Fire Fighting Operations

Involving

Grain Handling Facilities

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The procedures and protocols in this booklet have been based on several methods developed over a period of time that have assisted emergency services in dealing with situations involving agri-business properties.

This booklet is intended solely as a guide to the appropriate procedures to be considered when responding to these types of emergencies. It is not intended as a statement of fact; or, to be the procedures required in any particular situation. Circumstances can and will vary widely from one emergency situation to another.

Nor is it intended that this booklet shall in any way counsel emergency personnel concerning legal authority to perform the activities and/or procedures discussed within.

Other and/or additional safety measures may be required under certain particular circumstances.

The producers of this booklet make no guarantees as to, and, assume no responsibilities for, the correctness, sufficiency, and/or completeness of such information or recommendations.

The final local determination(s) concerning the information contained within should be made only with the assistance and/or aid of your local legal counsel(s).
STORAGE AND HANDLING OF GRAIN MILL PRODUCTS

This course is designed to present the participant with general concepts and overviews of conducting operations at emergencies involving fires at these types of facilities.

The grain industry encompasses the movement, storage, and processing of grains, such as wheat, corn, oats, and sorghums and oilseeds, such as soybeans and sunflower seeds. It can be separated into two broad categories—grain elevator operations, and millers or processors.

Grain elevators primarily accumulate, store, and ship whole grains seeds. Their end product is virtually identical to their raw material, with only minimal drying, cleaning, and fumigation to preserve and meet product quality standards.

Grain millers and processors, on the other hand, take whole grains as their raw material and process these into products, such as: animal feeds, cereals, flour, starch, vegetable oils, corn sugars, brewery products, etc.

The discussion that follows is primarily aimed at the grain elevator segment of the industry and that portion of grain milling and processing which handles and stores whole grains on a bulk commodity basis.

The growth of the grain industry in the United States has paralleled the phenomenal growth in production, consumption, and export of grains and oilseed products. This growth has been the result of many factors—the most important of which is the ideal temperate climate of the U.S. to produce these agricultural commodities, combined with mechanization of farming, the development of high yielding hybrids, the free market system, and uniquely efficient storage and transportation systems.
INTRODUCTION TO FIRE STRATEGY

FIRE STRATEGY DEFINED

1. The art of using available resources (manpower, apparatus, and equipment) on the fire ground.

2. The method or procedure by which an officer seeks to attack, control, and extinguish a fire.

PURPOSES OF FIRE STRATEGY

1. To provide a systematic method of dealing with major emergencies and fires.

2. To identify the various phases of emergencies and fire ground operations.

3. To provide a logical sequence of performing those operations which are required in order to effectively deal with emergencies and major fires.

FUNDAMENTALS OF FIRE STRATEGY

While fire strategy is a primary concern of officers, every firefighter on the fire ground should understand its principles. Fire fighting requires knowledge, skill, and initiative. A knowledge of the principles of fire strategy will enable the individual firefighter to better apply their skills and to use initiative in unusual situations. A firefighter is always better equipped to do a job when they understand the reasoning behind the job.

BASIC DIVISIONS OF FIRE STRATEGY - R.E.C.E.O.

1. Size-up
2. Rescue
3. Exposure Protection A. Ventilation
4. Confinement B. Salvage
5. Extinguishment
6. Overhaul

Basic divisions of Fire Strategy which are designated by number are listed in rank or sequence order. The first consideration at every fire must be size up; the second, rescue the third, exposure protection; and so forth. Ventilation and Salvage are designated by letter to indicate that they may be performed at any time during the attack and control of a fire.
BRIEF DEFINITIONS OF THE EIGHT BASIC DIVISIONS OF FIRE STRATEGY

1. Size-Up:

   An analysis by the officer in charge of a fire or incident by which the officer decides what to do and how to do it; a continuous mental process during an entire incident and until all operations are completed.

2. Rescue:

   Those operations which are necessary to remove persons (firefighters and civilians) from a place of danger and to deliver them to a place of safety.

3. Exposure Protection:

   Those operations which are necessary to prevent a fire from extending to other areas within the structures (interior), property, or areas outside of the structure (exterior).

4. Confinement:

   Those operations which are necessary to prevent further fire extension within an involved structure.

5. Extinguishment:

   Those operations which are necessary to knock-down or control the fire.

6. Overhaul:

   Those vital operations which must be performed in order to determine origin and cause of the fire, and to prepare the fire premises for release to owners and/or occupants.

A. Ventilation:

   Those operations which are necessary to bring about the planned and systematic removal of smoke, heat, and fire gases from a structure.

B. Salvage:

   Those operations which are necessary to protect property from additional loss or unnecessary damage.
Determine your capabilities and resources

Determine needed resources

Make probability projection based on facts

Make and implement initial decisions

Observe and analyze fire scene facts

Evaluate results and modify decisions as needed
PRINCIPLES OF DUST EXPLOSIONS

A. COMBUSTIBLE ORGANIC SOLIDS
Combustible organic solids burn more readily as their ratio of surface area to volume is increased.

Example: The chopping of kindling wood for ease of starting a campfire. Flammable dust approach the ultimate in this respect.

With the burning rate increased, as the result of a higher ratio of surface area to volume of material, it follows that the rate of heat release has also been intensified.

This last characteristic creates most of the problems in dust explosions.

B. DUST EXPLOSION
A dust explosion is simple combustion but at such a rapid rate of burning that the time interval at any one point of reference has diminished to a fraction of a second.

Dust explosions normally involve flame front speeds in excess of 10 feet per second. During this limited time interval, combustible particles suspended in air are consumed or oxidized, with the resultant heat release producing a rapid expansion of the surrounding air. The expansion is further amplified in many cases by the introduction of hot gases which are products of combustion.

When these expanding gases are not freely vented, the result is a sudden increase in pressure within the area of containment.

C. MULTIPLE DUST EXPLOSIONS
What you may hear is what resembles rolling thunder.

In fact what you hear is a several explosions following one another so rapidly that the report of one blends in with the next making a continuous roar.

For example: The original explosion, or primary, explosion may occur in a cleaning machine where the dust cloud is confined in a relatively small space. The pressure and percussion from this primary explosion throws into suspension the dust which has accumulated on beams, ledges, and floors.

This dust is ignited by the flame of the primary explosion, giving rise to the second explosion, which in turn stirs up the dust in the surrounding portion of the elevator. Thus the explosion is propagated through the elevator, or as far as dust is held in suspension or capable of being thrown in suspension.

 Apparently, the combustion process in the initial explosion uses up the available oxygen. The resultant gases are vented, then air enters the vent, and in the presents of the hot ignition source (hot wire or bearing), the next explosion is initiated after the
remaining unburned dust and fresh air (oxygen) mix rather briefly.

D. **THE SEVERITY OF EXPLOSION**
The severity likely to be encountered in any explosion is governed principally by the material involved, the particle size, and the amount of dust in suspension at the time of ignition.

The last item can be so variable in actual practice that an optimum condition is normally assumed.

In general, with all other factors remaining constant, a decrease in particle size will mean more sever explosion pressure, less energy need for ignition and a greater potential for accumulating electrostatic charges.

E. **HOW MUCH DUST DOES IT TAKE?**
Very little dust suspended in the air and a subsequent ignition to start a disastrous chain of explosion. (About the thickness of 2 - U.S. quarters per square foot).

For typical dust, such as wheat, mixed grain, rice, corn, soybeans, safflower, and cottonseed, the minimum concentration of dust in air necessary for an explosion to take place is only .035 -.055 ounces of dust per cubic foot of air. This amounts to roughly ½ to 2/3 teaspoon of grain dust in a cubic foot of air needed to effectively start a small explosion and possibly destroy a whole grain elevator.

F. **IGNITION TEMPERATURE OF GRAIN DUST.**
The ignition temperature of grain dust clouds ranges from about 750 degrees F to 900 degrees F depending on the type of grain and moisture content of the air.

The ignition temperature of settled dust (mixed grain dust) is about one half the temperature required for similar ignition of a mixed dust cloud. Again, moisture content of all grain dusts plays a key factor in the ignition temperature, with that in mind, the time of the year is a definite "probability" to consider when looking at all the ignition temperature factors.

G. **MAXIMUM EXPLOSIVE PRESSURE**
Depending on the type of dust, generally range from 85 to 105 P.S.I. along with maximum rates of pressure rise that may range from 3,000 - 9,000 P.S.I. /sec. These are closed container explosions test pressures which few grain elevators, as currently constructed can withstand. Unless such pressure can be quickly reduced by pressure relieving construction, the structure will be destroyed. Elevators, even those built within the last decade, and fully equipped with "blowout panels," have been totally destroyed.
EXPLOSIVE CHARACTERISTICS OF VARIOUS DUSTS

<table>
<thead>
<tr>
<th>TYPE OF DUST</th>
<th>IGNITION TEMP OF DUST CLOUD</th>
<th>MINIMUM IGNITION ENERGY</th>
<th>MAXIMUM EXPLOSIVE P.S.I.</th>
<th>EXPLOSIVE HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORN</td>
<td>400</td>
<td>.04</td>
<td>6,000</td>
<td>STRONG</td>
</tr>
<tr>
<td>SAFFLOWER</td>
<td>460</td>
<td>.02</td>
<td>2,900</td>
<td>STRONG</td>
</tr>
<tr>
<td>SUGAR</td>
<td>360</td>
<td>.035</td>
<td>6,000</td>
<td>SEVERE</td>
</tr>
<tr>
<td>WHEAT</td>
<td>480</td>
<td>.06</td>
<td>3,600</td>
<td>STRONG</td>
</tr>
<tr>
<td>WHEAT FLOUR</td>
<td>380</td>
<td>.05</td>
<td>3,700</td>
<td>STRONG</td>
</tr>
<tr>
<td>MIXED GRAIN</td>
<td>430</td>
<td>.03</td>
<td>5,500</td>
<td>STRONG</td>
</tr>
<tr>
<td>CORN STARCH</td>
<td>380</td>
<td>.02</td>
<td>9,000</td>
<td>SEVERE</td>
</tr>
</tbody>
</table>

FIRE RISK ANALYSIS

I. RISK:

A. RISK ASSESSMENT:
Risk assessment involves three elements: life risk, property risk, and consideration of community consequences. Life risk is affected by the number of people at risk, the degree of risk, and the ability of the occupants to provide for their own safety. Property risk is affected by construction factors, the condition of structures, exposures, occupancy, and the available water supply. Community consequences are determined by the potential impact of a specific incident on a specific community. Considerations include direct life loss and property damage potential, indirect losses such as wages and taxes, loss of pride and community spirit (e.g., a landmark destroyed), and environmental impact.

