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THE PENNSYLVANIA RAILROAD

INSTRUCTIONS

FOR THE

PREPARATION AND MAINTENANCE

OF

LOCOMOTIVE FIRES

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INTRODUCTION

The Pennsylvania Railroad is currently burning 800 cars of locomotive fuel a day. Coal is becoming daily harder to get, due to increased demands of new industries, foreign countries, plants converted from oil, etc. In addition, the coal which can be obtained is not so well mined, nor so carefully cleaned, as in normal times. For all of these reasons it has been necessary to obtain our fuel supply from districts where the coal is different from the Pennsylvania and Ohio coals we are familiar with. The following paragraphs will outline good firing practice for any kind of coal. Study these well, practice them consistently, and your reward will be two fold; first, good fires and fewer steam failures; second, better average coal because good fires save coal; hence the railroad will not have to buy so much low quality coal to keep up a supply.
Good combustion consists of supplying the proper amount of air to the fire so that all the coal put in will burn without any smoke. One pound of coal requires about 15 pounds of air, which amounts to approximately 200 cu. ft. of air to burn it completely. This air is drawn in by the locomotive draft and admitted through the ash pans and grates, or through the firedoor, or through induction tubes. The easier it is made for air to come up through the fire, the more completely the coal will be burned, which is another way of saying “keep your fire thin.” The thicker your fire, the more draft you need to pull enough air through the fire, or, if your draft is not increased, the less air will go through, resulting in a cooler fire and more smoke.

Combustion is best when the fire is thin, because the hottest fire is found roughly 4” above the bottom of the fuel bed. The temperature at this point is about 2600° F. The thicker the fire the lower the flame temperature, and the gases at the top of a thick 12” fire may be 500 to 600° cooler. A thin fire saves coal and makes freer steaming engine.

A good stoker fire is white hot and thin enough to be self cleaning. The grates and ash pans do not become filled up with cinders.

Heavy black smoke from the stack indicates that the fire is not in proper condition. A thin grey haze at the stack should be sufficient to maintain steam at boiler pressure. A darker brown smoke should be an indication of just enough coal to bring the steam pressure up.

Correct stoker firing is reflected in the steam pressure. If the steam pressure increases with a slight opening of the stoker engine throttle valve, and decreases with a slight closing, the fire is in good condition. If the pressure changes very slowly, the fire needs to be watched.

Good coal has from 11500 to 14000 heat units in each pound, about 90 percent of which can be liberated in the firebox if properly fired. One pound of coal should evaporate about one gallon of water.

**CLASSIFICATION OF COAL**

By “good coal” is meant well prepared coal from any district. Poor coal is of two kinds, and may be mined in any district. The worst of these is “crop” or “weathered” coal. This is very difficult to fire, because it has no life, forming a dull solid mass in the firebox. The second kind of poor coal is that which is improperly prepared at the mine, so as to have an excessive amount of impurities, such as slate,
sulphur balls and mud. This coal will burn, but the fire bed thickens rapidly, because the percentage of ash is high.

Clinkering coal, smokeless coal, wet coal, and high slack coal are not "poor coals" but merely "different" coals which must be studied how best to fire. We are going to have them with us for several years, at least, and the purpose of this pamphlet is to point out how to fire them without getting into trouble.

**NATURE OF COAL**

Low volatile, or so-called smokeless coal, found on our railroad in Pennsylvania only, has a high percentage of pure carbon, and less of the smoke producing hydrocarbon than any others. These hydrocarbons make a fire kindle easier, and their scarcity in low volatile coal makes this coal take longer to brighten a fire. Because it is friable, or easily broken, there are not many lumps and it is easy to choke the air spaces throughout the fire. Hence be very careful not to put too much coal at one time in any one location. In general, this coal will not clinker, and a thicker fire than normal will steam freely. All these coals coke easily.

True clinkering coals found mostly in Indiana, Illinois and Western Kentucky, but to some extent in high sulphur seams in Ohio and Pennsylvania, have an ash which melts at a relatively low temperature, below 2200° F. This ash, when fluid, runs down through the fire and, chilled by the cold air coming up through the grates, solidifies in large sheets or pieces. The process is gradual, however, and there are two important rules for keeping a good fire. First, keep the hook out; second, rock, not shake, the grates every 30 or 40 miles by lifting the keepers off, but leaving the dumping bar in place, and particularly just after the throttle is shut off or after the engine slips. Watch the fire frequently, keep it thin and do not allow uneven piles to grow. Any coal tends to clinker when the fire has holes in it, or uneven draft, or large piles, but the true clinkering coals are worse in this respect. Use of the fire hook opens holes in the fire and allows green coal to get into the hot portion of the fire, which melts the ash into clinker.

