SURFACE VEHICLE INFORMATION REPORT

J792™ SEP2022

Issued 1954-06
Revised 2022-09

Superseding J792 JUN1968

(R) SAE Manual on Blast Cleaning

RATIONALE

This revision considers necessary changes in language to address all the developments in bast cleaning process and equipment over the years since the last review. This includes, but is not limited to, blast cabinet, reclaim system, work handling, media propulsion, ventilation, and machine controls. Different media types, media maintenance in the machine, and testing are also clarified in this revision.

1. SCOPE

Blast cleaning may be defined as a mechanical pre-treatment process in which a suitable stream of solid particles is propelled with sufficient velocity against a work surface to cause a cleaning or abrading action when it comes in contact with the workpiece.

Blast cleaning may be employed for a variety of purposes. It is a well-established method for removing sand from castings and burrs or scale from forgings, mill products, or heat treated parts; to promote machinability; and to minimize the possibility of interference in actual operation. In addition to this use, blast cleaning also produces a suitable surface for downstream industrial coatings. All these objectives are often accomplished in the one operation.

As a general understanding, this document pertains to blast cleaning only. Any reference to shot peening or other processes is only to explain a context or concept related to blast cleaning. Processes prior to and/or after blast cleaning are entirely possible, but they do not take primary context in this document.

1.1 History

The cleaning problem of removing sand and scale has always been associated with the casting, forging, and heat treating of metal. Foundries employed the chisel, hammer, dull file, and wire brush to address this problem. Hand tools were gradually augmented by “rattling” or tumbling methods.

Pressure blasting, as we know today, was first introduced in 1870 by General Benjamin Chew Tilghman. He discovered that metals, stone, and glass could be shaded or etched by jets of sand. He patented pressure blasting with sand, powered by compressed air, steam, and water; with sand struck by a paddle wheel, thrown centrifugally, or dropped from a height through a tube. Thus, General Tilghman advanced the principles upon which modern blast cleaning is based.[1]

[1] Refer to “Modern Blast Cleaning and Ventilation,” by C.A. Reams, Cleveland, Ohio: Penton Publishing Co., 1939.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/J792_202209/

Tilghman's first commercial machine used a steam blast as a method of propelling the sand. This proved to have several disadvantages. The steam moistened the sand, necessitating a drying operation. It also tended to hide the work, break glass objects, and rust metals. As a result, Tilghman changed to a tank-type compressed air machine, which proved more successful.

A natural progression as a result of development efforts was a blasting machine in which sand could be refilled during operation. This was accomplished by pouring sand through a standpipe of sufficient height to overcome tank pressure.

Cabinets and barrels featuring pressure blast nozzles were advertised in magazines in 1895. That same year, W.W. Sly introduced the exhaust tumbling barrel, which also increased the dust removal problem. This was partially solved by the first cloth screen dust arrester patented in 1897.

Many industries recognized the superior surface quality of castings, forgings, heat treated parts, etc., cleaned by blast cleaning. However, the high operational cost and low productivity of the process at that time limited its use to the cleaning of large castings or products where high quality was necessary regardless of cost.

An old extension to a shed in the back of the plant comprised the up-to-date blast cleaning department of 1915. A blower fan provided the ventilation. Wooden walls which splintered were soon replaced by steel sheets. The sand blasting distorted the sheets and cut the nails. Brick was then used for better durability. However, the silica dust produced in the blasting process was harmful to the operator.

In 1917, process design improvements resulted in improved quality of sand blast rooms where the operator stayed out of the blast zone. Downdraft ventilation, rubber-lined steel walls, and better lighting all served to improve the sand blasting operation.

A new phase of development took place with the introduction of metallic abrasives in the 1920s. Acceptance was slow, due to its low availability and competing low initial cost of sand. Industry soon recognized the improvement in the quality of the finish and the lower operating cost, through increased durability of metallic abrasives. Improvements in reclaiming the metal abrasive eventually helped its widespread appeal. One of the chief benefits—savings in storage space and handling—was not appreciated until the later years of adoption of metal abrasives.

The development of metallic abrasives began with the use of chilled cast iron shot. The comparatively short life of chilled cast iron lead to advancement into malleable and annealed cast iron shot. Cast steel shot was then introduced into the metallic abrasive field and more recently cut wire shot. Although abrasives such as steel shot tend to have a higher initial cost than the iron shot, their durability is much greater, ultimately resulting in lower operating costs.

As more companies produced metallic abrasives, varied names and classification systems started being used. This resulted in the need for standardization of abrasive classification for the entire blasting industry. A big step in this direction was taken in 1943 when a group of shot producers, users, and equipment manufacturers met in Detroit and formed the Shotpeening Committee of the SAE. This committee established size and nomenclature standards for shot and grit (SAE Handbook). This committee continues to work on a standard testing procedure for the endurance and wear of metallic abrasives.

With the introduction and acceptance of metallic abrasives, the blast cleaning equipment suppliers were able to offer the industry their next big improvement—the use of centrifugal force for blast cleaning. Here the abrasive is propelled by a rotating wheel driven by an electric motor. The idea was first proposed in the 19th century but abandoned. The large volume of sand that even the smallest machines required, and the excessive wear caused by sand on metals, made its use prohibitive. In 1933, the American Foundry Equipment Co. demonstrated at Benton Harbor, Michigan, the use of a barrel-type machine using a wheel to propel the abrasive. Later, the Pangborn Corp. introduced a similar unit at Detroit, and another was introduced by the W.W. Sly Mfg. Co. in Cleveland. Among later improvements was an operator-less, single-purpose equipment to provide process control on certain high production parts. This was manufactured by Cargill Detroit Co.

Mechanization of blasting equipment, metallic abrasives, and the use of centrifugal force led to the development of more high production cleaning equipment to meet the industry's growing demands. The improved blasting equipment developed included the tumble type batch cabinets, continuous monorail machines, rotating tables, and the continuous barrel type, to list a few.

In the field of general cleaning, the centrifugal or airless type is by far the most popular means of metallic abrasive propulsion. However, in the case of specialized or precision cleaning, air propulsion of metallic abrasives is more adaptable because of its ease of control and great flexibility. As parts become more complex in size and shape, specialized cleaning becomes necessary.

Work in the development of abrasives, blasting equipment, processes, and standization is ongoing. The blast cleaning history has closely paralleled that of mass production. The blast cleaning industry has made many valuable contributions to the industrial growth of America and continues to do so.

1.2 Present Status

In foundries, the present trend of blast cleaning, with few exceptions, is to use the batch and continuous-barrel type equipment with centrifugal blast wheels for all small castings that can be handled as bulk material. The use of the continuous-monorail type blast equipment with centrifugal abrasive propulsion for large castings and forgings is very extensive. These two types of equipment are fast replacing the older pneumatic style blast equipment. The centrifugal type of blast equipment has proved more economical per ton of cleaned castings than the previously used pneumatic blast equipment, with few exceptions. An exception to the preceding statement is the specialized type of pressure blast equipment to process a part that has internal pockets and on which it is necessary to direct the blast stream at a small area that cannot be reached with centrifugal wheel type equipment. Cleaning applications outside of foundries involve plate and structural steel, forgings, finished fabrications and a multitude of new applications. Though use of centrifugal wheels is quite prevelant, the machines mainly differ in the way the part is handled through/in the machine.

The present focus in ferrous metal blasting abrasives is towards the use of materials with high durability. The result of this progressive change is a lower cost per ton of cleaned parts with reduced abrasive breakdown and reduced dust waste. Adequate auxiliary equipment are used as part of the process to recover, recycle, and re-use the abrasive that could potentially be carried out in pockets of the cleaned work.

1.3 Secondary Effects

1.3.1 Combined Cleaning and Peening

It is generally understood that components undergoing blast cleaning also get shot peened to a certain degree. However, the process control necessary to maintain uniform shot size, shape, abrasive velocity and flow rate is not always available and required in blast cleaning applications. Due to this reason, it is required to separate blast cleaning and shot peening as two distinct operations. Also, if the purpose of cleaning is to remove scale or rust, and peening is expected as a by-product of cleaning, it is also possible that the scale or rust layer could get peened and potentially flake-off at a later time with no peening effect on the substrate of the component.

1.3.2 Use as an Inspection Tool

Blasting is applied to facilitate inspection of selectively hardened parts; blasting often serves as a cleaning operation as well. The inspection of chilled iron parts and decarburized areas on hardened parts is made easier by blasting. It is also possible by blasting to expose leaks in masked areas after carburizing and hardening.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J441 Cut Wire Shot

SAE J444 Cast Shot and Grit Size Specifications for Peening and Cleaning

SAE J827 High-Carbon Cast-Steel Shot

SAE Handbook

2.1.2 Other Publications

"Modern Blast Cleaning and Ventilation," C.A. Reams, Cleveland, Ohio, Penton Publishing Company, 1939

"Simplified Practice Recommendation 118-50 Abrasive Grain Sizes," U.S. Department of Commerce Bulletin, June 1, 1950

"Hyrdo-Finish and Hydro Sandblast," W.I. Gladfelter, Pangborn Corporation

"Fine Particle Blasting or MicroBlast Fluid Honing and Finishing," E.E. Hawkinson, MicroBlast Manufacturing Corporation

"Fine Particle Blasting," A.P. Neuman and V.W. Nichols, Vapor Blast Manufacturing Company

"Effective use of steel shot and grit for blast cleaning," E.A. Borch, Ervin Industries

3. BLAST CLEANING MACHINES

Blast cleaning machines have any or all of the following components: abrasive propelling mechanism; cabinet or enclosure; abrasive cycling and regenerative system; work holding mechanism; load/unload arrangement; ventilation and dust collection; and electrical controls.

Abrasive blasting equipment is generally divided into air blast units, airless blast units, and wet blasting machines, according to the method of propelling the abrasive. Air blasting and airless blasting machines are dry processes for general cleaning, while wet blasting is usually restricted to the cleaning and finishing of precision parts requiring special finishes or cleaning action.

3.1 Air Blasting Machines

In air blast equipment the abrasive material is conveyed by compressed air through a small orifice or nozzle (Figure 1). The abrasive stream takes the shape of a small cone and asserts its effect over a defined area, the size of which is determined by several factors. The two advantages of air blasting are its flexibility in cleaning specific areas with a highly concentrated blast pattern and its ability to work efficiently with both metallic and nonmetallic abrasives. The narrow, coneshape stream of abrasive is ideal for cleaning interior cavities, blind holes, narrow recesses and localized areas of castings, forgings, and heat treated parts.

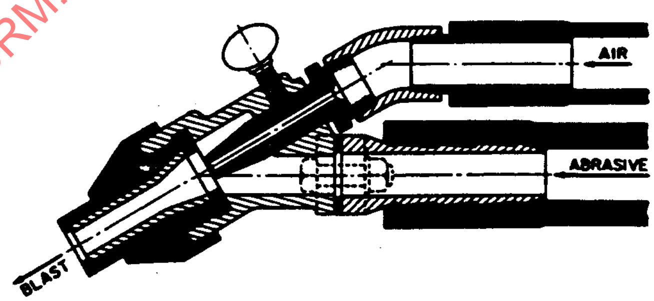

Figure 1 - Induction nozzle

Air blast cabinets are either of the suction feed, gravity feed, or direct pressure types, with the pressure type providing maximum blast/impact energy, which is desirable for removing burned-in sand, heavy scale, etc. The most common form of air blast equipment is that in which the blasting nozzle is manipulated by an operator, who may be located outside or inside the blasting cabinet. Automated airblast equipment, with nozzles manipulated by mechanical manipulators or a robot located inside or outside the cabinet, have replaced some of the manual processes.

