



# Fire Protection Training

Procedures Handbook 4300

PUMPING

**TOPIC:** Hydraulic Calculations

**TIME FRAME:** 1 Hour

**LEVEL OF INSTRUCTION:**

**BEHAVIORAL OBJECTIVE:**

*Condition:* A written quiz

*Behavior:* The student will compute proper engine pressures for a variety of fire problems.

*Standard:* With a minimum of 70% accuracy

**MATERIALS NEEDED:**

- Hydraulics problem sheet
- Hydraulics card
- Appropriate visual aids
- Audio visual equipment

**REFERENCES:**

- IFSTA, Fire Department Pumping Apparatus, 7th Edition, Chapter 6
- CDF, Basic Hydraulic Program Text

**PREPARATION:**

Understanding hydraulic principals is a primary responsibility of all fire engine operators. Whether the operator is pumping a 3000 feet progressive hoselay or a fire protection system in a high rise building, understanding hydraulics can minimize damage to pumping apparatus while ensuring adequate fire flow to the nozzle operator.



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## HYDRAULIC CALCULATIONS

PRESENTATION	APPLICATION
<p><b>I. HYDRAULIC CALCULATIONS</b></p> <p>A. Purpose</p> <ol style="list-style-type: none"><li>Allows pump operator to calculate how much pressure must be developed at the pump discharge to supply effective fire streams</li></ol> <p>B. Formula</p> <ol style="list-style-type: none"><li>Many used in the fire service</li><li>Most are good approximations</li><li>CDF formula<ol style="list-style-type: none"><li><math>NP + FL + A \tilde{n} H = EP</math></li><li>(1) NP = Nozzle pressure</li><li>(2) FL = Hose friction loss</li><li>(3) A = Appliance friction loss</li><li>(4) H = Head</li><li>(5) EP = Engine pressure</li></ol></li></ol> <p>C. Nozzle Pressure</p> <ol style="list-style-type: none"><li>A predetermined pressure, used for hydraulics calculations, which must be supplied at the combination nozzle or tip to produce an effective fire stream</li><li>Solid stream tips have optimum effectiveness when pressure at the tip is:<ol style="list-style-type: none"><li>Hand held line = 50 PSI</li><li>Master stream = 100 PSI<ol style="list-style-type: none"><li>For CDF formula use this figure</li></ol></li></ol></li></ol>	



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<ul style="list-style-type: none"><li>(2) Range is actually 80 - 100 PSI for most manufacturer's</li><li>(3) Consult tip manufacturer's specifications for exact pressure</li></ul> <p>3. Combination nozzles have optimum effectiveness when pressure at the nozzle is:</p> <ul style="list-style-type: none"><li>a. Hand held line = 100 PSI</li><li>b. Master stream = 100 PSI</li></ul> <ul style="list-style-type: none"><li>(1) For CDF formula use this figure</li><li>(2) Range is actually 100 - 150 PSI for most manufacturer's</li><li>(3) Consult combination nozzle manufacturer's specifications for exact pressure</li></ul> <p>D. Friction Loss Attributable to Hose</p> <ul style="list-style-type: none"><li>1. Caused by water flowing through the hose rubbing on the inside of the hose</li><li>2. All other factors being equal the greater the GPM flow the greater the friction loss<ul style="list-style-type: none"><li>a. Friction loss factors:<ul style="list-style-type: none"><li>(1) The smaller the hose diameter the larger the amount of friction loss</li><li>(2) The larger the tip or combination nozzle the greater the GPM flow and the greater the friction loss</li><li>(3) Friction loss is constant regardless of changes in elevation</li></ul></li></ul></li></ul>	<p>Information sheet #1</p>



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<ul style="list-style-type: none"><li>b. Overcoming friction loss:<ul style="list-style-type: none"><li>(1) Reduce nozzle pressure cutting GPM flow<ul style="list-style-type: none"><li>(a) Provided it does not adversely impact safe firefighting operations</li></ul></li><li>(2) Reduce size of tip, cutting GPM flow but maintaining nozzle pressure<ul style="list-style-type: none"><li>(a) Provided it does not adversely impact safe firefighting operations</li></ul></li><li>(3) Lay parallel lines which maintains overall GPM flow while cutting GPM flow and friction loss through each hoseline</li><li>(4) Lay larger diameter hose, cutting friction loss with same GPM flow</li></ul></li><li>3. Expressed in PSI per 100 foot length of hose in the hoselay</li><li>4. Amount depends upon:<ul style="list-style-type: none"><li>a. Length of hoselay</li><li>b. Diameter of hose</li><li>c. Size of tip or nozzle</li></ul></li><li>E. Friction Loss Attributable to Appliances<ul style="list-style-type: none"><li>1. Expressed in PSI per appliance</li></ul></li></ul>	



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<p>2. Representative examples:</p> <ul style="list-style-type: none"><li>a. Standpipe 25 PSI</li><li>b. Portable monitor 25 PSI</li><li>c. Hose tee 5 PSI</li><li>d. Gated Y or Siamese 5 PSI</li><li>e. Four way valve 5 PSI</li><li>f. 2 1/2" water thief 15 PSI</li><li>g. Ladder pipe (including head) 80 PSI</li><li>h. Aerial platform (including head) 80 PSI</li></ul> <p>F. Head</p> <ul style="list-style-type: none"><li>1. Pressure generated by or required to overcome changes in elevation between the pump and the nozzle or tip<ul style="list-style-type: none"><li>a. If net gain in elevation add .434 PSI per net foot of rise<ul style="list-style-type: none"><li>(1) For ease in performing hydraulics calculations use following guidelines:<ul style="list-style-type: none"><li>(a) 43 PSI per 100' rise in elevation</li><li>(b) 22 PSI per 50' rise in elevation</li><li>(c) 11 PSI per 25' rise in elevation</li></ul></li></ul></li></ul></li></ul>	



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<ul style="list-style-type: none"><li>(d) 5 PSI per floor (12') rise in a structure</li><li>(i) Do not count ground floor which is at pump elevation</li><li>b. If net fall in elevation subtract .434 PSI per net foot of fall<ul style="list-style-type: none"><li>(1) For ease in performing hydraulics calculations use following guidelines:<ul style="list-style-type: none"><li>(a) 43 PSI per 100' fall in elevation</li><li>(b) 22 PSI per 50' fall in elevation</li><li>(c) 11 PSI per 11' fall in elevation</li><li>(d) 5 PSI per floor (12') fall in a structure</li><li>(i) Do not count ground floor which is at pump elevation</li></ul></li></ul></li><li>G. Engine Pressure<ul style="list-style-type: none"><li>1. Amount of pressure registering on the pump pressure gauge at the discharge side of the pump</li><li>2. The mathematical answer to hydraulics calculations</li><li>3. The pressure that should register on the pressure gauge when undertaking a given pumping operation</li></ul></li></ul>	



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<ul style="list-style-type: none"><li>4. If more than one hoseline is being used and each is on a separate discharge, set engine pressure for the hoseline requiring the highest engine pressure</li> <li>5. If multiple hoselines branch off a single discharge, engine pressure must be the sum of all hoseline requirements</li></ul>	



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## **SUMMARY:**

A hydraulics formula is used in the field to give a pump operator a chance to deliver an effective fire stream without actually observing the fire stream.

If calculated properly, the nozzle person will have a safe fire attack tool. At best, hydraulics formulas are an imperfect tool in an imperfect world.

## **EVALUATION:**

A written quiz.

## **ASSIGNMENT:**

To be determined by instructor(s).