B. RISK MANAGEMENT:
The risk of liability suit or claim is inherent in the Fire Service. There is no practical way to eliminate this risk entirely, but much can be done to reduce the likelihood and severity of liability claims. The approach to protecting your organization from liability hazards is
embodied in the concept of risk management.

Risk management, for a municipal department, is the process of protecting a government's assets from possible loss. More significant, perhaps, is the underlying objective of providing for and ensuring public safety in all municipal operations. Dissecting the term may help you understand its application to the Fire Service.

Risk is used in everyday conversation, and has acquired a connotation we think we understand. Here are some examples of how the word is used:

"Lifeguard Not On Duty—Swim at Your Own Risk." "That's a risk I'm willing to take." "You don't get anywhere without taking risks."

Risk is the potential for loss. It refers to the probability of an event that causes damage or injury or some other type of adverse consequence. In other words, risk is the uncertain likelihood that an unwanted event may happen.

There is always risk where someone or something of value can be lost. A fire vehicle, for example, has financial value as the property of the Fire Department, not only because it can be sold, but also because it enables the organization to meet its objective. The value of key persons in the Fire Department is that they possess superior knowledge, experience and skill in leading others. From a Fire Department perspective everything of value falls into these four broad categories:

- Property including the Fire Service vehicles, equipment, structures materials and supplies
- People Fire Service personnel, employees and volunteers, who are vitally important to the ongoing success of the organization
- Net Revenues the total budget for the Fire Department minus its expenses for a given period
- Freedom from Liability an important value to be protected because legal liability can impose heavy burdens on an organization

There are two components to risk — probability (or frequency) and consequence (or severity), and they are sometimes related in a mathematical expression:

Risk = Probability x Consequence

Simply put, this says the greater the probability of an adverse event, the greater the risk. You are more likely to fall from a tight rope wire than from a sidewalk. Therefore, the risk is greater. The equation also suggests that the more severe the consequence of the event, the greater the risk. The injury of falling from a wire that is three stories high would most likely be greater than from one that is at knee height. The risk is greater.

The word management suggests a structured and organized approach that relies on proven techniques to control systems events and people. Management takes a
"pro-active" rather than reactive approach to problem solving. It relies on analysis and well-considered action to control potential loss situation.

The term risk management then, refers to a deliberate effort to understand and control risk, to reduce both the probability that something might go wrong and the effects if an adverse event does occur. Because risk entails uncertainty, no matter what you do or how much money you spend, you can never totally eliminate risk. You must live with the potential for loss, but appreciate that actions can be taken to control risks. Risk management controls an organization’s activities to minimize losses and ensure public safety.

One other term is important in understanding risk management, and it is one that you will see often in this guide: exposure. The word refers to a possible pathway or sequence of events that can lead to a loss. Standing on a high tightrope is an obvious exposure to risk. Driving a car can expose you to risk, as can simply walking down the street or eating in a restaurant. The point to remember now is that the term exposure refers to a threat—a possible action that can lead to a loss of some kind. Identifying exposures is an essential step in managing risks. You have to know what might happen in order to prevent or control events.

The concept of reducing risk is not new. People have been managing risks in some form since human beings first decided to keep their hands out of the cook fire. It was not until 1931, however, that the comprehensive view of risk management was proposed specifically for industry. Risk management has been a successful specialty within the general field of business management ever since. Within the last decade, this comprehensive approach to controlling potential losses spread to public service organizations at the municipal level of government.

Today, organizations without a formal risk management program often deal effectively with risk. Your Department, for example, requires that fire personnel wear full protective clothing when responding to a fire. This safety rule controls risks for fire fighters by reducing the probability that they will be exposed to high temperatures. You probably have policies in place that call for fire fighters to be trained, equipment to have regular inspections and fire apparatus drivers to hold a current license. All of these policies are examples of reducing risk. Risk management expands these strategies and provides a structured approach to safety and loss control. It encourages a comprehensive and detailed examination of the practical and economic ways of dealing with potential losses.

Regardless of the organization it serves, the goal of risk management is straightforward: to protect an organization and its members from loss. There is no explicitly right or wrong way to conduct risk management, as long as certain key objectives are met.

Any organized and rational approach to management must respond to an established purpose and clearly defined objectives. The objectives that guide the development of risk management programs add detail to the purpose and define the limits of its intent. The objectives also list what an organization hopes to accomplish in controlling losses. These
objectives may include an attempt to:

- Minimize public risk from municipal operations
- Enhance employee safety
- Reduce losses of equipment and materials
- Examine new programs for potential risk
- Minimize the costs of risk

Five steps are central in managing risks in any organization:

1. **Identify and Evaluate Exposures.** Managing risks requires an understanding of potential exposures, of the many ways an organization can suffer losses. Typically, this information comes from a record of past losses or from an analysis of operations. Some common liability exposures for a municipality include:

   - Accident at municipal swimming pool or recreation center
   - Failure to perform complete building inspection
   - Giving incorrect information about planning or zoning bylaws
   - Accident involving municipal vehicles
   - Failure to maintain essential utilities and sidewalks
   - Inadequate or defective water mains, sewers or drains

   Each of the exposure areas is usually evaluated in terms of the frequency (or probability) of occurrence and the severity of possible loss to determine high priority areas that need immediate attention.

2. **Examine Alternative Risk Management Techniques.** There are two principal protective approaches that can be applied to a known exposure to manage risk. First, there are control measures that allow an organization to avoid or minimize potential losses. These measures are collectively known as risk control techniques. Risk control suggests avoiding the exposure altogether if possible, or reducing the probability of loss, reducing the severity of consequence should a loss occur, or transferring the loss to another organization.

   The second set of techniques involves risk financing an approach where the actual losses are paid for after the event. This area of risk management deals with the insurance side of the question. Either an organization assumes the financial responsibility for losses (retention) or they contract with an outside agency to pay for losses (commercial insurance). In either case, losses must be financed somehow.

3. **Select and the Best Techniques.** Each exposure is commonly treated by a blend of risk control and risk financing. In other words, each potential area of loss will be examined for specific programs that can reduce the probability or consequence of loss, and each type of loss will be financed in some way. Selecting appropriate techniques calls for you to judge the effectiveness of each measure in reducing risk, and balancing this against the potential costs of each technique.
4. **Implement the Selected Techniques.** Implementation requires you to develop the technical details of the risk reduction measure. Fire Service personnel should receive explicit instructions regarding what to do, how to do it and when to complete the assignment. Some techniques, in addition, may require the co-operation or support of other municipal managers outside the Fire Department. Influence and persuasion may be required to implement selected techniques.

5. **Monitor and Revise Approach.** Risk management is a dynamic and thorough process that deals with constantly changing facts and directives. Selected techniques must be reviewed periodically to reflect changing exposures and control methods. Applied measures must be monitored to ensure they are meeting the stated objectives, and that they are cost-effective in their implementation. Risk management techniques must be routinely upgraded to initiate needed improvements and to make the most of the resources available.

A successful risk management program will use a combination of techniques that support each other rather than focus on just one approach. Risk control techniques hold risk financing costs down. Risk financing is essential to cover the losses that will inevitably slip through the controls. The key objective is to adopt a plan that makes the best use of municipal funds, whether investing in risk control or financing losses that do occur.

Risk management has proven especially useful in controlling losses from liability claims. In the past, municipal organizations could rely heavily on the financing side, primarily because liability insurance was affordable. The insurance crisis has changed all that. Some potential exposures may no longer be insurable at any price, and many municipalities are forced to insure themselves.

Municipal self insurance relies on a keen awareness of risk control measures to reduce overall costs of running a local government. Municipal risk management is most effective if responsibility is assigned to one person, sometimes called a Risk Manager or Loss Control Officer. A Risk Manager is responsible for leading a municipality in all aspects of liability protection, but may not necessarily perform the steps personally. A Risk Manager’s tasks include enlightening all personnel and encouraging their continued attention to safety and other liability issues.

Many municipalities have a dedicated Risk Manager on staff, and have adopted specific policies designed to control liability risks in the organization. The municipal Risk Manager may seek a counterpart in each municipal department, such as engineering, planning or Fire Departments.
II. STRUCTURAL:

A. COMPONENTS:

1. 1920 and Earlier Structure
   a. Bearing and Fire Walls - "Cribbed" timber for outside wall on heavy timber with sheet iron covering.
   b. Floors, Beams, Joist, and Girders - No floors in bin, wood floors and joists in head house. Openings from top to bottom.
   c. Roofs - Mostly sheet metal for pressure relief.
   d. Enclosures - "Legs" for conveyor belts; tunnels for convey belts, tunnels for conveyor common to all bins. Difficult exterior access. Hidden spaces allow dust accumulation - ledges, supports.

2. 1920 - to Present
   a. Bearing and Fire Walls - Concrete, reinforced with steel.
   b. Floor, Beam, joists and Girders - Concrete in head house.
   c. Roofs - Mostly sheet metal for pressure relief.
   d. Enclosures - "Leg", tunnels, storage bins with common interconnections; confined areas with lack of ventilation. Difficult exterior access. Hidden spaces allow dust accumulation.

B. HANDLING SYSTEMS:

1. "Legs" are vertical shafts for conveyors to move product. They are a common source of trouble due to dust accumulation and ignition source: i.e., overheated bearings.
2. The boot (bottom) and head (top) systems for conveyors are the main mechanical drive and supports for the product handling.
3. Conveyor belts (top and bottom) present hazard of dust accumulation on bearings and support structure with common interconnection to storage and shipping area in a confined space.

The primary process of a grain handler, other than storage and quality preservation, is that of conveying grain horizontally and vertically into and out of the storage facility. Conveyors common to most bulk handling industries are used in this process. The discussion below shows how these conveyors are used in the grain industry and highlights modified designs tailored to grain industry needs.

Belt Conveyors
The most common conveyor employed to move grain horizontally from point to point is the trough-belt conveyor. By virtue of the wide choices of speeds and belt widths available, any desired volume can be accommodated in this manner. The fire hazards associated with these conveyors are the combustible rubber construction material of the belting and the tendency of dust to be liberated from the grain moving on open belts. The fire hazard can be minimized by the use of flame-resistant belting and good hot work permit procedures. The dust hazard
can be mitigated by enclosures, aspiration, belt speed control, or a combination of these.

**Chain Conveyors**
Alternatives to the belt conveyor include the chain conveyors, which are totally encased in a housing that prevents the escape of dust. These are usually of more limited capacity and convey at reduced linear speeds with much deeper grain depths. Normally, only the loading point or discharge point needs to be aspirated. Higher energy use than belt conveyors and installation costs must be considered.