In large air blast rooms (Figure 2), the operator (or multiple operators), in special apparel, inside the room, manipulates a flexible air blast nozzle to clean large and intricate parts that, because of their size, must remain stationary. Parts with complex geometry and irregular shapes do not render themselves to an automated process. Cleaning of such parts are best addressed in such a manual airblast room. In some cases, such rooms are also used to "touch-up" parts that have been cleaned for majority of their surface in an automated process.

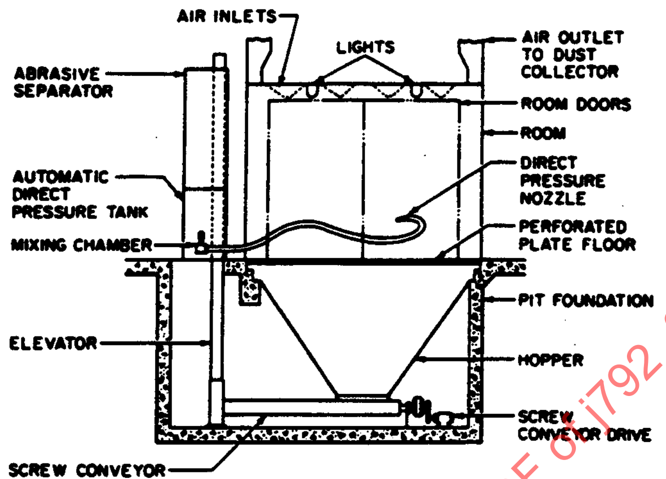

Figure 2 - Hand blast room

In a smaller machine, commonly referred to as hand blast cabinet (Figure 3), the operator reaches through two handholes in the front wall of the cabinet and manipulates the nozzle and/or the work while viewing his progress through a suitably protected glass window.

Manual cabinets, due to their flexibility, are generally used when a low quantity of, relatively smaller size workpieces constitute the entire production of that item. For cleaning higher production volumes, with airblast, dedicated and sometimes customized machines are used, whereby the parts are automatically located in relation to the nozzles, blasted, and unloaded onto downstream handling arrangements. Such machines, integrated with automatic loading/unloading devices, operate with minimal operator intervention.

3.2 Airless Blasting Machines

In airless blasting machines, the abrasive is propelled at the work by means of centrifugal force imparted by a single or multiple rotating wheels located strategically within the cabinet or enclosure (Figure 4). The abrasive forms an elongated blast pattern covering a relatively larger area as compared to a blast nozzle. The operator in an airless machine always remains outside the machine during the blasting cycle. This type of media propulsion is ideally suited for general purpose cleaning of high production volumes of parts with large surface areas. The units are built with integrated work handling arrangements designed to expose the parts in a single or multiple sequence, to the blast stream.

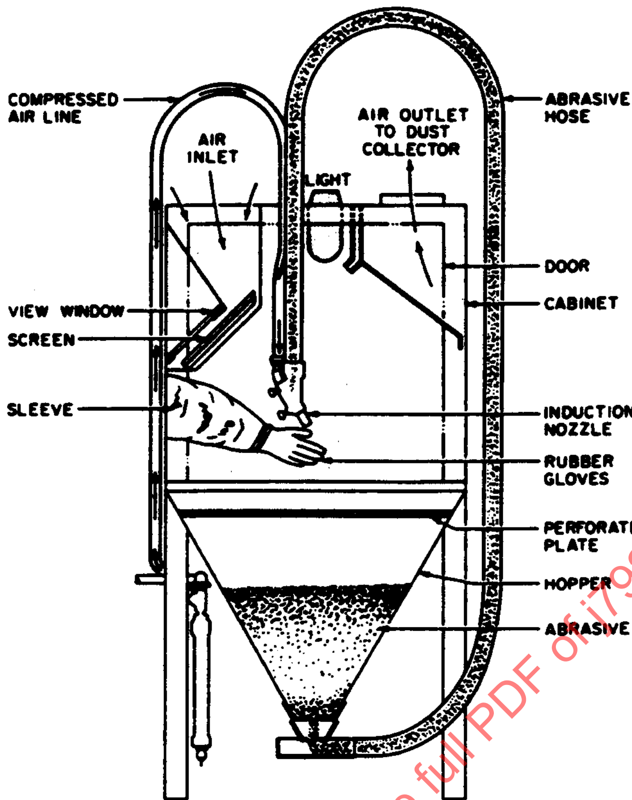

Figure 3 - Induction cabinet

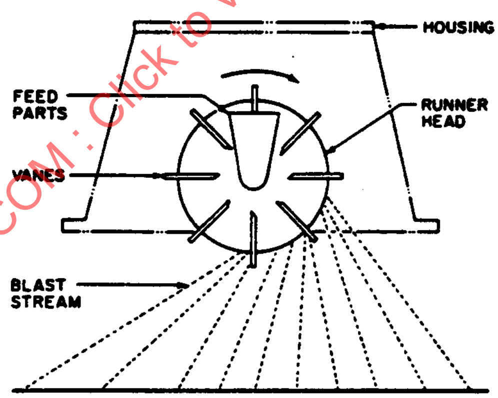

Figure 4 - Centrifugal wheel

The number of wheel units required, and their positioning in any cabinet are influenced by the combination of size, shape, complexity of the work geometry, areas to be cleaned, level of contamination and desired production rate. The most common airless blast machines used for general cleaning are the single-wheel units propelling a fixed downward pattern upon the work presented before this pattern. Such machines could either be batch type or continuous-table-type units.

In the batch type units (Figure 5) the parts are loaded into the machine in one batch, either in a barrel, a depressed cavity developed in a large endless type of flight conveyor (Figure 5), or a rotary table, all of which are completely enclosed. When the batch has been cleaned, the machine is opened and the parts unloaded.

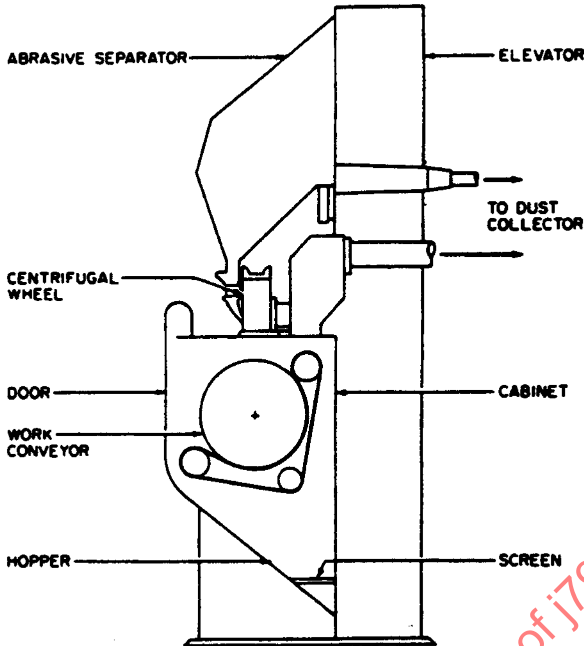

Figure 5 - Batch barrel

The table type machine (Figure 6) consists primarily of a large horizontal table, with or without auxiliary work handling mechanisms, which rotates in a continuous or indexing fashion. In a continuous table, a section of the table is exposed to the operator allowing continuous loading and unloading of parts; the other portion of the table is enclosed in the blast zone and exposed to the shot blast pattern.

Multiple-wheel machines (Figure 7) are more adaptable to high-production parts and utilize various types of conveyors to transport the parts through their multiple-blast patterns.

3.3 Wet Blasting Machines

In wet blasting equipment very fine mesh abrasives in water suspension are propelled at high velocity. These very fine abrasives react upon the surface of the parts imparting a very fine and smooth surface, typically desired on precision parts without causing any damage or alteration to details.

The abrasive is kept in suspension in water by means of an agitator. This slurry is blasted against the work by the use of compressed air and nozzles similar to air blasting. An added component of this type of equipment is a rinse to remove the adhering abrasive.

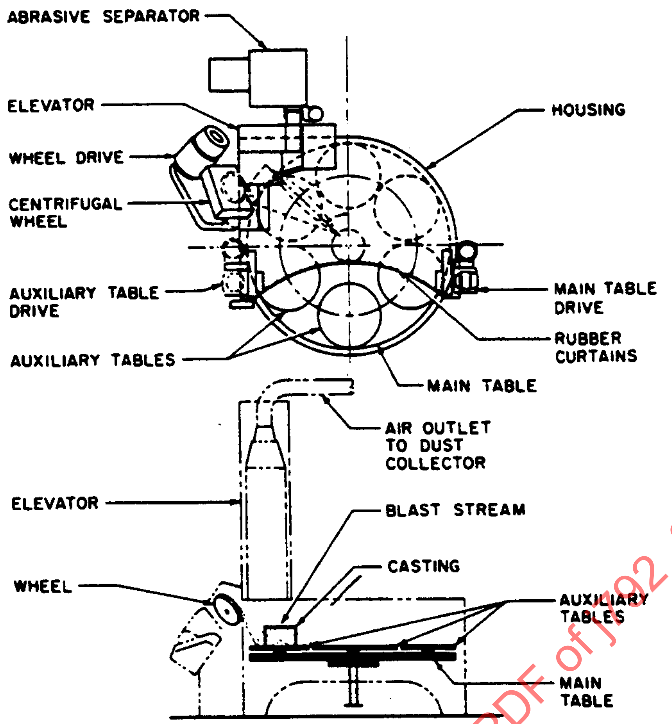

Figure 6 - Table type machine

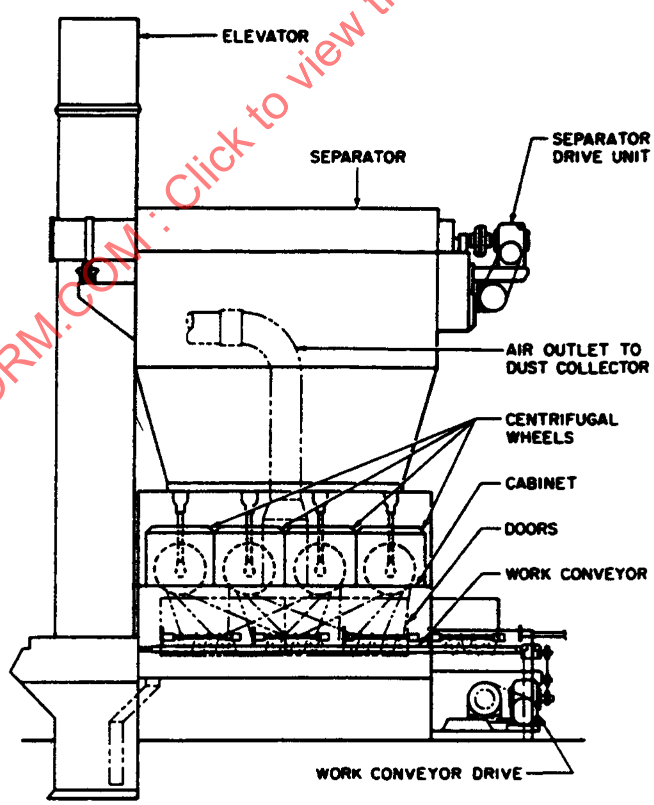

Figure 7 - Multiple-wheel machine

The common wet blasting machine (Figure 8) is a manually operated hand cabinet. For high production, specialized parts, automatic machines are used in which the work is automatically loaded and unloaded from the unit.

