INSTRUCTOR GUIDE

TOPIC: RELAY PUMPING OPERATIONS

LEVEL OF INSTRUCTION:

TIME REQUIRED: ONE HOUR

MATERIALS: APPROPRIATE AUDIO VISUAL SUPPORT

REFERENCES: PUMPING APPARATUS DRIVER/OPERATOR HANDBOOK, FIRST EDITION, IFSTA

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PREPARATION:

MOTIVATION:

OBJECTIVE (SPO): 1-1

Given information from discussion, handouts, and reading materials, explain the pump operator's responsibilities to pump a supply line, given the length and size of line, flow and desired intake pressure, so that adequate intake pressures and flows are provided to the next pumper in the relay. The student will perform to a written test accuracy of at least 70%, successfully complete the skills on a skills check-off list, and meet the job performance requirements of NFPA 1002 (1998).

OVERVIEW:

Relay Pumping Operations

- Relay Apparatus and Equipment
- Relay Pumping Operational Considerations
- Types of Relay Pumping Operations
- General Guidelines for Relay Operations

RELAY PUMPING OPERATIONS

SPO 1-1 Given information from discussion, handouts, and reading materials, explain the pump operator's responsibilities to pump a supply line, given the length and size of line, flow and desired intake pressure, so that adequate intake pressures and flows are provided to the next pumper in the relay. The student will perform to a written test accuracy of at least 70%, successfully complete the skills on a skills check-off list, and meet the job performance requirements of NFPA 1002 (1998).

EO 1-1 Determine what apparatus and equipment are required to design a relay. (NFPA 1002 (1998), 3-2.2, 6-2.2)

EO 1-2 Describe the various considerations associated with relay operations. (NFPA 1002 (1998), 3-2.2, 6-2.2)

EO 1-3 Describe the various types of relay operations. (NFPA 1002 (1998), 3-2.2, 6-2.2)

EO 1-4 Describe the basic operating guidelines for a relay. (NFPA 1002 (1998), 3-2.2, 6-2.2)

I. RELAY APPARATUS AND EQUIPMENT (EO 1-1)

A. Relay operation uses pumper at water supply source to move water under pressure through one or more hoselines to next pumper in line

B. Source pumper boosts pressure to supply next pumper, and so on until water reaches fireground

C. Any apparatus equipped with sufficient fire pump placed in middle of relay to assist with pumping chores

D. Following terms used to describe various functions of apparatus in relay pumping operation

1. Source pumper or supply pumper is pumper connected to water supply at beginning of relay operation

2. Water supply fire hydrant or static water supply source

3. Source pumper pumps water to next apparatus in line

4. Relay pumper is pumper or pumpers connected within relay that receives water from source pumper or another relay pumper, boosts pressure, and supplies water to next relay pumper or attack pumper

5. Attack pumper is pumper located at fire scene receiving water from relay and supplying attack lines and appliances

E. Fire departments use hose tenders to assist in hose lays associated with relay pumping operations

1. Hose tenders may or may not equipped with fire pump

2. Hose tenders carry mile or more of LDH

3. Hose carried in traditional style hose bed or on large, mechanically operated reel

4. Hose tenders carry wide assortment of relay valves, discharge manifolds, and other special water supply equipment used for relay pumping operations

F. Both 3-inch hose and LDH used for relay pumping operations

G. When 3-inch hose used for relay operations, two or three hoselines laid

H. Variety of hose and pump appliances used to assist with relay pumping operations

1. Intake pressure relief valves or relay reliefs intended to reduce possibility of damage to pump and discharge hoselines caused by water hammer when valves closed too quickly or intake pressure rises dramatically

2. Two basic kinds of intake pressure relief valves

    a. One type supplied by pump manufacturer and integral part of pump intake manifold

    b. Second type add-on device screwed onto pump intake connection

    c. Devices preset to allow set amount of pressure into fire pump

    d. If incoming pressure exceeds preset level; valve activates and dumps excess pressure/water until water entering pump at preset level

    e. Valves set within 10 psi of static pressure of water system supplying pumper or 10 psi above discharge pressure of previous pumper in relay

    f. Most screw-on intake pressure relief valves equipped with manual shut-off valve

    g. Bleeder valves on intake pressure relief valve allow air to be bled off as incoming supply hose charged

    h. Particularly important when using devices in conjunction with LDH

    i. Large amount of air pushed through hose until solid column of water reaches valve

    j. Bleeder valves located directly in intake piping to pump itself.

