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Analysis of Wet and Dry Chemical Extinguishing Systems

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October 25, 2018

Presentation Outline

1. Overview of System Components
2. Regs/Codes/Standards
3. UL300 and Wet Chemical Systems
4. Appliances/Fire Statistics
5. System Components
6. System Design/Installation
7. Inspection, Testing, and Maintenance
8. Inspections—Post Event
9. System Failure Examples

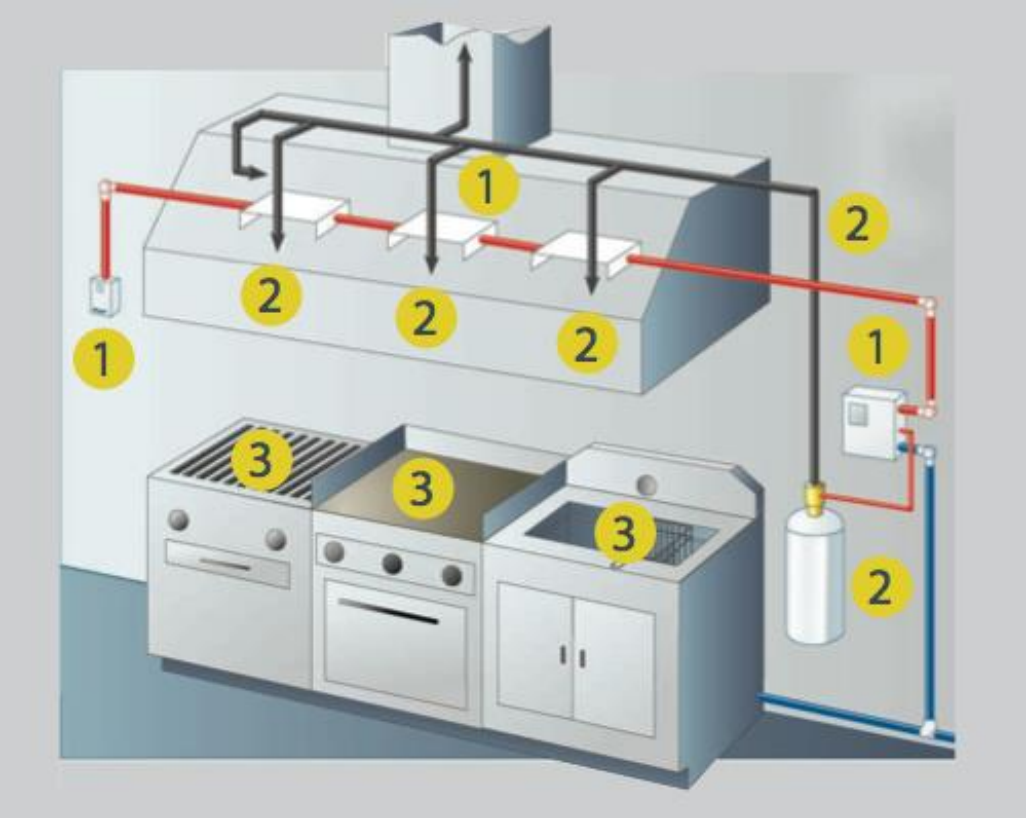
Section 1

Kitchen Suppression System

OVERVIEW OF SYSTEM COMPONENTS

Overview of a Kitchen Suppression System

1. Fire is detected by heat detectors, which activate the control box (or the manual pull station is activated), causing the cylinder valve to open
2. Pressure stored in the cylinder propels the wet chemical through the system piping and out of strategically located nozzles onto the fire, the system automatically shuts off appliances to remove the heat source
3. The wet chemical knocks down flames quickly and forms a protective layer that suppresses fire and prevents fire re-flash



Summary

- Agent
- Detection
- Releasing mechanism
- Fuel supply cutoff
- Fan shut down
- No alarm
- Nozzles

Section 2

Kitchen Suppression System

REGS/CODES/STANDARDS

Kitchen Suppression System—Regulations

- RCW 19.27.031 adopts IFC
- IFC adopts NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*
- NFPA 96 requires the installation of a fire suppression system in all commercial cooking hoods
- Two main types of systems:
  - Dry chemical systems (pre-1994)
  - Wet chemical systems (post-1994)

Kitchen Suppression System—Regulations *(continued)*

- NFPA 96 adopts NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* and NFPA 17A, *Standard for Wet Chemical Extinguishing Systems. These drive ITM requirements.*
- NFPA 96 requires compliance with ANSI/UL 300, *Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment,* for new/modified systems

NFPA 17—Dry Chemical Systems

- Minimum requirements for dry chemical fire-extinguishing systems
- Dry chemical systems are not UL 300 listed

Dry Chemical Systems - Grandfathered

- Dry chemical systems are obsolete
- Many are still in service and can remain in service (grandfathered) in most jurisdictions until:
  - Changes in the cooking media
  - Repositioning or replacement of cooking equipment
  - They can no longer be maintained

NFPA 17A—Wet Chemical Systems

- Minimum requirements for hoods, plenums, and ducts and associated cooking appliance design, installation, operation, testing, and maintenance of wet chemical systems
- Only systems that can pass the UL 300 test
- Some pre-UL 300 wet chemical systems are still installed (grandfathered)

NFPA 17A—Wet Chemical Systems

(continued)

- Pre-engineered systems:
  - Predetermined flow rates, nozzle pressures, and quantities of extinguishing agent. These systems have the specific pipe size, maximum and minimum pipe lengths, flexible hose specifications, number of fittings, and number and types of nozzles prescribed by a testing laboratory.
  - The hazards protected by these systems are specifically limited as to type and size by a testing laboratory, based on actual fire tests
  - Limitations on hazards that are permitted to be protected by these systems and piping and nozzle configurations are contained in the manufacturer's manual

Hood/Duct Cleaning- IKECA

- IMC – Adopts IKECA C10 through Section 609 "Commercial Kitchen Hoods"
- International Kitchen Exhaust Cleaning Association

TABLE 609.3.3.1
COMMERCIAL COOKING SYSTEM INSPECTION FREQUENCY

TYPE OF COOKING OPERATIONS	FREQUENCY OF INSPECTION
High-volume cooking operations such as 24-hour cooking, charbroiling or wok cooking	3 months
Low-volume cooking operations such as places of religious worship, seasonal businesses and senior centers	12 months
Cooking operations utilizing solid fuel-burning cooking appliances	1 month
All other cooking operations	6 months

609.3.3.2 Grease accumulation. If during the inspection it is found that hoods, grease-removal devices, fans, ducts or other appurtenances have an accumulation of grease, such components shall be cleaned in accordance with ANSI/IKECA C 10.

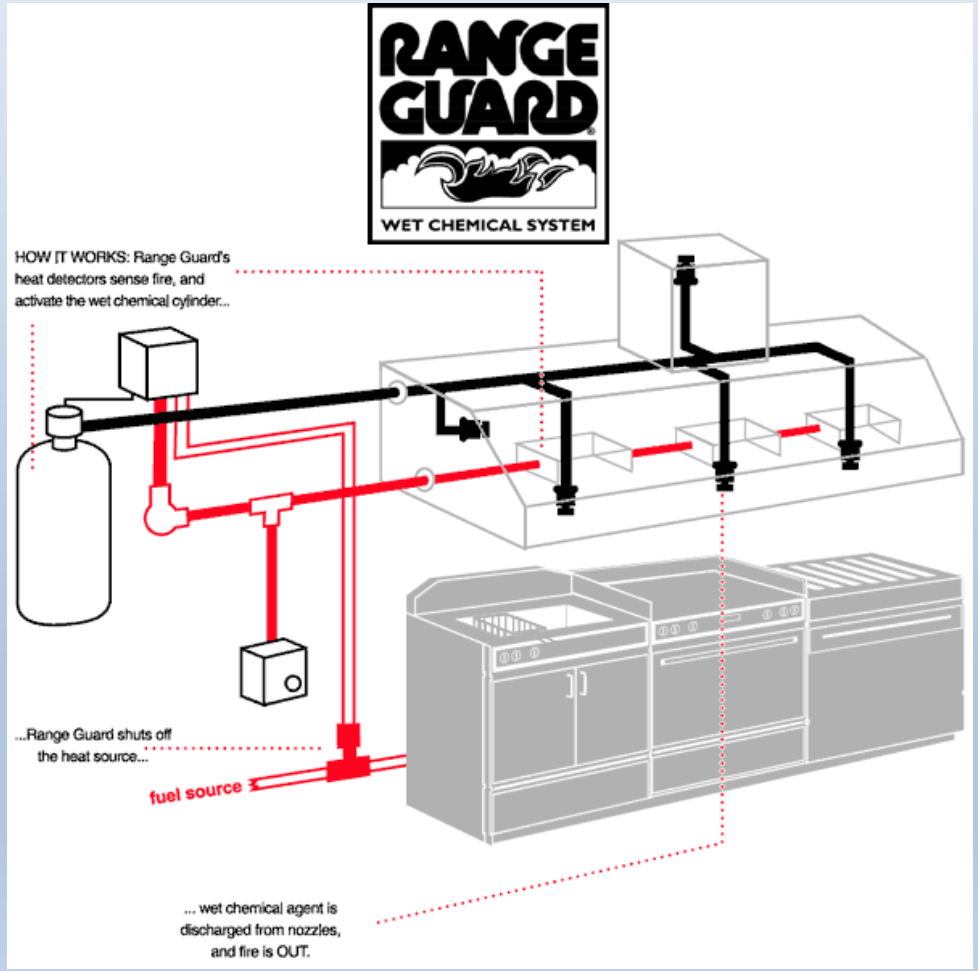
Section 3

Kitchen Suppression System

UL 300 AND WET CHEMICAL SYSTEMS

Wet Chemical—How It Works

- Wet chemical agent extinguishes fire by:
  - Saponifying the surface grease (converting it into combustion-resistant soap)
  - The cooling effects of water vaporization
  - Interrupting the chemical chain reaction of combustion



What is UL 300?