**Screw Conveyors**
The helical screw conveyor is a standard for low-volume conveying for short distances. The grain industry generally uses screw conveyors only for specialized purposes because of the damage they cause to whole grain.

**Pneumatic Conveyors**
The milling end of the industry uses pneumatic conveying systems extensively. These are especially effective for confinement and movement of finely ground commodities in a complex processing operation requiring multi-point pickup or distribution. There is some concern about static electricity buildup and discharge in ungrounded systems.

**Bucket Elevators**
The common principle used in grain elevator design is that of elevating the commodity to the highest optimum point, then permitting the material to flow by gravitational force down through the various gamers, weighing scales, cleaners, and finally through spouts into the storage compartment. This not only makes efficient use of the energy required to move the mass, but eliminates re-elevating and re-handling with all the inherent physical, damage to the kernel. Each subsequent re-handling contributes to reducing the quality of the grain, and generation of additional quantities of fine particles and dust. The bucket elevator (or "leg," as it is referred to in the industry) is the primary equipment used to gain these elevations. Inclined belts have been used in several large export terminals, but they are impractical for most applications.

The bucket elevator is not only the workhorse of the industry, but is also the single most hazardous piece of equipment from an explosion standpoint. The dust concentration within a bucket elevator is likely to be above the lower explosive limit (LEL) during normal operations. This combined with the pumping action of the buckets moving in a confined space and the high amount of mechanical energy inherent to its operation, have led to its identification as the principal ignition source in explosions.

**Spouting and Lining**
Grain and oilseeds are very abrasive commodities that can rapidly erode steel conveying spouts used to channel the flow through elevators. This creates an almost constant demand for maintenance to eliminate leaks and dust emissions. While patching and repair are adequate temporary measures, they seldom fully restore a spout. An alternative has been the wide use of abrasion-resistant liners which can be totally replaced without disruption of the outer spout. Materials most commonly used are abrasion-resistant alloy steel plates, high-density synthetic plastics, and certain vitreous ceramics. These can usually be formed
or molded to the contour of the spouts and bolted into place without the need for welding or other heating devices. Although the high-density plastics are not easily ignited they can burn and must be removed or protected when ever welding or cutting is conducted on the spout.

**Receiving and Shipping**
The first and last adjuncts to a grain storage elevator are the machinery and structures needed to unload or load the grain from and into a carrier. Whether a railroad, truck, or barge shipping/receiving system is used, these operations are at ground level, partly or completely in the open, and usually connected to the main storage structure with an underground tunnel beneath the discharge receiving hopper, or with an overhead bridge.

The free-fall of grain through open spaces into receiving hoppers presents a unique dust control problem influenced by surface winds and the lack of sufficient enclosures to contain the dust emission. The problem is less of an explosion or fire hazard than a nuisance, as the dust can fly about since the operation is essentially an open air one. Environmental laws and regulations have required the same attention to these ground-level emissions as to elevated sources of emissions which have a much more distant scatter and settlement pattern.

**Grain Drying**
The principal processing operation at most grain elevators is that of drying the grain to moisture levels low enough to preserve quality during storage or to meet grain standards.

The grain dryer's most significant fire hazard is that of igniting the grain or extraneous material. The large amount of heat needed—in some dryers, more than 20,000,000 Btu/hr (21.12 million kj/hr)—combined with the large size—up to 80 ft high (24.4 m)—requires that control of this hazard be focused on good operating procedures and mechanical/electronic safeties such as temperature sensors, UV flame detectors, and fuel train safety devices.

In addition to the preventive measures used to reduce the possibility of a grain dryer fire, each elevator must consider an emergency plan for dealing with a fire. The size and unique design of a grain dryer makes fighting the fire with hose streams difficult. Probably the most effective consideration in fighting a dryer fire is moving the burning grain to a safe area away from the elevator where water can be selectively applied.

**Grain Cleaning**
The second most important processing activity in a grain handling facility is usually a screening, cleaning, or scalping system that removes extraneous material from the grain, such as bits of stalks, stems, seed pods, husks, corn cobs, weed seeds, or fine broken grain particles. These materials not only affect the quality of the grain, but are also more prone to ignition than the grain itself by virtue of their extremely dry state and high fiber content. The grain is cleaned by passing it over vibrating or gyration type motion screening devices or stationary gravity screens for simple size separation. A positive air aspiration system is used to remove dust generated by the grain movement within the device.

**Grinding and Cracking**
Some grain facilities serve specialty industries that require grain to be cracked or ground
entails the use of hammer mills or grinders to accomplish the size reduction. These are common sources of dust explosions, particularly in feed milling operations. The hammer mills is frequently used to grind corn and other feed grains for use in rations Care must be taken to exclude foreign objects, especially stones and metallic objects, from entering the grinding

Dust Control
Supplementing the conveying, elevating, drying, screening, and storage activity is the dust control process. Each point of grain handling can produce suspended dust nearby. A complete dust control system at an elevator consists of a combination of passive dust control methods such as the use of enclosures and reduced grain handling speeds. Active dust control provided by mechanical dust collection systems is most effective in reducing fugitive emissions.

The dust collector most commonly employed is the "bag-house" or fabric filter wherein the dust-laden air is passed through filter media and exits virtually 99.95 percent dust-free. The dust is recovered in the filter housing, stored in a remote bin, and sold as a by-product of grain for use by the animal feed industry. Such systems are complex processing operations with self-cleaning devices for the bags, automatic discharge mechanisms, continuous conveying to disposal points or storage tanks, and separate load-out systems.

The cyclone collector, which was in common use prior to clean-air laws, served as a quasi-separator for dust aspirating systems, but was only 75 to 80 percent efficient overall. For fine particles, efficiency is only 50 to 60 percent and merely concentrates the collected dust at a central point for discharge to the atmosphere. The cyclone is still often used as a pre-skimmer in dust systems ahead of filters to remove and recover the very large particles for reentry into the grain stream. The fine dust particles only are then collected in the filters for disposal or for readmission into the grain if circumstances and practice permit.

Dust collection systems themselves can sometimes increase the fire hazard because they concentrate the dust in specific pieces of equipment. For this reason, dust filters should be located outside and should be equipped with deflagration vents to minimize possible damage should an explosion occur.

C. STABILITY:
Grain handling and storage yields a ready accumulation of dust. The dust may be thought of as a combustible solid. This dust presents an extreme surface area vis-a-vis volume of material ratio. A high rate of heat release is experienced. Flame front speeds in excess of 10 feet per second may occur causing an expansion of air and hot gases (Product of combustion) exceeding petroleum or man made explosives forces.

THE FIRE HAZARD
Although dust explosions are the overriding hazard in the grain industry, there are several other fire hazards unique to the grain industry. These are primarily the grain dryer, the grain itself, and the use of propane.
The hazard of grain itself igniting must also be addressed from a preventive, as well as a fire fighting, standpoint. Preventive measures are basically to keep open flame (welding, torch cutting, cigarettes) away from the grain. Once grain ignites, it becomes quite difficult to extinguish, and, if the extinguishing method creates a dust cloud an explosion is likely. Application of large amounts of water in a storage bin will not only deteriorate the grain, but, in the case of soybeans, could cause enough swelling of the soybeans to rupture the bin itself. Elevator management should consider meeting with local fire departments to review emergency procedures should a grain fire occur.

Another potential fire hazard in grain elevator operations is the use of propane. Whether used for grain drying or comfort heating, propane presents a serious fire hazard because of the below-grade tunnels normal present in grain elevators and because the heavy rail or truck traffic can cause deterioration in underground pro-pane pipes. If a leak occurs, the liquid propane vapors can seep into the below grade tunnels until discovered or ignited. Elevator management should insist that propane lines be installed according to NFPA codes and maintained regularly.

THE EXPLOSION HAZARD
Dust explosions certainly must be considered the number one hazard in the grain industry. They have been present in the industry probably since its inception, and there are recorded instances as far back as 1785. For instance, in the thirteen-year period between 1977 and 1990, the number of serious explosions peaked and resulted in 129 deaths as indicated.

<table>
<thead>
<tr>
<th>Year</th>
<th># of Grain Handling Facility Explosions</th>
<th># of Deaths</th>
<th># of Injuries</th>
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Dept. of Grain Science and Industry, Kansas State University.
<table>
<thead>
<tr>
<th>Location</th>
<th>No. of Facilities</th>
<th>Percent of Facilities</th>
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<td>Hammer mills roller mills or other equipment</td>
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<tr>
<td>Processing equipment</td>
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<td>1.2</td>
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<tr>
<td>Dust collector</td>
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<td></td>
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<td>Grain drier</td>
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<td>Pellet collector</td>
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<td>Storage room</td>
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<td>Boiler or feed mill</td>
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<td>Electrical switch</td>
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<td>Source</td>
<td>No. of Facilities</td>
<td>Percent of Facilities</td>
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<td>Friction from choked leg</td>
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<td>Overheated bearing</td>
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<tr>
<td>Other spark</td>
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<td>Friction sparks</td>
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<td>Lightning</td>
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<tr>
<td>Faulty motors</td>
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<tr>
<td>Slipping belt in leg</td>
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<tr>
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<td>Smoking material</td>
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<tr>
<td>Chemical release (soybean process)</td>
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<tr>
<td>External cob pile fire</td>
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<tr>
<td>Heating system</td>
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<td>Gas in bin ignited</td>
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<tr>
<td>Extinguishing fire</td>
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<tr>
<td>Leak in gas pipe ignited</td>
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<td>0.4</td>
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<tr>
<td>Electric control panel explosion</td>
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<td>0.4</td>
</tr>
<tr>
<td>Slipping conveyor belt</td>
<td>1</td>
<td>0.4</td>
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III. OCCUPANCY:
Life hazard is high due to danger of dust explosion. Usually small numbers of workers present.

IV. CONTENTS:
Large volumes of grain coupled with a modern emphasis on turn-over vis-a-vis storage: a drier and more brittle product; pesticides with gas producing properties. These offer greater chance for dust accumulation and possible explosions. Some grain products are susceptible to spontaneous heating and ignition when stored in large quantities and moisture is present.

V. FIRE PROTECTION:
On site suppression systems include sprinkler systems and stand pipes for the head house, heat or motion detectors for the conveyor bearings and belts. More sophisticated systems such as inerting agents (halon) are virtually non-existent due to cost and lack of technological advances. Old conventional suppression systems are ineffective in explosion protection. New technology is making great strides with explosion prevention and detection.

VI. OTHER FACTORS:
Routine operations or lack of them will increase the potential risk. Welding or cutting operations, poor housekeeping, smoking, lowering portable lamps into bins, foreign metals or material mixed with grain, poor maintenance of machinery are common sources of trouble.

