Introduction to and Operation of Compressed Air Foam Systems (CAFS)

Mesa Fire Department currently has nine (9) compressed air foam pumpers. Each unit has 20 to 30 gallons of Class A foam on board. Typical compressed air foam is available on the front jump line, crosslays, rear 2½ discharge, and deck gun. We will be discussing two types of Class A compressed air foam systems.

- Old style – Foam Pro
- New style – Husky 10

Both systems use the same compressed air system (Hercules) so they operate in the same manner.

There are three subsystems that make up a compressed air foam system.

- Water pump.
- Air compressor.
- Foam concentrate proportioner.

The air to make compressed air foam is supplied by a 200 cfm screw-drive compressor. The air is introduced into the foam solution downstream of the discharge valve.

An auto pressure balancer valve is used to match the compressor pressure (plus or minus 5%) to discharge water pressure when the compressor rocker switch is activated to the foam side.

The CAFS compressor’s PTO will only operate when the fire pump is engaged. The compressor’s PTO engagement is also prevented if the air compressor pressure is above 30 psi. This can be seen on the air pressure gauge.
The compressor system control panel has the following functions:

- PTO/compressor engagement switch (on/off).
- PTO engaged indicator light.
- Compressor air gauge.
- Oil temperature gauge to monitor the oil temperature in the CAFS system. Operating temperature will run 165° to 210° Fahrenheit.
- An audible and visible warning in the event of high temperature. The alarm activates at 250° Fahrenheit.

**Foam Mode**
- Automatic pressure balancer to match the compressor discharge pressure to the pump discharge pressure throughout a pressure range of 60 to 150 psi.

**Tools Mode**
- Fixed pressure to set the air pressure fixed for the use of air tools supply air, etc.

Note: (Both of the above functions are activated by a rocker switch on the CAFS control panel.)

The CAFS air flow meter monitors CAFS airflow in SCFM Standard cubic feet per minute.

The air outlet 1/4 turn valve and fitting are located on the pump panel and are activated by the rocker switch in the tools side.

**Note:** Before you operate any system on your apparatus, you must perform a daily check, per apparatus check sheet.

Before operating the CAFS system, you must first check:

- The compressor oil reservoir level should be 1/4 to 1/2 way up the sight glass. The sight glass is located on the right side,
lower front, behind the door on the pump panel. Check the oil on level ground, prior to system start up. If the system had been running, wait ten (10) minutes before checking. If the system is low, call Fire Maintenance.

**Foam Injection System (For Foam Pro System)**

The foam system is an electric motor driven, flow based proportioning system that measures water flow and then injects the proportional amount of foam concentrate to maintain the preset percentage. The system can deliver from .1 to 3.0% foam. As water flow increases or decreases, the foam concentrate rate of injection is increased or decreased. The foam is injected directly into the water stream after the discharge valve.

**Foam Digital Display (For Foam Pro System)**

To turn the foam system on, you must push the red “on/off” foam button. A red light will turn on, indicating that you are in the standby mode. Once water is flowing, the red light will begin to blink, indicating flow and foam will begin injecting into the discharge line(s).

The gray select button, when pushed (one at a time), will light up under different functions:

- flow
- total water flowed
- % of foam
- total foam used

Each time you push the gray select button, the red light will illuminate under each function, one at a time (i.e., red light illuminated under flow. The water flow rate will be seen on the display. The total water equals the total water flowed and so on. The foam percentage is preset at 0.3. You can use your arrow buttons to decrease or increase this percentage as needed. When the ignition switch is cycled, the system will always return to the default percentage (0.3).
If water flow exceeds the capacity of the foam pump, the pump will run at the maximum rate, and “Hi Flow” will flash on the display. The operator will know that the system capacity is being exceeded.

If water flow decreases such that the required injection rate is less than the lowest rating of the pump, the pump will run at its minimum rate, and “Lo Flow” will flash on the display. The operator will know that the system is running rich on foam percentage.

Foam Tank

Foam tank level can be checked by visual inspection of the foam tank. The foam digital display will also let you know when the foam level is low by flashing a “LO/CON” message on the display. (New style pumpers have tank level lights.)

