



The Simpson Mix-Muller® in The Pyrotechnic Manufacturing Industry

Pyrotechnic compositions are used as illuminants, smokes, flares, delays, igniters, infrared flares, incendiaries, tracers, heat powders, photoflash and simulated ammunition compositions.

"Pyrotechnic compositions are physical mixtures of finely powdered chemical compounds and elements which, when ignited, can readily undergo combustion (chemical reaction) with the evolution of a considerable amount of heat and light in a relatively short period of time. Various organic binders and color intensifiers may be included in the mixtures. The reaction may be accompanied by smoke and/or sound. The heat of reaction for one gram of pyrotechnic composition may range from 200 to 2,500 calories per gram, which represents an appreciable amount of energy."¹

For many years the standard mixer for various forms of explosives, propellants and pyrotechnics has been a muller type machine. The DuPont Company has used a muller type mixer for over one hundred years in making black powder. Over 280 Simpson Mix-Mullers have been installed worldwide in pyrotechnic materials manufacturing facilities.

The mixing of pyrotechnics and explosive materials is considered a most complicated procedure, particularly in view of the varied formulations and various flash points of the materials used. In addition, the materials used and processes are generally of a secret nature and it is difficult to elaborate in great detail on any of the particular processes involved. It has been said that the mixing of pyrotechnic materials is one of the most difficult operations to submit to scientific analysis as there is no known formula or equation which can be used to calculate the degree or speed of mixing under a given set of conditions.

Caution was used in adapting the Simpson Mix-Muller for use in the pyrotechnic industry. Close cooperation with leading manufacturers and government agencies over a period of years has been invaluable in our work along this line. Beginning in 1942 the Monsanto Chemical Company developed a new type of explosive and destroyed three standard No. 2UD Simpson Mix-Mullers in their test and development work before placing an order for over 100 highly customized Mix-Mullers for use in the war effort. More recently, Morton Thiokol Inc. has cooperated in upgrading the design of the #05 Simpson Mix-Muller to take full advantage of modern components and materials of construction.

The majority of explosive materials are mixed in small quantities, which means either a model LF or a model #05 Simpson Mix-Muller. Exceptions have been made where machines as large as a model #2 1/2GP have been installed. For example, at the Morton Thiokol Wasatch Division plant in Utah, a special #2 1/2GP Simpson Mix-Muller is used to prepare propellant fuels for rockets.

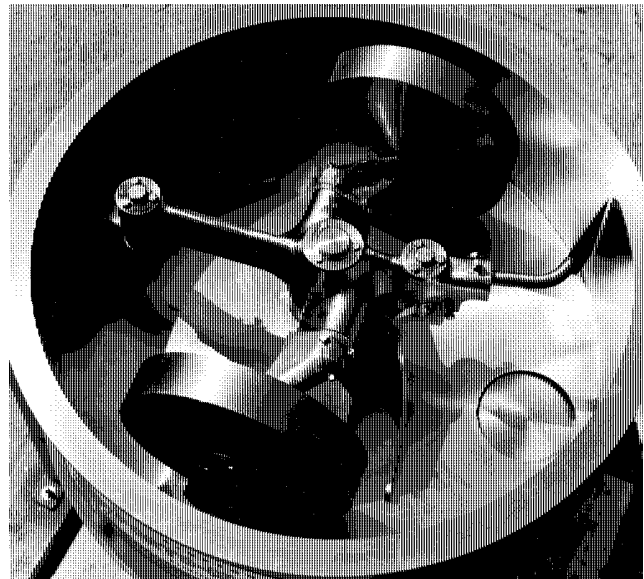
The smaller machines are more effective in that smaller batches are handled, which provides for ease of material handling, particularly loading and unloading the mixer. In many cases the mixer is located in a room equipped with reinforced concrete walls and a false roof or wall. In the event an explosion occurs, the roof and wall will expel the force of the explosion without too much damage to the equipment or building. Usually, remote controls are used for all motors and starters. Although of the explosion-proof type, the motors and controls are mounted outside the mixing room to reduce the possibility of an unexpected energy source. The mixer is usually connected with a long drive shaft to the motor. The mixer is also grounded to eliminate static electricity, which is one of the most feared conditions and which is capable of setting off a batch of material while mixing, or even in some cases after mixing.

