28

SAFETY LIBRARY PUBLICATION

September 2007

RECOMMENDATIONS FOR ACCOUNTABILITY AND SECURITY OF BULK EXPLOSIVES AND BULK SECURITY SENSITIVE MATERIALS

Member Companies (As of May 2011)

Accurate Energetic Systems
McEwen, Tennessee
Austin Powder Company
Cleveland, Ohio
Baker Hughes
Houston, Texas
Davey Bickford North America
Sandy, Utah
Detotec North America, Inc.
Sterling, Connecticut
Douglas Explosives, Inc.
Philipsburg**,** Pennsylvania
Dyno Nobel Inc.
Salt Lake City, Utah
Famesa Esplosivos S.A.C.
Lima, Peru
General Dynamics – Munitions Services
Joplin, Missouri
GEODynamics, Inc.
Millsap, Texas
IBQ-Britanite
Quatro Barras, Parana, Brazil
Jet Research Center/Halliburton
Alvarado, Texas
Maine Drilling & Blasting
Auburn, New Hampshire
Maxam North America, Inc.
Salt Lake City, Utah
Minerai Explosivos Y Servicios, S.A.
Panama City, Panama
MP Associates, Inc.
Ione, California
Nelson Brothers
Birmingham, Alabama
Nobel Insurance Services
Dallas, Texas
Orica USA Inc.
Watkins, Colorado
Owen Oil Tools LP
Godley, Texas
R&R Trucking
Duenweg, Missouri
Safety Consulting Engineers, Inc.
Schaumberg, Illinois
Senex Explosives, Inc.
Cuddy, Pennsylvania
SLT Express Way, Inc.
Glendale, Arizona
Special Devices, Inc.
Mesa, Arizona
Teledyne RISI
Tracy, California
Titan Specialties, Ltd.
Milford, Texas
Tread Corporation
Roanoke, Virginia
Tri-State Motor Transit Company
Joplin, Missouri
Vet's Explosives, Inc.
Torrington, Connecticut
Viking Explosives & Supply, Inc.
Rosemount, Minnesota
W.A. Murphy, Inc.
El Monte, California

Associate Status:
Federation of European Explosives Manufacturers
Brussels, Belgium

institute of makers of explosives

1120 NINETEENTH STREET, N.W.
SUITE 310
WASHINGTON, DC 20036-3605
(202) 429-9280
www.ime.org
info@ime.org

The Institute of Makers of Explosives (IME) is the safety association of the commercial explosives industry in the United States and Canada. The primary concern of IME is the safety and protection of employees, users, the public, and the environment in the manufacture, transportation, storage, handling, use, and disposal of commercial explosive materials.

Founded in 1913, IME was created to provide technically accurate information and recommendations concerning commercial explosive materials and to serve as a source of reliable data about their use. Committees of qualified representatives from IME member companies developed this information and significant portions of their recommendations are embodied in regulations of federal and state agencies.

The Institute's principal committees are: Environmental Affairs; Legal Affairs; Safety and Health; Security; Technical; and Transportation and Distribution.

TABLE OF CONTENTS

LIST OF ACRONYMS vii

INTRODUCTION 9

RECOMMENDED MEASUREMENT TOOL OR DEVICES 10
Weight Measurement Methods 10
Scales/Load Cells 10
Operational Considerations with Scales and Load Cells 11
Volumetric Measurement Methods 11
Operation Considerations with Volumetric Measurement 12
Flow Measurement Devices 13
Operational Considerations with Flow Measurement Devices 13
Security 14
Site-specific Documented System or Procedure for Accountability of Bulk Materials 15
Permanent Manufacturing and Bulk Storage Sites 15
Security During Transportation 16
Security of Storage Site and Facility 17
Storage on Bulk Trucks 17
Inventory Records 18

APPENDIX A – GLOSSARY OF TERMS 19
APPENDIX B – SUMMARY OF NIST HANDBOOK 44 30
APPENDIX C – RECOMMENDED PROCEDURES FOR DETERMINING BULK MATERIAL DENSITY 33
APPENDIX D – HOW TO CALCULATE THE VOLUME OF VARIOUS SHAPES OF CONTAINERS AND CONVERT PHYSICAL MEASUREMENTS INTO MASS 34
APPENDIX E – RECOMMENDED PROCEDURES FOR CALIBRATING AUGERS AND PUMPS 40
APPENDIX F – EXAMPLE FLUCTUATION ANALYSIS 45

SLP-28
Recommendations for Accountability and Security of Bulk Explosives and Bulk Security Sensitive Materials

LIST OF ACRONYMS

AN	Ammonium Nitrate
ANFO	Ammonium Nitrate Fuel Oil
ASTM	ASTM International
ATF	Bureau of Alcohol, Tobacco, Firearms & Explosives
C	Centigrade
CC	Certificate of Conformance
CEO	Chief Executive Office or equivalent
CFR	Code of Federal Regulation
cu ft	Cubic foot
DOT	Department of Transportation
DSMT	Daily Summary of Magazine Transactions
F	Fahrenheit
FMCSA	Federal Motor Carrier Safety Administration
g/cc	Grams per cubic centimeter
GPS	Global positioning system
IBC	Intermediate Bulk Container
IME	Institute of Makers of Explosives
in	inches
kg	kilograms
lbs	Pounds
LFT	Legal for Trade
NCWM	National Conference of Weights & Measures
NIST	National Institute of Standards and Technology
NIST	National Institute of Standards and Testing
NTEP	National Type Evaluation Program
RPM	Revolutions per Minute
SLP	Safety Library Publication
SOP	Standard Operating Procedure
SSI	Security Sensitive Information

INTRODUCTION

This document has two objectives. The first is to provide guidance to anyone who is involved in maintenance or regulation of inventory of bulk explosive materials. The second is to inform the bulk explosive materials user of the variables and conditions that affect the accuracy of their bulk materials inventories in so far as they are measured for volume and weight. With this knowledge, personnel can anticipate and identify fluctuations in their bulk materials inventories.

Guidance is offered for procedural accountability and security of operations using bulk Division 1.5 and 5.1 materials including ANFO, ammonium nitrate (AN) prills, emulsions, watergels, AN solutions, and other materials used in the manufacture of bulk explosive materials. All bulk material inventory measurements and calculations are approximations as discussed in appropriate sections of this document. Thus, consistency of methodology minimizes fluctuations in inventories.

Bulk Division 1.5 and 5.1 materials used for commercial blasting are distributed in a complex network involving many different modes and methods of handling. Because of this vast array of circumstances, it is impractical to recommend a single method for maintaining accountability of bulk materials. Instead, what follows is a description of appropriate methods and associated practices. Individual sites should review these recommendations to determine how they may be incorporated into their operations (i.e.: SOPs).

Bulk inventory systems consist of storage containers; bulk trucks; volume and weight measurements; and records.

RECOMMENDED MEASUREMENT TOOL OR DEVICES

Accountability of bulk products is accomplished by measuring the quantity of material at various stages of its commerce and comparing those measurements to other data to ensure the material was not diverted from its intended destination. The precision of all bulk measuring devices, systems and/or methods is limited to the capability and tolerances of the system or method. Operating in a consistent manner will minimize fluctuation in the accuracy of measurements. Table 1 summarizes different types of storage or transport containers used for bulk Division 1.5 or 5.1 materials and the recommended methods of measurement for each type.

Table 1: Methods of Measurement of Bulk Products

Type of Container	Methods of Measurement
Railcars	- Railcar Scales, - Load Cells, or - Scale weight of offloaded containers
Permanent Bins, Hoppers, Tanks or Silos	- Load Cells, - Flow, or - Container Volumetric
Mobile Tank Trucks, Bulk Trucks, or Intermediate Bulk Containers (IBC)	- Scales, - Load Cells, - Flow, - Container Volumetric, or - Borehole Volumetric

Weight Measurement Methods

Weight measurement systems can be divided into two general classes systems that actually weigh the material (scales or load cells) and systems that calculate a weight based on volume and density (volumetric).

Scales/Load Cells

The National Institute of Standards and Technology (NIST), publishes specifications, tolerances, and other technical requirements for weighing and measuring devices, also known as *Handbook 44*. *Handbook 44* applies to "all commercial weighing equipment"; that is, to all weighing and measuring devices commercially used to establish the quantity of goods offered for sale on the basis of weight or measure. This would include all commercial bulk explosive materials that are sold on the basis of weight. Within Handbook 44, scales are grouped into Accuracy Classes. Class III covers commercial weighing: Class III L covers vehicle, axle-load, hopper and vehicle on-board weighing systems; and Class III I for wheel load scales and portable axle-load scales used for highway weight enforcement.

Inherent in *Handbook 44* is an understanding that there is an acceptable tolerance in all measurements of large quantity bulk products. See Appendix B for details regarding *Handbook 44*.

Operational Considerations with Scales and Load Cells

Density of the material does not affect scale or load cell measurements.

Truck scales and load cells must be recalibrated on a regular basis as outlined in *Handbook 44* and local LFT regulations. This work should be performed by a competent third party.

The installation and use of these devices needs to be in accordance with the manufacturers' specifications.

Consistent weighing procedures should be established to account for the many variables that may affect accuracy and precision.

Trucks should be weighed consistently with the driver either in or out of the truck

Trucks and railcars should be free of snow, ice, or mud as possible before being weighed. Notation should be made of large accumulations on trucks and railcars that are weighed.

Above: Photograph of bulk truck with 620 pounds of mud as determined by weighing the vehicle clean and dirty

The weight of fuel used by the truck and accessories such as drill bits, packaged explosives, tools, hole liners, and other equipment may be significant and should be accounted for.

Volumetric Measurement Methods

Volumetric measurements depend on knowing the density of the product. Density is the mass weight of a volumetric unit and is usually expressed in grams per cubic centimeter. Product and material density must be measured on a regular basis to ensure volumetric calibration factors remain valid. Table 2 lists typical bulk density ranges for materials commonly used in making bulk explosives and the effect these ranges can have on volumetric mass equivalencies.

Table 2. Typical bulk density ranges for common materials used in bulk explosives

Material	Bulk Density Range (g/cc)	Weight (lbs)		Potential Difference (lbs)	
		1 gallon	1 cu ft	100 gallons	100 cu ft
Water	0.96 – 1.0[1]	8.0 – 8.3	59.9 – 62.4	33	249
Fuel Oil	0.85 – 0.99[2]	7.1 – 8.2	53.0 – 61.7	117	873
Emulsion	1.15 – 1.45	9.6 – 12.1	71.7 – 90.4	250	1,871
AN Prill	0.62 – 1.1	5.2 – 9.2	38.7 – 68.6	400	2,994

See Appendix D for guidance on how to calculate the volume of various shapes of containers.

Operation Considerations with Volumetric Measurement

Check the density of bulk materials on a regular basis and when the supplier changes. See Appendix C for recommended procedures for determining bulk material density.