Oil Cooler Strainer

The CAFS system air compressor uses oil to keep it cool and lubricated. The oil passes through the cooler. The inlet side of the cooler is connected to the discharge side of the fire pump, with a strainer that is used for catching any debris passing through the water system and/or pump. Operating temperature for the CAFS compressor is 165° to 210° F. An audible warning alarm and light will come on at 250° F. If your air compressor is over-heating, a clogged oil cooler strainer is most likely the cause. Each CAFS unit is equipped with a quarter-turn flush valve located and marked on the pump panel lower right hand side. This valve should be used to flush out any debris caught in the oil cooler strainer. This will allow you to continue with CAFS operation until you contact Fire Maintenance for removal and cleaning of the strainer screen. This valve should be flushed daily as part of the apparatus daily check. Good water discharge from the flush valve indicates no blockage in the strainer screen.

Air Flow Indicators

There are two air flow indicators on our CAFS pumpers: one on the right side behind the pump panel and one on the left side mounted in the engineer
panel. Both meters indicate airflow. Airflow is measured in standard cubic feet per minute (scfm).

An scfm air flow meter translates hot or compressed air flows into “standard cubic feet.” A standard cubic foot is the amount of air filling a cubic foot of space with its temperature at 60º F and a pressure of 14.7 psia.

**Starting CAFS Operations**

**Note:** The water source should not exceed 125 psi (maximum). Gate intake down to 70 psi and discharge at 120 to 125 psi. This will insure there is enough engine rpm for the pressure governor to work properly and also have enough water flow to keep the air compressor cool during CAFS operation. **Remember – a difference in pressure of 30 to 40 psi is needed for proper cooling through the oil cooler as well as to keep the engine off at base idle so pressure control can be obtained.**

1. Engage the fire pump per standard procedures. Follow all standard safety procedures to prevent vehicle rollaway.
   - When in pump gear, the speedometer will register mph. This will insure you are in pump gear.
   - At the pump panel, the green “OK TO PUMP OR THROTTLE UP” light will come on as well.

2. Check the CAFS air outlet supply valves to insure they are in the “Off” position (no green light). Check tools/foam switch; make sure it is in the foam mode for CAFS operation.

3. Turn the compressor switch on.
   - Turn compressor on at idle only.
   - Water pressure should not exceed 80 to a maximum of 125 psi (maximum).

  **Note:** The compressor will make noise if you run the water pressure too high.
Introduction to and Operation of
Compressed Air Foam Systems (CAFS)

Page 6

Note: You can disengage the air compressor at any rpm.

4. Turn on the foam system (*push red button*).
   - The red light will be on in standby mode – no water flow.
   - The red light will be flashing when water is flowing.

5. Open the desired discharge CAFS line(s).
   - 80 to a maximum of 125 psi (maximum) is sufficient.
   - Open discharge handle/valve almost all the way for maximum flow (structure/interior attack). (*95 to 110 gpm at that line*)
   - Gating the discharge handle/valve will result in less water flow – dryer foam – (*structure protection type foam only*).

Note: Dry foam structure protection cannot be achieved with a fog nozzle. For maximum effect, you need to use a smooth, bore nozzle or just the valve.

6. Activate the CAFS air valve switch. A green light will illuminate
   - Switches are marked “CAFS AIR LINE SUPPLY VALVE.”
   - Switches are typically located next to, above, or below each CAFS discharge gauge and are marked in blue.
   - Activating the CAFS switch will deliver compressed air to your discharge line.

7. Advance the throttle on the pressure governor and throttle control panel to obtain approximately 80 to a maximum of 125 psi. Move mode selector switch to pressure control side.
   - The air compressor’s air pressure will automatically follow the pump pressure. (This is an auto-balanced system.)
   - The green light will blink (no pressure control).
   - A yellow light indicates that the pressure control is activated.
   - Once the yellow light is illuminated, you can change your throttle up or down and still be in throttle control mode.