VII. SUMMARY OF RISK POTENTIAL:
There are some differences between dust explosion behavior and other ignition processes more familiar to firefighters. A dusty environment gradually becomes dangerous through a cumulative buildup of the dust hazard in contrast to the dispersing nature of gas or vapor hazards. The time interval may be considerable, and if dust can be removed during this interval, no explosion will occur. One of the most prevalent elevator hazards, however, is not dust in the air itself, but the layer of dust on heated surfaces - such as hot bearings, or overheated motors. Once this ignites explosively, the detonation both scatters more dust into the air and provides the high energy heat source to touch off. Such dust ignites at temperatures far below the ignition point of LPG or gasoline vapors.

Researchers have found that heated grain dust gives off visible aerosol particles and gases long before the dust reaches its ignition point. The L.E.L. and U.E.L. are approximately 40 to 100. A high level of humidity and/or moisture content of the product will aid in reducing the risk of an explosion.
GRAIN ELEVATOR STRATEGIES

Pre-Incident Surveys
As a matter of experience in pre-incident survey, it is a known fact that pre-incident surveys can be set up too tight by chief officers, robbing company officers of the initiative to move on their own. This is where flexibility important to the operation is lost.

Grain elevators present the hazard of explosion and/or extensive fire spread. Your guide must take into account the time it takes to get into operation. You must also try to envision (look ahead at) the problems you will be confronted with. From your look into the future (crystal ball), you must anticipate the best use of your manpower and equipment. Once your guide is developed, it should be tried out and practiced. Everyone must understand the guide. If a good guide is developed, your personnel will support the guide.

Don't be in too big of a hurry to complete your guide. Developing guides takes a lot of thought (input) which should not be hurried. Remember, you are deviating from S.O.G. which could be difficult for some to quickly comprehend. Also, your S.O.G. might be adequate with some modification.

Selection of one person to head up the process. Consider setting up a team who would jointly set up the guide. Input is highly important to get support for the guide.

Automatic mutual aid response. Assignments (positioning) for these units. Common radio frequency (154.295 fire mutual aid #1 and 154.010 fire mutual aid #2 and 153.830 RIT Team or interior attach crews) in Minnesota.

It is not uncommon to find retail stores incorporated with feed mill operation in the grain industry. In addition to retailing feeds and farm hardware, farm chemicals such as insecticides, fungicides, herbicides, fumigants, rodenticides, defoliants, and growth regulators may also be found in their retail inventories.

These chemicals may consist of chlorates, desiccants, sulphur or oil bases, which are oftentimes flammable and/or toxic. Some may be in bulk quantities. Others may be packaged in case quantities of highly flammable and explosive pressurized aerosol cans. In any case, storage and handling of these chemicals require special consideration before, during, and after the fire fighting operation.

FIRE CONDITION:
A report of fire is received at 11:00 on January 29, 2002. A concrete storage silo holding 30,000 bushels of corn is smoking. All elevator machinery is shut down. Management has evacuated the structure. Temperature is 25°F, humidity is 45%, wind NW at 10 MPH.

EFFECTS:
Usually smoldering fire in contents of bins produce smoke conditions. Flaming combustion
can produce an explosion. Heat can be transferred from bin to bin by conduction thru walls. Fire can transfer thru explosion producing holes in walls of adjacent bins.

STRATEGY:
A. All functions within elevator should be stopped. All machinery shut down.
B. All employees evacuated from premises to a block away from structure.
C. Confer with knowledgeable management as to:
   1. Determine the status of all employees and customers.
   2. Location of bin.
   3. Available standpipe(s) for hose line(s).
   4. Feed and exit accessibility of bin.
   5. Bin temperature.
   6. Smoldering or flaming fire.
D. Fire should be controlled or extinguished before emptying bin using low velocity stream.
E. Bin should be emptied to outside of premises if possible.
F. Clearing of bin should be accomplished by gravity rather than machinery.
G. Dust control must be a continuous operation.

SUPPORT FUNCTIONS
During major fires or emergencies, or during long-term operations, staff or support functions may become necessary. The need for staff functions will vary with the situation; not all will be required at each emergency. Staff officers and their subordinates are provided to allow the fireground commander and the fire suppression officers to concentrate on their primary tasks. The usual staff or support functions include:

WATER SUPPLY OFFICER
Manages the water supply operation. Responsible for the efficient, effective and safe delivery of water to the fire ground.

   *Knows flow being used and required
   *Anticipates changes in need
   *Insures efficient utilization of apparatus and equipment in the water supply operation

SAFETY OFFICER
Observes fireground operations and conditions, and remains alert to hazardous conditions (potential explosions, falling walls, wires down, etc.)

MEDICAL OFFICER
Establishes and supervises the delivery of emergency medical care on the fireground for firefighters and others.

   *Establishes first aid "station(s)"
   *Supervises first aid teams and triage teams
   *Coordinates transportation of injured to medical facilities

RESOURCES OFFICER
Responsible for keeping track of working and reserve personnel and equipment.
*Maintains status list, maps.
*Establishes reserve pools for personnel, equipment and apparatus.

SUPPLY OFFICER
Provides support services to personnel and apparatus.
*Provides for safe rest areas for personnel (protection from weather, potable water, food, etc.)
*Arranges fuel supply and emergency maintenance for apparatus and equipment.
*Provides other expendable supplies on the fire ground.

PUBLIC INFORMATION OFFICER
Relieves the command officer from the necessity to deal with the media and other agencies, and serves as the single source for reliable information

TACTICS:
A. The foregoing strategies should be accomplished in accordance with the following tactical and policy guidelines:
1. First engine company prepares to lay 1½ inch line from standpipe to top of bin to apply initial application of water fog into bin (only when ordered).
2. Second engine company lays 2½ inch line(s) (hydrant) to bottom of bin.
3. First ladder company determine status of the grain handling operations and employee location; to insure all systems are stopped and all employees vacated. The captain shall coordinate with other officers at the incident, the identification, location, and availability of knowledgeable company management.
4. Third engine and second ladder companies will stage at a safe distance and secure area to keep unauthorized people away.

POLICY:
1. Use minimum number of firefighters.
2. Disperse apparatus away from structure.
3. Evacuate elevator employees.
4. Shut down all equipment.
5. Take care in reducing any unnecessary air movement (inert) by discontinuing activity.
6. Lay into sprinkler system when appropriate.
7. Confer with knowledgeable management.
8. Apply water gently to outside of bin (or bucket elevator) first to cool, or steam when available.
9. Apply fine spray at reduced velocity from top of bin (or bucket elevator).
10. Watch above and below when moving heated product from one bin to another bin. If smoke or sparks appear, stop process immediately.
11. If product must be removed, do so by gravity only and apply fine mist of water at reduced velocity. Do not allow product to enter other parts of the handling system.
12. Allow to char and set.
13. Inert with gas, such as C02, nitrogen or steam.

ITEMS TO CONSIDER IN STRATEGIC PLANNING

1) STRUCTURAL FEATURES
   A) Metal Clad Wood (Pre-1920)
   B) Reinforced Concrete (Post-1920)
   C) Metal

2) OCCUPANCY
   A) Agricultural Chemicals (Storage, Wholesale, Manufacturing, Retail)
   B) Hazardous Materials Part of the Process (LP-Gas, Hexane Processing,
      Linseed Oil Manufacturing, Sulphuric Acid)
   C) Radio-active Components
   D) Milling
   E) Specific Dangers Presented to Fire/Plant Personnel in above

3) PRIVATE FIRE PROTECTION SYSTEMS
   A) Fire Extinguishers
   B) Alarm Systems
   C) Standpipe Systems
   D) Sprinkler Systems
   E) Early Warning Devices (Heat and Smoke Detectors, Hot Bearing Detectors,
      etc.)
   F) Cooperative (Fire Department and Plant) plan to assure proper working order
      of above systems

4) WATER SUPPLY
   A) Master Streams (Need for)
   B) Hydrant Locations (Usable/Unusable)
   C) Other Water Sources
   D) Getting Water to the Scene
   E) Procedure for Supplying Standpipe and Sprinkler Systems
   F) Water Runoff Control
   G) Contamination of Drinking Water

5) LOCATION OF STAIRWAYS, ELEVATORS, MAN LIFTS, VERTICAL LADDERS,
   ACCESS TO TUNNELS, ETC.
   A) How to Enter Building
   B) Access Holes in Legs, Conveyor Systems, Bins, etc.

6) OBSTRUCTIONS TO PERSONNEL (MOVEMENT)
A) Size of the Complex
B) Rail Cars and Trucks Blocking Entrances
C) Small Openings that Doesn't Permit Use of SCBA
D) Blocked Aisles

7) PERSONNEL TRAPS
   A) Boot Pits
   B) Tunnels
   C) Bins
   D) Upper Floor Exits
   E) Complicated Exits because of New Additions, Product Storage, Plant Layout, etc.

8) FEATURES HAMPERING VENTILATION EFFORTS
   A) Access to Top of Structure/Bin
   B) Built-In Doors/Hatches for Ventilation
   C) No Place to Ventilate (Filter Room, Tunnel, etc.)

9) HAZARDOUS MATERIALS LOCATIONS
   A) Pesticides (Toxic Properties)
   B) Flammable Liquids and Gases
   C) Anhydrous Ammonia
   D) Corrosives
   E) Hazardous Wastes

10) FEATURES THAT LIMIT SPREAD OF FIRE
    A) Fire Doors
    B) Fire Walls
    C) Building Location/Layout of Building

11) OBSTRUCTION THAT HAMPER FIRE FIGHTING
    A) Overhead Conveyors
    B) Overhead Electrical Wires
    C) Vertical Ladders where SCBA Cannot Be Worn

12) POTENTIAL LIFE HAZARDS
    A) To Emergency Personnel (Fire, Police, EMS)
    B) To Civilians (Crowd Control)
    C) Evacuation Procedures
    D) Area to be Evacuated (Minimum of One Block in All Directions)

13) SALVAGE OPERATIONS
    A) Heavy Equipment

14) UTILITY CUTOFFS
    A) In-plant Location
    B) At the Pole
15) STRENGTH AND FIRE RESISTANCE OF FLOORS, STAIRS, CEILINGS, ETC.
   A) Location of Heavy Equipment (Could Cause Early Failure)

16) RESPONSE ROUTES
   A) Own Department
   B) Mutual Aid
   C) Support Units (Tankers, Loaders, Dump Trucks, etc.)

