Designation: E1248 – 90 (Reapproved 2009)

Standard Practice for Shredder Explosion Protection[1]

This standard is issued under the fixed designation E1248; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers general recommended design features and operating practices for shredder explosion protection in resource recovery plants and other refuse processing facilities.

1.2 Hammermills and other types of size reduction equipment (collectively termed shredders) are employed at many facilities that mechanically process solid wastes for resource recovery. Flammable or explosive materials (for example, gases, vapors, powders, and commercial and military explosives) may be present in the as-received waste stream. There is potential for these materials to be released, dispersed, and ignited within or near a shredder. Therefore, explosion prevention and damage amelioration provisions are required.

2. Referenced Documents

2.1 *National Fire Protection Association Standards:*

National Electrical Code
NFPA 13 Sprinkler Systems
NFPA 68 Guide for Explosion Venting
NFPA 69 Explosion Prevention Systems
NFPA 497A Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

3. Terminology

3.1 *Definitions:*

3.1.1 *deflagration*—an explosion in which the flame or reaction front propagates at a speed well below the speed of sound in the unburned medium, such that the pressure is virtually uniform throughout the enclosure (shredder) at any time during the explosion.

3.1.2 *detonation*—an explosion in which the flame or reaction front propagates at a supersonic speed into the unburned medium, such that pressure increases occur in the form of shock waves.

3.1.3 *explosion*—a rapid release of energy (usually by means of combustion) with a corresponding pressure buildup capable of damaging equipment and building structures.

3.1.4 *explosion venting*—the provision of an opening(s) in the shredder enclosure and contiguous enclosed areas to allow gases to escape during a deflagration and thus prevent pressures from reaching the damage threshold.

3.1.5 *explosion suppression*—the technique of detecting and extinguishing incipient explosions in the shredder enclosure and contiguous enclosed areas before pressures exceed the damage threshold.

3.1.6 *inerting*—the technique by which a combustible mixture is rendered nonflammable by addition of a gas incapable of supporting combustion.

3.1.7 *shredder*—a size-reduction machine that tears or grinds materials to a smaller and more uniform particle size.

4. Significance and Use

4.1 Shredder explosions have occurred in most refuse processing plants with shredding facilities. Lessons learned in these incidents have been incorporated into this practice along with results of relevant test programs and general industrial explosion protection recommended practices. Recommendations in this practice cover explosion protection aspects of the design and operation of shredding facilities and equipment used therein.

4.2 This practice is not intended to be a substitute for an operating manual or a detailed set of design specifications. Rather, it represents general principles and guidelines to be addressed in detail in generating the operating manual and design specifications.

5. Design Practices

5.1 *Design Rationale:*

5.1.1 Each of the following design features is better suited for some types of combustible/explosive materials and shredders than for others. The selection of a particular combination of explosion prevention features or damage control features, or both, should be made with an understanding of the types of refuse entering the shredder, shredder operating conditions, the inherent strength of the shredder and surrounding structures, and the operating controls for screening input materials and restricting personnel access during shredding operations.

[1] This practice is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.03 on Treatment, Recovery and Reuse.

Current edition approved Sept. 1, 2009. Published November 2009. Originally approved in 1990. Last previous edition approved in 2004 as E1248–90(2004). DOI: 10.1520/E1248-90R09.

5.1.2 Several of the following explosion protection design practices are effective for deflagrations but not for detonations. Deflagrations usually result from accumulations of flammable gas-air, vapor-air, or powder(dust) air mixtures in or around the shredder. However, commercial explosives and military ordnance usually generate detonations. A few flammable gases (for example, acetylene and hydrogen) are also prone to detonate when dispersed in highly turbulent, strong ignition source environments such as exist inside a shredder. Because many explosion protection design practices are not applicable to detonations, rigorous visual detection and removal of detonable material before it enters the shredder is particularly important (6.1).

5.1.3 In view of the difficulties in preventing and controlling all types of shredder explosions, it is important to isolate the shredder and surrounding enclosure from vulnerable equipment and occupied areas in the plant. This is best achieved by locating the shredder outdoors or, if indoors, in a location suitable for explosion venting directly outside. Locations in or near the center of a processing building are not desirable. If the shredder is situated in an isolated, explosion resistant structure, the structure should be designed to withstand the explosion pressures specified in NFPA 68.

