



# SURFACE VEHICLE INFORMATION REPORT

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(R) SAE Manual on Blast Cleaning

## RATIONALE

This revision considers necessary changes in language to address all the developments in blast 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.<sup>1</sup>

<sup>1</sup> Refer to "Modern Blast Cleaning and Ventilation," by C.A. Reams, Cleveland, Ohio: Penton Publishing Co., 1939.

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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 prevalent, 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](http://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

"Hydro-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.

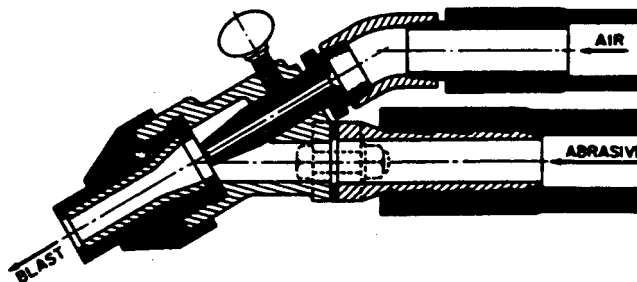


**Figure 1 - Induction nozzle**

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.

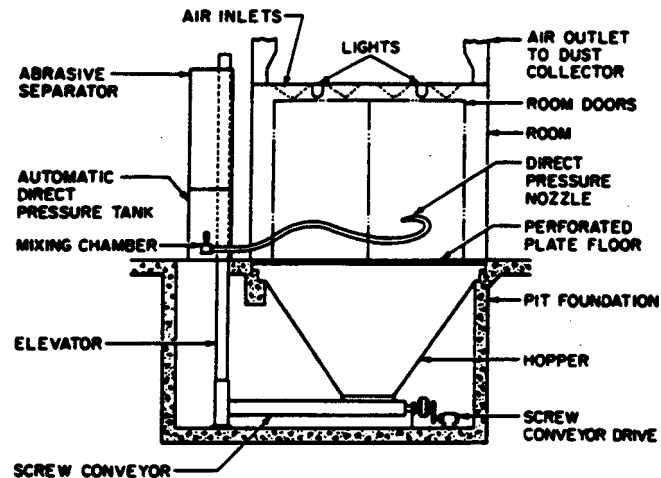


**Figure 2 - Hand blast room**

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.

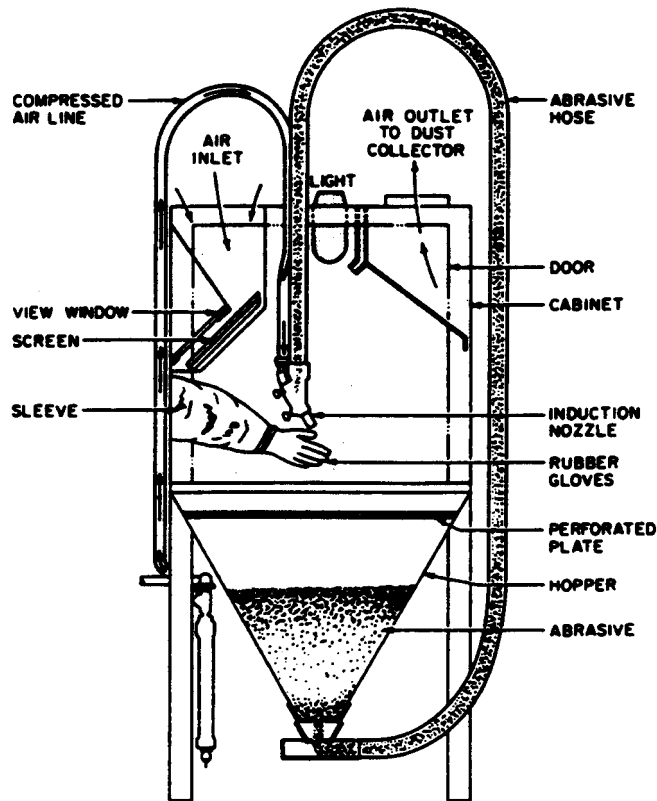


*Figure 3 - Induction cabinet*

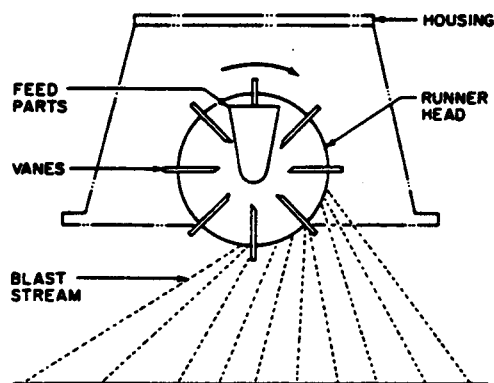


*Figure 4 - Centrifugal wheel*

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.