17) STAGING AREAS FOR VEHICLES, EMERGENCY PERSONNEL, AND SUPPORT
    PERSONNEL
   A) Establish Modern Fire Ground Command Procedures

18) TRIAGE AREA (EMS)
   A) Provision for Transportation and Hospital Care

19) REST AREA FOR PERSONNEL - CONSIDER ALL CLIMATIC CONDITIONS
   A) Food and Drink
   B) Beds or Cots

20) FLAMMABLE LIQUID AND/OR GAS STORAGE
   A) Separate Building
   B) Diked Area
   C) Built-in Protection Systems

21) EXPOSURES
    A) Structures
    B) Vehicles
    C) Storage
    D) Personnel

22) KNOW THE BUILDING
    A) Frequent Visits to The Structures

23) RESULT OF YOUR EFFORT IS A DISASTER PLAN FOR YOUR GRAIN
    ELEVATOR FACILITY

   A)
1. ALARM
The fire alarm may be transmitted by phone, radio, siren or other means. A set method of alarm and a back-up system should be established. Firefighters should know in advance whether to respond to the station, or to respond to the fire scene (volunteer departments). The pre-plan should be activated by the dispatcher at the time of the alarm. For volunteer departments without dispatchers, the chief or other officer-in-charge should activate the pre-plan.

2. RESPONSE
The fire department should pre-plan which units will respond, in what order and where to stage. Any automatic mutual aid requests should be included in the pre-plan and should be made at this time.

3. SIZE-UP
The first officer on the scene must size-up the situation, direct incoming units, report the situation to higher ranking officers, and generally take charge of the scene until relieved by a higher ranking officer. Some of the things that need to be considered and carried out during size-up are:

A. Is search and/or rescue needed?
It depends on the time of day as to whether or not anyone is in the elevator. The fire department and elevator personnel should agree on a headcount area at the time of the pre-plan. This is essential in the proper handling of an elevator fire or explosion. Life safety is always primary over fire fighting.

B. Is there fire?
Is there really a fire in the elevator?
Has it followed an explosion?
If not, is an explosion possible while fighting the fire?

C. Can the fire be safely accessed?
Try and determine where the fire is located, or the seat of the fire, and how hard and safe it is going to be to get too. Determine placement of apparatus and deployment of firefighters (review pre-plan).

D. Exposures.
Is the fire large enough to cause exposure problems to the surrounding buildings? What are the surrounding buildings and their life-safety exposures? (This should have been considered in the pre-plan). If exposures are a problem, deploy additional resources at this time for exposure protection. Also evacuation of adjacent buildings may be required and crowd control will definitely be required (police or other law enforcement agencies should have been notified by this time according to the
pre-plan).

E. What is burning and its properties and hazards?
   If the fire is very large, the properties of the construction material of the elevator, the
   grain and the chemicals stored inside will be one of the officer-in-charge’s main
   concerns. However, in the event of a smaller fire inside the elevator, individual items
   may be burning, and their individual burn characteristics and hazards must be
   considered. Some of the items that can be found in an elevator are listed below.
   Consider the burn characteristics of each:
   1. Grain
   2. Dust
   3. Wiring or motors
   4. Maintenance equipment
   5. Legs
   6. Belts
   7. Chemicals, fumigants or pesticides
   8. Trucks or other vehicles
   9. Wood or other combustibles

F. Water source and its accessibility:
   The water source should be determined at the time of the pre-plan. Always locate
   additional back-up hydrants as the hydrants closest to the elevator (within 500 to 1000
   feet) may not be accessible or operational after a major explosion. If water is to be
   trucked in, position trucks and/or portable tanks, and request mutual aid if required.

G. Mutual Aid and Staging Area.
   This also should have been determined at the time of the pre-plan. If additional
   companies are automatically called at the time of the alarm, determine during size-up
   if they really will be needed. If additional companies or departments have not yet been
   called, determine during size-up if they will be needed, and if so, have them
   dispatched. All additional companies or departments that will respond should be listed
   on the pre-plan. Agree on a mutual aid radio frequency (do this at the time of the
   Pre-Plan) and set up a Command Post to direct incoming companies.

4. ATTACKING THE FIRE

A. Hose Lines.
   At the time of the pre-plan it should be determined how the fire department will reach
   all areas of the elevator and how much hose it will take. Large fires, especially
   advanced fires in combustible elevators will probably have to be fought from the
   outside of the elevator, using master streams. However, never overlook an
   aggressive(do not disturb the dust) interior attack if it is feasible.

   Small fires in and around the elevator may require more care or caution than large
   fires. Only solid stream nozzles or fog nozzles with straight stream patterns should be
   used with very low pressure, so as not to kick up the explosive dust inside the elevator.
   Dust explosions have occurred when dust and burning particles have been put into
suspension by firefighters using a straight stream and too high of pressure (or both). Always be extremely cautious when using a hose line inside an elevator.

Use only as much water as needed. Over usage of water inside the elevator may put out the fire, but can also cause thousands of dollars of additional damage to the grain stored there. Careful usage of water is very important during salvage and overhaul of the fire.

B. Fire Extinguishers.

Some small fires in grain elevators may be quickly extinguished with fire extinguishers and thus save the time and effort required to pull a hose line. Small electrical fires are more safely fought with a dry chemical extinguisher approved for electrical fires, than with a hose line, if the power is still on. Old hand pump water extinguishers or Indian tanks are good for very small fires in grain or dust, as the pressure of the stream can be kept low, thus reducing the chance of kicking up the dust or burning material.

Always be extremely careful when using a fire extinguisher inside grain facilities as the pressure from the extinguisher could blow the dust and burning material into suspension, thus creating the potential for a dust explosion. During the fire department’s pre-plan, they should become familiar with the fire extinguishers provided in the elevator.

C. Removal

Occasionally, the best way to handle a fire in an elevator is to remove the burning material from the elevator. In the case of a small smoldering fire in grain or dust, such as one caused by grain or dust built up around an overheated bearing, it may be safer to remove the small amount of burning material than to use a hose line or fire extinguisher in a dusty area. This can be done by very carefully shoveling the burning grain or dust into a salvage pail and removing it.

Often the only way to completely extinguish a burning leg belt that has dropped down the leg shaft, is to remove the burning belt from the shaft. Again, this must be done very carefully. As with any vehicle on fire inside a structure, or a burning truck or other vehicle inside an elevator, should be removed outside, if it can be done safely.

Often after a major dust explosion and fire, there will be grain burning down in tanks and bins. In many cases salvage companies have to cut holes in bins or tanks and remove the burning grain, to extinguish it. This is usually done during the salvage and overhaul phase of the fire and not during the initial attack.

During removal operations it is still possible to have explosions caused by workers or falling material.
D. Other

Same other methods of fighting fires in grain elevators have been used such as filling bins with CO-2 to try and smother the fire, and using foam to blanket burning grain. If you apply foam you will most likely destroy the salvage value and food value of the grain. These are usually "last resort" methods used during the salvage and overhaul phase, when all else has failed. This has only been successful in some cases and usually destroys the value or usability of the remaining grain.

5. TACTICS

Elevator fire fighting should use the same basic tactics on the fire ground as with any structure fire. Truck and hose stream placement is important to make an aggressive attack. But firefighters and equipment must be protected from falling debris, especially considering the height of most elevators. Back-up lines are also very important. Ventilation is often not feasible due to the height of an elevator. However, be aware of how opening windows, or the driveway doors, will affect the air supply to the fire. Firefighters should be careful to leave a good means of retreat and officers must be flexible enough to make sudden changes in their attack, should conditions change suddenly, as they often do with an elevator fire.

The Chief or officer-in-charge should be in charge of the whole fire ground operation, preferably from a command post if it is a large fire, with other officers in charge of individual companies in and around the elevator. These other officers must constantly report their progress back to the chief or officer-in-charge.

6. OVERHAUL

After the bulk of the fire is brought under control and it is safe to do so, overhaul procedures should begin. Extinguishing spot fires after a major fire or explosion may take a few hours, or it can take up to several weeks. Smoldering fires in bins and tanks may burn for weeks and may have to be handled by a salvage company. As stated previously, grain may often have to be removed from the bin or tank to be extinguished. Also after a major explosion or fire, burning material may be buried under tons of debris and heavy equipment is often required during overhaul to remove the debris so that all fires can be extinguished.

Overhaul is also very important following a small fire in a grain elevator. After bringing a small fire under control, the fire department should use water very sparingly. Burnt or smoldering material should be carefully removed wherever possible. Excess water getting into the grain can often cause more damage than the damage caused by a fire.

7. SALVAGE

Elevator personnel may remove the grain from a damaged bin after a small fire. However, removal of grain from an elevator after a large fire is usually handled by elevator personnel and a professional salvage company. Salvage companies often
begin removing grain from a damaged facility before the fire is even out, to prevent further damage to the grain, and to make it easier to finish overhaul. Cooperation between the salvage company and fire department personnel is essential to ensure a safe operation.

8. SECURITY

In most states the Fire Chief or other officer-in-charge has control of the fire scene until he returns it to control of the elevator owner or Manager. The Fire Chief is in charge of the scene and usually has final control over police, ambulance personnel, utility personnel, and any other people on the fire scene. The Fire Chief is responsible for the fire from the time of the alarm until he releases the scene, and can be held liable for errors in judgment.

Elevator fires and explosions are media events. They often bring large crowds of sightseers and news media people. The fire department's pre-plan should include notifying the proper law enforcement personnel needed for crowd control. Also, the Chief, officer-in-charge, or designated media representative should be the only person on the fire department making any statements to the news media. No firefighter should make a statement of any sort to the news media, government agencies, insurance personnel or others, without first clearing it the chief or other officer in charge of media communications.

Fire departments must also be careful with control of the fire scene whenever there is any indication that arson may be involved. The fire department has control of the fire scene to make an investigation following the fire, as long as they do not return control of the property back to the owner, and leave the scene. However, court rulings have held that, once the fire department returns control of the fire scene to the owner, and leaves the scene, they may not re-enter the fire scene to conduct further investigations, without a search warrant. Furthermore, any evidence gathered after returning to the fire scene, without a warrant, will not be admissible in court. All fire departments must learn to look for and recognize the signs of arson when fighting a fire. If arson is suspected, remain in control of the fire scene and get hold of your State Fire Marshall or other law enforcement officials.