- November 21, 1994
- Pre-UL 300 systems were based on tests from the 1960s
  - Auto-ignition temperature of animal fat is 550–600°F
- Currently, 70–75% of commercial kitchens use vegetable oils in high-efficiency fryers
  - Auto-ignition temperature of vegetable oil is 685°F
- High-efficiency fryers heat faster and cool slower
- Fires are hot, stubborn, and difficult to extinguish

ND Truck Stop, Campground, Library, ER, Morgue and Animal Shelter Kitchen Fire

What is UL 300? *(continued)*

- Contains requirements for full-scale fire and flow testing
- Requires strict performance of the system to extinguish fire in duct, hood, plenum, and cooking appliances

What is UL 300? *(continued)*

- Test conditions:
  - Duct and hood are coated with grease
  - Appliances are located directly below the duct entrance to simulate a burning run back, worst case situation
  - Grease is ignited with a large burner
  - Tests are performed with a specified airflow through the hood and duct systems and with no airflow to evaluate performance under each condition
  - The system must successfully extinguish the fire in all areas without splashing or re-ignition of cooking grease

UL 300 Test Video

Fire Equipment Manufacturer's Association
1998/10 min run time

Cue separately

Section 4

Kitchen Suppression System

APPLIANCES/ FIRE STATISTICS

Commercial Kitchen Appliances—Range

- Common causes of fire:
  - Open flames
  - Poor housekeeping
  - Flare ups

Commercial Kitchen Appliances—Ovens

- Common causes of fire:
  - Poor housekeeping
  - Food/particulate buildup

Commercial Kitchen Appliances—Griddle

- Common causes of fire:
  - Full grease traps
  - Poor housekeeping
  - Flare ups

Commercial Kitchen Appliances—Broiler

- Common causes of fire:
  - Full grease traps
  - Poor housekeeping
  - Flare ups

Commercial Kitchen Appliances—Fryer

- Common causes of fire:
  - Low oil levels
  - Unattended fryers
  - Baffles broke down and clogged heat exchanger tubes
  - Not filtering correctly—dirty oil
  - Grease build up
  - Food particulate build up
  - Flue covered or food/grease in it

Commercial Kitchen Appliances—Solid Fuel

- Common causes of fire:
  - Sparks or hot embers igniting grease in hood or ductwork
  - Grease build up
  - Poor housekeeping

Commercial Kitchen Appliances—Wok

- Common causes of fire:
  - Poor housekeeping
  - Flare ups

Commercial Kitchen Appliances

- Cooking appliances that do not produce grease-laden smoke do not need to be protected
  - Rice cookers
  - Bread makers
  - Pasta makers

Commercial Kitchen Fire Statistics

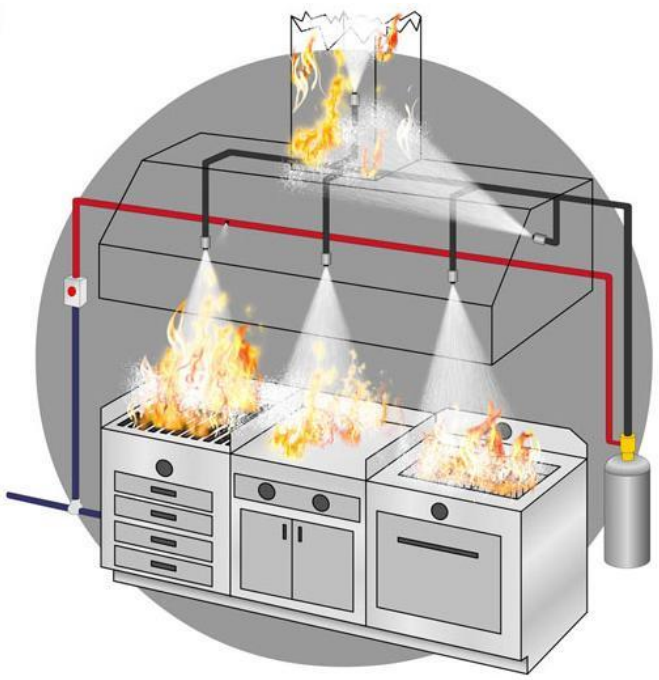
- ~8,500 fires a year
- 38% are confined
- 26% do not involve appliances

- Common appliance fire origins:
  - Fryers (3%)
  - Chimney/flue (3%)
  - Broilers (2%)
  - Ranges/stovetops (2%)
  - Grills (1%)
  - Ovens (1%)
  - Grease hood and exhaust fans (1%)

Section 5

Kitchen Suppression System

SYSTEM COMPONENTS



System Components—Kidde Cylinders

- 5 different sized cylinders
- Each cylinder is pressurized with nitrogen or air to 175 psig

System Components—Ansul Cylinders

- DOT specification
- Manufacturer
- Date
- Serial number
- Weight

AGENT TANK ASSEMBLY

The agent tank shipping assembly (3-Gallon, Part No. 429862, and 1.5 Gallon, Part No. 429864) consists of a stainless steel tank and an adaptor/tube assembly. The adaptor/tube assembly contains a burst disc. The burst disc prevents agent leakage due to significant temperature fluctuations in the area where the tank is located. Under normal conditions, the tank requires hydrostatic testing every twelve years. The date of manufacture is stamped on the tank nameplate.

The tank is shipped uncharged and must be filled with only ANSULEX Low pH Liquid Fire Suppressant during installation.

