CHEMETRON™ Fire Systems

CARDOX

CO_2 Application Bulletin

CARBON DIOXIDE FIRE SUPPRESSION —

Coal Pulverizer Inerting

The following is a quote from the January, 1988, issue of POWER Magazine :

> Electric Power Research Institute (EPRI) data reveals that pulverizer explosions occur at least once a day in USA utility power plants. Average cost per event is around $3 million. Looking at the data another way, there are five fires every four years and three explosions every 10 years at the average coal fired unit. Annual cost to the industry exceeds $1.0 billion.
>
> As many as 85% of USA coal fired units are not equipped with fire detection systems and less than 20% use some form of inerting type protection system.

Chemetron has provided CO_2 fire suppression and inerting systems for pulverizers for many years. Experience gained, along with recent changes in the code, are covered by this bulletin. Changes in inerting recommendations and developing technology have necessitated revisions in this bulletin originally written in 1988.

A coal mill (pulverizer) reduces raw coal to small particles, which can be conveyed by air directly to a boiler, kiln, etc. (direct firing), or to intermediate storage (indirect firing). There are a number of different types of mills which either grind the coal or smash it with steel balls. The drawing accompanying this bulletin shows a common type mill used in power plants. Raw coal enters at the top and drops onto the grinding table, where the rollers reduce it to fine particles. Heated air picks up the coal and conveys it up to the classifier, where the larger particles are separated and dropped back down onto the grinding table, while the lighter particles are conveyed through the coal pipes to the boilers.

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This bulletin deals primarily with coal mills in power plants that are operated under positive pressure. The mills protected in indirect firing systems that operate with a negative pressure are covered in Bulletin #0160, Coal Grinding, handling & Storage Systems.

The problem in the pulverizer can be either a fire or an internal explosion. For the purpose of this bulletin, we are going to discuss the uses of CO_2 in mills associated with steam electric generating stations.

The reference document is NFPA Standard No. 8503, Pulverized Fuel Systems. This document states:

> A fire ahead of or in the pulverizer usually causes an abnormal increase in temperature of the equipment or the mixture leaving the pulverizer. Fires are caused by feeding burning fuel from the raw fuel bin; by spontaneous combustion of an accumulation of fuel or foreign matter in the pulverizer, piping or burners; or by operating at abnormally high temperatures.
>
> A fire in any part of a pulverized fuel system shall be considered serious and dealt with promptly.

Fire Protection

Paragraph 3-5.3.2 of Standard No. 8503 outlines procedures for fighting fires. If CO_2 is used as a fire extinguishant (not just to inert), paragraph (a) or (b) below would apply. They state:

(a) If sufficient inertant flow capacity is provided (at least 50% by volume of the primary air flow of the system), inert the pulverizer air/-fuel flow, shut off the fuel feed, empty the pulverizer of fuel, shut down and isolate the pulverizer.

(b) Stop the primary air flow, trip the pulverizer and feeder, isolate the system and inert. Avoid disturbing any accumulation of dust within the pulverizing equipment. Do not open any access doors to the pulverizer until the fire is extinguished and all temperatures have returned to ambient.

If water is used, it should be introduced into the raw fuel or air tempering streams, or both. It should be introduced so as not to cause hang up or interruption of raw coal feed or to stir up any deposit of combustible material. After the fire is suppressed, the water shut off, and the pulverizer shut down, the mill is to be inerted.

The use of both water and CO_2 together for fire conditions is very common. Note: Some pulverizer manufacturers have restrictions on how water can be used.

Water spray is particularly effective when there is a large mass of coal remaining in the mill after shut down and it is burning. The mass must be cooled to achieve total extinguishment. While CO_2 will suppress burning, all cooling in a CO_2 atmosphere will be natural cooling, which could take some time. Water will, of course, accelerate the cooling of the hot coal mass.

Fire detection is possible by measuring outlet air temperatures or the amount of air temperature change.

Means for measuring carbon monoxide levels are available. There are companies offering detection systems designed for this specific application.