9. FIRE WATCH

Due to the design of most grain elevators a fire watch is extremely important after any fire. A fire in one section of the elevator may allow sparks or other burning material to fall down bins or spouts, into another section of the elevator (or even to another elevator if they have connecting spouting as may do). These sparks can smolder in grain for hours before any fire breaks out. A fire watch of elevator or fire department personnel should always be posted after any fire.
BASIC DIVISIONS OF FIRE-FIGHTING TACTICS

R. E. C. E. O.

SIZE UP
1. RESCUE
2. EXPOSURES A. VENTILATION
3. CONFINEMENT B. SALVAGE
4. EXTINGUISHMENT
5. OVERHAUL

Key Questions for Size-Up:
I. What Have I Got?
II. What's Burning?
III. Where Is It Going?
IV. What (and who) Is In It's Way?
V. How Am I Going To Put It Out?
VI. Where Am I Going To Get The Water/Extinguishing Agent?

Size-Up: A clear concise analysis of a situation based upon;
1. Prior Knowledge
2. Experience
3. Evaluation of immediate facts
4. Evaluation of potential change
5. Consideration of available resources

Six Steps of Size-Up:
1. Get the Facts
2. Estimate Probabilities
3. Estimate Possibilities
4. What is my own Situation
5. Make a Decision
6. Communicate the plan of Operation to division chiefs in clear text
   (no ten codes)

Fire Strategies:
1. Offensive
2. Offensive - Defensive
3. Defensive - Offensive
4. Defensive
CALCULATING WATER CARRYING POTENTIAL

\[ Q = \frac{1000}{A + (T1 + T2) + B} \times -10\% \]

\( Q \) = Maximum continuous flow capability in gallons per minute.
\( V \) = Tender capacity in gallons.
\( A \) = Fill time
\( T1 \) = Time in minutes for tender to travel from the fire to the fill site.
\( T2 \) = Time in minutes for same tender to travel from fill site back to the fire.
\( B \) = Unloading time

-10% = Amount of water supply (tanker capacity) considered not available due to spillage, under filling and incomplete unloading.

EXAMPLE:

\( V = 1500 \) Tender capacity in gallons.
\( A = 3.0 \) Fill time
\( T1 = 11.7 \) Time in minutes for tender to travel from the fire to the fill site.
\( T2 = 11.7 \) Time in minutes for same tender to travel from fill site back to the fire.
\( B = 4.0 \) Unloading time

\[ Q = \frac{1500}{3.0 + (11.7 + 11.7) + 4.0} \times -10\% \]

\[ Q = \frac{1500}{30.4} \times -10\% \]

\[ Q = 44.4 \text{ Gallons} \]
CALCULATING WATER TENDER DELIVERY POTENTIAL

Fill In The Blanks

V = Water tender capacity in gallons.
A = Fill time (the time that it takes to fill the tank with water)
T1 = Time in minutes for tender to travel from the fire to the fill site. (NFPA 1231 Table C-1-11(b) Use the table on the back side of this form.)
T2 = Time in minutes for same tender to travel from fill site back to the fire. (NFPA 1231 Table C-1-11(b) Use the table on the back side of this form.)
B = Unloading time (the time that it takes to unload the tank of water in minutes)

V = 

Q = ------------------------------- - 10%

A

T1

T2

B

Q = 

V = 

TT =

(V)________ / (TT)________ = (MQ)________ Gallons

10% of (MQ)________ = (SG)________ Spillage Gallons

(MQ)________ -- (SG)________ = (Q)________ Gallons

Q = Gallons of water available to the emergency scene for this size of water tender under these conditions.
NFPA 1221 TABLE C-1-11(b)
Time Distance Table Using An Average Safe Constant Speed Of 35 Miles Per Hour

\[ T = 0.85 + 1.70D \]

<table>
<thead>
<tr>
<th>Distance Miles</th>
<th>Time Minutes</th>
<th>Distance Miles</th>
<th>Time Minutes</th>
<th>Distance Miles</th>
<th>Time Minutes</th>
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<td>0.1</td>
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<td>5</td>
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<tr>
<td>0.2</td>
<td>8.6</td>
<td>0.3</td>
<td>11.9</td>
<td>2.7</td>
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<td>17.8</td>
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<td>26.1</td>
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<td>25</td>
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<td>30</td>
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<td>7.9</td>
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<td>111.8</td>
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<td>8.1</td>
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<td>4.2</td>
<td>158</td>
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<td>125.8</td>
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<td>166</td>
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<td>130.1</td>
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<td>174</td>
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<td>8.8</td>
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<td>4.8</td>
<td>182</td>
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<td>8.9</td>
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<td>4.8</td>
<td>138.1</td>
<td>5</td>
<td>190</td>
<td>5</td>
<td>9.1</td>
</tr>
</tbody>
</table>

36
### Fire Flow Rate and Tender Estimation Worksheet

#### Fire Building

<table>
<thead>
<tr>
<th></th>
<th>Length: ___ X Width: ___ X Height: ___</th>
<th>Cubic Ft./100</th>
<th>GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fire Flow Fire Building:

#### Exposures

<table>
<thead>
<tr>
<th></th>
<th>Length: ___ X Width: ___ X Height: ___</th>
<th>Cubic Ft./100</th>
<th>GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fire Flow Exposures:

#### Total Required Fire Flow

<table>
<thead>
<tr>
<th>Travel Times</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ _______ Minutes Out To Fill Site Travel Time</td>
<td>+ .6_ Time To Travel To Fill Site</td>
</tr>
<tr>
<td>+ _______ Minutes To Fill Tender</td>
<td>+ .2_ Time To Fill</td>
</tr>
<tr>
<td>+ _______ Minutes Back To Fire Scene Travel Time</td>
<td>+ .3_ Time To Travel Back To The Fire</td>
</tr>
<tr>
<td>+ _______ Minutes To Unload Tender</td>
<td>+ .3_ Time To Unload</td>
</tr>
<tr>
<td>+ .2 Minutes Of Make/Break Filling &amp; Unloading</td>
<td>+ .2_ Time To Open Doors, place extensions</td>
</tr>
</tbody>
</table>

= Total Time

= Tender Capacity In Gallons

( Miles ) = Distance To Water Source From Fire

Actual GPM Available From Tender To Fight Fire

Total Time = _______ * _______ = Tender Capacity In Gallons

Number Of "Like" Tenders Needed

Tender Water = _______ * _______ = Total Required Fire Flow

37
## QUICK ACCESS PREPLAN

<table>
<thead>
<tr>
<th>Building Address:</th>
<th>Evaluator:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Description:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Roof Construction:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Floor Construction:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Occupancy Type:</th>
<th>Initial Response Required:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCN = Type I II III IV V</td>
<td></td>
</tr>
<tr>
<td>OHCN = 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

### Hazards to Personnel:

### Location of Water Supply:

<table>
<thead>
<tr>
<th>Available Flow:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Estimated Fire Flow</th>
<th>Length x Width</th>
<th>Number of Floors</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{Exposures} = 25\% \text{ Of Total Flow Per Exposure} \]

<table>
<thead>
<tr>
<th>Level Of Involvement</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Estimated Fire Flow (1)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attached Building Fire Flow (2)</th>
</tr>
</thead>
</table>

### Fire Behavior Prediction:

### Predicted Strategies:

### Problems Anticipated:

<table>
<thead>
<tr>
<th>Standpipe: Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Location:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sprinklers: Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Location:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire Detection: Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Location:</td>
</tr>
</tbody>
</table>

### Length X Width

1. \[ \frac{X}{3} = \text{GPM} \]

2. \[ \frac{X}{3} = \text{GPM} \]

3. Exposure Side "A" (25% of total base 100% flow) = \( \text{GPM} \)

4. Exposure Side "B" (25% of total base 100% flow) = \( \text{GPM} \)

5. Exposure Side "C" (25% of total base 100% flow) = \( \text{GPM} \)

6. Exposure Side "D" (25% of total base 100% flow) = \( \text{GPM} \)

7. 100% involvement plus exposures potential = \( \text{GPM} \)

Total gallons = \( \text{GPM} \)
QUICK ACCESS PREPLAN

DETERMINING WATER SUPPLY

Occupancy Hazard Classification Number (OHCN) 3 - Sever Hazard Occupancies where quantities and combustibility of contents is very high. Fires can be expected to develop very rapidly and have high rates of heat release.

Examples:
- Aircraft hangers
- Straw or hay in bales
- Plastics manufacturing/storage
- Explosive manufacturing/storage

Chemical plants
- Grain elevators
- Saw mills
- Grain Elevators

Distilleries
- Lumber yards
- Feed mills
- Oil refineries

Occupancy Hazard Classification Number (OHCN) 4 - High Hazard Occupancies where quantities and combustibility of contents is high. Fires can be expected to develop rapidly and have high rates of heat release.

Examples:
- Barns and stables
- Theaters
- Repair garages
- Paint warehouse

Department store
- Feed stores
- Paper warehouse
- General storage warehouse

Auditoriums
- Mercantile
- Furniture warehouse

Occupancy Hazard Classification Number (OHCN) 5 - Moderate Hazard Occupancies where quantities and combustibility of contents is moderate and stock piles do not exceed 12 ft in height. Fires can be expected to develop quickly and have moderate rates of heat release.

Examples:
- Laundries
- Machine shops

Restaurants
- Dairy barns

Unoccupied buildings
- Metal shops

Occupancy Hazard Classification Number (OHCN) 6 - Low Hazard Occupancies where quantities and combustibility of contents is low and stock piles do not exceed 8 ft in height. Fires can be expected to develop moderately and have moderate rates of heat release.

Examples:
- Bakery
- Barber shops
- Cement plants

Gasoline service station
- Churches
- Municipal buildings

Post offices
- Doctors offices
- Telephone exchanges

Occupancy Hazard Classification Number (OHCN) 7 - Light Hazard Occupancies where quantities and combustibility of contents is low. Fires can be expected to develop at a low rate and have low rates of heat release.

Examples:
- Apartments
- Motels / Hotels
- Hospitals

Dwellings
- Schools
- Nursing homes

Fire Stations
- Police Stations
- Data offices

Construction Classification Numbers (CCN)

- Type I (Fire Resistant) CCN 0.50
  Constructed of non-combustible materials (reinforced concrete, brick, stone, etc. and having any metal members properly "fire proofed") with major structure members designed to withstand collapse and to prevent fire spread.

- Type II and IV (Noncombustible and Heavy Timber) CCN 0.75
  All structural members (including walls, floors and roofs) of non-combustible materials and NOT qualifying for fire resistive construction.

- Type III (Ordinary) CCN 1.0
  A structure having exterior walls of masonry or other non-combustible material, in which the other structural members are wholly or partly wood or other combustible material.

- Type V (Wood Frame) CCN 1.50
  A structure in which the structural members are wholly or partly wood or other combustible material and the structure does not qualify as ordinary construction.