Emulsion and oil density and viscosity vary with temperature. AN density may be changed by temperature cycling generating fines and moisture absorption or loss.

Emulsion is manufactured at high temperature and if not forcefully cooled, will have a temperature cooling gradient spanning several days. Users need to ensure their metering systems can accommodate these property changes.

Pumping emulsion can increase density by destroying sensitizing voids and can also decrease density by entraining air bubbles into the emulsion.

Bulk emulsion density may increase when transported long distances.

Maintaining a consistent method of measurement will minimize fluctuations. The best method may change with the product (AN, ANFO, Emulsion, Blend, etc.), container, or location.

The angle of repose or vortex causes an uneven top surface which can affect the volume calculation depending on the point at which the height of the material is measured. Measuring two-thirds of the way down the angled surface will yield an approximate equivalent height as if no repose or vortex was present.

Bridging creates voids within the container to be measured and must be eliminated when making volumetric calculations. Use bin vibrators or poles to collapse the bridged area prior to taking a measurement of the volume.

Proper confined space entry procedures should be followed when entering bins or tanks.

Atmospheric moisture may create lumps that must be broken up to assist in proper flow and measurement of material. Grates or screens placed at the point of transfer help to reduce or prevent the transference of lumps (particularly with AN prill).

---

[1] Density range of pure water between 0 and 100 degrees Celsius, CRC Handbook of Chemistry and Physics, 80th edition, CRC press.
[2] http://www.simetric.co.uk/si_liquids.htm.

Clean or scrape down containers prior to delivery of fresh product. Material must be removed from the sides and/or the top of the container to capture the total volume of product. Paddles or squeegee apparatus may be utilized to consolidate the product into a continuous mass.

Borehole volume calculations may be used for estimation of the amount of bulk explosives.

Flow Measurement Devices

Prilled ammonium nitrate and ANFO can be measured while being transferred or loaded with an auger. An auger is a helicoidal device of a fixed pitch (distance between flights) and fixed diameter. As the auger turns it generates a fixed displacement volume of material being conveyed. By counting the number of times the auger turns and relating this to product density the mass of the product being delivered can be calculated.

Emulsion and watergels can be measured while being transferred or loaded with a fixed displacement pump. The pump is normally a progressive cavity or lobe type device. As the pump turns it generates a fixed displacement volume of material being conveyed. By counting the number of times the pump turns and relating this to product density the mass of the product being delivered can be calculated.

Product and material density must be measured on a regular basis to ensure flow meter calibration factors remain valid. Pumps and augers produce a volume of product every revolution, density has no effect on the volume displaced, but affects the weight of the volume.

Operational Considerations with Flow Measurement Devices

Emulsion is manufactured at high temperature and if not forcefully cooled, will have a temperature cooling gradient spanning several days. This can result in a change in density on the order of one percent or more. Metering systems should be able to accommodate these property changes.

When working with equipment metering bulk products it is important to know the performance specifications of the equipment you are using. The maximum and minimum delivery rates should be observed during all calibration operations. The output will vary depending on the application and condition of such equipment.

Recalibrate the metering device if the average density of the bulk explosive or ammonium nitrate changes by more than +/–0.02 g/cc. See Appendix E for recommended procedures for calibrating augers and pumps.

All pumps should be calibrated at the backpressure they would experience under during normal operation. This can be accomplished by using the full length of hose or a device to simulate the backpressure under normal operation.

Emulsion and product pumps run at various speeds. By calibrating the pumps at a midrange operating speed with normal backpressure we can determine their efficiency.

Prill augers become more efficient during high speeds, due to the drop in friction. It is advised to always operate the auger at mid range of the low and high scale, therefore calibration of Prill auger should be done at normal operating speeds.

Match device to viscosity of material. Volumetric flow meters are sensitive to viscosity changes.
Positive Displacement pumps have rubber internal wear parts needing regular replacement to ensure accurate metering.

Container Volumetric – Prilled ammonium nitrate, emulsions and watergels are stored in trailers, overhead silos, and many types of hoppers and tanks. The volume of these devices can be calculated. By measuring the level of the material in the device and relating this to a chart based on product density and volume consumed by the material, the mass can be calculated.

Security

These recommendations are supplementary to security and safety requirements of local, state and federal regulations. The procedures in the Institute of Makers of Explosives Safety Library Publication Number 27 should be the basis for the security measures used by the industry for bulk blasting agents and precursor chemical used in the manufacture of blasting agents. The recommended security standards for the subject bulk materials intentionally exceed the security requirements for the same materials in packages due to the difficulty of determining exact quantities of bulk materials manufactured, in storage, on a vehicle or loaded in a blast hole. Due to the difficulty of determining the exact quantity of a bulk material and maintaining accurate inventory records, protecting bulk materials from unauthorized access is the focus and objective of the security provisions of this document.

The storage of all bulk blasting agent, 1.5 explosives, must be in accordance with the requirements of 27 CFR Part 555.

Each bin, tank or truck used for the storage of bulk 1.5D material is a magazine and comply with all ATF regulations including a DSMT each one. IBCs may be included if not stored in a magazine. When IBCs are stored in a magazine, the net weight of Class 1 material must be included in the package markings.

Precursor chemicals stored and handled in bulk should be subject to the same security requirements as bulk blasting agents except that padlocks need not be hooded. Precursor chemicals are not subject to quantity distance limits unless included in IME SLP 2.

All facilities storing bulk materials should have a security plan similar to the security plan required by the DOT, 49 CFR Part 172, Subpart I and provide security training as required by 49 CFR 172.704(4). See IME SLP 27 for an example security plan.

Conduct periodic reviews of your security plan as part of a commitment to sustain a consistent, reliable and comprehensive program over time.

Enhance security awareness and capabilities through periodic training, drills and guidelines that involve employees annually to some extent and, when appropriate, involve others such as emergency response agencies.

Conduct periodic third-party audits to measure the effectiveness of the planned physical and cyber security measures. These audits and verifications should be reported directly to the CEO or CEO’s designee for review and action.

Site-specific Documented System or Procedure for Accountability of Bulk Materials

Each location should have documentation defining the process that they use to account for bulk inventory. It should consist of, at a minimum, the following points.

Inventory should be allowed to reach zero in a bulk bin or tank at least annually.

Follow your site specific procedures consistently.

Verify the book amount vs. the actual amount on hand at a consistent interval, but at least once a month. The amount of Division 1.5 materials must be verified for each container while the amount of Division 5.1 materials may be verified on a site-wide basis.

Every fluctuation that results in an inventory adjustment should be documented with an explanation that is reasonable and has merit.

There may be a number of reasons for inventory fluctuations and these need to be reviewed based on operational issues associated with the location. Reasons for legitimate inventory adjustments should be identified in the procedural documentation associated with this process.

Records associated with this inventory process should consist of those necessary to comply with regulatory requirements.

Track inventory fluctuations and the reasons for the fluctuations. This will provide a means to evaluate operational issues that might account for some fluctuations. Evaluation and follow-up may eliminate fluctuations that are controllable.

Report shortage fluctuations determined to be outside of the normal fluctuation experienced at the site.

Report thefts or losses of Class 1 materials (explosives) and thefts of Class 5 materials (oxidizers) used in the manufacture of explosives to ATF.

Report thefts immediately to ATF and local authorities having jurisdiction.

Report losses to ATF after an investigation into the reasons for the fluctuation. Investigations should not take more than three working days. Communicate with local authorities having jurisdiction to determine the extent they want to be notified of losses.

Only shortages or losses should be reported.

Permanent Manufacturing and Bulk Storage Sites

All permanent facilities manufacturing or storing bulk materials should be protected by a fence. This includes all types of bulk storage and bulk trucks, cargo tanks and hopper trailers preloaded under the provisions of a variance from the ATF or used for storage.

Gates shall be locked when site is unattended.

All manufacturing buildings and storage facilities should be locked when unattended. Blasting agent storage must comply with the Requirements of 27 CFR Part 555.

Security During Transportation

All delivery of bulk materials over public highway is to be in accordance with state and federal transportation requirements.

Hopper trailers, cargo tanks, portable tanks, rail cars and bulk truck compartments should be locked or securely sealed.

Each discharge valve, inspection port, manhole, auger discharge opening and fill pipe should be locked or sealed when transporting bulk materials. Auger access points should be secured by lockable or tool removable covers.

If the vehicle is unattended at any time the driver should check all locks and seals prior to moving the vehicle. If locks or seals have been compromised the contents of the vehicle should be checked immediately. The carrier, shipper and appropriate authorities should be notified of any shortage of material.

Upon arrival at the destination the driver and/or receiving person should confirm the integrity of locks and/or seals. If locks or seals have been compromised the contents of the vehicle should be checked immediately. The carrier, shipper and appropriate authorities should be notified of any shortage of material.

The consignee should check the delivery vehicle in and out by weighing or visually checking the cargo carrying compartment.

If residual material remains in the cargo carrying unit or compartment after the unloading process is completed, for the purpose of security and safety the delivery unit should be considered as loaded.

When parked and not in use, an empty bulk delivery unit containing residual product should be considered storage and subject to the appropriate storage requirements. An inventory record should be maintained for the residual material contained in bulk delivery units. DSMT is required if the unit contains blasting agents.

All permanently mounted hoses filled with bulk materials should have terminations with a locking mechanism such as a hinged end cap with hasp or be contained in a permanently mounted lockable steel box.

Shippers and carriers should communicate with all shipments of bulk material from origin to destination and ship date to date of receipt similarly to how Division 1.1, 1.2, and 1.3 material must be tracked under FMCSA security plans per 49 CFR § 385.415(c)(1).

All motor vehicles transporting subject bulk materials should be equipped with a means of two way communication and /or two way GPS systems.

Security of Storage Site and Facility

To supplement other security devices and procedures bulk material storage sites should be enclosed by a fence.

Storage facilities should be locked at all times except when bulk material is being transferred to or from storage or inventory quantity being checked.

All components of the locking system not required to be protected by a hood should be constructed of a minimum 1/4 inch steel. The padlock should comply with ASTM Grade 5 requirements.

All ladders to fixed explosive or precursor bulk storage bins and tanks should have a locked shield to discourage access.

Toolboxes should be secure and locked to deny access to tools or other implements.

Auxiliary equipment used to meter material such as pumps, augers, and power switches shall be locked and secure.

Lock hardware should be inspected at each use or at least monthly to ensure that it has not deteriorated. Where hoods are required, they should fully cover padlocks and staples.

All doors, hatch covers, and closures should be in good repair and fit firmly in place.

Keys to storage facilities should be locked and secured in a security controlled lock-box. A policy controlling access and use of keys should be in place. The policy should include a sign in and out procedure for persons using the keys. Access to the lock-box should be limited to authorized personnel and the number of individuals with access should be restricted to the minimum number necessary to conduct operations.

Storage on Bulk Trucks

A variance must be obtained from the ATF to store Division 1.5 materials (blasting agents) on bulk trucks. All terms and conditions of the variance must be followed.