3.3.1 Cabinets or Enclosures

Due to the nature of the process, blast equipment are subjected to high wear conditions. Blast cabinets enclosing the blast operation (blast stream) are constructed of steel, and in critical areas lined with wear-resistant alloy steel plates and/or abrasive resistant rubber to withstand this service. The cabinets constitute the basic structure of the machine and generally support or are linked with the other sub-systems of the machine.

3.3.2 Abrasive Reclaim System

The abrasive reclaim system collects and transports the spent abrasive propelled from the blast nozzle(s) or centrifugal wheel(s) from the blast cabinet to the different parts of the reclaim and ultimately to a storage arrangement for re-use. Such systems can be vacuum (pneumatic) driven or mechanical in nature, dependent on the quantity and type of abrasive being reclaimed. In most cases, conventional material handling devices such as augers (screw conveyors), bucket elevators, and cyclones accomplish this task.

A pneumatic recovery system employs a cyclone reclaimer to separate the dust from the useable abrasive, whereas in a mechanical reclaim system, an airwash separator is used to remove broken down abrasive, fines and other foreign material from the blast stream. (See discussion in 6.1.) A ventilation and dust collection system is operated in conjunction with the abrasive handling system.

3.3.3 Work Holding Mechanisms

These are designed to present areas of the work requiring cleaning to the blast stream. An ideal work handling arrangement will feature a minimum number of moving parts, the ability to withstand abrasive conditions, and be simple in design. The load and unload mechanisms used in certain blast equipment are generally confined to batch cleaning operations and are simple, general-purpose materials handling units.

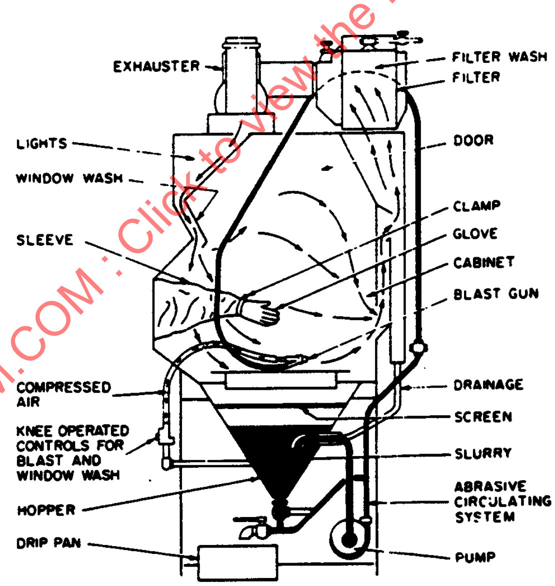

Figure 8 - Schematic of equipment for wet blasting with fine particles (detail arrangement varies among manufacturers)

For specialized blasting, automatic devices are becoming more prevalent for the handling of individual parts. Automation is also preferred in high-production environments where the need for consistent quality and reliability is critical and the potential for variation in cleaning/finish due to manual involvement is not acceptable.

3.4 Machine Controls

Machine controls form a critical part of the blast operation. They are provided to not only sequence different functions of the blast machine, but also to protect the operator and maintenance personnel from the potential dangers associated with the process. At a basic level, the machine controls are standard electrical and pneumatic devices manipulated by the operator as required. When the machine is used for repetitive tasks these controls are designed to function automatically, in sequence. Safety features such as door interlocks shut down the operation if an access or work door is opened by accident. Controls sophistication increases with the criticality of the process. In certain applications such as shot peening, the machines could be computer monitored or controlled. At the bare minimum, automated equipment of date incorporate a PLC and an operator interface.

4. MEDIA—TYPES AND SPECIFICATIONS

4.1 Ferrous Abrasives

4.1.1 Cast Iron Shot

Cast iron shot is made from cupola melted iron generally containing over 2-1/2% carbon. It is atomized into random sizes and quenched in water to produce ball shaped particles of white cast iron, having a hardness of approximately Rockwell C 65. The random sizes are screened into standard SAE sizes. Cast iron grit is made by crushing cast iron shot and is available in standard SAE sizes. (Refer to SAE J444.) This abrasive type has largely been replaced with cast steel shot.

4.1.2 Malleable Iron Shot and Grit

Malleable iron shot and grit are made by heat treating cast iron shot or grit to reduce the hardness and increase the resistance to fracture. They are available in the standard SAE sizes of shot and grit.

4.1.3 Cast Steel Shot

Cast steel shot is high carbon steel, melted in an electric furnace, atomized into random sizes and quenched in water to produce ball shaped particles. It is then heat treated and tempered to a uniform martensitic structure of various hardness. It is available in standard SAE sizes. Refer to SAE J827.[2]

4.1.4 Cut Wire Shot

Cut wire shot is the product of cold drawn carbon steel wire cut into the form of cylinders with lengths approximately equal to wire diameter. It is available in standard SAE sizes. (Refer to SAE J444 and SAE J441.) Cut wire shot, in its "as cut" form, is bombarded against a target to round (or condition) the sharp edges of the cylinders at both ends. This process is called conditioning and conditioned cut wire shot is used in shot peening, in some cases as an alternative to cast steel shot.

4.2 Nonferrous Abrasives

Nonferrous metallic abrasives are usually used on non-ferrous or stainless steel parts where ferrous shot or grit might cause a contamination problem or an objectionable color. They are generally limited in use and availability, but include copper, aluminum, stainless steel, and zinc. They are available as cut wire, cast, or a by-product.

4.3 Mineral Abrasives

Mineral abrasives consist of sand, crushed rock, garnet, pumice, and emery, to list a few. Most of the blasting sands are found in rock formation and are crushed and screened in various sizes for different uses. By far the largest volume of abrasives used are in this classification. The use of pumice, and emery for blast cleaning is very limited. Blast sand and ground rock products are usually available as shown in Tables 1 and 2.

---

[2] SAE J827, Cast Steel Shot. SAE Handbook, published by Society of Automotive Engineers, Inc.

Table 1 - Approximate sieve analysis, % (mineral abrasives)

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 7	Grade 7 Special	Grade 10
	Retained on						
No. 8 sq mesh	0.0	0.0	0.0	0.0	1.0	1.0	8.0
No. 10 sq mesh	0.0	0.0	0.0	0.0	10.0	12.5	40.0
No. 14 sq mesh	0.0	0.0	25.0	36.0	45.0	47.0	37.0
No. 20 sq mesh	0.0	5.0	49.0	51.0	32.0	36.0	12.0
No. 30 sq mesh	1.5	43.0	23.0	11.0	10.0	3.5	1.5
No. 50 sq mesh	78.5	48.0	3.0	2.0	2.0	0.0	1.5
Passing:							
No. 50 sq mesh	20.0	4.0	0.0	0.0	0.0	0.0	0.0

Principal uses of the grades are as follows:
Grade No. 1: Blasting soft metal castings, such as aluminum, aircraft and where a “satin” finish is desired.
Grade No. 2: Blasting soft metal castings, for pointing, aircraft, etc.
Grade No. 3: Blasting castings, for enameling, lettering marble, etc.
Grade No. 4: Blasting for metallizing.
Grade No. 7: Blasting for metallizing, general cleaning of scale, castings, etc.
Grade No. 7 (Special): Blasting for metallizing, general cleaning of scale, castings, etc.
Grade No. 10: Heavy blasting, such as removing paint from tank cars, etc., and where air pressure is 110 psi or more.

Table 2 - Screening specifications(1) (mineral abrasives)

High Limit Screen			Control Screen		Low Limit Screen		Cumulative Screen		Max 3% to Pass
No.	Max Retained, %	Screen No. and Aperture	Max Retained, %	Screen No. and Aperture	Min Retained, %	Screen No. and Aperture	Min Retained, %	Screen No. and Aperture	Screen No. and Aperture
20	0	14 (0.0555)	15	16 (0.0469)	45	18 (0.0394)	80	18 (0.0394) 20 (0.0331)	25 (0.0280)
24	0	14 (0.0469)	20	20 (0.0331)	45	25 (0.0280)	75 -	25 (0.0280) 30 (0.0232)	35 (0.0197)
30	0	18 (0.0394)	20	25 (0.0289)	45	30 (0.0232)	75	30 (0.0232) 35 (0.0197)	40 (0.0165)
36	0	20 (0.0331)	20	30 (0.0232)	45	35 (0.0197)	75	35 (0.0197) 40 (0.0165)	45 (0.0138)
46	0	30 (0.0232)	30	40 (0.0165)	45	45 (0.0138)	65	45 (0.0138) 50 (0.0117)	60 (0.0098)
60	0	40 (0.0165)	30	50 (0.0117)	45	60 (0.0098)	65	60 (0.0098) 70 (0.0083)	80 (0.0070)
70	0	45 (0.0138)	15	60 (0.0098)	45	70 (0.0083)	70	70 (0.0083) 80 (0.0070)	100 (0.0059)
80	0	50 (0.0117)	15	70 (0.0083)	40	80 (0.0070)	70	80 (0.0070) 100 (0.0059)	120 (0.0049)
90	0	60 (0.0098)	15	80 (0.0070)	40	100 (0.0059)	70	100 (0.0059) 120 (0.0049)	140 (0.0041)
100	0	70 (0.0083)	15	100 (0.0059)	40	120 (0.0049)	65	120 (0.0049) 140 (0.0041)	200 (0.0029)
120	0	80 (0.0070)	15	120 (0.0049)	30	140 (0.0041)	60	140 (0.0041) 170 (0.0035)	230 (0.0024)
150	0	100 (0.0059)	15	140 (0.0041)	40	170 (0.0035) 200 (0.0029)	75	170 (0.0035) 200 (0.0029) 230 (0.0024)	270 (0.0021)
180	0	120 (0.0049)	15	170 (0.0035)	40	200 (0.0029) 230 (0.0024)	65	200 (0.0029) 230 (0.0024) 270 (0.0021)	—
220	0	140 (0.0041)	15	200 (0.0029)	40	230 (0.0024) 270 (0.0021)	60	230 (0.0024) 270 (0.0021) 325 (0.0017)	—
249	0	170 (0.0035)	5	200 (0.0029)	8	230 (0.0024) 270 (0.0021)	38	230 (0.0024) 270 (0.0021) 325 (0.0017)	—

(1) From U.S. Dept. of Commerce Bulletin dated June 1, 1950, "Simplified Practice Recommendation 118-50 - Abrasive Grain Size."

The synthetic mineral abrasives include silicon carbide and aluminum oxide, and they are man-made in electric furnaces. They are crushed and screened to produce the required sizes. To this may be added glass shot or beads which are manufactured of optical crown glass, soda lime type. They are resistant to atmospheric moisture, dilute acids and alkalis, and are annealed in the spherical shape for stress equalization to reduce wear and fracture. Glass bead size ranges from 0.0005 in and larger.

4.4 Vegetable Abrasives

Vegetable abrasives include products such as wheat grains, ground corncobs, crushed nut hulls including walnut or hickory, and fruit pits. These materials are often referred to as “soft grit” and are used in special purpose cleaning and deburring, to prevent the surface from being marred. Examples of such applications include the cleaning of aircraft, automobile, and diesel pistons, electric motor armatures, and pump impellers.

