INSTRUCTOR GUIDE

TOPIC: ARE YOU PUTTING ENOUGH WET STUFF ON THE RED STUFF?

LEVEL OF INSTRUCTION:

TIME REQUIRED: TWO HOURS

MATERIALS: APPROPRIATE AUDIO-VISUAL MATERIALS

REFERENCES: ENGINE COMPANY FIREGROUND OPERATIONS, SECOND EDITION, NFPA; ESSENTIALS OF FIRE FIGHTING, FOURTH EDITION, IFSTA; FIRE ATTACK 1 AND 2, WARREN Y. KIMBALL, NFPA

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PREPARATION:

MOTIVATION: Selecting the proper size attack line and nozzle in relation to the volume of fire and potential heat production can be a challenge. Such knowledge generally comes from experience. Unfortunately, we may be having less fire from which to gain this knowledge. We also cannot use the fire scene as a testing laboratory to determine the proper size line and nozzle to be used for a given incident.

OBJECTIVE (SPO):

The firefighter will demonstrate a general knowledge of the factors affecting fire development; the water flow necessary to control a structural fire, and nozzle selection and use.

OVERVIEW:

ARE YOU PUTTING ENOUGH WET STUFF ON THE RED STUFF?
* Fuel Loading
* Fire Flow Requirements
* Handlines and Master Streams

ARE YOU PUTTING ENOUGH WET STUFF ON THE RED STUFF?

SPO: The firefighter will demonstrate a general knowledge of the factors affecting fire development; the water flow necessary to control a structural fire, and nozzle selection and use.

EO 3-1 Describe the concept of fuel loading and its effect on fire size and spread.

EO 3-2 Using various methods to determine production of heat, identify the rate of water flow necessary to control fire in a room of specified size.

EO 3-3 Describe the appropriate number, size, and placement of fire streams needed to deliver the required fire flow at structural fires.

I. FUEL LOADING (3-1)

A. Review of fire travel

1. Convection - travel of heat through motion of heated matter
    a. Smoke
    b. Hot air
    c. Heated gases
    d. Flying embers
2. Radiation - travel of heat through space (electromagnetic waves)
    a. Unaffected by wind
    b. Radiated evenly in all directions
    c. Travel blocked by solid surfaces
3. Conduction - travel of heat though a solid body
    a. Through walls and floors by way of pipes, metal girders and joists
    b. May cause steel building and roof supports to collapse

B. Fuel Loading

1. Consists of interior surfaces, furnishings, and contents for interior fires
2. Exterior surfaces when fire has extended
3. Factors affecting fuel loading
    a. Type of fuel involved
    b. Quantity of fuel
    c. Arrangement of fuel

4. Types of fuel

    a. Class A materials generally easier to ignite and produce approximately 8,000 BTU's of heat per cubic foot

    b. Class B materials more difficult to ignite but produce approximately 16,000 BTU's of heat per cubic foot

II. FIRE FLOW REQUIREMENTS (3-2)

NOTE: In each of the examples below, a typical size room for a residential structure (13 ft. x 16 ft. 8 ft) is being used for illustration and comparison purposes.

A. Theoretical Method Developed by Iowa State University

1. Heat produced or accumulated in a structure fire is limited by the available oxygen supply to support combustion

2. Accumulation of BTU's in vented areas will balance to the calculated heat production level for confined areas due to the escape of hot gases and incoming fresh air

3. One cubic foot of oxygen will produce 535 BTU's of heat

    a. Normal air - 21% oxygen content

    b. Flame production arrested at 14% oxygen content

    c. Oxygen available for producing heat - 7%

4. Seven percent of 535 BTU's = 37 BTU's of heat released for each cubic foot of normal air

    16 ft. times 13 ft. times 8 ft. = 1,664 cu. ft.

    1,664 cu. ft. times 37 BTU's = 61,568 BTU's

5. To raise the temperature of 1 lb. of water 1^{o}F requires 1 BTU

    62ºF to 212ºF = 150 BTU's

6. To convert the entire 1 lb. of water (at 212ºF) to 1 lb. of steam requires the addition of 970 BTUs

   From 212ºF water to 212ºF steam = 970 BTU's

7. To convert 1 lb. of water (at 62ºF) to 1 lb. of steam requires 1,120 BTUs

   150 BTU's plus 970 BTU's = 1,120 BTU's

8. One gallon of water will absorb 9,330 BTU's of heat when the water is completely converted to steam

   8.33 lb. (weight of water) times 1,120 BTU's = 9,330 BTU's/gal.

9. Gallons of water required

   61,568 BTU's divided by 9,330 BTU's/gal. = 6.6 gal.