Since none of these means are practical to operate a CO_2 extinguishing system automatically, the CO_2 system is actuated manually through a pushbutton station. The discharge rate is calculated based on the operating conditions specified, and the length of discharge is automatically timed. Provisions are included for follow up or subsequent discharges, if they're necessary. Tie-ins to shut down equipment, as prescribed, can be included in the CO_2 system design.

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Steam as a Fire Extinguishant

In a paper presented to "Coal Technology '84" based on work done by Riley Stoker for the Electric Power Research Institute: The Relative Effectiveness of Different Agents in Dealing with Coal Pulverizer Fire and Explosion Prevention, the following concern on the use of steam for fire suppression was raised.

> The use of steam as an extinguishing agent did create a precarious situation. Using steam with a fire present developed a more reactive gas, and if detonation developed, the carbon monoxide and methane produced magnified resultant forces. In addition, steam proved to be one of the worst agents — the more steam applied, the less effective it becomes.

Inerting

The most common use for CO_2 is for inerting the mill as an explosion prevention means. The Standard for Pulverized Fuel Systems, NFPA Standard No. 8503, paragraph 3-5.2.1.1, says: A pulverizer tripped under load shall be inerted and maintained under an inert atmosphere until confirmation that no burning/smoldering fuel exists in the pulverizer, or the fuel is removed.

Note that paragraph 3-5.2.2.2 says: Due to the danger of an explosion when opening and cleaning, pulverizers shall not be cleaned manually until they and their contents have been cooled to ambient temperature.

The use of CO_2 as an inertant allows the maintenance of the inert atmosphere until the mill cools and can be opened for cleaning.

Your attention is called to the other various requirements for inerting that appear in Standard No. 8503, based on other conditions that can occur. When CO_2 is used as the inertant, the more the air movement can be stopped, the less CO_2 that will be required.

The minimum CO_2 level required for inerting is such that oxygen levels will be below 15%. Chemetron recommends 65% CO_2 (7.5% oxygen) as a design level. When calculating CO_2 flooding in coal, remember that the coal adsorbs considerable CO_2, which is thus lost and will not help reduce the oxygen concentration.

Paragraph 3-5.2.1.2 says: The inerting procedure shall be as prescribed by agreement between the pulverizer equipment manufacturer and the purchaser. They should consider fuel characteristics, pulverizer temperature, size and arrangement of the pulverizer.

We strongly recommend that designers bring Chemetron into the planning and design process so we can calculate proper CO_2 quantities and flow rates to insure that adequate systems are specified. Remember, if inerting is done under different conditions, different CO_2 rates will be needed and the CO_2 system must be designed accordingly.

Several of the pulverizer manufacturers have already identified the CO_2 flow rates required for inerting different mill sizes.

Combustion Engineering

Combustion Engineering has considered CO_2 inerting as an auxiliary to the steam system and as a stand alone system. In the auxiliary mode, the CO_2 would be required only after the unit trips. With the primary air fans off, the pressure differential across the mill is low, the air infiltration low, and the CO_2 use low. For a stand alone CO_2 system, coal pipe shutoff valves, capable of sealing against full primary fan pressure, are needed.

Tests have shown that the application of CO_2 in the above conditions will inert a mill in a matter of seconds, but if the CO_2 is shut off, it is lost quickly.

The best inerting arrangement is to rapidly fill the mill with CO_2 to a safe level. This is done with a high rate discharge to achieve 30% CO_2 (15% O_2) within the first minute after shutdown.

Then, in worst case conditions, if external cooling (water) cannot be applied, the inert condition will have to be maintained for hours while the mill cools.

There is a small unclosable opening in the bottom of the mill. CO_2 must be added to make up for that which will leak out this opening. By using heated CO_2 vapor, the loss out this opening is greatly reduced. Therefore, CO_2 vapor application is recommended. A cost effective system results.

Another advantage of this system is that a continuous flow of CO_2 vapor is much, much easier to control than intermittent discharges of CO_2 liquid which had previously been recommended.

Babcock and Wilcox

Babcock and Wilcox has published data for their MPS Mills on pulverizer inerting and fire protection. The current (1990) material is Plant Service bulletin No. PSB 16-85 and Guide Specification 1A5-GR211-29Y.