A DSMT should be maintained for all bulk trucks storing Class 1 materials. A similar record must be kept for other bulk materials contained in bulk truck.

All bulk trucks should be parked in a secure area and immobilized when loaded with bulk materials. Types of immobilization locks can include a steering wheel lock or electronic devices that disallow current flow to engine ignition systems.

A battery disconnect switch is one method of immobilization. If the vehicle is equipped with a battery disconnect switch it should be lockable. The power unit storage battery (s), unless located in the engine compartment, shall be covered by a fixed part of the motor vehicle, or protected by a ventilated cover or enclosure. Protective boots shall be used over the terminals.

Vehicle ignition keys should be stored in a security controlled lock-box. Storage facility keys and vehicle keys should be kept in separate locations. Access to the lock-box should be limited to authorized personnel and the number of individuals with access should be restricted to the minimum number necessary to conduct operations.

Inventory Records

The accuracy and precision of all bulk measuring devices, systems and/or methods is limited to the capability and tolerances of the system or method. The records will be no more accurate than the measuring devices, systems and/or methods used. No two scales weigh exactly the same and the displayed weight of a load weighed twice on the same scales will more than likely be different, but within the allowable tolerance for the certified scales. The same is true for dry bulk material measured in a bin or tank. Due to the normal fluctuations in bulk inventory a base line or range should be established for the fluctuations in the bulk inventory. The base line or inventory range should be established from the daily fluctuations in the bulk inventory at a location. See Appendix F for an example of this process. Fluctuations below the established base line or outside the inventory range would be reported to authorities.

Records maintained for bulk blasting agents must comply with the requirements of 27 CFR 555 Subpart G.

It is recommended that additional information be included in the DSMT, such as: document number, destination or customer, disposition or use, bulk unit number.

A DSMT or similar document should be maintained for all precursor chemicals. Information should be recorded by the close of the next business day. This includes rail cars being unloaded, and over the road transport units.

APPENDIX A – GLOSSARY OF TERMS

This glossary helps you understand the specialized terms used in the attached PowerPoint presentation. Accepted definitions are used from recognized industry and regulatory sources wherever possible.

For the purposes of this study, only emulsions (a water based product) and ammonium nitrate were considered as they are the two most commonly used bulk explosive materials.

There are, however, other (bulk water based explosive materials) used today, e.g. water gels, slurries. The reader cannot assume all of the information concerning emulsions presented here is transferable to these other water based products as physical characteristics vary among general product lines and from manufacturer to manufacturer. The reader may assume that all of the chains of custody and accounting issues are the same.

When necessary, definitions were created to help you understand the context and scope of term usage.

1.5:
DOT hazard classification for blasting agent. An explosive material which meets prescribed criteria for insensitivity to initiation.

For storage, Title 27, Code of Federal Regulations (CFR), Section 555.11 defines a blasting agent as any materials or mixture, consisting of fuel and oxidizer intended for blasting, not otherwise defined as an explosive: pr4ovided, that the finished product, as mixed for used or shipment cannot be detonated by means of a No. 8 test blasting cap (detonator) when unconfined. (ATF Regulation).

For transportation, Title 49 CFR, section 173.50, defines class 1, Division 1.5 (blasting agent) as a substance which has mass explosion hazard but is so insensitive that there is very little probability of initiation of transition from burning to detonation under normal conditions in transport.[1]
The DOT placard is shown above.

5.1:
DOT hazard classification for oxidizer. A substance, such as a nitrate, that readily yields oxygen or other oxidizing substances to promote the combustion of organic matter or other fuel.[1]
The DOT placard is shown at the left.

5th wheel lock:
A lock that secures the trailer king pin when it is parked. {See; King Pin Lock}.


A


B[9]

Acceptance Tolerance:
The acceptance tolerance shall be one-half the basic maintenance tolerance. SYN: INSTALLED TOLERANCE

Accountability:
Accountability in this presentation refers to the accounting by pounds of bulk explosive materials by the company in custody.

Accuracy – degree of conformity of a measure to a true value.[1]

Ammonium nitrate:
"The ammonium salt of nitric acid represented by the formula NH_4NO_3." [1]

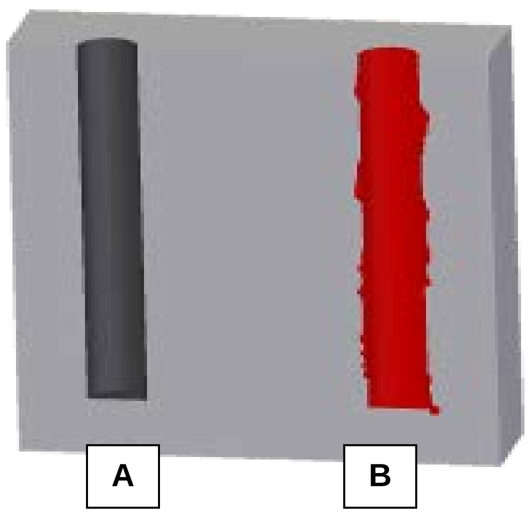
ANFO:
"A blasting agent (1.5D) containing no essential ingredients other than prilled ammonium nitrate and fuel oil." [1]

Bin:
See silo. Syn: silo.

Blend:
"A mixture consisting of:[1]
(a) water based explosives material matrix and ammonium nitrate or ANFO; or
(b) water-based oxidizer matrix and ammonium nitrate or ANFO."

Borehole:
"A hole drilled in the material to be blasted, for the purpose of containing an explosive charge, also called BLASTHOLE or DRILL HOLE." [1]

A) Ideal, cylindrical shape
B) Actual shape is irregular due to geology, drill bit wear, drill bit and drill steel chatter."



Borehole volume calculations:
The mathematical calculation of pounds of explosive per loaded foot into a borehole. 0.3405 is a constant that converts the product of density expressed in g /cc and diameter expressed in inches units into the pounds of explosive per foot of borehole loaded.

Pounds of Explosive per Foot of Borehole = 0.3405 x Density (g/cc) x Diameter (in).[2]

Bridging:
Bridging is the solidification or crusting of ammonium nitrate prills due to degradation that prevents the free flow of prills (i.e. a blockage).

Bulk material:
Division 1.5 materials (blasting agents) and precursor chemicals used in the manufacturer of explosive materials that are handled or stored tanks, railcars, IBCs, bins, and silos, hopper/dump truck/trailers.

Change of custody:
A change of person or company responsible for the accounting and security of an explosive material as it moves through the transferring process from manufacture to use.

Change of state:
A change of DOT hazard classification (due to mixing e.g. AN prills with diesel fuel oil; introduction into emulsion of sensitizing materials: e.g. gassing agents, microballoons; or blending of a sensitized emulsion with AN prills.)

Density:
"The mass of an explosive per unit volume, usually expressed in grams per cubic centimeter or pounds per cubic foot."[1]

Emulsion:
"An explosive material containing substantial amounts of oxidizer dissolved in water droplets, surrounded by an immiscible fuel, or droplets of an immiscible fuel surrounded by water containing substantial amounts of oxidizer." [1]

Entrain air:
The entrapment of air in an explosive material due to handling. Entraining air lowers the products density and can change its sensitivity.

External factors:
Factors affecting the accuracy of inventory accounting of bulk explosive materials that are beyond the manufacturer, shipper or user's control.

Fence:
A physical structure, barrier, or intrusion detection system including electronic detection systems, motion detectors, cameras, thermal imaging systems or other systems or methods used to discourage or identify entry into an area, unless otherwise described by law.

Fines:
Fines are dust like particles of ammonium nitrate formed by the mechanical breakdown of the prills during handling or cycling. Fines are defined by particle size usually by the individual manufacturers as the amount that passes through a specific sieve screen size to the pan in a sieve test.

Fuel:
"A substance which may react with oxygen to produce combustion."[1]

Fuel Oil:
Fuel oil normally refers to diesel fuel used to blend with ammonium nitrate prills to make ANFO or to blend with the oxidizer phase of an emulsion. SEE FUEL.

Gassing Agent:
"Chemicals used to introduce gas bubbles to impart sensitivity and reduce density of explosive compositions."

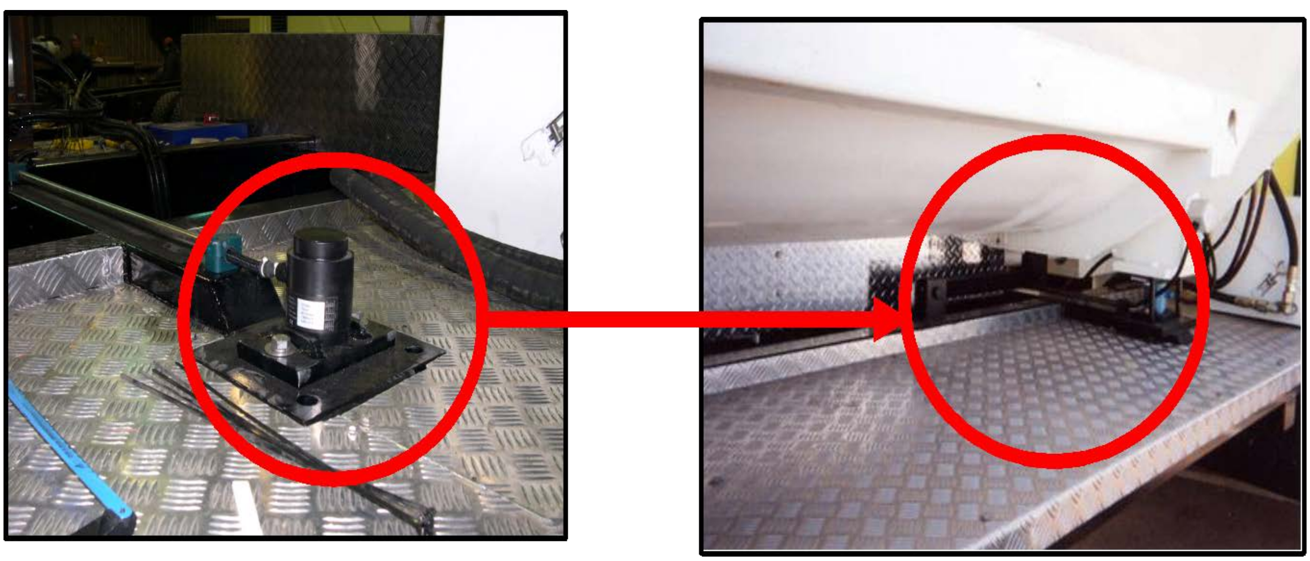
IBC (Intermediate Bulk Container):
"Intermediate Bulk Container or IBC means a rigid or flexible portable packaging, other than a cylinder or portable tank, which is designed for mechanical handling. Standards for IBCs manufactured in the United States are set forth in subparts N and O of part 178 of this subchapter."[4] (49 CFR §171. 8)

Inherent factors:
Factors that affect the accuracy of inventory accounting of bulk explosive materials that are due to the bulk materials natural characteristics, shipping containers characteristics or bulk materials change in natural characteristic due to natural outside influences (e.g. weather conditions)

Installed Tolerance: SYN: ACCEPTANCE TOLERANCE

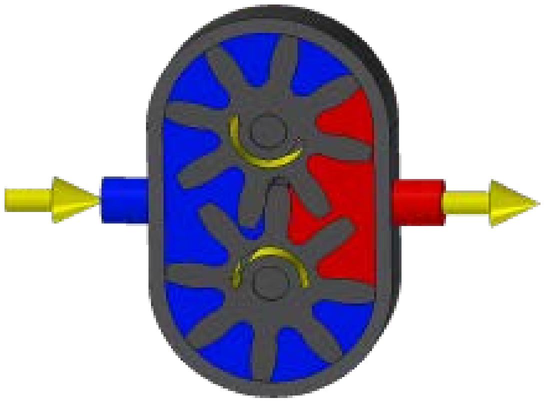
King pin lock:
See 5th wheel lock. Syn: 5th wheel lock

Load cells:
"A device, whether electric, hydraulic, or pneumatic, that produces a signal proportional to the load applied."[3]



Lobe pump:
"Lobe pumps are similar to external gear pumps in operation in that fluid flows around the interior of the casing. Unlike external gear pumps, however, the lobes do not make contact.