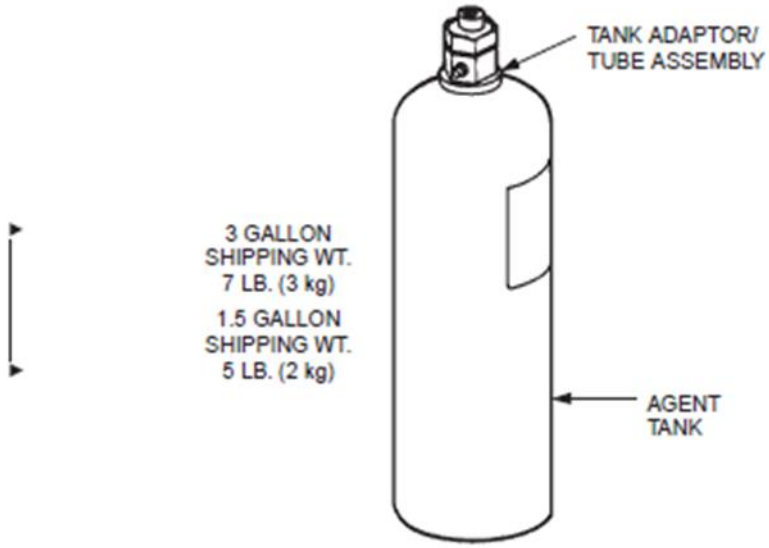


FIGURE 7
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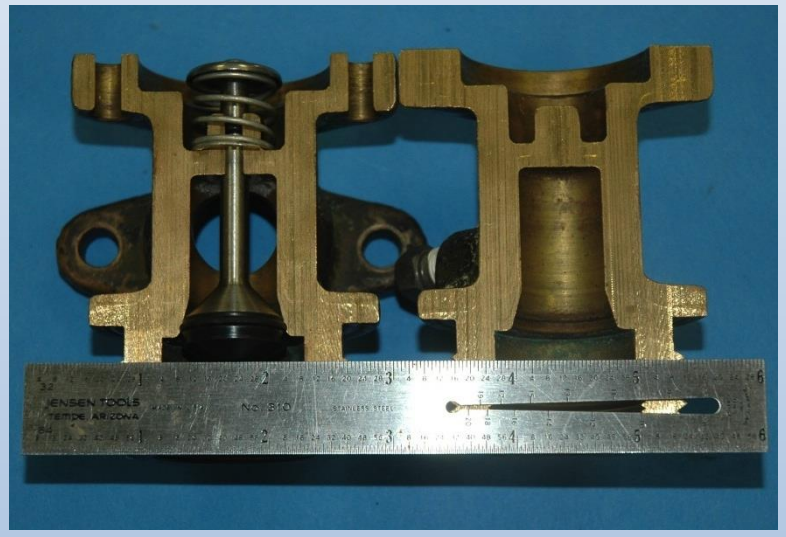
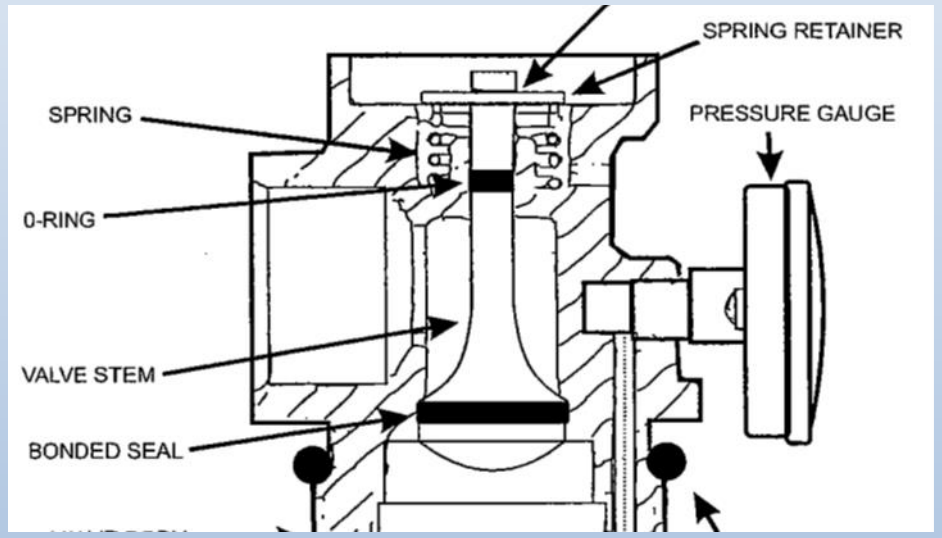
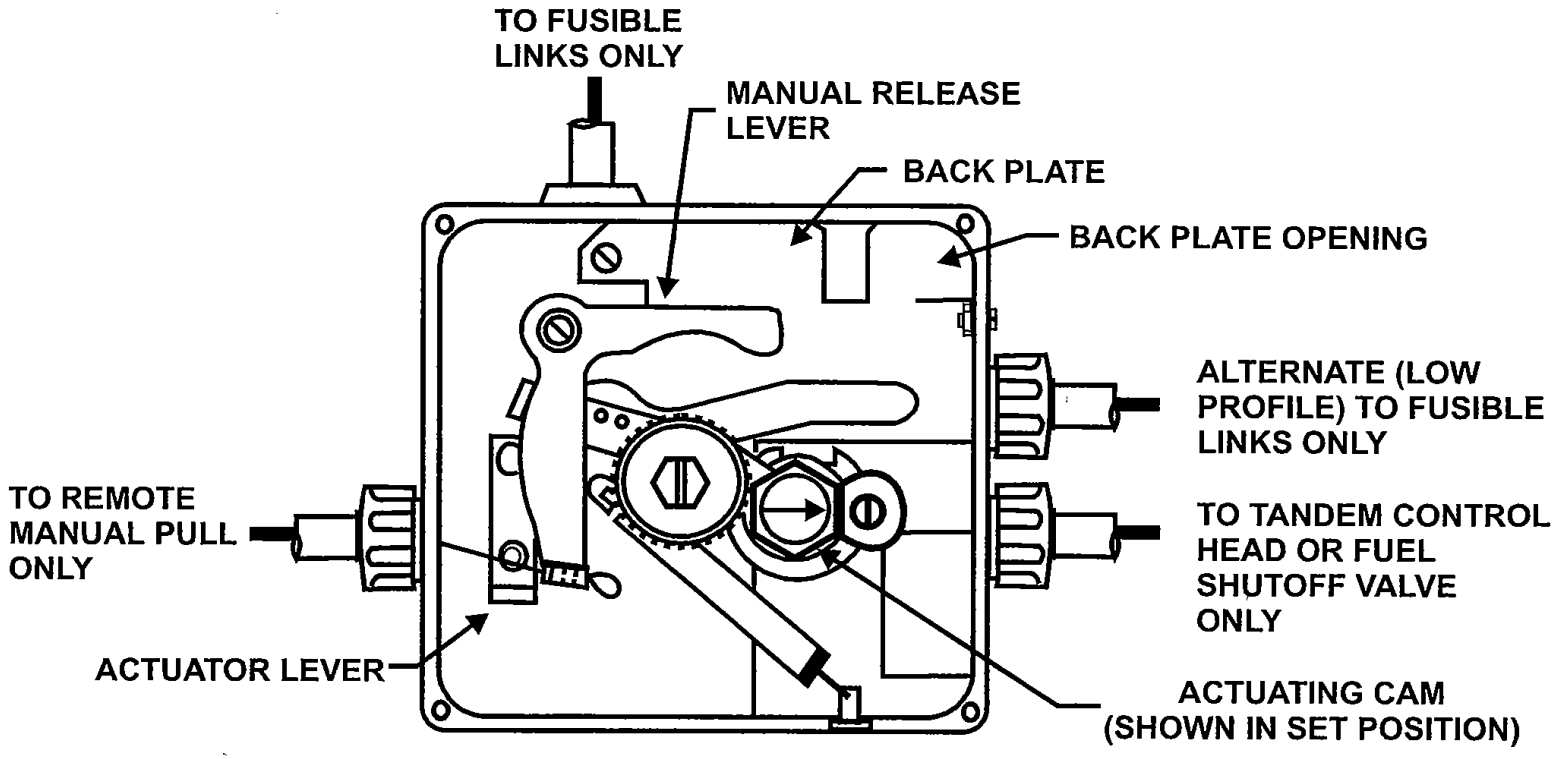
System Components—Kidde Cylinder Valve





System Components—Mechanical Control Head



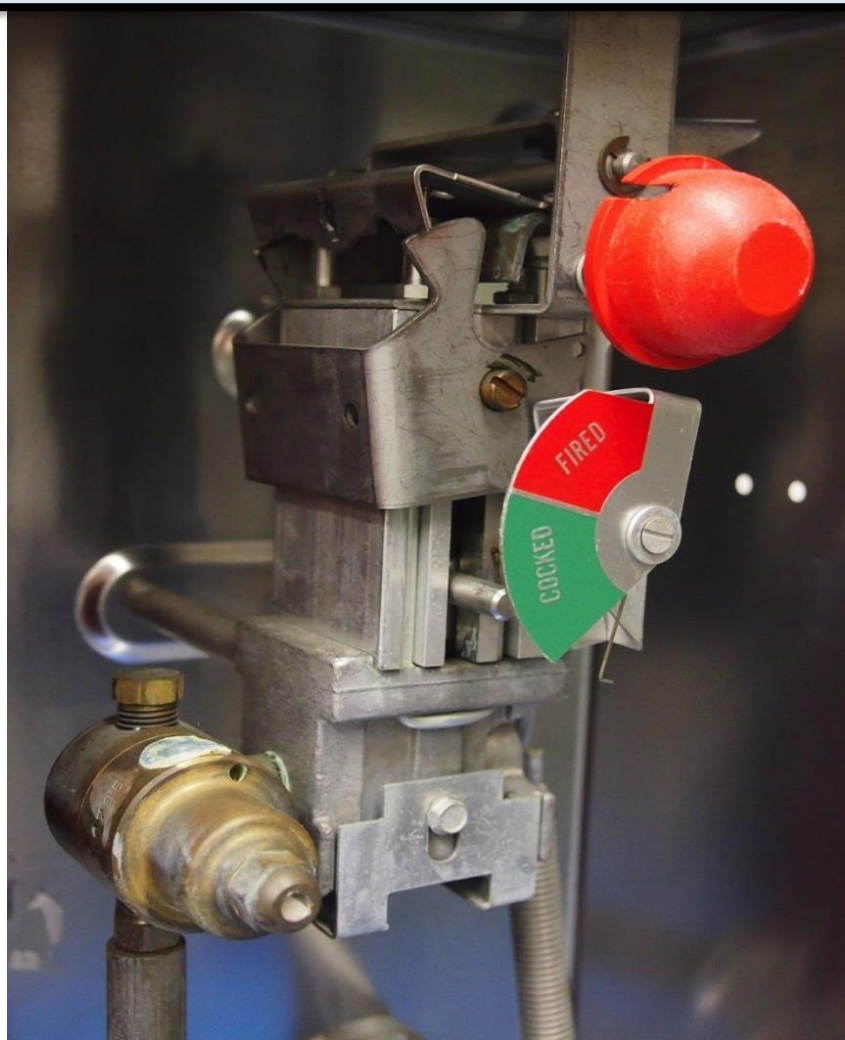
System Components—Pneumatic Control Head

System Components—Electric Control Head

- Used on systems equipped with thermostats
- Requires power
- Detectors close power circuit to control head
- A solenoid releases a spring-loaded plunger which depresses the valve stem in the cylinder valve, discharging the contents of the cylinder

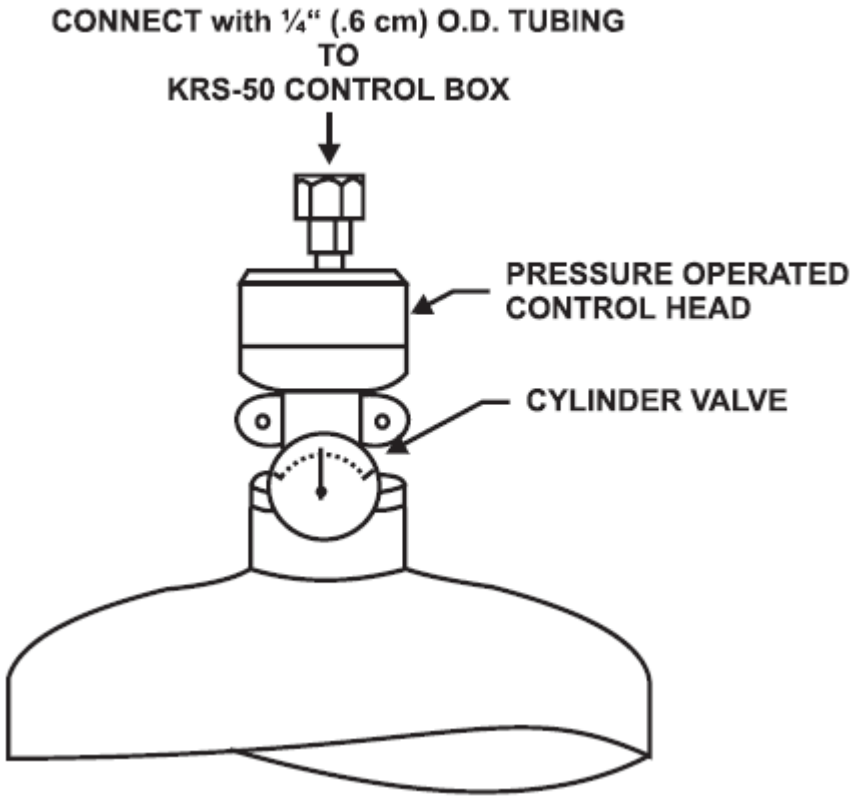
System Components—Ansul Releasing Mechanism