5.1.4 The shredder and all contiguous enclosures should be equipped with an explosion protection system consisting of one or more of the following: inerting system (5.2); explosion vents (5.3); explosion suppression system (5.4). Water spray systems (5.5), combustible gas detectors (5.6), and industrial fire protection systems (5.7) should also be installed for additional protection. Adjacent structures and personnel should be protected (5.8).

5.2 *Inerting Systems:*

5.2.1 An inerting system is intended to prevent combustion explosions within a shredder (and contiguous enclosures) by maintaining oxygen concentrations below the level required to support combustion.

5.2.2 The following factors must be accounted for in designing a shredder inerting system: inert gas source and distribution; operating controls and associated instrumentation; leakage of inert gas from and entry of air into enclosures; maintenance and inspection constraints in an oxygen deficient atmosphere during normal operations; effect of inert gas on shredder materials and waste throughput; and contingency plans for inert gas source supply interruption.

5.2.3 Flue gas from an on-site furnace or boiler can be a suitable inert gas providing there is a reliable means to prevent flame propagation into the shredding system and providing flue gas conditioning is installed to maintain suitable temperature (to prevent steam condensation or spontaneous ignition) and flue gas composition (including dew point, oxygen, carbon monoxide, soot, and contaminant concentrations).

5.2.4 Steam from an on-site boiler can be a suitable inert gas providing the temperatures of the shredder and contiguous enclosures are sufficiently high (at least 180°F (82°C)) to prevent steam condensation and the associated increase in oxygen and flammable gas concentrations.

5.2.5 Oxygen concentrations in the shredder and all contig uous enclosures should be no higher than 10 % by volume, unless test data for the particular inert gas employed and the variety of combustibles expected in the shredder demonstrate that a higher oxygen concentration can be tolerated without generating a flammable mixture. Test data for maximum oxygen concentrations for nitrogen and carbon dioxide inerting are as listed in Appendix C of NFPA 69.

5.2.6 Reliable oxygen concentration monitors should be installed, calibrated, and maintained to verify that the maximum oxygen concentration is not being exceeded in the shredder and contiguous enclosures. This will require multiple monitors and sampling points depending on the extent and uniformity of flow in the enclosed volume. Provision for cleaning and clearing sample lines, as recommended in 5.4.5 are needed.

5.2.7 The inert gas distribution system should be designed in accordance with the provisions of Chapter 2 of NFPA 69.

5.3 *Explosion Venting:*

5.3.1 Explosion venting is intended to limit structural damage incurred during deflagrations by allowing unburned gas and combustion products to be discharged from the shredder or contiguous enclosures, or both, before combustion and the associated potentially destructive pressure rise is completed. The effectiveness of explosion venting for a particular explosion depends on the rate of combustion versus the rate of discharge of gases through the explosion vents. The rate of combustion in the shredder or adjacent enclosure depends upon the composition of the combustible gas-air, vapor-air, or dust-air mixture, the size of the shredder/enclosure, and the turbulence level as determined by air flow rates and hammer tip speed.

5.3.2 In general, explosion venting is most effective with large vent areas, low vent deployment pressures, low vent panel weight, and vent locations near the expected ignition source (which is often hammer impact sparks within the shredder). The following quantitative guidelines for these factors are intended to protect against near worst-case flammable gas-air mixtures occupying the entire shredder internal volume.

5.3.3 Explosion vent areas should be sufficiently large to maintain explosion pressures under the damage threshold value for the particular shredder installation. Previously published guidelines relating peak pressure to vent area are not directly applicable to Municipal Solid Waste (MSW) shredders because shredder hammer velocities can increase the combustion rate well above that considered in establishing previous guidelines. The following recommended relationship is based on propane-air explosion tests conducted in a full-scale large shredder mock-up, including rotating hammers (**1**).[2]

5.3.3.1 The vent area, A_v, required to maintain explosion pressures under the shredder damage threshold (in units of psig), P_M, is given by the equation:

$$A_v = 0.13V^{2/3}P_M^{-0.435}(5+0.034v_H) \quad (1)$$

where:

V = shredder internal volume, and

[2] The boldface numbers in parentheses refer to the list of references at the end of this practice.

v_H = hammer tip velocity, ft/s.

