moisture content/furnace efficiency graph in the operator's manual.) At 62% moisture content, the fire will not continue to burn!

Do not try to adjust for symptoms, correct the cause of the problem! ie: clean the grates if they are dirty, get drier fuel if the fuel is too wet, add moisture to extremely dry fuel. If the condition will be ongoing and is within the parameters of operating the furnace safely, have one person adjust the fuel-air ratios to restore the furnace to operating condition. Please note though, if the fuel is very wet the furnace efficiency will be lowered. If the fuel is very dry, the flame will be very hot and refractory damage will occur.

The following facts apply:

First, you must operate the metering bin fast enough to provide the fuel needed to supply the BTUs required to satisfy the demands of the plant.

Second, there needs to be enough undergrate air to burn that amount of fuel. (The undergrate air controls the size of the fuel pile. More undergrate air decreases the fuel pile size; less undergrate air increases the fuel pile size.) When making undergrate damper adjustments, wait a t least 1/2 hour to assess the reaction in the fuel pile size.

Third, enough overfire air is required to burn the hydrocarbons cleanly. (The overfire air controls the excess 02. More overfire air increases excess 02. Less overfire air decreases excess 02.). When making overfire air adjustments, wait at least 1/4 hour to assess the reaction of the excess 02. A good 02 reading will be somewhere between 6% to 10%. This will vary between fuels and flue gas chemistry.

WELLONS

OPERATION AND CONTROL OF WELLONS CELL FURNACE

The Cell Furnace is comprised of an outer metal casing and an inner vertical 9" thick refractory tube with water cooled grates at the bottom. Gasification of the fuel pile takes place on the grates while above, ignition/combustion take place inside the refractory tube. The tube in the upper section of the cell is smaller than the casing, creating a space for air flow. Horizontal seals between the casing and tube divide the air space into separate air zones that are called the windboxes. The lower section of the cell has water cooled rotary hearth grates and the air zone below the grates is called the undergrate. Air passing up through the rotary hearth grates, combined with heat radiating from the upper section of the refractory tube, causes the fuel pile on the hearth grates to gasify. Depending on fuel moisture content, the undergrate air flow can be up to 30% of that needed for complete combustion.

Above the hearth grates, in the windbox area combustion of the wood fuel takes place where tangential tuyere holes, through the refractory tube, introduce combustion air in a cyclonic action to mix with and ignite the gases rising from the decomposing fuel pile. An enclosed auger which minimizes the uncontrolled air admitted into the system, feeds fuel into a refractory chute that deposits the material inside the refractory tube near the top of the lower windbox air zone. The fuel particles fall from the end of the fuel chute onto the rotary hearth grates located below. The windbox air section is divided into two (2) separate air zones, each controlled by a separate air flow damper which delivers a staged combustion air supply to the furnace. (See Figure No. 1)

Wood ash varies from .1% to 3%, depending on species and product and slags at generally low temperature (1700°F to 2500°F). Therefore, in most instances, a wet wall is developed on the cell lining. Fine ash from the small wood particles is trapped and slagged on the wet surface of the cell. This slag runs to the bottom of the cell and is chilled by water-cooled grates. Since a good portion of the ash and dirt is captured in the cell, far less material is placed in transit with the furnace gases, and exhaust emissions are substantially reduced. The rotary hearth grates are automatically self-cleaning and will not upset the furnace system or reduce the output capacity of the cell.

CONTROL SYSTEM

Steam pressure is sensed at the boiler and is translated into an equivalent electrical signal by a pressure transmitter. The firing rate of the furnace system is increased or decreased according to this pressure generated electrical signal.

The Wellons Cell Furnace has a fast response to a changing control signal because the fuel pile encased in the refractory tube will respond to the amount of air admitted into the furnace almost immediately. The rate of destructive distillation or wood gasification follows the change in rate of the air supply to the undergrate and windbox air zones. The normal control response time from low to high fire in Wellons' wood-firing system is approximately one minute. Under normal demand fluctuations of steam production, the boiler operating pressure can be held within 5% of control pressure setting.

When the firing rate is reduced rapidly, the heat in the refractory may cause a small boiler pressure surge. With a complete drop-off of load and fuel cut off, the small fuel reserve in the cell soon dissipates and the response to a shutdown is quite rapid.

COMBUSTION AIR AND FUEL RATE

The output steam pressure of the boiler is sensed and then is converted into an electronic signal by a pressure transmitter*.

A computerized controller, labeled "Firing Rate", compares the electronic signal to a programmed set point signal, then computes the error (difference) into an electronic control signal. On single cell furnaces, this controller also functions as a manual/automatic station. On multi-cell furnaces, each cell has an manual/automatic controller labeled "Cell #1," "Cell #2," etc., which allows an individual cell to be removed from the furnace system "Firing Rate" control and operated manually. The "Firing Rate" controller allows the operator the following separate options:

a) Operate on automatic control signal from the controller.

b) Lock-out and manually over-ride the firing rate automatic control signal.

c) Change the ratio of fuel and/or air being supplied to the cell for burning.

The electronic control signal from the manual/automatic controller is connected to two (2) electric actuators* and a variable speed controller for each cell in the furnace system, which all move in relationship to the "firing rate" control signal. One (1) actuator is connected to the undergrate damper and one (1) actuator is connected to the two (2) windbox dampers and the sidegrate damper. The connecting linkages are adjustable to obtain the proper relationship between actuator movement and damper openings into the undergrate, sidegrate and windbox air zones of the cell. The variable speed controller changes the speed of the motor driving the metering bin/auger and is provided with maximum and minimum speed trim controls that allow the range of the fuel feed rate to be set for the amount of heat required from the furnace. The "firing rate" controller has been programmed to permit the following to be changed in relation to the "firing rate" control signal:

a) Windbox air ratio changes the overfire damper opening span to adjust excess air levels in the furnace for better burning efficiency.

b) Undergrate air ratio changes the undergrate damper opening span to adjust the gasification rate of the fuel pile and maintain the proper pile height.

c) Fuel feed rate ratio changes the feed rate span to adjust for the type of fuel being burned.

INDUCED DRAFT

An Induced Draft fan is used to "pull" the gaseous products of combustion through the boiler/furnace exhaust system creating a negative pressure throughout the system.

The negative pressure is maintained at a constant level in the cell furnace and combustion chamber by means of a draft controller. The negative pressure in the combustion chamber is sensed and then converted to an equivalent electronic signal by a pressure transmitter*. A computerized controller, labeled "Induced Draft" compares the electronic signal to a programmed setpoint signal, then computes the error (difference) into an electronic control signal. This controller also functions as a manual/automatic station, allowing the operator to completely lock-out and manually over-ride the automatic control signal. The electronic control signal from the draft controller is connected to an electric actuator* which is linked to the Induced Draft fan damper to maintain a -0.4 to -0.6 inch W.C. negative pressure in the combustion chamber.

A pressure switch is used to sense the negative operating pressure in the combustion chamber. If the pressure rises to less than -0.1 inch W.C., the switch, through a time delay, activates an alarm and disengages the "master control" stopping the FD fan and fuel feed to the cells. The ID fan remains operating.

> Note: Because the burning process produces a fluctuating pressure in the combustion chamber, the pressure switch must be activated continuously for 10 seconds before the time delay will disengage the "master control".

Note:

a) All actuators are located adjacent to their respective dampers. All actuators have auto-manual controls. Controls are to remain in Auto mode during furnace operation.

b) For operation of the computerized controller, see the Wellons User's Manual.

*For operation and maintenance instructions, see the Manufacturer's Service Bulletins.

ZELLONS

BOILER START-UP INSTRUCTIONS

After the hydrostatic test and boiling-out with drying-out, the following rules for starting the boiler should be observed:

1. Check all open drums carefully to make certain that all tools, waste and other items that do not belong in the drums are removed. Also check the furnace area, boiler passes, ductwork and airheater for items that do not belong in these areas, and make certain that they are removed.

2. After the above inspection, close the boiler. Make a complete inspection to determine definitely that all handhole caps and manhole covers are securely in place and locked for operation. Also check and see to it that all access doors in the setting and in the ducts and breeching are securely closed and tight.

3. Make sure that all control dampers are free and in good working order.

4. Check the water gauges to see that the gauge cocks are open and that the drain valve is closed.

5. When superheater is furnished, open the drain valves on the superheater outlet and the vent valves on the upper drum or drums.

6. Check all blowoff valves and other drain valves to make certain that they are all closed.

7. When starting the new boiler, it is good practice to fill the boiler until the water is well in sight in the water glass. Then drain just enough water to be sure that it will flow from the water glass. This is to check that all pipe caps have been removed for free flow both above and below the water line. This will also make certain that there are no errors in the piping erection that would allow water to be trapped, and to show a false water level even though the boiler were empty. Always use feedwater from the normal source of supply when possible. Add such water treatment chemicals as needed and recommended by your water treatment consultant.

8. Check all pressure parts to make certain that they are free to expand in the manner shown on the drawings, that the steam drum can move upward and longitudinally, and that the mud drum and all waterwall headers are free to move longitudinally. If the boiler is equipped with a superheater, the headers should be free to move upward and longitudinally, and the tubes able to expand downward.

9. Set the water level just below the normal water line.

10. When placing a boiler in operation where there are no other boilers, the following procedure should be used:

    a) The boiler stop valve and all drain valves in the piping system should be open, so pressure can be raised in the boiler and piping system simultaneously.

b) After the piping system is pressurized, close the drains when all evidence of moisture has disappeared.

c) See Step #15 for placing boiler in parallel operation with other boilers.

11. See "Sequence for Start-Up of Furnace" for proper procedures to light off the boiler.

12. The boiler should be brought up to operating pressure as slowly as plant conditions permit. Avoid unnecessary expansion strains and allow the setting refractories to come up to operating temperatures gradually. Do not increase boiler pressure more than what is sufficient to increase the saturation temperature by 80^0F. to 100^0F. per hour. See Table B in "Preparing Boiler for Service" for allowable heat up times.

13. If the boiler is furnished with a superheater, the firing rate must be kept under careful control during this period to prevent damaging it. The drain at the inlet side of the superheater should be closed as soon as steaming begins. As the pressure increases, the steam flow through the superheater and attendant coding of the metal is limited by the capacity of the outlet drain. Therefore, gas temperatures entering the superheater should be held to about 800^0F. A thermocouple may be used to check the temperature of the gases.

14. Close drum vents when pressure reaches about 10 psig.

15. When placing a boiler in parallel operation with other boilers, the following procedure should be used:

a) A double boiler stop valve arrangement is required in the steam main and both stop valves should be closed whenever the boiler is not on line.

b) When the boiler approaches line pressure, the steam line from the boiler should be warmed by cracking the downstream valve slightly and slowly opening the drain between that valve and the boiler stop valve. When the line has been warmed, open the downstream gate valve slowly to equalize the pressure in the header, and then close the drain when all evidence of moisture has disappeared.

c) When the unit reaches line pressure and begins to steam, the boiler stop valve should be slowly opened, allowing the line pressure and boiler pressure to equalize.

16. When steam flow of 10,000 lb/hr. is established close any remaining steam line drains and the superheater outlet drain. The boiler is now on the line steaming.

17. Be certain of the water level at all times. Do not depend entirely on the automatic alarm devices. If in doubt, blow the water gauge to aid in detecting the correct water level.

18. Do not hesitate to kill the fire if the water level is lost. Immediately after killing the fire, close the boiler stop valve and continuous blowdown to prevent the remaining water in the boiler from evaporating. Check out the feedwater regulator.

19. Check the safety valves in operation at intervals of six (6) months to make certain that they pop at the pressure marked on their nameplates.

Important: Note this activity in the log book.

20. Operate the sootblowers as often as necessary to keep the boiler clean. Blow soot preferably at loads between half and full load. Follow instructions from sootblower manufacturer. To prevent condensate from damaging the heating surfaces of the boiler prior to blowing soot, the sootblower piping should be warmed up thoroughly by blowing steam through the piping to the drain valve.

21. Maintain a careful watch of feedwater treatment and make the necessary routine analysis of boiler water as directed by a water treatment consultant.

22. Blow down the boiler to maintain the concentration of dissolved and suspended solids within safe limits to prevent priming and carry-over. The amount of frequency of blowdown is determined by analysis of the boiler water. For intermittent blowdown, it is preferable to blow small quantities of water at more frequent intervals. Continuous blowdown is best suited for controlling boiler water concentration. Adjust blowdown valve to suite safe limits of the boiler water.

23. Use extreme precautions against getting oil into the boiler water and against organic material into the boiler water originating from raw make-up water or from condensate returns from process equipment.

24. Keep the boiler setting tight against air-infiltration at all times.

ZELLONS

SEQUENCE FOR START-UP OF CELL FURNACE

1. Thoroughly inspect the furnace, boiler, air/gas ducting, and precipitator to ensure all hatches and doors are properly secured.

