PT. ADARO INDONESIA

adaro

ENVIROCOAL

A GUIDE TO STOCKPILING AND STORAGE

SUMMARY

Envirocoal stores well in stockpiles under normal weather conditions and can normally be stored for 30 – 40 days without special handling. However, for extended storage periods up to a year or more and/or unfavourable weather conditions good stockpile management practices including compacting should be observed.

The least favourable weather conditions for dust control are periods of low humidity with strong winds. The frequency of fog spraying should be increased to maintain dust suppression during these periods and minimize surface coal degradation.

Strong wind conditions may generate an unacceptable rate of temperature increase in specific areas of the stockpile, the remedial action of “turning over” the affected area of the stockpile will quickly reduce coal temperatures in the affected area to near ambient temperature levels.

Hot spots in coal stockpiles are a local effect only and are confined to small areas that are easily handled. These areas are always close to the surface of the stockpile, within 1 – 2 meters of the surface, and generally along the toe of the stockpile. If a hot spot occurs it does not mean the entire stockpile is heating or in danger of burning up.

Stockpiled Envirocoal has excellent load bearing capacity and can readily support tracked or rubber-tired equipment. Stockpile compacting is then simple and economic.

Stockpile faces should be formed with a smooth and compacted surface, this can be performed readily with minimum coal degradation

Envirocoal has a low percentage of ultra fines (approx. 7 - 10% minus 0.5 mm) so watering for dust suppression requirements is minimal. Frequent but judicious fog spraying is recommended as this maintains the condition of the surface coal in addition to minimizing wind borne dust without increasing the moisture content of the stockpiled coal.

Water should <u>not</u> be used for temperature control of stockpiles.

INTRODUCTION

PT Adaro Indonesia has developed a major steam coal deposit in the Tanjung district of South Kalimantan. The defined coal resource to date is 1,970 million tonnes of surface mineable coal. The coal is classified as subbituminous and is exceptionally clean at 1.0% ash and 0.1% sulphur, it has been trademarked Envirocoal.

Adaro commenced coal production in September 1991. Envirocoal is now widely used in power plants and industrial plants throughout Europe, Asia and the Americas. To date over 90 million tonnes of Envirocoal has been shipped to customers around the world. Current annual production capacity is 20 million tonnes a year.

Adaro is currently mining coal by open pit methods from its Tutupan deposit. The coal as mined is clean and coal washing is not required, the coal processing operations are simple and consist of crushing and screening to minus 50 mm at the Kelanis crushing and stockpiling facility.

Coal is delivered by barge from Adaro's barge loading terminal at Kelanis on the Barito River to the transshipment location, offshore Banjarmasin (Taboneo) or to International Bulk Terminal (IBT) at South Pulau Laut, where it is stored in stockpiles. Coal is also barged direct from Kelanis to domestic customers in Indonesia.

The specification for Envirocoal is shown in Table 1.

Table 1: Specifications of Envirocoal

Proximate Analysis (as received)	Average (% by weight)	Range (% by weight)
Fixed Carbon	40.5	37.0 - 42.0
Volatile Matter	42.0	39.0 - 43.0
Total Moisture	25.0	23.0 - 28.0
Ash	1.0	0.8 - 2.0
Total Sulphur	0.1	0.05 - 0.15
Heating Value Kcal/Kg (gar)	5250	5000 - 5400

SELF-HEATING IN COALS

Self-heating is the process whereby a coal particle undergoes chemical and physical reactions that generate heat within the coal particle. Nearly all coals will exhibit some self-heating, it is a natural property of solid, carbon-containing materials. Figure 1 shows the tendency for self-heating in coals based on the percentage of fixed carbon.

