CHAPTER C14
ASH HANDLING PIPING SYSTEMS

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INTRODUCTION TO ASH HANDLING SYSTEMS

Automatic ash handling systems developed as the size of coal-fired boilers increased beyond the sizes permitting manual handling of the quantity of ash. To remove ash from the boiler vicinity to a remote disposal location, conveying systems utilizing pipe offered the greatest flexibility for routing. The ash falling to the bottom of the boiler furnace for removal is known as *bottom ash*. The particulate carried in the flue gas stream to economizer, air heater, or other downstream hoppers is called *fly ash*. As environmental standards have evolved, more complete removal of particulate from the flue gas stream has necessitated increasing emphasis on fly ash collection and conveying systems. In ash-handling systems, the pipe utilized for conveying ash is termed the *conveyor* or *conveyor line*.

TYPES OF SYSTEMS

Ash is conveyed manually, mechanically, pneumatically, and hydraulically. Only pneumatic and hydraulic systems utilize pipe and are discussed here. Pneumatic systems may be positive or negative pressure, as described later. Hydraulic systems are also known as sluice systems and may be used independently or in combination with pneumatic systems. Mechanical systems typically include submerged or dry-flight conveyors, screw conveyors, or belt conveyors.

Negative-Pressure Dilute-Phase

In negative-pressure dilute-phase systems (vacuum systems), a vacuum pump (mechanical exhauster) or steam or water exhauster is used to create a vacuum, inducing air to flow through the conveyor line. Ash is admitted to the moving airstream and conveyed to the disposal point (Fig. C14.1). In systems using water exhausters, the ash is sometimes mixed with the water and sluiced to the disposal location. The pressures in these systems range from −16 in Hg (40 cm Hg) to atmospheric at the air intake point.

A vacuum (negative pressure) system is a popular choice for conveying fly ash. Several inherent features make this an advantageous design: simple ash intake valves; conveyor feed sensing that provides positive ash feed control; low headroom requirements; and clean operation, because any joint leakage will be *into* the conveyor. As the number of collection points in the system increases, the cost advantage of a vacuum system increases when compared with a pressure system. Conveying distance and capacity requirements sometimes limit the use of a vacuum system; the alternative is generally a pressure system, or a combination vacuum/pressure system.

Advantages of negative-pressure (vacuum) pneumatic systems include their inherent cleanliness, single valve requirement at the ash intake, and low headroom requirement. Leaks in a vacuum system are inward. Conveying capacities are generally limited to 50 tons per hour (55 Metric Ton per hour) and conveying distances less than 1000 ft (305 m).

All joints, fittings, and expansion joints are gasketed with suitable material for the temperature and service. Since pneumatic systems are subject to cyclical heating and cooling with temperature excursions as great as 1000°F (538°C), expansion

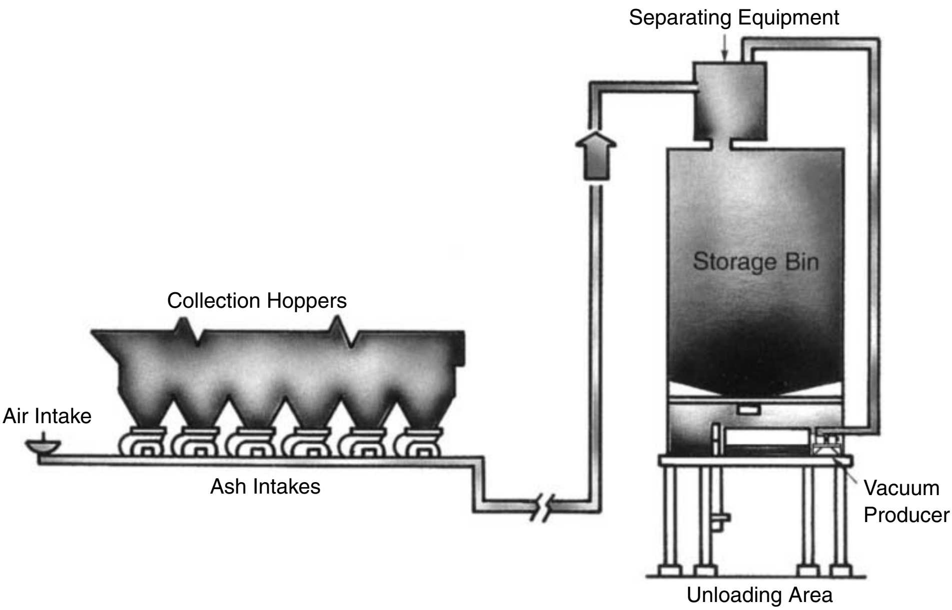


FIGURE C14.1 Diagram of vacuum system.

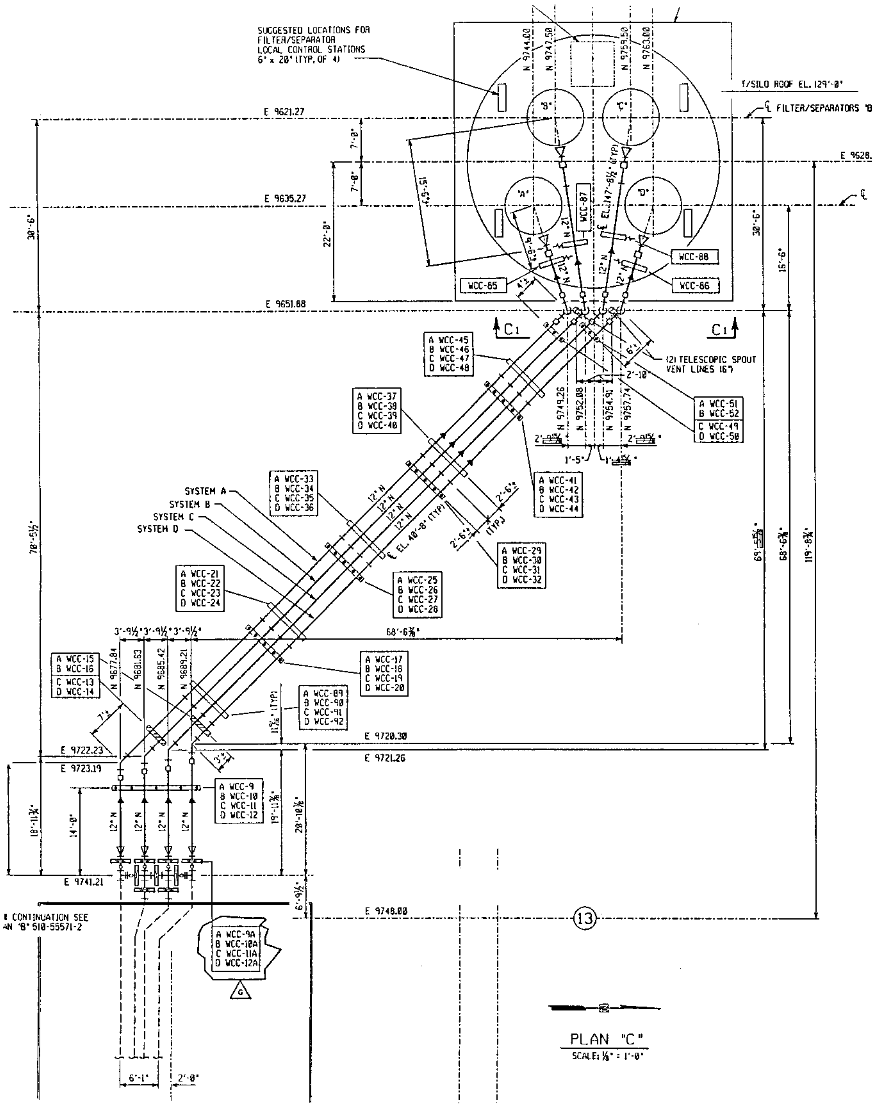


FIGURE C14.2 Single line drawing of crossover arrangement.

joints are generally required in every straight run of pipe. Branch-line and crossover gates (Fig. C14.2) are generally automatic and are either knife gates designed for abrasive ash service or totally enclosed rotary slide gates. In both cases, the inside diameter of the pipe should be maintained through the valve with minimal interference which could cause turbulence and wear. The preferred method of metering ash is by opening and closing valves completely, as often as required. Valve position is not used to regulate the flow of ash.

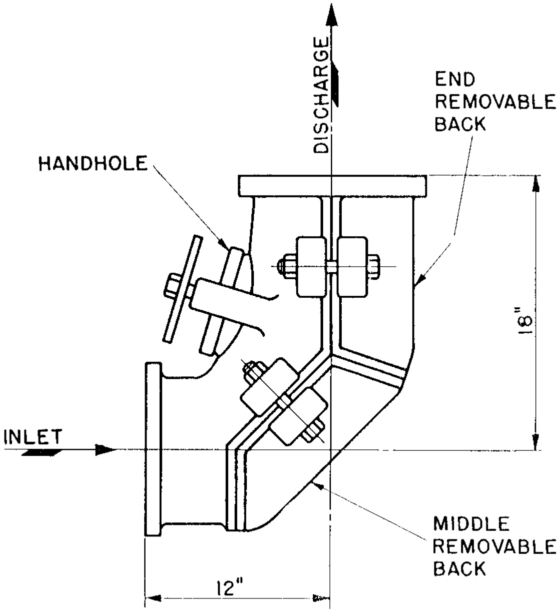


FIGURE C14.3 Drawing of replaceable wearback.

Pipe in vacuum systems is generally abrasion-resistant cast iron or carbon steel, particularly for long, straight systems. Fittings are chromium cast iron with cast in or removable, replaceable, thick-wearback sections (Fig. C14.3). Hand-hole access covers are often provided on the inside radius of elbows or near them to allow removal of foreign objects or blockages. Chromium cast-iron pipe is usually used for a short distance after changes in direction to better protect against the abrasion from turbulence downstream of fittings.

In any pneumatic system, velocity must be carefully controlled while maintaining design capacity, and so the selection of pipe size is of great importance. Transitions to larger pipe must be located to keep ash velocities above the pickup velocity and below the velocity at which severe sandblasting abrasion results. Velocity increases as the ash/air mixture moves downstream and pressure and friction losses decrease, and the air volume increases due to heating. The calculations for the pipe size and location of transitions are partly empirical and considered proprietary by the manufacturers of conveying systems. Generally, the minimum velocity in fly ash conveyor lines should be 3800 ft/min (19 m/s), as extensive testing of a wide range of ashes has shown this to be the usual minimum pickup velocity. In the event that a system is shut down in emergency and ash falls out in the conveyor line, this minimum velocity ensures it will be picked up and conveyed when the system is restarted. Bed ash from fluidized-bed combustors varies considerably, but typically requires at least 4500 ft/min (23 m/s). Bottom ash, if pneumatically conveyed, may require 5000 ft/min (25.4 m/s) or more. Maximum velocities should be minimized, as previously explained, but should not exceed 6500 ft/min (33 m/s) to avoid elbow impact damage and severe erosion of pipe material.