2. To turn on and operate the computerized boiler control system, see the User's Manual.

3. Turn "ON" all rotary valves and ash augers in the ash handling system.

4. Turn on the air supply to the pneumatic controls, if required.

5. On multi-cell furnaces, switch each cells controller to manual and adjust the firing rate to minimum (zero output).

6. Turn "OFF" the "EXCESS OXYGEN" controller.

7. Switch the "INDUCED DRAFT" controller to manual and adjust the draft to minimum (zero output).

8. Adjust the "EXHAUST PRESSURE" controller so the process signal coincides with the set point, then switch the station to Automatic.

9. Fill boiler to proper water level. Turn the "gratewater pump" selector to "On". Check the gratewater sight glass to be sure water is circulating through the water-cooled grates.

10. With dry wood and kindling, build a fire in the cell large enough to cover the grates. Close the cell door.

11. Start the "I.D. FAN". "OPEN" the combustion air by-pass damper at the air preheater.

12. Adjust the "INDUCED DRAFT" controller so the process signal coincides with the set point, then switch the station to automatic.

13. Start the "MASTER CONTROL". The automatic master control will become, and remain, engaged as long as the correct boiler water level is maintained and the I.D. fan continues to run.

14. When fire is burning well, turn the "COMBUSTION AIR FAN" selector to "AUTOMATIC" to start the fan.

15. Turn "METERING BIN/AUGER" selectors to "AUTOMATIC". Turn all fuel conveyor selectors to "AUTOMATIC".

16. The metering bin/auger, operating at minimum RPM, will start delivery of fuel to the cell. The fuel conveyors will start on demand.

17. When the boiler starts producing steam, causing the boiler water level to drop, turn the "FEEDWATER PUMP" selector to "ON".

    Note: a) On high pressure boiler plants, the pump runs continuously and the boiler drum level is maintained by a modulating feedwater flow valve.

    If there is a condensate return pump, it should be turned on at this time.

18. Manually control the fuel feed rate until the cell refractory is hot and the cell is able to sustain the fire at the maximum fuel feed rate. Important - See the following:

    a) Table B in "Preparing Boiler for Service" for allowable boiler heat up times.

    b) "Boiler Start-Up Instructions" for the proper procedure to place the boiler on line.

19. On multi-cell furnaces, switch each cells controller to automatic when the process signal coincides with the set point.

20. The furnace system is now under "AUTOMATIC CONTROL".

21. Test the boiler low water level switches for proper operation.

22. Turn "ON" the electrostatic precipitator.
    Note: See "PRECIPITATOR START-UP AND OPERATING PROCEDURES."

23. Start the furnace/boiler system's automatic cell cleaning cycle.

24. When the stack temperature reaches 350°F, close the combustion air bypass damper at air preheater.
    Note: The bypass damper may be left slightly open to obtain a higher gas temperature into the precipitator.

25. After the furnace system and boiler demand have stabilized, the excess oxygen controller may be turned "ON".

IMPORTANT NOTE:
The furnace system should never be operated in the manual/hand/maintenance mode unless operator is in constant attendance.

WELLONS

SEQUENCE FOR SHUTDOWN OF BOILER PLANT

1. Turn off the gas burner – if in operating mode (see Manufacture's Operators Manual).
2. On multi-cell furnaces, switch each cells controller to manual and adjust the output to zero.
3. Turn the metering bin/auger, and all fuel system conveyors to "OFF". (See Note "b")
4. Allow the fire to burn down.
5. Turn the "COMBUSTION AIR" fan to "OFF."
6. Allow the ID fan to run until the boiler exhaust gas temperature is below 250°F.
7. Isolate boiler from common steam main.
8. "STOP" the I.D. fan. Turn "OFF" the electrostatic precipitator.
9. Switch the "EXHAUST PRESSURE" controller to manual and close the control/isolation damper.
10. Turn "OFF" all components of the ash handling system.
11. Turn the boiler feedwater, gratewater, and condensate pumps to "OFF".
12. Turn off the air supply to the pneumatic controls, if required.
13. See the Computerized Boiler Control User's Manual for computer shut down procedure.

IMPORTANT NOTE

If the boiler is to be out of service for a prolonged period of time:

a) See the boiler manufacturer's instruction for proper boiler storage preparation.

b) Plan ahead to have no more than a cone full of fuel remaining in the Wellons storage bin, and empty the fuel conveyors and metering bin/auger.

ZELLONS

FURNACE ASH HANDLING SYSTEM

The ash handling system for the furnace/boiler consists of:

1. The cell's water-cooled rotary grate unit which drops ash onto a conveyor which in turn, deposits the ash into a moveable cart.

2. One (1) rotary air lock discharging from the multiple cone collector into a moveable ash cart.

3. The boiler ash hoppers and combustion air heater drop ash into ducting and removed with an ash handling fan.

The ash handling fan sends the ash into the multiple cone collector.

CELL ROTARY GRATE OPERATION

The heat generating furnace system consists of one (1) cell, with one (1) water-cooled rotary grate unit for ash removal. The furnace ash removal system consists of the following:

A. One (1) hydraulic unit used to drive each cell's rotary grate unit, one at a time, in a sequence as selected by the operator. The hydraulic unit consists of a tank for oil reservoir, an electric motor driven pump, and a by-pass valve to operate the system at a pressure of 1200 psig. A tank low oil level switch and a pump discharge high pressure switch (set at 1500 psig) are used to protect the system during operation. If either switch is activated, the hydraulic pump will immediately stop and an alarm will indicate hydraulic system trouble. When the trouble has been cleared, the pump must be manually restarted.

B. There are two (2) water-cooled rotary grate units per furnace. Each unit consists of one (1) forward/reverse solenoid actuated hydraulic valve controlling six (6) hydraulic cylinders that drive a total of twelve (12) rotary grates. Each cylinder drives through a ratchet mechanism, one (1) rotary grate that in turn, through a set of spur gears, drives a mating rotary grate. This arrangement produces six (6) individual pairs of counter-rotating grates. In the event that one (1) pair becomes jammed, the remaining five (5) rotary grate sets are still free to operate. Each ratchet mechanism is equipped with a drive pawl that can be manually reversed to change the direction of rotation of the pair of jammed grate rolls and remove any obstructing material that has become wedged between them.

Field adjustable timers/counters are programmed in the computer to control the duration of the cleaning cycle. Each cell has a counter that sets the number of steps per cleaning cycle (two steps equal one extension, and one retraction of the hydraulic cylinder equals one index). Each complete index of the ratchet mechanism rotates the grate rolls 1/16 of a revolution. Indexing the cylinders is accomplished by energizing, in sequence, the forward mode of the hydraulic valve (extends cylinder) and the reverse mode of the hydraulic valve (retracts cylinder). Each heater furnace system has a second and third timer that sets the duration that the valves operate in each mode. A fourth adjustable time controls the interval between the automatic furnace cleaning cycle (one complete two [2] cell cleaning cycle every "X" number of minutes/hours).

Note: Each time the pump is started, a 15 second interval is required before energizing the hydraulic direction control valve to allow the hydraulic system to become operational.

Because of operation in a high temperature furnace, the rotary grates are water cooled. Each of the two (2) rotary grate units has a manifold that supplies water to three (3) sets of four (4) mating grate rolls, which are piped in a series arrangement to a discharge manifold at each unit. Water from the discharge manifold is piped to the side grates which completes the cooling water circuit in each cell. A thermocouple senses the water temperature leaving each set of four (4) grate rolls. Also, one (1) thermocouple is located in the water line to the supply manifolds and a thermocouple is located in each line discharging from the side grates to sense the water temperature at these locations. Each thermocouple signal is connected to the computer and is displayed on the screen. Temperature levels are programmed in the computer to give an alarm if excessive temperatures occur in each cell rotary grate system.

Note: The hydraulic system is designed to use a water-glycol mixture that eliminates the possibility of a fire hazard and also gives protection from freezing.

INITIAL SET-UP OF THE CLEANING SEQUENCE

After six (6) hours of initial furnace operation at normal firing rates and burning the typical wood fuel, the following procedure should be followed:

A. Take readings of the gratewater temperature.

B. Take readings of the undergrate pressure and damper opening.

C. Set the forward and reverse mode timers at eight (8) seconds.

Note: If after operating for several days, it is found that the hydraulic cylinders do not complete their extension or retraction before being reversed, then the mode timer setting should be increased.

D. Set the indexing counter to ratchet the grate rolls four (4) times.

E. Start the cleaning cycle. Look through the undergrate ash hopper sight glass for any burning material dropping through the rotating grates.

F. Repeat Step E above until burning material is observed. Count the number of roll indexes to this point and set this number into the indexing counter.

OPERATIONAL NOTES

A. IMPORTANT: A layer of ash must remain to cover the grate rolls after each cleaning cycle. This ash layer insulates the grate roll from the burning fuel pile and ensures that only ash and NOT combustible fuel is discharged into the ash handling system.

B. The operator must stay alert to changing furnace load and fuel (dirt content) conditions. The number of roll indexes required to clean a cell is completely dependent upon the amount of fuel being burned, and the amount of non-combustible material going into the cell with the fuel.

It is highly recommended that during each cleaning cycle the operator look into the ash hopper to ensure that burning material appears only at the very end of the cycle.

C. Besides visually observing each cell cleaning cycle, other indicators of correct cell cleaning are:

1. Gratewater temperature: if the temperature increases above normal immediately after a cleaning cycle, it indicates that the grate rolls were indexed too many times.

2. Undergrate air pressure: if the air pressure decreases below normal immediately after a cleaning cycle, it indicates that the grate rolls were indexed too many times.

Note: The damper opening will also affect the air pressure reading.

D. There is one (1) common hydraulic pump unit for the furnace system, which can drive only one (1) cell's rotary grate unit at a time.

OPERATION

A cell's rotary grate cleaning cycle is an integral part of the furnace's cleaning cycle. The furnace cleaning cycle is initiated and controlled from the computer when in automatic mode.

A. AUTOMATIC MODE OPERATION

1. The ash conveyor system must be operational (

2. Turn cell rotary grate system to "Auto". The furnace system cleaning cycle is now engaged and will sequentially clean the cells each time the system's counter reaches the set time interval.

   Note: The cell can be locked out of the furnace system cleaning cycle sequence, by turning the rotary grate switch for that cell to "Off", and it will not interrupt the automatic cleaning cycle.

B. <u>MANUAL MODE OPERATION</u>

The cell's rotary grate system can be manually activated for one (1) cleaning using the following procedure:

1. The ash conveyor system must be operational (see Ash Conveyor Operation).
2. Turn all cell rotary grates that are served by the hydraulic power unit to "Off".
3. Turn "On" the hydraulic pump.
4. Turn the rotary grate switch for the cell to be cleaned to "Manual".
5. If an additional cell cleaning cycle is required, turn the cell's rotary grate switch to "Off" to reset the counter then back to "Manual" to start of a new cleaning cycle.