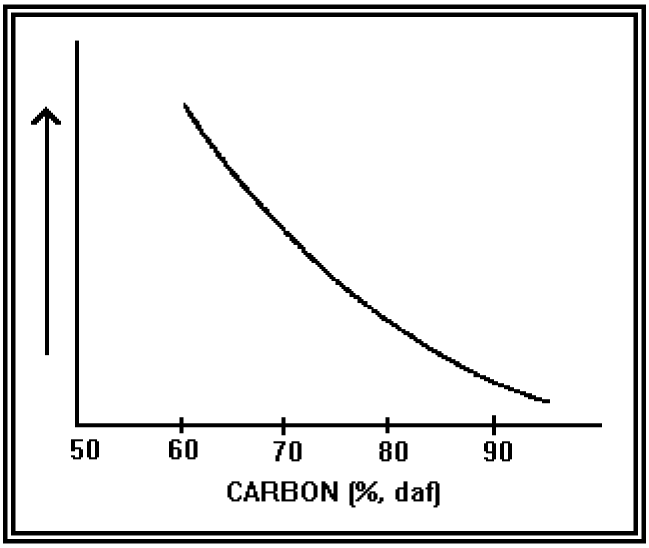


Figure 1: Susceptibility of Spontaneous Heating (Das & Hucka)

When coal is first laid down in a stockpile, oxygen is absorbed/adsorbed and some heat will be generated. This, along with adsorption of water, will usually cause the temperature in the stockpile to increase slightly. Normally, if the supply of oxygen is stopped or used up, as in the middle of a stockpile, the temperature will then decrease, stabilize and self-heating will not proceed further.

Das and Hucka have suggested six stages in the process of self-heating and combustion. These are summarized in Table 2. The early steps are thought to proceed slowly and the level of heating is small. However, if the heat generated during these processes or the source of oxygen is not removed, then other reactions can become dominant, and ultimately fires can result.

Stage	Reaction	Weight	Temperature (C)	Heat generated (cal/g)	Remarks
Adsorption	Water Adsorption	Gain	Any temp.	2-25	• Physical process • Large amount of heat produced
Chemisorption	Oxygen absorbed to form peroxides	Gain	70	2-16	• Traces of water required • CO is typical product
Peroxygen decomposition	• Disintegration of peroxygen • Release of water from coal	Loss	70-150	4-18	• Wet spots in the stockpile can be visible • Steam can be seen coming from the stockpile
Oxycoal formation	Formation of stable oxygen complexes	Gain	150-230	6-27	Much heat
Onset of combustion	• Devolatilization • Combustion	Loss	230	10-58	Much heat
Active burning	Combustion	Loss	>230	3,500-7,800	Much heat

Table 2: Stages of Spontaneous Heating and Combustion(Das & Hucka)

Since water is thought to be a significant contributor to self-heating, Das and Hucka show data of the heat of wetting for various coals. (Table 3) It can be seen that for subbituminous coals the heat of wetting is almost two times higher than for bituminous coals. This might be due to the higher surface area of subbituminous coals, which is typically about two times that of bituminous coals. The higher surface area is due to the greater number of microfractures present in subbituminous coal particles.

Table 3: Heat of Wetting for Coal Ranks (Das & Hucka)

Coal Rank	Vol. Mat. (%, daf)	Carbon (%, daf)	Heat of wetting (cal/g)
Subbituminous	45	77.5	25
HV Bituminous	35	82.5	10-15
MV Bituminous	30	85	3-4
LV Bituminous	20	89	2
Anthracite	5	93.3	6-9

TEMPERATURE CHARACTERISTICS OF ENVIROCOAL IN STOCKPILES

Controlled testing of Envirocoal, has been conducted to determine its heating characteristics in a variety of storage conditions. The results show that Envirocoal will store well under normal conditions but can be subject to heating, especially along the windward side of loosely stacked coal piles after a period of 30 – 40 days.

Bulk coal shipments are normally received at 36 ^{0}C to 37 ^{0}C “in hold” temperature. The coal temperature on receipt at the stockpile area will be reduced in the intermediate handling processes to near ambient temperature.