The calculated vent area will be in the same units as $V^{2/3}$. The metric equivalent, if P_M is in bar, and v_H is in m/s, is

$$A_v = 0.041V^{2/3}P_M^{-0.435}(5+0.112v_H) \quad (2)$$

5.3.3.2 If the shredder discharge is at least 3 ft (0.91 m) above an unenclosed discharge conveyor, half the discharge area can be credited toward attaining the required vent area, A_v. The difference should be made up with unobstructed explosion vents. No credit should be taken for the inlet area which is usually too obstructed to be an effective vent.

5.3.3.3 To illustrate the use of Eq 1 and 2, consider a hypothetical shredder with an internal volume of 1000 ft^3 (28.3 m^3), including the portion of the inlet hood directly above the hammermill. Let us suppose that structural calculations indicate that the weakest structural member can withstand an applied load equivalent to a hydrostatic pressure of 10 psig (0.70 bar). At the design shaft speed in this shredder, the hammer tip speed is 250 ft/s (76.2 m/s). Substitution of these values into Eq 1 and 2 results in a calculated required vent area of 64 ft^2 (5.95 m^2). If the shredder discharge area is 20 ft^2 (1.9 m^2), an explosion vent of at least 54 ft^2 (5.0 m^2) area should be installed on the shredder.

5.3.4 The explosion vent opening should discharge combustion gases and flame into an unoccupied outdoor area. If the shredder is situated inside a building, vent ducting will be needed to channel gases and flame out of the building. This ducting, which should have a strength at least equal to the shredder itself, should be kept as short as possible in order to avoid further burning and gas compression during venting.

5.3.4.1 Vent ducting of any length will cause the pressure to increase significantly above the value expected for unrestricted venting. The increased pressure can be related to the unrestricted (no duct) vented explosion pressure through Fig. 1. The parameter in Fig. 1 that determines this relationship is the ratio of vent duct volume to shredder volume. In the example in 5.3.3.3, the use of only a 5.5-ft (1.7-m) long duct attached to the 54-ft^2 (5.0-m^2) vent area would represent a duct volume of 300 ft^3 (8.5 m^3), corresponding to a duct/shredder volume ratio of 0 to 3. According to Fig. 1, an explosion pressure of 10 psig (0.7 bar) without the duct would be increased to about 21 psig (1.5 bar) with a duct/shredder volume ratio of 0 to 3.

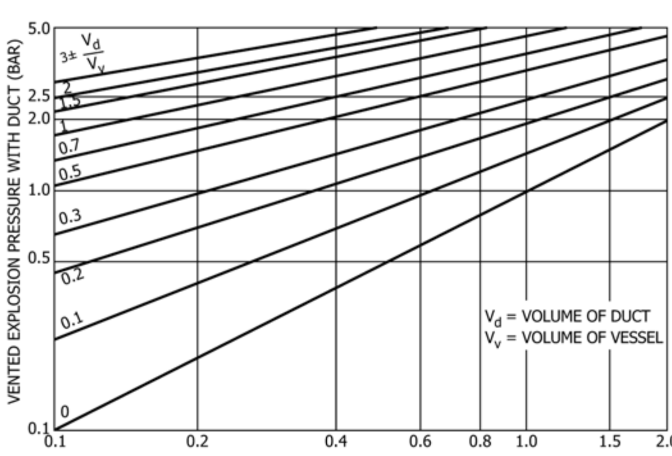

FIG. 1 Influence of Vent Duct Volume on Vented Explosion Peak Pressures (Ref. 2)

5.3.4.2 If the pressure increases shown in Fig. 1 are intolerable, a duct with a diverging cross-section area should be used. Apparently, there have not been any published test data on how much divergence is required to prevent significant pressure increases above the unrestricted vent values given by Eq 1 and 2. Even with large divergence angles, the vent duct should be designed to withstand a pressure equal to the shredder damage threshold pressure.

