Def Sci J, Vol 36, No 3, July 1986, pp 257-264

Manufacture of the Futuristic Castable Type of Screening Smoke Composition

AMARJIT SINGH, U.K. PATIL & P.K. MISHRA
Explosives Research & Development Laboratory, Pune-411021

Received 15 March 1985; revised 29 August 1985; re-revised 3 February 1986.

Abstract : The present trend abroad is to replace conventional smoke compositions with castable type of smoke compositions because of superior performance of the latter over the former. The technology of castable screening smokes has been recently developed for the first time in India by the Explosives Research & Development Laboratory, Pune. This paper discusses the various advantages in large scale manufacture of castable type of screening smoke composition. A comparison is also made with the conventional method of manufacture of screening smoke composition currently followed.

1. Introduction

Screening smokes are used for hiding from the enemy, advancing or retreating troop movements, fighting vehicles and local tactical operations. The screening smokes are aerosols with tiny particles/droplets in the range of 0.5 μm to 1.5 μm, and can be produced by mechanical means or pyrotechnic means. The pyrotechnic screening smokes are produced by combustion of either a single material (e.g. white phosphorus) or a mixture of ingredients (hexachloroethane, zinc oxide, calcium silicide and potassium nitrate or carbon tetrachloride adsorbed on kieselguhr) in the atmosphere[1,2].

2. Conventional screening smoke composition

The current pyrotechnic screening smoke compositions in use are SR 264 and SR 269. They are based on the hexachloroethane (*HCE*), zinc oxide (*ZnO*) system. SR 269 consists of *HCE* (44%), *ZnO* (40.5%), calcium silicide (13.5%) and potassium nitrate (2%). SR 264 contains the same ingredients as SR 269 but in differing proportions. Even-though these compositions are in use for several years, their preparation and their filling is time consuming and labour intensive. There is a requirement of specialized and costly equipment like pneumatic and hydraulic presses and a rigid control of the factory conditions is required so that the composition does not absorb moisture, and the finished product behaves within well laid out specification parameters.

In the existing process, the screening smoke composition is filled by two different methods viz. (a) Direct Filling into the Empties, and (b) Pelleting of Composition

2.1 Method of Direct Filling

The process followed in the method of direct filling is as below[3] :

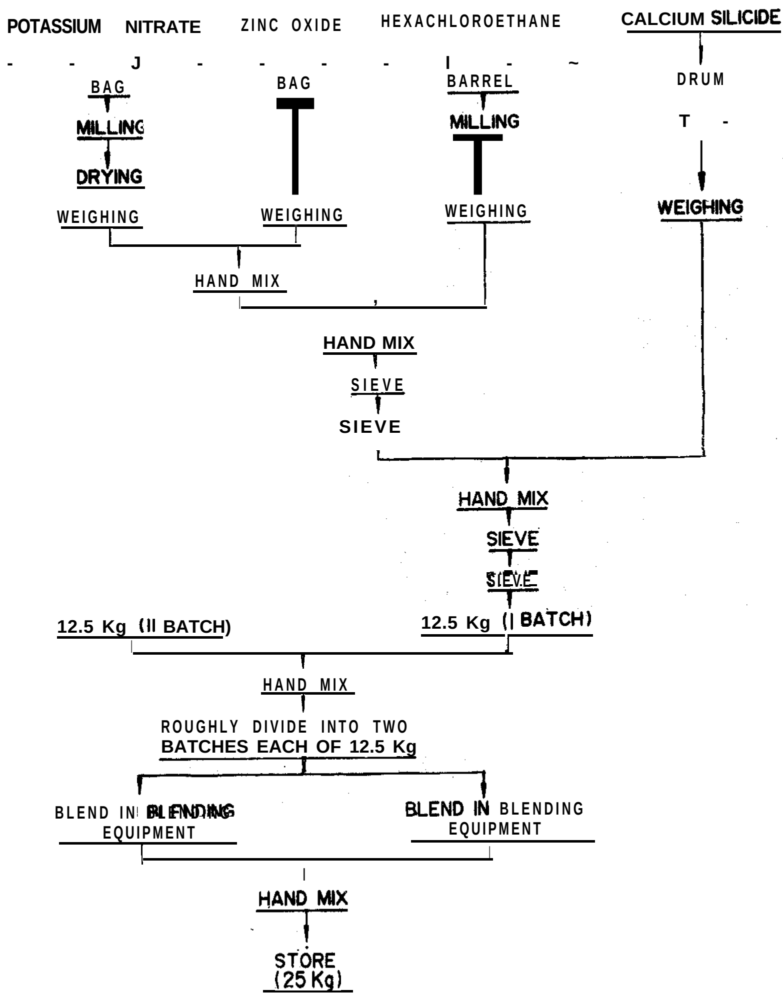

Figure 1. Preparation of the conventional screening smoke composition by hand mixing.