Industrial boiler houses with stoker-fired boilers, many of which are extant, usually had fly ash systems that were 4 or 6 in (100 mm or 150 mm) in diameter and bottom ash systems that were 8 in in diameter. A small utility's pulverized coal boiler with a silo about 400 ft (122 m) from the first row of the precipitator and a conveying capacity of 30 tons per hour (33 Metric Ton per hour) might have a combination 8-in (200-mm), 9-in (225-mm), and 10-in (250-mm) system. A cogeneration plant burning fuel that is 50 percent ash or more might have a 50 tons/h (55 Mt/h) system, 400 ft (122 m) long with 10-in (250 mm) 11 (275), and 12-in (300) pipe. A utility power plant with a remotely located silo might have a vacuum collection system 8 in (200 mm) and 9 in (225 mm) in diameter and a pressure system 2500 ft (762 m) long of 12-in (300-mm) and 14-in (350-mm) pipe.

Positive-Pressure Dilute-Phase

In positive-pressure dilute-phase ash handling-systems, a positive displacement blower is used to generate the airflow through the pipeline (Fig. C14.4). Ash is admitted into the conveyor through air lock devices, which bring the ash up to the pressure of the conveyor. As a general guideline, pressure systems are used when required capacities exceed 50 tons per hour (55 Metric Ton per hour) or conveying lengths exceed 1000 ft (305 m). Pressures are typically less than 35 psig (240 kPa) at the blower discharge.

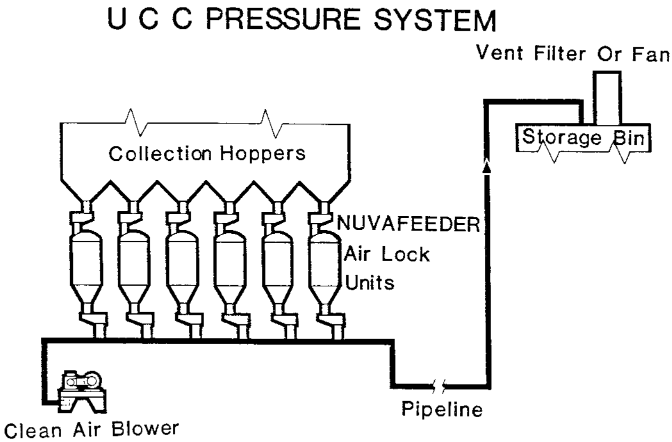


FIGURE C14.4 Single line drawing of pressure system.

Construction of the conveyor line is similar to that in vacuum systems, except that integral wearback fittings are used to minimize the amount of potential leak sites (gasketed area) (Fig. C14.5). Again, velocities are key to conveying capacity and minimizing wear, and the determination of pipe size and location of size transitions are calculated as in vacuum systems.

Positive-Pressure Dense-Phase

Dense-phase pneumatic systems use compressed air to push "slugs" of ash along the conveyor line. In general, pressures are higher than those in dilute phase, but

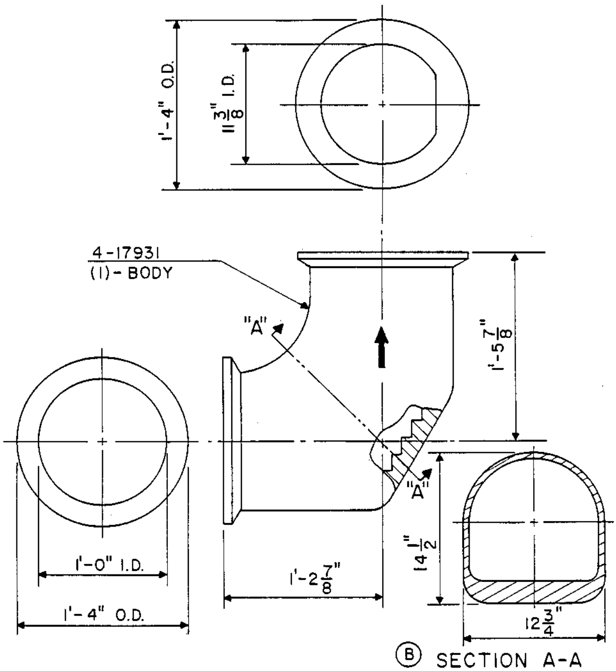


FIGURE C14.5 Drawing of integral wearback.

velocities are much lower, at least near the ash pickup points. Typically, ash is collected in a pressure vessel, which is sealed and pressurized to commence conveying. A discharge valve is opened, and the slug of ash travels along the conveyor line. Often, additional air must be admitted to complete conveying to the discharge location. Dense-phase systems typically are used for shorter and lower-capacity systems than dilute-phase. They work best when ash is of uniform consistency.

Typical dense-phase systems use NPS 2 to 8 (DN 50 to 200) pipe, usually carbon steel although cast iron may be used for the NPS 4 (DN 100) and larger systems. Pressures at the pressure vessel may reach 60 psig (414 kPa). For carbon-steel pipe, fittings and pipe may be welded, with periodic bolted flanges for access to pluggages. Fittings and joints for cast-iron pipe are described later.

Hydraulic Systems

Hydraulic (sluice) systems (Fig. C14.6) use quite a variety of pipe materials depending on the length of the run and the longevity required for the pipe. Steel or cast iron is normally a minimum with chromium cast-iron fittings and straight sections after changes in direction, when conveying fly ash. Bottom ash may require steel or cast iron, but basalt-lined steel, ceramic-lined steel, and fiberglass-reinforced epoxy with ceramic are all also used for sluice pipe. Basalt is a castable igneous rock with relatively low melting temperature and high abrasion resistance.

Sluice pipe requires design consideration for freeze protection and may be

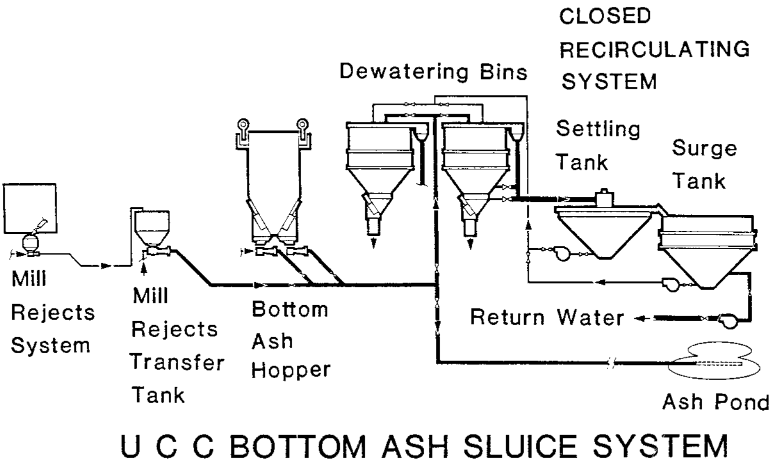


FIGURE C14.6 Single line drawing of sluice system.

pressurized to discharge or gravity flow to discharge. It is often laid directly on the ground for long runs to remote locations. Significant life extension can be achieved with regular rotation of sluice pipe, as most abrasion occurs on the bottom.

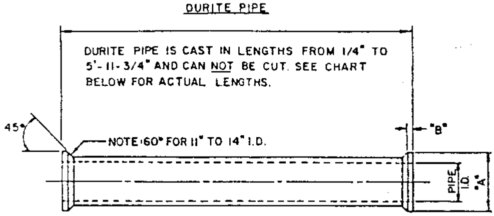
CODES AND STANDARDS

There are no specific codes and standards that apply to ash conveyor piping. Most of the major manufacturers of ash-handling systems have their own proprietary materials for ash conveyors with pipe sizes and materials, fittings, expansion joints, and specialty devices which are not readily interchangeable from one manufacturer to another. American manufacturers each provide conveyor pipe in nominal 1-in (25-mm) increments (inside diameter) from 4-in (100-mm) to 12-in (300-mm), and occasionally larger sizes. Dimensions are nonstandard, and Tables C14.1 and C14.2

TABLE C14.1 Nuvaloy Pipe Dimensional Data

Nominal pipe size, in	Outside diameter, in	Inside diameter, in	Wall thickness, in	Weight, lb/ft
4	5.00	4.04	0.48	21.3
5	6.00	5.00	0.50	27
6	7.10	6.00	0.55	35.3
7	8.375	7.001	0.687	51.8
8	9.05	7.75	0.65	53.5
9	10.33	9.01	0.66	63.0
10	11.10	9.96	0.57	58.8
11	12.20	11.0	0.60	66.2
12	13.20	11.96	0.62	76.5
14	15.30	13.80	0.75	107

TABLE C14.2 Dimensions of Durite (UCC) Pipe



Pipe size (Nom.)	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"
Pipe I.D.	4"	5"	6"	7"	7-3/4"	9"	10"	11"	12"	13"	14"
"A"	6-1/2"	7-5/8"	8-3/4"	10-7/8"	10-7/8"	12"	13-5/16"	16"	16"	17-5/8"	17-5/8"
"B"	3/8"	3/8"	3/8"	3/8"	3/8"	1/2"	3/8"	1/2"	1/2"	1/2"	1/2"
Outside diameter	5.50"	6.50"	7.75"	8.87"	9.62"	11.00"	11.87"	12.875"	14.00"	15.75"	15.75"
wt./ft. empty	45#	50#	70#	90#	100#	120#	130#	130#	155#	218#	152#
w/ash or slurry	54#	64#	90#	117#	133#	164#	185#	200#	234#	300#	259#

Durite Pipe Lengths Show part no. only in B/M

Details on Drawing No.		2-174104-#	2-174105-#	2-174106-#	2-174107-#	2-174108-#	2-174109-#	3-170285-#	2-174111-#	3-170284-#	2-174112-#	2-174113-#
Part Number		2-174104-#	2-174105-#	2-174106-#	2-174107-#	2-174108-#	2-174109-#	3-170285-#	2-174111-#	3-170284-#	2-174112-#	2-174113-#
Pipe size	-NO#	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"
1/2"	-05	←					1/4"					→
1"	-10	←					3/4"					→
1-1/2"	-15	←					1-1/4"					→
2"	-20	←					1-3/4"					→
3"	-30	←					2-3/4"					→
4"	-40	←					3-3/4"	3-1/2"	3-3/4"	3-1/2"	3-1/2"	3-1/2"
5"	-50	←					4-3/4"					→
6"	-60	←					5-3/4"					→
7"	-70	←					6-3/4"					→
8"	-80	←					7-3/4"					→
9"	-90	←					8-3/4"					→
10"	-100	←					9-3/4"					→
11"	-110	←					10-3/4"					→
1'-0"	-120	←					11-3/4"					→
1'-6"	-180	←					1'-5-3/4"					→
2'-0"	-240	←					1'-11-3/4"					→
3'-0"	-360	←					2'-11-3/4"	3'-0"	2'-11-3/4"	3'-0"	3'-0"	3'-0"
4'-0"	-480	←					3'-11-3/4"	4'-0"	3'-11-3/4"	4'-0"	4'-0"	4'-0"
5'-0"	-600	←					4'-11-3/4"					→
6'-0"	-720	X	←				5'-11-3/4"					→
FRM LGT.	-NO#	Actual Pipe Length										

CONN S w/fill S See DWG. No. 1700-156

list conveyor pipe sizes commonly used by one major manufacturer for centrifugally cast and sand-cast pipe, respectively. Lengths are typically 18-ft (5.4-m) random length for centrifugally cast pipe, with shorter 1-ft (0.3-m) incremental lengths up to 12 ft (3.6 m) for sand-cast pipe. When capacity, economy, or system configuration permits, the pipe used may be a standard size and material, such as the use of NPS 10 (DN 250), schedule 80, ASTM A36 carbon-steel pipe for long, straight runs of pneumatic conveyor line.