5.3.4.3 It is desirable to prevent flammable gas from entering and accumulating in a vent duct during normal shredder operation. Although this is difficult to achieve, two possible approaches are use of a sturdy vent cover (5.3.5), or vent cover and projectile deflector to separate the shredder from the vent duct; or, as a less desirable alternative, use of air sweeping of the vent duct by the induced draft of the shredder or by a high-capacity dust collection or pneumatic transport system, or both. These systems should be equipped with their own explosion protection systems.

5.3.5 Vent covers are usually needed either (preferably) directly on the shredder, or at the far end of the vent duct. Without these covers, dust and debris generated during the shredding process would be ejected and would possibly create a health and safety hazard to nearby personnel. Since impact forces from large ejected debris could prematurely open the vent cover, deflection gratings, heavy chain links, or wire rope are often employed to rebound these missiles back into the shredder.

5.3.5.1 The opening pressure of the vent cover should be low in comparison to the shredder structural damage threshold, P_M. Based on the explosion tests described in EPA Report M2052 (**1**), it is recommended that the static deployment pressure be no more than $P_M/5$ since the cover will open at a somewhat higher pressure under rapid explosion loads than under static test conditions. The vent opening pressure should also be higher than pressures developed by air motions and waste throughput during normal shredding operations.

5.3.5.2 Several different types of vent covers can be used. Some of the simplest covers consist of rubber flaps on the vent duct outlet. Rain hoods situated at least one vent duct diameter from the end of the duct have also been used in conjunction with a deflector grating inside the duct, but the rain hoods must be restrained from being blown off during the explosion. Vent cover construction and release mechanisms are described in NFPA 68.

5.3.5.3 If explosion vent panels or doors are used, they should satisfy several criteria in addition to the vent area and release pressure criteria cited-previously. First, vent panel/door inertia should be as low as possible, so as not to obstruct the open vent. NFPA 68 specifies that the vent panel area density be less than 2.5 lb/ft^2 (12.5 kg/m^2). Another important factor is that a rugged and shock-resistant hinge or steel cable (of at least 1-cm diameter) is required to prevent the panel/door from flying off during explosions. Finally, there is a need to periodically inspect the vent actuation mechanism so that it will function when needed. Some explosion doors have not deployed at all during shredder explosions involving major damage. Therefore, an inspection and preventive maintenance program is recommended.

5.3.6 During an explosion, flame and potentially damaging pressure waves propagate out from the shredder explosion vent and from the inlet and discharge openings. Blast wave pressures can be estimated from the following hypothesized generalization of test data. Thus, the peak overpressure, P_d, at a distance, d, directly ahead of the vent opening is given by the equation:

$$\frac{P_d}{P_M} = \frac{k}{k + d\sqrt{A_v}} \quad (3)$$

where:

P_M = maximum pressure in shredder (same units as P_d) (as used in Eq 1 and 2, also),
A_v = area of shredder vent or other opening closest to target structure (same units as d^2), and
k = constant Z1.7.

The value of k is probably dependent upon gas composition and shredder volume. The suggested value of 1.7 is based on test data for methane-air explosions in 28-m^3 (1000-ft^3) enclosure.

5.3.6.1 Blast pressures exerted on a target located at some angular displacement from a line perpendicular to the vent opening will probably be somewhat less than given by Eq 3 at the same distance, d. However, test data are inconsistent as to how much of a reduction occurs. Therefore, a conservative approach would be to use Eq 3 to estimate pressures at off-axis locations as well as in-line targets.

5.3.6.2 Adjacent structures vulnerable to blast waves include the shredder feed conveyor enclosure and picking station (for removing oversized hazardous materials from the waste streams), the discharge conveyor, dust collection ducting, and the nearest building wall. As an example of the use of Eq 3, consider the blast wave loading on the discharge conveyor for the same hypothetical 1000-ft^3 (28.3-m^3) shredder described in 5.3.3.3. If the discharge conveyor is 4.5-ft (1.4-m) below the 20-ft^2 (1.9-m^2) discharge opening, the calculated value of P_d/P_M is 0.63. Thus, the discharge conveyor could be subjected to a 6.3-psig (0.43-bar) blast loading and should be strengthened accordingly to avoid damage. If the discharge conveyor is enclosed, the enclosure may also be subject to internal pressure loads during an explosion and it should be strengthened or explosion vented, or both, in accordance with 5.3.7.