The Simpson Mix-Muller continually has proven itself a valuable asset in the mixing of explosives. Just recently, in one of the ordnance plants, a certain type of tracer explosive including both the igniter material and tracer substance were presenting problems in obtaining a good mix. The proving grounds reported that too many rejects were being produced, primarily due to inefficient mixing. Steps were taken immediately to improve the mixing of this material and, of course, a muller type mixer proved to be the answer. Prior to the use of the Simpson Mix-Muller, this material was mixed in dry form in a ribbon or tumbling type mixer. Here the particles were not coated with one another, but merely placed next to each other and upon handling and loading of the shells they became segregated due to the varying specific gravities. Since these materials were light, finely ground powders, there was initially insufficient body to properly support and rotate the muller wheel. However, this problem was overcome by adding a liquid carrier to the batch during the early stages of the mixing cycle. This liquid densified and dampened the material to such an extent freely, providing for a very efficient mulling action. As the

mixing cycle progressed, the liquid carrier evaporated and passed off, leaving a fine thoroughly mixed dry powder as it was discharged from the mixer. This procedure provided for excellent quality tracer ammunition.

The Simpson Mix-Muller utilizes the intensive mixing action of mulling. Mulling, an extension of conventional mixing methods, employs the principles of the mixing action achieved with a mortar and pestle. The unique kneading, smearing and spatulate action of mulling carefully regulates and develops each component of the mix to its maximum potential. The mixing tools in the muller are adjustable over a wide range to provide precisely the required amount of mixing intensity.

In designing the Simpson Mix-Muller for the mixing of explosives, special materials of construction are of the greatest importance. It is not possible to submit a single set of mixer specifications for mixing pyrotechnics and explosives, as the conditions vary. Special materials of construction are necessary, proper muller weights play an important part in effectively mixing this material, and in some cases jacketed mixers are used. Each installation must be handled as an individual problem and the designation of the extent of the special features required to be adapted to the Simpson Mix-Muller to properly mix the material safely will necessarily be jointly defined by the end-user and the manufacturer.



Pyrotechnic Compositions

Illuminating Compositions: These compositions consist of a finely divided metal, an oxidizer and a binder. The usual metals employed are magnesium and aluminum, or any alloy of the two. Sodium nitrate is commonly used as the oxidizer. Paraffin, used as a binder in older formulations, has been largely replaced by synthetic resins. The newer binders used in illuminating compounds usually consist of a synthetic resin, a polymerization agent, and a catalyst.

The mixing of illuminants is one area where special Simpson Multi-Mulls have been successfully used to continuously mix pyrotechnic materials prior to pelletizing.

Smoke Compositions: These pyrotechnic signal compositions are designed to burn to produce as much smoke as possible. Burning usually take place less energetically than with other types of pyrotechnics because at lower temperatures less of the solid smoke particles are consumed. Smokes are usually mixed in two stages: in a premix of retardant and oxidizers, to which the fuel, dyes and volatile solvents are added.

Flare Compositions: Flare compositions are designed to produce white and colored light in various signaling devices. A typical flare formula is that used to produce the red flare. It consists of potassium perchlorate, strontium nitrate, magnesium coated with paraffin, hexachlorobenzene and gilsonite.

Delay Compositions: Delay compositions are used to delay the detonation of explosive devices. Delay compositions commonly used are the so-called gasless type, consisting of a metal as a fuel

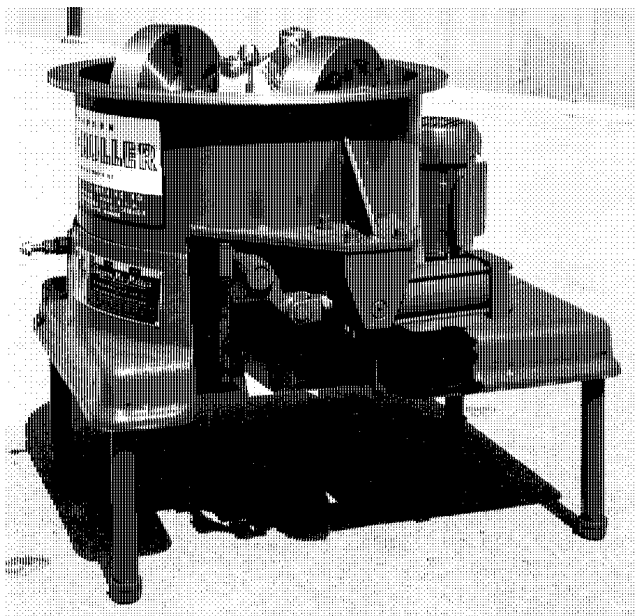
a. The mixer bowl, agitators and other parts which come in contact with the mixture are constructed of type 304 stainless steel. Construction of the mixer is carefully monitored to assure that there will be no cracks or crevices inside the mixer bowl where explosives may accumulate. The interior surfaces of the bowl, as well as the mixing tools, are polished to a smooth finish.