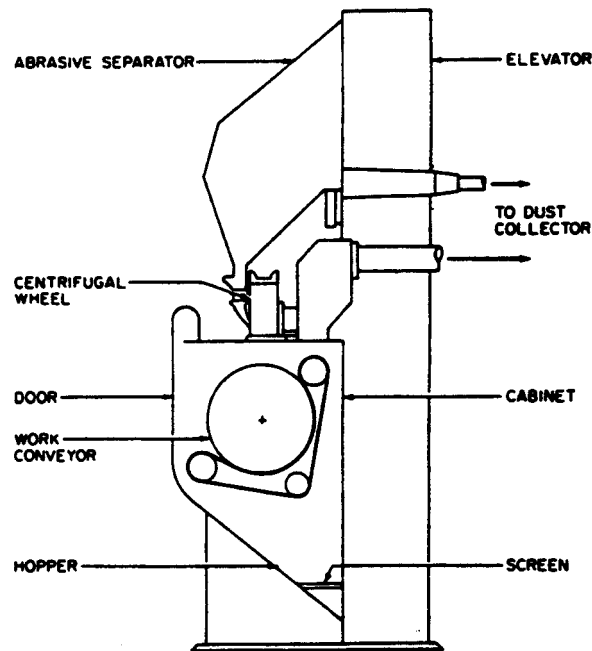


**Figure 5 - Batch barrel**

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.

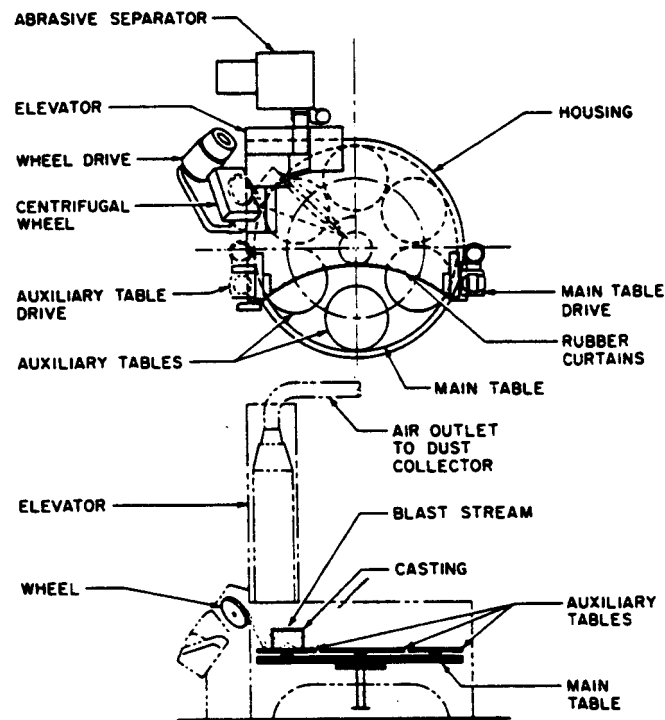


Figure 6 - Table type machine

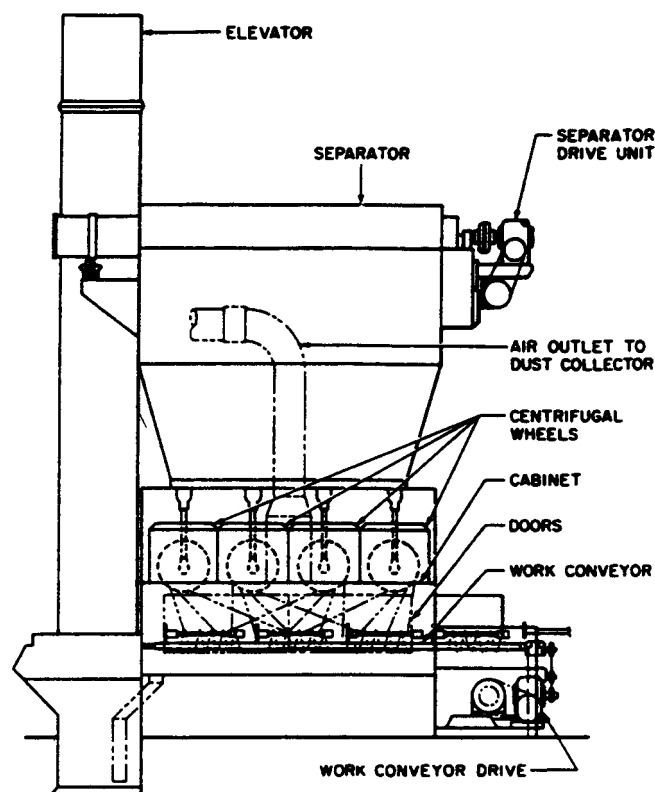


Figure 7 - Multiple-wheel machine

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.