<u>CELL ASH CONVEYOR</u>

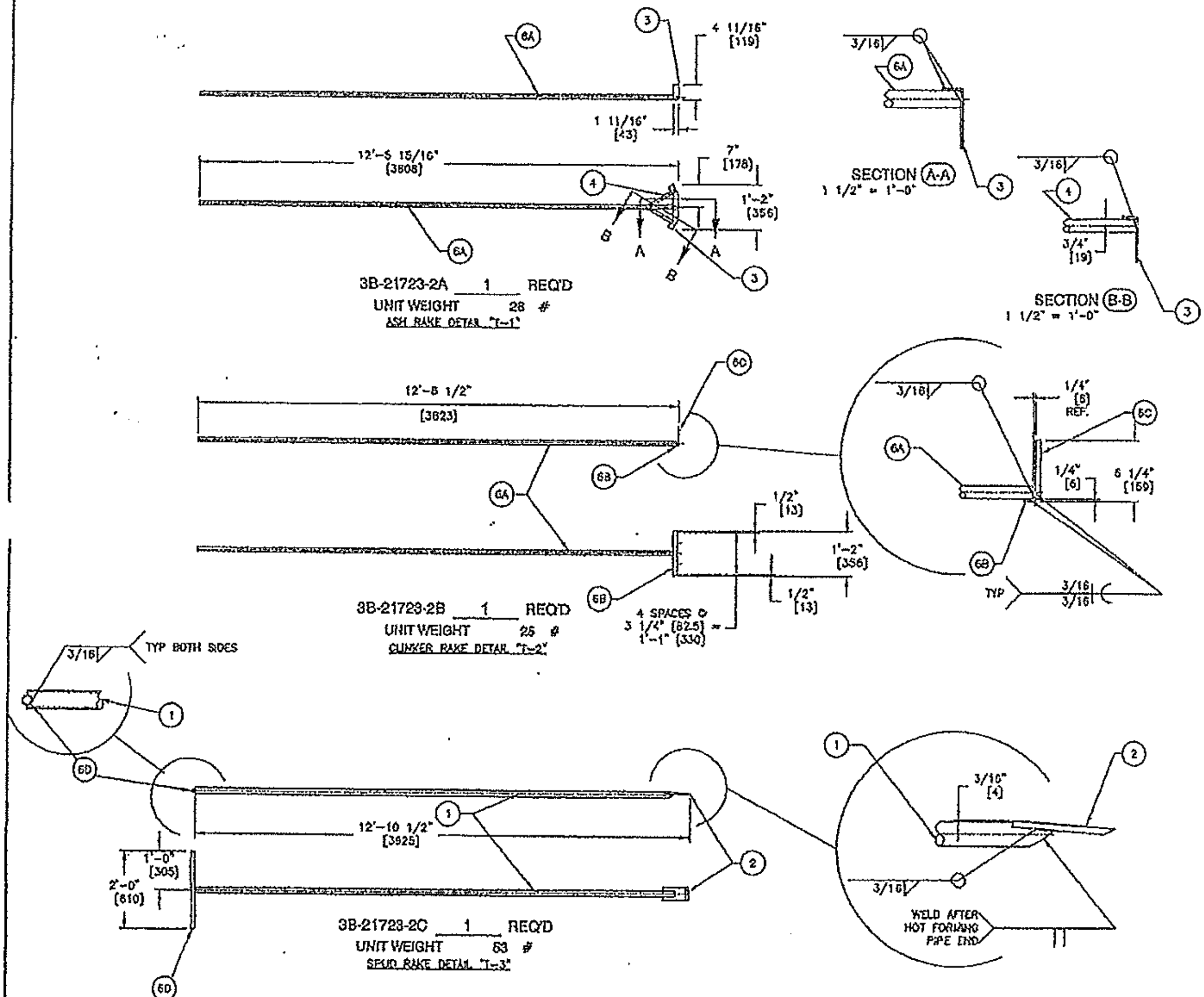
The ash removal conveyor under the rotary grate unit receives the cell ash and drops it into a separate ash cart. The cell ash conveyor is interlocked with, and will operate when either of the cell's rotary grate units is activated.

<u>MULTIPLECONE ROTARY VALVE</u>

Exhaust gases from the boiler/furnace system discharge into one (1) multiplecone collector where ash can drop-out from the gas steam and collect in the hopper because the hopper is located in a negative pressure air zone, a 'valve' is required to allow collected material to discharge from the bottom of the hopper while sealing out any outside air that might enter. The 'valve' on the bottom of the multiplecone collector is a rotary airlock that automatically discharges the collected ash. When the furnace is operating, the collector rotary valve must run continuously to prevent internal ash build up in the hopper that could cause the valve to jam or the hopper to bridge over. An alarm is indicated if this valve is not running. Material discharged by this valve is delivered to an ash dumpster.

WELLONS M222B

ITEM	QTY	DESCRIPTION		SPEC	SHEET	WT
		3B-21723-2A ASH RAKE ("T-1")				28#
3	1	PL 3/16 X 6"	1'-2 3/4"	A36	0-1	5
4	2	PIPE 3/4" SCH 40 X	0'-10"	A53	0-1	2
6A	1	PIPE 1", SCH 40 X	12'-5 3/4"	A53	0-1	21
		3B-21723-2B CLINKER RAKE ("T-2")				25#
6A	1	PIPE 1", SCH 40 X	12-5 3/4"	A53	0-1	21
6B	1	L 1 1/4 X 1 1/4 X 1/4 X	1'-2"	A36	0-1	2
6C	5	BAR 1/2" DIA X	0'-6"	A36	0-1	2
		3B-21723-2C SPUD RAKE ("T-3")				53#
1	1	PIPE 1 1/2 , SCH 80	12'-5 3/4"	A53	0-1	45
2	1	BAR 1/2 X 4"	0'-8"	A36	0-1	5
6D	1	PIPE 1", SCH 40 X	2'-0"	A53	0-1	3



3B-21723-2 (SETS) ______ REQ'D
Total Weight: 106 #

NOTE: SEE DWG. 3B-21723-0-1 FOR CELLS 6 FT. DIA.
SEE DWG. 3B-21723-0-4 FOR CELLS 9 FT. DIA.

JOB	REV	REVISION	BY	DATE	CHECKED	DATE
	3	REDWN TO AUTOCAD & CHGD DWG SIZE, ADDED ITMS 4 & 6D	CSN	1/9/03	MTC	1/14/03

WELLONS P.O. BOX 1030 SHERWOOD, OR 97140-1030

FURNACE SYSTEM MRP 0318

CELL CLEAN OUT TOOLS FOR CELLS UP TO 6 1/2 FT TO 8 FT DIA

SCALE: 1/2" = 1'-0"
DRAWN: CN DATE: 8/23/85
Assy
1 of 6

3B- 21723 -0-2 REV 3

ZELLONS

CLEANOUT INSTRUCTION FOR BOILER ASH HOPPERS

1. Start ash hopper cleaning sequence at the end of the shortest air duct.
2. Clean all the ash hoppers attached to the short air duct before proceeding to the longer air duct.
3. Turn on ash handling fan.
4. Open air piping system isolation damper at ash handling fan inlet.
5. Open the end damper of the air duct, which is on the side to be cleaned.
6. Open ash hopper drop gate 1/4 to 1/2 open and hold drop gate in this position until ash material cannot be heard falling into air piping system.
7. Close drop gate sharply to loosen any additional ash material in ash hopper.
8. Repeat ash hopper cleaning procedure (7 and 8).
9. Complete cleaning ash hopper by fully opening drop gate to remove all remaining ash material.
10. After all ash hoppers of this duct have been cleaned, close the air duct end damper.
11. Move to the longer air duct and repeat steps 5 through 10.
12. Turn off ash handling fan.
13. Close air piping system isolation damper at ash handling fan inlet.

NOTE: When cleaning the boiler ash hoppers, the boiler plant should be operating at a minimum of 40 to 50 percent firing rate to ensure that the material is carried into the collector.

ZELLONS

BOILER MAINTENANCE
AND
SYSTEM MONITORING ROUTINES

The development of routines for monitoring and verifying the proper operation of all systems and for the cleaning of components on a regular basis is essential for safe and efficient performance of your waste fired boiler system. A specific schedule of performing these routines should be created in accordance with your particular operator-working schedule. A log must be kept indicating by whom and when the system monitoring and basic routines have been carried out.

The following two pages (Maintenance Schedule and Typical Log Sheet) show the boiler system monitoring points to be logged as well as many of the maintenance routines required for a waste fired boiler system, some of which may not be applicable to your particular installation.

Some maintenance routines such as boiler mud drum blow down, boiler tube sootblowing, manual cell grate cleaning, as well as others, may need to be performed while the boiler load is less than maximum. This is to ensure that those systems receiving maintenance do not adversely affect the overall operation of the boiler plant such as the boiler feedwater system being able to keep up with the sudden out flow of steam condensate from the boiler, the induced draft system being able to maintain proper negative pressure with the addition of sootblowing steam, or the furnace system* being able to satisfy the process steam demand on the boiler with a cell off-line. These types of maintenance operations can usually be done without a boiler or process system upset by carrying them out during the normal daily cyclic lulls in heat demand.

In order to perform other types of maintenance routines, the entire boiler and furnace system will need to be shut down. Coordinating between the production department and the boiler room on all maintenance routines that affect either the usage (by production) or the generation (by boiler room) of process steam will reduce the total amount of down time required for maintenance.

* Single Cell Systems: There will be a reduction in process heat production and pressure while the cell is being cleaned.

ZELLONS

BOILER/FURNACE
SUGGESTED MAINTENANCE DUTIES AND SCHEDULE

Cleaning gas surfaces of ash, dirt, and slag requires most of the maintenance time spent on a waste fired boiler system. Because frequency of cleaning will vary widely depending on the amount of dirt present in the fuel, the maintenance schedule listed below should be used as a guideline only.

WARNING: SEE "ASH HANDLING EQUIPMENT SAFETY" NOTICE

MAINTENANCE DESCRIPTION	NOTES	FREQUENCY
Clean-Out Ash On Cell Rotary Grates	1	A.O.
Note: If the fuel has a high concentration of dirt more frequent cleaning will be required.		
Clean-Out Boiler Ash Hopper		A.O.
Clean-Out Air Pre-Heater Ash Hopper		A.O.
Clean-Out Multiplecone Ash Hopper		A.O.
Clean-Out Precipitator Ash Hopper		A.O.
Clean-Out Ash From Combustion Chamber Floor By Operating Sootblowers		D.
Clean Boiler Tubes by Operating All Sootblowers	1	3/D.
Clean Economizer Tubes by Operating All Sootblowers	1	3/D.
Clean All Sight Glass Lenses on the Furnace System		D.
Blow Down All Boiler Low Water Level Controls to Check for Proper Operation	1	3/D.
Blow Down Boiler Mud Drum & Headers	1	D.
Blow Down Boiler/Deaerator/Make-Up Tank Gauge Glasses		W.
Blow Down Deaerator Water Column		W.
Drain Water Collection Devices on All Air Filters, Regulators and Pneumatic Devices		W.
Drain Air Receiver Tanks		D.
Check for Adequate Cooling Water Flow to the Furnace Grates		3/D.
Check Cell Rotary Grate Ash Removal Operation	1	3/D.

BOILER/FURNACE
SUGGESTED MAINTENANCE DUTIES AND SCHEDULE

Take and Analyze Samples of Boiler/Blowdown to Verify Proper Water Treatment		D.
Check the Boiler Gauge Glass Water Level to Ensure It Corresponds to the Remote Indicator Reading		D.
Check Discharge from Each Rotary Valve in the Ash System		D.
Operate Stand-By Feedwater Pump for one (1) hour		W.
Check Ash Collection Container		D.
Check Boiler System Chemical Feed Tanks		D.
Check Make-Up Water Tanks for Sediment Build Up		Y.
Switch the Operation of the two (2) Make-up Water Pumps		W.
Check Feedwater & Gratewater Pump Strainers for Material Build-Up	2	M.
Check Rotary Grate System to Include:		
• Check Hydraulic Unit Fluid Level & Filter		M.
• Check Grate Rolls for Wear & Straightness	3	2/Y.
• Check Rotating Unions for Water Leakage		W.
Note: Lubricate the Rotary Unions		M.
• Lubricate the Grate Roll Journal Bearings		W.
Note: Use an EP-#1 Grease with a minimum dropping point of 350°F to Lubricate the Journal Bearings.		
Inspection of Refractory to Include:		
• Check & Log Cell Refractory Measurements	3	2/Y.
• Check Cell Side Grates for Water	3	2/Y.
• Check Condition of All Door Refractory Linings	2	M.
• Check Condition of the Boiler Wall and Roof Refractory Tiles	3	2/Y.
Check FW Pump Turbine for Vibration		D.
If used as Standby		W.
Check FW Pump Turbine Lubrication		W.
Check Lubrication of Sootblowers, Gearboxes, Pump Bearings Fan Bearings, Actuators, Rotary Valve Bearings, Compressors & Motors		MR.
Check Lubrication of Bearings on the Following Components:		
• Fuel Handling System		M.
• Ash Handling System		M.
• Rotary Grate System		M.
• Combustion & Gasifier Air & Induced Draft Dampers		M.

BOILER/FURNACE
SUGGESTED MAINTENANCE DUTIES AND SCHEDULE

Check Induced Draft Fan Rotor for Blade Wear and Ash Build-Up - Clean If Necessary	2	4/Y.
Check Water Side Surfaces of Boiler & Deaerator for Corrosion & Scale Build-Up - Clean if Necessary	3	Y.
Check Fire Side Surfaces of Boiler & Economizer Tubes for Slag Build-Up - Clean If Necessary	3	2/Y.
Check All Damper & Valve Actuators for Freedom of Travel and for Full Stroke Operation	2	2/Y.
Check Air Heater Tubes for Corrosion and Ash Build-Up Clean If Necessary	3	2/Y.
Check Multiplecone Collection Tubes for Wear; Also Hopper & Tubes for Ash Build-Up - Clean If Necessary	3	2/Y.
Check Precipitator Plates, Electrodes, and Hoppers for Ash Build-Up - Clean If Necessary	3	2/Y.
Check Ash Conveyor Chain for Wear		2/Y.
Check Ash Augers & Troughs for wear		2/Y.
Check Alignment Between Sootblower Nozzles and Tube Rows in Boiler & Economizer	3	2/Y.
Check Air Dryer Desiccant		4/Y.
Check Gas Burner & Controls	MR	Y.