5. RECOMMENDED PRACTICES

5.1 Oxide and Scale Type

Castings, forgings, hot rolled shapes, etc., may be classified into three general groups according to the type of scale or oxide to be removed:

5.1.1 Group A - Heavy Scale

Examples of this group are as follows:

a. Steel castings

b. Alloy forgings—heat treated and annealed

c. Large hot-rolled shapes

d. Certain heat treated gray iron castings

e. Miscellaneous parts for surface effect

5.1.2 Group B - Medium Scale

Examples are as follows:

a. Carbon steel forgings

b. Miscellaneous gray iron castings

c. Miscellaneous malleable castings

d. Light section—hot-rolled shapes and sheet

5.1.3 Group C - Light Scale, Oxides, and Carburizing Smut

Examples are as follows:

a. Heat treated finished parts

b. Nonferrous castings

c. Miscellaneous parts for surface effect

After a part is classified into its proper group, the next step should be the selection of the size of grit or shot to be used. This selection will depend upon a number of conditions and may require considerable experimentation. To clean effectively, it is necessary to use a grit or shot with sufficient impact to break the scale quickly and yet be small enough for adequate coverage. The coverage factor is particularly important when castings with deep or partially accessible cavities are being cleaned. It may be necessary, in some cases, to blend two or more different sizes to obtain the necessary stabilization of sizes in the machine, especially when using slow breakdown type of abrasives. In certain applications, it may also benefit blending shot and grit in the working mix.

A general guide or starting point for selecting abrasive size in a wheel type machine is provided in the impact intensity versus wheel speed chart (Figure 9). Group A materials may require 0.006 to 0.014 ft-lb impact intensity; Group B may require 0.001 to 0.006 ft-lb; and Group C may require up to 0.001 ft-lb. Therefore, the selection of abrasive size will depend upon the wheel speed, as shown by Figure 9.

For example, a steel casting in Group A would probably require an abrasive size between 0.042 and 0.057 with a wheel speed of 2250 rpm. The abrasive size referred to in Figure 9 is, of course, the stabilized size in the machine as screened from a sample taken at the nozzle or hopper discharge chute.

PARTICLE SIZE	NUMBER OF PARTICLES PER LB
0.020	852,000
0.030	252,000
0.040	106,000
0.050	54,000
0.060	31,000

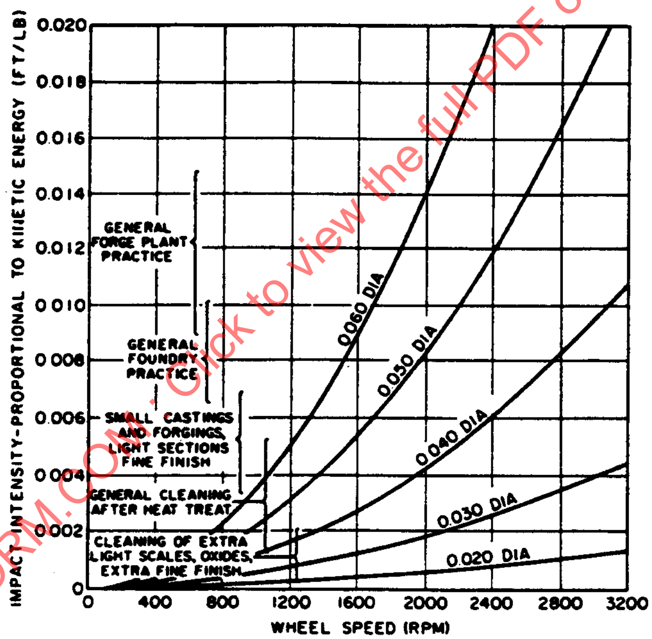

Figure 9 - Impact intensity versus wheel speeds for various size particles, 19.5 inch dia standard wheel

5.2 Cleaning Practices

The following general cleaning practices are recommended:

5.2.1 The cleaning machine should always be loaded to full capacity in order for the pattern to give proper coverage and to prevent excessive wear on the machine barrel or conveyor.

5.2.2 The frequency of exposure of the parts being cleaned to the abrasive spray is an important factor in minimizing the cleaning cycle time. It is recommended that the action of the parts be investigated, especially in barrel-type machines, and necessary steps be taken to reduce sliding action and to increase tumbling action. In some cases welding steel bars on the barrel or conveyor flights will be sufficient. This is just one example for a specific machine type. Different machine types will require other techniques to achieve this result.

5.2.3 Abrasive losses through carry-out can be minimized by tumbling the parts for a predetermined time in batch-type machines, by vibrating parts over a screen in some cases, and by turning by hand or mechanically on the monorail-type machine. In some cases, especially when cleaning structural steel and weldments, it may be required to incorporate a manual station, downstream to the blast compartment, to allow an operator to blowout or vacuum the retained abrasive from the pockets and crevices in the workpiece and minimize carryout.

5.2.4 Adjustment and periodic inspection of the blast gate in a gravity-type separator can be facilitated by installing a small spring-mounted screen and air vibrator under the dribble valve to determine effectiveness of the suction in removing the fines from the abrasive without removing usable abrasives. A discharge chute to collect abrasive not passing through the screen can be employed to return the usable material to the cleaning machine.

5.2.5 It is recommended that a production test procedure be established. This procedure will vary somewhat depending upon the type of material being used, type of machine being cleaned, and individual plant practices. However, the data form shown as Figure 10 and the following methods of accumulating and evaluating data may aid in setting up a procedure:

Type Machine ________ Equipment No. ________

Number of Wheels ________ Wheel Speed ________ Wheel Diameter ________

Type of Parts Cleaned ________

Type of Abrasive ________ Abrasive Size ________

Abrasive Source ________ Abrasive Cost/Ton ________

Date	Total Wheel Hours	Cumulative Wheel Hours	Pounds of Abrasive	Cumulative Pounds of Abrasive	Cumulative Abrasive Cost	Cumulative Maintenance Cost

Figure 10 - Production test of abrasive - data sheet

a. The machine wheel hours on an airless blast machine can be accurately determined by installing an hour meter on one wheel of the machine. The recorded time must then be multiplied by the number of wheels operating on the machine to determine the total machine wheel hours. This procedure assumes that all wheels in a multiple wheel machine are always operating simultaneously. A suggested method of wiring is as shown in Figure 11.

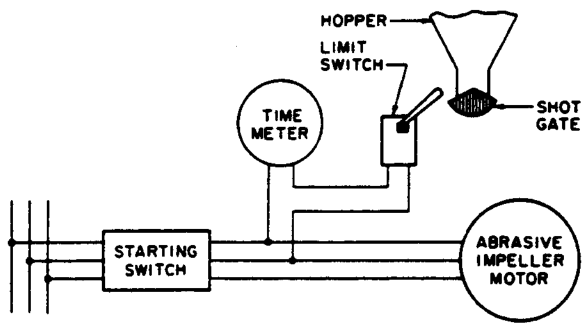

Figure 11 - Wheel timer

b. An abrasive consumption curve shows graphically not only the abrasive usage rate per wheel hour at any time but also the point at which an abrasive reaches a stabilized condition in the machine. Abrasive cost figures and screen analysis should be based on data obtained beyond the point of stabilization.

Any radical change in the slope of the curve during a test is an indication of excessive abrasive losses, negligence in maintaining the proper abrasive level in the machine, lack of recording new abrasive additions, or defective wheel hour timer circuit. See Figure 12.

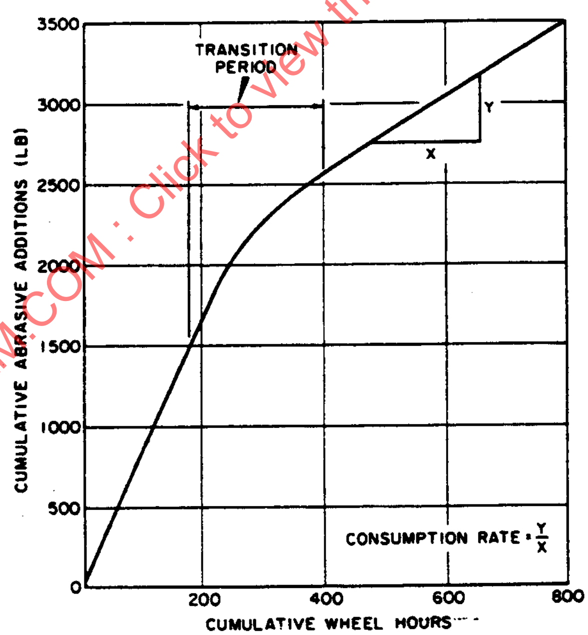

Figure 12 - Abrasive consumption curve

c. Monthly operating cost figures and/or curves can be generated to show comparative costs of abrasives, maintenance materials, maintenance labor, and productive labor. They can be based on either wheel hours or tons of material cleaned. It must be remembered that two abrasives can be compared economically only if all the direct costs are added into the total operating cost.

6. PRODUCTION PROCEDURES

6.1 Control of Abrasive Spray Pattern

When setting up a new machine, and periodically during its use, the abrasive spray pattern should be checked. This is done by placing a suitable piece of sheet steel at the same height and in the same position as the work to be cleaned and exposing to the shot blast for a few seconds. Remove and examine the sheet. If the centerline of the shot pattern, as shown on the sheet steel, is not in the center of the work, shift the work location or adjust wheel or nozzle alignment.

6.2 Control of Abrasive Size

Cleaning in a blast cleaning machine is accomplished when sufficient high velocity abrasive particles impinge on the work surface. The impact energy or work capability of the abrasive thus created is directly proportional to its mass and the square of its velocity (Figure 9). Fine particles have relatively lower mass, which is the reason for their low energy transmission and work capability. If these fine particles (generally below 0.0117 inch U.S. standard screen size) are not removed but are allowed to accumulate to be an appreciable percentage of the machine's abrasive content, the cleaning time will proportionately increase. Thus, control of the abrasive size is necessary to eliminate the finer particles, which break down from continued impact cycles.

The separator of the blast cleaning machine is employed to remove all fine abrasive particles, the fines or sand removed from the work surface, and any heavy flash or scale. The finer materials, if not removed, will cause a contaminating interference, reducing the efficiency of the cleaning operation. The sand, if allowed to circulate through the machine, will cause excessive wear on the blades. Circulation of heavy flash or scale will break blades, wear nozzles, and reduce the life of the machine.

The gravity type separation principle is generally employed in all mechanical type blasting equipment and considered critical in determining cleaning efficiency. An air wash and suction from the exhaust system removes the fines, sand, and dust, as this material and the good abrasive cascade over the edge of stratifying plates. This type of separator is adjustable so that any size particle can be removed. This adjustment is generally made possible by increasing or decreasing the velocity of the air wash by opening or closing baffle plates (blast gates) in the separator exhaust line.

When adjusting, it is good practice to conduct a screen analysis of the abrasive as well as the rejected fines. The level of separation should be high enough to remove all fines or sand from the abrasive, and yet low enough so that good abrasive particles (above 0.0117 inch U.S. standard screen size) are not rejected from the machine.

In the gravity type system, the abrasive and fines or scale from the work are elevated from a hopper located below the blast cabinet to the separator above. Coarse separation or the removal of large flash or scale takes place when the elevator bucket content is passed through a perforated plate or screen.

In cases where a greater amount of coarse separation is necessary, a perforated revolving drum replaces the perforated plate. The abrasive, fines, or small scale, falls through the drum, while the larger flash or scale carries through to a discharge hose leading to a floor mounted trash drum.

After the coarse separation, the abrasive, fines, sand, etc., fall into the fine separating chamber. In foundry applications, with a high sand and/or scale content (Figure 13), this material, after being dispersed by the perforated drum or plate, falls onto an inclined plate. The abrasive, fines, sand, etc., are carried by gravity down the plate and fall over the edge. At this point, the air wash furnished by the exhaust system stratifies the finer material. The heavier, good abrasive, with greater momentum, is not capable of stratification and falls directly into the storage hopper. The fines, sand, and dust are lifted by the air wash up into a series of vertical baffles. As the heavier fines are carried down by the air wash, they resist an upward turn and are deposited into a settling chamber where they leave the machine. The remaining dust held in suspension is carried out to the dust collector by the exhaust system ductwork.