*Shutting Down CAFS Operations*

1. Close the air valve switch (green light off).
2. Reduce pump pressure at the pressure governor and throttle control panel.
3. Disengage air compressor (compressor on/off switch).
4. Turn off the Class A foam system. Push red button at foam display (red light off at display).
5. Flow water until clear (no foam – clear water).
7. Push system shut down (red button on the pressure governor and throttle control panel).
8. When pumping operations are completed, always push and activate the system shut down (red button). This will clear the system out. The ECM vehicle computers will then know you have completed pumping operations.
9. Disengage the fire pump per standard procedures. Follow all standard safety procedures as required.

**Husky 10 Foam Injection System** *(New System)*

The Husky 10 foam system operates as an on-demand system by measuring water flow and injecting the required foam based on an operator-defined percentage. Foam is drawn from the on-board foam tank or through a draft hose from an alternate foam source such as a curbside container.

The foam concentrate is injected into a manifold that distributes the foam/water solution to all designated discharges. Check valves in both the waterline and foam line prevent contamination of the water and foam supplies.

**System Capacity**

The hydraulic foam pump can supply a maximum of 10 gpm of foam concentrate. The display will provide a message when the set point exceeds the maximum 10 gpm.

**Maximum Foam Solution Flow***

<table>
<thead>
<tr>
<th>Foam</th>
<th>Water Flow</th>
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Introduction to and Operation of Compressed Air Foam Systems (CAFS)

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Water Flow (gpm)</th>
</tr>
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<tbody>
<tr>
<td>6%</td>
<td>166</td>
</tr>
<tr>
<td>3%</td>
<td>333</td>
</tr>
<tr>
<td>2%</td>
<td>500</td>
</tr>
<tr>
<td>1%</td>
<td>1,000</td>
</tr>
<tr>
<td>.5%</td>
<td>2,000</td>
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</tbody>
</table>

*Maximum water flow will depend on plumbing restrictions.

**Foam System Components and Functions**

*Hydraulic Drive System*

The PTO is mounted on the truck transmission and is powered by the engine and transmission, which powers the air compressor. The foam hydraulic pump is powered by a pump mounted on the fire pump transmission.

**Main Components**

- Hydraulic gear pump (pumps hydraulic fluid to activate foam pump)
- Hydraulic filter (filters hydraulic fluid)
- Hydraulic tank (approximately 4 gallons – holds hydraulic fluid used to activate foam pump)
- Hydraulic cooler (cools hydraulic oil using fire water pump)
- Hydraulic pump assembly (pumps foam concentrate to water manifold and discharges)
- Foam check valves (prevents water from flowing back through the foam system)
- Water flow meter (measures the flow of water supplied to the foam/water discharges)
- Foam system controller (contains electronic hardware and programming to control the various parts of the foam system)
- Foam system control head (Husky 10) (the operator interface to the foam system)

**Husky 10 Control Head**

The Husky 10 control head has six operating buttons
1. **On/Off**: When the on/off button is pressed, the red light will come on. When the system is turned on, it will automatically read “Class A.3” drafting from the on-board tank.

2. **Mode**: When the mode button is pressed, a display will indicate what mode the system is in.
   a. Foam source (A or B foam)
   b. Manual mode (shop only)
   c. Priming foam system (shop only)
   d. Flushing foam system (when switching foams)
   e. Flow meter (reading gpm)
   f. Draft (using auxiliary foam pickup for filling Class A tank or drafting Class B foam from external source)

3. **Display**: By pressing the display button during normal operation, the operator can scroll through the following information:
   a. Current water flow
   b. Current foam flow
   c. Total water flowed
   d. Total Class A foam used
   e. Total Class B foam used.

4. **Enter**

5. **Arrow up (for foam percentage change)**

6. **Arrow down (for foam percentage change)**

The following operating instructions are taken from the Pierce Manufacturing Husky 10 Foam System operator's manual.