Slack coal is that portion below 1 3/4" in maximum size. High slack coals from any district will burn just like lump coal from the same territory, if the coal is properly distributed over the firebox. With the stoker, fine coal can be blown further, so that the jets must be closed down slightly for slack, and opened up a little if the coal gets more lumpy. If this is not carefully watched, the arch can easily be plugged. Although slack coal will, in general, have slightly
more ash than lumpy run-of-mine, the common practice of referring to it as "dirt" is not justified. If the fire builds up in thickness faster than normal, rock, not shake, the grates a little more often.

Pennsylvania gas and coking coals are ideal for locomotive service, but they are in enormous demand for the war effort, and there is not much available for railroad use. Watch this coal for size, blowing harder for lump portions and lighter for fine coals. This coal seldom clinkers.

Wet coal is much heavier than the same coal dry, and hence the jets must be carefully watched, just as with slack coal. Increase the jet pressure if the coal is noticeably wet at the distributor, and be sure to decrease pressure again as soon as dry coal is being brought up by the conveyor, thus avoiding a plugged arch. If wet coal cakes on the firing table, or in Duplex stoker distributors, use a stoker slide hook or a coal pick handle to break it up.

High ash coal, from 15 to 20 percent bone, slate and sulphur, are not intended for our locomotive service, but when encountered, should be fired according to the instructions for slack coals, that is, check fire frequently, keep the fire thin, shake lightly and often, and keep the hook back on the tender.

Crop coal is refused by the railroad whenever found, but occasionally some gets by. It is readily recognized by having no blocky structure, with usually a grey stain throughout any given lump, which can be broken in one hand. When fired, it tends to explode like popcorn due to the high moisture content, but falls dully into the firebed and clogs the air passages. When found on an engine out on the road, the engineman will have to work the engine hard to get sufficient air through it, until the train arrives at the first coaling station where better coal can be obtained. Mixing with better coal from the rear of the tender will help the engine over the road.

No matter what kind of coal you may have on the tender, it is important to realize that no set jet pressure can be given or used with the various sizes and kinds of coal, and it is the duty of the firemen to watch the fire very closely, particularly when starting out, to regulate the jet pressures to get the best distribution, to supply only the required amount of coal to the fire, to regulate an even supply of coal, and to watch the fire very closely by shutting off the stoker and looking at the entire fire (not just the back portion) and to know at all times the condition of the fire.
PREPARATION OF FIRES AT THE ENGINEHOUSE

Engine watchers at the round house can do much to help prevent steam failures later on, when the engine gets on the road. They should put a small bank in the two rear corners to form a coke pile and then build the fires thin and level over the entire grate area. When more coal is needed, scatter sufficient coal all over the fire. Keep the blower on until the fire gets bright. Care must always be used not to plug the arch, and not to allow fire bed to become over six (6) inches in thickness.

At certain terminals local conditions will require special preparation as will be set up by the Division officials.

Engine should be turned over to the outbound crews having within fifty (50) pounds of maximum steam pressure, two gauges of water, the ash pan clean, and ash pan doors properly closed.

PREPARATION BY THE FIREMAN BEFORE LEAVING

On arrival at the engine, the fireman, when taking charge of a locomotive, must see that the grates and ash pan, particularly the wings, are in good condition, free from ash and clinker, that grates are level, and the ash pan properly closed and secured, to prevent hot coals from dropping along the road, as they are liable to start fires.

Before starting stoker, fill the four-compartment oil cup located in the bulkhead of tender cistern with engine oil, and apply a few drops to the universal and slip joints. These parts when in service should be oiled once every eight (8) hours unless the bearings indicate that they are running dry. With Standard stokers note if engine bed has sufficient oil (oil should show when the pet cock on side of engine bed is opened). With both Standard and Duplex stokers the lubricator should feed about three (3) drops per minute to stoker engine while running. Stoker should then be run sufficiently to see that it is operating properly.

Make the fire thin and level, except for the coke banked at the rear. Build the fire up, if necessary, by hand, and do not use the hook, nor shake the grate unless absolutely necessary.

A few minutes before leaving with the train (or before going under the electric catenary wires) use the hook to spread the corner banks over the fire. These coke banks will help provide steam at starting while the fire is being adjusted to the sudden increase in load.

If you are getting a “through” engine at an intermediate terminal, do not shake the grates while standing still unless absolutely necessary.
While standing around waiting for the train, crack the blower just lightly enough to lift any smoke, but do not turn it on full, which only burns up coal wastefully.

When ready to use the stoker, open the distributor jet valves, then slowly open the main control valve of the distributor to gradually force out any condensation that may be in the distributor pipes. Next open the main engine steam valve, then the small throttle valve to the stoker engine gradually to allow all condensation to escape through the automatic drain valve, then place the reversing rod handle in the normal operating position by placing the control lever in the cab in down position. See if the engine operates in the reverse position. After the control lever has again been placed in normal operating position, give the stoker engine sufficient steam to run at the speed desired.