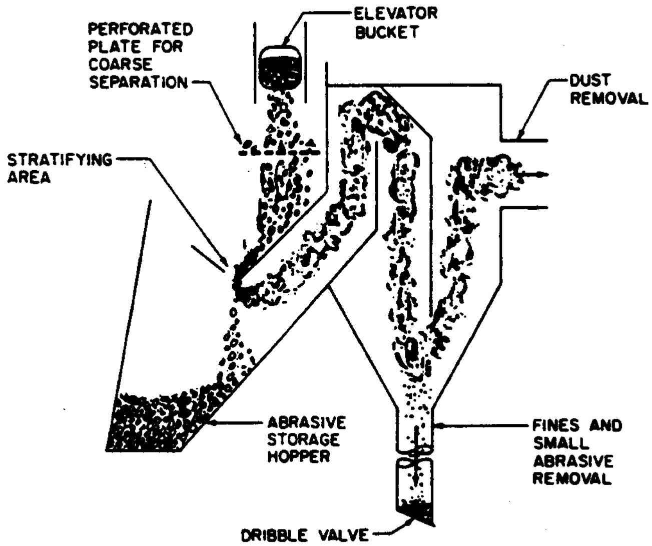

Figure 13 - Small gravity type separator

In a second type of gravity system (Figure 14), coarse separation is also achieved by a perforated rotating drum or plate. In the fine separation chamber, the material passing through the coarse separator is evenly distributed when it falls through a perforated inclined plate. After being distributed, the particles fall over the edge of a second inclined plate where they become stratified. The material is then conveyed via air and gravity down another incline. As the particles fall over the edge of this plate, the heavier, good particles, having greater momentum, resist the air wash and fall directly into the abrasive storage hopper. The heavier fines are partially turned by the air wash and deposited into a fines refuse discharge duct. An adjustable skimmer can be regulated to ensure that all fines are removed.

Removal of larger or smaller particles is accomplished by adjusting velocity through the baffling (slide gates/dampers) in the exhaust ducts. The dust collector or main exhaust system (either dedicated to a machine, or accommodating several machines) draws air from within the machine, creating an air vacuum, which has a dual purpose, that is, to furnish the suction or air wash in the separator to cause stratification of the finer particles and to ventilate the cleaning chamber (blast cabinet) (Figure 15). Baffles B and C are used to balance the total amount of air removed by the dust collector blower or main exhaust system. Closing baffle C will reduce the air velocity in the separator and increase the velocity of the cleaning chamber draft. Reducing the air velocity in the separator (closing baffle C) will cause the removal of smaller particles. Increasing the air velocity (opening baffle C) will cause the removal of larger particles. Baffles B or C should never be closed more than halfway, for this will cause abnormal wear on the piping and elbows. If this becomes necessary, baffle A should be closed, reducing the total velocity.

In all above cases, the setting of the airwash separator Is very critical and should be monitored on a regular basis. The purpose of this setting is to ensure a full length of abrasive curtain across the lip of the airwash separator at all times. Different manufacturers use their individual design criteria to calculate the required airwash length, commonly determined by the application and the allowable lbs. per inch of separator lip. Multiple wheel machines will require a longer length, or multiple airwash separators. Maintenance of a full length of abrasive curtain is important because any gap in the curtain length will result in ventilation air taking the path of least resistance through this gap, without cleaning the dust that is part of this curtain.

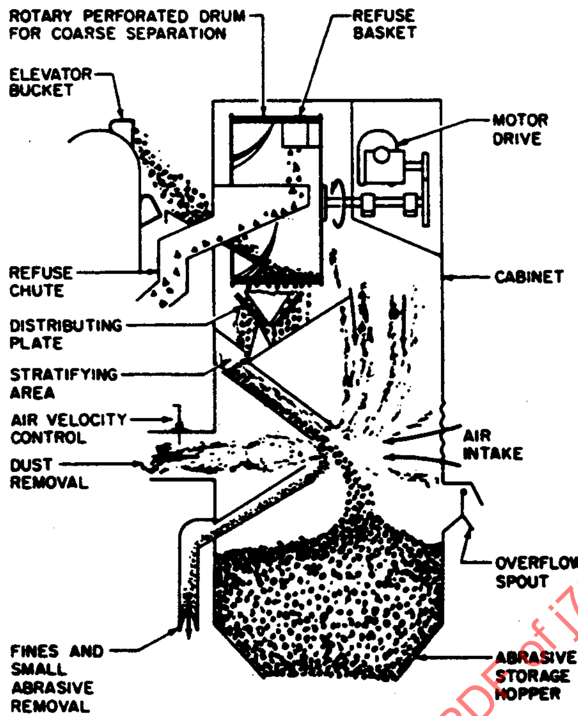

Figure 14 - Large gravity type separator

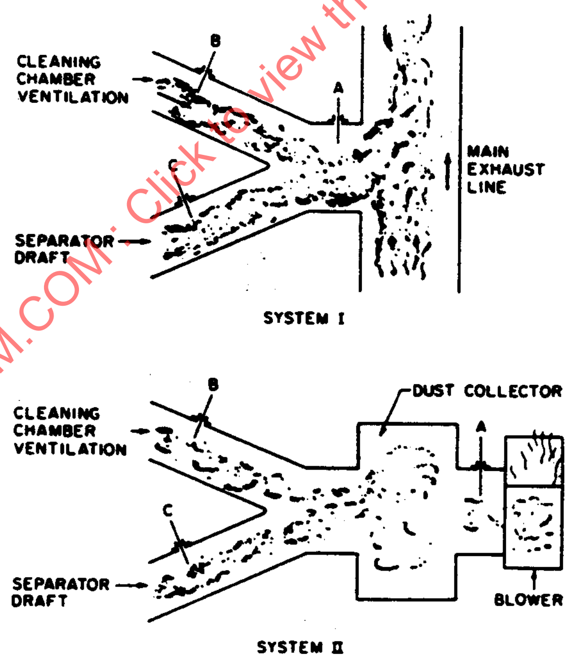

Figure 15 - Schematic drawing of pneumatic system for blast cleaning equipment

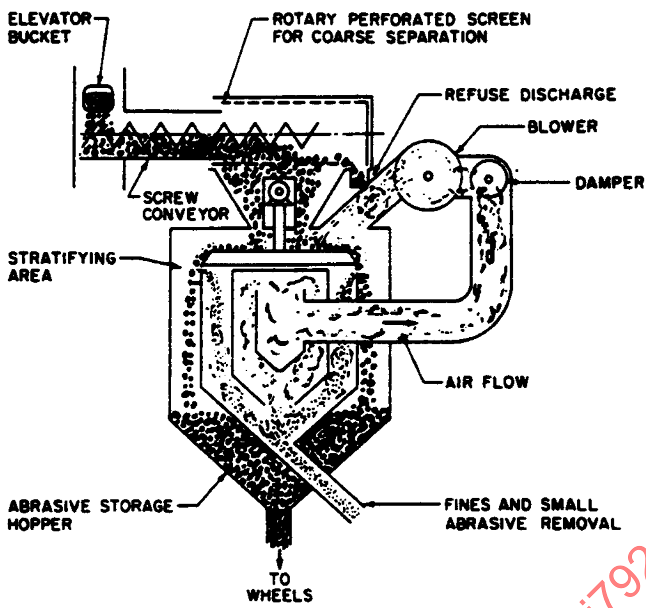

Figure 16 - Rotary type separator

6.3 Control of Abrasive Flow Rate

Cleaning of the work surface is accomplished by particle impact and by having sufficient particles impinge on the work surface—for sufficient coverage. The impact is influenced by the particle size and its velocity. Coverage is influenced by the overall particle size distribution and the flow rate. Thus, control of the flow rate is necessary to maintain coverage. Increasing the flow rate will offer greater coverage and possible reduction in the cleaning time.

The rate at which a wheel can propel abrasive is largely dependent on the horsepower rating of the motor that rotates the wheel. For example, a 15-hp motor and 15-1/2 inch wheel rotating at 3600 rpm will flow approximately 228 to 235 pounds of abrasive per minute. A 25 hp motor powering the same wheel will allow about 400 lb/min to flow through it. For the same diameter and HP of wheel, different wheel openings will change the abrasive flow rate. Greater flow rates require larger motors and correspondingly up-sized reclaim and ventilation systems.

In air blast equipment, the abrasive flow is dependent upon the nozzle size and design.

Control of the flow rate is accomplished by controlling the aperture (orifice plate) through which the abrasive must pass. A larger opening will allow a greater amount of abrasive flow, while a smaller opening will reduce the rate.

To change the flow rate of a machine using an orifice plate, a complete plate having a larger or smaller opening must replace the one in use (Figure 17). With the adjustable metering device, the opening can be changed by moving the baffle plate in or out (Figure 18). Other designs have automated adjustment using pneumatic cylinders and electro-mechanical actuators to facilitate controlling flow. In shot peening machines, where maintenance of a constant abrasive flow is very important, flow control is achieved using valves with closed feedback loops that automatically adjust the media flow to the desired level and maintain it there.

A gate located below the metering device is actuated to stop or start the set flow of abrasive. A manual slide gate above such a metering arrangement allows isolating the valve during times of maintenance.

In smaller equipment (typically airblast), where the storage hopper head pressure is relatively low, an orifice or metering device is not always employed. The flow rate is controlled by merely opening the hopper gate partially or fully. A partially opened gate reduces the rate of flow of the abrasive by diminishing the size of opening at this point.

In a wheel type machine, the motor ampere reading varies with the load on the motor caused by the abrasive flow rate. The ampere reading then becomes a means of determining the flow rate, once a calibration is made.

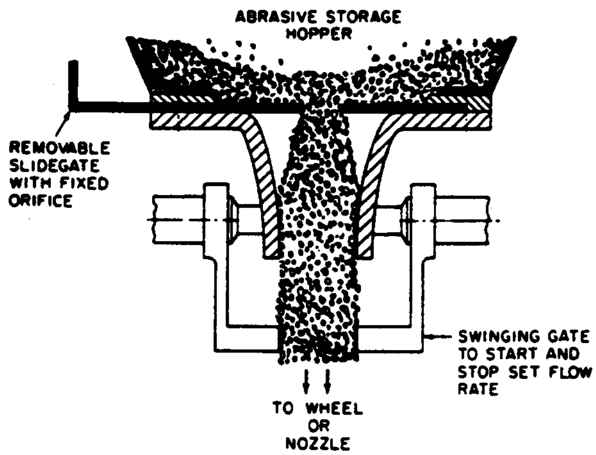

Figure 17 - Orifice type flow rate control

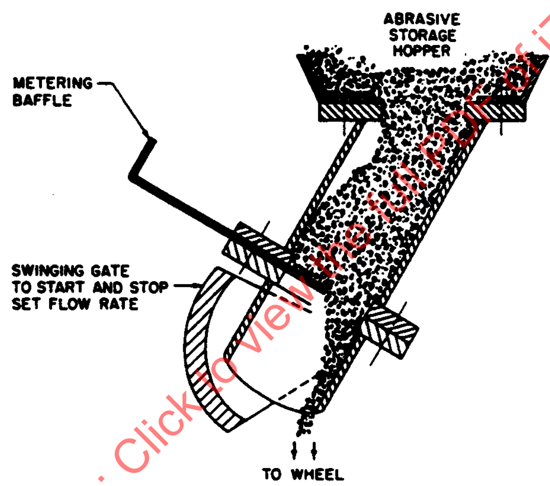

Figure 18 - Metering baffle type flow rate control

A recommended method of determining an unknown flow rate is as follows: collect the abrasive that would normally pass through the control orifice receptacle for a period of 15 seconds. Weigh this abrasive. Multiplying this weight by a factor of 4 will give the weight in terms of pounds per minute.