Pressure-operated actuator

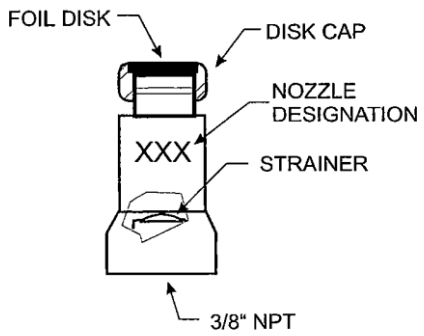


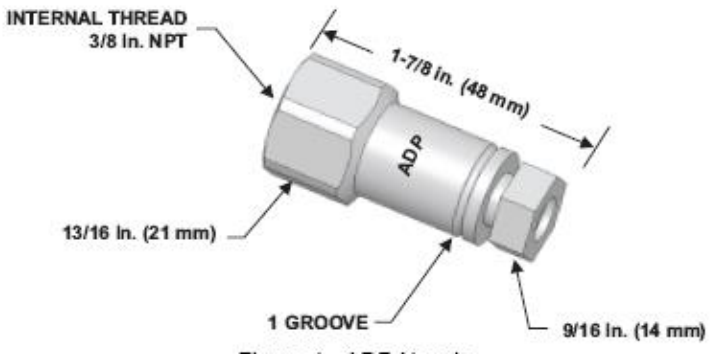
System Components—
Kidde Pressure Operated Actuator

- Used with the KRS-50/A+ control
- Contains a piston that is driven down by CO_2 pressure
- The piston will remain in the “discharged” position as long as CO_2 pressure is maintained



System Components—Kidde Nozzles





- Seven types:
  - Appliance/duct/plenum nozzle (ADP)—1 groove
  - Fryer nozzle (F)—2 grooves
  - Mesquite nozzle (DM)—0 grooves
  - Range nozzle (R)—4 grooves
  - Gas radiant/wok nozzle (GRW)—3 grooves
  - Low proximity fryer (LPF)—2 grooves in 1 and 4 position
  - Low proximity range (LPR)—0 grooves (blunt shape)

System Components—Ansul Nozzles

NOZZLES

There are twelve types of discharge nozzles each designed to distribute the liquid agent in a uniform pattern throughout the hazard area:

1. 1W Nozzle
2. 1N Nozzle
3. 1/2N Nozzle
4. 3N Nozzle
5. 2W Nozzle
6. 230 Nozzle
7. 245 Nozzle
8. 260 Nozzle
9. 290 Nozzle
10. 2120 Nozzle
11. 1F Nozzle
12. 1100 Nozzle

Although these nozzles are similar in appearance and have certain common parts, the tip of each nozzle is designed for a specific application and must only be used in those areas. See Nozzle Application Chart in Section IV – System Design, for individual nozzle usage.

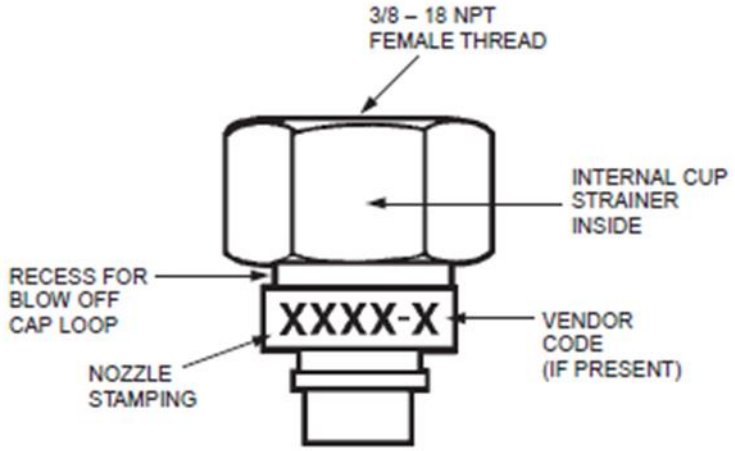


FIGURE 13

System Components—Ansul Nozzles *(continued)*

RUBBER BLOW-OFF CAPS

The Rubber Blow-Off Cap, Part No. 77676, help keep the orifice of the nozzle free of grease or other substances that could interfere with agent distribution. A retaining strap attaches the blow-off cap to the nozzle. Rubber Blow-Off Caps must be ordered as a Shipping Assembly, Part No. 77695, which contains 50 blow-off caps, or Part No. 77411, which contains 12 blow-off caps.

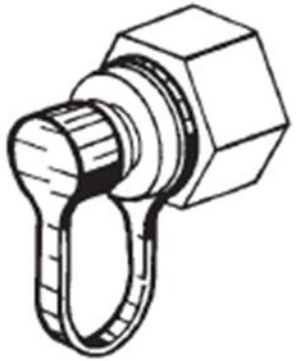


FIGURE 15
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System Components—Detectors

Figure 1. Thermo Bulb, P/N 87-12009*X-XXX*

Figure 2. KML Heat Detector Links, P/N WK-282661-*XXX*

Figure 3. KFA Heat Detector Link, P/N 87-120060-001

System Components—Detector Ratings

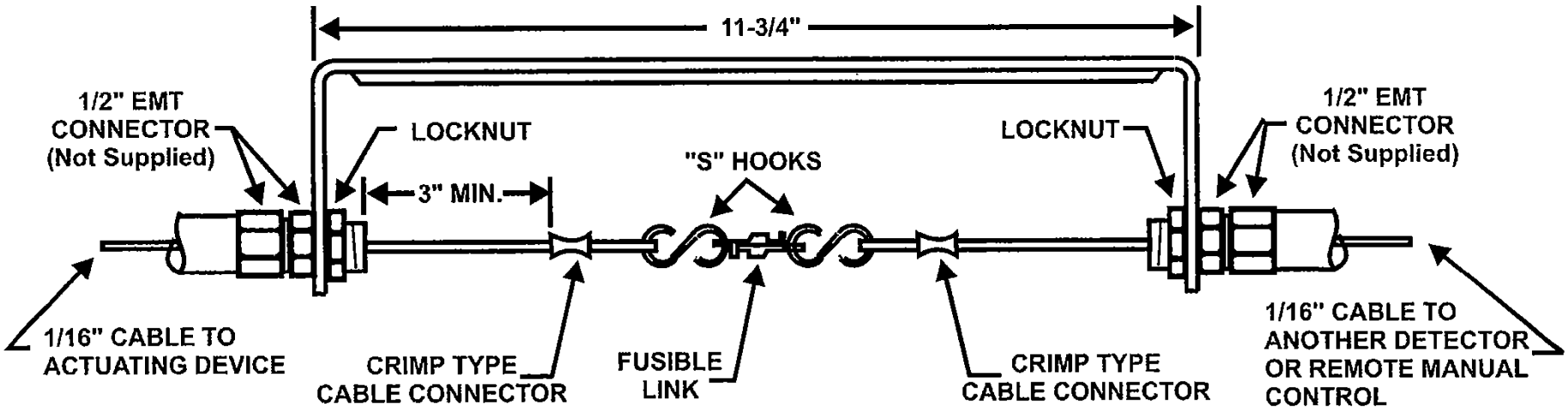
Table 1. Thermo Bulb Detector Link Ratings

Standard Response Part Number	Rapid Response Part Number	Detector Temperature Rating	Color	Maximum Exposure Temperature
87-120090-165	87-120095-165	165°F (74°C)	Red	100°F (38°C)
87-120090-212	87-120095-212	212°F (100°C)	Green	150°F (65°C)
87-120090-286	87-120095-286	286°F (141°C)	Blue	225°F (107°C)
87-120090-360	87-120095-360	360°F (182°C)	Mauve	300°F (149°C)
87-120090-450	87-120095-450	450°F (232°C)	Black	375°F (191°C)
87-120090-500	87-120095-500	500°F (260°C)	Black	435°F (224°C)

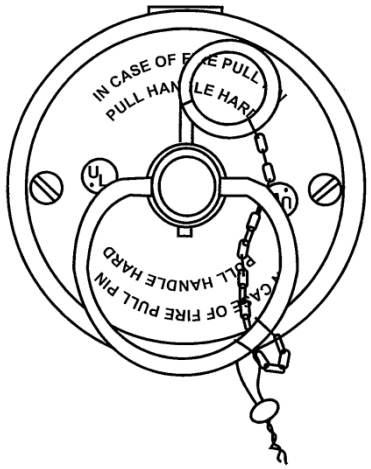
Table 2. KML and KFA Detector Link Ratings

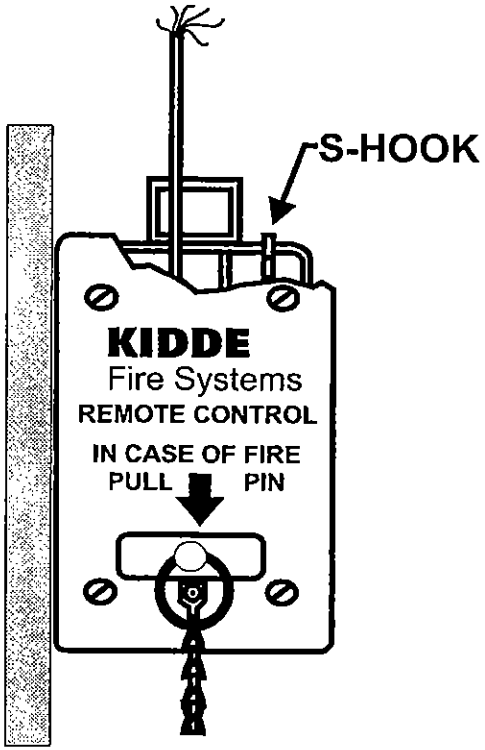
Fusible Metal Detector Link Part Number	Detector Temperature Rating	Color	Maximum Exposure Temperature
Model KML			
WK-282661-000	165°F (74°C)	Yellow	100°F (38°C)
WK-282662-000	212°F (100°C)	White	150°F (65°C)
WK-282664-000	360°F (182°C)	Unpainted	300°F (149°C)
WK-282666-000	500°F (260°C)	Orange	440°F (226°C)
Model KFA			
87-120060-001	360°F (182°C)	Unpainted	300°F (149°C)