I. Relays dependent upon later-arriving companies set up initial relay of lesser volume and greater spacing with in-line relay valves in relay line for incoming pumpers

J. Valves allow late-arriving pumpers to hook up after relay operating and boost pressure (and corresponding volume) without interrupting operations

K. If LDH relay pumping operation intended to support more than one attack pumper, discharge manifold used to break down LDH into two or more hoselines then connected to attack pumpers

II. RELAY PUMPING OPERATIONAL CONSIDERATIONS (EO 1-2)

A. Relay operation based on two things

1. Amount of water required at emergency scene
2. Distance from emergency scene to water source

B. Relay must supply total water necessary to complete fire fighting operation

C. Relay used to supplement inadequate municipal water supply system

D. Amount of water needed to flow has major impact on design of relay

E. Longer relay distance, more hose necessary

F. More hose equates to more friction loss

G. Desirable to increase amount of flow through relay, one of three things necessary

1. Increase size of hose or number of hoselines used in relay
2. Increase pump discharge pressure of pumpers operating in relay
3. Increase number of pumpers in relay

H. Generally impractical to shut down existing relay to replace hose being used with larger hose

I. Possible to have engine or hose tenders not already committed to pumping in relay to lay additional hoseline between relay pumpers

J. Each pumper may have additional hoseline attached to pump and begin flowing hose when all pumpers ready

K. Possible to have pumpers increase pump discharge pressure, not necessarily mean that volume of water through relay increased

L. Pumpers rated to pump maximum volume capacity at net pump discharge pressure of 150 psi

M. Depending on length of hose lay and volume of water being flowed, eventually get to point where increasing pressure will not increase volume

N. When considering increasing pressure, limited by pressure to which fire hose annually tested

1. At no time should discharge pressures exceed maximum operating pressure for hose being used

2. Hose pumped at pressures do not exceed 90 percent of annual service test pressure

O. Elevation pressure factor in relay pumping operations

1. If relay operation pumping uphill, pressure loss on system greater than caused simply by friction loss

2. Reverse true if operation going downhill

3. Elevation pressure not affected by amount of water moved, only by topography

P. Increasing flow in relay accomplished by placing additional pumpers in relay

1. By shortening length of hose each pumper has to supply, maximum pressures and flows maintained within hose assembly

2. If in-line relay valves not placed in hose lay from outset, necessary to shut down relay when additional pumper(s) added

Q. In situations where low flow rates required and LDH available, required spacing between pumpers so great that exceeds amount of hose carried on each pumper

R. In cases may be necessary to call pumpers solely to lay hose but not actually participate in pumping process

III. TYPES OF RELAY PUMPING OPERATIONS (EO 1-3)

A. Each fire department, or group of fire departments in particular region, should have SOP for type of relay pumping operation they will use

B. Agencies that have potential to work together on relay pumping operations should perform relays in training environment on regular basis

C. Some organizations have organized procedures for providing relay pumping capabilities at emergency scene

1. When IC determines necessary to use relay to provide adequate amount of water to scene, relay task force or strike team requested

2. Three to five pumpers dispatched to scene

3. Companies come in and establish water supply independent of companies already operating on scene

D. Two basic designs for relay pumping operations: the maximum distance relay method

and constant pressure relay method

E. Maximum Distance Relay Method

1. Involves flowing predetermined volume of water for maximum distance pumped through particular hose lay

2. By using table in Appendix A, operator can determine distance that certain flow pumped through hose carried on apparatus