During the discharge operations it will be normal for some steam to be visible as the coal is handled, this will be due to the temperature difference between the “in hold” temperature of the coal and the ambient air temperature. The greater the temperature differential between ambient temperature and the “in hold” temperature the more visible this effect. In colder climates a good deal of steam will be visible as the coal is being discharged. As the coal cools to near ambient temperatures the steam will disappear.

Well-formed stockpiles with smooth compacted surfaces will exhibit a steady increase in overall temperature with day by day variations depending on ambient weather conditions until a (relatively) stable temperature condition is reached around 40 ^{0}C. A well-managed stockpile will be fairly stable at these temperatures for long periods.

HEATING IN STOCKPILES

Envirocoal has good stockpile characteristics. In reasonable weather conditions and with good stockpile management the coal will remain in a stable condition for years. However, heating may occur if Envirocoal is stockpiled without any stockpile management for periods in excess of 30 – 40 days and/or unfavourable weather condition, in particular conditions with strong winds.

The important factors affecting heating include time, coal temperature, oxygen concentration, handling and storage conditions (compaction and drainage), and ambient conditions, such as precipitation and air temperature (relative to the coal pile). For instance, differences in air temperature between the pile and the outside air can encourage air movement through the pile, thereby increasing oxidation. A pile which has been compacted can help to prevent free air movement throughout the pile, thereby reducing oxidation.

Under extreme weather conditions, particularly high winds isolated "hot spots" may occur on the exposed coal surfaces. These "hot spots" may stabilize if weather conditions improve. Intermittent heavy rains can also initiate heating behaviour in stockpiles after a few days.

These hot spots are a local phenomenon only, a hot spot in one area does not mean the entire stockpile is in a hot condition. Why one area of a coal stockpile will heat and an immediate adjacent spot remain cool and stable is not entirely clear, but is probably due to a combination of factors such as sizing, chemical makeup of the coal particles, reactivity of the coal in that area, etc., etc.

Hot spots in coal stockpiles are normally confined to coal at or near the stockpile surface, usually within 1 – 2 meters of the stockpile surface. It is generally thought that the first 0.5 – 1 meter of coal in the stockpile is able to dissipate heat to the ambient air. Coal that is within 1 –2 meters of the coal surface can still receive some oxygen from the ambient air but cannot effectively dissipate the heat generated and therefore the heat tends to build up. Coal more than 2 meters from the stockpile surface will use up the entrained oxygen, which will in turn stop the heating/oxidation reactions from progressing any further. Additional oxygen cannot reach this deeper coal and therefore the oxidation reaction is effectively stopped.

It is recommended, however, if the coal temperature in a hot spot increases above 50 ^{0}C, remedial action should be undertaken. This action entails removing the heating coal from the pile, spreading in a thin layer and allowing to cool for up to 1 hour. The coal can then be replaced to the pile, recompacting the affected area will normally control any heating that may be occurring.

The coal yard operators should monitor the temperatures in the coal pile every day. Coal above 65 degrees (and certainly above 70 degrees) should be cut out, cooled down and after cooling compacted back into the pile.

The base of the coal yard should not allow pooling of water underneath the coal pile, and promote drainage of water away from the coal. Hot spots should not be treated with water, except in emergency situations. It is true that water will cool hot coal, but water will usually accelerate heating if it cannot be drained away immediately. There will always be problems when water forms pools underneath a coal pile.

SUGGESTIONS FOR HANDLING SUBBITUMINOUS COALS

When a subbituminous coal, such as Envirocoal, is to be stored for longer than 4 - 6 weeks, it is ideal standard practice to compact the stockpile, and shaped into a relatively low profile, dome-shaped pile. Compaction can be done with steel-tracked bulldozers or normal rubber-tired loaders/bulldozers. Sides are ideally sloped and compacted to prevent the penetration of air (oxygen) into the pile. If a hot area develops, the hot coal should be removed and allowed to cool, after which it is replaced to the pile and recompacted. Compacting normally prevents a further hot spot from occurring in that location. Water should not be used to cool the hot spots, except in extraordinary circumstances. These procedures are generally known as the “standard” procedures for storing subbituminous coals.