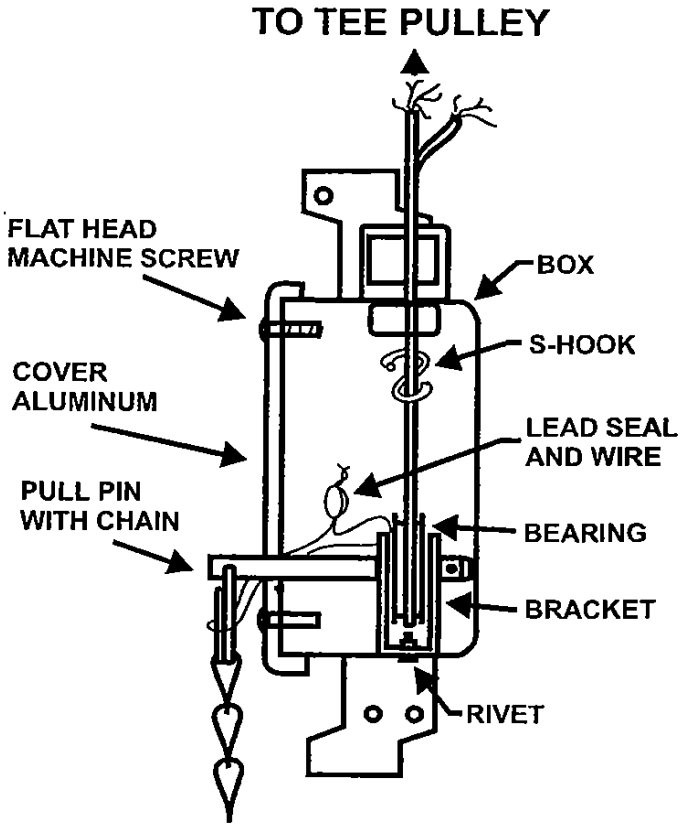
System Components—Detector



System Components—Manual Pull

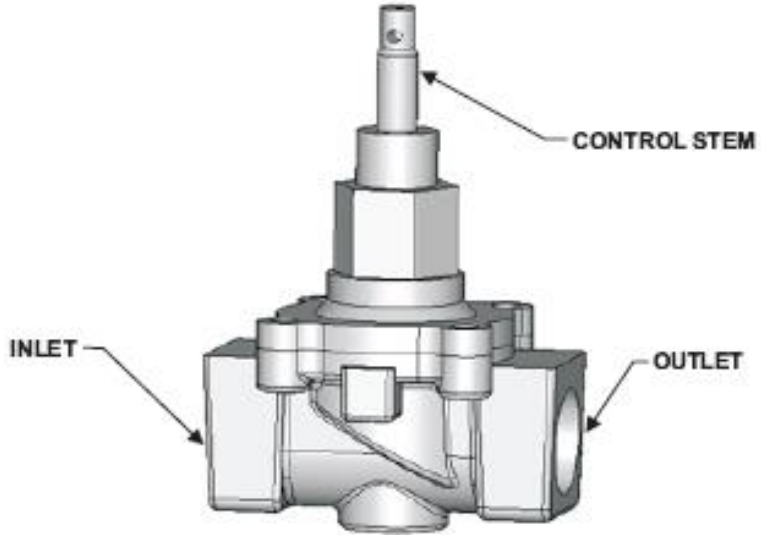


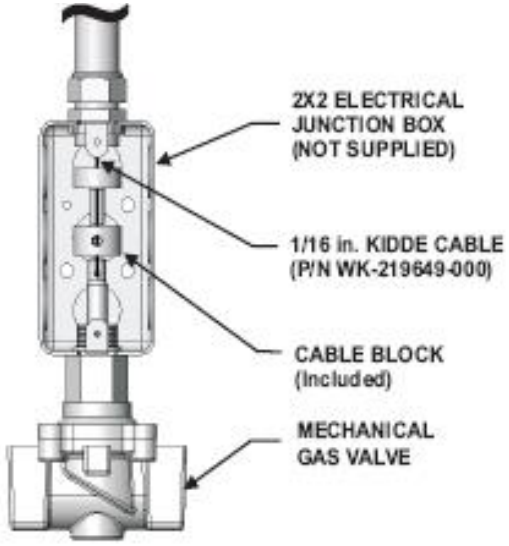




System Components—Gas Valve

- Mechanical or electrical
- Required on systems used to protect gas-fueled appliances

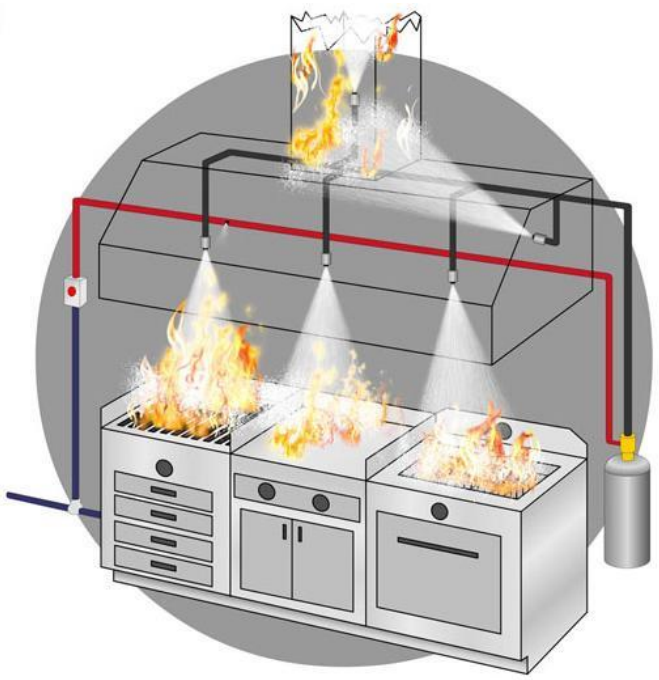




Section 6

Kitchen Suppression System

SYSTEM DESIGN/ INSTALLATION



System Design—Badger Range Guard Procedure

3-2.1 General Design Procedure

Analysis and design should be approached as a methodical process, and performed step-by-step. Only when all the steps are followed is the resulting system likely to perform as desired. If any step is omitted, it is probable that the system will not function as well as it should. The steps in the analysis and design process are:

- Hazard analysis
- Nozzle selection, number and location
- Cylinders (Number, size, and location of cylinders)
- Detector selection
- Piping layout
- Auxiliary requirements

3-2.1.1 HAZARD ANALYSIS

Sketch out the kitchen exhaust hood and appliances, taking note of the path of egress for remote pull station location, discuss with owner the placement of cylinders and control heads, automatic fuel shut down device locations, and any power shutdowns required.

Consult NFPA 17A and 96 for design guidelines. Record the following and include in your sketch:

- Size of exhaust hood(s) and exhaust duct opening(s)
- Size and fuel type of appliances (take note if open flames are sufficiently separated from combustible cooking media)
- Size of gas line(s) feeding appliances
- Building or local alarms

Nozzles

Cylinder Volume

Detectors

Piping

Aux Shutdown

- Make up air or auxiliary equipment
- Are the correct hand portable fire extinguishers present or are additional extinguishers required

3-2.1.2 NOZZLE SELECTION AND LOCATION

Select the number and type(s) of nozzle(s) needed and locate them so that the entire hazard is covered. Use the coverage/distribution specifications for each nozzle type to determine the number of discharge nozzles required to deliver the necessary quantity of wet chemical given nozzle placement appropriate to the hazard.

3-2.1.3 CYLINDER DETERMINATION (NUMBER, SIZE, AND LOCATION OF CYLINDER(S))

Determine the number of nozzles required, whether additional agent or nozzles may be needed, and select the cylinder which will supply the needed amounts wet chemical. After determining the quantity and types of wet chemical needed to control the hazard itself, determine whether any special conditions necessitate additional wet chemical quantities and/or nozzles. For example, it may be necessary to adjust the agent discharge rate in order to offset the effects of ventilation, or it may be necessary to screen openings in an enclosure to prevent wet chemical leakage through those openings.

3-2.1.4 DETECTOR SELECTION

Detector selection will depend on the response speed required, the probable heat level and rate of spread of the fire. The detectors sense the heat energy released by the combustion of fuel and oxygen. Upon detection of a fire, the detection system sends a signal to the system control head(s) which initiates the wet chemical discharge. The most commonly used detectors are the:

1. Fixed-temperature thermo-bulb or fusible link
2. Fixed-temperature rate-compensated thermostat

3-2.1.5 PIPING LAYOUT

Careful piping layout assures that the agent reaches the distribution nozzles appropriately, and that piping parameters are not exceeded. These parameters involve pipe lengths, the number of elbows, and other factors such as the allowable distances (equivalent/feet) from Cylinder and Valve Assembly. These parameters are discussed in detail in the design examples in Paragraph 3-8.

3-2.1.6 AUXILIARY REQUIREMENTS

Controls are required to turn off force-draft ventilation systems, fuel (or combustible-liquid) pumps, conveyors, and so on.