The iron and chromium-iron alloys used for cast conveyor line and fittings are proprietary alloys specified by their similarity to ASTM alloy designations.

DESIGN CRITERIA

The design criteria for ash conveyor piping are based on several fundamental considerations. Ash is extremely abrasive, and consequently, ash conveyor piping is expected to wear. Whether conveying pneumatically or hydraulically, the conveying fluid must be induced into motion and imparted with sufficient energy to convey the required quantity of ash for the required distance, in the required time. Wear is a function of velocity and material characteristics of both the pipe and ash. Accordingly, conveyor routing and sizing are key design criteria in any ash handling system.

SYSTEM-SPECIFIC CONSIDERATIONS

The following considerations must be clearly defined to design a specific ash handling system.

Routing

The arrangement of the conveyor from the ash pickup locations to the disposal point should be as direct and simple as possible. Every elbow adds significant pressure drop, which impacts the sizing of the prime mover, whether pump, mechanical exhauster, or blower. Elbows are high-wear points, as the ash impacts the fitting because of momentum and vorticity effects. Elbows, like any fitting, are also potential leak points. While leaking pressure in pneumatic and hydraulic systems will simply cause housekeeping problems, vacuum pneumatic systems are particularly sensitive to leaks which bleed air into the conveyor and dilute the airflow, causing lower velocity and its effects: reduced conveying capacity, ash fallout, and line pluggage.

Routing in the vicinity of the ash pickup points should be as straight as possible to allow the ash time to reach conveying velocity before encountering changes in direction. This will minimize fallout and pluggage problems as well.

Another consideration for routing is the maintainability of the conveyor line system. Valves, expansion joints, and fittings in particular are maintenance areas and will require regular access by personnel. Components are heavy and usually will require rigging lift devices to support steel for replacement. Adequate clearance for removal of wearbacks and fittings should also be provided.

Required Conveying Capacity from Each Pickup Point

The required ash-conveying capacity is fundamental to the conveyor system design. The boiler or furnace manufacturer determines the total ash production for the design fuels and the split of fly ash and bottom ash expected.

Bottom ash and fly ash are usually conveyed through separate systems, with bottom ash handled hydraulically and fly ash pneumatically. Bottom ash may include slag falls and clinkers, but in general comprises larger particles than fly ash and falls to the bottom of the boiler because of its size and density. Water-impounded hoppers are traditionally employed for utility-size boilers to collect the bottom ash and quench and fracture it to a conveyable size. Additional sizing is usually accomplished with a crusher or grinder before admitting the bottom ash into a conveyor line. The ash typically shatters on contact with water at 140°F (60°C) or less, but crushers are used to make sure particles larger than about 20 percent of the inside diameter of the conveying pipe are reduced in size prior to conveying.

Industrial-size boilers, stoker-fired boilers, and, where environmental factors dictate, utility boilers may use dry pneumatic conveying for bottom ash. Sizing is critical in these systems as the ash is hot and may still be burning, and clinkers and large particles are common. Small boilers often require manual raking of the ash from the hopper through sizing grids, into the vacuum pneumatic system intake. Oversized chunks are forced through the grid, breaking them to conveyable size, manually transported to an intake with a crusher, or disposed of manually. Where water is scarce or treatment is expensive, economics may dictate a dry bottom ash system for a utility-size boiler. Manual raking and handling of large quantities of bottom ash are labor-intensive and dangerous, so automatic dry systems may be warranted. The crushers in these systems may be exposed to burning materials, and heat-resistant alloys and air cooling may be required to reduce the particles to conveyable size. The heat of the ash may be sufficient to deleteriously affect the heat treatment of conventional abrasion-resistant conveyor pipe and fittings, requiring the use of ceramics or unconventional piping systems.

Boiler manufacturers also specify the rates of fly ash collection in the economizer hoppers and air heater hoppers. Precipitator, baghouse, or scrubber suppliers similarly know the collection efficiencies of their equipment and provide the collection rate information, even broken down by percentage of ash collected in each row of hoppers. Most of the fly ash will be collected in the baghouse or precipitator, the device designed for just that purpose. Locating the fly ash silo, the usual disposal point, as close to the precipitator or baghouse as possible minimizes the size of the blowers or exhausters required to convey the ash, and similarly minimizes support steel (conveyor diameter), power consumption (pressure drop), and maintenance (number of fittings).

Ash handling system capacities are usually specified as an average-capacity, maximum conveying time per shift to convey all the ash produced or as a minimum average conveying rate. Here are two examples:

- In 2 h, convey all the fly ash produced in an 8-h shift. The collection rates for economizer, air heater, and baghouse hoppers are provided.
- Provide a 40 tons/h (44 Meteric t/h) vacuum pneumatic conveying system.

Since each collection point is a different distance from the silo with different numbers of fittings and losses, the instantaneous capacity from each hopper will necessarily be different. The loading in each row of hoppers also varies considerably. The first row of a modern precipitator may collect as much as 90 percent of the fly ash collected by the entire precipitator. Specifying the average conveying capacity or minimum conveying time per shift allows the ash handling manufacturer to optimize the system design for the most efficient operation and power consumption. Guarantees should be based on this average capacity, which can be field-verified through capacity tests. If a minimum conveying capacity is specified, the ash handling supplier will design the pneumatic system based on the worst collection point in the system, usually the farthest hopper from the silo, allowing for pressure drop or the farthest hopper in the most heavily loaded precipitator row (first row). This will cause the average conveying capacity to be much greater than intended and the total conveying time to be much less.

Ash and Ambient Temperatures and Pressure

The temperature of ash when it enters the pneumatic conveying system has a significant impact on the pipe size and material selected, particularly in vacuum systems. Pneumatic designs are based on mass ratios of ash to air for conveying. The prime movers that drive the system are volumetric, usually positive displacement blowers or vacuum exhausters. Since a vacuum exhauster moves a constant volume of air per time, measured at the inlet, heating of the air by introducing hot fly ash causes the airstream to expand, lowering the inlet mass and hence the conveying velocity. This is an important design consideration when the ash may be entering the conveyor line at 1000°F (556°C) higher than ambient. Fly ash can be as hot as 700°F (371°C) in a hot-side precipitator or economizer hopper. Bed ash—the bottom ash produced by a fluidized-bed combustor—may be 750°F (400°C) at the outlet of the cooling screws, or exceed 1000°F (538°C) if discharged directly to the conveyor. In these cases, the prime mover may be sized to pull air in sufficient quantity to cool the ash to adequately low temperature to avoid damage to collection equipment on the silo. On these hot systems, the conveyor pipe becomes an important cooling factor, and personnel protection is usually provided in the form of offset screening rather than insulating the conveyor line. As fly ash systems do not run continuously, thermal cycling of the pipe is also a consideration, and expansion joints are provided generally in every straight run of pipe.

Ambient temperature and pressure play a related role in system design. Arctic or tropical ambient temperatures affect system sizing in a lesser but identical way, and plant elevation and corresponding atmospheric pressure affect the mass of air in a given volume and must be considered.

The manufacturer of each fly ash collection device must identify the hopper movements expected from the cold to hot positions. The ash handling manufacturer will then select expansion joints and will design sufficient lateral movement in the conveyor lines to allow for these movements.

Fuel and Fuel Analysis

Different fuels produce ash with different characteristics which must be considered in conveyor system design, particularly in material selection. If bituminous coal ash from a pulverized coal boiler were considered a baseline for abrasivity, less abrasive ashes might include petroleum coke fly ash, wood fly ash, dry scrubber ash, municipal sludge fly ash, and oil soot. More abrasive ashes would include bottom ash from wood-fired units, anthracite ash, bagasse (sugar cane waste) ash, gob and culm ash, rice hull ash, and slag from cyclone-fired units. The comparison is general and not strict, as each fuel type may vary considerably in the constituents that produce abrasivity. Silicon is a common element to each of the highly abrasive ashes. Better than fuel analysis, if there has been a test burn or an ash analysis can be provided, this is obviously preferred because it eliminates the uncertainties about characteristics that will be imparted in the ash from the furnace. If samples of the ash are available, such as when building a duplicate unit, the major ash handling manufacturers have the ability to do their own testing to accurately determine the minimum velocity needed for ash pickup and to optimally size the system.

Clean Air/Water Piping

Clean air pipe is used in vacuum systems between the ash separating equipment and vacuum producer; in pressure systems, between the blower and first ash inlet into the conveyor; in dense-phase systems, to feed the pressure transport vessel; and in hydraulic systems, upstream of the ash inlet.

For vacuum applications, schedule 10 spiral weld carbon-steel pipe is typically used. For other clean air or water piping, schedule 40 or 80 carbon steel as indicated by pressure conditions is used.

PIPING COMPONENTS AND MATERIALS FOR PIPE, FITTINGS, AND JOINTS

Because ash handling-systems are standardized only within the design of each major manufacturer, there are no national or international component or material standard specifications. Individual suppliers may follow ASTM specifications for the alloys used in the manufacturing of the ash piping components, but even here, the specifications for pipe typically resemble ASTM specifications but do not fall neatly within their recipe ranges.

PIPE

Typically, heavy wall gray cast-iron pipe, centrifugally cast, is utilized on long, straight runs for pneumatic systems. Sold under such trade names as Nuvaloy (UCC), Ashcolite (A-S-H), and Birchaloy (Beaumont Birch), this pipe is usually plain-end and supplied in 18-ft (5.4-m) random lengths. It can be supplied for field cutting or in factory-cut spool lengths. Variations include longer lengths or mechanical (bell-and-spigot) joints primarily for sluice lines.

Also common in pneumatic fly ash conveying is the use of carbon-steel pipe, usually schedule 80. Since long, straight runs properly sized for velocity convey the ash primarily in the center of the pipe, there is little wear. A section of cast pipe approximately 10 pipe diameters long is always provided after a change in direction, as the turbulence after the fitting causes high abrasion.

Chromium cast-iron alloys with trade names such as Durite (UCC) and Ashcolite A or B (A-S-H) are also used for pipe. Since this pipe is not centrifugally cast, it is provided in shorter sections as long as 12 ft (3.6 m). Older pneumatic systems used this pipe for negative-pressure bottom ash conveying, which requires higher velocities and is significantly more abrasive than fly ash; and some of these systems are still in service, though this is no longer the practice.