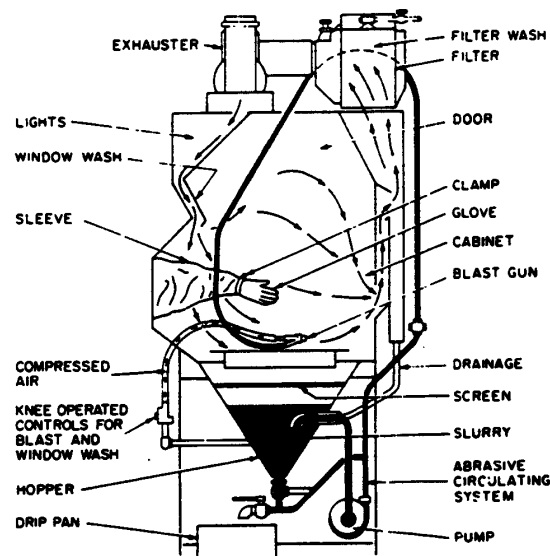


**Figure 8 - Schematic of equipment for wet blasting with fine particles  
(detail arrangement varies among manufacturers)**

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.<sup>2</sup>

#### 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.

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<sup>2</sup> 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<br>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<sup>(1)</sup> (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)<br>20 (0.0331)                   | 25 (0.0280)             |
| 24                | 0               | 14 (0.0469)             | 20              | 20 (0.0331)             | 45               | 25 (0.0280)                  | 75<br>-           | 25 (0.0280)<br>30 (0.0232)                   | 35 (0.0197)             |
| 30                | 0               | 18 (0.0394)             | 20              | 25 (0.0289)             | 45               | 30 (0.0232)                  | 75                | 30 (0.0232)<br>35 (0.0197)                   | 40 (0.0165)             |
| 36                | 0               | 20 (0.0331)             | 20              | 30 (0.0232)             | 45               | 35 (0.0197)                  | 75                | 35 (0.0197)<br>40 (0.0165)                   | 45 (0.0138)             |
| 46                | 0               | 30 (0.0232)             | 30              | 40 (0.0165)             | 45               | 45 (0.0138)                  | 65                | 45 (0.0138)<br>50 (0.0117)                   | 60 (0.0098)             |
| 60                | 0               | 40 (0.0165)             | 30              | 50 (0.0117)             | 45               | 60 (0.0098)                  | 65                | 60 (0.0098)<br>70 (0.0083)                   | 80 (0.0070)             |
| 70                | 0               | 45 (0.0138)             | 15              | 60 (0.0098)             | 45               | 70 (0.0083)                  | 70                | 70 (0.0083)<br>80 (0.0070)                   | 100 (0.0059)            |
| 80                | 0               | 50 (0.0117)             | 15              | 70 (0.0083)             | 40               | 80 (0.0070)                  | 70                | 80 (0.0070)<br>100 (0.0059)                  | 120 (0.0049)            |
| 90                | 0               | 60 (0.0098)             | 15              | 80 (0.0070)             | 40               | 100 (0.0059)                 | 70                | 100 (0.0059)<br>120 (0.0049)                 | 140 (0.0041)            |
| 100               | 0               | 70 (0.0083)             | 15              | 100 (0.0059)            | 40               | 120 (0.0049)                 | 65                | 120 (0.0049)<br>140 (0.0041)                 | 200 (0.0029)            |
| 120               | 0               | 80 (0.0070)             | 15              | 120 (0.0049)            | 30               | 140 (0.0041)                 | 60                | 140 (0.0041)<br>170 (0.0035)                 | 230 (0.0024)            |
| 150               | 0               | 100 (0.0059)            | 15              | 140 (0.0041)            | 40               | 170 (0.0035)<br>200 (0.0029) | 75                | 170 (0.0035)<br>200 (0.0029)<br>230 (0.0024) | 270 (0.0021)            |
| 180               | 0               | 120 (0.0049)            | 15              | 170 (0.0035)            | 40               | 200 (0.0029)<br>230 (0.0024) | 65                | 200 (0.0029)<br>230 (0.0024)<br>270 (0.0021) | —                       |
| 220               | 0               | 140 (0.0041)            | 15              | 200 (0.0029)            | 40               | 230 (0.0024)<br>270 (0.0021) | 60                | 230 (0.0024)<br>270 (0.0021)<br>325 (0.0017) | —                       |
| 249               | 0               | 170 (0.0035)            | 5               | 200 (0.0029)            | 8                | 230 (0.0024)<br>270 (0.0021) | 38                | 230 (0.0024)<br>270 (0.0021)<br>325 (0.0017) | —                       |

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