5.3.7 *Discharge Conveyor and Other Downstream Enclosures*—Discharge conveyors, dust collectors, and other enclosures downstream of the shredder require their own explosion vents to cope with explosions initiated either in the shredder or downstream of the shredder. Discharge conveyor and dust collector ducts and other elongated enclosures should have vents installed at regular intervals along the duct, with each vent having an area at least equal-to the duct cross-sectional area. The distance between vents depends on the strength of the duct, but should be no further than 15 vent diameters. Detailed vent area and spacing requirements for elongated pressure-resistant enclosures can be found in NFPA 68. If discharge conveyors are constructed of thin sheet metal without any significant pressure resistance, adjacent equipment and personnel should be protected from metal sections torn asunder during the explosion.

5.3.8 *Exposure to Vented Flames*—Flames emerging from shredder explosion vents can seriously injure nearby personnel and can ignite other combustibles in the vicinity causing secondary fires and explosions. Therefore, personnel and vulnerable equipment should be restricted from the area around the shredder explosion vents during shredder operation. The restricted area should also include the outlet of any explosion vent ducting.

5.4 *Explosion Suppression Systems:*

5.4.1 Explosion suppression systems are intended to detect and suppress an incipient deflagration before pressures reach the damage threshold and before flame is vented from the shredder. Detection of incipient shredder explosions is accomplished with diaphragmatic pressure sensors. Suppression is achieved by the rapid discharge of an extinguishing agent from pressurized containers mounted on the shredder walls. Suppression systems are effective only for deflagrations that require shredder air for oxidation. Deflagrations involving combustible gases or dust/powders with exceptionally rapid burning velocities (for example, hydrogen, acetylene, and aluminum) are not amenable to explosion suppression.

5.4.2 To be effective in a shredding facility, suppression system detectors and agent distribution should cover the entire shredder and all contiguous enclosed areas including inlet hoods, discharge conveyors, reject chutes, dust collection systems, and so forth.

5.4.3 Halogenated and dry chemical suppression agents have been shown to be effective for most deflagration-type explosions. Most agents are equally effective for explosions with relatively slow or moderate rates of pressure rise, but some of the dry chemicals (particularly monoammonium phosphate) may be more effective for explosions with a rapid rate of pressure rise. Halon 1011 (chlorobromomethane) and a hybrid combination of dry chemical and Halon 1301 (bromotrifluoromethane) have been used extensively in refuse shredder suppression systems. The success of a particular agent in a particular installation depends upon the pressure detector setting and location, agent distribution uniformity, and retention of minimum agent concentrations in the shredder/enclosure until combustion is terminated. The latter requirement implies that explosion vent deployment pressures should be greater than suppression system activation pressures.

5.4.4 Explosion suppression system components should be tested and accepted by a nationally accredited approval testing organization. Component system design, installation, inspection, and maintenance should be in accordance with Chapter 4 of NFPA 69. This includes system recharging and testing by qualified personnel following each activation.

5.4.5 Provisions for cleaning and clearing the mountings for suppression system detectors and extinguishers are critical for successful operation in a shredding facility. Sample arrangements for providing air purges, pneumatic rodding, and manual cleanout are shown in Fig. 2. Manual cleanout intervals of at least once per work shift have been found necessary in several facilities.