(i) The first step involves preparation of screening smoke composition. It consists of hand mixing potassium nitrate and zinc oxide before hexachloroethane or calcium silicide is added. The sequence of operations is shown in the flow sheet in Fig. 1.

(ii) The screening smoke mixture is added in weighed quantity in three to four increments into the empty and pressed using a hydraulic press each time.

(iii) The delay composition and the priming composition are added and pressing is repeated.

(iv) The assembly is completed.

The different steps involved in the process description utilizing the Direct Filling Method are given in Fig. 2.

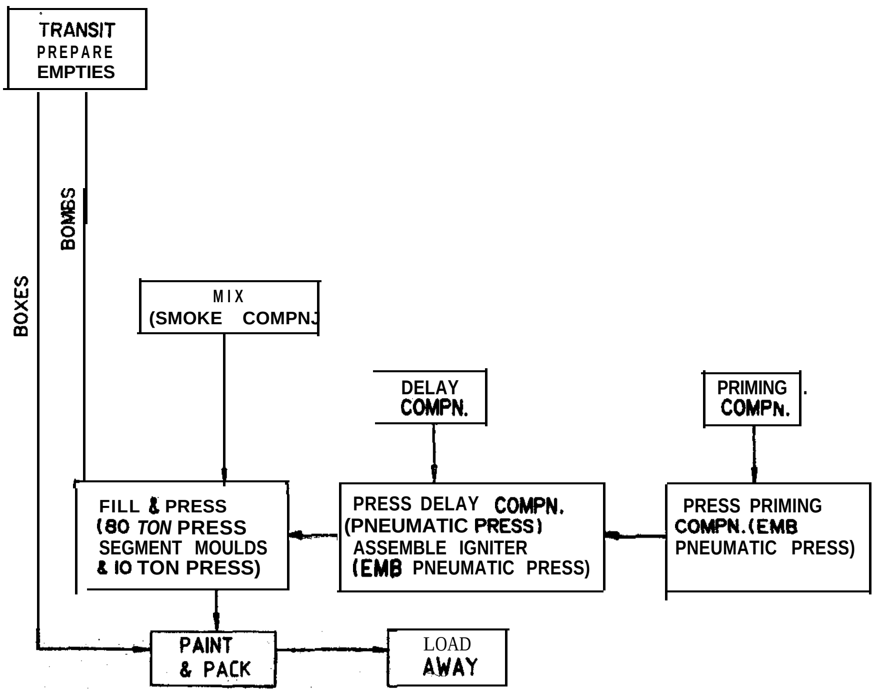

Figure 2. Process description for the direct filling method with conventional screening smoke composition.

2.2 Pelleting Method

The screening smoke composition is prepared by hand mixing as outlined in Fig. 1. Thereafter the composition is pelleted on a suitable hydraulic press using a multimould and fixed punches. The moulds are filled with the composition, each with a quantity pre-weighed into a separate pot of kit. The top punches are brought down to close the mould and the bottom punches move up to complete the consolidation. The top punches are raised, while the bottom punches continue upward and push out the pellets. The pellet is inserted into a metal container having a central channel surrounded by the priming composition and the container pressed on a suitable hydraulic press. The edge of the closing disc is cemented and again the container is pressed on a 10 ton press, These containers are inserted into the shell along with the burster bag. The base of the shell is then screwed in. The process description using this method[3] is given in Fig. 3.