6.4 Control of Exposure Time

Overcleaning of the work surface is a costly and unnecessary operation. Exposing the work surface to a blast stream for longer periods of time than necessary results in reduced productivity as well as increased abrasive consumption, maintenance, and labor costs per piece. Underexposure, which allows sand or scale to remain on the work surface, is detrimental to tool life and consequently increases the perishable tool costs in the machine shop. Control then becomes necessary to ensure that the work is cleaned properly but without over-exposure.

When cleaning castings, exposure times vary with the size and contour of the work. Smaller parts, which tend to pack closer while being tumbled, or parts with deep cavities generally require a longer cleaning cycle than large, bulky parts. There are some cleaning time differences encountered between castings of the same type, varying pouring temperatures being the cause. High temperatures cause the sand to burn in and become more difficult to remove, necessitating a longer cleaning time. When cleaning forgings, the type of heat treat scale as well as the material, size, and contour of the part affects the cleaning time. When cleaning weldment and fabricated sections, complexity of the workpiece geometry will determine cleaning time. In an automated machine cleaning such work, it is not uncommon to install a manual touch-up station, downstream to the automated blast process, to clean areas that remained uncovered in the automated part of the process.

Methods of controlling the exposure time differ with the type of equipment. For machines that clean the work in batch loads, this control is commonly left to the discretion and experience of the cleaning room supervisor and the operator. Work of a particular type is known to take a prescribed amount of time and is cleaned for that time period. At the end of this period, the abrasive flow and wheel are stopped and the work is emptied. A new work batch is then loaded.

The use of automatic cycle time controls for batch type equipment is common in such machines. After the work has been loaded, the door is closed and the timer is set to a prescribed time period. The hopper gate automatically opens after the wheel has reached its rated rpm. Cleaning is then carried out and stopped automatically at the termination of this time. A light or buzzer indicates when the batch load is ready for unloading. The operator can do other necessary work without being concerned about overcleaning. As a result, a single operator can run multiple machines, leading to increased productivity.

In monorail type equipment, heavier parts such as engine heads or blocks are hung onto a monorail hook and transported through a blast compartment fitted with multiple blast cleaning wheels. Exposure time is controlled by varying the speed at which the monorail conveys the parts through the machine. In some designs, the parts stop and spin in the blast zone to experience greater blast coverage, thereby rendering the operation slower than with a continuous conveyor. In the continuous barrel type of equipment, the work is placed in the cleaning chamber at one end, conveyed through the barrel under the blasting wheels via a tumbling action, and then emptied at the exit end. Several techniques are in use to control exposure time. For example, the angle that the barrel is to the horizontal is adjustable to affect the rate at which the parts are transported through the cleaning chamber. Increasing the angle forces the parts through faster, reducing the cleaning time; decreasing the angle increases the travel time.

In another design, the barrel is remains horizontal and the rate at which the parts are fed controls the exposure time. The entering parts force the work through the machine. The faster the parts are placed in the cleaning chamber, the faster they come out, thus reducing the cleaning time.

In automatic air blast equipment, exposure time in front of the blast is controlled by cycle timers or by varying the conveyor or transfer speeds and feeds. In designs with manipulating nozzles (using a robot or multi-axes carriages), the nozzle traverse speed also determines the cycle time. Certain parts, due to their inherent requirement, may require nozzles to dwell in certain areas to effect proper cleaning.

6.5 Ventilation of Abrasive Blast-Cleaning Equipment

6.5.1 Importance of Proper Ventilation

The proper design (sizing), installation, and maintenance of the ventilation and dust collection systems is necessary for efficient and satisfactory operation of abrasive blast equipment.

The blast operation will not only wear down the abrasive material passing through the wheel or nozzle, but will also “grind” the material being removed from the work, whether sand, scale, paint, rust, etc., into a dust of varying fineness.

The fine dust must be continuously removed from the blast machine to prevent contamination of the air surrounding the machine, since the dust is a hazard to personnel and equipment.

The coarse dust from the disintegration of scale or rust from the work must be continuously removed from the abrasive cycling system, in order to return a proper blasting mixture to the wheel or nozzle.

Dust slows down the cleaning action, increases the length of cleaning cycle, discolors the work, and greatly increases wear.

6.5.2 Elements of an Exhaust System

Equipment manufacturers are expected to follow guidelines established and published by ACGIH (American Conference of Governmental Industrial Hygienists). Manufacturers use such guidelines and customize them to their specific equipment design such as ventilation requirements for different cabinet types (batch type, pass-though etc.), size of bucket elevators, length of airwash separator, velocity requirement in air inlets, vent plenums, etc. In general, it is useful to consider the following broad rules of ventilation systems:

- Determine whether the dust is explosive in nature. This could be from the part generating explosive dust such as aluminum, magnesium, etc., or the abrasive's propensity to generate explosive dust (such as urea). NFPA guidelines and other governing authorities determine the ventilation system design in such cases.

- Ventilation duct velocity is generally in the range of 3500 to 4500 FPM. Duct diameter is to be sized accordingly.

- Manual blast gates (baffles/dampers) with a slider are best installed with the slider in the horizontal orientation. Blast machines experience vibration and a vertically installed slider has the potential to close shut or stay fully open due to vibration.

- Straight length of ducts will require inspection ports at regular intervals (interval length to be determined by standards, but generally at every 10 feet) to clean the duct for dust accumulations.

- Drop-out box, if provided with the blast system and if located at an elevation, should be inspected regularly to ensure that any media collected is constantly discharged to a floor-mounted drum.

An exhaust or ventilation system consists of:

6.5.2.1 Piping or Duct Work

An adequate system of duct work must be constructed of suitable material, diameter, and—with the required elbow radius—length of tappers, etc. Ducting should be maintained in good condition and the joints and connections checked periodically to prevent possibility of leakage or wear.

Follow the recommendations of the equipment manufacturer in regard to system design, materials of construction, etc. Have a competent metalsmith install the system, preferably someone who has had wide experience in the design and installation of industrial exhaust systems.

6.5.2.2 Dust Collector

A properly sized dust collector is an important part of the exhaust system. It must have ample capacity for both the air volume and dust load involved. The dust collector type must provide collecting efficiency in keeping with the requirements of the point of discharge of the cleaned air. The unit must be operated and serviced in accordance with manufacturers' recommendations in order to realize the greatest value and utility.

There are several types of collectors commonly in use on abrasive blast equipment:

a. Dry-Type Dust Collectors

1. Cloth tube (bag or stocking type). Uses woven fabric bags without an internal wire mesh support.

2. Cloth envelope or screen type. Uses woven fabric bags over an internal supporting wire mesh frame.

3. Pleated cartridge with manual or automated compressed air pulsing to clean the dust from the pleats.

4. Dry centrifugal (high efficiency cyclone), which is characterized by relatively small diameter body with relatively long cone. It often has a small constant unit capacity and is usually employed in multiples.

5. Dry centrifugal ("common" cyclone), which is characterized by relatively large-diameter body with short or medium cone length. Usually, a single unit is employed, with size varying according to capacity required.

6. Dry dynamic (combination cyclone -collector), which is usually used as a pre-collector to trap separate bulk of the extremely coarse dust upstream to the baghouse or cartridge collector.

b. Wet-Type Dust Collectors

1. Wet centrifugal, usually in the form of a tower with multiple stages of baffles to provide increased area of wet surfaces for impingement and a tortuous path for the dusty air.

2. Wet orifice type employing specially shaped passages for the concurrent flow of air and water, plus baffles for impingement. Some models employ power-driven rolls or drums for water.

3. Wet dynamic type (combination exhauster-collector) often employing a primary chamber for the settling of coarse dust and the storage of collected sludge.

Collector types (a4), (b1), and (b2) must be operated at rated capacity for maximum efficiency. It is wise to provide a gated stub in the pipeline to such a collector to provide make-up air, if necessary.

A central exhaust system serving several machines, possibly of different types, is often used successfully. However, an individual exhaust system for each blast machine is recommended as being a more flexible arrangement.

6.5.2.3 Exhaust Fan and Necessary Drive Equipment

The exhaust fan is the third main component of an exhaust system. Common types of exhaust fans include: small cast iron or large steel plate “planning mill” exhausters, and large steel plate backward pitched blade exhausters with load limiting characteristics. Propeller fan, “axial” flow fan, and ventilating (low pressure) fans used in comfort air conditioning systems are not suited for use with blast machines.

The exhaust fan casing and rotor must be whole, and suitably balanced. The rotor must revolve in the right direction (blade tips moving in the same direction as the path of air discharging from the outlet) and the rotor must be located from side to side in the casing, according to manufacturer’s recommendation. The drive must operate with minimum slippage. Direct-connected fans are seldom used. A V-belt drive with overhung sheave is the popular type of drive.

6.5.3 Adjustment of an Exhaust System

An abrasive blast exhaust system should be adjusted so that the machine surroundings are visibly clean during the blasting cycle, and so that the abrasive is nearly free from fines and dust. However, this condition can only be achieved with proper maintenance of the machine dust seals and other dust emitting components in the machine. Airwash separators not adequately sized to handle the dust loading could also result in dust dissipation to the area surrounding the blast machine.

6.5.3.1 Abrasive Separators

There are three basic types of abrasive separators used on blast equipment. These are as follows: gravity separator, closed-cycle gravity separator, and rotary separator. Their function is to airwash useless fines and dust from the abrasive stream after they have been spent against the work. The basic operation of the three types is the same: the abrasive is cascaded in a spreadout stream or curtain over the end of an inclined shed plate. Air is exhausted through this stream into a duct under this shed plate. An expansion chamber within the separator settles out a coarse fraction of the sand or scale. This is discharged through a dribble (airlock) valve, and flexible tubing, to a floor box. In the gravity separator, all the exhausted air passes to the exhaust system. In the closed-cycle gravity and rotary separators (having an integral exhaust fan independent of the ventilating system), the air is returned to the separator, except for a controllable fraction, which is bypassed into the exhaust system. The separators with integral fans will remove coarse contaminants, with a fixed airflow, independent of the exhaust system. The bypass into the exhaust system reduces the recycling fine dust to a satisfactory level.

An uneven or discontinuous curtain of abrasive over the shed plate will upset the separator operation. With a proper curtain, the separator blast gate (gravity separator) should be opened to the point of carrying over a detectable amount of full sized shot or grit, then backed off slightly. A proper blasting mixture will include fractions of smaller-than-full-size new abrasive, up to the fifth smaller commercial size. However, it is false economy to try to hold the bulk of finer metallic particles in the stream. The fraction settled out in the separator expansion should be thrown away or used in an operation requiring smaller abrasive. It should not be returned to the same machine. If it is necessary to return abrasive to the same machine, it is an indication that the separator is improperly adjusted. If the discharge of the settled material is dusty, open the adjustable sleeve on the dribble valve just enough to offset this condition.

6.5.3.2 Abrasive Elevators

The blast gate in the duct from the elevator should be opened only enough to prevent escape of dust into the room.

6.5.3.3 Abrasive Blasting Chamber

There are three general types of exhaust arrangements for blast machines. These are:

a. Baffled outlet on top of the machine (self-draining into the top of the cabinet) with the exhaust duct leading to the line-size abrasive trap installed in the horizontal run of the exhaust duct, the trap located to drain back into the machine through the dribble (airlock) valve and the flexible hose.

b. Tapered outlet (non-baffled) on top of the machine with the exhaust duct leading to the oversize abrasive trap located as above.

c. Expansion box (usually internal) large enough to eliminate the need of auxiliary traps or baffles. The duct from the top of the expansion leads directly to the dust collector.