Recommended inertant quantities are shown in the Table 1 at the top of the right-hand column.

Ball Mills

Figure #2 shows a roller-type mill, while Figure #1 shows a ball-type mill in which a drum rotates, causing steel balls to crush the coal. Foster Wheeler has this type mill in their D Series. Table 2 provides information for inerting with CO_2.

The CO_2 injection points are shown at the classifiers and at the exhausters, and since methane gas can accumulate in the ducts above the mill in case of fire, CO_2 is injected there as well.

For long term inerting, an external discharge is applied through these upper nozzles, and a procedure is established to periodically roll the mill while it is inerted to facilitate cooling for fire extinguishment.

Table 1
Inerting & Clearing Media Supply Requirements

NOTE: The inerting cycle is 8 minutes duration

Mill	Volume (Cu.Ft.)	CO_2 (Pounds Per Cycle)	Mill	Volume (Cu.Ft.)	CO_2 (Pounds Per Cycle)
44K	470	312	75K	2,000	1,557
44N	470	390	75N	2,000	1,783
44G	470	468	75G	2,000	2,000
49N	610	511	89K	2,250	2,400
49G	610	611	89N	2,665	2,755
56K	750	667	89G	2,665	3,020
56N	750	744	104K	4,400	3,670
56G	750	822	104N	4,400	4,037
67K	1,500	890	104G	4,400	4,404
67N	1,500	1,112	118K	6,200	3,803
67G	1,500	1,334	118N	6,200	4,691

Table 2
CO_2 Requirements for Inerting Ball Mills

Pulverizer Series	Volume FT^3	Carbon Dioxide	
		Lbs	*Lb/Hr
D2	300	43	1,300
D3	500	72	2,200
D4	750	100	3,000
D5	950	136	4,100
D6	1,200	172	5,200
D7	1,500	215	6,500
D8	2,000	286	8,600
D9	3,100	443	13,300
D10	3,900	558	16,900

*The rates in Lb/Hr are for a 2 minute inerting duration period.

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System Arrangement

Figure #2 illustrates a pulverizer inerting system.

The CO_2 storage unit is sized with at least the amount of CO_2 recommended by the pulverizer manufacturer. [Obviously, the same CO_2 storage can be used for other fire protection and inerting requirements (particularly coal silo/ bunker inerting, see Bulletin #0040) if these are within a reasonable distance of the storage. Storage unit sizing is to be based on the total of all hazard requirements where simultaneous use is considered.]

For initial inerting, liquid CO_2 is piped through the master valve to the selector (directional valve) near the mill. The CO_2 is introduced into the mill through the hot air inlet, plus perhaps, several other injection points. The manufacturer will have provided a pipe connection(s) (usually at this point) of at least 1" per NFPA #8503, but more like 2" to 3".

When CO_2 is required, a remote pushbutton is operated and liquid CO_2 is directed through the master valve, discharge piping, and selector valve to the nozzle(s) at the mill.

The duration of the discharge is set on the timing panel provided. If follow up CO_2 vapor discharge is needed, similar controls are employed to introduce liquid CO_2 to the vaporizer and then direct CO_2 vapor to the proper mill.

Safety Aspects

In addition to the normal safeguards necessary when dealing with CO_2 systems — see NFPA Standard No. 12, Carbon Dioxide Extinguishing Systems — it is required that procedures be developed to positively prevent inadvertent introduction of the inerting media when personnel are present. Chemetron can be consulted as to how best to accomplish this.

Reliability

There is material in the literature questioning the reliability of all gaseous agent inerting. In order to maximize the effectiveness of the inerting system, one should understand:

1. "Homemade" systems are potential problems. Those experienced in CO_2 system design can calculate proper agent quantities and application rates, and do the flow calculations that ensure the required rate is achieved. It is mandatory that this be done.

2. Systems should be given full discharge tests to check that design concentrations are obtained. Various expected conditions should be included in the test procedure and multiple tests run, if necessary.

3. Operating conditions change and there may not be one fixed agent discharge rate that will handle all desired conditions. The system can be arranged to handle two or more application rates; but only if the operating procedures identify the need for same and it is designed into the system from the start.