3. Built into figures in table is 20 psi residual pressure at next pumper in relay

4. Figures in chart based on discharge pressure of 200 psi for 2½- and 3-inch hose and 185 psi for 4- and 5-inch hose

5. When considering distances in table in Appendix A, operator must keep in mind--all fire department pumpers rated to flow maximum volume at 150 psi, 70 percent of maximum volume at 200 psi, and 50 percent of maximum volume at 250 psi

6. Because table in Appendix A based on discharge pressures of 185 and 200 psi, following are minimum pump capacities used to achieve flows/distances on tables:

    a. 250 and 500 gpm flows: 750 gpm rated pumper

    b. 750 gpm flow: 1,250 gpm rated pumper

    c. 1,000 gpm flow: 1,500 gpm rated pumper

    d. 1,250 gpm: 1,750 gpm rated pumper

7. If local procedure use distances less than those on chart, possible to use smaller capacity pumps than listed or remove one or more pumpers from relay

8. Using figures in table in Appendix A, number of pumpers needed to relay given amount of water determined by using following formula:

    $$\frac{\text{Relay Distance}}{\text{Distance From Appendix A}} + 1 = \text{Total Number of Pumpers Needed}$$

    Note that when using formula, always need to round up to nearest whole number. For example, if answer 3.2, actually need four pumpers to achieve flow.

    Example

If single line of 3-inch hose used, how many pumpers needed to supply 1,000 gpm to fire scene 1,000 feet from water source? From table in Appendix A, can be seen that maximum distance water will flow at 1,000 gpm through 3-inch hose 225 feet. Divide figure into distance to fire, add 1 for attack pumper:

$\frac{1,000}{225} = 4.4 + 1 = 5.4$ or 6 pumpers needed

Example

If two lines of 3-inch hose used, how many pumpers needed to supply 750 gpm to fire scene 2,000 feet from water source?

Find distance in table in Appendix A for two 3-inch inch hoses at 750 gpm

Then divide distance into total distance

$\frac{2,000}{1,600} = 1.25 + 1$
1,600 = 2.25 or 3 pumpers needed

9. When using method to establish relay, common sense used

10. By checking tables, 750 gpm flowed for 1,600 feet through dual 3-inch hoses

11. If distance to fire scene 2,000 feet away, place 1,600 feet between source pumper and relay pumper, with only 400 feet remaining between relay pumper and attack pumper

12. Place relay pumper more toward middle of supply hose

13. If engine companies with different sizes of supply hose on board, distances between pumpers varied accordingly

14. For example, if several engine companies setting up 1,000 gpm relay using 5-inch hose, each pumper 2,050 feet apart

15. If engine shows up with dual lay of 3-inch hose, it can participate as long as dual 3-inch lay limited to 900 feet

F. Constant Pressure Relay Method

1. Second type of relay pumping operation is constant pressure relay

2. Relay method establishes maximum flow available from particular relay setup by using constant pressure in system

3. Constant pressure relay depends on consistent flow being provided on fireground

4. Attack pumper can maintain flow by using open discharge or secured waste line to handle excess beyond flow being used in attack lines

5. Relay using constant pressure has several advantages if operators properly trained in use

    a. Speeds relay activation

    b. Each operator knows exactly how much hose to lay out and how to pump it without awaiting orders

    c. Requires no complicated calculations

    d. Radio traffic and confusion between pump operators reduced

    e. Attack pumper operator able to govern fire lines with greater ease

    f. Operators only have to guide and adjust pressure to one constant figure

6. Forming the Constant Pressure Relay

    a. Position attack pumper at fire

    b. IC makes size-up and determines quantity of water needed

    c. Initial attack made with water carried on pumper

    d. Position largest capacity pumper available at water source if possible

    e. Crew begins making necessary connections to water supply

    f. Lay out hose load from relay pumpers according to procedures used jurisdiction

    g. Always leave at least two sections of hose in reserve in hose bed in event hose failure occurs during operation