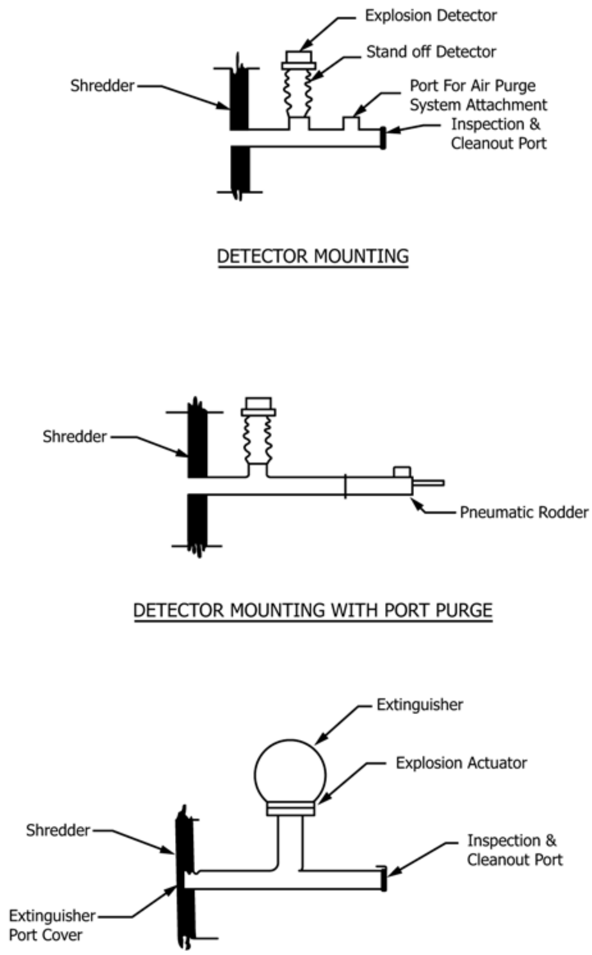

FIG. 2 Conceptual Schematic of Extinguisher Mounting on Side of Shredder (Ref. 3)

5.5 *Water Spray Systems*—Installation of a water spray system in the shredder for use during normal operations can reduce the frequency and severity of shredder explosions by reducing the frequency of impact sparks and by providing a heat sink to reduce explosion temperatures and pressures. The most effective type of water spray for this purpose is a fog composed of small droplets in high concentrations, generated from high pressure or atomizing spray nozzles (**4**). An alternative to use during normal operations is to actuate the spray nozzles by gas detectors or by any other indication of flammable vapor release in the shredder. A spray system is also useful in extinguishing post-explosion fires and fires ignited during shredder coast-down.

5.6 *Combustible Gas Detectors:*

5.6.1 A combustible gas detection system is an important supplemental explosion protection measure. For use in a refuse shredding facility, a typical system would consist of one or more sampling lines, a sampling pump, a flammable gas sensor, an audible and visual alarm and possibly electrical relays to control other explosion protection or refuse processing equipment. Several types of gas-sensing units and calibration schemes are available. The selected unit should be listed with a nationally recognized approval organization and should be responsive to a wide variety of flammable vapors including hydrocarbons, alcohols, ketones and ethers. Periodic thorough inspection and maintenance (including calibration) is critical if the system is to remain operational in a refuse shredding environment.

5.6.2 The locations of the sampling lines should be based on site specific considerations. For example, if there is a larger air flow rate out of the shredder towards the shredder inlet hood, it would be desirable to locate a sample line in the hood. If there is very little air flow, it would be desirable to locate a sample line in the shredder itself. One possible location in the shredder where vapors have been reported (**1**) to accumulate is at the end of the shaft in a horizontal hammermill. It is also desirable to locate a detector downstream of the shredder. Periodic automated purging and rodding of sensor ports, as recommended for explosion suppression system components, should also be used on sampling parts and sensors outfitted with flame arrestors.

5.6.3 For most catalytic combustion-type sensors, calibration with heptane provides the most sensitive indicator of common hydrocarbon vapors. Catalytic sensors must be tested and replaced periodically (monthly intervals are reported in Ref. **5**) because of contamination/poisoning by a variety of vapors including compounds containing lead, silicon, or halogens. The sensor should be tested following activation of a suppression system using a halogenated agent such as Halon 1011.

5.6.4 Sensor set points commonly used in other processing industries include alarm annunciation at 25 % of the calibrated lower explosive limit (LEL) and relay tripping at 50 % of the LEL. In a refuse shredding facility, the relay might signal building evacuation, shut down the shredder and the conveyor that feeds the shredder, and trigger a water spray system in the shredder.