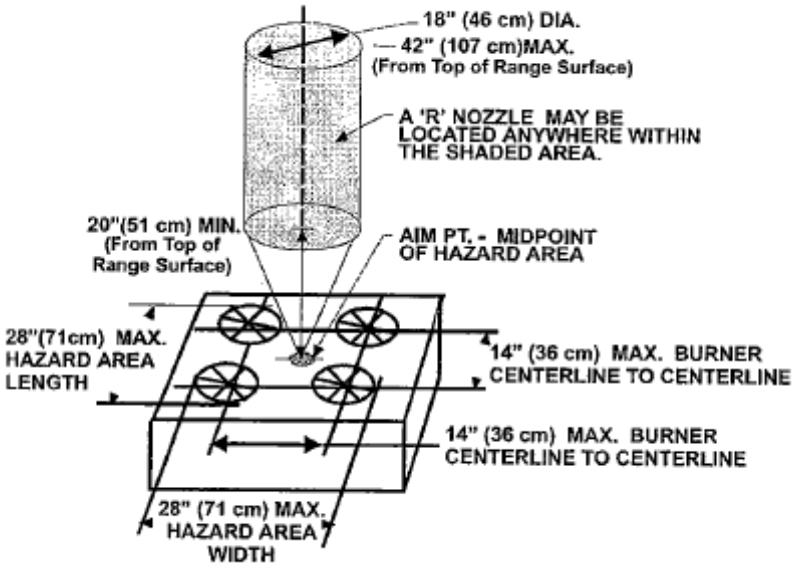
System Design/Installation

- Must be installed by a manufacturer-certified installer
  - Recommended by NFPA 96 and NFPA 17A
  - Required by most manufacturers
- Acceptance testing required
- Inspection/maintenance must be performed routinely
- Installer designs per guidelines provided by manufacturer
- Manufacturer typically provides the components (not piping/tubing)

System Design/Installation *(continued)*

- Nozzle placement is critical
- Based on laboratory tests
- Manufacturer-specific schematics for placement zones
- Depends on hazard and nozzle used

Kidde—Range Protection



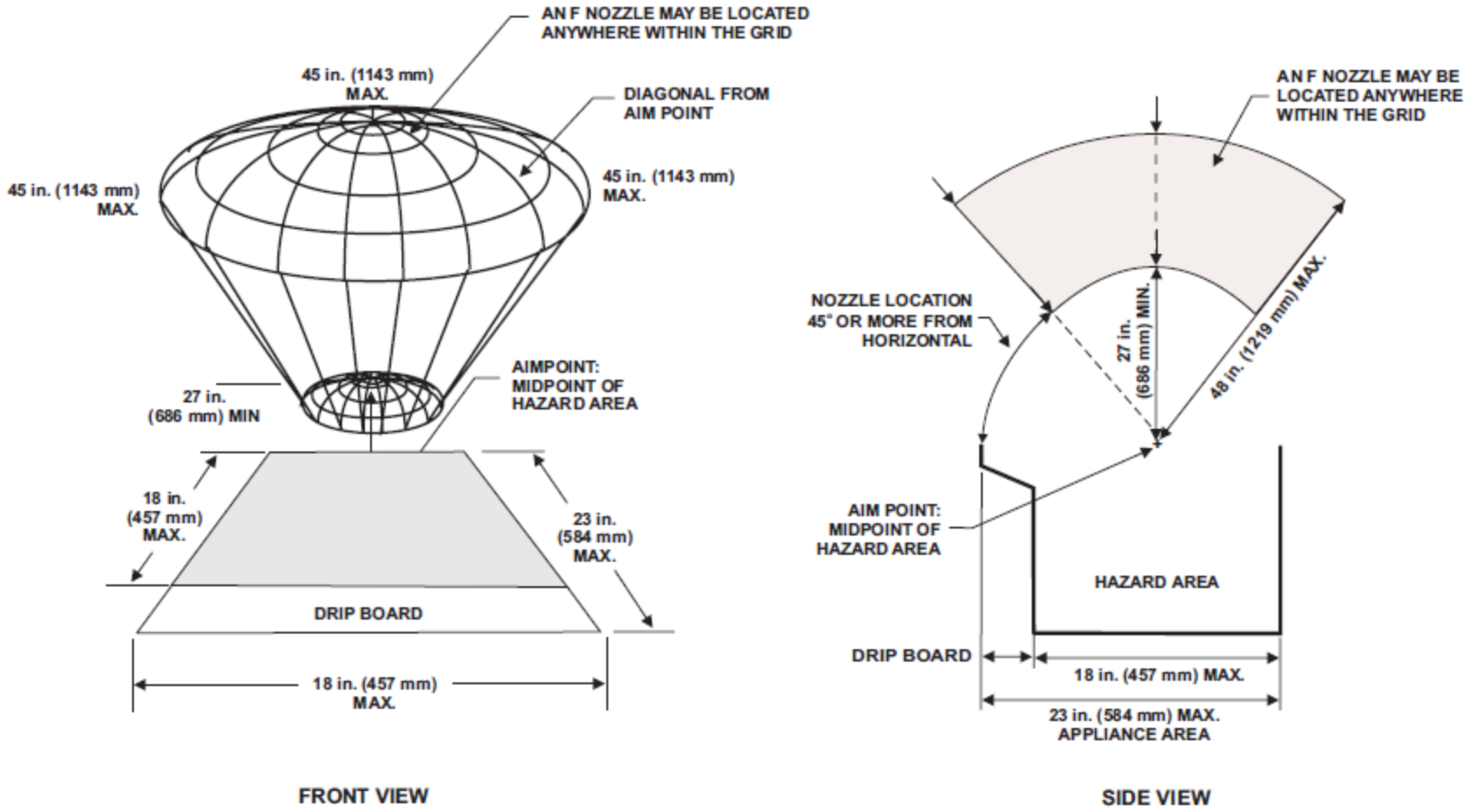
Nozzle Identification		Nozzle Part No.	Flow No.
ADP	(Appliance-Duct-Plenum)	87-120011-001	1
F	(Fryer)	87-120012-001	2
GRW	(Gas Radiant-Wok)	87-120013-001	1
R	(Range)	87-120014-001	1
DM	(Mesquite)	87-120015-001	3

Table 3-3. Cylinder Flow Number Limits

Maximum Flow Numbers of Cylinders		
Cylinder	**Flow Number**	
WHDR-125 (4.7 L)	4	Single Cylinder Only (Cannot Manifold)
WHDR-260 (9.5 L)	8	Single Cylinder Systems Only (Cannot Manifold)
WHDR-400(15 L)(Long or Short) 1 Cylinder 2 Cylinders 3 Cylinders 4 Cylinders	12 24 36 48	Can Manifold * Up to 4 Cylinders
WHDR-600 (22.7 L) 1 Cylinder 2 Cylinders	18 36	Can Manifold * Up to 2 Cylinders

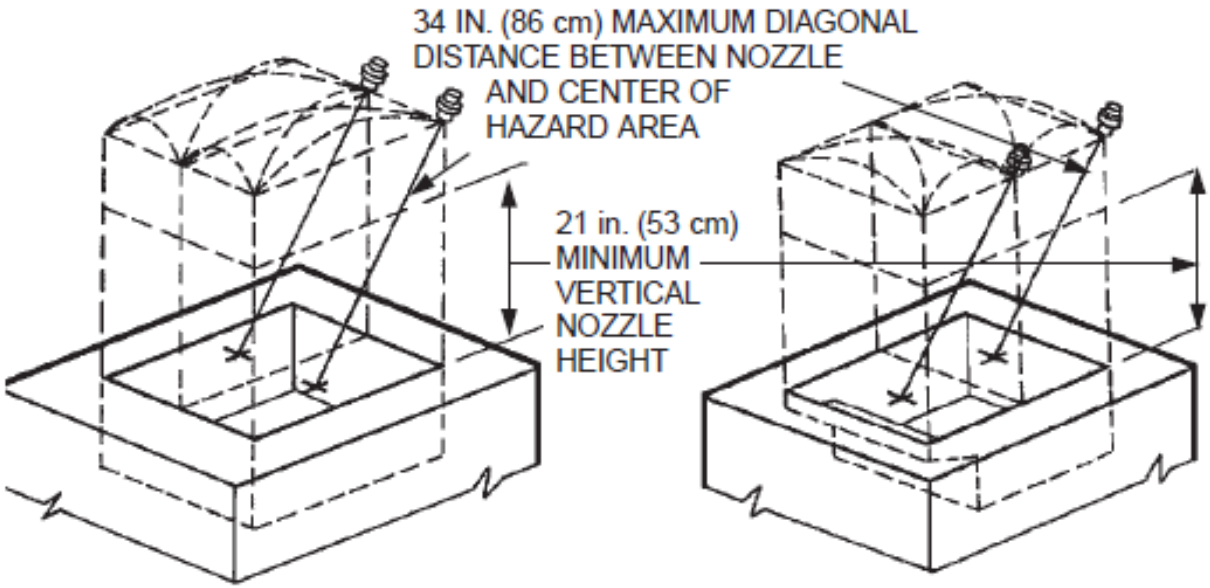
*Only like cylinders can be manifolded (ie, four WHDR-400, two WHDR-600.)

Badger—Fryer Protection



Ansul—Fryer Protection

- Series of figur
- Nozzle placem
- Size of fryer



3N NOZZLE TIP MUST BE POSITIONED ANYWHERE ALONG OR WITHIN THE PERIMETER OF THE MODULAR IT IS PROTECTING AND AIMED AT THE MIDPOINT OF THAT RESPECTIVE MODULE AREA.

FIGURE 23
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Same Concept for Ductwork Protection

- Coverage depends on perimeter of duct
  - Maximum area per nozzle
  - Larger = more nozzles
- Cross-section—round or square
- Transitions
- Manufacturer information is specific

Ansul Guidelines

The chart below shows the maximum protection available from each duct nozzle.