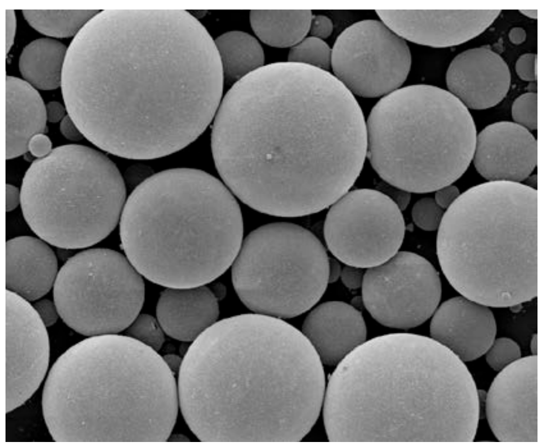
Lobe contact is prevented by external timing gears located in the gearbox. Pump shaft support bearings are located in the gearbox, and since the bearings are out of the pumped liquid, pressure is limited by bearing location and shaft deflection."



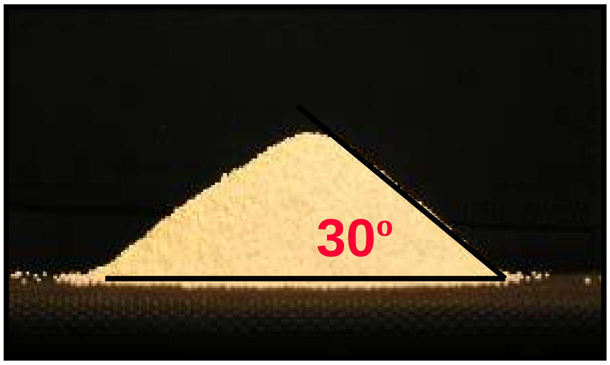
Measurement tools:
Man made instruments used to measure volumes or weights of bulk materials.

Maintenance Tolerance:
The maintenance tolerance is defined by NIST for grain and non-grain commodities
Grain: The basic maintenance tolerance shall be 0.1 percent of test load.
All others: The basic maintenance tolerance shall be 0.2 percent of test load.

Microspheres:
"Tiny, hollow spheres … made of glass, ceramic, polymers and minerals manufactured in hollow forms."[5]



Natural angle of repose:
The angle formed by the sloping edge of a pile of freely flowing material with a horizontal plane. For AN prills the angle equals 30º.



"**National Institute of Standards and Testing**. (**NIST**) Founded in 1901, NIST is a non-regulatory federal agency within the U.S. Commerce Department's Technology Administration. NIST's mission is to develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life. NIST carries out its mission in four cooperative programs…"[2]

"NIST has a statutory responsibility for "cooperation with the states in securing uniformity of weights and measures laws and methods of inspection." In partial fulfillment of this responsibility, NIST is pleased to publish these recommendations of the NCWM." [3]

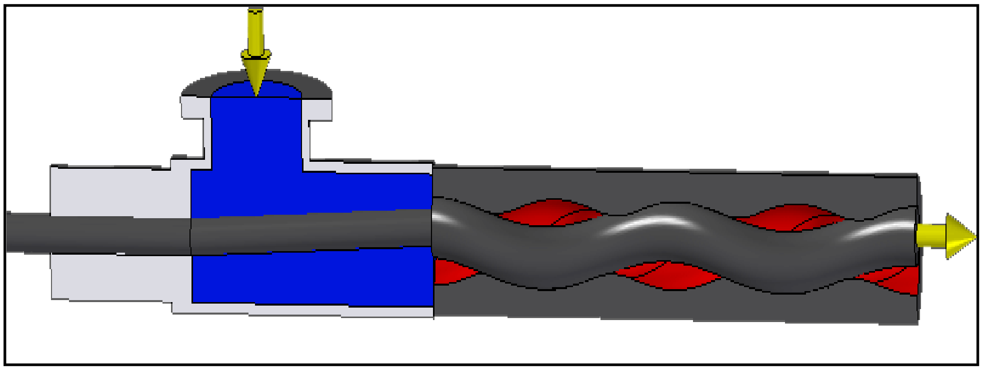
Perlite:
"Perlite is not a trade name but a generic term for naturally occurring siliceous rock. The distinguishing feature which sets perlite apart from other volcanic glasses is that when heated to a suitable point in its softening range, it expands from four to twenty times its original volume."[6]

Precision:
The inherent limits of a measurement.

Precursor Chemicals:
Two or more unmixed, commercially manufactured, prepackaged chemical ingredients (including oxidizers, flammable liquids or solids, or similar ingredients) which are not classified as explosives but which, when mixed or combined, form an explosive.

Prill Caking:
The formation of crust like clumps of ammonium nitrate prills due to prill degradation.

Progressive cavity pump:
"Progressive (or Progressing) Cavity pumps, a type of Single Screw pump, are used for highly viscous liquids such as peanut butter or glue, and also for liquids with significant amounts of solids such as cement or sand slurry. Fluid proceeds from the entrance, at the top on the right side here, to the left. The rotor revolves inside the stator. The stator is a twisted cavity with an oval-shaped cross-section. It is usually made of natural or synthetic rubber, steel, or plastic. The rotor is usually steel. For a given diameter and shape of the rotor, doubling the number of stages (the length) will double the output pressure. The area of the cross-section of the rotor determines the backpressure the pump must withstand."[7]



Rotary volumetric:
A method of measuring the volumetric movement of materials through rotating devices such as augers. The total weight of material moved is calculated by multiplying the recorded volume by the material's density.

Seals
Any of a variety of plastic or metal securing devices number coded used to indicate securement of closed openings of transport containers. Seal numbers are recorded on bills of lading. Examples are shown below.[9]


Metal Plastic Wire rope

Scale division:
"The value of the scale division, expressed in units of mass, is the smallest subdivision of the scale for analog indication or the difference between two consecutively indicated or printed values for digital indication or printing."[3]

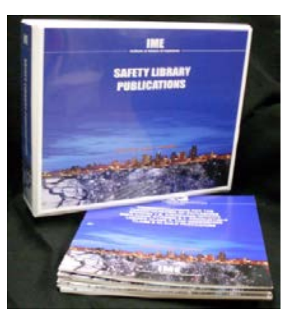
Security Sensitive Information (SSI):
Documents and data that may be helpful to individuals wishing to breach the security of an explosives operation. Typically, SSI includes items such as vulnerability assessments, security plans, route plans, dispatch reports, magazine contents and locations, and customer lists.

Sensitized:
See sensitivity

Sensitivity:
"A physical characteristic of an explosive material classifying its ability to be initiated upon receiving an external impulse such as impact, shock, flame, friction or other influence which can cause explosive decomposition."

Silo:
A vertical storage container used to store ammonium nitrate prills, ANFO, or emulsion. Syn: Bin

SLP:
Safety Library Publication (SLP) as published by the Institute of Makers of Explosives (IME).
Currently there are 12 SLPs in print providing recommendations for the safe use, storage, handling, transportation and security of explosive materials.



Tare mechanism:
"A mechanism (including a tare bar) designed for determining or balancing out the weight of packaging material, containers, vehicles, or other materials that are not intended to be included in net weight determinations."[2]

Tare weight:
The net or empty weight of a container.

Temperature cycling:
Ammonium nitrate transitions through crystal form changes at three temperatures; 35ºC = 95ºF, 83ºC = 184ºF, 125ºC = 257ºF. Practically, the only temperature of concern when using AN prills is the transition temperature of 95ºF. Every time AN prills cycle through this temperature the prills experience a crystal change that caused the prill to break down and get weaker. The more times AN prills cycle, the more degraded its condition gets and caking results. Caking produces handling and use problems.

Tolerance
"A value fixing the limit of allowable error or departure from true performance or value."[3]
SEE ACCEPTANCE TOLERANCE, INSTALLED TOLERANCE AND MAINTENANCE TOLERANCE

Use:
Use refers to the loading of the bulk explosive material into the borehole.

Vortex effect:
The conically shaped depression created at the surface of a material flowing by gravity out of the bottom of a container.

References

[1] IME SLP 12 Glossary of Commercial Explosives Industry Terms, Feb 2007.
[2] NIST Web site, 2005
[3] NIST *Handbook 44*, 2005
[4] CFR Citation as noted
[5] CRC Press LLC, Copyright ©1989. All rights reserved.
[6] www.perlite.com
[7] The Internet Glossary of Pumps
www. animatedsoftware.com/pumpglos/progrssv.htm
[8] www. composite about .com
[9] www. pplmotorhomes.com

APPENDIX B – SUMMARY OF NIST HANDBOOK 44

What is *Handbook 44*?

The National Institute of Standards and Technology (NIST) publishes a standard for specifications, tolerances, and other technical requirements for weighing and measuring devices known as *Handbook 44*. NIST is a non-regulatory federal agency within the U.S. Department of Commerce whose mission is to develop and promote measurement standards and technology. *Handbook 44* is product of the National Conference on Weights and Measures (NCWM), which is made up of State and local weights and measures officials from all parts of the United States. NIST provides technical support to NCWM and publishes the handbook.

What does *Handbook 44* apply to?

Handbook 44 applies to "all commercial weighing equipment"; that is, to all weighing and measuring devices commercially used to establish the quantity of goods offered for sale on the basis of weight or measure. This would include all commercial bulk explosive materials that are sold on the basis of weight.

Specific codes are written to cover different types of weight and measure systems, including scales, liquid-measuring devices, and vehicle tanks used as measures. The code for scales is most applicable to the sale of bulk explosive materials by weight, and includes belt-conveyor scale systems and automatic bulk weighing systems.