Key to Notes:

1) See Procedure Bulletin in Sections 1 & 2
2) Requires Equipment Shutdown
3) Requires Furnace System Cool-Down

Key to Frequency:

3/D = 3 times daily	D = Daily	W = Weekly
M = Monthly	2/Y = Twice Yearly	4/Y = Four times year

MR = Manufacturers Recommendations
A.O. = Automated Operation

SUGGESTED OPERATING LOG

Date ____________

	STEAM FLOW	STEAM PRESSURE	FEEDWATER PRESSURE	CONTROL AIR PRESSURE	GRATEWATER PRESSURE	GRATEWATER TEMPERATURE	BOILER DRUM LEVEL	STACK OPACITY	WINDBOX PRESSURE	UNDERGRATE PRESSURE	F.D. AIR PRESSURE	F.D. AIR TEMPERATURE	DEAERATOR PRESSURE	DEAERATOR TEMPERATURE	BOILER EXHAUST TEMPERATURE	I.D. STACK TEMPERATURE	I.D. FAN CONTROL	I.D. PRESSURE	FIRING RATE		
1:00 AM																					
2:00 AM																					
3:00 AM																					
4:00 AM																					
5:00 AM																					
6:00 AM																					
7:00 AM																					
8:00 AM																					
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11:00 PM																					
12:00 AM																					

ZELLONS

TROUBLESHOOTING GUIDE FOR

BOILER/BURNER SYSTEM

LOSS OF ELECTRICAL POWER

1. Close boiler steam outlet valve to prevent loss of steam.
2. For low pressure 15 psig design boilers:

   Maintain boiler water level by opening the emergency water supply manual valve slowly to admit cold make-up water to the boiler feedwater supply circuit. Close valve when water reaches normal level.

   Note: Add cold water slowly when restoring normal water level in boiler.
3. If a steam driven feedwater pump is installed, start it up.

LOSS OF PLANT COMPRESSED AIR

1. For boilers with pneumatically actuated modulating feedwater control valves:
   a. Maintain boiler water level by use of the manual feedwater bypass valve.
   b. Use normal shutdown procedure.

LOSS OF GRATEWATER FLOW

1. Stop gratewater pump.
2. Open manual valve to admit cold make-up water to gratewater supply circuit.
3. Reduce opening of gratewater flow control valves to maintain 150°F temperature.
4. Open valve on gratewater return line to connect to drain. Close return valve to feedwater/deaerator tank.
5. Check pump suction strainer for plugging.
6. Check gratewater cell piping for leakage.
7. Check condition of pump.

FREQUENT UPSET OR LOSS OF BOILER DRAFT

1. Switch "Induced Draft" operator's station to manual and adjust draft to 0.6" neg.
2. If successful, look for problems in automatic control system, including the draft pressure transmitter.

3. If not successful, verify that damper actuator is responding to signal. Check actuator arm connection to damper. Check actuator electrical input signal and motor operating voltage.

4. If damper is responding, look for plugging in the boiler convection section, and the boiler exhaust ducting, including the air preheater and multiple cone collector. Also check the inside surface of the tubes in the air preheater for leaks due to holes caused by corrosion. Shutdown is necessary.

LOSS OF BOILER FEEDWATER PRESSURE

1. Check feedwater tank gauge glass to verify water level in the tank.

2. Open standby pump valving and start in place of main pump.

3. Check pump inlet strainer for plugging. Check condition of pump.

4. If standby pump does not raise pressure, check pressure gauge. Low boiler water level shutdown may follow.

LOSS OF BOILER STEAM PRESSURE

1. Steam flow demand may be exceeding boiler capability. Reduce load.

2. Fuel feed rate may be deficient. Check operation of metering bin or metering auger and furnace feed screws.

3. On single cell systems, check the "Firing Rate" operator's control station. On multi-cell systems, check the "Cell Control" operator's station for negative bias setting of the fuel feed rate. Check that the fuel type selected in the computer matches what is being burned in the furnace.

4. If the "Firing Rate" or "Cell Control" stations do not indicate 100% firing rate, check steam pressure transmitter, check piping from the boiler to the pressure transmitter.

5. If "Firing Rate" or "Cell Control" stations indicate 100% firing rate, verify that the overfire and undergrate damper actuators are responding to the signal. Check speed of metering bin or metering auger. Check the input signal to the variable speed drive controller - check the controller's maximum speed setting. Check electric actuator arm connection to damper. Check combustion air fan for proper operation. (Note: On close-coupled gasifying furnaces, check the gasifier air fan for proper operation.)

BOILER STACK SHOWS SMOKE

1. If cell shows loss of flame brilliance or high fuel pile, stop metering bin. Restart after flame brilliance recovers.

2. If condition persists, an overfire and/or undergrate damper adjustment may be necessary. Check moisture content of fuel. Check speed of metering bin or metering auger. Check the overfire air bias setting in the controller.

LOWER BOILER WATER SHUTDOWN

1. Check for pump shutdown -- see low feedwater tank shutdown and low feedwater pressure.

2. Check boiler gauge glass to verify water level in boiler.

3. If feedwater pump is operating, open feedwater bypass valve to restore water level. Check feedwater level controller and piping.

4. Check for false signal from low water safety switches.

5. If not remedied, handle as instructed with loss of electrical power.

LOW FEEDWATER TANK LEVEL ALARM

1. Check feedwater tank gauge glass to verify water level in the tank.

2. If water level shows normal, check the low-level float switch/probe for proper operation.

3. If water level shows low:

a. Check water softeners for proper operation. Open water softener bypass valve.

b. Check make-up water level probe, relay and solenoid valve for proper operation.

c. Check for interruption of condensate return.

d. Open by-pass valve around the feedwater/deaerator tank make-up water control valve.

4. If feedwater pump does not restart, low boiler water level will follow.

OTHER AUTOMATIC BOILER SHUTDOWNS

1. Restart boiler and watch for malfunction to reappear. Which annunciator lights show first?

2. Check other "system indicators" for malfunction.

BOILER SAFETIES RELEASE

1. Steam flow demand may be less than minimum firing rate of furnace. Increase load.

2. On single cell systems, check the "Firing Rate" operator's control station. On multi-cell systems, check the "Cell Control" operator's station for positive bias setting of the fuel feed rate. Check that the fuel type selected in the computer matches what is being burned in the furnace.

3. If the "Firing Rate" or "Cell Control" stations do not indicate 0% firing rate, check steam pressure transmitter.

4. If the "Firing Rate" or "Cell Control" stations indicate 0% firing rate, verify that the overfire and undergrate damper actuators are responding to the signal. Check speed of metering bin or metering auger. Check the input signal to the variable speed drive controller - check the controller's minimum speed setting. Check electric actuator arm connection to damper.

5. If condition persists, shut down the boiler master control.

EXCESSIVE CARRYOVER OF UNBURNED FUEL

1. Keep fuel feed limited (use bias control) until after fuel has been built on grates. This applies to restarting after grate cleaning or cold start-up. See start-up and cleaning procedures.

2. Check fuel feed rate and overfire air bias settings in the furnace controller.

3. Too much combustion air through cell grates at elevated firing rates.

4. Check for high boiler draft pressure.

5. Check moisture content of fuel.

BIEWER LUMBER™

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3.3

Electrostatic Precipitator

User's manual

For the Wellons

Electrostatic precipitator

Wellons, Inc.
1998

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For technical support, call 1-800-Wellons.

Wellons designs and manufactures boiler-turbine systems, dry kiln systems, and related equipment for the lumber industry. Our main office and manufacturing facility is located in Sherwood, Oregon. We have several sales and technical support branches around the country, including: Vancouver, Washington; Atlanta, Georgia; Boston, Massachusetts; Hot Springs, Arkansas; and Pittsburgh, Pennsylvania.

Table of contents

Welcome

Wellons has custom-designed your electrostatic precipitator to help meet air quality emission requirements.

This manual explains how the precipitator works, describes each of the components, and shows you how to operate and maintain the Wellons electrostatic precipitator.

About this manual

For the user who was involved in the precipitator startup training, this manual explains the system components and gives various procedures for operation and maintenance.

The chapter, "About the precipitator," describes the structural, electrical, and mechanical components, and how the components work together.

"Operating the precipitator" shows you how to startup the equipment, how to make adjustments, and how to shut down the equipment.

The chapter, "Maintaining the precipitator," describes how to prepare the precipitator for personnel entry. Procedures are included for performing the air load test, cleaning, and routine maintenance.

"Appendix: Programming the rappers" gives you the guidelines to set the rapper controls.

In the *Wellons' manual for the Electrostatic Precipitator* we provided checklists for routine inspections, and procedures and checklists for performing a major overhaul.

Use the table of contents and the comprehensive index for locating specific information in this manual.

Refer to the technical information on supporting systems in the *Wellons' manual for the Electrostatic Precipitator.*

About the precipitator

The electrostatic precipitator removes the particulate from the exhaust gases produced by your boiler plant's combustion system.

Dust-filled exhaust gases enter the precipitator where high voltage electrodes negatively charge the dust particles. The charged dust particles are then attracted to the positively charged collector plates. Rappers periodically strike the plates to knock the particulate loose. The particulate falls into hoppers at the bottom, and is carried out by the precipitator ash augers.

About the structure

The precipitator structure is a gas tight enclosure. It is fabricated from ASTM A-36 steel plate with stiffeners to support the precipitator equipment.

A structural steel support under the precipitator allows clearance for maintenance of the hoppers and ash conveying equipment.

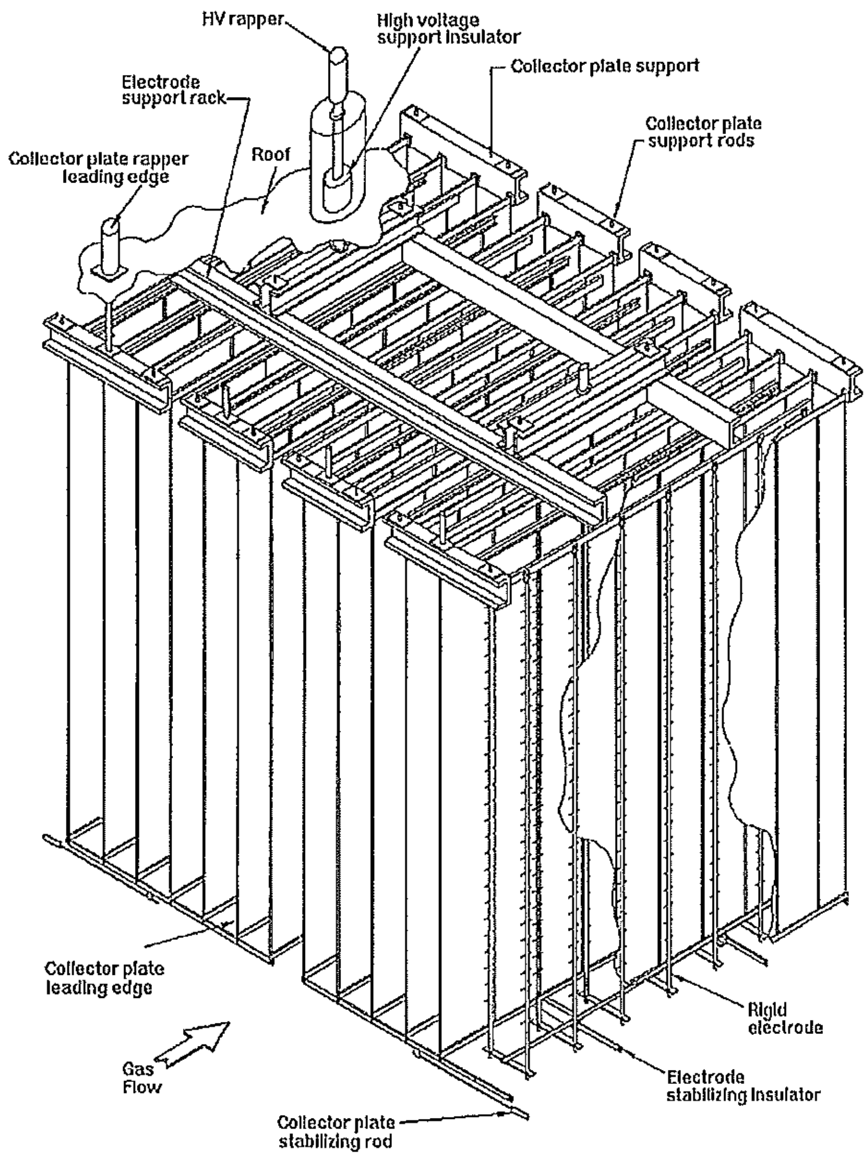

Figure 1. Single field precipitator

Most of the precipitator's electrical equipment is mounted on the roof, including: transformer-rectifiers, high voltage bus, rappers, rapper control panel, purge air system, and the optional power distribution panel.

Handrails with kickguards are installed around the perimeter of the roof and the stack testing platform. An optional walkway runs from the boiler breeching to the precipitator roof, and a caged ladder provides roof access from the ground. All access structure comply with OSHA standards.