Basalt-lined steel pipe is often used for bottom ash sluice systems where long life is demanded. Basalt is an igneous rock mined commercially in Europe and cast into annular sections assembled into carbon-steel shells.

Other specialty pipes and fittings are used on occasion for special applications or experimentation and are listed in Table C14.3. Some typical system descriptions

TABLE C14.3 Special Pipe Materials and Ash-Handling Applications

Type of pipe	Fly ash	Bottom ash	Wet	Dry
Fiberglass-reinforced epoxy	X		X	
Ceramic tile lined		X	X	
Ceramic bead impregnated		X	X	
Extruded fiberglass	X		X	
Rubber-lined steel	X	X	X	
Ceramic-lined steel		X	X	
Stainless steel	X	X	X	X
AZS-lined steel	X	X	X	X
Induction-hardened steel	X			X

TABLE C14.4 Typical Pneumatic Fly Ash Systems

Boiler size	Coal type	System type	Conveying capacity	Conveying distance	Pipe size
90 MW	Eastern bituminous	Vacuum	14 tons/h (13 Mt/h)	400 ft (122 m)	8 in (200 mm)
200 MW	Eastern bituminous	Vacuum	20 tons/h (18 Mt/h)	500 ft (152 m)	6 in (150 mm)
320 MW	Eastern bituminous	Vacuum	50 tons/h (45 Mt/h)	550 ft (168 m)	7, 8, 9 in (175, 200, 225 mm)
475 MW	Eastern bituminous	Pressure	35 tons/h (32 Mt/h)	400 ft (152 m)	10 in (250 mm)
630 MW	Eastern bituminous	Vacuum	39 tons/h (35 Mt/h)	600 ft (183 m)	9, 10 in (225, 250 mm)

are referenced by boiler size, coal type, conveying capacity, conveying distance, and pipe size in Table C14.4.

FITTINGS

Fittings are typically made of chromium cast iron. These sand-cast components are heat-treated to hardnesses of 320 to 600 BHN. A complete range of elbows, tees, laterals, reducers, wedges, and special fittings are manufactured to allow for any conceivable piping geometry. Many fittings are available with replaceable wear-backs, which are of thicker section than the rest of the fitting and can be replaced repeatedly before the entire fitting wears out. Symmetric (rotatable) and two-piece wearbacks allow extension of the life of the wearback itself by permitting replacement of just the highest-wear area of the fitting. Replaceable wearback fittings have a considerable gasket area with leakage potential and should only be used on negative-pressure conveying systems. Representative tables of fittings available from a major supplier are provided for reference (Figs. C14.7 through C14.10).

VALVES

There are a wide variety of valve types used in ash handling piping applications. Typical valve applications in negative-pressure, dry ash handling include fly ash hopper isolation for intake maintenance, fly ash intake, branch-line air intake, branch-line isolation, vacuum exhauster isolation, vacuum breaking, equalizing, and vacuum relief applications. Positive-pressure systems include regulators, dome, and pressure relief valves as well. Sluice systems include high-pressure water supply, sluice line isolation, drain, and decant valves. Since most valving in ash-conveying systems is pneumatically operated, conventional solenoid valves are common with local test pushbuttons preferred. Descriptions of commonly used specialty valves follow.

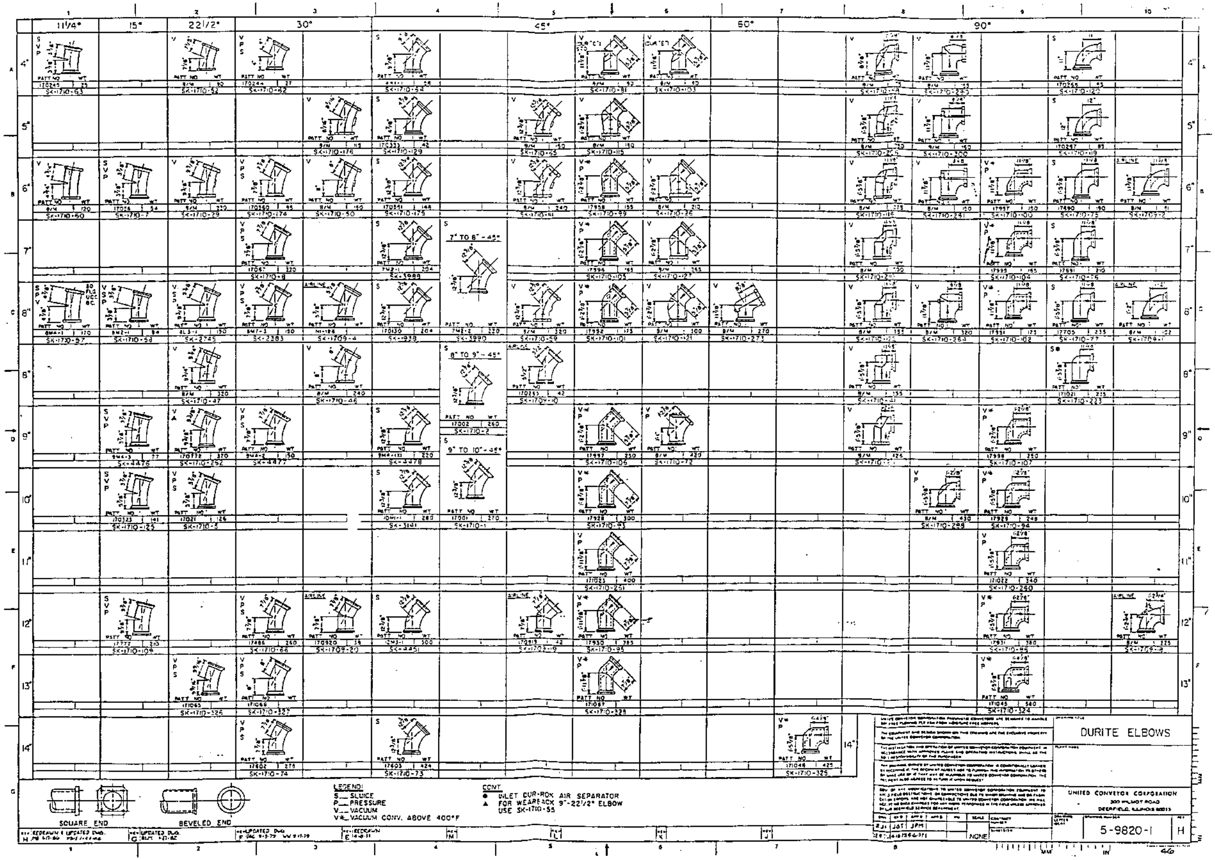


FIGURE C14.7 Durite (UCC) fitting selection drawing, 1 of 4.

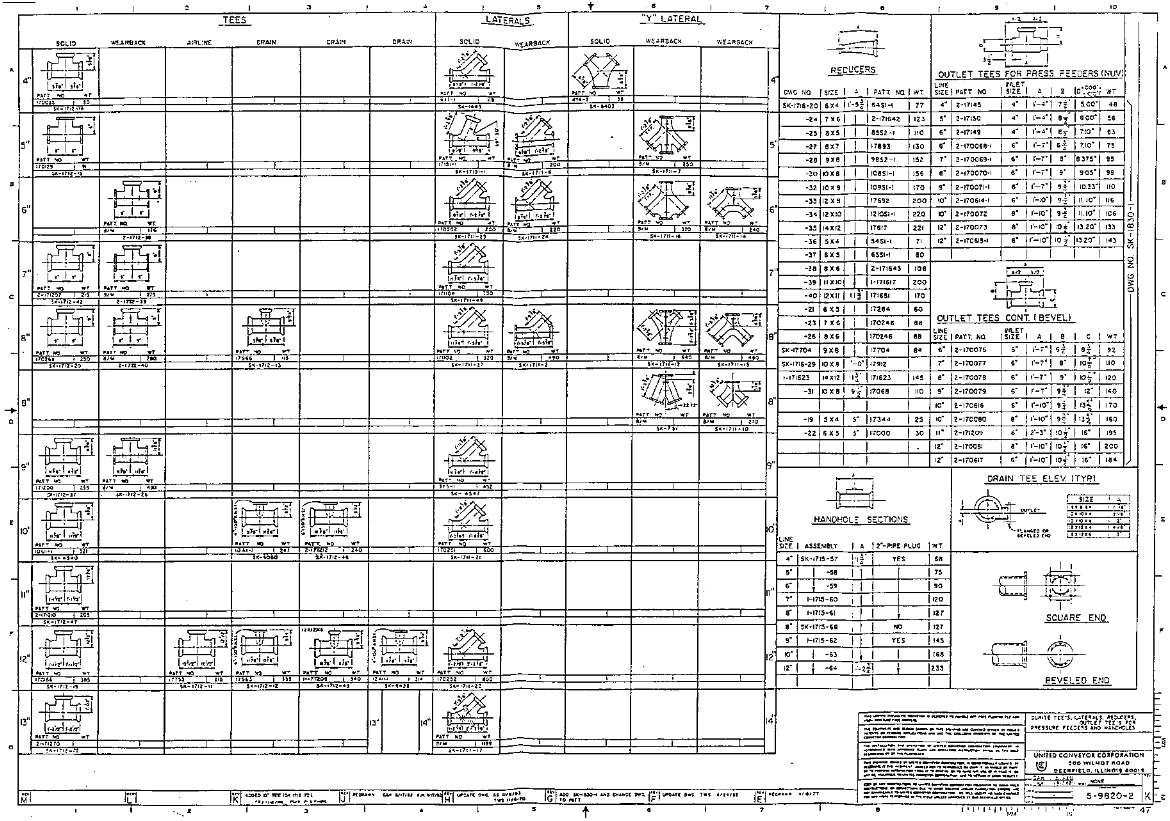
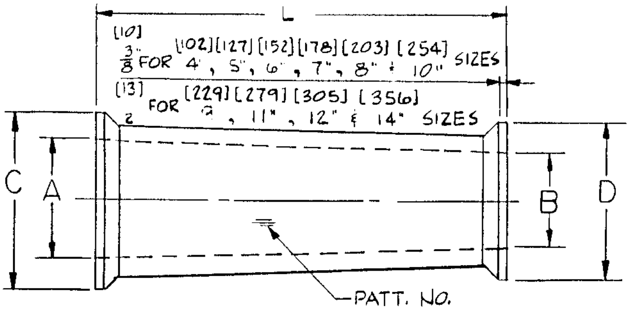


FIGURE C14.8 Durite (UCC) fitting selection drawing, 2 of 4.