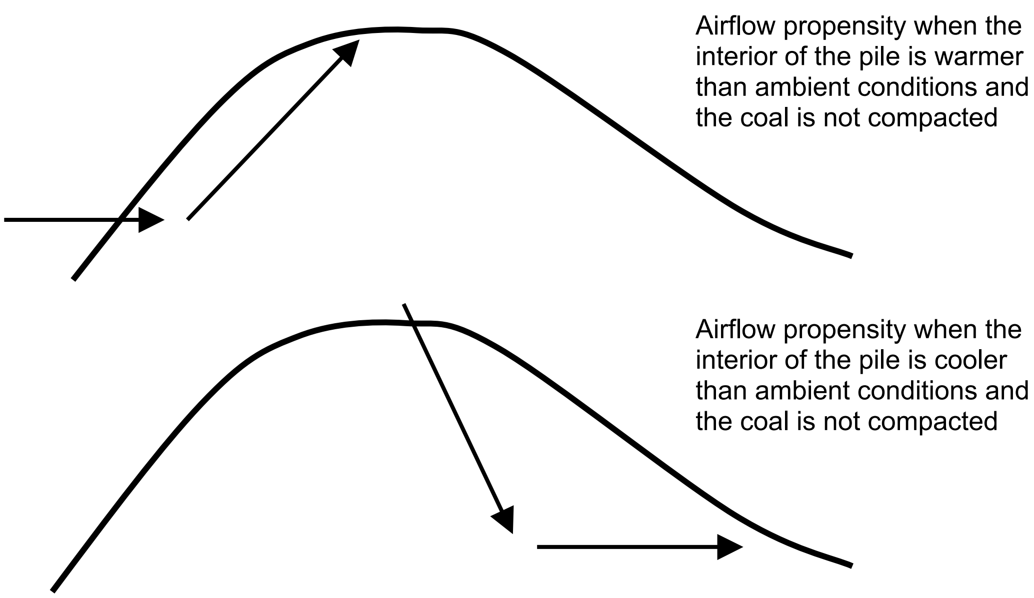
The only known effective method of controlling or eliminating heating in stockpiles is to compact the pile during stacking. There are crusting agents in use that seal the stockpile surface, however they are expensive to apply and impractical for an active stockpile. The most effective compacting technique involves laying down the coal in 2 - 3m thick levels and using a bulldozer to travel back and forth on the coal to lightly compact it.

It is not necessary to compact the coal to the point of being rock hard, one or two passes with a bulldozer is sufficient to compact the coal. Too much travel on the coal with heavy equipment such as bulldozers may result in excessive generation of fines with attendant dust problems during subsequent reclaim operations. The bulk density of the coal will not increase to the point where it affects the reclaim capacity of the reclaim machine, the bulk density will increase from approx 0.83 tonnes/m3 to 0.85 – 0.87 tonnes/m3.

One good operating procedure when dealing with subbituminous coal is to lightly compact the “toe” of the pile (that is, the outer bottom edge of the coal pile), which is susceptible to

air flow, particularly as the coal pile ages. The compacting of this portion of the pile prevents air from flowing into or out of the bottom of the pile when the coal pile is either warmer than or cooler than ambient conditions. Note the schematics, below:

Figure 2: Airflow Propensity



Slopes should be kept as shallow as possible, 20 – 25 deg, however the size constraints of the coal yard may not allow slopes to be built this flat. It may be necessary therefore, to use a backhoe or loader to dress and compact the slope sides to minimize heating on these slopes. This technique is being used in some coal yards and has proved effective in controlling heating.

Envirocoal has been stored in large compacted stockpiles for periods of more than a year or more without serious self heating problems.

Subbituminous coals should not be left in the coal bunkers for extended periods, because fires might occur. Normal practice is to empty bunkers if the unit or pulverizer is to be shut down. If the shutdown is unplanned, coal should not be left in the bunker for longer than 7-10 days. It might be necessary to manually empty the bunkers and return the coal to the coal pile. It is also good practice to reduce the coal in the bunker to a minimum level once per week. Any coal hanging up in the bunker should be manually dislodged.