5.6.5 Battery-operated, hand-held, flammable vapor detectors are useful for screening incoming waste and for checking for the presence of flammable vapor in other areas of the shredding facility following an installed vapor detector alarm or an explosion, or both.

5.7 *Fire Protection:*

5.7.1 Standard industrial fire protection equipment, including automatic sprinklers, applicable to plants with ordinary combustible process materials, should be provided throughout the plant in order to fight a fire generated following a shredder explosion. Water flow rates, sprinkler size and spacing, and so forth, should be as specified in NFPA 13. Sprinkler piping and supports should be located so as to provide protection against damage from explosions.

5.7.2 A water spray on the shredder inlet and outlet conveyors is useful for putting out fires caused by shredder explosions and for wetting materials in the event the liquids or gases are detected. Spray nozzles should be able to be actuated from the control room and other work stations. Hose stations near the shredder and at intervals along the feed and discharge conveyors should also be provided.

5.8 *Protective Barriers:*

5.8.1 Shredders should be located away from control rooms, offices, restrooms, lounges, and so forth. The potential effects of an explosion on critical plant systems such as electrical cables, control cables, or air lines should also be taken into account when choosing shredder location. If a control room is located near a shredder, the room should be designed to withstand blast pressures (5.3.6) and the impact from projectiles. Control room doors should be designed to open outward, control room windows should be of small cross-sectional area (for example, 10 by 10 in. is the NFPA recommendation for the maximum size of fire-rated windows) and constructed of pressure and impact resistant materials (for example, polycarbonate plastic or wired glass).

5.8.2 Blast mats or similar blast resistant barricades should be installed between the shredder and plant areas normally occupied by personnel. Picking stations represent one such area sometimes located near the shredder inlet. It should be noted that blast mats stop missiles and shrapnel, but only deflect pressure fronts. The blast mat supports should be designed to carry the blast load (specified in 5.3.6) exerted on the mat during an explosion.

5.9 *External Ignition Sources*—Flammable vapors generated and released in the shredder have sometimes been ignited by equipment located downstream and, in at least one incident, upstream from the shredder. This can occur if additional vaporization or vapor accumulation, or both, occurs downstream, or if the flammable vapor does not encounter an ignition source in the shredder, but is exposed to a downstream ignition source. Potential downstream ignition sources include furnaces, various electrical equipment such as motors, lights, relays, and so forth, and conveyor transfer points (where scrap metal can be lodged against moving parts and subjected to frictional heating or sparking). Electrical equipment on or near the shredder discharge conveyor and other contiguous equipment should be approved for use in hazardous (classified) areas as defined by the National Electrical Code and NFPA Standard 497A.

6. Operating Practices

6.1 *Employee Training and Visual Inspection*—Refuse haulers as well as plant personnel should be trained to identify potentially exposive materials and instructed in regard to safe removal and disposal. Visual detection and removal of potentially explosive or damaging materials is one of the most effective methods of reducing the size and frequency of shredder explosions. However, it cannot be relied upon to prevent all, or even most, explosions.

6.1.1 All plant personnel should be made aware that, by looking for potentially dangerous materials, they can play an important part in reducing the hazard to themselves and the equipment. Among the types of materials to be visually detected and removed are gasoline cans or tanks, lawnmower engines, compressed gas cylinders, cases of bullets or other ammunition, commercial and military explosives, combustible powders (for example, aluminum powder), paint thinner, and cartons of aerosol spray cans.

6.1.2 Visual detection is a tedious job and provision must be made to relieve monotony among plant personnel (for example, by rotating job assignments). The effectiveness of the visual inspection increases as the depth of the waste stream on the conveyor decreases. Visual inspection of the input stream to the shredder may be done from the control room, preferably through the use of remote TV cameras.

6.1.3 Incoming vehicles should be considered suspect and subjected to special screening in the following situations: they have previously been identified as hauling potentially explosive waste; they are hauling industrial or commercial waste from facilities known to contain large quantities of combustible liquids or powders; or, they trigger a positive response from a hand-held flammable vapor detector. Once the suspected haulers have been identified, the measures described in 6.1.3.1 – 6.1.3.3 can be taken to reduce potential explosions.