    h. Connect all supply lines to pumpers in relay

    i. Operator for each pumper, except source pumper open unused discharge gate if pump does not have relay relief valve which allows air from hoselines to escape

    j. Pump 175 psi from pumper at water source

k. Operator at first relay pumper closes unused discharge gate once steady stream of water flows, then advance throttle until 175 psi developed

l. Each successive operator follows same procedure

m. Each operator sets pressure regulating device

n. Attack pumper operator adjusts discharge pressure(s) to supply attack line (s)

o. Maintain flow from attack pumper during temporary shutdowns by using one or more discharge gates as waste or dump lines

p. Do not shut down attack lines unless absolutely necessary

q. If hoseline bursts, open discharge gate on relay pumper before rupture to dump water until length replaced

r. Lay additional hoselines between apparatus in relay if additional water needed on fireground

7. Operators in constant pressure relay keep correcting pump discharge pressure to 175 psi until:

   a. Intake pressure from pressurized sources drops to 20 psi

   b. If intake pressure drops below 20 psi, danger that pump will go into cavitation

   c. Operating hand throttle does not result in increase in rpm

8. Constant pressure of 175 psi modified as needed for:

   a. Variations in relay pumper spacing

   b. Severe elevation differences between source and fire

   c. Increases in needed fire flow

   d. LDH requires lower discharge pressure to supply same volume of water

9. When increasing relay pressure, source pumper adjusted until desired pressure reached

10. Each successive pumper similarly adjusted

11. When decrease in flow required, attack pumper throttles down

12. One way is by opening dump line to relieve excessive water

13. Source pumper should discharge dump line back into water supply source

14. Relay pumpers toward water source successively throttle down to desired pressure

15. Water supply officer or IC must realize flow and pressure limitations of given relay setup and should not attempt to exceed capabilities of apparatus and hose

IV. GENERAL GUIDELINES FOR RELAY OPERATIONS (EO 1-4)

A. Basic guidelines for all relay pumping operations, regardless of type chosen

B. Operators familiar with guidelines to be successful in relay pumping operation

C. Putting Relay into Operation

1. Operation always begins with source pumper

2. Largest capacity pumper used at source

3. If relay being supplied from draft, source pumper have to develop higher net pump discharge pressure than other pumpers in relay

4. Higher net pump discharge pressure needed because relay pumpers will have residual pressure at intake to reduce amount of pressure needed from pump

5. Important to remember that maximum capacity of relay determined by capacity of smallest pump and smallest hoseline used

6. Once water supply established, source pumper opens uncapped discharge or allows water to waste through dump line until first relay pumper ready for water

7. Failure to keep water through pump could result in loss of prime

8. Discharge pressure built up to desired value by increasing throttle

9. Dump line discharge valve slowly closed to keep from wasting all water from water supply

10. Relay pumper waiting for water with dump line or discharge open and pump out of gear

11. When both source pumper and relay pumper ready, discharge supplying hoseline on

source pumper opened while valve on dump line closed in coordinated action

12. Discharge to supply line opened slowly to prevent sudden discharge into empty hoseline

13. Water begins to move from source pumper to relay pumper

14. As water fills line, air forced through pump and out open dump line of relay pumper

15. When water comes out of dump line, pump on relay pumper engaged

16. Another option to start relay, or at least fill hoselines, with water from apparatus water tank

17. Works best on short relays using 3-incbh hose

18. On long lays of LDH, may not be possible to completely fill hose between two pumpers

19. Most desirable to maintain intake pressure of 20 to 30 psi

20. If relay pumper receiving intake pressure greater than 50 psi, valve to dump line on relay pumper adjusted to limit residual to 50 psi maximum

21. Pump discharge pressure increases as throttle setting on relay pumper increased; therefore, valve to dump line gated down to maintain 50 psi residual pressure

22. If dump line allowed to flow unrestricted, friction loss would increase in hoseline from source pumper to point pump would go into cavitation

23. Once pump discharge pressure on relay pumper reached desired pressure with water being discharged, portion of relay established and no further adjustments necessary