STOCKPILE MANAGEMENT

STOCKPILE MANAGEMENT – LARGE STOCKPILES

Stockpile management is the major factor in maintaining good storage conditions and controlling any coal heating. Envirocoal can be readily stockpiled by stacker/reclaimers, stacking conveyors or tip trucks. Accessing the stockpile will present no difficulties as Envirocoal has a high load bearing capacity to support mobile equipment and will produce a thin but adequate compacted surface for equipment movement.

The recommended method of building a stockpile with stacker/reclaimers is to lay down windrows of coal approximately 2 - 3 meters in height the length of the stockpile. These windrows can then be leveled to 1.5 – 2 meters with a bulldozer and a new lift laid down on top of the recently leveled coal. It is not necessary to heavily compact the coal as this will needlessly degrade the coal, possibly leading to dust or fine coal handling problems during subsequent reclaim operations. One or two passes with a bulldozer is sufficient to compact the coal to prevent self- heating.

Ideally the sides of the stockpile should be rolled out with the bulldozer to present a shallow compacted slope to any prevailing winds. However it is quite common for space constraints to prevent this option. If space constraints result in slope angles that are inappropriate or unsafe for equipment operation it is good practice to use a backhoe or loader bucket to compress the slope surfaces with the backside of the bucket.

Stockpiles that are built with stacking conveyors should have the coal pushed out and leveled in 2 – 3 meter lifts as the coal is laid down. As with stockpiles that are built with stacker/reclaimers the ideal method is to roll out the sides and ends of the stockpile.

Stockpiles are also built by the use of end dump tip trucks, these types of stockpiles are usually well compacted due to the travel of the trucks across the stockpile to dump their loads..

The degree of mechanical breakdown (size reduction) of Envirocoal due to development of a stockpile access route can be minimized by varying the truck route across the stockpile. The dumping trucks can be reversed to the left and right of the pile with the coal loads lightly spaced.

Any stockpile should, if practical, be rectangular in shape presenting a minimum face to prevailing wind direction and the ingress or egress ramp constructed on the windward face.

The stockpile face slope should be such that a bulldozer can trim and compact the surface to produce a "gradable" smooth surface to inhibit air entry. As with the access roads this is a surface effect only and the effect on overall coal sizing is negligible.

STOCKPILE MANAGEMENT – SMALL STOCKPILES

Small stockpiles can be built up by front-end loader as Envirocoal can readily support rubber-tired equipment.

For prolonged storage life, it is necessary to smooth off and compact the stockpile faces. This can be readily achieved with the back of the front-end loader bucket.

If the stockpile area is retained by walls it is ideal to raise the stockpile level to wall height as wind eddying has been found to cause heating. Our experience has been that often coal stored against a concrete wall heats faster than the pile in general. This is probably because of loose coal and possible poor drainage.

The top of the coal pile should be contoured so that few, if any, peaks and valleys are present. Wind will promote heating in the peaks, and water can accumulate in the valleys. Dressing the pile to remove unevenness will compact the pile, and also help to prevent chimneys where air rises. Chimneys always cause self-heating.

Ideally all stockpiles should be constructed to present minimum windward exposure.

STOCKPILE MANAGEMENT - GENERAL

Stock Rotation: It would be to the benefit of all coal yards to try and implement a "first in – first out" rotation of the piles in order to reduce to a minimum the amount of time the coal is kept in stock.

Stacker/Reclaimer machines can sometimes only reclaim in one direction (east to west e.g.) and therefore the stockpiles need to have a space between them in order for the machine to reclaim coal from stockpiles that are located in the middle or western end of the pile prior to reclaiming coal from the eastern piles.