6.1.3.1 Spread out and sort through suspicious waste loads using a front end loader and a hand-held flammable vapor detector to scan the dispersed load.

6.1.3.2 Divert suspected waste loads to other modes of safe, environmentally acceptable disposal.

6.1.3.3 Inform suspected haulers that future loads will be subjected to particularly thorough inspections.

6.1.4 Plant managers, operators, mechanics, and other employees should be aware of the potential problem and should be trained to take the measures necessary to prevent and control explosions.

6.2 *Isolation of Personnel from Shredder:*

6.2.1 Establish "off limit" areas for employees and visitors during operation of the shredder. This may require roping off the area and installing **CAUTION** and **WARNING** signs.

6.2.2 Provide a phone system or intercom, or both, to enable clear communication between the operating floor and the control room.

6.2.3 Personnel should not be near a shredder in operation. If absolutely necessary, they should be protected by blast mats or other blast protection devices, in addition to personal protective equipment (safety glasses, hard hats, and so forth).

6.3 *Maintenance and Housekeeping:*

6.3.1 Maintenance must be performed on explosion protective systems. This includes removing obstructions from vent areas, cleaning pressure and vapor detectors, and checking whether sensors are working properly.

6.3.2 Maintain good plant housekeeping practices. What may start out as a small explosion or fire in the shredder can turn into a major fire or explosion by spreading throughout the conveyors and other auxiliary equipment due to accumulations of dust and shredder refuse.

6.4 *Post-Explosion Procedures*—The post-explosion procedures described in 6.4.1 – 6.4.8 through are recommended to protect personnel, reduce fire damage, and facilitate recovery from the explosion.

6.4.1 Evacuate the building and assemble all personnel in a predesignated place for a head count. Toxic gases may be generated and secondary explosions may occur following a shredder explosion. Therefore, personnel should not reenter the facility immediately. A portable combustible gas detector should verify the dispersal of residual flammable gas concentrations throughout the facility before personnel reenter to begin cleanup and repair operations.

6.4.2 Following an actuation of an explosion suppression system that uses a halogenated hydrocarbon such as bromochloromethane (Halon 1011) as the suppression agent, operating equipment must be purged before permitting access to personnel or personnel must use auxiliary breathing equipment when reentering the shredder area. Eye protection must be worn at all times.

6.4.3 Stop the conveyor that feeds the shredder.

6.4.4 The decision whether to keep the dust collection system running is site-specific and will be dependent primarily upon the type of dust cleaning devices employed, and the type of fire protection used within the dust collection system.

6.4.5 If any nonautomatic sprinkler systems are used in the areas affected by the explosion, these should be activated as soon as possible after the explosion, consistent with personnel safety.

6.4.6 Call the fire department. An automatic or semiautomatic alarm to the nearest fire department should be considered.

6.4.7 If operable, the shredder outlet conveyor may be kept running after an explosion in order to clear burning material from the shredder. This is especially advisable where the burning material can be diverted outside the facility to facilitate fire-fighting. The decision to keep outlet conveyors running is site-specific, however, because for some facilities it may be easier to fight a fire in the shredder itself than in areas fed by the outlet conveyors.

6.4.8 At the discretion of the facility operator, the shredder itself may either be kept running or stopped. Keeping the shredder running has the advantage of clearing the shredder of burning material. Stopping the shredder may reduce windage that may fan the flames but may also leave a *plug* of burning material inside the shredder to be extinguished and later removed (usually manually). The shredder will continue running (by momentum) for a period of several minutes even after the motor is turned off, but this period may not be sufficient to clear the shredder. For each facility, the decision of whether to keep the shredder running will be more dependent upon operator preferences for fire-fighting and material cleanup than upon explosion safety considerations.

6.5 *Miscellaneous Plant Specific Operating Practices*—A detailed listing of miscellaneous pre-explosion and post-explosion operating practices that have evolved in one plant in which the operators have experienced numerous documented shredder explosions is reported in Ref. **5**.

REFERENCES

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