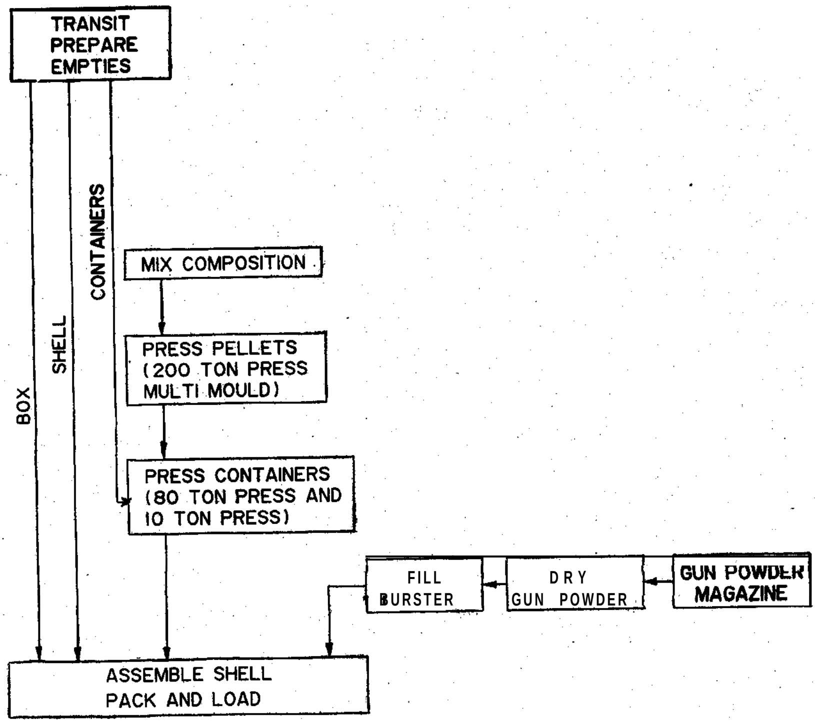

Figure 3. Process description for pelleting method, with conventional screening smoke composition.

2.3 Equipment Required, for Manufacture of Conventional smoke composition

A glance at the process description (Figs. 2 & 3) makes it clear that the factory for the manufacture of conventional screening smoke composition covers a large area and needs several buildings for operations like mixing, pressing, storage, assembly etc. In addition, several equipments mentioned below are required :

(i) ***Grinding Equipment :*** It is used for grinding the ingredients. KEK Mill or Gardner Disintegrator is used.

(ii) ***Sieving Equipment :*** It is required for mixing the ingredients into a uniform mass. Finex sieve (a vibratory sieve) is used.

(iii) ***Blending Equipment :*** Smoke composition is blended or 'drummed' in cylinders which are fixed to a cradle which is rotated. The cylinder has two helical vanes fixed to the inside wall.

(iv) Presses and Moulds : A 200 ton hydraulic press is used for composition pelleting. The container pressing work is done on a 80 ton hydraulic press. Pneumatic Presses (EMB type) are used for smoke generators. The presses are quite sophisticated with remote control and other arrangements for safe operations. Segmented and barrel moulds are also required.

3. Castable Screening Smoke Composition

The castable screening smoke composition contains a polymeric material along with the normal smoke producing ingredients. The unsaturated polyester resin was prepared using polyethylene glycol (0.7M), propylene glycol (0.2M), diglycidyl ether of bis-'phenol A (0.3M), chlorendic anhydride, isophthalic acid, maleic acid (together 1 M). The resin was then mixed with crosslinking monomers, styrene (15%) and methyl methacrylate (15%) alongwith methyl ethyl ketone peroxide (2%) and cobalt naphthenate (2%) to give the polymeric binder. One part of polymeric binder was used for five parts of the conventional screening smoke composition.

The superior performance parameters of castable screening smoke composition over the conventional screening smoke composition have already been described elsewhere[4].

3.1 Method of Preparation

The method of preparation of castable screening smoke formulation is as per the flow sheet shown in Fig. 4. The specified ingredients are added into the sigma mixer directly along with the polymeric binder. After mixing for about half an hour, the mixture has a dough like consistency and is easily filled into the empties and allowed to cure. Once the curing is over, assembly is undertaken.

3.2 Equipment Required

The only equipment required for the manufacture is the sigma blade mixer. There is no need for grinding equipment, sieving equipment, blending equipment, presses or moulds.

3.3 Firing Trials

Dynamic firing trials were carried out for the ammunition filled with conventional screening smoke formulation and castable screening smoke formulation. The details

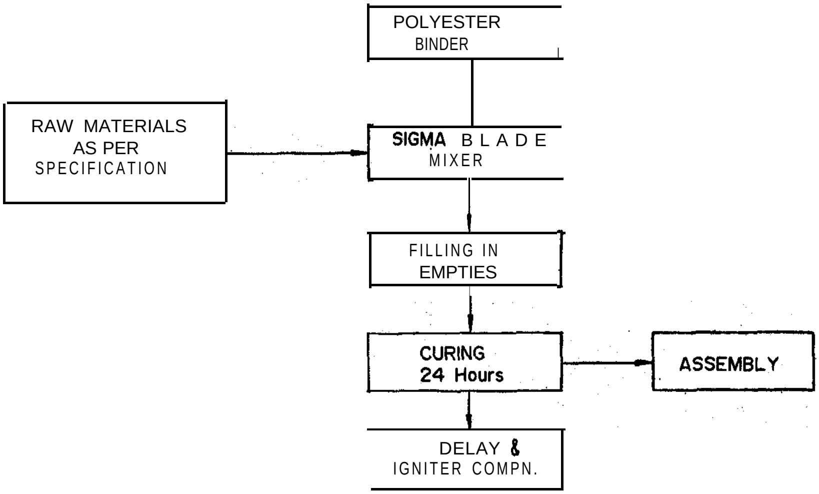

Figure 4. Process description for preparation of castable screening smoke composition.

are given in Table 1. It was observed that at low humidity (less than 50% RH) the conventional screening smoke formulation gave a smoke screen of length only 40 metres, whilst the castable screening smoke formulation produced smoke screen of length 80 metres. However, at higher humidity (80% RH) the press filled conventional smoke formulation gave a smoke screen of length 80 metres.