The stockpiles should be separated into discrete areas that are large enough to store a complete shipload with a 10m gap between the piles to allow the bucketwheel reclaimer to reclaim the pile prior to any adjacent pile being reclaimed. For a Panamax size vessel (65 – 70,000 tonnes) the pile would be approximately 100 – 120 meters in length depending upon the height (10 – 13m) and width (40 – 45m) of the pile.

Monitoring: The stockpiles should be checked at least once per day for signs of heating, generally hot spots will issue steam for several days before any active burning takes place. This allows ample time for remedial action to be taken before any ignition of the coal at the hot spot takes place, it is recommended however that hot spots be treated as they develop. Waiting will only allow more coal to be affected. If heating coal is noticed, the heating coal should be removed from the pile, spread in a thin layer (approx. 20 – 30cm thick), allowed to cool for an hour or so and then replaced in the pile and recompacted with the loader bucket. This is normally sufficient to control any heating.

Appearance: It is normal for Envirocoal in a stockpile to appear brownish in color, this is an effect of the surface coal drying out and approaching a very low level of surface moisture. The coal will return to a black color once it is rewetted and the surface moisture returned to its normal level of 7 – 10 %.

DUST CONTROL

Dust is fine coal less than 0.5 mm in size The majority of dust is formed by attrition, that is, coal particles falling and tumbling on each other, which occurs during mining, shipping, storage, and reclaim. Additional dust is formed as equipment such as bulldozers and loaders travel over the coal. Some dust is caused by the breakage of large coal particles as it 'ages,' i.e., dries and cracks. All these processes occur more rapidly with subbituminous coals, than with bituminous coals.

All stages of mining and crushing of Envirocoal are designed to generate a minimum of fines. Coal stockpiles will then require a minimum of watering for dust suppression during establishment. A surfactant is used at Kelanis for improved wetting of the coal and subsequent dust control.

Adaro's Envirocoal performs best in stockpile and on conveying equipment when it has not lost too much of its surface moisture. Envirocoal has inherent moisture of between 14 - 16 percent . When the coal has surface moisture of at least seven percent (7%), the coal tends to exhibit low propensity to spontaneously combust and low propensity to produce dust. Therefore, tests should be run on the moisture of the coal to determine whether the surface moisture (total moisture less 16%) has fallen below eight percent (8%). If so, then water should be added to the pile to increase surface moisture to the eight to nine percent (8-9%) range. Adaro's envirocoal will also exhibit lower dust levels when it is maintained at the correct total moisture level.

Water can be used to keep the piles damp for dust suppression purposes, however it is not necessary to soak the piles to control the dust. Stockpiles are normally only dried out for a few centimeters below the surface, beyond this depth the coal will remain close to its original moisture levels.

Generally there are the following ways to apply water to control dust with coals. Keep in mind that large amounts of water are not needed to control dust. The objective is to maintain the surface moisture at a level so that dust does not become a problem, which for Adaro coal is 24-25% total moisture (7-8% surface moisture). For other coals it might be slightly more, or less. The fine coal has a much greater need for water to control dust than the larger particles. Surfactants should be helpful to increase the efficiency of the water added to 'wet' the fine coal.

- <u>Water can be sprayed on the coal as it moves on conveyor belts</u>. The objective is to get water on the fine coal, most of which lies at the bottom of the coal, next to the belt. This means the large coal particles on the top receive a large portion of water. When water is sprayed directly on coal as it moves along a belt, water must 'filter' down through the coal to wet the fine coal. More water than is needed must be added to control the fines. Conveyor belts become wet, causing sticking and housekeeping problems. Nozzles producing large droplets can be used, and the spray pattern should be confined to only cover the coal on the belt. Over-spray should be minimized.

- <u>Water can be sprayed at a transfer point where the coal is falling</u>. Several nozzles should be used The spray pattern should cover the entire coal stream, and a majority might be applied to the underside of the coal stream where the fines are. It is best to spray in an enclosed transfer point. If necessary, some nozzles might be used to

- create very small fine water particles – a fog – which can contain any dust that become airborne. Some trial-and-error will be required to get the pattern and amount of water correct in an enclosed transfer point. Sometimes the aerodynamics can be such that too much water and/or pressure can cause the dust to be carried out of the enclosure.