b. The mixer is designed for compatibility with remote controlled devices for feeding ingredients into the mixer. In addition, the open design of the mixer makes it easily compatible with sensors and remote controlled high-pressure hot water wash-down systems. Vapor removal is similarly easy to prepare. The mixing bowl and tools are easily accessible for operator inspection and additional hand cleaning as required. The special pyrotechnic version of the Simpson Mix-Muller has a number of special features:

c. Care has been taken to assure mechanical reliability and simplicity. All internal bolts are wire locked to prevent loosening. The new Simpson Mix-Muller uses permanently lubricated greaseless bearings that are well sealed from the mix materials. The plows are coated with industrial grade Teflon. The motors and starters can be remotely mounted and are supplied in explosion proof designs. For materials that require temperature control the Simpson Mix-Muller can easily be jacketed for heating and/or cooling.

and chromates as the oxidizer. Delay work is normally very hazardous in that very sensitive igniters are usually required. Mixing operations are normally performed using remotely controlled mixers installed behind adequate shielding.

Machine Specifications: The Simpson Mix-Muller is available with many optional features in addition to those normally provided. As a member of The International Pyrotechnic Society and a longtime supplier to the Energetic Materials Industry, Simpson Technologies desires to continue to supply equipment and services which are the best of their respective kind, and in conformance with modern industry practices.



**Special Model #LF
Simpson Mix-Muller**

Specifications for equipment must be jointly defined by the end user and the mixer manufacturer. Because of the wide variety of formulations used, the responsibility for proper equipment specification and operating procedures must rest primarily with the end user.

The greatest number of Simpson Mix-Mullers installations in pyrotechnics are of the Models #LF and #05. The following are the specifications for these two popular models.

Model #LF Simpson Mix-Muller

Capacity: The **Model #LF** is typically capable of mixing batch sizes up to 3/4ths of a cubic foot, or approximately .021 cubic meters, discharged product. The type of product being mixed may effect the maximum batch size.

Mixing Pan: The mixing pan consists of a one-piece, reinforced machined crib constructed of #304 stainless steel. Dimensions of

the pan are 24" (approx. 610mm) diameter and 9" (approx. 230mm) height. The interior surfaces of the mixing pan and muller wheel surface are machined to a surface finish of 63 microinch. All welds are continuous and ground smooth to a 125 microinch finish, except the welds in contact with the mix are a 63 microinch finish. All nuts, bolts, and grease fittings are held in place by wire-locking.

Mullers: The Model #LF contains two (2) separate muller wheels, each mounted on separate rocker arm type suspension arms which allow the mullers to impart an intensive kneading, smearing, and spatulating action to the mixture contained within the mixing pan. The wheels rise perpendicular to the pan bottom and have the capability to be adjusted so that contact with the pan bottom is prevented. Dimensions of each wheel are 11-3/4" diameter by 2-1/2" width at the circumference. The effective weight of each wheel is approximately 100 lbs. The muller caps are flush with the side face of the mullers and are equipped with a standard grease nipple to provide for lubrication.

Plows: Two (2) separate plows are provided to completely blend and fold the material into the muller path. The plows are manufactured of #304 stainless steel. The front surfaces of the plows have a smooth surface finish. The plows are coated with industrial grade Teflon.

Discharge: Discharge of composition is accomplished by remote operation of an automatic, pneumatically operated bottom discharging single door which is fitted with a positive lock which will fail-safe during the mixing operation. The discharge door and associated discharge mechanism is designed to allow ready access to the discharge area.

Rotating Elements: All materials and parts in contact with the mix composition are of #304 stainless steel. The crosshead consists of a one-piece, streamlined crosshead casting to prevent material build-up. The inside and outside plow straps are of one-piece construction with vertical and horizontal adjustment at the top of the crosshead. Any cast steel surfaces are blasted or machined to give a smooth surface and promote ease of cleaning.