Total Cubic Feet of Structure
Minimum Water Supply = ------------------------------- X Construction Classification Number X Exposure
Occupancy Hazard Classification
Exposure = any structure within 50 ft. and over 100 sq. ft. multiply by 1.5

40
# ESTIMATED TENDER DELIVERY RATES

## Handling Time in Minutes - 1000 Gallon Tenders

<table>
<thead>
<tr>
<th>Travel Distance Each Way in Miles</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tbody>
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## Handling Time in Minutes - 2000 Gallon Tenders

<table>
<thead>
<tr>
<th>Travel Distance Each Way in Miles</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
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## Handling Time in Minutes - 5000 Gallon Tenders

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BRIEF INITIAL REPORT

"Chief ___________ arrived location Side _____ of a (describe the structure type)."

Describe fire situation. Indicate where the fire is located and from where the smoke and flames are exiting the structure.

"Chief ___________ is Command."

Call for additional resources if needed at this time. Assign the other resources.

TACTICAL CHECKLIST

To provide consistency and a system for logical thinking, a checklist is provided for officers. They must determine the best methods of accomplishing the tactic. They must determine needed resources and provide for safety and control of the operation. The checklist assists with developing the correct information.

This is an example of a simple Tactical Action Model.

- Receipt of tactical order from your supervisor.
  - Tactical size up.
    - Safety considerations.
    - Area of involvement.
    - Construction.
    - Occupancy.
    - Problem identification.
    - Prioritize.
    - Evaluate resources.
  - Assignment of tasks to crew members.
  - Take action to complete the assignment given.
  - Evaluate the effectiveness of the actions being performed.
  - Report to your supervisor the effectiveness of your actions.
SHORT TACTICAL THOUGHTS

BY TOM BRENNAN

I HAD A GREAT FIRE SERVICE instructor, a prolific writer, who once told me, "It was perfect when you got it, sonny; don't edit it!" Well, I think I fell into that trap myself. I have tried the past few months to "drop" some short thoughts on a bunch of tactics we face in our everyday emergency operations—thoughts that are short enough to start a conversation or a drill or a critique and easy enough to put down in front of aggressive firefighters so that we won't have to be bored with all the surrounding data about what makes the thought "right" or "according to all the standards."

Well, I finally heard from one of you on this set of documents—a great friend, who asked on the phone, "What the heck are you talking about?"

I wanted to say JUST that a portable ladder's objective is to get out of a burning building. I wanted you to figure out how to choose it, raise it, and climb it and to remove a victim without my having to write all that I know and had to plagiarize.

Now for this month's column.

Rail service tracks. A few thoughts on operating on rail service tracks. How many of you think you are safe when the electrical service is shut down? Well, we lost and injured some firefighters because no one accounts for diesel machine operations or knows that train operators are told to coast as long as possible after losing power.

How do you know the power is off? Throw the switch to the OFF position. Right? Never! Get the message to the main control site through your dispatcher, and then order that he get the name and identification of the supervisor reporting that power is "down" as asked.

Also about rail traffic, there is no assigned direction for rolling stock in relation to the track position. Enough said.

Silo fires. If the silo at the farm location is on fire, DO NOTHING! NOTHING! Our farm districts still represent a significant life hazard to our structural firefighting brotherhood. After hearing of many frustrating losses of life during these operations, I went to a state fire academy to read as much as I could about the subject (there are no tenn- ment silos). If the vents were closed, there was an explosion; if the vents were opened, there was an explosion. If you applied water from the base, there was an explosion; and if you applied it from the top, there was an explosion. Some storage required ventilators to be closed, and some required them to be open. If you get the message here, nothing you can do can help, and anything you do can put you in harm's way for nothing!

At a semisophisticated participative drill program at one state fire academy, the stage behind the screen the "incident command- ers" were using housed an instructor with his finger on the tape recorder's "play" button. The tape was of an explosion, and the button already was set on "too loud."

"When do you get to play that thing?" I asked.

"Every time!" he answered.

So I came to my little conclusion to share with you: Leave the silos alone. And then find the time to read why.

Doorways. Get the nozzle and the line through the doorway to the fire room, and operate from the inside wall. In short, get out of the doorways. If the fire is keeping you on the "unburning" side of the opening in a doorway or a bend in the hall or room, or at the bottom of a basement or cellar stair, you either don't have enough water or you have more fire than you think you have. Remember, there is less punishment inside and adjacent to the opening than in it.

With that statement, here's a question: When do you seek out and get into door assemblies? When the structure you are in begins to collapse before you make your retreat to the outside. The door and alcove assembly has stronger framing than any other spot in the room or structure for you to pause in during your Mayday escape.

Rhoselle stretch. Remember to set up every hoseline stretch before you stretch. You will always regret having to recover from too many lengths, too few lengths, incorrect location, and poor size selection. Adding a length of hose in a halted interior fire attack in a structure is always inefficient, ineffective, confusing, and unprofessional—and it could be litigious.

Unconscious victim. Speaking of occupied structures on fire, What do you do with the unconscious victim you found? After you call for help and announce where you are, pull at the head of the victim and nowhere else. Sounds dumb, I know; but if you don't take the time to ensure that, you could change a smooth drug to an area of refuge into an impossible task at best. Save all the rescue training victim carries until you get to the area of refuge. Real rescues in fire buildings save two people—you and the victim.

Ensure that the victim is moving horizontally head first, and keep the arms and legs from stopping the process at every door, stair assembly, and window opening.

Charge the water extinguishers at the scene of the fire after the critique and before you take up. Water extinguishers and critiques share a common lesson: Both are less effective if you don't "take care of them" before you get back to the station.
Agriculural structures account for much of what we envision as an idyllic farm scene. In fact, it's almost impossible to picture a farmhouse without a barn and silo nearby.

Such structures are used to house livestock and store machinery, grains, animal feed and manure, but those innocent uses can mask a considerable variety of dangers. Such problems can be hazardous not only to the farm's workers and residents, but to the fire, rescue and EMS personnel who are called to the farm for emergency incidents.

The hazards faced by farmers and rescuers involving agricultural structures include falls from heights; electrocutions; entrapments in grain, feed, animal waste and machinery; hazmat exposures;IDLH atmospheres; and fires and explosions.

Several firefighters have been injured or killed during fireground and rescue operations at farm structures. These injuries and deaths typically result when responders aren't familiar with the structures and their hazards, or when rescuers fail to follow proper confined-space or firefighting procedures.

For example, many structures on farms qualify under one or more of the OSHA criteria for confined spaces. OSHA's confined-space standard, 29 CFR 1910.146, defines a confined space as one that:
- Is large enough for someone of any size to enter and work,
- Has limited or restricted entry and exit, and
- Isn't designed for continuous occupancy.

A "permit-requiring" confined space has one or more of the following characteristics:
- Hazardous atmosphere.
- Material that could engulf an entrant.
- Internal configuration of inwardly converging walls or a sloped or tapered floor that could entrap or asphyxiate an entrant.
- Any other recognized serious safety or health hazard.

Even if a local fire-rescue agency hasn't made any written agreements with the owners or operators of such facilities to provide confined-space rescue, it's likely to be summoned to such an incident. As a result, every agency should have and follow a confined-space rescue plan, which includes risk assessment, pre-

planning, choosing and purchasing equipment, establishing SOPs, and providing the necessary training to agency members. Fire-rescue crews must decide what level of confined-space rescue they can provide and then prepare for that level.

One of the more common confined spaces on a farm is the silo, where forage crops to be used for animal feed are stored for later use. Silos should not be confused with grain bins or grain elevators, which are used to dry and store grains like wheat, corn, oats and barley. They have different forms, and their own hazards.

Preplanning specific to silos is essential and should include the following:
- Type and brand of silo and silo unloader.
- Owner and manufacturer.
- Normal types of contents.
- Dimensions and age.
- Modifications, if any.

Common silos
- Vertical, also called tower or upright silos, are the recognizable round cylinders on farm-

Inspectors with the Ohio State Fire Marshall's office stand in front of the Hoge Lumber Co. woodchip and sawdust silo in New Knoxville, Ohio, that exploded Oct. 1, killing one firefighter and injuring at least six others.
Tall TROUBLE

steads. The fact that there are one million tower silos in North America, coupled with the multiple hazards of these structures, make silo rescue and firefighting an important issue for many rural rescuers. However, many farmers aren’t using their tower silos in favor of larger trench and/or bag silos.

Vertical silos are subdivided into conventional, oxygen-limiting and modiﬁed. Each type presents different problems and challenges, so rescue personnel need to be able to distinguish between these types. Misidentifying a silo and employing incorrect procedures can result in needless injury or deaths of patients and rescuers.

Conventional silos are constructed from poured concrete, concrete staves (curved concrete blocks held in place by steel rings) or steel. Older ones were made of tile blocks or wood. Conventional silos usually can be identiﬁed by the 3-foot diameter chute that runs the height of the silo. However, some modiﬁed oxygen-limiting silos have been retroﬁtted with exterior unloading chutes. The chute allows the silage to fall down into the barn, wagon or conveyor during unloading operations. The silos may have no roof at all or a hemispherical domed roof.

Oxygen-limiting silos are designed to limit the amount of oxygen in the structure, a feature that can rapidly kill farm workers and rescuers. Farmers and ﬁreﬁghters have been injured and killed entering from both the top and the bottom of these silos. Many ﬁreﬁghters also have died when they were trying to oxygen-limiting silo exploded while they were on top of the structure during firefighting operations.

Oxygen-limiting silos are constructed of steel or poured concrete, with the blue-colored Harvestore brand being the most common. These silos generally have a ﬂatter roof than conventional silos, and most will have roofs with two 18- or 24-inch openings. Unmodiﬁed oxygen-limiting silos have no exterior unloading chute, as they unload from the bottom.

Modiﬁed silos is a catch-all grouping of silos that have been modiﬁed from their original design. These modiﬁcations can change the tactics employed in rescue/recoveries and ﬁreﬁghting. One example of these silos is the oxygen-limiting Harvestore silo that is modiﬁed for top unloading with unloading doors and an exterior chute or center unloading design. Another example of a modiﬁed silo is the conventional silo that has a center unloading system that replaces the exterior chute.

Fire suppression

The deaths of ﬁreﬁghters during the suppression of an agricultural silo ﬁre are a grim reminder of the need for education in farm emergencies. These tragedies, unfortunately, have occurred across the country numerous times. Fireﬁghters must be very cautious and continually analyze the risks and beneﬁts of each of their actions.

Silo ﬁres usually occur when farmers fail to follow proper forage storage procedures. They also can occur at saw mills, where agricultural-type silos are used to store sawdust and saw chips. These fires produce carbon monoxide, carbon dioxide and nitrogen oxides. Therefore scba, full protective gear and conﬁned-space techniques must be used when dealing with silo ﬁres.