Table 1. Comparative firing trials

Type of filling	Meteorological conditions: Temp (°C)	Wind Speed (metre/sec.)	Relative Humidity (% RH)	Smoke length (metre)	Duration of smoke (sec.)	Remarks
Press filled by conventional smoke composition (charge wt 2.1 kg)	36	5.0	21	35	280	
	32	3.5	40	40	270	
	19	3.0	80	75	280	
Castable screening smoke (charge weight 2.1 kg.)	36	5.0	21	80	205	The faster burning is due to increased burning area4
	36	5.0	21	80	205	

3.4 Futuristic Factory to Manufacture Castable Smokes

The proposed layout of the futuristic processing plant for the manufacture of castable screening smoke ammunition is given in Fig. 5. The specified ingredients, as per

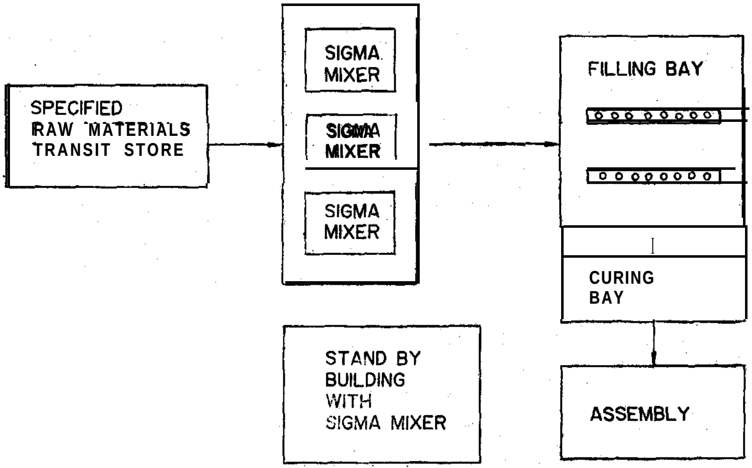

Figure 5. Proposed layout of the futuristic processing plant for manufacture of castable screening smoke ammunition.

required sieve size, purity, etc. could be directly obtained from the manufacturer of chemicals and stored in the factory. The weighed quantity of ingredients would be added into the sigma mixer in the mixing room having a battery of mixers. Any lumps formed during storage will be broken down automatically during mixing. A standby mixing room could be utilized during maintenance runs. After completion of mixing cycle, the smoke mix could be emptied into trollies and pushed to the filling bay for filling into the empties. The latter could be transferred using trollies to the curing bay, where the mass can be cured for 24 hrs on the trollies themselves. Afterwards, the trollies could be pushed to the assembly room for complete assembly.

4. Discussion

The processing plant for the manufacture of castable screening smokes requires minimal space and few equipments, Hence, standby facilities, spares, overhead costs, etc. will be less thereby reducing the operational and maintenance cost every year. If automation could be introduced, the production would be faster and still cheaper[6]. The plant would have added safety because the dough like smoke mix is insensitive to friction and flying dust hazard is minimised. Hexachloroethane vapour is hazardous to health, but by utilizing the casting technology the health hazard to occupationally exposed personnel can be drastically reduced. The smoke produced from castable compositions is also superior in screening acton and gives excellant performance even in dry desert conditions.

5. Conclusion

The castable method of manufacture of screening smokes outlined above has distinct advantages over the conventional method of manufacture. Therefore, a futuristic factory to manufacture castable screening smokes should be designed incorporating the points raised so that it will effectively meet the demands of the twenty first century.

Acknowledgements

The authors are thankful to Dr. K.R.K. Rao, Director, ERDL, Pune for permission to publish the paper and to shri S.G. Avachat, Shri K. S. Job and Shri V.S. Wani for assistance rendered.

References

1. Cackett, J.C., Monographs on Pyrotechnic compositions, Ministry of Defence, RARDE, 1965, p. 99.
2. Ellern, H., 'Military & Civilian Pyrotechnics', (Chemical Publishing Company, Inc. New York), 1968, p. 148.
3. 'Text Book of filling', (Ministry of Supply, UK), 1958, Chapter 6.
4. Patil, U.K., Amarjit Singh & Mishra, P.K., *J. Armt. Studies*, **19 (1983), 116.**
5. Smith, M.D., Ferrett, C.S., Jr., Advanced Technology for Pyrotechnic Mixtures and Munitions, Technical Report ARCSL-TR-77043, 1977.