Description	Part No.	3.0 Gallon System	1.5 Gallon System
2W Nozzle	419337	Maximum 100 in. (254 cm) Perimeter	Maximum 100 in. (254 cm) Perimeter
1100 Nozzle	430912	Maximum 50 in. (127 cm) Perimeter	Maximum 50 in. (127 cm) Perimeter

GENERAL INFORMATION

1. Nozzles must be located 2-8 in. (5-20 cm) into the center of the duct opening, discharging up. See Figure 1.

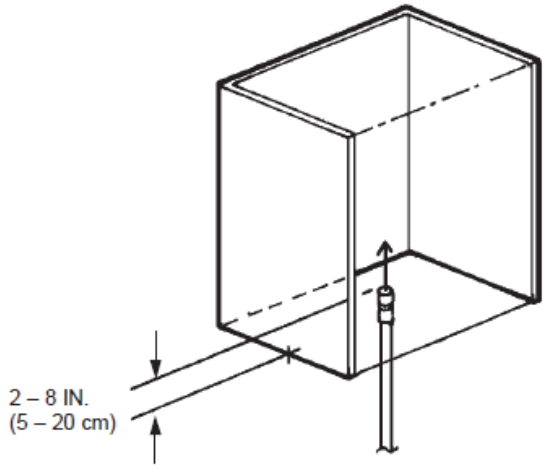
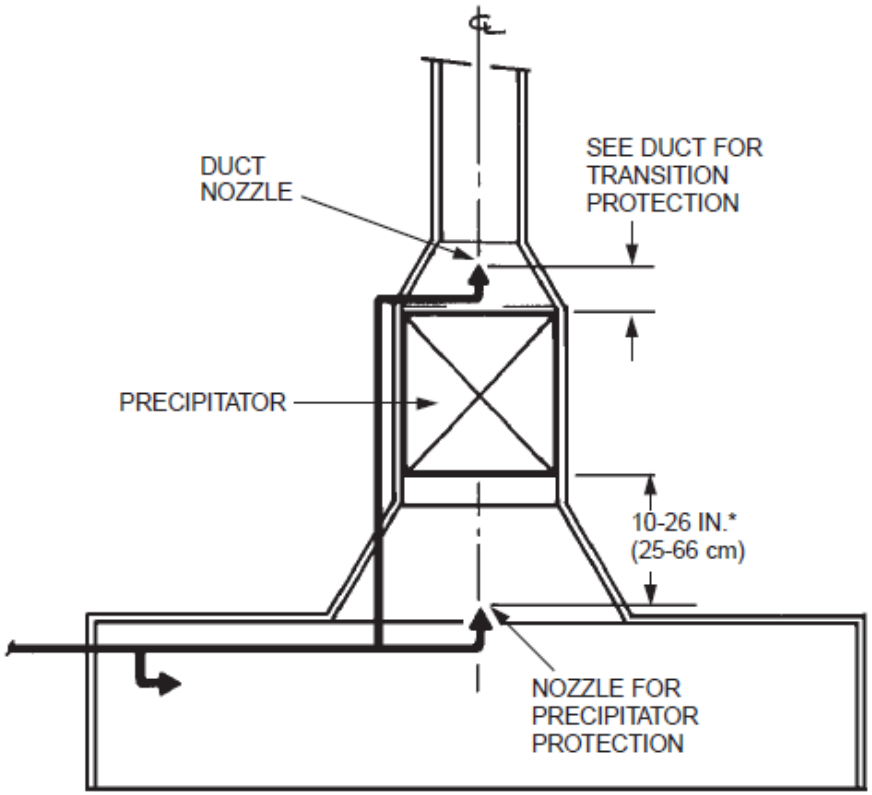


FIGURE 1
000173

Ansul—Precipitator Coverage



* IF PHYSICALLY IMPOSSIBLE AT 10 TO 26 IN. (25 TO 66 cm), NOZZLE MAY BE MOUNTED CLOSER THAN 10 IN. (25 cm).

FIGURE 5
000196

Ansul—Plenum Protection

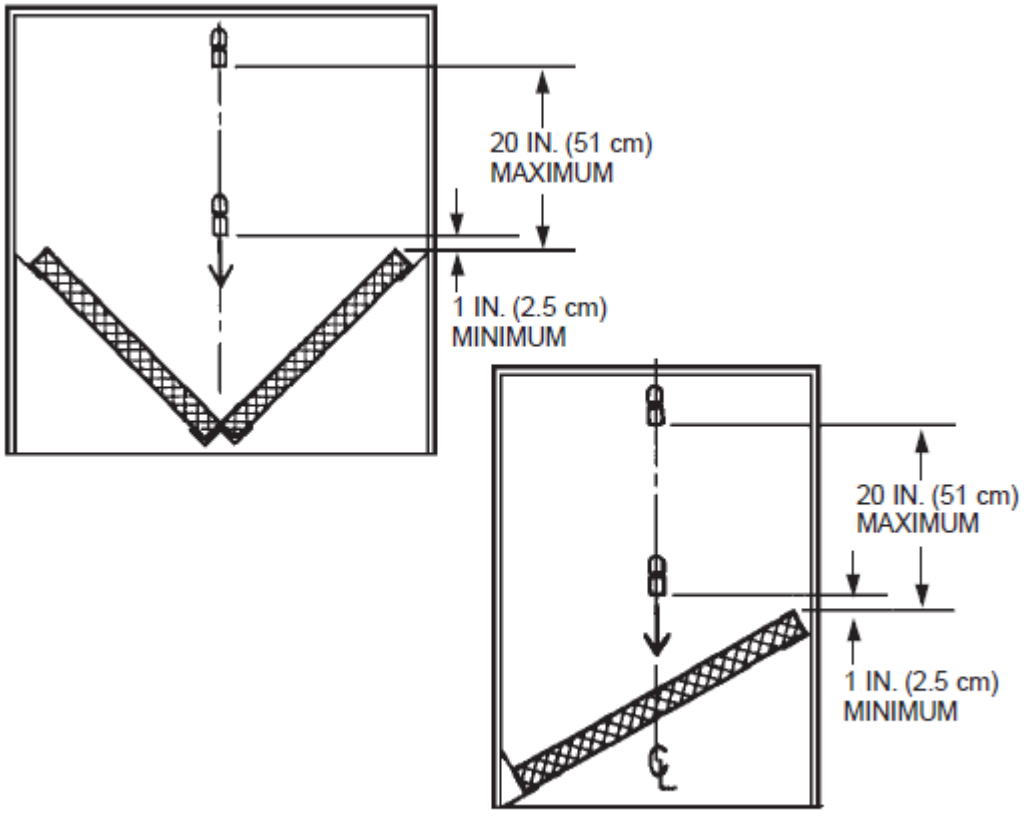
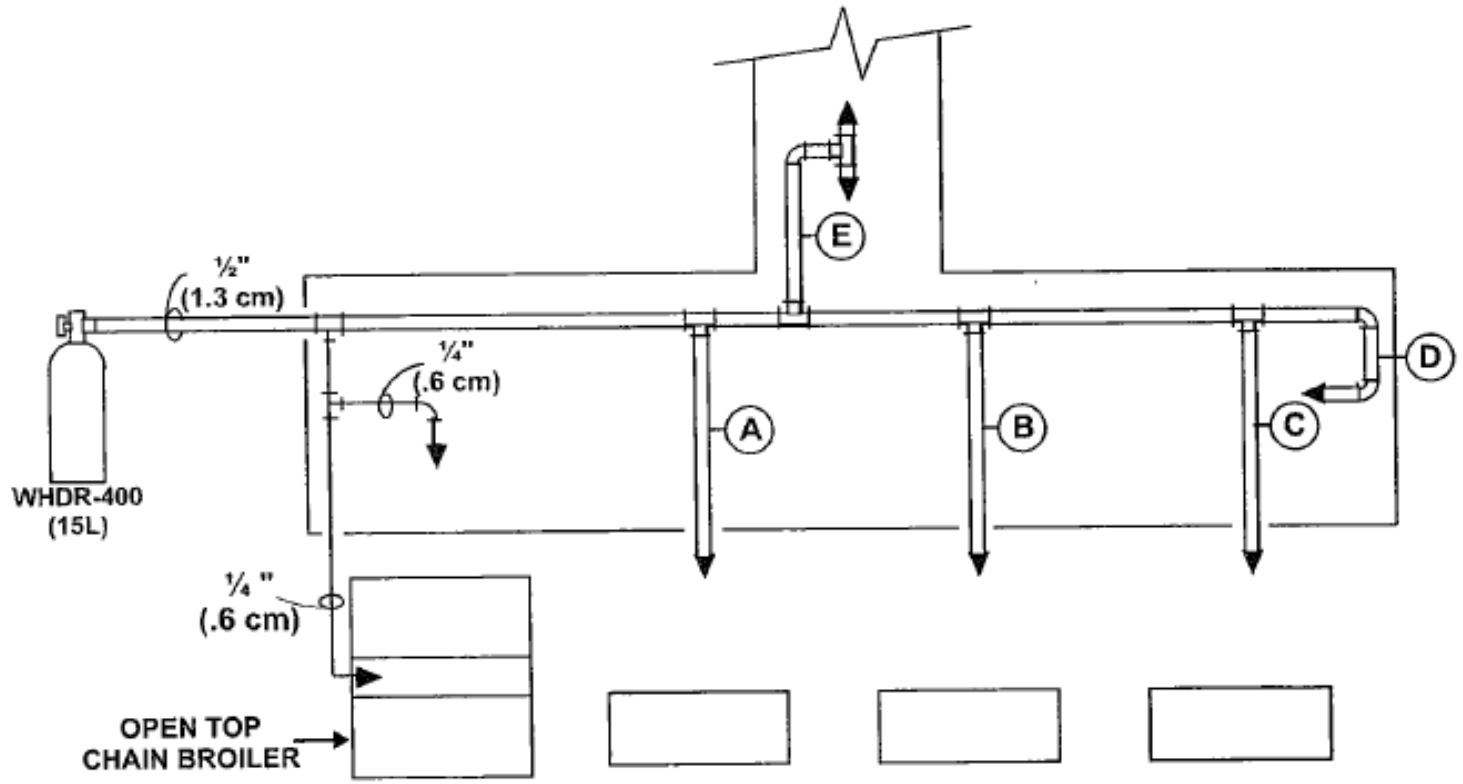