24. When next relay pumper ready for water, same procedure followed

25. First relay pumper opens discharge valve supplying next pumper while closing dump line on coordinated basis

26. Next relay pumper allows water to discharge through dump line and follows same procedure used by first relay pumper receiving water from source pumper

27. When water reaches attack pumper, operator bleed out air from supply line by opening bleeder valve on intake being used

28. Intake valve on attack pumper opened and water supply established through relay

29. When one attack line shut down, operator opens dump line to allow water to flow and prevent dangerous pressure buildup in relay

D. Operating the Relay

1. Once relay in operation and water moving, pump operators set automatic pressure control devices

2. Use of automatic pressure control devices essential when operating in relay due to cumulative nature of pressure increases when changes in flow occur

3. Auxiliary cooler adjusted as necessary to maintain proper engine operating temperature over extended periods of time

4. If pumper equipped with intake relief valve put in service

5. If valve adjustable, set to discharge at 10 psi above static pressure of water system attached to or 10 psi above discharge pressure of previous pumper in relay

6. At no time should relief valve be set for higher amount than safe working pressure of hose

7. At setting, valve not open and cause excessive fluctuations when minor changes in flow occur

8. If attack pumper equipped with readily adjustable intake relief valve, set between 50 and 75 psi to establish stable operating condition for attack pumper

9. If attack line shut down or amount of discharge changes, friction loss in supply line decreases and residual pressure increases

10. Intake relief valve opens, allowing water to dump out of intake

11. Flow through supply line and entire relay increases and pressures return to original settings

12. Additional flow requirements by attack pumper reduces residual pressure and causes relief valve to close

13. Dumping action stops, allowing pressure to again return to original setting

14. Small variations in pressure not significant and no attempt made to maintain exact pressures

15. As long as the intake pressure does not drop below 10 psi or increase above 100 psi, no action required

16. Changing pressure at any pumper in relay operation has effect on others

17. Excessive changes result in constantly varying pressure throughout relay

18. Takes long period of time for pressure change to actually occur in long relay

19. Time delay often responsible for overcorrection errors that have negative effects for entire relay operation

20. Effective relay operations require good communications

21. Each unit in relay aware of actions of other units so operations coordinated properly

22. When pumpers within sight of each other, hand signals used; in extreme cases, messengers on foot effective

23. Where additional radio frequencies available, one channel dedicated to coordination of water supply operation

24. Once water moving, minimum of communication required

25. When units involved in relay equipped with incompatible radios, portable radios useful

26. Radio equipped ambulances or utility units used to establish communications throughout relay

E. Shutting Down the Relay

1. Relay operations shut down from fire scene first

2. If source pumper shut down while rest of relay still operating, pumpers run out of water and cavitation can result

3. Starting with attack pumper, each operator slowly decreases throttle, opens dump line, and takes pump out of gear

4. Once all pumpers shut down, hose drained and readied for reloading

REVIEW:

Relay Pumping Operations

- Relay Apparatus and Equipment
- Relay Pumping Operational Considerations
- Types of Relay Pumping Operations
- General Guidelines for Relay Operations

REMOTIVATION: Being able to effectively and efficiently relay water at the scene of a fire may make the difference between a good save and another foundation.

ASSIGNMENT:

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EVALUATION:

Appendix A

Maximum Distance Relay Lengths in Feet

Flow in gpm	One 2-1/2”	One 3”	One 4”	One 5”
250	1,440	3,600	13,200	33,000
500	360	900	3,300	8,250
750	160	400	1,450	3,670
1000	90	225	825	2,050
1250	50	140	525	1,320

Flow in gpm	Two 2-1/2”	One 2-1/2” One 3”	Two 3”
250	5,760	9,600	14,400
500	1,440	2,400	3,600
750	640	1,050	1,600
1000	360	600	900
1250	200	375	500

Source: Pumping Apparatus Driver/Operator Handbook, 1st ed., IFSTA