Paragraph 3-5.3.4 of NFPA Standard #8503 states: In the event of fires detected in components such as cyclones, dust collectors, pulverized fuel bins for the pulverized fuel systems other than direct fired systems, the affected components shall be isolated and inerted.

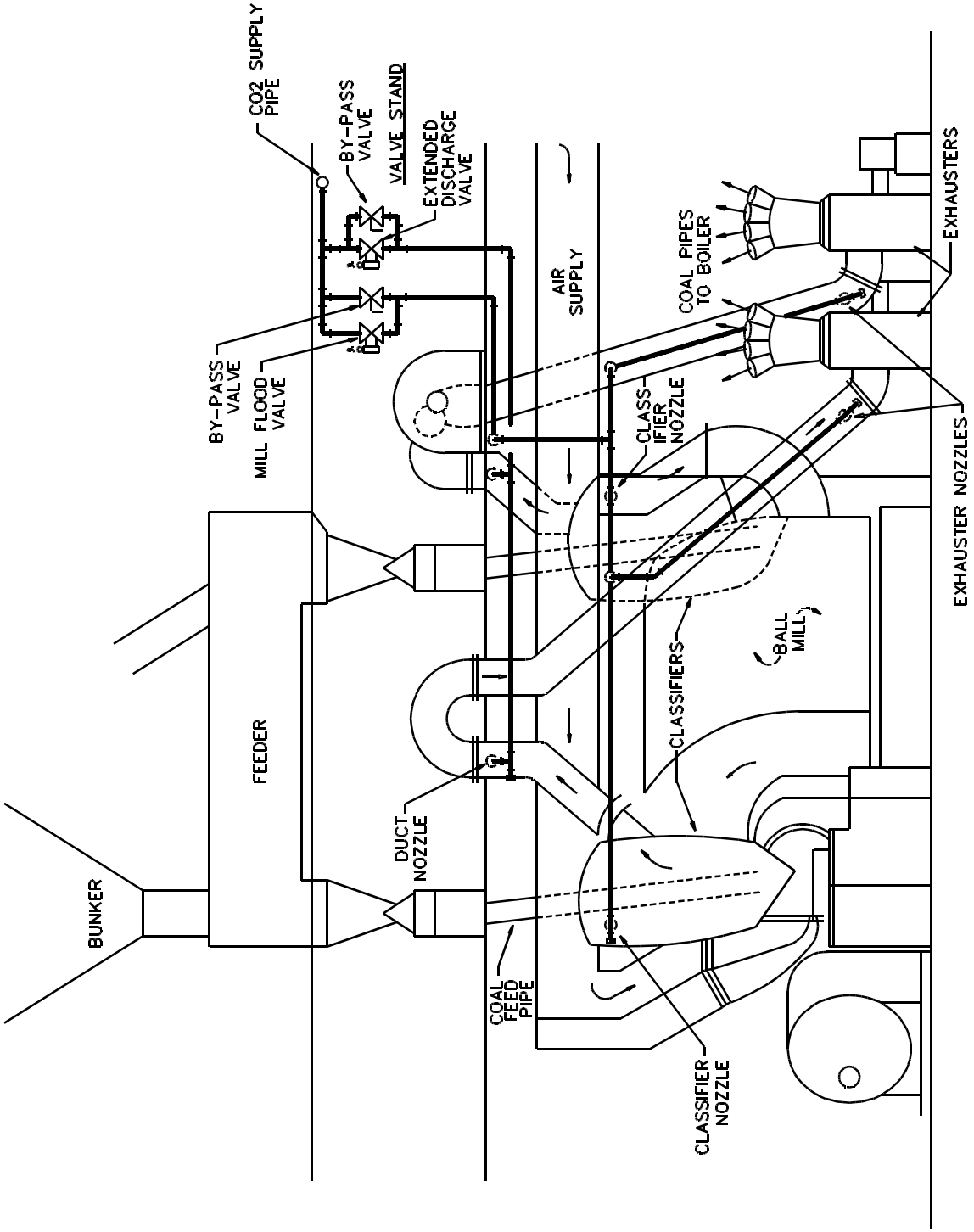

Figure #1 - Low Pressure CO_2 Coal Pulverizer Inerting/Fire Protection for a Ball Mill