If abrasive traps are used, and if the internal baffle is adjustable, the bottom of the baffle should be one-fourth the diameter of the trap pipe opening above the bottom of the opening or collar. If an oversize trap is used, the inlet connection must be a long taper from pipe diameter to trap diameter. An identical taper should be used on the trap outlet, if space is available. The blast gate(s) should be open enough to provide clean surroundings during the blasting cycle. All trap reclaim should be returned to the machine.

6.5.3.4 Blast Gates

Standard slide type blast gates are usually used in all branch exhaust lines from blast equipment. These gates should always be as remote from the machine collar as possible, should never be located between machine collar and abrasive trap, and should always be installed with the slide travel horizontal. Usually, these branch gates are used only for balancing the exhaust between the various branch pipes. If closed more than halfway, abnormal wear on piping and elbows will result. They should never be used for throttling an abnormal capacity system. Either throttle the fan inlet or outlet or a separate collector system or install a throttle gate in the machine main duct at its junction with the large main of a central exhaust system.

6.5.4 Care of a Cloth-Type Collector

These instructions are necessarily brief and are recommended unless they conflict with the directions supplied by the manufacturer:

6.5.4.1 Care—Daily Attention

a. Hoppers should be emptied daily when the exhaust fan is not operating. Shaker devices should be operated before emptying the hoppers, not after. Make sure that the hoppers are clean; do not presume that the hoppers are empty just because dust stops flowing. Make sure that the hopper vales are closed after emptying, before the exhauster is started again.

b. Shaker devices (when provided to dislodge the dust from the filter bags) should be operated every 4 hours if possible, for about 2-1/2 minutes, when the exhaust fan is not operating. If your collector is equipped with an automatic shaker timer, the shakers will operate each time the exhauster is shut off; after an automatic time delay to allow the exhauster to coast to a stop. If you should start the exhauster before the automatic cycle is completed, the shaking will stop instantly, and the timer will reset for the next cycle.

If your collector is equipped with a draft gage indicating draft loss through the cloth, then, as a general rule, when the draft gage shows 2 inches differential pressure through the bags (one side of the manometer to the clean air side and the other to the dirty air side), it is time to operate the shaker devices.

NOTE: Cartridge style collectors are typically provided with pulse valves that pulse compressed air to a bank of cartridges as means to clean/dislodge the dust collected in the pleats of the cartridges.

6.5.4.2 Lubrication

The fan and shaker device should be lubricated once a month (where lubrication fittings are provided), under normal service, with the recommended ball-bearing grease. The fan and shaker motors should be lubricated according to the maker's instructions, or as per your shop practice.

6.5.4.3 General Attention

It is advisable to inspect the interior of the collector at regular intervals, watching for worn bags, cartridges, or envelopes, and to check on the mechanical condition of the shaker device. Baffle plates should be replaced when worn appreciably.

6.5.5 Conclusion

The ventilation and dust collection system for an abrasive blast machine is necessary to achieve the maximum production, minimum costs, and best quality of work.

7. INSPECTION

Inspection for cleanliness of the workpiece is a rather undefinable procedure. Cleanliness in itself is a relative matter, and the degree of cleanliness desired for a certain piece of work is reasonably indeterminate and not readily specified. However, before one can inspect, the inspector must have some specification and idea of the actual requirements. This information is usually supplied by the process department or the division that will perform the next operation on the parts. There is no generalized specification that can be applied to suit any or all conditions.

The best and most widely used means of inspection for cleanliness of any type of work is visual inspection. Here, the inspector observes the surface conditions of the casting, forging or other type of work to see if they meet the established requirements. If the workpiece is a casting, visual inspection would consist of looking for sand in the critical areas or perhaps on all surfaces, depending on the nature of the end use. In intricate castings with considerable core work, it is sometimes possible to be lenient on the complete removal of sand from the hard-to-get-at-places, provided such leniency does not affect the final usage of the casting.

Certain methods of inspection are used other than visual observation. One of these is the scratch test. A chisel or sharp instrument is used to scratch a critical area of a casting to determine if the sand has been completely removed. Burned-in sand will appear as a white mark as the sharp instrument scratches over it, while the metal will appear in the normal dark color.

Another test used on ferrous castings or forgings or other types of work is the copper sulphate test. Here, a concentrated solution of copper sulphate in water is applied with an eye dropper or small brush to the surface of the work. Scale that has not been removed from the work will appear black, while a clean area will "plate-out" copper color. This test is rather widely used.

Another test commonly used for gray iron sand castings (especially bathtubs and other sanitary ware) is the heating up of the casting to a cherry red temperature and then allowing the casting to cool—this procedure is called "burning-in." Here, any sand that is left on the surface will appear very light gray, while the remainder of the casting will be black. This clearly indicates the amount of sand on the surface of the casting.

Other requirements for inspection may include surface roughness and type of etch. In castings (both ferrous and nonferrous), as well as forgings and roll-steel products, there are many instances where the surface roughness of the final cleaned product is of considerable importance. This is defined by the requirements of the parts in question, and it is a good idea to have a comparator sample to use. This specimen would be a sample of the type of surface desired that will permit visual inspection to see if it has been attained. Considerable care and judgment should be exercised in preparing the comparator so that it will properly serve its purpose. If the surface condition is of little or no importance, this should be disregarded.

8. MAINTENANCE OF BLAST CLEANING EQUIPMENT

Blast machines are very effective in cleaning rust, scale and other contaminants from steel components. Unfortunately, they have the same effect on the exposed machine parts as well. Therefore, regular (routine and preventive) maintenance is critical for efficient plant operation. Blast cleaning maintenance costs could amount to one-third the total cost of the operation. Therefore, preventive maintenance is highly recommended on this equipment.

It is best to follow the equipment manufacturer's recommended maintenance procedures including inspection routines.

Some of the general items that should be checked regularly are as follows:

1. Any abrasive that has spilled or accumulated around the machine should be cleaned up and returned to use only after screening out the contaminants.

2. Keep the machine loaded with parts so that the parts cover exposed areas of the conveyor or other work loading surfaces and reduce the wear on them. If the loading is not continuous the abrasive should be shut off between loading intervals.

3. Proper abrasive flow must be maintained for the type of abrasive used, and abrasives must be kept free of any contaminants which might clog the regular flow.

4. Setup tested and defined cleaning cycles whenever possible so that the parts are not run longer than necessary. However, please note that visual inspections are the only means of determining acceptable levels of cleanliness, and that factor determines the cycle time.

5. The abrasive should be added at regular intervals and in quantities that are in relation to the amount of fines generated. Keep the abrasive supply hopper full. The operating rule is to add frequently, in small quantities.

6. In wheel type equipment all wheel parts that come in direct contact with the abrasive—including the blades, control cage, and impeller—should be checked regularly and replacements made so as not to cause the wheel to become unbalanced. Blade inspection is relatively easier as compared to the other components as this can be accomplished from inside the cabinet, without needing to dismantling the wheel.

7. The blast pattern generated by individual blast wheels consist of a hot spot, head stream and tail stream. The hot spot is the area of maximum abrasive concentration, and its shift created by wear of wheel components could alter the quality of cleaning. Therefore, it is important to verify the location of the hot spot at defined intervals with a pre-established template (typically created with new wear parts in the blast wheel).

8. Ventilating and dust systems must be properly adjusted for efficient operation. When dust is not controlled it will create hazardous working conditions, possibly damage other equipment in the vicinity and reduce the cleaning efficiency of the machine. The exhaust system should be finely adjusted so that all the dust is removed but none of the abrasive is carried out.

9. The blast cabinet should be regularly inspected for wear and leaks to prevent loss of abrasive and spillage around the machine.

9. TESTING OF SHOT LIFE IN THE LABORATORY

It has been well established that abrasive breakdown is the primary cause for inefficient blast operation. Premature breakdown not only results in higher abrasive costs but also leads to an increase in other operating cost elements such as wear parts and labor for maintenance. Therefore, it is useful to follow an established test procedure for lab testing of abrasive so that breakdown rate for a particular media type and size can be estimated. In a lab test, in addition to durability, the abrasive is also tested for its several properties such as its hardness, chemistry, mechanical appearance (presence of voids and other surface defects) since all these have a direct impact on the durability of the abrasive.

It is generally agreed that breaking down the shot by subjecting it to repeated impacts under its own momentum provides results most likely to correlate with service performance in a production style blast machine. Accordingly, drop-hammer impact tests, ball mill tests, crushing tests, etc., are regarded as unsatisfactory.

Testing machines, devices to subject the shot particles to impacts due to their own momentum, have been developed and are described later.

It is the purpose of this section to describe how these machines may be used.

All these machines have a means of accelerating the shot particles to velocities likely to be encountered in service (about 200 fps), and some sort of target, which the shot particles strike. The sample to be tested, therefore, is repeatedly accelerated to a fixed velocity and subjected to the impact of striking a target. The number of times that the shot particle can be subjected to such treatment before failure is the value that is measured.

Failure is a subjective term when used with abrasive breakdown. It is determined by the extent to which the user chooses to use broken down abrasive before discarding it as waste.

The number or cycles that a particular single shot particle can endure before failure is easily determined. The number of cycles that this particular particle could be subjected to impacts before it fails is a direct measure of the endurance of the abrasive. In this case, however, we are confronted with a sample that has hundreds or even thousands of particles. Therefore, it is necessary to determine the average life of the group of particles.

The procedure usually follows this pattern:

1. A sample that is as nearly representative of the whole as possible is obtained.

2. This sample is put through standard sieves and separated into the various sizes.

3. A sample of 100 gr is taken from the sieve holding the largest proportion of the original sample.

4. This 100 gr is then put into the shot tester. As it passes through the tester, it is subjected to several impacts. In the case of the Ervin test machine, the sample is run 500 passes per test run. The sample is then removed from the machine and test screened on an 8” diameter screen of defined opening for about three minutes to remove all fines from the metallic shot. The % retained is then determined and the lost sample is replaced until the weight adds up to 100 g. Multiple test runs are performed until 100% of the shot is replaced. Durability is then determined by using the formula: Total passes - (passes per test run / % last lost) x (accumulative % loss - 100). This procedure is listed as one of the examples in SAE J445 - Metallic Shot and Grit Mechanical Testing - 100% Replacement Method. However, it is acknowledged that other procedures exist from different manufacturers.

5. After a predetermined number of passes or time, the sample is removed from the tester and screened, using screens with selected opening sizes. The selection of screen opening size depends upon the definition of failure. Since shot is used mainly for blast cleaning purposes and shotpeening purposes, we use the following definitions of failure:

   a. For blast cleaning, the shot particles are considered broken when they pass through a screen with an opening of 0.0117 inch (No. 50 U.S. standard sieve), for shot of sizes SAE 230 and over. For the smaller sizes of shot, a screen with an opening of 0.0049 inch (No. 120 U.S. standard), is used. The choice is made because some production machines discard material when such a small size is reached.

   b. For shotpeening, the particles are considered broken when they pass through a screen with an opening next in line smaller in the U.S. standards than the sieve that held the material at the beginning of the test. For example, suppose the 100 gr sample to be tested was held initially on a sieve with an opening of 0.033 inch; then the sieve to be used for measuring the breakdown would be one with an opening of 0.028 inch. The choice of this definition of broken material for peening is based on the premise that full sized and uniform particles are wanted in a controlled peening operation, though it is acknowledged that this is sometimes impractical. Another important aspect to note in terms of shot peening machines is that such machines should be also fitted with a vibratory classifier that is expected to screen out sizes that are not in line with the requirement of the process.