**QUICK REFERENCE OPERATING INSTRUCTIONS**
**PIERCE HUSKY 10 / HERCULES FOAM SYSTEM**

**TO MAKE CLASS A FOAM**
1. Turn foam system “ON” with control switch on Red Husky control panel.
2. Open water discharge valve and begin to flow from hose line.
3. Set to the desired percentage (normal default is A onboard tank@ 0.3%).
4. You are now making foam solution.
TO SHUT DOWN AFTER CLASS A FOAM
1. Turn foam system “OFF” with control switch on Red Husky control panel.
2. Open the water discharge valve on the discharge(s) that were used and begin to flow from hose line until the water from the hose runs clear.
3. Disengage water pump and open all manifold drains and water drains to relieve any trapped pressure.
4. Close all drains and valves. The system is now ready to be put back into service.

TO MAKE CLASS A COMPRESSED AIR FOAM (CAF)
1. Turn foam system “ON” with control switch on Red Husky control panel.
2. Turn air compressor “ON”, (under 1000 engine R.P.M.) on the blue Hercules control panel.
3. Open water discharge valve and begin to flow from hose line.
4. Set to the desired percentage (normal default is 0.5%).
5. You are now making foam solution.
6. Turn on the air injection to the corresponding discharge with the toggle switch located by the discharge valve control.
7. You are now making compressed air foam.
8. Adjust the “WET” / “DRY” ratio of the compressed air foam by opening or closing the water discharge valve. The more the water valve is opened the “wetter” the CAF will be.

TO SHUT DOWN AFTER CLASS A COMPRESSED AIR FOAM (CAF)
1. Turn off all air injection switches (compressor may be turned off at this point if no longer needed).
2. Turn foam system “OFF” with control switch on the Red Husky control panel.
3. Open the water valve to the discharge(s) that were used and begin to flow from hose line until the water from the hose runs clear.
4. Shut off water valve to the discharge.
5. Turn off the compressor on the blue Hercules control panel.
6. Disengage water pump and open all manifold drains and water drains to relieve any trapped pressure. Close all valves/drains. System is ready to be put back into service.

**NOTE:** System shut down and flushing can be started during MOP UP, this way all foam is used on the fire.

*Typical Operator Errors*

- Flowing water and air before turning foam system on.
  - *This will cause pulsation of the hose line with no compressed air foam being produced.*

- Operating CAFS in fixed or tools mode.
  - *This will cause pulsation of the hose line with compressed air foam being produced intermittently.*

- Nozzle operators tend to gate nozzles, thus stripping the air from the system while attempting to make dry foam.
  - *Dry foam is produced by using a smooth bore nozzle and gating down the discharge valve at the pump panel (less water content).*

- Running water pump pressure too high (over 160 psi).
  - *This will cause no air to flow into the discharge. Check valves will close, not allowing air to discharge due to high water psi. Water and air pressure must be balanced for CAFS operations.*

- Running air compressor at too high pressure, not in the correct mode. (80 to a maximum of 125 is sufficient) (In foam mode only.)
  - *This will cause no water flow into discharge. Water and air pressures must be balanced.*
Running CAFS at too high pressure.

- 80 – to a maximum of 125 psi is sufficient. Hose line will be hard to handle. Air compressor will be very noisy.

Operating with little or no difference in pressure between intake and discharge side of pump.

- This will cause system to overheat due to poor water flow through the compressor oil cooler. (A differential pressure of 30 to 40 psi is needed for proper cooling.)

Kinked supply hose

- This will cause slug flow and pulsation.

What is a CAFS System?

Compressed air foam systems (CAFS) are high-energy foam generators. They will work well with either Class A or B agents. (Do not mix foams.) Pump compressed air or compressed gas into foam solution, and you will get compressed air foam (CAF).

Key Features

- Suitable for all foam systems and applications—wildland, structural, and industrial.
- Boasts tremendous knockdown capabilities and can lay down a long-lasting protective blanket.
- Delivers 30% increase in range for safer firefighter positioning.
- Hose is 50% lighter, helping to reduce firefighter fatigue.
- Variable foam expansion rates allow for broad-spectrum application with dry foam 30 to 1 for exposure protection and wet foam 4 to 1 for fire attack.
• Friction loss is substantially less than in an identical hose line delivering water.
### Types of Foam