- Water can be sprayed on the entire pile to control fugitive dust arising from wind around the pile. Many coal yards have large agricultural sprays to wet the entire pile. Some customers wet the pile daily, and others only add water as needed.

- To control dust when dumping coal into hoppers, a fine spray of water can be used to make a barrier to contain the dust. Some nozzles use air to atomize the water into a drops that can capture the dust. A picture of fog sprays in a hopper are shown below.

Storage life will be enhanced by minimizing water application for dust control. Dust suppression watering should then be done frequently but sparingly.

The recommended practice is to fog spray or mist the stockpile surface as frequently as necessary to maintain the surface coal in a moist (but not wet) condition. This will minimize surface coal breakdown and then, minimize further dust particle generation.

Heavy water addition such as water cannons can cause erosion and washout of the pile surfaces.

EXPERIENCE CONTROLLING DUST WITH ADARO COAL

Over the years using Adaro coal the experience of controlling dust has resulted in some observations and guidelines:

1. The production level and demand for Adaro coal is very high, and has been for several years. This means that coal is not excessively handled, or stockpiled at the mine or loading port for longer than 10-14 days. (The chart below shows typical size analysis of Adaro shipments in 2000.)

2. Almost all Adaro coal will arrive at the customer dust free. This means the amount of fines <0.5 mm are relatively low, and the amount of total moisture will be sufficient so that dust will not be a problem upon unloading the coal. [This depends to some extent upon the conditions during shipping.]

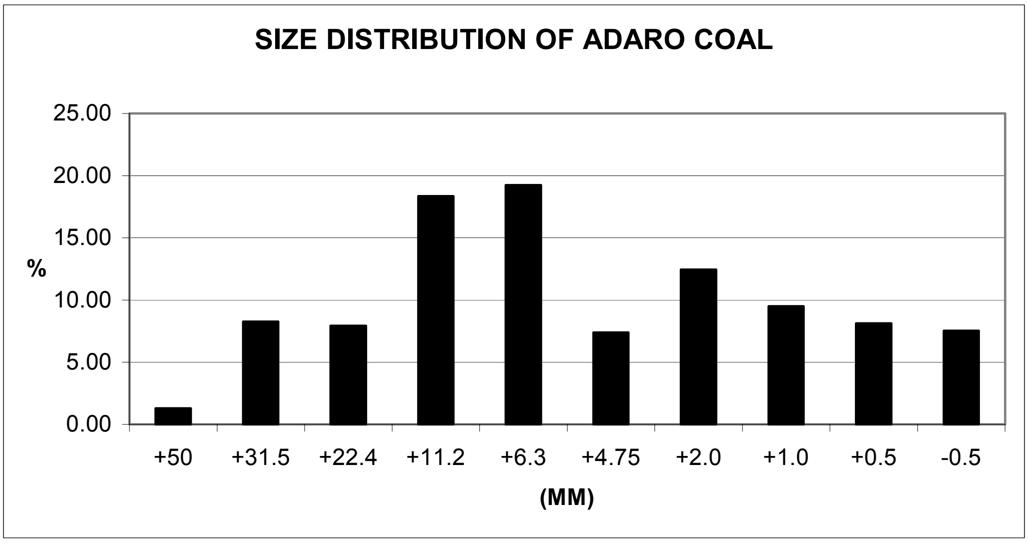
3. The more the coal is handled, including compacting, the greater the potential for dust.

4. It is not good practice to accumulate fine coal from clean up activities into a special, segregated pile. If the stockpile area is kept tidy and clean as the coal is consumed, there is less likelihood of a large amount of ‘clean-up’ coal at the end. Clean-up coal is usually higher in fines, and if it is used along with the other coal, it rarely becomes a serious problem.