CO-OPERATION ON THE ROAD

Reference has already been made to certain methods for firing various kinds of coal. Before going into firing instructions which apply to any coal, however, it will be well to call attention to the value of co-operation between engine-men and firemen in getting an engine over the road. The work of the engine crew is a constant exercise of good judgment on the part of both.

The engineman should observe the activities of the fireman and instruct him as to the proper method of firing an engine. The fireman should keep in mind that the engineman is responsible for the proper and safe management of the locomotive, and his orders should be obeyed.

Good even pumping of the boiler is very essential to good firing. When the water is carried too high in the boiler and the locomotive works water, this causes an extra draft which tears holes in the fire, and may in extreme cases lift the arch off the tube. Lifting water also destroys the lubrication to the valve, cylinders and stoker engine, and causes water to come from the stoker jet, affecting distribution and disturbing the fire and locomotive operation in general. Water should be carried at the lowest level consistent with safe operation. Physical characteristics of the Division should be taken into consideration in pumping the boiler. The fireman should be well acquainted with these physical characteristics so that he can anticipate varying demands for steam. The engineman should keep the fireman advised of any sudden change in throttle or reverse setting.

Engine should be worked with full throttle wherever practicable. This results in higher superheat, thus requiring less steam to do a given amount of work. It should be
clearly recognized that the setting of the reverse gear controls the volume of steam going to the cylinders, while the throttle controls only the pressure and temperature of the steam.

**FIRING ON THE ROAD**

The following general instructions apply to firing locomotives in service.

After the stoker has been started and the coal begins to appear at the jets, adjust the pressure on the jets so as to get a hot clear thin fire. Supply valve to the jet manifold should be wide open. Throttle the stoker engine so that it will supply just enough coal for the work being done by the locomotive. Care should be exercised not to feed too much coal, for the fire should be carried much lighter than with hand firing. When the train is standing, or drifting on long grades, the stoker engine should be shut off, and the fire kept in proper condition by hand firing.

The aim of the fireman should be to have his jets so adjusted that all the coal is burned at the same rate. This requires watching the fire, particularly at the beginning of the trip, to see that no piles are forming, that no coal is being blown up against the throat sheets, and that, if there is any deviation from a level fire, it is in the form of a slightly thicker fire along the side sheets and back sheet.

Once this thin level fire has been established, very little handling of jets is necessary, so long as the coal remains reasonably uniform. A slight opening of the stoker throttle valve will start the steam pressure rising, and a slight closing should promptly cause a drop in pressure. If, however, the coal changes in size, moisture, or quality as it is brought to the distributor, the proper adjustment of jet valves, as explained previously, must be promptly attended to. Any tendency to pile coal unevenly anywhere in the firebox must be corrected by jet manipulation. Normally, neither hook or grate shaker should be used for this purpose. The importance of watching the fire cannot be overestimated.

If, however, the growth of a pile is not noted until too late, use the grate shaker to break up the pile and any clinker which may be underneath. If this is not successful on very large piles, use the hook: but only as a last resort. If the use of the hook is required over the road, the fireman has usually not been paying close attention to the fire.

A light spot, or hole, in the fire can be easily brightened up by adjusting the proper jet to blow coal to that point.

Bear always in mind that too much coal in the rear of the fire is bad, but not so serious as too much up front.
Wherever coal piles up, a clinker may form, and they are more easily handled at the rear.

Clinkers should be broken up by opening the grates far enough to raise the clinkers so the fire rake can be used to pull the clinker back under the distributing plate or to the back corners. Where practicable the clinkers should be knocked through the grates or taken out of the firebox through the fire door hole. In opening grates to break up or remove clinkers, only one section should be opened at a time, and clinkers removed, saving as much fire as possible.

A good stoker fire goes out quickly when engine is standing. If a long station stop, or road delay, is imminent, use the scoop to cover the fire with coal, which will be coking until the engine starts again. Do not let the fire go out in spots.

Watch the coal in the tender at intervals. Do not allow rocks, iron, wood, waste, or other foreign material to be fed into the stoker if it can be detected in the coal and removed before it enters the conveyor trough. Do not use slide hooks or firing tools in such a way as to risk getting them caught in the conveyor screw.

Before taking coal en route, or at terminals, see that all tender slides are pushed back so the opening is in front. Stoker slide plates, where used, must be closed a sufficient distance from the end of the run in order that the coal in the conveyor may be economically used and the engine arrives on the pit with the conveyor as nearly empty as possible.

The jet valves should be left cracked when the locomotive is drifting, or standing; as this tends to prevent burning out of the firing table or distributor.