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>Type 1</td>
<td>Wet Foam</td>
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<tr>
<td>Type 2</td>
<td>Medium Foam</td>
</tr>
<tr>
<td>Type 3</td>
<td>Medium Foam</td>
</tr>
<tr>
<td>Type 4</td>
<td>High Expansion Foam</td>
</tr>
<tr>
<td>Type 5</td>
<td>Dry Foam</td>
</tr>
</tbody>
</table>

**Generated by**
- Type 1: Low expansion air aspirating nozzles at 0.5%, automatic or variable gallon fog nozzle at 0.5%, or CAFS at 0.3%.
- Type 2: Medium expansion air aspirating nozzles at 0.5 to 1.0%.
- Type 3: CAFS at 0.3%.
- Type 4: High expansion foam generators at 0.5% to 1.0%.
- Type 5: CAFS at 0.3% to 0.5%.

**Attributes**
- Type 1: Watery, very runny on vertical.
- Type 2: Watery/cream
- Type 3: Resembles watery shaving cream.
- Type 4: Very dry and fluffy.
- Type 5: Resembles shaving cream.

- Type 1: Does not hold peaks.
- Type 2: Has little body.
- Type 3: Holds peaks
- Type 4: Blows away in wind.
- Type 5: Does not cling well to vertical surfaces.

- Type 1: Takes time to run on vertical surfaces.
- Type 2: Very little runoff on vertical surfaces.
- Type 3: Very dry.
- Type 4: Clings well to vertical surfaces.
- Type 5: "Cap" over medium foam for structure protection at wildland conflagrations.

**Uses**
- Type 1: Direct fire attack.
- Type 2: Fill up voids between walls or in poorly ventilated fire compartment areas.
- Type 3: Exposure protection on unsealed wood fuels.
- Type 4: Total flooding of basements and other confined areas where conditions won't allow advancement of hose line into the fire area.
- Type 5: Exposure protection on glass and vinyl siding.

- Type 1: Deep-seated fires in materials such as baled cardboard, etc.
- Type 2: Structure overhaul.
- Type 3: Final "coating" after overhaul is complete.
- Type 4: Barrier on surfaces that won't absorb moisture.
- Type 5: "Cap" over medium foam for structure protection at wildland conflagrations.
Factors that Dictate Foam Type

The two factors that primarily govern the foam type or consistency produced by each hardware device are *scrubbing* and *expansion ratio*.

*Scrubbing* is the amount of mechanical agitation the air and foam solution receive within the foam generation hardware prior to discharge. The higher the level of scrubbing, the greater the production of foam (bubbles), which produces a high quality finished foam having a longer drain time.

*Expansion ratio* is the amount of air used during the foam generation process. This dictates the moisture content of the foam blanket per unit volume. The moisture content is an important factor in foam type or consistence.

Using CAFS for Interior Attack

When using water, very high water flow rates, applied for short duration, effectively stop interior fires. When using these high flow rates, we have learned to immediately shut the nozzle when flame darkening occurs. This prevents excess water damage.

When using the same principle of high flow, short duration with CAFS, nozzles must not be shut as soon as flames darken. If a CAFS hose stream is immediately shut after an interior fire is darkened, the fire will most likely rekindle and/or the atmosphere will remain untenable for the fire fighters because of high heat.

Why does this happen? Because compressed air foam (CAFS) is a very efficient flame-extinguishing agent. It is believed that it absorbs enough heat from solid fuels to reduce vapor distillation to the point where flaming combustion ends in a very short time. However, even though the flames are quickly darkened, there still remains considerable heat radiating from a room’s interior finish and content.

A tactic that works well is to continue applying foam to interior surfaces (even though visible flames are gone) for the same amount of time it initially took for blackout to occur. If it takes 10 seconds for blackout to take place while combating a well-involved room and contents fire, continue applying foam to the room’s interior surfaces uninterrupted for an additional 10 seconds. This coats fuels with a layer of foam and provides enough additional agent to absorb residual heat from the compartment.
The trick is not to over apply foam and defeat the water stretching benefit it provides. How will you know if you apply foam for too long? When foam begins to collect and flow over the floor.

The CAFS apparatus creates the foam inside its piping and/or the attack line hose line, not at the nozzle. All that is required is a control valve so the hose team can shut off the foam flow. That is why it is referred to as “finished foam.”