PART No.	REV.	NOM. SIZE	PATT.	DWG. NO.	A	B	C	D	L	WT.
SK-1716-19	A	[127×102] 5"×4"		2-17344	[127] 5"	[102] 4"	[194] 7 5/8"	[165] 6 1/2"	[127] 5"	[11 Kg] 25 Lbs.
SK-1716-20	J	[152×102] 6"×4"	6451-1	3S-815	[152] 6"	[102] 4"	[221] 8 3/4"	[165] 6 1/2"	[451] 17 3/4"	[35 Kg] 77 Lbs.
SK-1716-21	J	[152×127] 6"×5"		SK-17284	[127] 5"	[127] 5"	[221] 8 3/4"	[194] 7 5/8"	[298] 11 3/4"	[27 Kg] 60 Lbs
SK-1716-22	J	[152×127] 6"×5"		2-17000	[152] 6"	[127] 5" J	[221] 8 3/4"	[194] 7 5/8"	[127] 5"	[14 Kg] 30 Lbs
SK-1716-23	J	[178×152] 7"×6"		2-170246	[178] 7"	[152] 6"	[276] 10 7/8"	[221] 8 3/4" J	[298] 11 3/4"	[40 Kg] 88 Lbs
SK-1716-24	J	[178×152] 7"×6"		2-171642	[178] 7"	[152] 6"	[276] 10 7/8"	[221] 8 3/4"	[451] 17 3/4"	[56 Kg] 123 Lbs.
SK-1716-25	B	[203×127] 8"×5"	8552-1	2S-719	[197] 7 3/4"	[127] 5"	[276] 10 7/8"	[194] 7 5/8"	[451] 17 3/4"	[50 Kg] 110 Lbs
SK-1716-26	J	[203×152] 8"×6"		2-170246	[178] 7"	[152] 6"	[276] 10 7/8"	[221] 8 3/4" J	[298] 11 3/4"	[40 Kg] 88 Lbs.
SK-1716-27	A	[203×178] 8"×7"		SK-17893	[197] 7 3/4"	[178] 7"	[276] 10 7/8"	[276] 10 7/8"	[451] 17 3/4"	[59 Kg] 130 Lbs
SK-1716-28	A	[229×203] 9"×8"	9852-1	2S-1150	[229] 9"	[197] 7 3/4"	[305] 12"	[276] 10 7/8"	[451] 17 8/8"	[63 Kg] 182 Lbs
SK-1716-29	A	[254×203] 10"×8"		2-17912	[243] 9 9/16"	[203] 8"	[338] 13 5/16"	[276] 10 7/8"	[305] 12"	
SK-1716-30	A	[254×203] 10"×8"	10851-1	2S-1007	[248] 9 3/4"	[197] 7 3/4"	[338] 13 5/16"	[276] 10 7/8"	[491] 17 3/4"	[71 Kg] 156 Lbs

REV.
A CS-6427 6-21-72 CWF | B CS-6427-B 11-4-75 DRM | C CS-6729 7-9-76 MR | D CS-6879 10-13-76 WRK | E CS-6848-K 12-3-76 JZN | F CS-7011-E 7-31-78 FWS | G CS-7064 10-10-79 MLG | H CS-7157-B 10-17-80 RÆ | J CS 7064-B 11.29.82 LK

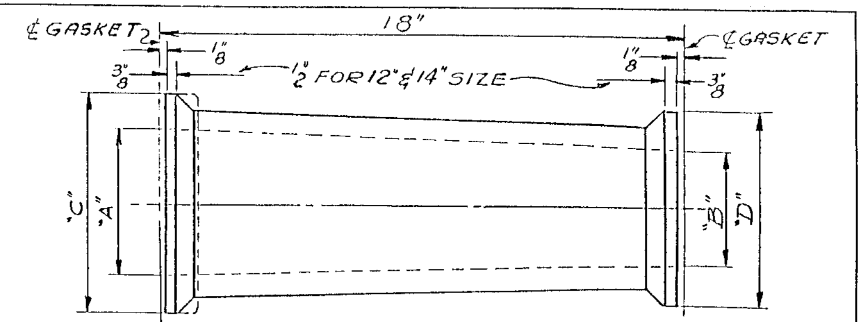
UNITED CONVEYOR CORPORATION
300 WILMOT ROAD
DEERFIELD, ILLINOIS, 60015

SCALE ~
TITLE DURITE PIPE REDUCERS
DATE 10-17-80
RE-DRAWN RÆ
CHECKED DDT 10-17-80
APPROVED

SK-1716-19 THRU 40
SHT. 1 OF 2
REV.

FORM 8600-873

FIGURE C14.9 Durite (UCC) fitting selection drawing, 3 of 4.



	PATT.	"A"	"B"	"C"	"D"	REFERENCE
BYSK-1716-36	5451-1	5"	4"	7 5/8"	6 1/2"	3S-722
" -20	6451-1	6"	4"	8 3/4"	6 1/2"	3S-815
" -37	6551-1	6"	5"	8 3/4"	7 5/8"	3S-722
" -25	8552-1	7 3/4"	5"	11"	7 5/8"	2S-719
" -38	8653-1X1	7 3/4"	6"	11"	8 3/4"	2S-715
" -27	17893	7 3/4"	7"	11"	11"	SK-17893
" -24	8653-1X2	7"	6"	11"	8 3/4"	2S-1064
" -28	9852-1	9"	7 3/4"	12"	11"	2S-1150
" -30	10851-1	9 3/4"	7 3/4"	13 1/2"	11"	2S-1007
" -32	10951-1	10"	9"	13 1/2"	12"	2S-1168
BYSK-17692-K	17960	11 3/8"	7 3/4"	16"	11"	SK-17960
BYSK-1716-33	17692	12"	7 3/4"	16"	11"	SK-17692
" -34	121051-1	12"	10"	16"	13 1/2"	2S-1143
" -35	17617	14"	12"	17 5/8"	16"	SK-17617
	859-5	7 3/4" x 10" RECT.	7 3/4"	12 1/2" x 14 1/2" RECT.	11"	2S-714

NOTE: FLANGES ROUND EXCEPT AS NOTED

WAS SK-1437

REV.				
	C NEW PATT. ADDED 4-14-49	F ADD. 14" TO 12" - 12-16-63 SK-17617, C.S. 4958	J C.S.-5556 2-21-66	M
	B 8" TO 6" PATT. No. CH'G 6-18-48	E "A" DIM. FOR 8" TO 6" & 8" TO 5" & 8" TO 6" RECT. REF.	H C.S. 5430 10-18-65	L CS-5556-A 3-30-66 - EEB (M)
	A CHG'D FLG'S ON 6" X 4" C.S. #140, 10-15-38,	D GASKET ADDED 10-22-54	G C.S.-5147 8-11-64	K C.S-3710 3-2-66 R.N.

UNITED CONVEYOR CORPORATION
CHICAGO, ILLINOIS, 60626

SCALE NONE

TITLE UNITED DURITE PIPE REDUCERS

DATE 3-14-38 RE - 3-2-66
DRAWN RE R.N.
CHECKED RE
APPROVED

SK-1716-1

FIGURE C14.10 Durite (UCC) fitting selection drawing, 4 of 4.

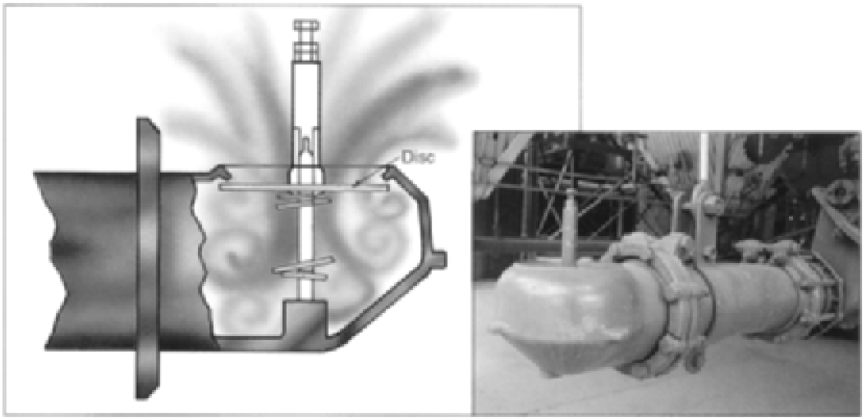
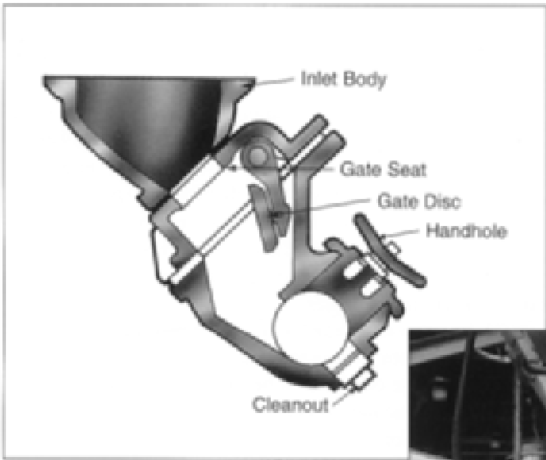


FIGURE C14.11 Air intake photograph (UCC).

Hopper Isolation. Typically, manual bolt-up gates, manual butterfly valves, or handwheel-operated knife gates are used to isolate a fly ash hopper for on-line maintenance of the ash conveying system. The bolt-up gates are the least expensive and require removal usually of four of the bolts on the typical NPS 8 (DN 200) or NPS 12 (DN 300) Class 150 flange on the hopper. The gate must then be hammered closed or open. Manually operated knife gates are common for this application, but care should be taken to specify the ash temperature for selection of seat and packing materials. Large heads of ash may make knife gate operation difficult, and manually operated butterfly valves have proved quite reliable in this service. Valves in this application are used infrequently, only for on-line service of downstream equipment.

Air-Intake. At the end of each branch line in a negative-pressure conveying system, air must be introduced into the conveying line to establish mass flow. The air intake restricts the airflow into the conveyor line and controls vacuum. An adjustable spring-regulated check valve is preferred in this application, although some manufacturers use ball valves or just orifice plates (Fig. C14.11). In the event of a leaking fly ash intake, the check valve prevents spillage of the ash out the end of the branch line.

FlyAsh-Intake. Fly ash intakes vary widely in design from one manufacturer to the next. While some horizontal slide gate styles are occasionally used, preferred is the swing gate design where the gate swings completely out of the flow of ash to open and closes against a replaceable sharp-edged seat (Fig. C14.12). Valves may be hand, air cylinder, or power chamber actuated with manual operators rarely used. Fly ash intakes should not regulate the flow of ash by throttling, but rather by opening and closing completely as often as required to minimize wear and leakage in this extremely abrasive application. Intakes are made of cast iron, chromium cast iron, fabricated steel, stainless steel, and ceramic-lined cast iron. The most common intakes consist of three sections: inlet hopper, valve assembly, and intake tee. The inlet hopper connects to the fly ash hopper or isolation valve and provides a transition to the intake valve assembly. The valve assembly includes the gate, seat, and operator, and it should be easily removable for service, as this is the primary wearing part of the intake. The intake tee is a tee in the conveyor branch line that



Fly ash intake valves are air-powered operated for automatic remote control and dependable, trouble-free operation. This valve provides a transition from the collection hopper to the conveyor line and isolates the hopper from the line while the hopper is filling. The tight valve and seat assembly is designed to prevent leakage, which helps assure good system performance. The swing disc inside the valve rotates out of the ash flow path to minimize wear, while the seat provides positive shutoff.