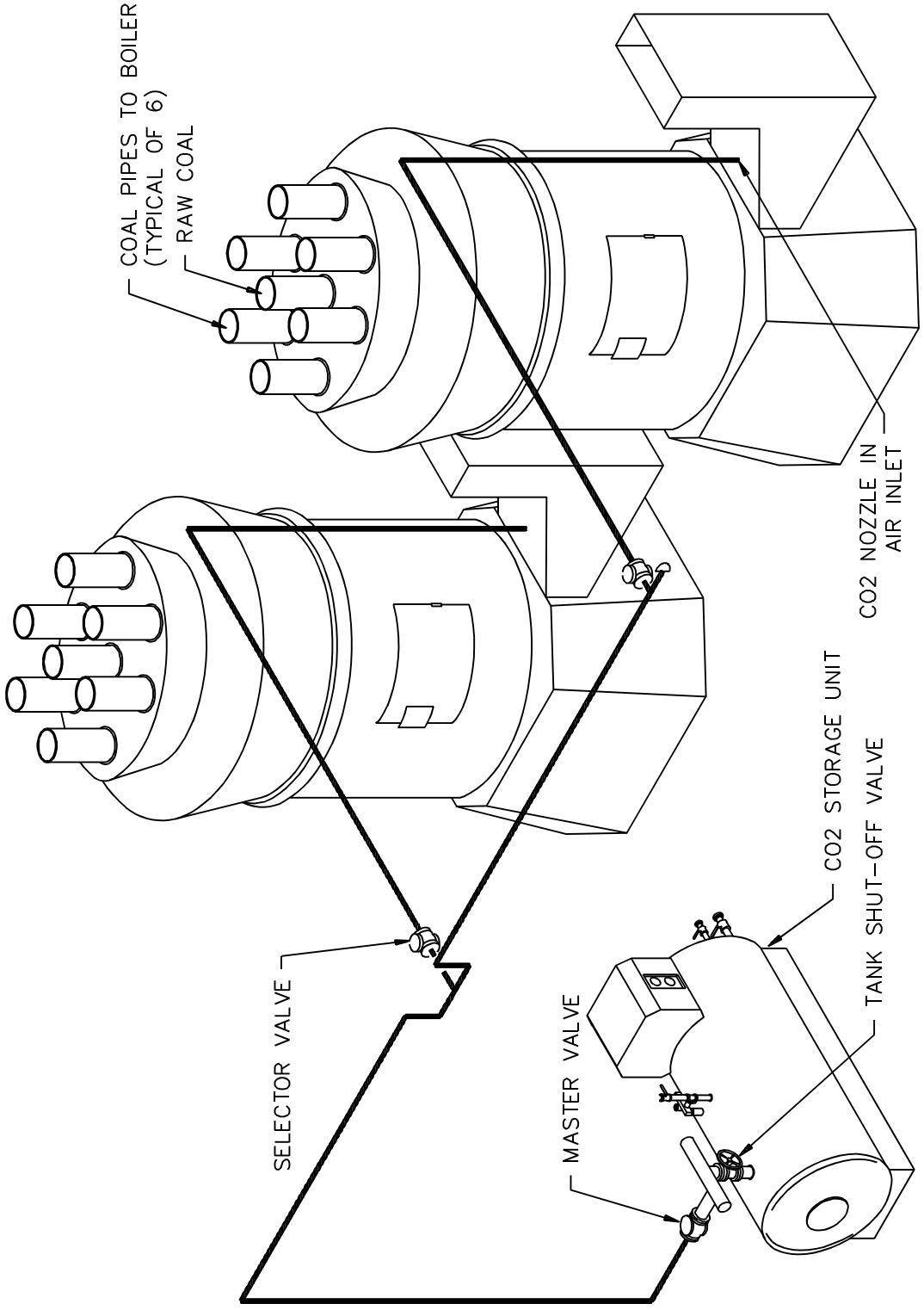

Figure #2
Low Pressure CO_2 Coal Pulverizer
Inerting/Fire Protection for a Roller Type Mill