The codes for flow measurement devices and volumetric measurement are not particularly applicable to bulk explosive materials. The handbook has no sections that apply to highly viscous materials and solids that have an angle of repose. The handbook primarily addresses low viscosity liquids and solids used in agriculture.

Does *Handbook 44* provide for different levels of accuracy?

Yes, for example scales and load cells are grouped into to Accuracy Classes, or type of weighing device by application, and each Class has different parameters for accuracy. These are: Class I for precision laboratory weighing; Class II for precious metals and gem weighing; Class III for all commercial weighing not otherwise specified; Class III L for vehicle, axle-load, hopper and vehicle on-board weighing systems; and Class IIII for wheel load scales and portable axle-load scales used for highway weight enforcement.

Which Accuracy Class is applicable to bulk explosives operations?

Class III L is the most applicable Accuracy Class for bulk explosives operations.

How do I know a scale or load cell is a Class III L?

The National Type Evaluation Program (NTEP), is a cooperative effort between NIST and the National Conference on Weights and Measures (NCWM). NTEP examines the design and performance of weighing and measuring devices to ensure compliance with national requirements, and issues a Certificate of Conformance (CC) indicating compliance with *Handbook 44* specifications. The CC number can then be included on the manufacturer's data plate.

How precise is a Class III L scale or load cell?

The precision of different Accuracy Classes are:

1. the measurable division,
2. the minimum number of scale divisions, and
3. the maximum number of scale divisions.

For Class III L:

1. each division must be equal to or greater than 5 lb meaning a Class III L device cannot measure more precise than +/– 5 lbs, the minimum number of scale divisions is 2,000 meaning that a Class III L device must be able to measure at least 10,000 pounds, and

2. the maximum number of scale divisions is 10,000.

A greater number of scale divisions results in greater precision for a given weight. The maximum of 10,000 divisions gives a precision of 0.01% of full scale. However, a given design may have less than the maximum number of divisions.

For example, a standard 40-foot steel deck truck scale with a gross capacity of 75 tons, and the maximum number of 10,000 scale divisions would have a scale division equal to 15 pounds. The same 15-pound division might also apply to a set of load cells with a gross capacity of 75 tons used to weigh a bulk prill or emulsion bin.

> What's the difference between "accuracy" and "precision"?
>
> The terms "accuracy" and "precision" are often misused and misunderstood. Accuracy is the degree of conformity of a measure to a true value while precision is the inherent limit of a measurement.
>
> In the context of shooting a gun at a target, an accurate but imprecise gun puts bullets near the aiming point, but spread apart. A precise but inaccurate gun will group all the bullets close together, but away from the point of aim.
>
> With scales and load cells, accuracy can be improved through calibration, but precision is limited by the capabilities of the measurement device.

A scale with 15-pound divisions would be precise to within 15 pounds only if errorless performance were achievable. In practice, tolerances are specified to fix the range of inaccuracy within which scale equipment is officially approved for commercial use.

How accurate is a Class III L scale or load cell?

When scales or load cells are installed they must conform to the acceptance tolerance in *Handbook 44*. As scales or load cells are used they are allowed to drift out of calibration up to a deviation defined in the maintenance tolerance.

What is the acceptance tolerance of a Class III L scale or load cell?

Acceptance tolerance must be at least one half of maintenance tolerance. Acceptance tolerances apply to new installations, first commercial use, returned to commercial use and scales 30 days after major reconditioning.

What is the maintenance tolerance of a Class III L scale or load cell?

The maintenance tolerance for Class III L is +/– 1 division for each 500 divisions.

Using the same truck scale example as above, each division is 15 pounds and 500 divisions are equal to 7,500 lbs making the tolerance 0.2 percent. The scale would need recalibrated if it were to drift outside this tolerance. For a 75,000 pound gross weight bulk truck the tolerance would be +/– 150 pounds. For a 60 ton gross weight bin, the tolerance would be +/– 240 pounds.

APPENDIX C – RECOMMENDED PROCEDURES FOR DETERMINING BULK MATERIAL DENSITY

Equipment requirements:

A. Calibrated scale such as a postal or lab scale that is capable of measuring grams,
B. Rigid sample cup,
C. Spatula,
D. Notepad and pen, and
E. Calculator.

Procedure with a tare-capable scale:

A. Turn power on scale and set to measure in grams.
B. Level scale and clean weighing surface.
C. Weigh the sample cup and record the tare weight or tare the scale with the empty cup.
D. Fill the sample cup with clean water to the top or to where the level the sample material would be when the excess is scraped off the top of the cup.
E. Record the weight displayed and subtract the tare weight of the empty cup
F. Fill sample cup with sample material being careful to not trap air in the sample.
G. Tap the cup on a hard surface to eliminate any air pockets. The type of surface, number of taps, and force used is less important than following a consistent method each time.
H. Scrape any excess sample material from the top of the cup and wipe clean the outside of the cup.
I. Record the weight displayed.
J. Divide the weight of the sample material by the weight of the water.
K. The result is equivalent to the density of the sample material in grams per cc.

Procedure with a basic scale:

A. Turn power on scale and set to measure in grams.
B. Level scale and clean weighing surface.
C. Place the empty sample cup on the scale and record the weight displayed.
D. Fill the sample cup with clean water to the top or to where the level the sample material would be when the excess is scraped off the top of the cup.
E. Record the weight displayed.
F. Fill sample cup with sample material being careful to not trap air in the sample.
G. Tap the cup on a hard surface to eliminate any air pockets. The type of surface, number of taps, and force used is less important than following a consistent method each time.
H. Scrape any excess sample material from the top of the cup and wipe clean the outside of the cup.
I. Record the weight displayed.
J. Divide the weight of the sample material minus the weight of the sample cup by the weight of the water minus the sample cup.
K. The result is equivalent to the density of the sample material in grams per cc.

(Sample – Cup)/ (Water – Cup) = density

APPENDIX D – HOW TO CALCULATE THE VOLUME OF VARIOUS SHAPES OF CONTAINERS AND CONVERT PHYSICAL MEASUREMENTS INTO MASS

Volumetric accounting of bulk materials can be very accurate but requires:

- Knowing the bulk density,
- Taking a consistent and accurate measurement of a point on a straight line within the container, and
- A table or chart to convert the measurement to mass within the container.

Density

The importance of knowing the precise density of bulk materials have been covered previously in this document. See Appendix C for guidance on how to determine bulk density. As shown in the following example, a 0.05 g/cc error in bulk density can equals nearly a 1,000 pound error in a 10 foot diameter bin.

Measuring the Top Surface

Measure the location of the top surface of the product along the same straight line within the container. This is absolutely necessary for the conversion to mass to be accurate. For example, if a measurement of 72 inches was supposed be taken along a vertical line, but the measurement point was actually 12 inches away from vertical, then the measurement would be 1 inch too long. As shown in the following example, one inch of measurement error in a 10 foot diameter bin equals up to 2,000 pounds error in mass.

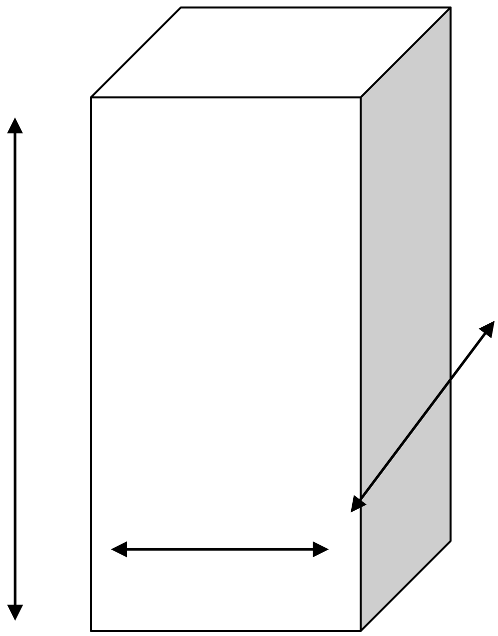
Liquid products generally have a flat surface meaning the surface can be measured anywhere. But solids such as AN prill may have a convex or concave conical shaped surface due the material's natural angle of repose. The natural angle of repose for AN prill is usually 30 degrees. The effect of uneven surfaces on measurements should be accounted for.

Convert the Measurement into Mass

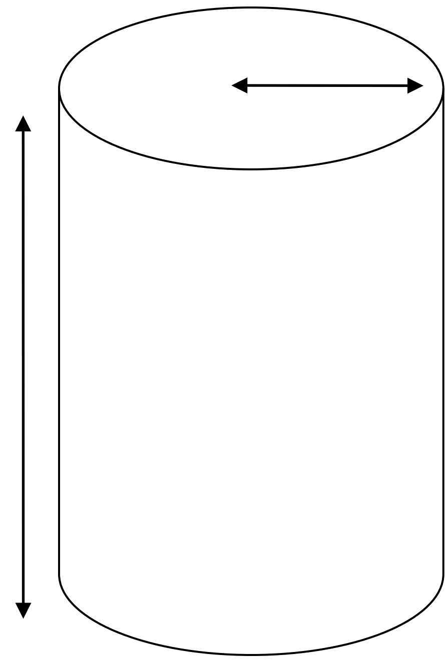
The final step in this process is to develop a table or chart to convert the measurement into a mass of product within the container. The table or chart will have separate columns or lines representing different densities of product in the container.

The basic mathematical formula to determine the mass within the container is:
Mass = (volume of container – volume of void) x density.

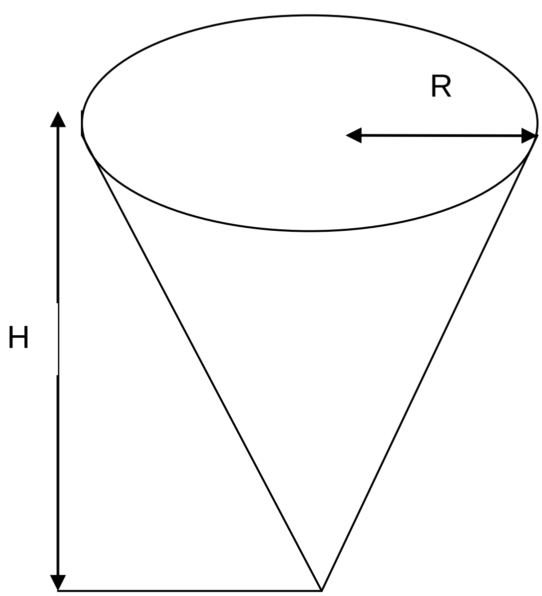
Following are formulas that may be used to calculate the mass within common shapes of containers used for bulk materials.