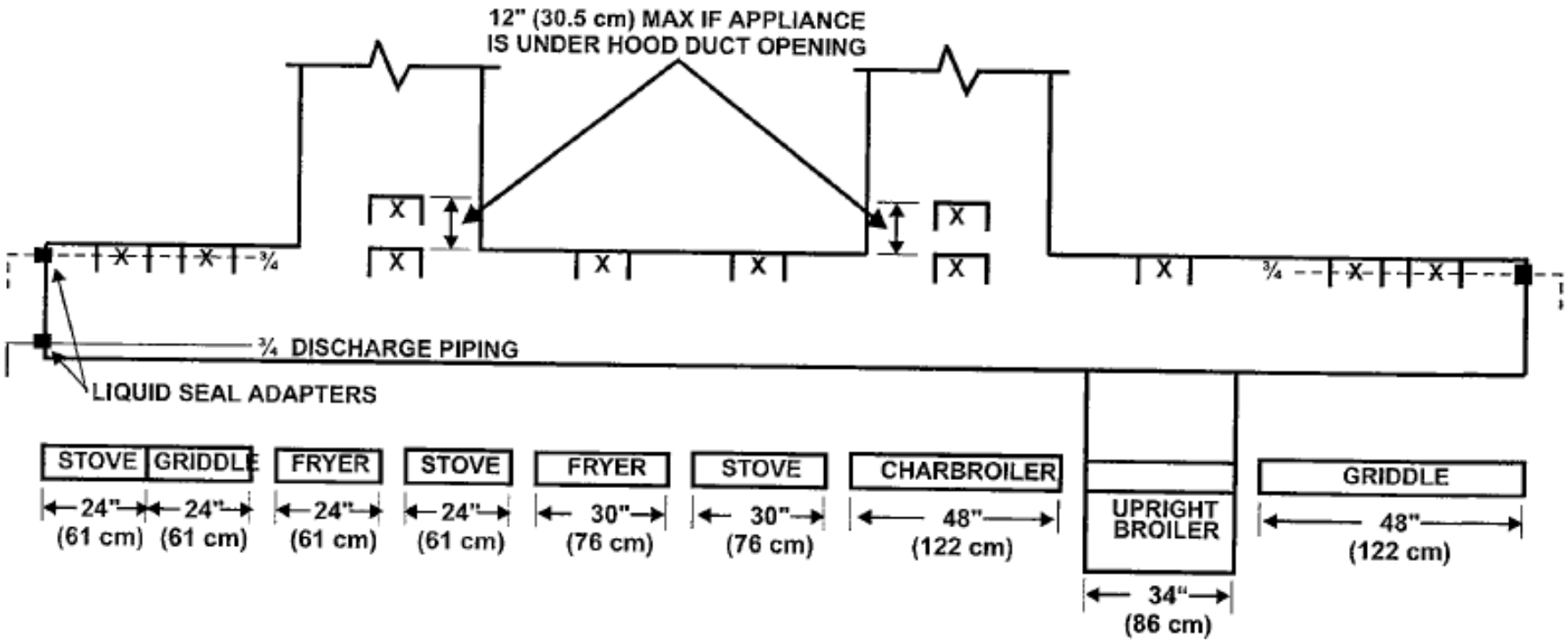
FIGURE 7
000199

Pipe Sizing—
Depends on Number of Nozzles Served



BRANCH LINES A, B, C, D AND E ARE NORMALLY ½" (1.3 cm) BUT CAN BE ¼" (.6 cm) OR 3/8" (1.0 cm)

Detector Placement—
Number of Appliances/Locations



- **NFPA 17A**
- **Acceptance tests**
- **Monthly inspection**
- **Semiannual inspection**
- **12-year inspection**

Section 7

Kitchen Suppression Systems

INSPECTION, TESTING AND MAINTENANCE

Acceptance Testing—Typical

Procedure for Acceptance Test

1. Make a check of the system to insure compliance with the installation manual.

2. Check to insure that ADP, DM, R, GRW and F nozzles are installed in the appropriate positions and locations.

3. Automatically or manually activate the system utilizing a cylinder pressurized with air or nitrogen only.

4. Check to insure that all nozzle seals have broken and all fuel shut-offs have operated.

5. Remove and inspect nozzle strainer.

6. Reset the system. Replace all nozzle seals.

Monthly Inspection/Maintenance

- The owner is to perform the following "quick check" inspection to verify the following:
  1. Proper location (system and cylinder)
  2. Manual pull stations are unobstructed and in clear view
  3. Tamper seals are intact and system is in the ready condition
  4. No obvious physical damage exists that might prevent operation
  5. The pressure gage on the cylinder is in the green operable range
  6. The nozzle caps and their seals are intact, undamaged, and tight
  7. The inspection tag or certificate is in place and current
  8. Deficiencies require corrective action
  9. Keep a record
  10. Schedule semiannual inspection

Semiannual Inspection/Maintenance

- Semiannually, the following inspection and testing shall be performed by a certified installer:
  1. Check for any changes to appliances and positioning
  2. Check that all seals are intact, there are no signs of tampering, and inspect cylinder and system components for damage
  3. Disconnect mechanical control head(s) or remove the CO_2 cartridge
  4. Replace or hydrostatically test corroded components or if the cylinder is over 12 years old
  5. Check nozzle seals, remove and clean nozzle, and replace the seal annually
  6. A. Operate the last detector; check control head and gas valve operation
     B. Operate remote pull; check control head and gas valve operation
  7. Operate any pneumatic releases or electrical shut-offs and check system gas valve for grease build-up

Semiannual Inspection/Maintenance

(continued)

8. Replace fusible links with fusible links that have the required temperature rating
9. Clean grease out of conduit openings at detector bracket
10. Remove covers and check corner pulleys for grease accumulation; make sure that the cable is on the pulleys
11. Check that the fan warning sign is legible and conspicuous (if not, replace)
12. Reset the detection system and adjust cable if necessary
13. Replace the removed $C0_2$ cartridge (Step 3) with a new, manufacturer approved, $C0_2$ cartridge
14. Reconnect mechanical control head(s)
15. Remove keeper pin
16. Date and sign the inspection tag or certificate
17. Review system operation again with owner

12-Year Inspection/Maintenance

1. Hydrostatic testing is to be performed on the cylinder in compliance with the appropriate DOT requirements
2. The wet chemical is to be discarded when performing the hydrostatic test. DO NOT REUSE THE OLD AGENT as per NFPA-17A.
3. The cylinder is to be either hydrostatically tested or volumetric-expansion tested to two times its standard rating. The cylinder's standard rating is stamped on the crown or footing of the cylinder.
4. To protect the restaurant during this testing period, a substitute cylinder is to be used, one of equal or greater size. You may use an alternate protection method as long as it is acceptable to the authority having jurisdiction.
5. Return the system to service

Section 8

Kitchen Suppression Systems

INSPECTIONS—POST-EVENT

Site Inspection

- Site inspections include many parties, experts, and interests
- Site inspection activities include:
  1. General documentation
  2. Tank discharge status
  3. Interview employees/witnesses
  4. Basic system layout/arrangement with dimensions
  5. Pipe and nozzle blockages analyzed
  6. Kitchen cleaning/housekeeping
  7. Hood cleanliness

Site Inspection *(continued)*

- Site inspection activities continued:

8. Condition of protective caps
9. Gross installation errors:
    a. Missing or off-position nozzles
    b. Missing or off-position heat detectors
    c. Presence of activation cartridges
    d. Control head cable(s) mis-installed
    e. Detection line or agent piping issue
10. Energy source isolation status

Site Inspection *(continued)*

- Site inspection activities continued:
  11. Type, location, and condition of all appliances
  12. Presence, type, and condition of plenum filters
  13. Exhaust duct condition, proximity to combustibles
  14. Exhaust fan condition
  15. Origin and cause tasks
  16. Burn pattern analysis
  17. Evidence collection

Evidence Inspection

- Evidence inspections typically are more detailed and focused
- Evidence inspection activities include:
  1. Detailed component documentation
  2. Case-specific testing
  3. Functionality testing
  4. Agent sampling
  5. Chemical analysis
  6. Metallurgical examination
  7. Destructive examination and disassembly
  8. Origin and cause related testing, examination, disassembly

Note Nozzle Position—Dowels and Clips/Tape

Weigh Cylinders

- Helps to determine if any agent remains in the system
- Complete discharge or other issues?
  - Nozzles
  - Piping
  - Leak in discharge gas seal

Inspect Detectors—
Type, Location, and T Rating

Inspect Nozzle Caps and Condition

Section 9

Kitchen Suppression Systems

SYSTEM FAILURE EXAMPLES

System Failures—Installation/Servicing

- Incorrectly connected control box
- Inspection tools (disarming pins) left in control box
- Solution not flushed out of system piping
  - Turns to thick sludge, impairing operation
- Actuator installed backwards
- Dirty nozzles/screens
- Discharged test gas cylinder left in control box

Holes in Pressure Actuating Line

Blockages

Actuator Assembly

Wood Fired Oven in Common Exhaust

Questions?

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