Drive: The drive consists of a motor mounted on the machine base and coupled to the reducer by a variable speed drive arrangement to allow vertical shaft speeds of between 14-44 RPM. The drive includes a torque limiting device to prevent accidental overloads. The drive motor is a one (1) horsepower (1800 RPM) explosion-proof motor manufactured to meet Class 1 and 2, Groups D, E, F, and G for hazardous duty applications.

Starter: The starter is a Nema size one (1), Nema type 7 and 9 with a circuit breaker type disconnect and equipped with start/stop pushbuttons. The starter is manufactured to meet Class 1 and 2, Groups D, E, F, and G for hazardous duty applications.

Model #05 Simpson Mix-Muller

Capacity: The **Model #05** is typically capable of mixing batch sizes up to three (3) cubic feet, or approximately .09 cubic meters, discharged product. The type of product being mixed may effect the maximum batch size.

Mixing Pan: The mixing pan consists of a one-piece, reinforced, machined crib constructed of #304 stainless steel. Dimensions of the pan are 39.25" (approx. 1000mm) diameter and 12" (approx. 300mm) height. The interior surfaces of the mixing pan are machined smooth to close tolerances. The interior surfaces of the pan and muller wheels have a surface finish not less than 63 microinch. All welds are continuous and ground smooth to a 125 microinch finish, except the welds in contact with the mix are a 63 microinch finish. All nuts, bolts, and grease fittings are held in place by wire locking.



**Special Model #05
Simpson Mix-Muller**

Mullers: The Model #05 consists of two (2) separate muller wheels, each mounted on separate rocker arm type suspension arms which allow the mullers to impart an intensive kneading, smearing, and spatulating action to the mixture contained within the mixing pan. The wheels rise perpendicular to the pan bottom and have the capability to be adjusted so that contact with the pan bottom is prevented. Dimensions of each wheel are 16" diameter by 3" width at the circumference. The effective weight of each wheel is approximately 210 lbs. The muller caps are flush with the side face of the mullers and are equipped with a standard grease nipple to provide for lubrication.

Plows: Two (2) separate plows are provided to completely blend and fold the material into the muller path. The plows are manufactured of #304 stainless steel. The front surfaces of the plows have a smooth surface finish of approximately 32 microinch. The plows are coated with industrial grade Teflon.

Discharge: Discharge of the composition is accomplished by remote operation of an automatic, pneumatically operated bottom discharging single door which is fitted with a positive lock which will fail-safe during the mixing operation. The discharge door and associated discharge mechanism is designed to allow ready access to the discharge area.

Rotating Elements: All materials and parts in contact with the mix composition are of #304 stainless steel. The crosshead consists of a one-piece, streamlined crosshead casting to prevent material build-up. The inside and outside plow straps are of one-piece construction with vertical and horizontal adjustment at the top of the crosshead. Any cast steel surfaces are blasted or machined to give a smooth surface and promote ease of cleaning.

Drive: The drive consists of a motor mounted on the machine base and coupled to the reducer by a variable speed drive arrangement to allow vertical shaft speeds of between 14-44 RPM. The drive motor is a three (3) horsepower (1800 RPM) explosion-proof motor manufactured to meet Class 1 and 2, Groups D, E, F, and G hazardous duty application.

Starter: The starter is a Nema size one (1), Nema type 7 and 9, with a circuit breaker type disconnect and equipped with start/stop pushbuttons. The starter is manufactured to meet Class 1 and 2 Groups, D, E, F, and G for hazardous duty applications.

Options on both the Model #LF and Model #05: Various options, such as remote drives and steam heating jackets, may be added to the above specified machine. Please do not hesitate to inquire about these options.

Explosives, Propellants and Pyrotechnic Safety Covering Laboratory, Pilot Plant, and Production Operations. Oct. 20, 1961, United States Naval Ordnance Laboratory, White Oak, Maryland, pg. 59.

For more information, please contact Simpson Technologies Corporation on the internet at www.simpsonstech.com.

Additional information on the pyrotechnic manufacturing industry is available on the internet –

International Pyrotechnics Society – www.intlpyro.org
Journal of Pyrotechnics - www.jpyro.com