Access hatches to the interior, high voltage compartments, and hoppers are 24" x 30" in size. Each hatch is equipped with a hinged steel door, quick release hold-downs, gas tight seals, and a "Danger – High Voltage" warning sign. Each door is part of the safety key interlock. The hopper access hatches are accessible from the ground and the internal support hardware and rapper hardware are accessible from the roof platform.

The precipitator has inlet and outlet gas flow diffuser (perforated) plates to direct the gas flow distribution. Some of these plates have rappers to remove accumulation of dust.

The exhaust stack directs clean exhaust gases out of and away from the plant. The stack is equipped with test ports at the EPA test platform. All external surfaces of the transition and stack are painted with high temperature primer and finish paints.

Mechanical and electrical components

The mechanical and electrical components work together to charge and remove the particulate from the exhaust gases.

Collector plates and electrodes

The collector plates are fabricated panels of sheet steel with stiffened edges and intermediate ribs. The plates are held in vertical alignment parallel to each other by hangers at the top and an alignment assembly at the bottom. Alignment bars at the top and bottom edges of the collecting plates, support and maintain the spacing of the plates.

The high voltage electrodes have a tube-type mast design with discharge studs at equal spacing. The electrodes are suspended from the electrode rack to hold vertical alignment. The tubular mast is held in horizontal alignment by stabilizing insulators attached to the bottom spacer rack.

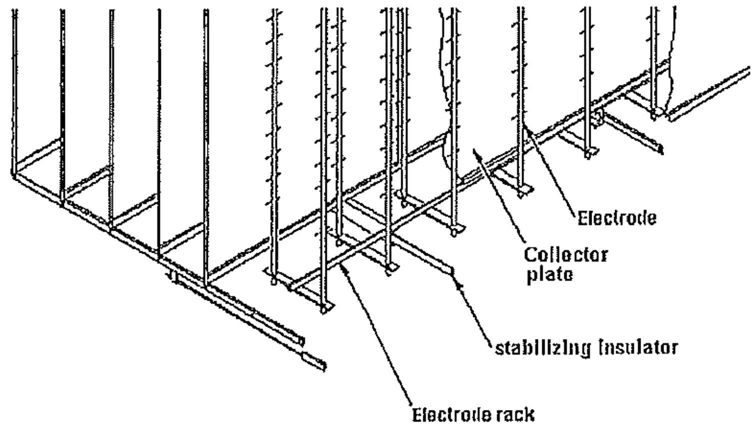

Figure 2. Electrode rack

The collector plates are at earth-ground potential, while the electrodes are at a high negative DC voltage — 60 KV nominal. Thus, the electrodes are supported with electrical insulators to prevent the grounded plates from shorting out the high voltage electrodes.

The collector plates and electrodes must maintain a uniform clearance between them throughout the precipitator. This minimizes electrical arcing between plates and electrodes, and provides an efficient charging and collection of the particulate.

High voltage bus and insulators

The high voltage bus conducts power from the transformer-rectifier set (T/R set) to the electrode rack. The bus is made of 3/4" pipe is surrounded by a protective sheet metal duct.

Due to the high voltage, the bus and electrodes are supported and isolated from the structural steel and collector plates by insulators. The bus is supported by the T/R set bushings and porcelain insulators. The electrode racks are supported at the top of the precipitator by porcelain or alumina insulators, and are stabilized at the bottom by alumina insulators.

Transformer-rectifier

The transformer-rectifier (T/R) sets are mounted on the roof. They convert AC to DC to power the electrodes. Each T/R converts 400 volts AC (500 VAC for 575 VAC applications), single phase, to approximately 60,000 volts DC (60 KV), which is applied to the electrodes.

Each T/R set also houses a safety grounding switch used during maintenance.

Current limiting reactor

The current limiting reactor (CLR) protects the transformer-rectifier by limiting the current passing through it. The CLR is also a balance control between the TR set and the SCR.

Depending on your configuration, the CLR is either built within the T/R case or installed in the power line between the T/R and the motor control center.

Rappers

For procedures on programming the rappers, see page 27.

The rappers hit striker plates attached to the collector plates, electrodes, and diffuser plates to knock loose the particulate. They act much like sledge hammers. Collector plate rappers strike the frame holding the collector plates. The high voltage rappers strike the bar that supports the electrode rack.

Rappers operate through a quick on-off cyclical signal. Energizing a rapper lifts a cylindrical metal slug. Once the rapper is de-energized, the slug falls and strikes the striker plate. The rapper control panel on the roof controls the pulse rate and intensity of the raps.

Hopper equipment

Each precipitator field has a hopper that funnels the particulate falling from the collector plates into the precipitator ash auger.

Hopper heaters

Several electric heaters are installed on each hopper to keep the hopper dry to prevent the ash from caking on the interior walls. This helps with the particulate flow to the precipitator ash augers.

Hopper vibrators (optional components)

Depending on your system's configuration, the hoppers might have vibrators installed. Each vibrator is an electric rotating offset-cam that helps keep the particulate flowing to the precipitator ash augers.

Precipitator ash auger

The precipitator ash augers are screw type conveyors that remove the ash from the hopper for disposal. The ash augers are often integrated with your existing furnace ash handling system.

Alarms

Your alarm system is configured at startup to give you system troubleshooting data. Alarms indicate problems with the rapper control, purge air fan, and purge air heater. The voltage controller has a number of fault conditions that are continuously monitored by the SQ-300. See the BHA manual for details on re-setting alarm limits; or call Wellons' technical support.

Precipitator controls

This section describes how each system is controlled. The precipitator controls are housed in the automatic voltage control panel (AVC panel), the motor control center (MCC), and roof-mounted panels.

High voltage control

Each high voltage field is computed independently by a microprocessor-based controller; this is the SQ-300 interface, a dedicated controller at the AVC panel. Wellons configures the controller settings during startup. Each controller has a keypad with a data display mounted on the door of the AVC panel.

For procedures on adjusting the high voltage, see refer to the SQ-300 manual.

Each controller automatically calculates the voltage applied to the electrodes, by continuously verifying spark-over voltage and making the necessary adjustments. The precipitator obtains maximum efficiency when the voltage on the electrodes is as high as possible without exceeding the programmed spark rate.

The controller also provides several protective functions for the T/R sets and associated equipment. It has a display for monitoring precipitator readings, and it controls alarm functions.

Silicon rectifier stack

The silicon control rectifiers (SCRs) are installed either in the AVC panel or in the MCC, depending on your configuration. Each voltage controller adjusts the voltage by firing a silicon rectifier stack, which controls the voltage to the transformer-rectifier. The SCR acts like a valve, controlling how much power goes to the T/R set.

Rapper control

The rapper automatic control system is located in the rapper control panel which is mounted on the roof of the precipitator. The rate (how often the rappers run) and the intensity (how high the rapper is lifted) can be adjusted by use of the interface panel. See page 27 for procedures on programming the rappers.

Purge air heater control

The heater uses two temperature controllers programmed at the AVC panel. One serves as a trip, shutting down the system if the thermocouple senses too much heat, possibly due to fan shutdown. The other monitors and maintains an even temperature. The heaters are controlled and powered from the MCC.

Purge blower

The blower fan runs continuously to pressurize the insulator compartments with clean, dry air. For smaller fan motors, the fans are powered from a 120 VAC distribution panel on the roof, and for larger motors, from 480 VAC (575 VAC where applicable) at the MCC. If the purge blower shuts down, the heater is shut off. If insufficient air pressure is sensed at the insulator housing, a warning indicator alerts you to a problem, such as a plugged filter, access door ajar, fan problem, etc.

Hopper heater control

The hopper heaters are supplied 480 VAC (575 VAC where applicable), single phase power, from the MCC and are thermostatically controlled from a temperature controller located at each ash hopper.

Hopper vibrator control (optional)

The hopper heaters are controlled by the same processor and interface panel that controls the rapper system (see page 27). The processor and interface are located in the rapper control panel located on the precipitator roof. The rate (how often the vibrators run), and the intensity (how long they run), are set in the same manner as the rappers.

The vibrator rate and intensity value will use all three thumbwheels. These values are in seconds and cannot be set lower that 10 seconds. Note that a vibrator intensity value that is greater than the vibrator rate value will result in the vibrator running continuously.

The purge air system

The purge system keeps the support insulators clean and dry. The purge air ducting directs air to each of the support insulator compartments, which hold the high voltage conductors.

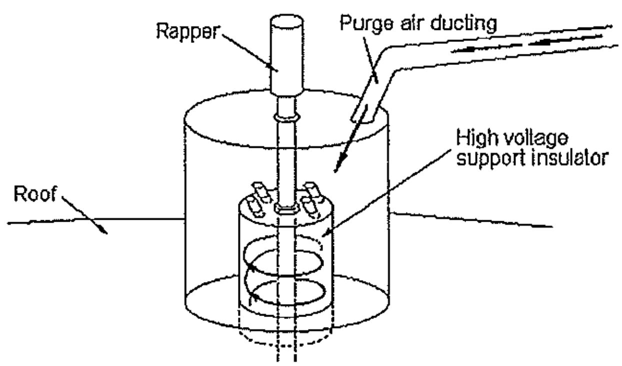

Figure 3. Compartment holding the high voltage support insulator

Purge air enters the insulator compartment from the purge air duct, then enters the support insulator. Inside the support insulator, the air swirls at a rapid rate, cleaning the insulator. The air exits out the bottom of the insulator into the precipitator

The purge air operates at a higher pressure than the gases inside the precipitator and is heated to keep temperatures above dewpoint. The purge air system includes a forced-air blower with an air filter and thermostatically controlled heater. At the top of the insulators, the air is channeled in at an angle so that the high speed, swirling air scrubs the insulators clean. The heated air keeps the insulators dry. The purge air system runs at a slightly higher pressure than the precipitator, to prevent dirty process gases from entering the insulator compartments.

The manual damper controls how much air gets through. If the insulators do not remain clean and dry, you can open the dampers slightly to increase the amount of air. A warning system will alert you to problems with air supply.

About the safety key interlock system

For the operational sequence of the key interlock system, see page 21.

The safety key interlock system is a series of mechanical locks that can only be opened and closed in a particular sequence. This system ensures that the precipitator high voltage is properly de-energized before you can enter the precipitator.

The keys control the circuit breakers, the T/R sets, and the access hatches to the precipitator. Since the system is fully mechanical, it is effective during power outages.

A full technical description of the interlock system is enclosed in the technical section of *Wellons' manual for the Electrostatic Precipitator*.

Operating the precipitator

This chapter describes the routine operation of the electrostatic precipitator, showing you how to startup the precipitator, keep records, monitor the system, and shut down the system.

You must familiarize yourself with the precipitator components. Attempting to operate the precipitator without a thorough knowledge of its proper operation can result in unsafe conditions and poor precipitator performance.

Safety precautions

Treat the precipitator with extreme caution, it creates extremely high voltages. You do not have to touch the high voltage electrode to receive a fatal shock — an arc can jump six to eight inches.

Never enter the precipitator while it is in operation.

Never work on the precipitator alone.

Never remove any access hatches, bolt-on panels or covers, structural panels, etc., while precipitator is in operation.

Never drill or make any type of penetrations into the body of the precipitator while it is in operation.

Never energize the precipitator or allow combustible gases, liquids, or solids to pass through the precipitator when the precipitator is energized — if there is sufficient oxygen present, a dangerous explosion can result.

Never perform any spark producing action such as using portable grounding electrode, opening hatches, etc., while explosive gases might be present.

When the precipitator is properly secured, do not enter the precipitator until it has cooled, and until all toxic or combustible gases have been purged.

When the precipitator is properly secured and purged, use extreme caution opening access hatches — opening may cause hot ash or particles to fly out and burn or injure personnel near the opening.

When the precipitator is properly secured and purged, do not touch or approach any internal components until the components have been properly grounded with the portable grounding electrode.

Starting the precipitator

When performing operating functions, you must have a basic knowledge of mechanical and electrical components and be familiar with typical industrial safety precautions for routine tasks.

Observe the safety precautions while operating the precipitator. Do not attempt to operate this equipment without a thorough knowledge of its function and potential dangers.

Preparing to start the precipitator:

1. Close and lock each access hatch. Return all keys to the key transfer box, which is mounted on the roof.
2. From the key transfer box, remove the ground switch key and proceed to the corresponding T/R ground switches. Turn the key interlock to retract the bolt and then unground the T/R.
3. Lock the ground switch in the ungrounded position. Remove the key.
4. Repeat steps 2 and 3 for each T/R.
5. Proceed to the AVC panel or the MCC and unlock the main circuit breaker; close the circuit breaker when ready to startup the precipitator.
6. Repeat step 5 for each T/R.

Starting up before the boiler

When starting the precipitator, you might be prepared to startup the boiler, or the boiler may already be running. If the boiler is already running when you startup the system, see the procedures beginning on page 17.