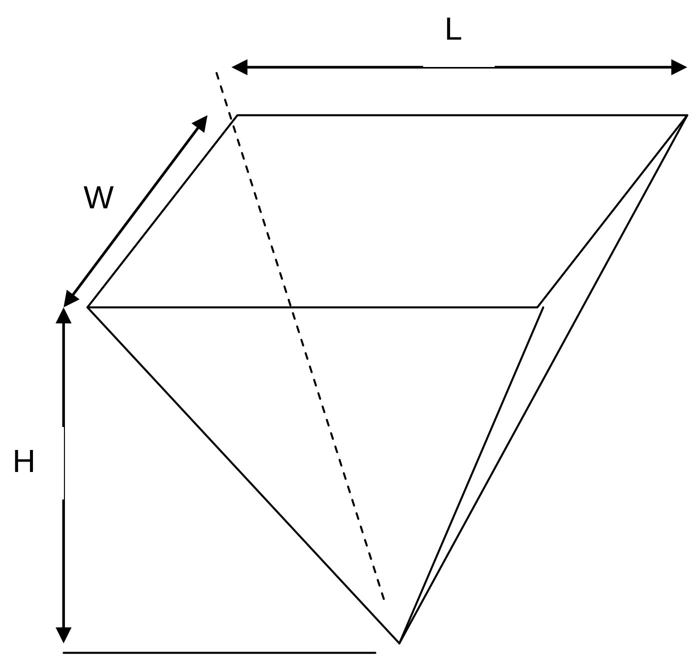
Mass = L x W x H x density



Mass = R^2 x 3.14 x H x density



Mass = 1/3 x R^2 x 3.14 x H x density



Mass = 1/3 x L x W x H x density

There are many websites that provide formulas and calculators for volume or the amount of material inside for various shapes of containers. IME maintains a webpage that links to some of these sites and has sample spreadsheets available for download. See http://www.ime.org/dynamic.php?page_id=106

Conversion Factor
To convert from g/cc to lbs/ ft^3, multiply by 62.43.

Use these formulas to create a spreadsheet table with the columns representing different densities of products and the rows representing the mass of product at one inch increments from the top of the container. Typically, the container will be a combination of shapes, for example a cylinder on top of a cone. In these cases, the table will have different calculations for each region. Following is an example exercise for a cylinder on top of a cone.

Example Bin Chart

Dimensions of the Container:

Diameter = 10 feet
Height of Cylindrical portion of Container = 20 feet
Height of Conical portion of Container = 6 feet.

Step 1. Calculate the total volume of the container.

Volume of Cylinder = $20 \times 3.14 \times (10/2)^2 = 1{,}570\ ft^3$
Volume of Cone = $6 \times 1/3 \times 3.14 \times (10/2)^2 = 157\ ft^3$
Total volume of container = $1{,}570 + 157 = \underline{1{,}727\ ft^3}$

Step 2. Create the portion of the table representing the cylinder.

Create a table in a spreadsheet with columns for density in 0.05 g/cc increments within the range of product densities you may store. In the following example, we expect our product to be between 0.8 and 1.15 g/cc.

Inches from Top	**Density (g/cc)**							
	0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15

Add the first row of data by placing a zero in the second column and a formula for the container volume times the density times the conversion factor in the density columns. The formula in the column headed "0.8" would be 1,727 x 0.8 x 62.43 = 86,253.

Inches from Top	**Density (g/cc)**							
	0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15
0	86,253	91,644	97,035	102,426	107,817	113,207	118,598	123,989

Add the second row of data. Enter 1 in the second column and in the next column, enter a formula for the total mass minus the void mass. The formula in the column headed "0.8" would be 86,253 – 1/12 x 3.14 x $(10/2)^2$ x 0.8 x 62.43 = 85,927.

Inches from Top	**Density (g/cc)**							
	0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15
0	86,253	91,644	97,035	102,426	107,817	113,207	118,598	123,989
1	85,927	91,297	96,667	102,038	107,408	112,779	118,149	123,519

Complete the remaining rows of the table representing the cylindrical portion of the tank. Fill out the second column in one inch increments and use the same formula as above. The table will look like the following.

Inches from Top	**Density (g/cc)**							
	0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15
0	86,253	91,644	97,035	102,426	107,817	113,207	118,598	123,989
1	85,927	91,297	96,667	102,038	107,408	112,779	118,149	123,519
2	85,600	90,950	96,300	101,650	107,000	112,350	117,700	123,050
3	85,273	90,603	95,932	101,262	106,591	111,921	117,251	122,580
4	84,946	90,256	95,565	100,874	106,183	111,492	116,801	122,110
			Middle Portion of Table Omitted					
236	9,148	9,720	10,292	10,863	11,435	12,007	12,579	13,150
237	8,821	9,373	9,924	10,475	11,027	11,578	12,129	12,681
238	8,495	9,026	9,556	10,087	10,618	11,149	11,680	12,211
239	8,168	8,678	9,189	9,699	10,210	10,720	11,231	11,741
240	7,841	8,331	8,821	9,311	9,802	10,292	10,782	11,272

Check the arithmetic in the table at this point. The mass at a measurement of 240 inches should be equal to the mass of product in the conical portion of the container. In this case, 157 x 0.8 x 62.43 = 7,841; which is equal to the number in the table. Our math checks out.

Step 3. Create the portion of the table representing the cone.

Because the volume of a cone depends on knowing the radius of the cone, we must add the radius of the cone at the point of measurement in the first column we have left blank until now. A formula for the radius of the cone at the measurement point is:

Radius (m) = ((height of container – measurement) x radius of cylinder)/height of cone

So, at 241 inches from the top, the radius of the cone is ((26 – 241/12) x 10/2) / 6 = 4.9306 feet.

Complete the second column in one inch increments and enter the formula above in the first column to calculate the radius of the cone at each measurement point. At this point, the table should look like this:

Radius of Cone	Inches from Top	**Density (g/cc)**							
		0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15
	0	86,253	91,644	97,035	102,426	107,817	113,207	118,598	123,989
	1	85,927	91,297	96,667	102,038	107,408	112,779	118,149	123,519
	2	85,600	90,950	96,300	101,650	107,000	112,350	117,700	123,050
	3	85,273	90,603	95,932	101,262	106,591	111,921	117,251	122,580
	4	84,946	90,256	95,565	100,874	106,183	111,492	116,801	122,110
			Portion of Table Omitted						
	236	9,148	9,720	10,292	10,863	11,435	12,007	12,579	13,150
	237	8,821	9,373	9,924	10,475	11,027	11,578	12,129	12,681
	238	8,495	9,026	9,556	10,087	10,618	11,149	11,680	12,211
	239	8,168	8,678	9,189	9,699	10,210	10,720	11,231	11,741
	240	7,841	8,331	8,821	9,311	9,802	10,292	10,782	11,272
4.9306	241								
4.8611	242								
4.7917	243								
4.7222	244								
4.6528	245								
			Portion of Table Omitted						
0.2778	308								
0.2083	309								
0.1389	310								
0.0694	311								
0.0000	312								

Notice that as another check on our arithmetic, the radius is zero when the measurement from the top is the same as the height of the container.

Now insert the formula for the volume of a cone x density x conversion factor in the remaining blanks. The upper left cell would contain the formula:

$1/3 \times 3.14 \times 4.9306^2 \times (26-241/12) \times 0.8 \times 62.43 = 7{,}519$

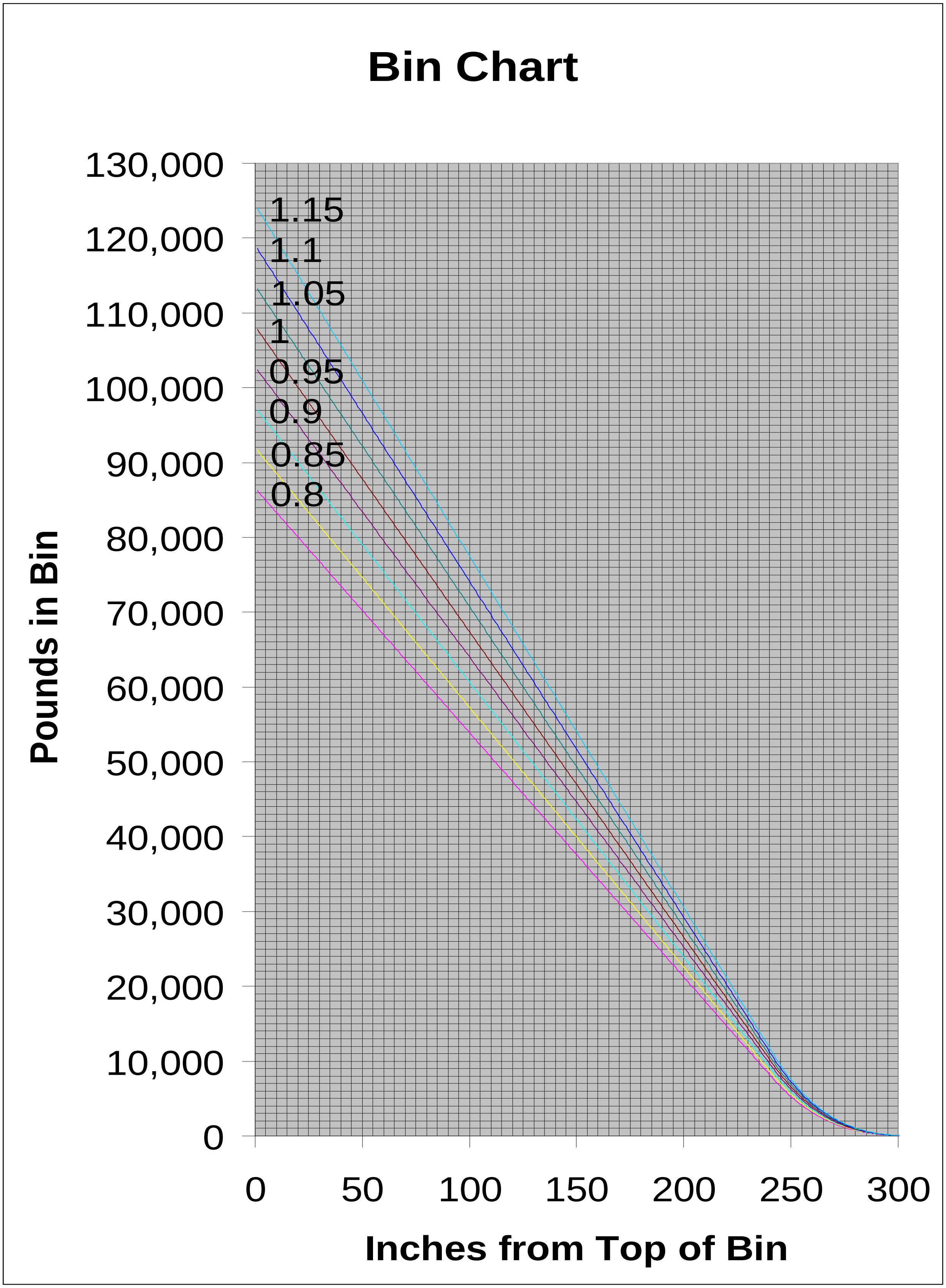
The completed table would look like this:

Radius of Cone	**Inches from Top**	**Density (g/cc)**							
		0.8	0.85	0.9	0.95	1.0	1.05	1.1	1.15
	0	86,253	91,644	97,035	102,426	107,817	113,207	118,598	123,989
	1	85,927	91,297	96,667	102,038	107,408	112,779	118,149	123,519
	2	85,600	90,950	96,300	101,650	107,000	112,350	117,700	123,050
	3	85,273	90,603	95,932	101,262	106,591	111,921	117,251	122,580
	4	84,946	90,256	95,565	100,874	106,183	111,492	116,801	122,110
			Portion of Table Omitted						
	236	9,148	9,720	10,292	10,863	11,435	12,007	12,579	13,150
	237	8,821	9,373	9,924	10,475	11,027	11,578	12,129	12,681
	238	8,495	9,026	9,556	10,087	10,618	11,149	11,680	12,211
	239	8,168	8,678	9,189	9,699	10,210	10,720	11,231	11,741
	240	7,841	8,331	8,821	9,311	9,802	10,292	10,782	11,272
4.9306	241	7,519	7,989	8,459	8,929	9,399	9,869	10,339	10,809
4.8611	242	7,206	7,656	8,106	8,557	9,007	9,458	9,908	10,358
4.7917	243	6,901	7,333	7,764	8,195	8,627	9,058	9,489	9,921
4.7222	244	6,606	7,018	7,431	7,844	8,257	8,670	9,083	9,496
4.6528	245	6,318	6,713	7,108	7,503	7,898	8,293	8,688	9,083
			Portion of Table Omitted						
0.2778	308	1	1	2	2	2	2	2	2
0.2083	309	1	1	1	1	1	1	1	1
0.1389	310	0	0	0	0	0	0	0	0
0.0694	311	0	0	0	0	0	0	0	0
0.0000	312	0	0	0	0	0	0	0	0

Make sure the table shows zero product when the container is empty. Do not be concerned if several lines at the bottom of the table show zero product; a pound will fill several inches in the bottom of a cone.

Make a graph of the table using the spreadsheet X-Y chart function and examine it for anything that looks unusual. The graph could be used to determine the approximate amount of material in the container, but does not have the fidelity needed for inventory purposes. A graph of the example above would look like this:

Are all the lines evenly spaced? Can you see the transition from cylindrical portion to the conical portion of the container?


Bin Chart
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Pounds in Bin
0
50
100
150
200
250
300
Inches from Top of Bin

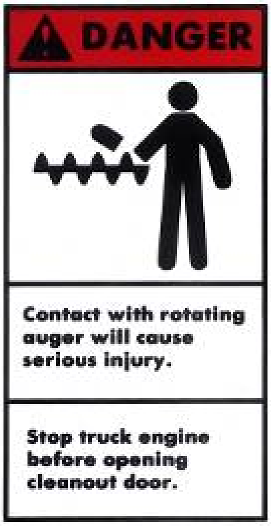
APPENDIX E – RECOMMENDED PROCEDURES FOR CALIBRATING AUGERS AND PUMPS

This appendix provides recommended procedures for calibrating flow measurement devices such as augers and pumps. Specific manufacture recommendations may differ and should take precedence over these procedures.

These procedures are directed to blasters and other field personnel when calibrations are performed on metering and transfer devices. Following these procedures will minimize fluctuations in measurement.

Remember to follow proper lock-out/tag-out procedures when working with bulk equipment!

Definitions:



Calibrate: Checking a measuring instrument against an accurate standard to determine any inaccuracy and correct for errors.

Target: A device or object that activates a sensor.

Meter: A measuring device

Sensor: A device capable of detecting and responding to physical stimulation such as movement, light, or heat.

Totalizer: A device that records pulses from a sensor and calculates totals.

Component: Any one of the substances necessary to describe each phase of a formula. i.e., Emulsion, AN Prill, Gassing solutions, Water and Diesel Fuel Oil.

Formula: The combination of components at a specific rate or quantity.

Equipment: The tools, clothing, or other items needed for a particular purpose or activity.

Scale value: Converts incoming pulse to a value. (ex. lbs, KG, and feet etc.)

Calibration of Ammonium Nitrate or ANFO Auger

A. Perform density check on AN or ANFO
B. Ensure sensors and meters are working properly.
C. Document the scale value in totalizers and rate meters.
D. Check the AN or ANFO compartment for proper amount of product for calibrations.
E. Set the engine RPMs at the speed of normal operation.
F. Pre-fill auger path until a steady stream of product is flowing.
G. Tare scale and reset totalizer.
H. Run sample.
I. Document actual scale weight and totalizer display.
J. Enter the corrected scale value in totalizer.
K. Repeat steps 5 to 10 to confirm the calibration is correct (If the calibrations are correct the scale reading should match the totalizer)
L. If the sample did not match totalizer repeat steps 3 to 11 and confirm. If the samples did not match add all three correct scale values and divided by three to obtain an average. Enter correct scale value to correct the totalizer.
M. Document the correct scale value.

Always make sure when doing calibrations that the bin or hopper closest to the exit point of the auger is full when doing calibrations.

NOTES: To add 6% diesel fuel oil to a sample (Divide the sample by .94 = actual weight with 6% diesel fuel oil (EX. 650 LBS AN / .94 = 691.48 LBS ANFO. (The totalizers used must show ANFO weight)

Calibration of Auger-mixed Ammonium Nitrate and Fuel Oil

A. Perform density check of AN.
B. Assure sensors and meters are working properly.
C. Document the scale value in totalizers and rate meters.
D. Check the AN compartment for proper amount of product for calibrations and fuel oil tank.
E. Set the engine at the speed of normal operation.
F. Test fuel system for proper operation. (make fuel flow control is a the 6% setting.)
G. Remove fuel oil line from injectors and install testing injector kit.
H. Pre fill auger path till steady stream of product and fuel oil is flowing
I. Tare scale, reset meters and tare fuel oil scale.
J. Run sample (make sure the fuel oil container is large enough)
K. Document the actual scale weight of the AN, fuel oil and the meters.
L. Add the fuel oil and the AN totals = Actual ANFO weight
M. Apply the scale factor correction formula
N. Enter the correct scale value in meter.
O. Repeat steps 5 to 14 to confirm that the calibrations are correct. (If the calibration is correct the scale reading should match the totalizer)
P. If the sample did not match meter repeat steps 5 to 13 and confirm. If the samples did not match add all three correct scale values and divided by three to obtain an average. Enter correct scale value to correct the totalizer.
Q. Document correct scale value.

To calculate the fuel percentage (fuel weight /ANFO weight (AN and fuel oil) = fuel oil percentage. (EX 600 lbs AN + 37 lbs fuel oil = 637 lbs ANFO; 37 lbs fuel / 637= .058 or 5.8% fuel

- Five-gallon oil pails usually have 5-gallon mark inside the bucket.
- Must maintain operating backpressure.

Calibrate Fuel Oil Meter

A. Must bypass AN auger.
B. Use a 5-gallon container.
C. Install test injector kit
D. Maintain normal operating speed on DFO pump.
E. Reset meter and run sample in container.
F. Compare container to meter. (Ex. Meter-4.6gal container 5.0-gal.)
G. Adjust meter to match container.
H. Repeat steps 5 to 7 till sample and meter matches.

Calibration of Emulsion Pumps:

A. Perform a density check on emulsion.
B. Assure the meters and sensors are operating properly.
C. Document the scale values in the totalizers and rate meters (not all units have rate meters).
D. Check the emulsion tank to ensure there is enough product to obtain sample.
E. Set the pump speed to a midpoint.
F. Pre-fill the emulsion path (Obtain a sample where the hose connects to the injection port or vessel to be filled to ensure proper back pressure.)
G. Tare scale and reset meters.
H. Run sample
I. Document the actual scale weight and the totalizer display.
J. The meters can then be adjusted, to reflect the actual weight delivered.
K. Repeat steps 5 to 8 to confirm that the calibrations are correct. (If the calibration is correct the actual weight should match the totalizer.)
L. If the sample did not match totalizer repeat steps 3 to 11 and confirm totalizer value.
M. Document correct scale value.

Below is an example of commonly used pumps and augers for the metering and transferring of bulk products and their expected output. This information can only be used as a reference and not as a definite delivery rate of a pump. Consult the information supplied with the pump or auger for specific performance information.

Density and Delivery Rate Information				
		Emulsions		
		Sensitized	***Un-Sensitized***	
		Blasting Agent	***Oxidizer***	***AN Prill ****
Product Density Values		***1.5D, UN 0332***	***5.1, UN 3375***	***5.1, UN 1942***
	g/cc	**1.24**	**1.35**	**0.84**
		10.3 lb/gal	11.3 lb/gal	52.4 lb/cf
	Volume			
	per			
	Revolution	**Pounds / Revolution**		
Small Emulsion Gear Pump	0.3 gal	3.3	3.6	na
Large Emulsion Gear Pump	**0.5 gal**	**5.1**	**5.6**	**na**
Small Progressive Cavity Pump	0.1 gal	1.4	1.5	na
Large Progressive Cavity Pump	**0.3 gal**	**2.6**	**2.8**	**na**
Typical Full Pitch bed auger (side discharge units)	0.13 cf	na	na	6.8
Typical ⅔ Pitch bed auger (most overhead units)	**0.09 cf**	**na**	**na**	**4.7**
Typical ½ Pitch bed auger (newer overhead Quads)	0.07 cf	na	na	3.6

APPENDIX F – EXAMPLE FLUCTUATION ANALYSIS

At periodic intervals, a comparison should be made between the amount of material on hand and the amount of material that *should* be on hand based on a calculation of throughput for each storage container. A record of variations over time should be recorded and analyzed. Through simple analysis, this will provide reasonable boundaries for expected fluctuations and potentially identify sources of error. Following is an example of how this process might be conducted for a site.