   6.6 gal. times 2 (apply in 30 sec.) = 13.2 GPM

   13.2 GPM times .25 (safety factor) = 3.3 GPM

   13.2 GPM plus 3.3 GPM = 16.5 GPM

NOTE: This method assumes that all the water is vaporized and the amount of water will only blacken the area involved. This method makes no allowance for exposures although that could be factored into the initial dimensions used in the calculations.

B. Rate-of-Flow (Cubic Foot) Formula Developed by Iowa State University

Based on the results of the theoretical method described in item "A", this method was developed as a pre-fire planning tool to establish the minimum amount of water application required to control a fully involved fire in the largest single open area in a building. Additional lines for back-up and exposure protection should be addressed based on the needs identified by the user. In theory, if the minimum amount of water identified by the Rate-of-Flow formula can control the fire on the initial attack, the need for additional water will be minimized, but should be planned for. Immediate fire control with minimal resources also buys additional time for additional resources to arrive.

1. Formulas: Volume (in cubic feet) of area involved divided by 100 = GPM flow necessary for 30 seconds

2. Volume (in cubic feet) of area involved divided by 200 = gallons of water needed

   13 ft. times 16 ft. times 8 ft. = 1,664 cu. ft.

   1,664 cu. ft. divided by 100 = 16.6 GPM for 30 seconds

   1,664 cu. ft. divided by 200 = 8.3 gallons of water required

C. Simplified formula developed by National Fire Academy

1. Determine the area of the structure (length times width)
2. Divide the area by 1/3 to determine GPM for fire area
3. Allow 25% for each exposure including another room, floor or structure
4. Determine percentage of involvement to determine water delivery needs

   13 ft. times 16 ft. = 208 sq. ft.

   208 sq. ft. divided by 3 = 69 GPM

   1 interior exposure (25%) 69 GPM times 25% = 17 GPM

   No exterior exposures

   Total Required Fire flow 100 GPM*

   * Rounded to nearest 100 GPM

   Flow shown for single area or floor of involvement, must be increased for multiple areas or floors

Note the closeness of results in the methods after discounting the allowance for the interior exposure in the last method.

III.HANDLINES AND MASTER STREAMS (3-3)

A. Initial Attack

1. Methods of attack
    a. Direct – water is applied in short bursts directly on the burning fuels until the fire is darkened down

    b. Indirect – Used when firefighters are unable to enter the fire area due to intense heat to direct a stream from outside the fire area at the ceiling and played back and forth in the superheated gases at the ceiling level

    c. Combination – uses the steam-generating technique of ceiling-level attack combined with a direct attack on burning materials at lower levels

2. Solid streams versus fog streams

    a. For safest and most effective operation where people in area, solid stream or fog nozzle on straight stream position should be used

        1) Aid rescue

        2) Reduce steam production

    b. Use of fog should be restricted to unoccupied confined spaces to avoid steam occupants

    c. When the building is adequately ventilated in the direction opposite from fog nozzle, fog stream can be used

        1) No more than 30-degree angle

        2) Produces reach and fog pattern

    d. Fog streams produce greater heat absorption and quicker fire suppression along with greater steam production

    e. Solid streams produce greater reach and penetration as well as less steam

3. Effective stream operation

    a. Use solid stream nozzles or set fog nozzles on straight stream or narrow fog setting to minimize upsetting the thermal balance

    b. Stay low upon entering fire area to let heat and gases vent before moving in

    c. Before the door to the fire area opened, all firefighters should be positioned on same side of the entrance and remain low

    d. Crack the nozzle and bleed the air out of line ahead of the water

    e. If fire shows at the top of the door as it is opened, the ceiling should be hit with a stream to cool and control fire gases

    f. Sweep the floor with the stream to cool burning debris and hot surfaces

    g. Do not open the nozzle until the fire can be hit unless firefighter safety is involved

    h. Direct the stream at the base of the fire if localized

    i. As the advance is made, the angle of the stream should be lowered and an attempt made to hit the main body of fire

    j. When the main body of fire is knocked down, shut down the stream and let the area vent

    k. When the fire is knocked down, shut down the nozzle and move in to overhaul

    l. Upon entering an area which is very hot and finding no fire, withdraw immediately and check the area below

    m. When attacking a basement fire down using the interior stairs, a straight or narrow stream should be used because fog will generate steam

    n. Do not attack a fire from opposing directions because it will push the heat on the other crew

o. Do not conduct an exterior fire attack while an interior attack is still being conducted

p. Keep the fire in front of the nozzle and avoid letting the fire cut off the path of escape

q. Know where crew members are before initiating the attack to avoid having someone in an opening or path of heat and steam

r. Consider venting the fire area just prior to initiating the fire attack to provide a path for heat and steam to exit