To start the precipitator before starting up the boiler:

1. Perform the 6 steps in the key transfer procedure above. Make sure the precipitator is clear of personnel.
2. Turn on the purge air blower fan and the purge air heater. Run the fan for four hours before starting up the boiler.
3. At the MCC, turn on the hopper heaters to allow the hoppers to heatup during the 4-hour warm up and purge period.
4. After the 4-hour purge, begin startup of the boiler, which introduces hot flue gases. Take extreme care to warm the

Make sure the furnace's induced draft fan is running. If the fan shuts down, the precipitator's high voltage fields shut down and do not start until the fan is running.

precipitator up *slowly* to allow for uniform thermal expansion, which prevents internal damage. The maximum rate of temperature increase should not exceed 100 degrees F per hour.

5. Before you energize the precipitator, allow the output gas temperature to reach between 250 and 300 degrees. This procedure eliminates free moisture and lessens the possibility of an explosive gas mixture.
6. Turn on the rappers and the hopper vibrators. All precipitator systems should be on except for the high voltage.
7. At the AVC panel, make sure each field's T/R high voltage switch is set to Auto. The corresponding meters read near zero.
8. Double check steps 1 through 7, and make sure personnel are clear of the area around the precipitator.
9. From the AVC panel, push each Start push-button to energize each precipitator field.

   Note: If a master furnace control system operates the ESP, place it in a run status also.

10. Turn on the precipitator ash augers.

Observe the meters from the AVC panel and perform routine system inspections as outlined in the next chapter, "Maintaining the precipitator."

Starting up with the boiler running

If the boiler is running, the precipitator is already hot.

To start the precipitator while the boiler is running:

Make sure the furnace's induced draft fan is running. If the fan shuts down, the precipitator's high voltage fields shut down and do not start until the fan is running.

1. Perform the 6 steps in the key transfer procedure from page 15. Make sure the precipitator is clear of personnel.
2. Make sure the purge air blower fan and the purge air heater are operating.
3. Make sure the hopper heaters are operating.
4. Check the temperature of the output gas; it should read 300 degrees or more.
5. Turn on the rappers and the hopper vibrators. All precipitator systems should be on except for the high voltage.
6. At each high voltage control panel, turn the manual-auto switch to Auto. The meters at the AVC panel read near zero.
7. Double check steps 1 - 6, and clear personnel from the area around the precipitator.
8. From the AVC panel, push each Start push-button to energize each field.

   Note: If a master furnace control system operates the ESP, place it in a run status also.
9. Turn on the precipitator ash augers.

Observe the meters from the AVC panel and perform routine system inspections as outlined in the next chapter, "Maintaining the precipitator."

Monitoring and recording

In the AVC panel, Wellons installs the SQ-300 display, manufactured by BHA. For complete information on the SQ-300 panel, read the BHA manual included in the *Wellons' manual for the Electrostatic Precipitator*.

Keeping a daily log

You begin keeping a daily log during startup. The main source of data for the log comes from the SQ-300 panel.

From the SQ-300 display, write down the readings and any message displayed. You should also make a note of uncommon events related to the precipitator.

Compare the SQ-300 readings with the meters. If the meter readings and screen readings do not match, this might indicate a problem. Readings should be consistent from day to day. To check the consistency, compare your notes in the daily log.

For specific information on using the control screens, refer to Section 8 of the BHA manual. Pages 8-4 and 8-5 explain the Main Status screens from where you get your log information.

Shutting down the precipitator

Observe the safety precautions while operating the precipitator.

To shutdown the precipitator:

1. From the AVC panel, push each Stop push-button to de-energize each field.
2. Leave the purge blower fan and heater running continuously as long as gases are passing through the precipitator.
3. Do not enter the precipitator until it is secure and purged.

Before maintenance is performed on the precipitator, it must be shutdown, secured, and purged of gaseous air. For further instructions, see "Shutdown for maintenance" in the next chapter.

Maintaining the precipitator

This chapter describes the maintenance procedures that keep the precipitator in good operating condition. One person should be responsible for routine maintenance of the precipitator. This one person should either supervise or perform all maintenance activities.

We provide you with sample forms for routine maintenance. You can photocopy these forms or develop your own. We also include checklists for a major over haul of the equipment. All the forms and checklists are in the *Wellons' manual for the Electrostatic Precipitator*.

Observe all safety precautions while operating or performing maintenance activities on the precipitator equipment.

Safety precautions

Treat the precipitator with extreme caution, it creates extremely high voltages. You do not have to touch the high voltage electrode to receive a fatal shock — an arc can jump six to eight inches.

Never enter the precipitator while it is in operation.

Never work on the precipitator alone.

Never remove any access hatches, bolt-on panels or covers, structural panels, etc., while precipitator is in operation.

Never drill or make any type of penetrations into the body of the precipitator while it is in operation.

Never energize the precipitator or allow combustible gases, liquids, or solids to pass through the precipitator when the precipitator is energized — if there is sufficient oxygen present, a dangerous explosion can result.

Never perform any spark producing action such as using portable grounding electrode, opening hatches, etc., while explosive gases might be present.

When the precipitator is properly secured, do not enter the precipitator until it has cooled, and until all toxic or combustible gases have been purged.

When the precipitator is properly secured and purged, use extreme caution opening access hatches — opening may cause hot ash or particles to fly out and burn or injure personnel near the opening.

When the precipitator is properly secured and purged, do not touch or approach any internal components until the components have been properly grounded with the portable grounding electrode.

Shutdown for maintenance

Before you enter the precipitator to inspect or perform maintenance, the system must be shutdown, secured, and purged of gaseous air. Not all inspections require entry. Observe the safety precautions during operation or maintenance.

Shutdown the precipitator per the following procedure:

1. From the AVC panel, push each Stop push-button to de-energize each field.
2. Leave the purge blower fans and heaters running continuously as long as gases are passing through the precipitator.
3. Do not enter the precipitator until it is purged and secured.

Purging gaseous air for entry

Never enter the precipitator until it is properly secured and all toxic and combustible gases have been purged from the system.

Observe all safety precautions when working around the precipitator.

To purge the precipitator:

1. Shutdown the system per the procedures above.
2. Begin securing the system per the procedures on page 22.
3. Cut off gas flow by shutting down the furnace firing system.
4. Continue to run the boiler's induced draft fan, to help quickly purge the air.
5. After securing the system, open hopper and roof access hatches to draw outside air through the precipitator.

   Note: Use caution when opening access hatches. Hot gas and ash might be present.

6. Do not enter the precipitator until it has cooled, and all toxic and combustible gases are exhausted. Attach the portable grounding electrode for each field to ground the collector plates and electrodes.
7. Follow all safety precautions. Do not enter the precipitator until it is secured. See the following procedures for securing.

Securing the precipitator for entry

To secure the precipitator means to leave it grounded and without power. The key transfer system ensures you that the system has been secured. Never enter the precipitator until it is properly secured and all toxic and combustible gases have been purged from the system.

To secure precipitator for entry:

1. Shutdown the system per the procedures on page 21.
2. Begin purging the gaseous air per the procedures on page 21.
3. At the MCC panel, open the main circuit breaker. This shuts off power to the associated T/R.
4. Turn the key interlock to extend the bolt to lock the circuit breaker open. Remove the key.
5. Repeat steps 3 and 4 above for each main breaker.
6. Proceed to the T/R set ground switches and insert the corresponding keys into the key interlock. Turn each key to retract the bolt to allow ground switch operation; the keys are retained.
7. Move the ground switch to the Grounded position and turn the other key interlock to extend the bolt to lock the ground switch in the Grounded position. Remove the key.
8. Proceed to the key transfer box located on the roof and insert the grounding switch keys in the corresponding key slots.
9. When the keys are in the key transfer box, each field is properly grounded. Turn the access hatch keys and remove.
10. Take the necessary key to each access hatch and unlock.
11. Do not enter the precipitator unless it is purged (see procedures for purging on page 21.)

Periodic maintenance

Regular maintenance of the electrostatic precipitator ensures safety, and prevents performance problems. We provided forms, located in the "Periodic maintenance inspections" section of the *Wellons' manual for the Electrostatic Precipitator*, to help you develop a routine check-out of the precipitator.

Performing regular inspections

We designed check-outs to cover a shift inspection, and weekly, monthly, semi-annual, and annual inspections.

Keep the completed inspection sheets with the daily logs. If you need technical assistance, the technical engineer will need to review this data.

Conducting infrequent maintenance procedures

When you need to perform a major overhaul of the precipitator, or shutdown the system for general cleaning, follow the procedures in this section.

Observe the safety precautions while performing maintenance on the precipitator.

Conducting a major overhaul

Develop a thorough inspection procedure for a major overhaul. Wellons recommends a major overhaul each year. However, if your plant uses clean fuel, the precipitator accumulates less debris, and you can, for example, conduct overhauls once every two years. On the other hand, if your plant uses dirty fuel, the precipitator accumulates heavier debris, and you might want to conduct overhauls every six months.

You can photocopy the checklist forms we provided, or you can use the forms as a guide to develop your own overhaul procedures.

Air load test

The air load test is performed to verify the precipitator is ready for startup. Conduct this test after any cleaning or overhaul. The air load test is conducted when the precipitator is first installed to give you initial startup data.

Use the data taken during the air load test as baseline data (assuming 100 percent) for new equipment. For older equipment, compare data against the initial startup data to provide you with an operational status check of the precipitator.

Perform the air load test with no exhaust gases in the system, only static air. Test each field separately with the other fields shut off and grounded.

Record the data on the section of the "Major Overhaul Checklists" in *Wellons' manual for the Electrostatic Precipitator*.

Before beginning the test, follow these steps:

1. Do not enter the precipitator unless it is purged and secured.

2. Clean and dry all insulators, and remove all portable grounding electrodes.

3. Close the precipitator tightly and prepare for startup before the test is started. See procedures beginning on page 15.

   Stop if flue gases have entered the ESP; repurge the system before continuing.

4. Check the proper operation of these systems: the rappers, the purge blower air systems, the hopper heaters, and the vibrators.

5. Turn off all the above systems.

Testing the air load

These procedures show you how to prepare each field and how to conduct the air load test. *Test one field at a time.* This test should take about 15 minutes per field. Use a form like the one we provide in the *Wellons' manual for the Electrostatic Precipitator* labeled "Air Load Test."

Preparing each field:

1. For the field being tested, ensure the T/R set is locked in the Ungrounded position. Turn on its main circuit breaker located at the MCC or the AVC control panel.

2. For fields *not* being tested, make sure each main circuit breaker is locked off and its T/R set is locked in the Grounded position.

3. Turn the AUTO-MANUAL switch to Manual and turn the manual voltage control potentiometer to minimum; a full counter-clockwise.

4. Ensure all the preceding steps and conditions have been satisfied and all personnel are out of the area. The field is ready for the air load test, see procedures below.

To test the air load *on one field*:

1. At the AVC panel, energize the precipitator field by pushing the Start push-button.

2. Slowly ramp up the secondary field milli-amps by 10KV steps with the voltage control potentiometer. Read the SQ-300 display and verify the readings with the corresponding meters. Using the "Air Load Test" form, in the first column, record meter readings for primary volts, primary amps, secondary volts, and secondary amps. Record the values at each step until 60KV is reached, or until maximum control voltage is reached.

3. Ramp *down* by 10KV steps, and record the data in the second column of the form. Continue to ramp down and record.

4. Compare the differences. Slight differences are normal. If you have a concern, call Wellons technical support.

5. After all the readings are recorded, turn off the field and ground it per procedures for the key interlock sequence (see page 21.)

6. Repeat steps 1 - 5 for each precipitator field one at a time while the other fields are grounded.

Reviewing the air load data

After all fields have been tested, review the data recorded. If the data looks consistent with the expected values or is comparable to the initial startup data, then the electrical clearances are correct and the equipment is ready for startup.

If the data shows arcing or high amperages at lower voltages than the initial startup data, then the electrical clearances and insulator cleanliness and condition must be checked and remedied for efficient operation.

Appendix: Programming the rappers

The rapper automatic control system is located in the rapper control panel which is mounted on the roof of the precipitator. The rate (how often the rappers run) and the intensity (how high the rapper is lifted) can be adjusted by use of the interface panel.

On the interface panel you will find:

- Three thumbwheel switches (used to adjust seconds and milliseconds)
- One selector switch labeled "Program Mode" (used to select rate or intensity)
- Push buttons, used to enter in the time selected on the thumbwheels and the selected mode. Push the button that corresponds to the rapper or rapper-vibrator group you wish to program.

Programming procedure

To set rate (period):

- Set the thumbwheel switches to number of seconds between firing cycles.
- Set selector switch to Rate.
- Press the appropriate pushbutton (Perf 1, Perf2, Inlet, Outlet, HV, Vib 1, or Vib 2) that is to be adjusted.