Create a spreadsheet with five columns with headings like day, activity, quantity, balance, and variance. Enter the amount of bulk product in the container as your starting balance in the first row. The table will something look like this:

Day	Activity	Quantity	Balance	Variance
			52,500	

Add rows and fill in the columns every time material is removed or added to the bin. After a week, the table will look like this:

Day	Activity	Quantity	Balance	Variance
			52,500	
1	shot service truck 1	(17,087)	35,413	
2	shot service truck 2	(18,454)	16,959	
3	receipt	42,250	59,209	
3	shot service truck 1	(15,584)	43,625	
4	shot service truck 1	(17,068)	26,557	
5	shot service truck 2	(15,456)	11,101	

Take a measurement of the amount of material in the bin using a volumetric method and enter the value in the balance column. Subtract the book amount from the measured amount and enter the value in the variance column. In our example below, 11,874 – 11,101 = 773 lb variance in the first week. The table will look like this:

Day	Activity	Quantity	Balance	Variance
			52,500	
1	shot service truck 1	(17,087)	35,413	
2	shot service truck 2	(18,454)	16,959	
3	receipt	42,250	59,209	
3	shot service truck 1	(15,584)	43,625	
4	shot service truck 1	(17,068)	26,557	
5	shot service truck 2	(15,456)	11,101	
Measurement			**11,874**	773

Continue to record data in this manner until you have at least 20 values in the variance column. The table will look like this:

Day	Activity	Quantity	Balance	Variance
			52,500	
1	shot service truck 1	(17,087)	35,413	
2	shot service truck 2	(18,454)	16,959	
3	receipt	42,250	59,209	
3	shot service truck 1	(15,584)	43,625	
4	shot service truck 1	(17,068)	26,557	
5	shot service truck 2	(15,456)	11,101	
Measurement			**11,874**	773
6	receipt	42,472	54,346	
6	shot service truck 1	(15,681)	38,665	
7	receipt	42,314	80,979	
8	shot service truck 1	(14,412)	66,567	
8	shot service truck 2	(15,241)	51,326	
9	shot service truck 1	(15,215)	36,111	
10	shot service truck 2	(15,364)	20,747	
Measurement			**20,287**	(460)
11	shot service truck 1	(14,785)	5,502	
12	receipt	41,024	46,526	
12	shot service truck 2	(14,541)	31,985	
12	shot service truck 1	(14,782)	17,203	
13	shot service truck 2	(17,203)	0	
Measurement[3]			**487**	487
14	receipt	42,500	43,300	
15	shot service truck 1	(17,495)	26,300	
Measurement			**26,200**	(105)
15-20				354
21-25				(357)
26-30				(1,125)
31-35				204
36-40				350
41-45				14
46-50				(159)
51-55				358
56-60				1,354
61-65				(724)
66-70				206
71-75				(155)
76-80				(608)
81-85				338
86-90				(452)
91-95				253

Daily activity from days 15 to 90 omitted from chart.

[3] Take a measurement when the book amount shows zero.

Calculate the average variance and the standard deviation of the data using the spreadsheet functions. In the example above, the average variance is 27 lbs and the standard deviation is 565 lbs.

Because the average variance is close to zero, we can be confident that our system is relatively accurate. If the average was more than 10% of the standard deviation, 57 lbs in this case, it may indicate there is a consistent cause of error in the system. For example, using the incorrect density or a meter out of calibration will result in measurements consistently off in one direction or another. If an inherent inaccuracy is found and corrected, adjust the data accordingly and recalculate the average and standard deviation.

Multiply the standard deviation by two, in this case it equals 1,130 lbs. This tells us, assuming we have a normal distribution of data[4], that 95.5% of all measurements should have a variance of between –1,130 and +1,130 lbs. A variance within this range should be an expected variance. A measurement outside of this range should be investigated, but may still be due to expected fluctuations. If only 1 in 22 measurements (4.5%) are outside two standard deviations, then everything may still be as expected.

However, if the variance of a measurement is three or more times greater than the standard deviation, +/-- 1,693 lbs in this case, there is only a 0.27 percent probability that the variance is due to expected fluctuations. In this case, the reason for the fluctuation should be investigated and explained in the record. If a reasonable explanation cannot be determined or it is determined to be a theft or loss, contact ATF.

Continue to record and analyze the data. As you collect more data, the average and the standard deviation may change. If the system is accurate or improving, the average should move closer to zero. Movement away from zero or movement to the other side of zero may indicate a source of error has been introduced. Standard deviation is a measure of the precision of the system, but changes in the standard deviation will occur simply by adding more data. Adding more data provides more confidence in the established boundaries for expected fluctuations. If an operation is following the guidelines in this document, the standard deviation established over time should be considered acceptable for establishing boundaries for expected fluctuations.

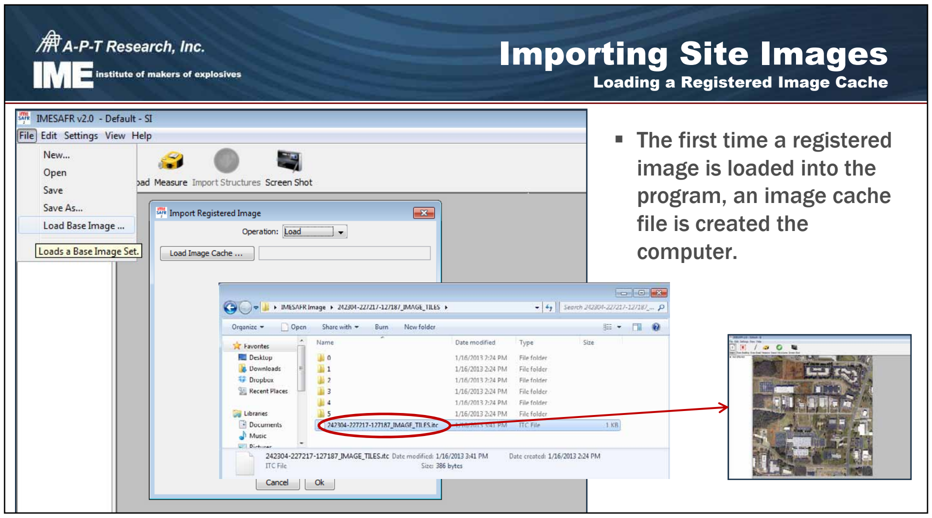
[4] There are many statistical methods to determine how closely a set of data follows a normal distribution. The closer values are to zero for the spreadsheet functions that determining skewness and kurtosis, the closer the data set is to a normal distribution.

A-P-T Research, Inc.
Providing Safe Solutions

Institute of Makers of Explosives

IMESAFR

Safety Analysis for Risk

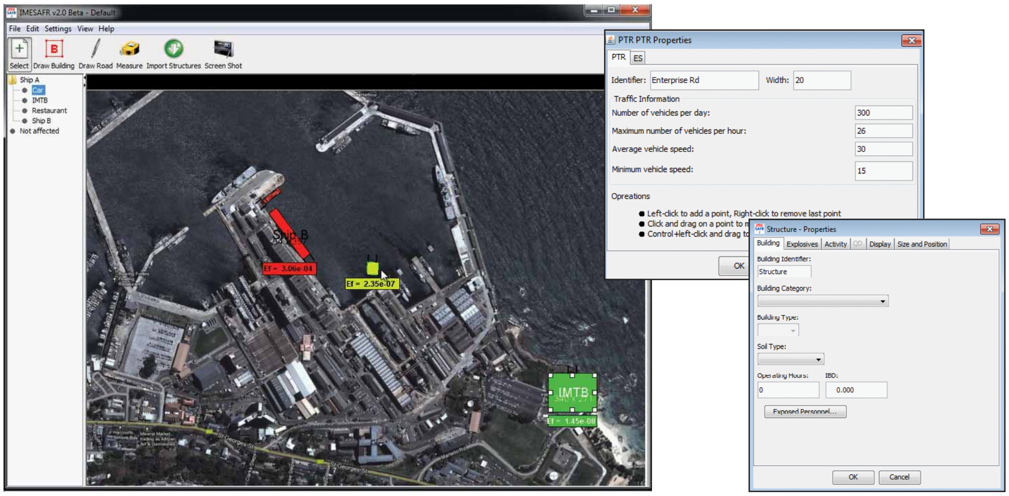


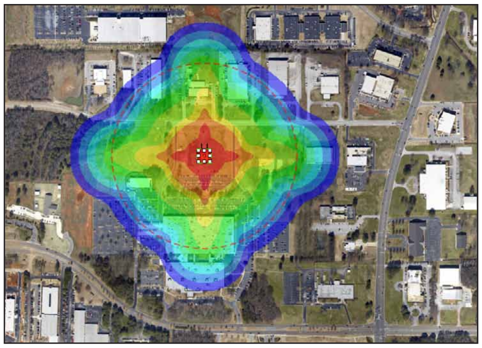
What is IMESAFR?

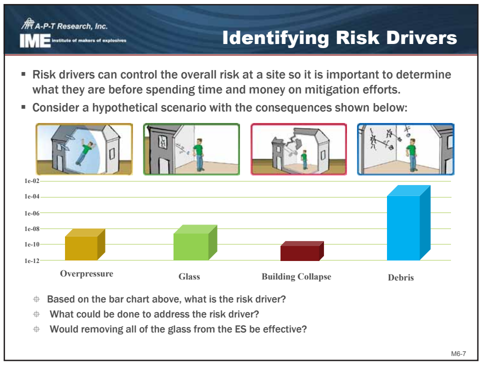
IME Safety Analysis for Risk (IMESAFR) is a software model that was developed through a joint effort by the Institute of Makers of Explosives and APT Research.

IMESAFR is a probabilistic risk assessment tool used to calculate risk to personnel from explosives facilities. This software not only calculates Quantity Distances based on the American Table of Distances (ATD) and other QD regulations, it can determine a level of safety based upon risk.

IMESAFR uses the donor structure and activity, the structure of the exposed sites, and duration of exposed personnel to determine a level of safety. The program provides users with the ability to work in metric or Imperial measures, and allows users to import maps or drawings of their site to assist with visualizing facility layouts and results.







Why Was IMESAFR Developed?

IMESAFR was developed to provide a more comprehensive assessment of the overall risk of explosives operations. The commercial explosives industry in the United States uses the ATD as the basis for safe siting of explosives storage facilities. ATD siting involves the evaluation of a specific magazine and inhabited building or public highway, which are referred to as a Potential Explosion Site (PES)/Exposed Site (ES) pair in IMESAFR. This evaluation yields the recommended separation distance based on the factors that affect risk, including whether a barricade exists. Although the same criteria can be applied to explosives manufacturing operations, the ATD was intended for use in limited permanent storage situations. In addition to permanent storage situations, IMESAFR accounts for other activities such as manufacturing, assembly, and loading and unloading.

DESTRUCTION OF COMMERCIAL EXPLOSIVE MATERIALS

At times it may be necessary to destroy commercial explosive materials. These may consist of explosives or blasting agents from containers that have been broken during transportation or may be materials that have exceeded their recommended shelf life or are believed to be overage or are no longer needed.

Due to the many developments in explosive technology over the past few years, the appearance and characteristics of products have undergone marked changes. To be sure that you are familiar with the properties of the product that you plan to destroy, the manufacturer of that product should be consulted for the most current product information and the recommended method of disposal and/or destruction.

The member companies of the Institute of Makers of Explosives have agreed to supply advice and assistance in destroying explosives. If the manufacturer is known, seek his assistance. If the manufacturer is not known, a member company of the Institute of Makers of Explosives may provide advice or assistance.

The above policy of IME member companies relates only to commercial explosive materials. It does not include handling improvised explosive devices or bombs, military ordnance, military explosives, or homemade explosive materials.

IME member companies also cannot become involved in destroying explosive materials, which have been used for illegal purposes, are reportedly stolen property or are considered as evidence in any potential civil litigation or criminal prosecution.

IME
institute of makers of explosives

1120 Nineteenth Street, N.W
Suite 310
Washington, DC 20036-3605
202/429-9280
Fax 202/293-2420

www.ime.org
info@ime.org

Printed in the USA