For high system capacities (above 45 tons per hour), gravity flow alone may not be sufficient to achieve the full capacity of the system. In this situation, a fluidized intake is used to assure high capacity flow of ash into the conveying line.

FIGURE C14.12 Fly ash intake cutaway drawing.

adapts to the intake valve assembly. It often contains a gasketed covered port called a *handhole*, which may be opened to remove obstructions in the valve assembly. Care must be taken when this operation is performed, as hot ash may be present. Variations on fly ash intakes include diffuser feeders, which incorporate air fluidizing media to permit high ash flow capacities.

Branch-line isolation valves are usually cylinder-operated knife gates or cylinder or power chamber operated, totally enclosed, rotary slide gates (Fig. C14.13). Hand or chain operators are occasionally used on ash systems at small industrial plants. Knife gates are specially designed to seal against the pressure differential, depending on whether they are used on positive or negative pressure systems; i.e., they are unidirectional. Flow cones and liners of abrasion-resistant materials are options to be specified or recommended by the manufacturer. Also, the gate should be designed to self-purge the slide cavity so that ash does not become packed, preventing sealing. All branch-line gates should be totally enclosed to avoid spillage. Totally enclosed rotary slide gates include a slide that has a full pipe diameter hole in it for the open position. The gate cavity has a small orifice, which either allows atmospheric air to bleed in, purging the cavity of ash, or is connected to a source of compressed air to accomplish the same purpose in a positive-pressure system. Branch-line isolation gates typically require less than 4 in (100 mm) of pipe length for installation, but must be protected from pipe growth or weight due to thermal expansion or deadweight in risers, which may pinch and prevent proper operation.

Sluice valves are designed with similar considerations. Knife gates are most common and typically have aluminum bodies with stainless-steel or elastomer liners and are usually cylinder-operated for branch-line isolation but may be handwheel-

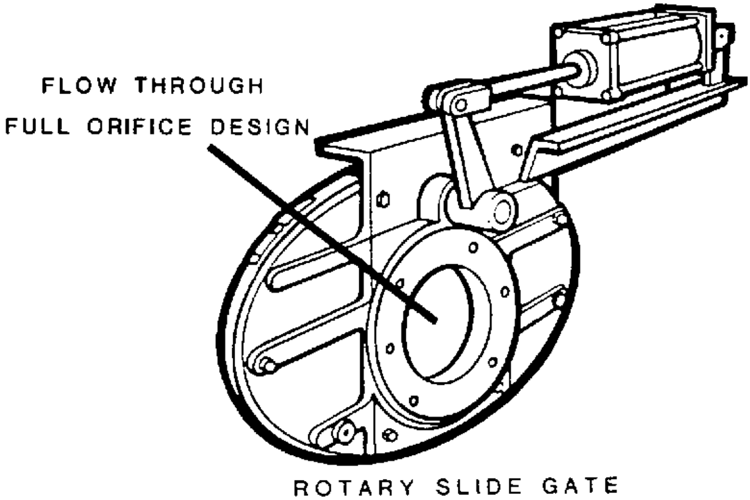


FIGURE C14.13 Totally enclosed rotary slide gate drawing.

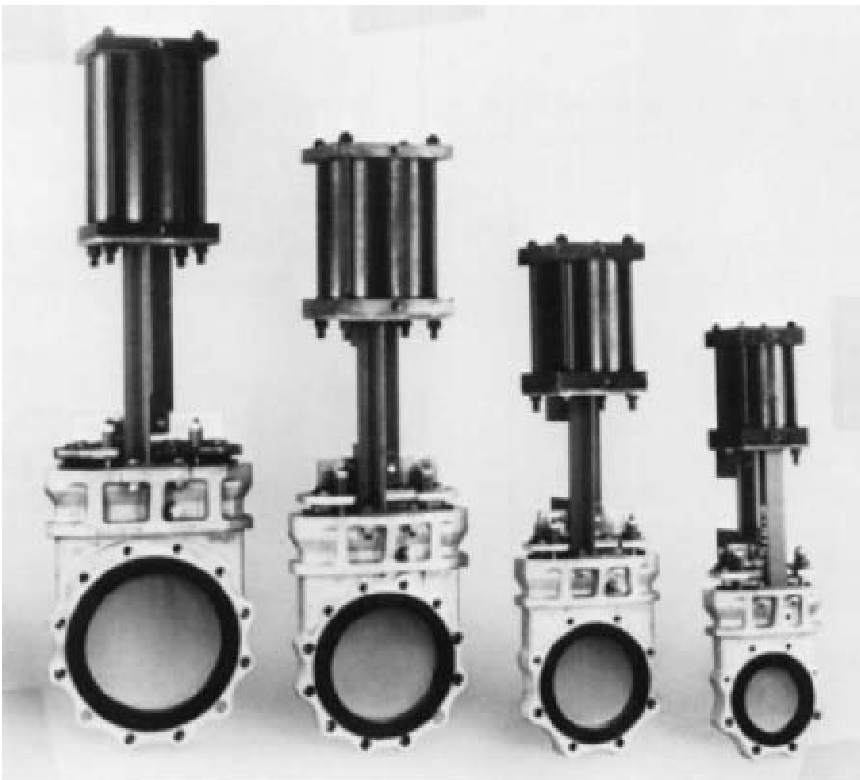


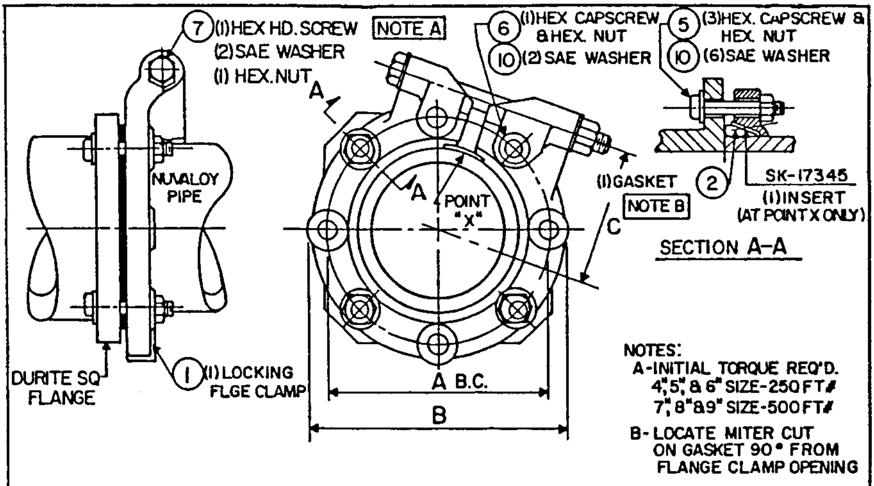
FIGURE C14.14 Knife gates for sluice service photograph (UCC).

operated for maintenance isolation (Fig. C14.14). Slurry knife gates are available with standard designs rated to 300 psig (2070 kPa). Rotary slide gates are available rated to 100 psig (690 kPa). Balanced valves such as butterfly valves were also common but are rarely employed today.

Most of the valves used in clean air or water applications are standard configurations of knife gates or butterfly valves with consideration given to high-temperature requirements.

COUPLINGS

Couplings for ash piping take a variety of forms, again specific to the manufacturer and pipe and fitting material (Fig. C14.15). To connect plain-end cast-iron pipe, clamp-type couplings are sometimes employed that also serve as expansion joints. This method wears quickly and should be avoided. Preferred are gasketed clamp-on flanges, which are then bolted together normally. Fittings typically have plain-end, raised-bevel, or square flanges, and each manufacturer has a gasket and clamping system to assemble them. Common are flange clamp halves or thirds which are held together by the through-bolts at the end of each clamp section. Sluice piping is similar except for the gasket materials.



PIPE SIZE	DWG.NO.	DIM. A	DIM. B	DIM. C	ITEM 1 PATT. NO.	ITEM 2 DWG. NO.	ITEM 5 SIZE	ITEM 6 SIZE	ITEM 7 SCREW DIM.	ITEM 7 SPEC. NO.	ITEM 10 SIZE
4"	SK-1701-185	7 1/2"	8 3/4"	4 3/8"	17081	SK-17336-1	5/8"-11X3 1/2"	5/8"-11X4 1/2"	3/4"-10X6"	46249-8	5/8"
5"	SK-1701-186	8 1/2"	9 3/4"	4 7/8"	17078	SK-17337-1	5/8"-11X3 1/2"	5/8"-11X5"	3/4"-10X7"	46249-2	5/8"
6"	SK-1701-187	9 1/2"	10 3/4"	5 7/16"	17079	SK-17338-1	5/8"-11X3 1/2"	5/8"-11X5"	3/4"-10X7"	46249-2	5/8"
7"	SK-1701-188	11 3/4"	1'-1 1/4"	6 5/8"	17086	SK-17357-1	3/4"-10X4"	3/4"-10X5 1/2"	1"-8X8 1/2"	46259-6	3/4"
8"	SK-1701-189	11 3/4"	1'-1 1/4"	6 5/8"	17071	SK-17339-1	3/4"-10X4"	3/4"-10X5 1/2"	1"-8X8 1/2"	46259-6	3/4"
9"	SK-1701-190	1'-1 3/4"	1'-3 1/4"	7 1/2"	17082	SK-17356-1	3/4"-10X4"	3/4"-10X5 1/2"	1"-8X8 1/2"	46259-6	3/4"

FIGURE C14.15 Typical coupling drawing (UCC).

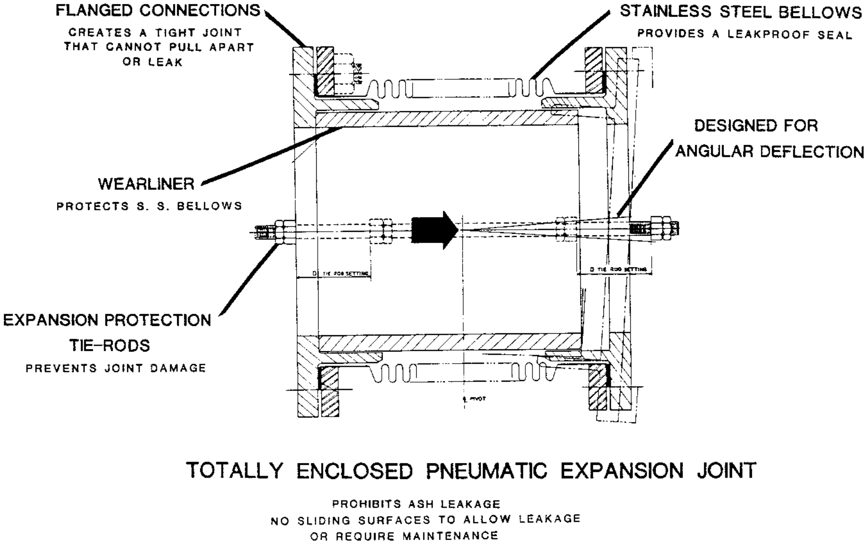
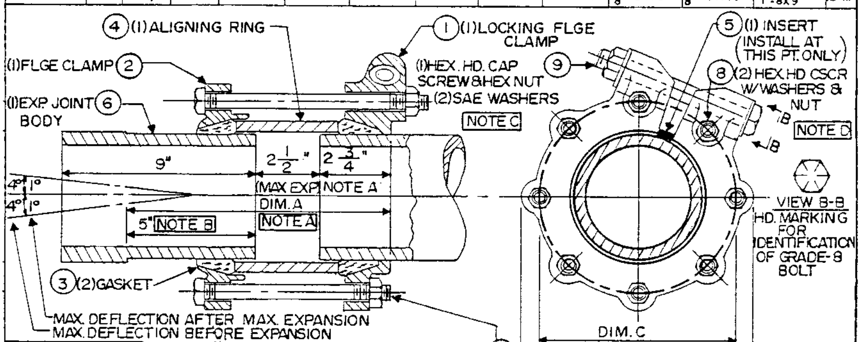


FIGURE C14.16 Cross section of bellows expansion joint (UCC).