Note: The minimum rate setting is 10 seconds, thumbwheel settings below 10 seconds. The maximum rate setting is 999 seconds for three thumbwheels or 9999 seconds for four thumbwheels. All thumbwheels are active.

To set intensity (pulse width):

- Set thumbwheel switches to number of milliseconds to the intensity (pulse width).
- Set selector switch to Intensity.
- Press the appropriate pushbutton (Perf 1, Perf2, Inlet, Outlet, HV, Vib 1, or Vib 2) that is to be adjusted.

Note: The minimum rate setting is 10 milliseconds, thumbwheel settings below 10 milliseconds will be set to 10 milliseconds. The maximum rate setting is 100 milliseconds. Only the two least significant thumbwheels are active, right to left. All thumbwheel settings are rounded to the nearest 10 milliseconds, for example, 12 will be rounded to 10, 95 to 100.

Reference Wellons drawing number #OBE-49490 for the rapper control program.

Index

The Wellons electrostatic precipitator

Periodic maintenance inspections

For procedures on cleaning and checking clearances for the following routine inspections, refer to the chapter, "Maintaining the precipitator," in the *User's manual for the Wellons electrostatic precipitator*.

Inspect every shift — for the electrostatic precipitator

Plant: ______________________ *By:* ______________ *Date:* __________

	Init.	*Result*
1. Check and record transformer oil level and temperatures.		
2. Check hopper skin temperature.		
3. Take instrument readings of the precipitator controls.		

Comments:

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Weekly check-out — for the electrostatic precipitator

Plant: ______________________ *By:* ______________ *Date:* ___________

	Init.	Result
1. Verify purge blower is functioning audibly.		
2. Check each purge blower filter and clean if necessary.		
3. Verify each rapper is functioning audibly.		
4. Verify each hopper vibrator is operating by feel.		

Comments:

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Monthly check-out — for the electrostatic precipitator

Plant: ______________________ *By:* ______________ *Date:* __________

	Init.	*Result*
1. Check oil level in precipitator ash auger gear reducers.		
2. Check precipitator ash auger drive belt tightness and condition; replace if necessary.		

Comments:

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Quarterly inspection — for the electrostatic precipitator

Plant: ______________________ *By:* ______________ *Date:* __________

	Init.	*Result*
1. Check for gas leaks.		
2. Verify hopper heaters amperage draw to ensure all heaters are functioning.		
3. Lubricate bearings at each end of precipitator ash augers.		
4. Check cleanliness of all electrical panels; clean if necessary.		

Comments:

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Semi-annual inspection — for the electrostatic precipitator

Plant: ______________ *By:* ______________ *Date:* ______________

	Init.	Result
1. Lubricate pivots & threads on all access hatches.		
2. Inspect interior and exterior for corrosion, damage, loose insulation, etc.		

Comments:

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The Wellons electrostatic precipitator

Major overhaul checklists

For procedures on conducting a major overhaul of the precipitator, refer to the chapter, "Maintaining the precipitator," in the *User's manual for the Wellons electrostatic precipitator*.

Use the following 9 forms, or develop your own inspection procedures using these forms as guidelines.

Structural inspection

Plant: ______ *By:* ______ *Date:* ______

	Init.	*Result*
1. Check all welds for seal tightness and structural integrity.		
2. Check gasket tightness of all access hatches.		
3. Check all gas, air, and oil gasketed connections for leaks.		
4. Check for abnormal condensation and corrosion at access hatches.		
5. Check expansion joints and slide plates while precipitator is hot.		
6. Check structural bolts for tightness.		
7. Verify structure ground.		

Comments:

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Plates and electrodes inspection

Plant: ______________________ *By:* ______________________ *Date:* ______________

	Init.	Result
1. Check collector plates for warping; repair or replace as necessary.		
2. Check electrodes for bent or missing spikes; repair or replace as necessary.		
3. Check electrode and collector plate spacing and alignment; adjust.		
4. Check for cracked or broken electrodes and plates; repair or replace as necessary.		
5. Check internal components for binding and misalignment.		
6. Clean all collector plates and electrodes.		
7. Verify the collector plate ground.		
8. Check electrical isolation between electrodes and plates using a 500V megger.		
9. Check spacing between all support brackets and electrodes.		
10. Remove sharp corners from brackets.		

Comments: ____

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Bus and insulators inspection

Plant: ____________________ *By:* ____________________ *Date:* ____________

	Init.	*Result*
1. Verify high voltage bus connections are tight.		
2. Verify high voltage bus is clean.		
3. Check clearances around high voltage bus.		
4. Clean all support bushings, rapper insulators, and antisway insulators.		
5. Inspect bushings and insulators for hairline cracks and evidence of tracking.		

Comments:

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Air system check

Plant: ____________________ *By:* ____________________ *Date:* ____________

	Init.	Result
1. Test and record purge air blower fan insulation with 500 VDC megger.		
2. Check and record purge air blower fan amps.		
3. Test and record purge air heater insulation with 500 VDC megger.		
4. Check and record purge air heater amps.		
5. Verify purge air heater thermostat functions and that it is set properly.		
6. Verify that there are no air leaks in purge fan ducting.		
7. Check purge air fan filter is clean and fits properly.		

Comments:

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Transformer-rectifier inspection

Plant: ______________________ *By:* ______________ *Date:* __________

	Init.	Result
1. Check and record T/R oil level and temperature if gauges provided.		
2. Check T/R grounding switch with ohm meter to verify proper function.		
3. Verify T/R nameplate data.		
4. Verify T/R primary and secondary terminations are tight and connected properly.		

Comments:

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Rappers inspection

Plant: ______________________ *By:* ______________________ *Date:* ______________

	Init.	*Result*
1. Test and record each rapper insulation with 500 VDC megger.		
2. Check and record each rapper lift (in inches).		
3. Verify rapper firing sequence.		

Comments:

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Hoppers check

Plant: ______________________ *By:* ______________________ *Date:* ______________

	Init.	Result
1. Test and record hopper heater insulation with 500 VDC megger.		
2. Check and record hopper heater amps.		
3. Verify hopper heater thermostat function and setting.		
4. Test and record hopper vibrator insulation with 500 VDC megger.		
5. Check and record hopper vibrator amps.		
6. Verify hopper vibrator timing sequence.		

Comments:

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Key interlock test

Plant: ____________________ *By:* ____________________ *Date:* ____________

	Init.	Result
1. Verify that each key interlock is properly installed.		
2. Clean and lubricate key interlock mechanisms.		
3. Verify that the key interlock sequence is correct and functional.		

Comments:

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Instrument check

Plant: ____________________ *By:* ____________________ *Date:* __________

	Init.	Result
1. Verify all interconnect wiring is per the drawing.		
2. Verify the precipitator controls interlock with the induced draft fan.		
3. Review daily log sheets for possible performance deterioration.		
4. Simulate each alarm condition and verify operation.		
5. Perform air load test from the *User's Manual for Wellons Electrostatic Precipitator* on page 24.		

Comments:

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Biewer Sawmill, Inc.
6251 W. Gerwoude
McBain, MI 49657
Local: 231-825-2855
Fax: 231-825-8113

3.4

Recommended Spare Parts

BIEWER LUMBER™

Biewer Sawmill, Inc.
6251 W. Gerwoude
McBain, MI 49657
Local: 231-825-2855
Fax: 231-825-8113

Recommended Spare Parts

Most parts needed are common to sawmill parts inventory on hand. Parts that can be purchased through current vendors will be stocked accordingly. Parts specific to Wellon's will be purchased and kept on hand in event of malfunction. All vendors we use are capable of next day delivery.

Recommended Spare Parts

40,000PPH Wood-Fired Boiler System with Electrostatic Precipitator and two (2) Storage Bins

Biewer Sawmill, Inc.
McBain, Michigan

Contract No. B-2517

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September 2006

Table of Contents

Emission Control Equipment

Fuel Handling System

Storage Bin

Qty.	Ref. #	Description of Equipment
1	0008	Roto Level Control, Conveyor Components #CR-2A
1	0008	Curved Vane Paddle #CR-62
1	0008	Flexible Shaft #CR-71
1	0015	Universal Assembly, Dwg 0A-54527
1	0017	Agitator Truck Bearing, Dwg 1A-19448
2	0017	Colson Wheels 6", #5-6-339
6	0017	Compression Springs .0981ID x .845OD x 4" Lg.
4	0017	Chain Rachets, Dwg 1A-7470
1	0020	Air Valve, 4-Way Single Solenoid, Parker B31HB553C
1	0020	Valve, Right-Angle Flow Control, Parker 032510250
1	0020	Filter/Regulator, Parker #O6E-21A18AC, w/ Gauge
1	0020	Lubricator, 3/8" Micro-Mist, Parker #16L21BE
1	0020	Lubricator Maintenance Kit, Parker #PS131B
1	0020	Filter Element, Parker #PS103
10	0021	Ft./Mill Chain, #W-82 (3.075" Pitch)
1	0021	Mill Chain Connecting Pin, #W-82
1	0022	Air Cylinder Repair Kit, #720-00-400
1	0022	Limit Switch, Sq. D #C54B2
1	0022	Level Arm, Sq. D 1 1/2" Type MA-11
1	0033	Reducer, Cone #HU50, Feed Screw Drive
1	0033	Reducer, Cone #HV70, Agitator Drive
1	0035	Flange Bearing, Dodge SCM, 3", 4-Bolt
1	0035	Flange Bearing, Dodge SCM, 3 15/16", 4-Bolt
1	0035	Pillow Block Bearing, Dodge Type E, 3 15/16", 4-Bolt
1	0036	Cogged Belts, 3VX-670, Matched Set of 4
10	0036	Ft./Roller Chain, 1 1/4" w/ Connecting Link
10	0036	Ft./Roller Chain, 1 3/4" w/ Connecting Link
1	0037	Feed Screw, 14", RH, 5'-10 1/2" Lg. Dwg 1A-8979

Fuel Handling System (cont.)

Fuel Conveyor

Qty.	Ref. #	Description of Equipment
1	0102	Flange Bearing, Dodge SCM, 2 15/16", 4-Bolt
1	0102	Take-Up Bearing, Dodge SC, 2 7/16" #125162
1	0102	Flange Bearing, Dodge SCM, 2 7/16", 4-Bolt
1	0103	Reducer Cone #50FHO
1	0104	Cogged Belts, 3VX-475, Matched Set of 3
10	0104	Ft./ 1 1/2" Roller Chain
1	0104	1 1/2" PRC Connecting Link
1	0104	1 1/2" PRC Half Links
10	0109	Ft./Refuse Drag Chain, WD116
1	0110	Photoswitch, Emitter, Allen-Bradley #42GRL
1	0110	Photoswitch, Receiver, Allen-Bradley #42GRR

Fuel Mixing Auger

1	0127	Torque-Arm Speed Reducer, Dodge, #TA6307H25
1	0127	Flange Bearing, Dodge SCM, 3 7/16", 4-Bolt
1	0128	Cogged Belts, 3VX-1400, Matched Set of 2
1	0129	Conveyor Screw, 20" Dwg 1B-61253

Metering Surge Bin

1	0152	14" Variable Pitch Auger, Dwg 1C-58164
1	0153	Reducer, Cone Model RU50, Assembly #2, 100:1 Ratio
1	0153	Flange Bearing, Dodge SCM, 3 7/16", 4-Bolt
1	0153	Flange Bearing, Dodge SCM, 2 7/16", 4-Bolt
1	0154	Cogged Belts, 3VX-530, Matched Set of 3
1	0155	Emitter Photoswitch, Allen-Bradley #42-GRL
1	0155	Receiver Photoswitch, Allen-Bradley #42GRR

Fuel Handling System (cont.)

Cell Feed Screw

Qty.	Ref. #	Description of Equipment
1	0177	Flange Bearing, Dodge SCM, 2 15/16", 4-Bolt
1	0177	14" Heavy Duty Auger, Dwg 1C-56840
1	0178	Shaft Mounted Reducer, Falk #4203-JSC-25
1	0179	Cogged Belts, 3VX-670, Matched Set of 2

Furnace System

Cell

1	0301B	3" Dia Sight Glass Lens
1	0303	Refractory Casting Form for 18" x 24" Cell Access Door
1	0306	Flange Bearing, Dodge Type E, 2 15/16", 4-Bolt
1	0306	Viton Seal, 2-15/16", Chicago Rawhide
3	0307A	Rotary Union, Deublin, #555-514-395
1	0307B	S.S. Flex Hose, 1-1/4" Parrap, 22" OAL (Supply Hose)
1	0307B	S.S. Flex Hose, 1-1/4" Parrap, 31" OAL (Loop & Return)
1	0307B	Thermocouple, Grant Edgel, Type J
1	0307A	Directional Control Solenoid Valve, Bosch D05
1	0310B	Hydraulic Cylinder, Parker, P/N 2"CBB-2H
1	0312	Pillow Block Bearing, Dodge Type E, 2 15/16"

Hyddraulic Power Unit Assembly

1	0313	Filter Breather Hydac #0080MA010P
1	0313	Return Filter Hydac #RFMBN3HC165BD10E1.0/12T

Energy System and Associated Equipment

Boiler

Qty.	Ref. #	Description of Equipment
1	0522	Manhole Gaskets, 12" x 16" x 15/16" x 1/4" Spiralwound
1	0522	Manhole Gaskets, 3" x 4" x 1/2" x 1/4" Spiralwound
1	0526	Water Column Probe, Cut to Fit

Energy System and Associated Equipment (cont.)