   If shot testing is to be done with some particular production machine in mind, the definition of failure, and hence the size of “breakdown” screen used in the test, should correspond with the size of the material being discarded as useless by the machine.

6. The data obtained from the sieve analysis are plotted on a chart such as Figure 19, which shows the percent broken versus the life in passes or time.

7. Repeating the testing and separation of broken particles from the good particles, as many points as desired can be obtained to establish this curve.

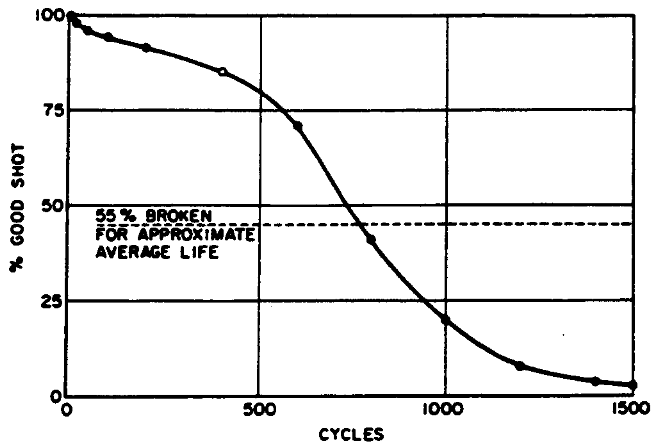

Figure 19 - Typical breakdown curve

Now comes the question of how this curve should be interpreted. We want an expression for the average life, because shot is fed into the production machine on the basis of average life. For a true value of the average life, this curve must be established accurately and completely—that is, until all the particles are failed (see peening breakdown curve, Figure 19). From the curve, one can see that some of the particles are weak and break down quickly, while others last a long time. To find the average life, it is necessary to add up the individual lives of all the particles and to divide by the total number of particles. This can be done by measuring the area under the curve and dividing by the height of the diagram. This procedure is yet another example listed in SAE J445 - Metallic Shot and Grit Mechanical Testing - Average life by measurement of the area under the breakdown curve.

Since curves for different shot materials are quite similar in nature, an approximation of the average life can be obtained by determining the life at the point where 55% of the sample is broken.[3] The value of 55% was established experimentally by measuring a number of typical diagrams.

To continue, there are definite liberties which can be taken, deviating from what has been said. For example, for testing incoming shipments of material, it would only be necessary to run the sample for some predetermined number of passes and measure the percentage of shot that is still good, provided that the selected number of passes is near the 55% breakdown point. A specification can be readily set up for this type of inspection.

It is not to be construed that these life tests tell the whole story about the performance of shot in blast cleaning operations. Proper consideration must be given to hardness. It can be appreciated that, in order to break or cut the scale from the surface, the stress at the instant of contact must be great enough to exceed the breaking strength. If a particle flattens out when it hits the work surface, it cannot produce the same stress as a particle that stays reasonably sharp. Long fatigue life can be obtained with relatively soft material, but its cleaning ability is also low. A compromise, then, must be made between the life and the hardness. In general, harder abrasive tends to be brittle, leading to faster fractures and breakdown. Good results seem to be obtained with shot of “spring” hardness.

9.1 Shot Testing Machines

As a result of committee activities directed toward establishing a common testing procedure for shot quality, there are at present four testing machines. These are described here in the order in which they appeared.

[3] From SAE Iron and Steel Technical Committee, Division 20.

9.1.1 American Wheelabrator Shot Tester

The shot tester developed and used at American Wheelabrator and Equipment Corp. consists of a centrifugal wheel 4-5/16 inch in diameter. The wheel is driven by a 1/2-hp electric motor by means of an adjustable-speed belt drive. The wheel speed is adjustable between 5000 rpm and 10000 rpm in order to obtain the influence of wheel speed on the life of shot. The handle at the rear of the tester is attached to an adjusting screw for selecting the desired speed.

Surrounding the wheel is a specially designed, hardened-steel target. This target is provided with internal teeth, somewhat like an internal gear. Figure 20 shows a cross section of the wheel and target. The teeth of the target are inclined at a helix angle of 15 degrees for the purpose of deflecting the shot into the hopper below, to prevent rebound of shot back into the wheel.

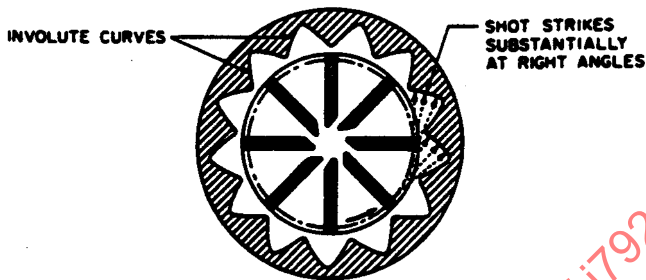

Figure 20 - Shot tester - wheel and target

9.1.2 Pangborn Ev-1 Shot Tester

The Pangborn shot tester (Figure 21) is a small laboratory machine developed for the purpose of comparing different types of abrasive by means of a breakdown test.

It is a vertical type of tester with a centrifugal wheel 4-1/2 inch in diameter mounted on a vertical spindle, which runs on ball bearings. The wheel rotates counterclockwise (when looking into the wheel from the top of the machine).

The speed of the wheel is adjustable from 0 to 10500 rpm. At 9315 rpm the abrasive is propelled at a speed equal to that of a standard 19-1/2 inch wheel running at a standard speed of 2150 rpm.

The drive for the wheel is mounted in the bottom of the cast-aluminum housing of the machine. The blasting compartment, which is lined with rubber, is in the top.

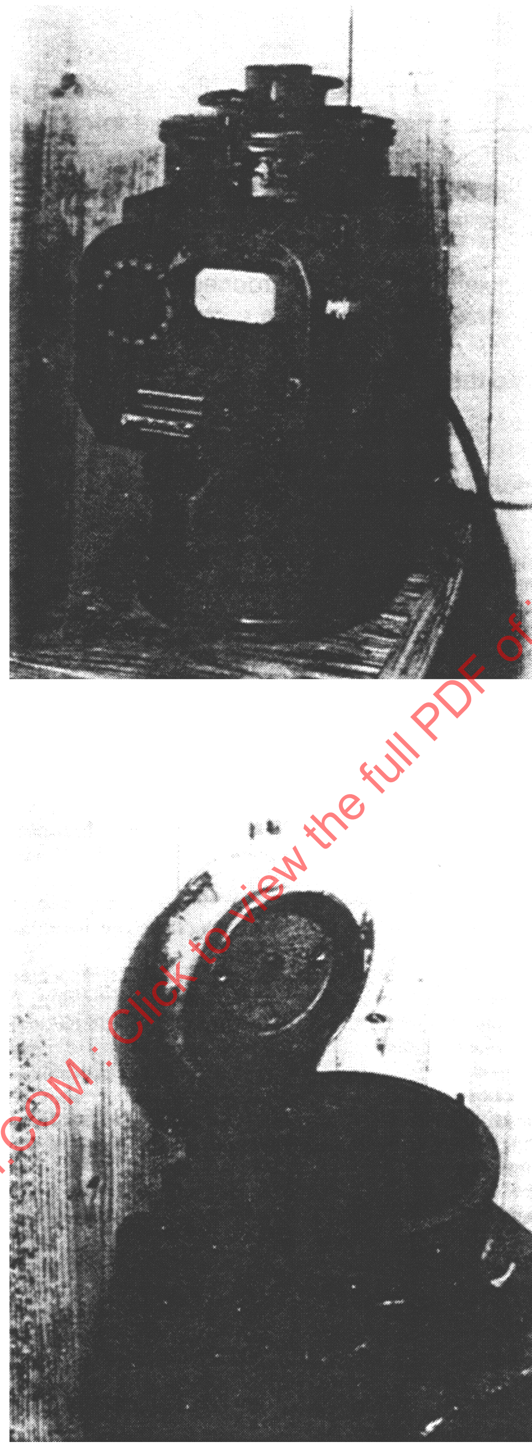

__Figure 21 - Pangborn shot tester__

The blasting compartment has a bottom, which slopes 45 degrees into an outlet spout, on the end of which is inserted the receptacle receiving the abrasive after it has passed through the wheel.

A 1/3 hp, 12000 rpm universal motor drives the wheel. It is located directly under the spindle and connected to it by a flexible coupling. A pickup unit, driven from the vertical spindle through a belt, is also mounted in the bottom of the housing. This pickup unit registers the speed of the wheel on a speed indicator mounted on the front of the machine.

A hinged cover, mounted on the top of the housing, allows access to the blasting compartment. The anvil is mounted on the bottom side of this hinged cover and has a 17-1/2 degrees angle surface on which the shot, hurled from the wheel, is impacted.

Mounted on the outside and in the center of the hinged cover is a cone-shape receptable with a removable orifice in the bottom for feeding the abrasive uniformly to the center of the wheel.

Several instruments and controls are mounted on the front of the machine: a speed indicator for registering the speed of the wheel, a voltage controller for adjusting the speed of the wheel, a counter for registering the number of passes of shot or abrasive through the machine, an on and off switch for starting and stopping the motor, and a fuse to protect the motor.

The machine is equipped with an extension cord, which can be plugged into any 110 V light circuit.

9.1.3 Ervin Test Machine

This machine was developed to give accurate breakdown results and do the job automatically and obtain accurate results in a comparatively short time. It has a recycling device that returns the material to the beater wheel, which is used for accelerating the shot against an anvil. This machine is shown in Figures 22 and 23 (inserted new pictures); it operates automatically. The shot particles are accelerated by means of a belt-driven wheel, and the axis of rotation is horizontal. The target is inclined at a slight angle to the direction of discharge from the beater wheel. This anvil is driven by a separate motor by means of a belt and rotates about the same axis as the beater.

The alloy metal abrasive shot tester machine has the following features:

9.1.3.1 The Ervin test machine was designed to simulate the action of a production blast cleaning and/or shot peening machine and provide a laboratory tool to quickly test the performance of metal abrasives.

9.1.3.2 During testing, the abrasive is propelled by a centrifugal wheel or beater head rotating at approximately 7000 rpm which accelerates the abrasive to a velocity of approximately 200 ft/s, comparable to the velocity of a production blast cleaning or shot peening machine. The abrasive is thrown against an anvil surface. After impact, the abrasive falls to the bottom of the rotating anvil recycling assembly which picks up the abrasive and returns it to the wheel where it is thrown against the anvil surface again. The anvil recycling assembly rotates at 25 rpm which means that the abrasive is recycled through the wheel 25 times per minute.

9.1.3.3 This machine will make a complete and accurate breakdown test in a comparatively short time, even for long life materials.

9.1.3.4 The machine is equipped with a feature to test the transmitted energy of the abrasive using an Almen A strip mounted on an Almen block. During durability testing, the peening attachment is replaced by a plug that continues the curved surface of the anvil. For testing of transmitted energy, the plug is replaced with the peening attachment which holds the Almen strip in the path of the abrasive being tested. The operation other than charging and discharging the material is automatic.

9.1.3.5 The charging and discharging the material from the machine requires only the removal of a rubber plug.

9.1.3.6 The Ervin test machine should be recalibrated with every 20 durability test or after any mechanical changes (such as new V-belts) in order to maintain reliable results. An S-550 calibration shot developed in the Ervin laboratory is supplied with the machine for this purpose.