ASS'Y. NO.	PIPE SIZE	DIM. B	DIM. C	ITEM 1	2	3	4	5	6	7	8	9	EST WT.
SK-1730-108	4"	$8\frac{7}{8}$"	$7\frac{1}{2}$"	2-17081	2-17137	SK-17336-1	SK-17131	SK-17345	SK-17049	$\frac{5}{8}$"-11X$7\frac{1}{2}$"	$\frac{5}{8}$"-11X9"	46249-8 $\frac{3}{4}$"-10X6"	43#
SK-1730-109	5"	$9\frac{3}{4}$"	$8\frac{1}{2}$"	2-17078	2-17138	SK-17337-1	SK-17132	SK-17345	SK-17050	$\frac{5}{8}$"-11X$7\frac{1}{2}$"	$\frac{5}{8}$"-11X9"	46249-2 $\frac{3}{4}$"-10X7"	52#
SK-1730-110	6"	11"	$9\frac{1}{2}$"	2-17079	2-17112	SK-17338-1	SK-17111	SK-17345	SK-17051	$\frac{5}{8}$"-11X8"	$\frac{5}{8}$"-11X9"	46249-2 $\frac{3}{4}$"-10X7"	60#
SK-1730-111	7"	$13\frac{3}{4}$"	$11\frac{3}{4}$"	2-17086	2-17139	SK-17357-1	SK-17133	SK-17345	SK-17090	$\frac{3}{4}$"-10X8"	$\frac{3}{4}$"-10X$9\frac{1}{2}$"	46259-6 1"-8X$8\frac{1}{2}$"	82#
SK-1730-112	8"	$13\frac{3}{4}$"	$11\frac{3}{4}$"	2-17071	2-17123	SK-17339-1	SK-17124	SK-17345	SK-17052	$\frac{3}{4}$"-10X8"	$\frac{3}{4}$"-10X$9\frac{1}{2}$"	46259-6 1"-8X$8\frac{1}{2}$"	92#
SK-1730-113	9"	$15\frac{1}{4}$"	$13\frac{3}{4}$"	2-17082	2-17083	SK-17356-1	SK-17084	SK-17345	SK-17091	$\frac{3}{4}$"-10X8"	$\frac{3}{4}$"-10X$9\frac{1}{2}$"	46259-6 1"-8X$8\frac{1}{2}$"	103#
SK-1730-114	10"	$15\frac{3}{4}$"	$14\frac{1}{4}$"	3-17076	2-17010	SK-17057-1	SK-17055	SK-17345	SK-17053	$\frac{3}{4}$"-10X$8\frac{1}{2}$"	$\frac{3}{4}$"-10X$9\frac{1}{2}$"	46259-6 1"-8X$8\frac{1}{2}$"	114#
SK-1730-115	12"	$18\frac{3}{4}$"	17"	3-17077	2-17029	SK-17058-1	SK-17056	SK-17345	SK-17054	$\frac{7}{8}$"-9X9"	$\frac{7}{8}$"-9X10"	46259-7 1"-8X9"	134#



EXPANSION	DIM. A
0"	$7\frac{3}{4}$"
$\frac{1}{2}$"	$8\frac{1}{4}$"
1"	$8\frac{3}{4}$"
$1\frac{1}{2}$"	$9\frac{1}{4}$"
2"	$9\frac{3}{4}$"
$2\frac{1}{2}$"	$10\frac{1}{4}$"

NOTE D HEX. HD. CSCR W/WASHERS & NUT
(6) REQ'D FOR 4"-9" SIZES
(10) REQ'D FOR 10"-12" SIZES

NOTE- A-HOLD DIMENSIONS SHOWN FOR PROPER EXPANSION CLEARANCE
B-EXP. JOINT MACHINED SURFACE COATED WITH DRY LUBRICANT IN SHOP
C-INITIAL TORQUE=-4",5",& 6" SIZE-250 FT.# 7",8",9",10",& 12" SIZE-500 FT.#
D-DURING ASS'Y, TIGHTEN ITEMS #7 & #8 TO FOLLOWING TORQUE
4",5",& 6" SIZE-80 FT.# 7",8",& 9" SIZE-145 FT# 10"& 12" SIZE 175 FT#
E-ACTUATION FORCE: 4"-6" SIZE-3500#, 7"-9" SIZE-6500, 10"-12" SIZE-10,000#

FIGURE C14.17 Cross section of sleeve-type expansion joint (UCC).

EXPANSION JOINTS

Expansion joints take several common forms in pneumatic ash-conveying piping. The bellows type, with a stainless-steel bellows to seal against atmospheric pressure and an internal cast-iron sleeve for abrasion resistance, is quite common and allows for several degrees of angular misalignment (Fig. C14.16). A gasketed, machined cast-iron expansion joint, as shown in Fig. C14.17, is also widely used. The use of Dresser-type couplings for expansion joints should never be permitted, as they are not designed for wear and will soon leak in service, creating housekeeping problems and reducing capacity. It should be remembered in designing pipe supports that every straight run of conveyor piping will need an expansion joint, and typically it requires 1000 lb (454 kg) of axial force for every 1 in (25 mm) in diameter to actuate the expansion joint.

PIPE SUPPORTS

Pipe supports are of standard configurations, but nonstandard sizes because of the unusual outside diameters of ash piping. Most pneumatic conveyor lines will have one fixed support in each horizontal run with sliding (U-bolt) types of supports

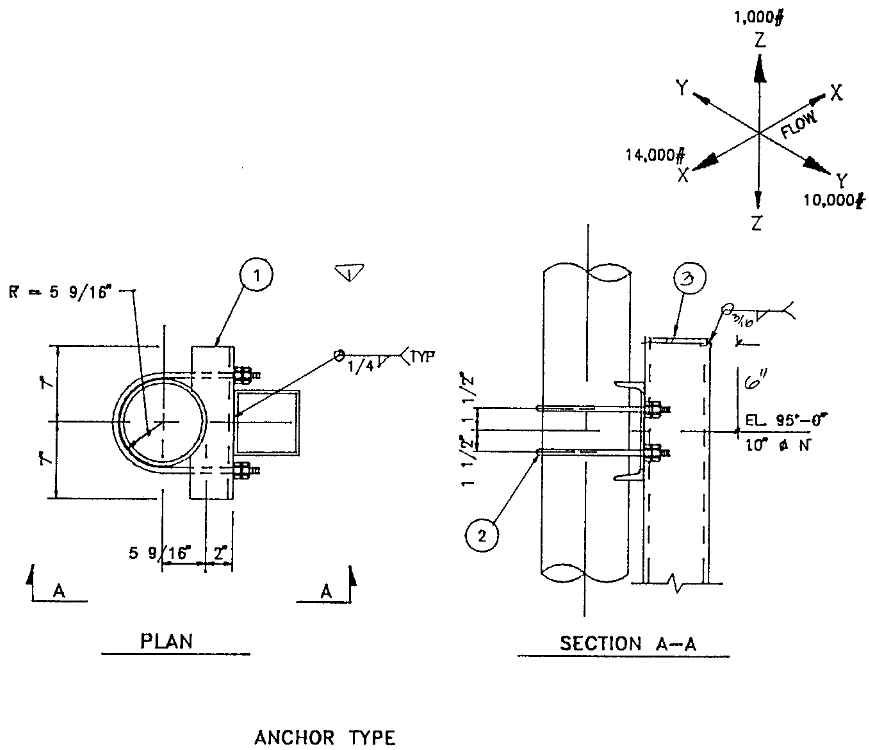


FIGURE C14.18 Rigid pipe support.

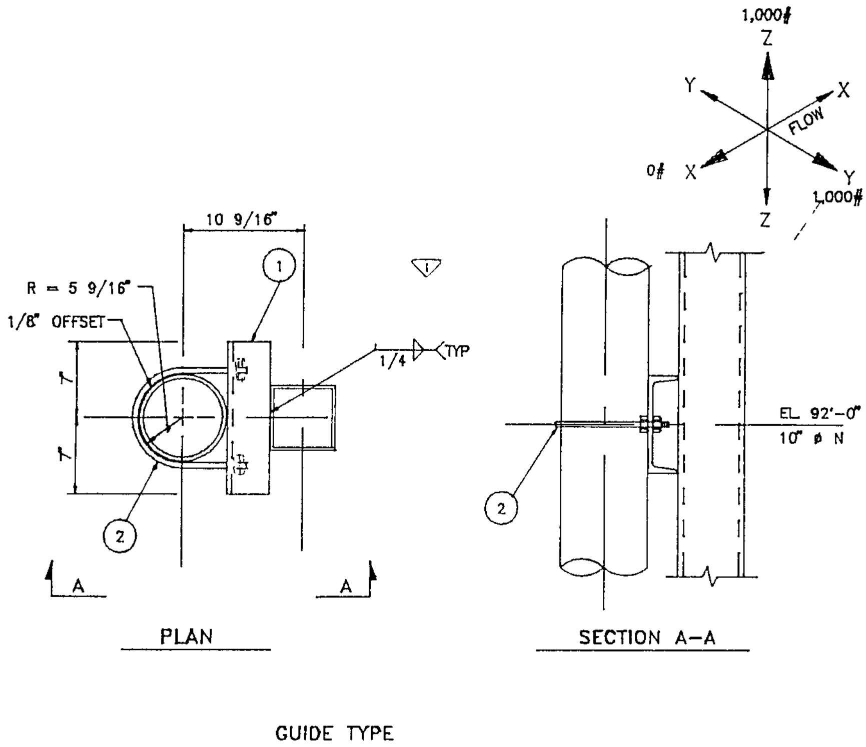


FIGURE C14.19 Sliding pipe support.

supplementary. Risers will have a fixed support at the bottom and allow expansion upward. Fixed supports are to be located on each side of branch-line isolation gates to prevent pinching. Some ash conveyor line in bottom ash service is installed on roller supports to allow for the large potential thermal expansion. Typical support configurations are shown in Figs. C14.18 through C14.21.