Boiler (cont.)

Qty.	Ref. #	Description of Equipment
1	0526	Glass Gauge Assembly, Flat Glass and Gasket Kit, Size 9
1	0526	Packing for the Water Gauge Valve #SG860
1	0526	Level Arm Probes

Feedwater, Deaerator, Gratewater Equipment

1	0551	Stickle Deaerator
		Parts as recommended by Manufacturer - See Manual
1	0553	Feedwater Pump, Grundfos Series C Multi-Stage Centrifugal Pump, #CR-32-6
1	0555	Gratewater Pump, Grundfos Series C Multi-Stage Centrifugal Pump, #CR-20-5
1	0560	Actuator & Valve Soft Kit for DA Steam PRV, Fisher 657EZ, 1 1/2", 150#
1	0562	Actuator & Valve Soft Kit for Boiler FW, Fisher 667ED, 1 1/2" 300#
1	0563	Repair Kit for 1 1/2" Pipe Size, Site Flow Indicator OPW #1582
1	0563	Angle Thermometer, Jay #5-269-34R, 50/400F
1	0565	Actuator & Valve Soft Kit for DA Make-Up Water, Fisher 667ED, 2" 600#

Water Treatment Equipment

1	0627	Boiler & DA Chemical Feed Pump, #LM1AA41-257

Piping Systems

Boiler Piping

1	0706B	GW & Make-Up Water Stainless Steel Screen for 4" Y-Strainer, 125#

Induced Draft & Forced Draft Systems (cont.)

Induced Draft Fan

Qty.	Ref. #	Description of Equipment
1	1202	3 7/16" Diameter Bearings, Internals
1	1202	Wheel & Shaft, Balanced Assembly

Induced Draft & Forced Draft Systems (cont.)

Multiple Cone Collector

1	1232	Repair Kit for 8" Rotary Airlock
1	1249	Boiler Pneumatic Differential Pressure Transmitter Siemens 7MF4433-1CA22

Gas Ducting and Stack

1	1284	ID Damper Actuator, Beck #11-157-080-040

Forced Draft Ducting

1	1302	3 3/16" Diameter Bearing
1	1303	Polyband Belts, 4/8V-1700

Ash Handling Systems

Ash Handling System

1	1403A	Reducer, Cone HU60
1	1403A	Cogged Belts, 3VX-560, Matched Set of 3
1	1403A	Pillow Block Bearing, Dodge S 2000, 3 15/16", 2 Bolt
1	1403A	Flange Bearing, Dodge SCM, 2 7/16", 4-Bolt
1	1416	HEA Auger, 9", Dwg 1C-48694
1	1417A	Torque-Arm Reducer, Dodge, #TA4207H25
1	1417A	Cogged Belts, 3VX-850, Matched Set of 2
1	1417A	Flange Bearing, Dodge SCM, 2 15/16", 4-Bolt
1	1430	Ash Fan, Smitty-Bilt PB-18, Type T, 18"
1	1431	Cogged Belts, 3VX-500, Matched Set of 3

Instrumentation & Controls

Energy System Electric I & C Remote

Qty.	Ref. #	Description of Equipment
1	2005	Ethernet Switch, 8-Port, N-Tron #805TX
1	2005	Power Supply, Condor #HD24-4.8A+
1	2005	Circuit Breaker, 5AMP, Sq. D #GCB-50
1	2005	Circuit Breaker, 10AMP, Sq. D #GCB-100
1	2005	Control Relay, 10AMP, IDEC #RH2B-ULC-120V
1	2005	Induction Relay, 120VAC Power, Clark-Reliance #ECID-26R
1	2005	Induction Relay, 120VAC Power, Clark-Reliance #ECID-23R
1	2005	Fuse, 5 X 20 MM, Slo-Blo, 1Amp, Littelfuse
1	2005	Fuse, 5 X 20 MM, Fast Acting, 0.050Amp, Littelfuse
1	2006	ControlLogix, I/O Power Supply, Allen-Bradley 1756A75
1	2006	Processor 1.5Mb, Allen-Bradley 1756L55M13
1	2006	ControlLogix, Ethernet Bridge Module, Allen-Bradkey 1756ENBT
1	2006	ControlLogix, 6pt. Isolated Thermcouple Module, Allen-Bradley 1756IT6I
1	2006	ControlLogix, 8pt. Non-Isolated Current Output Module, Allen-Bradley 1756OF8
1	2006	ControlLogix, 6pt. Isolated Analog Output Module, Allen-Bradley 1756-OF6CI
1	2006	ControlLogix, 8pt. Non-Isolated Analog Input Module, Allen-Bradley 1756IF8
1	2006	ControlLogix, 16pt. 120VAC Isolated Input Module, Allen-Bradley 1756IA16I
1	2006	ControlLogix, 16pt. 120VAC Isolated Output Module, Allen-Bradley 1756OA16I
1	2006	ControlLogix, 16pt. 24VDC Isolated Output Module, Allen-Bradley 1756OB16I
1	2006	ControlLogix, Isolated Analog Input Module, Allen-Bradley 1756-IF6I
1	2013	Low Pressure Switch, Antunes JD-2
1	2013	Differential Pressure Transmitter, Ashcroft #XL-5-MB2-42-ST-XCL-1.5-9.OIWC
1	2016	IBM Computer System, Boiler Configuration, Tower Only

Instrumentation & Controls (Cont.)

Energy System Electric I & C Remote (Cont.)

Qty.	Ref. #	Description of Equipment
1	2022	Remote I/O Panel Fuse, 5 x 20 MM, Slo-Blo, 2.5Amp Littelfuse
1	2052A	Main Steam Pressure Transmitter, Siemens Model 7MF4033-1DA10
1	2052E	Forced Draft Differential Pressure Transmitter, Siemens Model 7MF4433-1CA22
1	2052F	Induced Draft Differential Pressure Transmitter, Siemens Model 7MF4433-1BA22
1	2052G	Main Steam Flow Differential Pressure Transmitter, Siemens Model 7MF1133-1FA22
1	2052H	Feedwater Differential Pressure Transmitter, Siemens Model 7MF4433-1DA22
1	2053	Boiler Drum Level Differential Pressure Transmitter, Siemens Model 7MF4433-1DA22
1	2059	Repair Kit, Fyrite #10-5000
1	2062A	Deaerator Tank Level Differential Pressure Transmitter, Siemens Model 7MF4433-1CA22
1	2062B	Deaerator Pressure Transmitter, Siemens Model 7MF4033-1CA10
1	2064	Gratewater Temp Elements Thermocouple Assembly, Type J, Style C, "U" Length 1 5/8"

Emission Control Equipment

Electrostatic Precipitator (ESP)

Qty.	Ref. #	Description of Equipment
1	2426B	EGR w/Plunger, BHA #864-1002-002
1	2426B	Cast Rapper Shaft Guide, 2-1/2" ID, BHA #866-1137-001
1	2426B	Boot Seal (Hypalon), BHA #866-0065-H01
1	2426B	Adapter, Double Taper, BHA #866-0106-000
1	2426B	Insulator Shaft, G-10 3'-0" Lg OA, BHA #866-1024-036.00
1	2426B	Tadpole Seal, BHA #866-1034-001
1	2426C	Support Insulator (Alumina), BHA #867-1006-A01
1	2426C	Gasket Support Insulator, BHA #867-1016-001

Emission Control Equipment(cont.)

Electrostatic Precipitator (ESP) (cont.)

Qty.	Ref. #	Description of Equipment
1	2426C	Alumina Stabilizers, BHA #877-0054-A01
1	2436A	ESP Purge Air Thermocouple, Type J, Style A, "U" Length 6"
1	2436A	ESP Purge Air Differential Pressure Switch, Dwyer #1950-1
1	2436B	Filter, 20" x 16" x 1", Aluminum Frame w/ Foam, McMaster-Carr #2068 K17

ESP Ash Conveying

1	2454	Ash Hopper Auger, 12" Dia x 12" Pitch x 22'-11 1/2", Dwg 3C-59950-1A
1	2455	Cogged Belts, 3VX-1060, Matched Set of 2
1	2456	AHA Reducer, 25:1 Ratio, Dodge, #TA4207H25
1	2468	Repair Kit for Rotolok Rotary Airlock, 10"

ESP Electrical

1	2478	Circuit Breaker, 10A, 125VAC, Sq. D #GBC-100
1	2478	Circuit Breaker, 5A, 125VAC, Sq. D # GBC-50
1	2478	Control Relay, IDEC #RH4B-ULC-120VAC
1	2478	Current Monitor Relay, 0-50A, Diversified Electronics #CMB-120-AFA-1
1	2480	Metering Surge Arrestor
1	2480	Current Limiting Reactor
1	2480	Fuse, Bussman #KTK-5 (5 Amp)
1	2482	Controller, High Voltage, BHA #SQ-300
1	2482	Stack, SCR, BHA #8690200-160F
1	2484	Control Relay, ABB #A16-30-10-51 (Hopper Heater)
1	2485	Bridge Rectifier,International Rectifier #35MB120A
1	2485	Rapper Control Solid State Relay, A-B 700-SH40GZ25
1	2485	Circuit Breaker, 30A, A-B #1492-CB-G300
1	2485	Fuse, Dual Element Time Delay, 15A, 250V, Buss #LP-CC-15
1	2485	Fuse, 5A, 250V, Buss #KTK-5
1	2485	Heavy Duty Relay, Allen-Bradley #700DC-PH200Z24
1	2488	ESP Purge Air Differential Pressure Switch, Antunes #JD-2

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4.0 *Emissions Monitoring*

4.1 *Fuel*

Fuel will be monitored for quality by particle size and moisture content. Two silo systems will ensure fuel ratios of furnace will be at consistent levels to ensure optimum combustion. Weighted tests will be used to calculate fuel usage in tons per hour. Steam loads produced during tests will yield a ton(s) per pound(s) of steam produced figure. This will be used to calculate and record daily fuel usage so it does not exceed permit specifications. Boiler computer records steam production continuously and produces reports for calculations.

4.2 *Boiler*

Boiler computer control system ensures precise control of furnace. System will be operated and monitored 24/7 with operator and maintenance support present during all operations. All system information is displayed on screen to maintain operations; all displayed information has mechanical back-up on boiler. Automatic controls allow boiler to adjust to changing fuel, air and steam loads automatically by adjusting firing rate to meet demand. This ensures best combustion during changing loads which will minimize emissions. In addition operators take C02 reading to ensure fuel to air ratio is correct inside cell. CO_2 should be between 6-12% for optimum fire. Boiler operators will keep a daily log of all displayed information on a record for review or submission to ensure proper operation of boiler.

4.3 *Electrostatic Precipitator (ESP)*

Operators will be required to perform all inspections on ESP. Daily log of ESP voltage in each field greater than 25 KV with sparking in the range of 0 - 100 SPM and a stack gas temperature of 250 - 350F. Setting will be recorded and compared to hourly opacity readings to make sure unit is operating correctly. Differential pressure operation range across the MC of 1.5 - 4.5 inches WG. Any Variance in ESP readings that affect opacity will be addressed immediately. Any exceedance of COMS above permit limitation will be recorded as to cause duration and corrective action taken. Under no conditions will the boiler be operated without ESP or COMS functioning properly.

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4.4 *Multi Cone*

Operators will be required to perform all inspections on multi Cone. Daily log of multi cone Differential pressure operation range across the MC of 1.5 - 4.5 inches WG. Setting will be recorded and compared to hourly opacity readings to make sure unit is operating correctly. Any Variance in multi cone readings that affect opacity will be addressed immediately. Any exceedance of COMS above permit limitation will be recorded as to cause duration and corrective action taken. Under no conditions will boiler be operated without multi cone functioning properly

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4.5 Stack Tests

Biewer Sawmill will be responsible for all stack emission testing as required by permit 286-05.

4.6 Reporting

All required reports will be submitted appropriately to Direct Supervisor Air Quality division as required by permit 286-05.

5.0 Affected People

People listed below are responsible for administering this plan as written and submitting all information required to comply with permit 286-05.

General Manager
Facilities and Engineering Manager
Electric/Maintenance
(A.M.) Boiler Supervisor
(A.M.) Boiler Operator
(P.M.) Boiler Operator
(P.M.) Boiler Operator