Explosions in agricultural silos are not the same as explosions in grain elevators. Grain elevator explosions are a result of very-dense dust environments that detonate from a spark or ﬂame within the elevator. Explosions in agricultural silos are caused when oxygen enters a smoldering ﬁre inside the structure and causes the carbon monoxide to explode.

Controlling fires in silos depends on the kind of silo involved. Misidentiﬁcation or not accounting for modiﬁcations can and will injure and kill ﬁreﬁghters.

Conventional-silo ﬁre suppression. Fires in conventional silos historically have posed little threat of explosion because the silos aren’t designed to be sealed structures. Time is also in the ﬁreﬁghters’ favor unless exposure problems to attached or proximal buildings develop.

On arrival at a conventional silo ﬁre, the ofﬁcer in charge should:

- Conﬁrm preplan information;
- Have the operator and silo dealer respond;
- Check for and extinguish any hot embers that may have left the silo;
- Have the farmer move any livestock or machinery from the area and adjacent structures, if possible;
- Raise the silo unloader machine as far as possible via a hand crank or electrical switch at the base of the silo to minimize damage to its parts from heat and ﬁre;
- Disconnect and lock-out the electrical supply to the silo unloader.

Once these preliminary steps have been taken, a ﬁreﬁghter with full protective gear, including scba and a full-body harness and lifeline, should assess the ﬁre from above the silage. If it’s safe to do so, this task can be performed with a ladder truck or by climbing the silo’s exterior or chute. Climbing silos should be done with caution, as the ladders and steel rungs usually are very slippery. In addition, the chute ladder may be broken or damaged by the ﬁre. The chute also may be full of hot embers. Once above the ﬁre, the ﬁreﬁghter should extinguish any visible hot spots.

A ﬁre in a tower silo is typically located
around the perimeter, the unloading doors and/or the top few feet of silage. Because a fire burning for an extended period of time can create hollowed-out cavities in the silage, any firefighter entering a burning conventional silo after knockdown of the burning surface must be secured with lifelines and stand on long boards or ladders. There are no interior ladders, per se, only the steel support rings at the chute opening. Confined-space techniques must be followed. At this point, penetrating nozzles can help to reach subsurface burning.

Using carbon dioxide or nitrogen to extinguish conventional silo fires is a questionable practice, as the structure is open to atmosphere and oxygen usually can still reach the fire. Some departments have had success with these gases, but more experimentation is needed.

It's usually impossible to completely extinguish fires in conventional silos. Even when the fire appears to have been extinguished, it sometimes re-ignites. The farmer must partially or sometimes totally empty the silo. Firefighters may have to be present during this unloading to douse hot spots. When unloading is an extended operation, consider rotating personnel and/or lending the farmer a portable pump, pond and hose. Fire officers, farmers, and the farmer's insurance representative need to discuss any further actions.

Oxygen-limiting–silo fire suppression. Oxygen-limiting silos can explode when on fire, so it's imperative that firefighters know when this type is involved. An unmodified oxygen-limiting silo will not have an exterior chute.

Allowing any air to enter the carbon-monoxide-rich environment of the silo can cause an explosion. Therefore, do nothing that may cause air to be drawn into the silo. Don't attempt to open hatches or spray water or foam inside. Firefighters have been killed when they inject water and/or foam into burning oxygen-limiting silo.

Response to a fire in an oxygen-limiting silo should involve the following steps:

- Confirm preplans.
- Have the farmer and silo dealer respond.
- Do not increase the amount of oxygen inside the silo. Don't open hatches or unloader doors, and don't inject water or foam.

Firefighters should stay off a structure that is shaking, hot, noisy, smoking heavily or has been opened within the past few days. If the structure is quiet, motionless, cool and has not been opened within the past few days, and if smoke is minimal, firefighters should close the bottom unloader door and top hatches. Do not lock down these hatches, as they allow the silo to vent itself.

Inspect for extension into any adjacent structures and have the farmer evacuate these structures if possible. If the silo walls next to combustible barn walls are hot, create a space between the two to reduce the likelihood of the silo igniting the barn.

Leave the silo closed for two or three weeks. If the structure is well sealed, the fire may self-extinguish. Regular monitoring of the silo and adjacent areas is important. If the fire continues to burn, you may have to inject carbon dioxide or nitrogen. Ask the silo dealer for assistance.

Modified-silo fire suppression. Extreme caution should be exercised when dealing with a modified silo. Fire departments that have employed incorrect suppression techniques on these structures have paid a high price in firefighter injury and death. Securing technical assistance is critical. As there are many ways silos can be modified, each case must be managed individually.

Silo fires are not common, but the possibility of firefighter death and injury is always present. Usually there's no great hurry to

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**Not The Average SILO**

Horizontal silos include the plastic-bag type or the so-called bunker, trench or pit.
- Bunker, trench and pit silos are open areas with earthen or concrete walls. Silage is dumped to these silos by tractors or wagons. The silage is then compressed by driving heavy tractors over the silage, which then is spread with plastic sheeting. As the year goes on, the farmer removes just enough to feed the livestock each day. The farmer uses a bucket loader to unload the silo.

The primary hazards surrounding bunker-type silos are tractor overturns and entanglement of people by falling silage. Overturns occur during the filling and compacting of the silo. The overturns, which can occur to the side or rearward, can be fatal if the tractor doesn't have a roll-over protective structure and the farmer fails to wear a seatbelt. Rescuers need to be proficient in tractor overturn extraction. Sometimes the silage in trenches consolidates. This can produce vertical walls of silage that can collapse and bury workers or children.

Because these silos are open to the air, hazardous gases are less of a concern under the plastic cover. Farm workers have little reason for going under the plastic cover. However, it is not beyond a child's inquisitive nature to hide and play anywhere on the farm.

Silage mold and dust can accumulate in these silos and become airborne during unloading. Some farmers and rescuers can have adverse reactions to these particles. Rescuers can protect themselves by wearing appropriate, well-fitted particle mask.

The other type of horizontal silo uses large, white, tubular bags, of which the Ag-Bag is a popular example.

Silage is brought to the fields and is "packaged" into these long plastic bags. Because these bags pack the silage tightly, driving on the silage is compacted it is eliminated. This eliminates the risk of tractor overturn, like with trench silos. The silage wagon and bag storage packaging machinery, however, do contain many moving parts. Therefore, bring the hazards of machinery entanglement with it.
Tall TROUBLE

extinguish silo fires because they generally are well-contained by the structure. Rushing into fire suppression activities can be disastrous.

Rescue challenges

Rescues and recoveries of farmers from inside silos can be very challenging operations. Removal of a farmer can be difficult and time-consuming. The manner in which a victim is physically removed from the silo depends on four factors:

1) Patient's condition. Is this a rescue or recovery? Is the patient's condition stable or unstable? Basically, how much time do you have to accomplish this rescue? An unstable patient will suggest a more aggressive manner of egress. A stable or non-salvageable patient dictates a less aggressive manner.

2) Expertise of rescuers on scene or through mutual aid. In many areas rural fire-rescue companies do not have much, if any, high-angle or confined-space rescue experience. This lack of expertise reduces the number of options that departments can employ safely. Good pre-incident planning and regular practice and training on different rescue scenarios are a must. Successfully practicing rescue skills is a good predictor of how rescuers will act in real situations.

3) Availability of ladder company. Most rural rescuers have little or no access to an aerial apparatus. For the services that can get access to such pieces, calling for them may be helpful. Extreme care must be taken if such pieces are used on farms because of the lack of a solid base for the piece to work from.

4) Conditions inside the silo. A hazardous environment will affect the amount of time the patient can remain viable.

All these conditions need to be evaluated when deciding which form of patient egress to be employed. Limiting the number of injured or killed is an ever-present priority, requiring command officers to continually analyze the risks and benefits of operations.

Egress methods

Conventional silo rescues and recoveries can be accomplished by different methods. The following are options for removing victims who can't safely exit under their own power.

Down the chute. This method involves placing the victim into a full-body harness and lowering him or her by rope from an anchor point above. This method is arguably the easiest, safest, and often the fastest to accomplish. However, not all victims can be removed by this method. Victims on backboards will obviously won't "bend" at the waist to make the turn down the chute.

Because this type of egress can be done relatively quickly, unstable victims who do not require spinal immobilization may benefit from this method. On the other hand, it's difficult to keep the victim in the chute so he or she is lowered down the chute. Also, non-salvageable patients can be taken out this way to keep rescue risk at a minimum.

Through the chute. This manner of egress is accomplished by passing the patient on a long board out a silo unloader door and then through the exterior chute. This is a more technical rescue as it employs a rigging system and/or an aerial apparatus, making it more difficult and time-consuming.

Through the wall. This manner of egress is similar to the through-the-chute style, only the egress takes place through the wall of the silo. Breaching the wall of a conventional-silo can be easy or difficult, depending on its construction: Concrete-stave silos walls are easy to breech; whereas poured-concrete walls are much more difficult. The rigging or aerial apparatus requirements are similar to the through-the-chute method.

Out the top. Bringing the patient out the top of the silo is the most technical manner of rescue/recovery this requires a specially trained high-angle team that has successfully practiced on silos. The patient must be secured in a secured basket that is equivalent and then raised out the top of the silo from an anchor point above the opening. The roof of the silo itself may have to be widened to accommodate this rescue. Once the stokes basket is raised out the top, it is lowered to the ground by a rigging system or taken down with the assistance of an aerial apparatus.

All of these techniques are intended for conventional-silo rescues. In fact, many people question whether rescue from an oxygen-limiting silo is even possible. Victims taken from these silos often are non-salvageable due to the oxygen-deficient and toxic-gas atmosphere. However, at least one successful rescue of a farm worker from this type of silo has occurred, but the victim was only a short distance from the silo's top hatch.

Rescue detractors say these emergencies should be treated as body recoveries, noting that several rescuers were injured in New York state in 1985 during an oxygen-limited-silo rescue. Entry into these silos for a rescue or recovery needs to be done by well-qualified, well-trained personnel. Rescuers with little or no confined-space expertise place themselves in great peril.

Emergencies involving silos present hazards that may not be obvious and can injure and kill farm workers and fire-rescue personnel. Rural rescuers need to educate themselves on local agricultural practices and prepare themselves appropriately. [FC]

Ted Halpin is an extension support specialist for Cornell University, Ithaca, NY, and the co-founder of the university's FARMEDIC program, which has been training rural fire-rescue personnel for farm emergencies since 1981. Halpin grew up on his family's farm and has 24 years of volunteer and career fire, rescue and EMS experience. He holds undergraduate degrees in agriculture and fire protection and a master's degree in public administration.