INSTRUMENTATION

Because of the highly abrasive nature of ash, instrumentation is usually relegated to the clean portions of ash conveyor piping, i.e., upstream of the first ash intake point or downstream of separating equipment. Pressure and vacuum transmitters are used to control ash flow into pneumatic conveyor lines, and maximize capacity without plugging the line. Opacity and temperature are usually monitored upstream of vacuum exhausters to protect them from excessive ash in the case of broken bags in the separating equipment, or temperature excursions that could damage their precision components. Pressure taps are occasionally used in conveyor lines to help locate pluggage when it occurs. Valving typically employs limit switches to

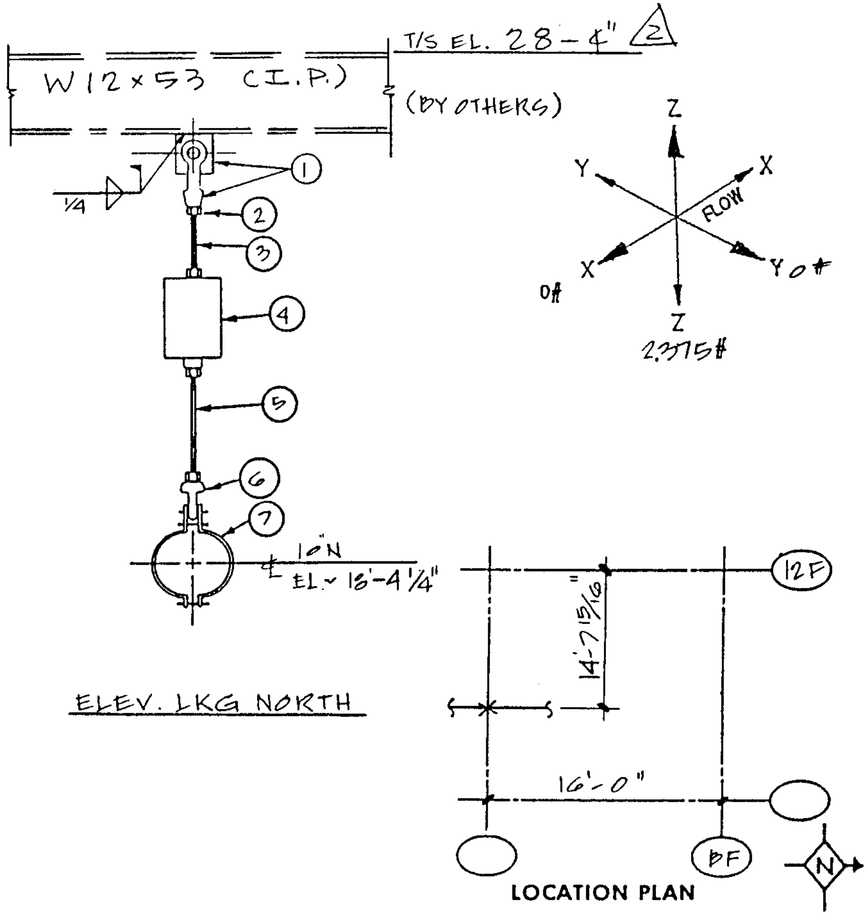
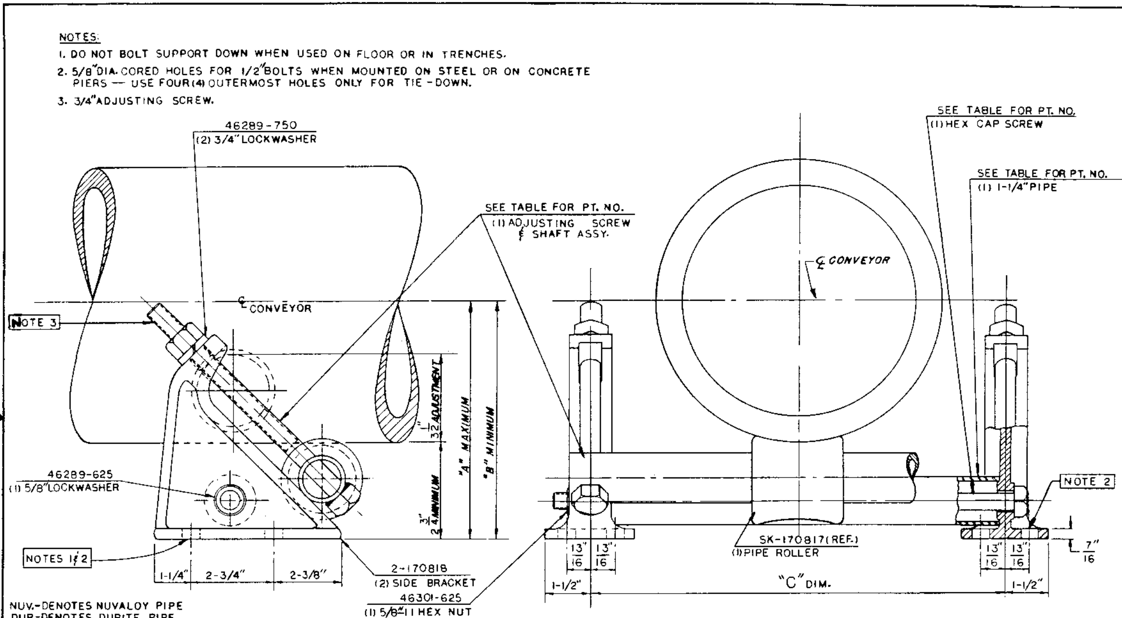


FIGURE C14.20 Hanger in ash conveyor service.

monitor system configuration from a remote control panel or cathode-ray tube (CRT) screen.

FABRICATION AND INSTALLATION CONSIDERATIONS

Ash conveyor piping usually uses bolted couplings except when carbon-steel pipe is utilized, which may be welded for straight sections. Even then, two bolted flange connections should be provided in every straight section of pipe to remove foreign objects that may be inadvertently introduced into the conveyor or to remove pluggages. Contractors should be familiar with the gasketing systems and torque require-



TABLE

PIPE SIZE	4"		5"		6"		7"		8"		9"		10"		12"	
TYPE	NUV.	DUR.	NUV.	DUR.	NUV.	DUR.	NUV.	DUR.	NUV.	DUR.	NUV.	DUR.	NUV.	DUR.	NUV.	DUR.
"A" MAX.	8 3/4"	9"	9 1/4"	9 1/2"	9 13/16	10 1/8"	10 7/16	10 11/16	10 13/16	11 1/16	11 7/16"	11 3/4"	11 13/16	12 3/16	12 7/8"	13 1/4"
"B" MIN.	5 1/4"	5 1/2"	5 3/4"	6"	6 5/16"	6 5/8"	6 15/16	7 3/16"	7 5/16"	7 9/16	7 15/16"	8 1/4"	8 5/16"	8 11/16"	9 3/8"	9 3/4"
"C" DIM.	11 3/8"						13 7/8"						16 1/2"			
MAX. LOAD	2000#						1700#						1400#			
HEX CAP SCREW	PT. NO. 46295-1300 5/8"-11 X 13" LG.						PT. NO. 46295-1600 5/8"-11 X 16" LG.						PT. NO. 46295-1800 5/8"-11 X 18" LG.			
1-1/4" PIPE	PT. NO. 17850-1 13" LG.						PT. NO. 17850-2 13-1/2" LG.						PT. NO. 17850-3 16-1/8" LG.			
ADJ. SCREW & SHAFT	PT. NO. 4195 B/M						PT. NO. 4196 B/M						PT. NO. 5128 B/M			
PART NO.	2-1717-3						2-1717-4						2-1717-5			

SHIPMENT: LOOSE

WAS 2S-673

Est. Wt. 30#

TOLERANCES UNLESS OTHERWISE SPECIFIED

General fabrication specification 98001 is a part of this drawing.

AJUSTABLE ROLLER PIPE SUPPORT

UNITED CONVEYOR CORPORATION
300 WILMOT ROAD
DEERFIELD, ILLINOIS. 60015

SCALE 1/2"=1"

2-1717-3, -4, -5

FIGURE C14.21 Roller support.

ments of the couplings and fittings, which are provided by the ash-handling system manufacturers with the system installation instructions. Some gaskets require silicone or other gasket cements to be mixed and applied, and may require a cure time. Cast-iron conveyor pipe is extremely heavy and relatively brittle, and care must be taken accordingly during handling. Cast-iron pipe can be field-cut with an abrasive saw, but permanent welding to it is not advisable. Owners may prefer to have the conveyor line completely designed and shipped from the manufacturer as spool pieces, marked for specific assembly per installation drawings.

EXAMINATION AND TESTING OF ASH HANDLING PIPING SYSTEMS

Visual inspection for leaks is the normal mode of examination on a new system before start-up and during operation. Positive-pressure and sluice systems will be obvious when they leak. Leaks in vacuum systems can be detected by ''walking down'' the system while it is operating and listening for leaks. Any noticeable increase in required conveying time is an indication of wear or leakage. Smoke testing is also effective in finding leaks. Some users have employed commercially available ultrasonic thickness testers to measure internal wear on cast-iron and ceramic-lined ash conveying pipes.

OPERATION AND MAINTENANCE

While critical components may be replaced on a time schedule to improve system availability, ash conveyor lines can typically be patched or repaired temporarily until maintenance can be scheduled. Systems are usually designed to operate only one-half the time or less, to allow maintenance during the remaining period. Pneumatic systems' condition can be monitored by use of a pressure strip chart recorder, and considerable specific detail about the conveyor condition can be learned from analysis of the charts, such as overall system condition, intake valve wear, and valve leakage.

Ash conveyor systems are forgiving in the short term, but if sufficient leaks and wear occur, conveying capacity is quickly impaired. A leaky system has reduced capacity and must be run longer to empty the hoppers and convey all the ash. In the extreme case, the system will be run continuously, and a large amount of flue gas will be pulled from empty hoppers. In condensing in the conveyor and collecting equipment as sulfuric acid, corrosion becomes a significant factor in shortening service life.

The useful life of sluice piping can be extended by periodically rotating the pipe one-quarter turn, since most of the abrasion occurs on the bottom of the pipe. With basalt-lined pipe, it may be possible to extend the life of the conveyor to the life of the plant, usually 30 years.

EXPERIENCE FEEDBACK—PROBLEMS AND SOLUTIONS

Problems with ash conveyor piping result from improper design or specification, fuel switching and hence ash changes after installation, unexpected high-wear areas, or unacceptable maintenance levels. Whatever the reason, if unacceptable wear or failure is occurring, the options for remediation are repair in kind, reconfigure the problem area, or replace with different materials or equipment. A user finding one particular elbow to require too frequent replacement may install one of harder material, longer or shorter radius, or different design, such as with a replaceable wearback.

The major ash-handling system manufacturers maintain staffs of field service engineers to examine the operation and condition of installed systems and to recommend improvements in components, operation, or maintenance procedures. Once the system has been in operation, it may be determined that a harder (and more expensive) material will provide a significantly longer life in a specific location, to justify its replacement.