For long term use of Adaro coal, there must be provisions to apply water to the coal. The most common ways of adding water are:

- Many customers have sprays to contain dust as it is unloaded, such as in the picture above. Not all have such installations, and generally no water is needed during discharge.
- Almost all customers have provision to spray water on the coal during reclaim.
- Most customers have the possibility of spraying water on the pile to contain fugitive dust arising from the pile. Most of those that spray the coal pile do so with all coals in the coal yard. However, the necessity of spraying subbituminous coals, like Adaro, is greater than with bituminous coals.

Figure 3: Size distribution of Adaro Coal shipped in 2000.



COAL DEGRADATION

Envirocoal contains a moderately high percentage of moisture. Loss of part of this moisture from the coal on stockpile faces will cause breakdown or weathering of the surface coal particles. The rate of this breakdown will depend largely on air humidity and wind conditions.

The weathering (breakdown) will be a "skin affect" only and the bulk of the stockpile will remain unaffected.

As previously mentioned, frequent application of water as a fog spray will maintain the moisture condition of the coal on the stockpile surface and little degradation will occur.

This stockpile management practice is recommended to provide a maximum level of dust suppression and stability of the compacted surface and an optimum storage condition.

However, this may not be convenient or practical in some stockpiling situations. It is then acceptable practice to permit the outer face of the compacted stockpile to dry out with some surface degradation (breakdown) resulting and it may be necessary to water the surface occasionally for dust suppression.

USE OF WATER FOR TEMPERATURE CONTROL

The use of water for temperature control is considered to be poor practice and may actually promote heating, it is generally considered ineffective and unnecessary. Except in extraordinary situations the use of water for temperature control is not recommended and should be actively discouraged.

EFFECTS OF LONG TERM STORAGE ON COAL QUALITY

There have not been any specific studies on subbituminous coals to determine if there are any measurable changes in quality during long-term storage of the coal. There have been some studies carried out in the USA on various types of coal but none that deals specifically with subbituminous coals.

It is known from experience that all coal stockpiles will absorb moisture from rainfall and therefore have an apparent CV loss. The stockpiles will eventually drain excess moisture by natural drainage through the base of the stockpile. The coal in the stockpile will however always retain some of the moisture that has ingressed from rainfall. The level of moisture increase will have more to do with the total moisture of the coal as it was laid down in the stockpile and the saturation level of the coal, if the % total moisture of the coal is much lower than the saturation point of the coal, then the coal will retain more moisture and the apparent CV losses will be greater.

There will be some CV loss due to oxidation reactions in coal stockpiles, but this is a small amount as the oxygen entrained in the stockpile is soon used up and the oxidation reaction therefore stops. There will continue to be some oxidation at and near the surface of the stockpile as oxygen is continually present due to the coal's proximity to the atmosphere, it is estimated to be the case for the first 0.5 – 1 meter of coal in the pile. However, the CV loss of this coal from oxidation will be an insignificant amount of the total CV of the coal in the stockpile as this surface coal will be a small percentage of the total tonnage of coal in the stockpile. This effect can be minimized by compacting the surface of the stockpile thereby effectively sealing the surface.

The oxidation process described above will affect all coal stockpiles as all coal types are reactive with oxygen to some degree. Coals such as subbituminous coals are more reactive than bituminous coals and therefore the oxidation process will take place at a faster rate than for bituminous coals. The higher reactivity of subbituminous coals will cause the oxidation reaction inside the stockpile to run its course and stabilize after a few days or a week or two while the bituminous coals may take a few weeks or months to utilize all the oxygen in the pile.

The level of deterioration in coal quality for long-term stockpiles will probably be similar for subbituminous coals as for bituminous coals, however only a scientific study of the process for different types of coal would conclusively answer the question.

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B. Das and V. J. Hucka, "Control of Spontaneous Combustion of Coal Through an Analysis of its Mechanism and the Affecting Factors," **Society of Mining Engineers of AIME**, Preprint # 86-62, Presented at the SME Annual Meeting, New Orleans, LA, March, 1986.