4. Number of lines

a. Attack main body of fire

b. Get over the fire (this may need to be done before the attack on the main body of fire to reduce the potential for extension)

c. On each side of the fire

d. Consideration must be given to mobility of hose and flow requirements

B. Back-Up Lines

1. Purpose of back-up lines

a. Used when the initial attack lines cannot quickly control the fire

b. Not used to protect exposures or attack the fire

c. Held in readiness for use in place of the attack lines

2. Stretched whenever it is not completely obvious that the fire can quickly be extinguished with the initial attack lines

d. Taken into the building immediately after initial attack lines

e. Positioned close to the initial attack lines

f. Charged and ready for use

3. Size of back-up lines

    g. For 1-1/2-inch lines, minimum 1-3/4-inch

    h. For 1-3/4-inch lines, minimum 2-1/2-inch

    i. For 2-1/2-inch lines, minimum 2-1/2-inch with larger tip

    j. For fire where the initial attack is a 2-1/2-inch line, master stream devices may be required

4. If back-up lines are placed in service, the initial attack lines should be shut down

5. Once the fire is controlled, back-up lines should be shut down and a smaller line used for mop up

C. Hose line selection

1. Engine companies must be considerate of limitations of various sizes of hose

2. In addition to flow limitations, there is factor known as friction loss which affects fire flows

    a. Loss of pressure within hose line due to internal resistance of water against hose lining

    b. Friction loss affected by three factors

        1) Flow

        2) Hose length

        3) Size of hose

    c. Should be consideration for engine company crew when selecting attack lines which must be stretched over long distances

3. Maximum flow capabilities for attack lines

1-1/2-inch	125 GPM

1-3/4-inch	150 GPM
2-inch	200 GPM
2-1/2-inch	250 GPM
3-inch	400 GPM

4. Range of nozzle flows for combination nozzles with recommended nozzle pressure of 100 PSI

1-1/2-inch	30 GPM to 125 GPM
1-3/4-inch	95 GPM to 150 GPM
1-3/4-inch/2-inch	95 GPM to 200 GPM
2-1/2-inch	125 GPM to 250 GPM

5. Flows for a 2-1/2-inch solid tip nozzle with recommended nozzle pressure of 50 PSI

1-inch tip	210 GPM
1-1/8-inch tip	266 GPM
1-1/4-inch tip	328 GPM

6. Flows from master stream devices

    a. Fog nozzle minimum is 500 GPM at 100 PSI nozzle pressure

    b. Flows for straight tips with recommended nozzle pressure of 80 PSI (rounded)

1-1/2-inch	600 GPM
1-5/8-inch	700 GPM
1-3/4-inch	800 GPM
1-7/8-inch	900 GPM

2-inch 1000 GPM

7. Friction loss for attack lines

    a. For 1-1/2-inch, 1-3/4-inch, and 2-inch attack lines, 30 PSI per hundred feet

    b. For 2-1/2-inch attack lines, 15 PSI per hundred feet

    c. 1-1/2-inch, 1-3/4-inch, and 2-inch attack lines should not exceed 300 feet in length

    d. 2-1/2-inch attack lines should not exceed 500 feet

    e. When lengths of attack line beyond those recommended are required, consideration should be given to using 3-inch, 4-inch, or 5-inch hose to get water closer to the fire scene and dividing the flow into more manageable size attack lines using wyes or manifolds (leader line)

8. Select hoselines and flow rates that use a much greater flow than needed

    a. Nozzle pressure may be insufficient to flow the required flow rate

    b. Fire may be larger than anticipated

    c. Fire can be extinguished quicker thereby reducing damage

    d. Do not rely on the maneuverability and convenience of smaller lines and flows when larger flows are needed

9. Points to consider

    a. Unless you are using a flow meter you cannot be certain that the nozzle is flowing what you expect.

    b. Insufficient flow in relation to the heat production can cause injury or death to firefighters.

    c. The previous examples are based on a room and contents fire in a residence. Unless you are certain of how much or what is involved, plan beyond the initial attack.

d. The previous examples are based on darkening the fire and all the water converting to steam. This is not realistic so plan beyond that.

e. Do not be afraid to deploy larger attack lines because the standard line used in a 1-3/4-inch which may be inadequate fro the situation.

If you have flow meters available, you may want to go out and test the flows of the nozzles used in your department to make sure that they are flowing what you expect based on the friction loss calculations and nozzle being used. It may be found that they are not producing what is expected which presents a safety concern for individuals on the attack line in a fire situation.

REVIEW:

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* Fire Flow Requirements
* Handlines and Master Streams

REMOTIVATION: Remember, any fire will eventually go out but going to larger hoselines and flows initially will make that happen quicker with less structural damage and create a safer work environment.

ASSIGNMENT:

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EVALUATION: