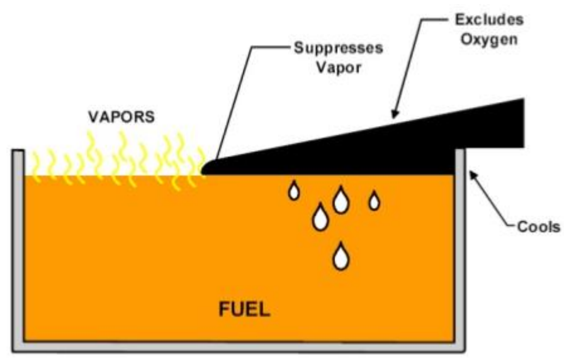
Foam Operations & Foam Systems

FOAM THEORY AND CHARACTERISTICS

In general, firefighting foam works in the following ways:

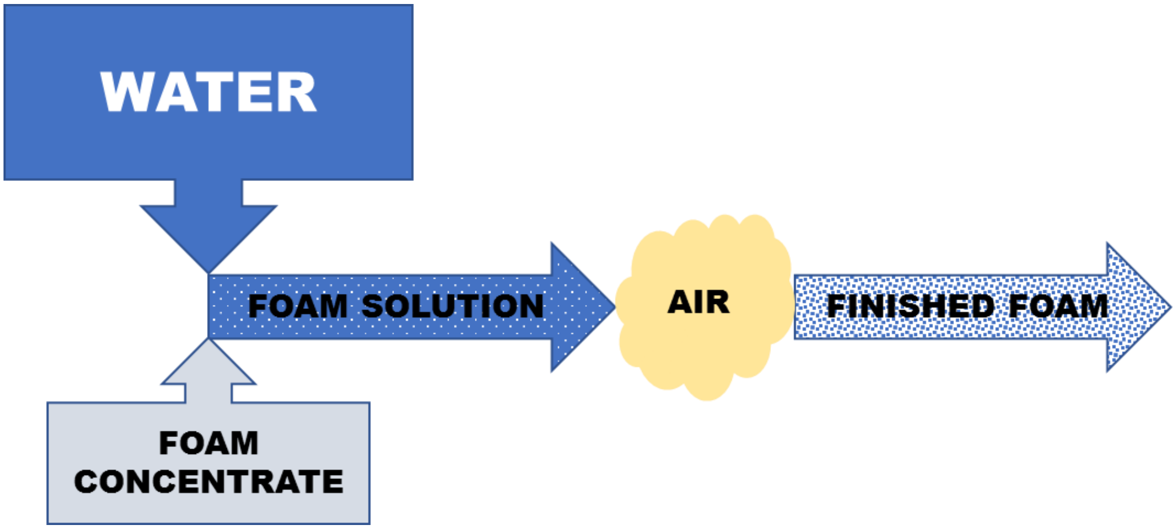
- ✓ It smothers a fire by separating the fuel from air.
- ✓ It cools the fuel and adjacent surfaces below their ignition temperature or flash point.
- ✓ It prevents flammable vapors from reaching ignition sources by encapsulating the fuel.
- ✓ It reduces the volume of flammable vapors being released that can mix with oxygen.



Definitions

- **Aspirate** – to draw air in; aspirating nozzle attachments draw air into foam solution as it discharges to make finished foam.
- **Surfactant** –Wetting agents that lower the surface tension of a liquid, allowing easier spreading and penetration into solid materials.
- **Emulsifier** – Emulsifiers will surround an oil (or other immiscible molecule) and form a protective layer so that the oil molecules cannot "clump" together. This action helps keeps the dispersed phase in small droplets and preserves the emulsion.
    - Immiscible materials are incapable of being mixed or blended together and will eventually separate into separate layers even if shaken or blended.
        - Oil and water are immiscible
- **Foam Concentrate –** liquid supplied by a manufacturer which when mixed with water in the correct proportion forms a foam solution. MCFRS uses both Class A and Class B concentrates.
    - Never mix brands or classes of concentrates in the same batch, onboard system, or appliance.
    - Each manufacturer offers recommendations for compatibility, application, and proportioning. Consult the container or contact MCFRS Fleet Services for access to manufacturer information.
- **Foam Solution –** a solution of water and foam concentrate after they have been mixed together in the correct proportions. There is no specific nozzle, agitation, or injection of air into the mix.

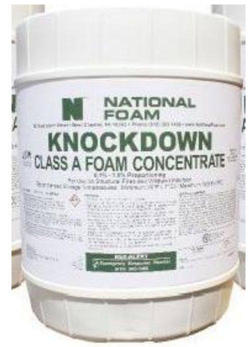
- **Finished Foam –** Foam solution as it exits a discharge device, having been aerated. Finished foam consists of Foam Concentrate, Water, and Air that are subjected to mechanical agitation within the pumping system and/or by the nozzle.



- **Nozzle Aspirated Foam System (NAFS)** –Often called "low-energy" generation systems because they rely on the energy created by a fire pump to propel the foam stream from the nozzle, and to aspirate the foam solution at the nozzle.
- **Compressed Air Foam System (CAFS)** – An air compressor injects air into foam solution within the fire pump discharge piping. The air and foam solution combine as they move through the mixing chamber and into the attack hoseline. Unlike low or medium-expansion air-aspirating nozzles that mix air with foam solution in the foam tube, CAFS use te scrubbing action of the turbulence within the mixing chamber and the attack hoseline to create the finished foam. No special nozzle or nozzle attachment are required. Foam bubbles produced by CAFS are of high quality – very small, uniform, dense, and tightly packed. Therefore, they interact with fire differently than foam produced through NAFS and have much longer (almost 25%) drain times. MCFRS CAFS operations use only Class A concentrate.
- **Hydrocarbons** - Most hydrocarbons are byproducts of crude oil or have been extracted from vegetable fiber. Hydrocarbons have a specific gravity of less than 1.0 and therefore float on water. Examples of hydrocarbon fuels include:
  - Gasoline
  - Diesel
  - Jet propellant (JP4)
  - Kerosene
- **Polar Solvents** - Polar solvents are products of distillation or products that have been synthetically produced. Polar solvent fuels are miscible, that is they will mix with water. Polar fuels have a varying attraction for water. For example, acetone has a stronger affinity for water than does rubbing alcohol. Some examples of polar solvent fuels include:
  - Ketones
  - Esters
  - Ethanol
  - Amine
  - Methyl tertiary butyl ether (MTBE)
  - acetone

Class A Foam

Class A foam is deployed by MCFRS in both CAFS and non-CAFS configurations. As of this revision, MCFRS utilizes National Foam Knockdown Class A foam.



Class A foam has two primary benefits. It reduces the surface tension of plain water which allows it to penetrate surfaces where water might normally run off, to reach deep-seated fires. This helps reduce the amount of water required to extinguish the fire and also provides quicker knockdown.

Secondly, Class A foam increases the heat absorbing capabilites of water. Foaming ingredients give water the ability to adhere to vertical surfaces which allows the water longer contact with the fuel. The longer the water is in contact with the fuel, the more heat it is able to absorb.

A coating of Class A foam may also be used for exposure protection to prevent fuels from igniting by raising their moisture content and providing a protective barrier to impinging heat or fire.

Class A foam works as an emulsifier on liquid hydrocarbon fuels at a 0.3% application rate. Special care should be used when using Class A foam on Class B fire spill situations. The utilization of air-aspirating nozzles over non-aspirating nozzles may offer more effective control of these situations. Class A foam should never be used on polar solvent or water miscible fuels.

Proportioning of Class A Foams is dependent upon the type of firefighting operation. Normal proportioning varies from 0.1% up to 1%. For example, at 0.5% proportioning there will be 5 gallons of concentrate consumed in every 995 gallons of water.

- **Nozzle Aspirated Foam** – 0.3% - low expansion, 1.0% high expansion
- **Compressed Air Foam** – 0.3% - “Wet”, 1.0% - “Dry”

Class B Foam

Class B Foams do NOT voluntarily mix with hydrocarbons and they form a cohesive blanket on top of flammable liquids. Class B foams are "oleophobic" (Oil-Hating). This means that it produces a chemical effect that tends to prevent hydrocarbon (fuel) pickup and blanket contamination. A contaminated foam blanket is undesirable since it can "candle," the presence of small flames from the foam blanket.

As of this revision, MCFRS uses National Foam Universal Gold AR-AFFF. This concentrate is alcohol resistant (AR) aqueous film forming foam (AFFF). Proportioning of Class B foam is dependent upon the type of fuel encountered and needs to follow specific foam concentrate manufacturer guidance. In general, the following proportions apply:

- 1% or 3% - hydrocarbon fuels
    - gasoline blends and biodiesel require 3%
- 3% - polar solvents

FOAM EXPANSION TUBE

When greater expansion rates of foam solution are needed, a foam aeration tube can be attached to the fog nozzle. The foam expansion tube clamps directly to compatible fog nozzles to enhance the apiration of the finished foam.

FOAM PROPORTIONING SYSTEMS

Foam Proportioning Systems introduce foam concentrate into hose streams. MCFRS uses a variety of inboard and outboard proportioning methods to generate foam. These methods are summarized here, but personnel are encouraged to consult manufacturer information for specifics regarding the equipment on their assigned apparatus.

IN-LINE FOAM EDUCTOR

The Task Force Tips (TFT) in-line foam eductor is capable of proportioning Class A or Class B foam concentrates at rates of 0.25%,0.5%, 1%, 3%, and 6%. For the eductor to function properly, a pressure of 200psi must be maintained at the appliance. The maximum back pressure is 130psi.

The eductor is often supplied by a finite amount of concentrate either stored in 5-gallon buckets or an onboard foam cell. The following provides guidance on anticipated consumption rates using the 95gpm eductor and matched nozzle:

Concentration	Time to Empty 5-gallons	Foam Consumption Rate
0.25%	20 minutes 50 seconds	0.24gpm
0.50%	10 minutes 25 seconds	0.5gpm
1%	5 minutes 16 seconds	1.0gpm
3%	1 minute 45 seconds	2.9gpm
6%	53 seconds	5.7gpm

The maximum hose lay is based on the back pressure. Pushing the foam solution thru the hose and nozzle causes back pressure on the eductor exit. If the back pressure is over 130psi the eductor will not work. Back pressure is the sum of hose line friction loss between the eductor and nozzle and the nozzle's operating pressure when flowing 95 gpm. Elevation loss adds to the back pressure when the nozzle is higher than the eductor. For each foot in vertical height there is 0.5 PSI elevation loss.

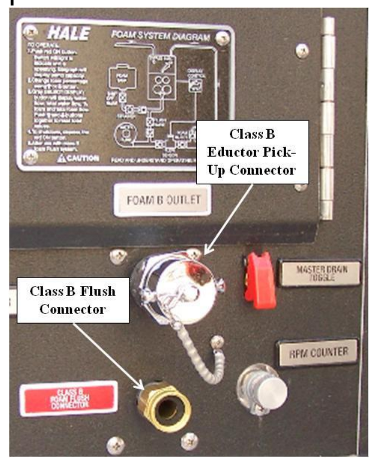
The attached foam suction hose is matched to the eductor and should not be lengthened.

If finished foam is of poor quality or not being discharged, consider the following to troubleshoot:

- Too much hose between the nozzle and the eductor
    - Eductors are most often positioned at the pump for convenience, however can be placed anywhere on the hoseline as long as 200psi is maintained at the eductor
    - The allowable length of hose from the eductor to the nozzle is not infinite and depends upon the friction loss, nozzle pressure, and elevation loss of the hose lay.
- Mismatched Nozzle
    - Eductors work with any nozzle whose gallonage is equal or larger than 95gpm
    - Larger gallonage nozzle effects both the reach of stream and the proportioning rate of the eductor
- Excessive elevation increase between the nozzle and eductor
- Nozzles must be fully open or fully closed when using a foam eductor to create the necessary venturi effect and draw concentrate into the water stream. A partially closed nozzle creates too much back pressure.
- Excessive lift between the eductor and foam source; keep lift less than 6 feet. Normally the length of the pickup tube supplied with the eductor is what should limit the lift.
- Eductor port or pickup tube is clogged
- Eductor is on the wrong proportioning setting

In-Line Eductor Operation with Onboard Foam Cell

Some MCFRS apparatus carry a supply of Class B foam in an onboard cell rather than 5-gallon buckets. This cell is plumbed to a discharge on the pump panel that allows the eductor be attached. The foam concentrate is gravity fed to the discharge and is not pressurized or piped to the main pump. Below is a typical setup:



1. Select a pump discharge that allows the eductor pickup tube to reach the foam discharge and attach the eductor body to the pump discharge. Attach the attack hose to the discharge side of the eductor.
2. Attach the eductor pickup tube to the foam discharge
3. Open the foam cell valve begin discharging foam concentrate to the eductor.
4. Open the appropriate pump discharge to flow water through the eductor.
5. Adjust pump discharge pressure to provide 200 psi at the eductor.
6. When foam operations are complete and foam cell valve is closed:
   - Flush all exposed hose and appliances with plain water
   - Flush foam cell piping by attaching garden hose to pump panel fitting and flowing plain water
   - Refill foam concentrate as needed

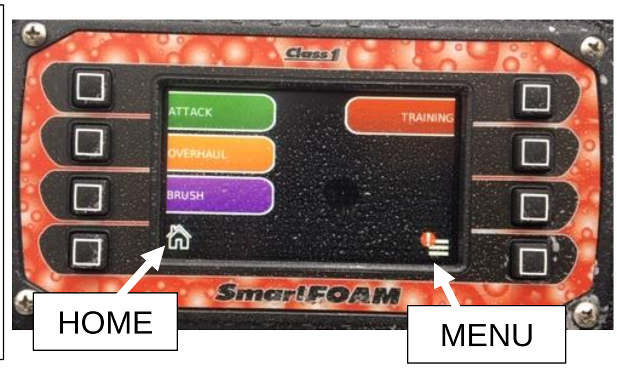
As a general rule, a 25-gallon foam cell used in combination with the 95gpm eductor generates sufficient finished foam to cover:

- **Normal Hydrocarbon** - 950 Square Feet (Approx - 31' x 31') spill fire
- **Polar Solvent** - 400 Square Feet (Approx 20' x 20') spill fire
- Approximately 50 to 100 gallon fuel spill
- Site conditions, weather conditions, fuel containment, wind conditions, and other factors may effect these assumptions
  - Best practice is to have reserve capacity on scene to generate more foam if needed
  - 3-D or flowing fuel fires are complex and often beyond the capability of a single unit resource

HALE SMARTFOAM FOAM PROPORTIONING SYSTEM

SmartFOAM is a direct injection foam proportioning system integrated to the apparatus pump. The MCFRS system has four preset Class A foam injection rates for specific fireground or training scenarios. These systems are defaulted to “off” so the apparatus operator must consciously choose to flow foam. The system is engaged when the pump operator presses the preset button with the text indicating the desired scenario. The foam pump has a maximum injection rate of 6.5gpm. Pump discharge pressure must be below 200psi and a flow of at least 20gpm is necessary for the foam to be injected properly.

***Home Screen** – Default view when pump is first engaged and returns upon pushing the “home” button on the controller.*
System defaults to the foam being “off” and pump is in “plain water” mode.
Operator initiates desired foam operations by selecting the corresponding mode: ATTACK, OVERHAUL, BRUSH, TRAINING.

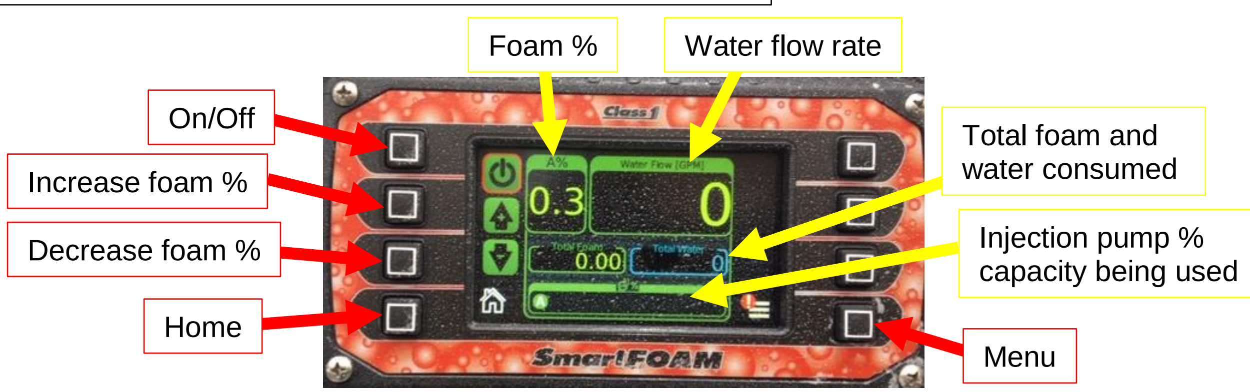


***Operations Screens** – Engaged after selecting one of the modes from the home screen. Screen allows the operator to:*

- *Turn off the foam injection*
- *Adjust and monitor the proportioning*
- *Monitor foam and water usage*
- *Monitor foam pump capacity being used*
- *Access menu screen*

Note: leaving this screen does not shut off the foam. The operator must select the “power” button on the upper left to shut down. The screen will change from a full color display to grey to indicate the system is “off”.

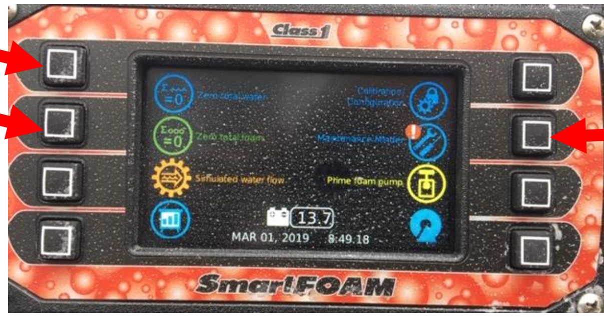
Preset Proportions
***Attack –** 0.3%; up to 2,167gpm*
***Overhaul –** 0.5%; up to 1,300gpm*
***Brush –** 0.1%; up to 6,500gpm*
***Training –** 0.1%; up to 6,500gpm*



System Information – viewed by pressing the menu button on the home or operations screens. Enables basic maintenance and monitoring of systems. Most common uses are resetting totals and identifying any maintenance needs. Note: water and foam totals automatically reset each time power is shut off.

Reset water total

Reset foam total



Maintenance Minder

Maintenance Minder – viewed by pressing the Maintenance Minder button on the system information screen. Allows the operator to identify upcoming or past due maintenance on the foam system.

Refilling the Concentrate

Apparatus equipped with the SmartFOAM system have an external fill inlet on the officer side pump panel. The system does not have an onboard pump to refill the foam cell. Bulk storage locations for Class A foam have transfer pumps to complete the task. The absence of an integral pump requires personnel to carefully monitor the foam cell as it fills to avoid overfilling and spillage of foam concentrate. There is no automatic shutoff and the tank will overflow if left unattended.

Shutdown Procedures

When the SmartFOAM system is only used for Class A foam the system shutdown and flushing of the system is simplified. Upon completion of foam operations, the foam injection is stopped by using the On/Off button on the applicable Operations screen. Once the injection is stopped, continue to flow plain water through the discharges used during the operation to flush out residual solution. Hose, appliances, and nozzles should also be flowed until plain water is discharged.

If a pumping apparatus is encountered that uses Class B foam in conjunction with the SmartFoam system, a different flushing procedure is necessary and the manufacturer's manual should be consulted.

COMPRESSED AIR FOAM OPERATIONS

Advantages of CAFS:

- Increased penetration (high energy)
- Increased "soaking" ability – penetrates densely packed or compressed fuels
- Clings to vertical surfaces for exposure protection
- Lighter hose lines
- More efficiently uses water. Studies suggest that CAFS is four to five times more effective than plain water when suppressing fire and dissipating heat.

Contraindications of CAFS Use:

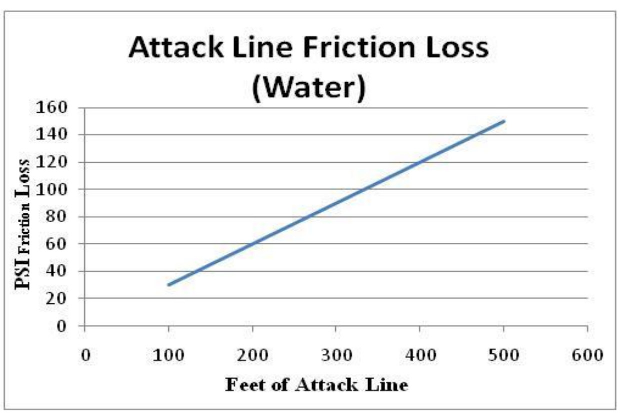
☒ Supplying fire protection systems, i.e. sprinkler or standpipe

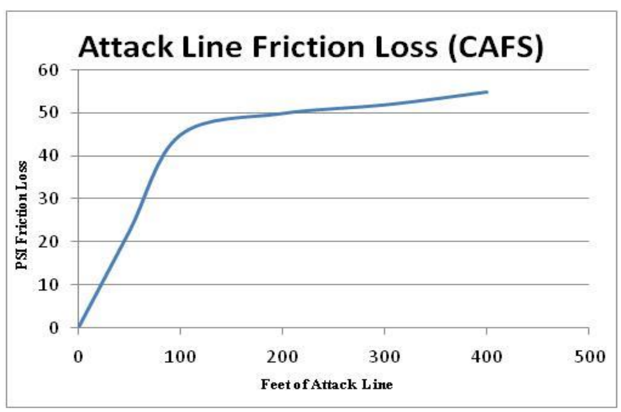
☒ Master stream or high-volume operations

☒ Supplying other fire apparatus – centrifugal pumps cannot pump CAFS

Many of the same principles for pumping traditional water pumps apply to pumping Compressed Air Foam Systems (CAFS), with a few exceptions. Friction loss still occurs with CAFS, but behaves differently than plain water. Pump operators must still account for friction loss due to appliances and loss or gain due to elevation.

The primary difference between plain water friction loss and CAFS friction loss is the non-linear relationship between friction loss per length of hose when using CAFS. With traditional water, 'Q' formulas allow operators to estimate friction loss in each length and diameter of hose flowing a known quantity of water. For example, a typical accepted value is 30 PSI of friction loss per 100 feet of 1 ¾" hose when flowing 150 GPM. This information can allow an operator to quickly decide that 200 feet of hose under the same circumstances would develop 60 PSI of friction loss and 300 feet develops 90 PSI. There is an assumed linear relationship between the length of hose and total friction loss within a hoseline.





Unlike hose flowing plain water, a CAFS attack line does not have friction loss equally distributed through the entire length of the hose. A CAFS attack line generates 45 PSI of friction loss in the first 100 feet of attack line and then proportionally less for every additional foot of deployed hose. Ultimately, a CAFS attack line may have more friction loss in a portion of the hose than plain water operations, but ultimately less friction loss when considering the entire hose length.

CAFS friction loss resembles a curve where plain water is a straight line. Given these conditions friction loss equations are not useful. CAFS operations dictate use of a pump pressure chart to obtain the desired flows. CAFS Engines are also equipped with flow meters to make monitoring flows possible.

Pump operators can remember some general flows for common CAFS attack lines in lengths between 100 and 400 feet with pump discharge pressures of 120 to 140 PSI:

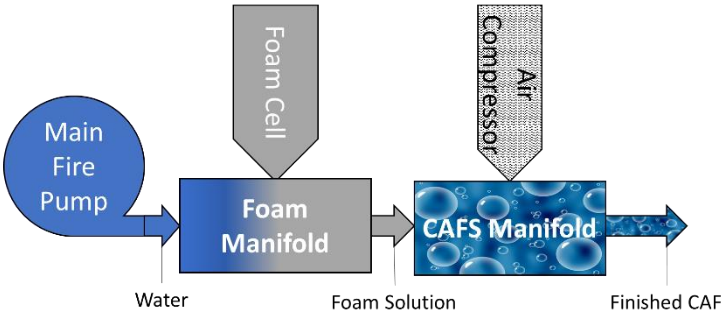
- ✓ 120 GPM for 1.75” hose
- ✓ 160 GPM for 2” hose

Pump Chart for MCFRS Crimson Engines				
Attack Line Features			Flow Rate	
Tip	Diameter (inches)	Length (feet)	120psi Pump Discharge Pressure	140psi Pump Discharge Pressure
TFT Metro 1	1 ¾”	200	120gpm	140gpm
TFT Metro 1	1 ¾”	350	120gpm	140gpm
TFT Metro 1	1 ¾”	400	110gpm	130gpm
TFT Metro 1	2”	300	160gpm	180gpm
1” smooth	2 ½”	250	170gpm	195gpm
1 1/8” smooth	2 ½”	250	205gpm	230gpm
1 ¼” smooth	2 ½”	250	245gpm	270gpm
TFT Metro 1 Leader Line	2 ½” and 1 ¾”	250 200	120gpm	135gpm
Note: slightly higher flows are expected with a 7/8” tip on TFT Metro 1 nozzles				

Major CAFS Components

Component	Function during CAFS
Main Fire Pump	Generates discharge pressure to push water, foam solution, or finished foam out of the nozzle
Water Tank	Supplies the water needed to make CAF
Foam Cell	Stores 25 gallons of Class A foam concentrate necessary for foam solution or CAF
Foam Manifold and Pump	Where the foam concentrate is proportioned and injected into the water stream and foam solution is created
CAFS Manifold and Compressor	Where compressed air is proportioned and injected into the foam solution and the air/water/concentrate mix is turned to finished CAF by X-type mixers within the manifold
Hoselines and Nozzles	Deliver the foam solution or finished CAF to the fire or other operation

Basic CAF Process



1. Water leaves discharge side of the pump.
2. Water enters the foam manifold where concentrate is injected by the foam pump.
3. Foam/water mixture (solution) enters the CAFS manifold where air is injected by the air compressor.
4. After air is injected in the CAFS Manifold, the foam product passes through mixing grates. This provides agitation. Further agitation and mixing occurs in the hose lines. Finished foam then comes out of the nozzle.

Air Compressor

CAFS utilizes a compressor that is separate from the chassis air compressor that supplies the brake systems, air horns, and other chassis functions. The CAFS compressor is a rotary screw oil-bathed design, thus oil is necessary for cooling internal components.

Belt-Driven Air Compressor

The compressor is powered by a belt originating at the pump gear box. The Crimson engines have a 210 standard cubic foot per minute compressor that generates pressures of 75 to 150psi. The pump impeller must be turning at a minimum of 1000 RPM to spin the compressor belt fast enough for the compressor to generate adequate volume (SCFM) and pressure (PSI) to support CAFS operations. This is what necessitates the use of the auto-fill feature on the pump intake when receiving a pressurized water supply.

Air/Oil Separator

The air compressor is attached to an Air/Oil separator that provides the following functions:

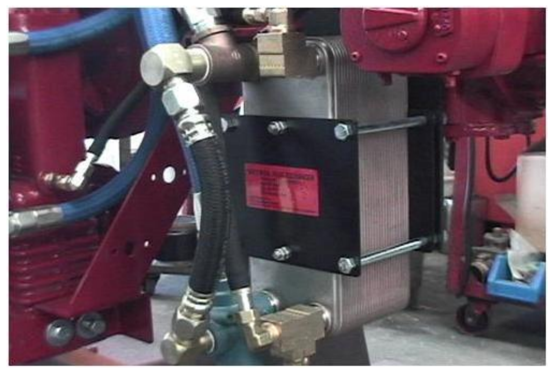
- Reduces the amount of stray oil that might be accidently injected into compressed air,
- Provides cooling oil for the compressor rotary screw,
- Acts as an oil reservoir,
- Provides some over pressure protection

Air/Oil Separator

The Air/Oil separator is located behind the pump panel. The oil level may be checked using an integrated sight glass. The level is checked when the oil is cool and free of froth. The sightglass is arranged between a Min/Max label. **DO NOT OVERFILL THIS RESERVOIR**. Bleed the water out of the Air/Oil Separator every month.

Water/Oil Heat Exchanger

The Water/Oil Heat Exchanger provides cooling for the oil that in turn cools the air compressor. The water used to cool the oil is circulated from the discharge side of the fire pump. This exchange of heat is critical for keeping compressor cooled, therfore it is critical to keep water circulating in the pump.



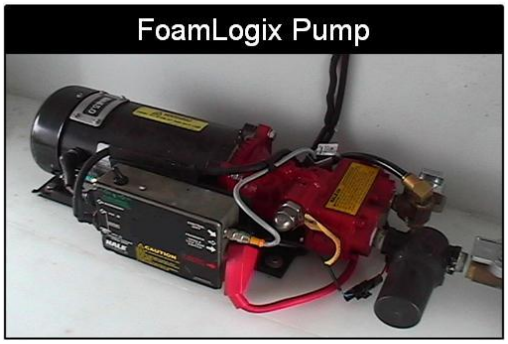
Water/Oil Heat Exchanger

Water/Oil Heat Exchanger Strainer

Water/Oil Heat Exchanger Strainer

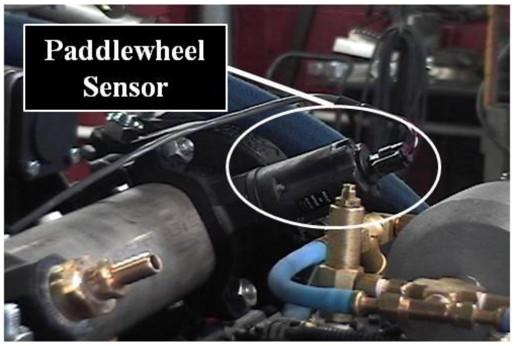
This strainer protects the air compressor water/oil heat exchanger and is located on the pump panel. The strainer should be cleaned out after every use of the CAFS system. *Do NOT open this cap when the pump is engaged - the cap will be under pressure and could cause serious injury.*

Foam Pump



Foam concentrate is delivered to the CAFS Manifold using a FoamLogix foam propotioning system. This pump is mounted on the foam manifold. This pump is capable of delivering up to 5 GPM of foam with the concentration controlled at the pump panel. The pump itself is rotary gear driven by an electronic motor.

The pump discharge pressure must be below 250 PSI for the pump to inject foam concentrate into the water stream.

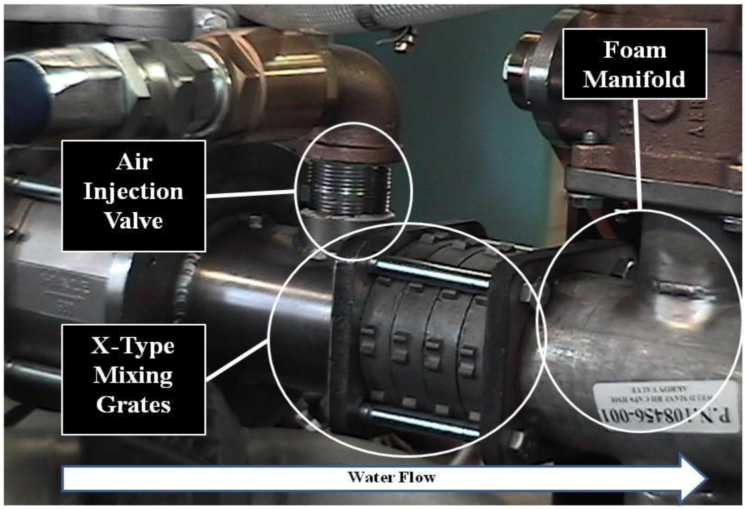


The foam injection volume is automatically monitored and adjusted based upon information received from a “paddlewheel” attached to the foam manifold. The “paddlewheel” sensor communicates electronically with the foam pump to adjust the foam flow to maintain the proportions set by the operator. The sensor is accurate when the manifold throughput is between 30 and 800 GPM.

CAFS Manifold

The foam manifold piping that distributes and discharges the completed foam product is constructed from stainless steel to resist the corrosive effects of foam. The manifold is capable of up to 1,000 GPM flow, thus total CAFS fire flow via any combination of handlines is 1,000 GPM.

On the Crimson engines, the CAFS manifold is installed downstream of the plain water discharge manifold that feeds the pump panel discharges (2 ½” and 4”) and deck gun discharge, therefore those discharges are not CAFS-capable. The CAFS Manifold receives water from a 4” discharge directly from the main pump manifold.

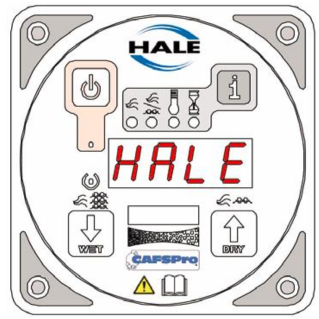


Foam Manifold

CAFS Manifold Operation

The CAFS Manifold is where air is injected into the foam solution to make CAF. A valve allows the operator to vary the quality or consistency of the finished foam being discharged, i.e. “dry” to “wet”. When a drier proportion is selected, the water valve partially closes and increases the volume of air mixed into the stream.

This valve is controlled by the CAFS Controller. When switching from Wet to Fluid Foam, or Fluid to Dry Foam, you must hold the up arrow down for three beeps before the controller will allow this action. This delay ensures the operator really wishes to perform this action.



- **Wet** - Full Water Flow – 1000 GPM
- **Fluid** – Medium Water Flow - 400 GPM
- **Dry** - Minimal Water Flow – 40 GPM

Always use Wet (default setting) CAFS for interior fire attack.
<u>Never</u> switch to fluid or dry CAFS when any crews are operating in a fire attack mode!

Switching to drier foam settings will decrease the amount of water available to the crews inside!

CAFS Audible Alarm

The CAFS is equipped with an audible alarm mounted at the pump panel that warns the operator of the following situations:

- When the air compressor oil temperature exceeds 205º F
- When the foam concentrate is running low
  - Refill the Class A foam tank or the compressed air foam operation will end.
- The compressor drive clutch is disengaged.

Direct Tank Fill (Auto Fill)

In order to support the necessary RPM for the CAFS compressor, pressurized water supplies are normally redirected to the onboard water tank rather than directly into the pump. CAFS operations always occur using tank water.

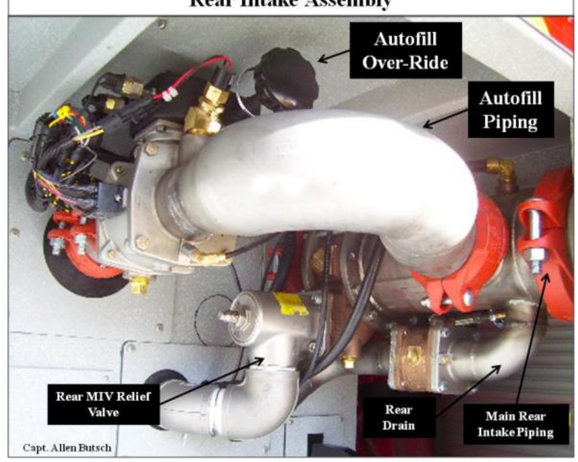
On the Crimson engines, the Direct Tank Fill is integrated with the rear intake and controls a 2½" pipe that connects to the booster tank. When operating using the Direct Tank Fill the rear MIV is left in the closed position.

The Direct Tank Fill has two operating modes; Auto or Manual. In Manual Mode the operator manages the water tank level by opening and closing the valve by utilizing the toggle switch. Auto Mode automatically monitors water tank levels and manages the level by automatically opening and closing the valve.

AutoFill Valve Specifications:

- Autofill Valve is plumbed from the rear master intake on the Crimson engines, outboard of rear MIV.
- Supplies a 2 ½" intake to the main tank fill.
- Auto Mode is indicated by an illuminated blue light on the control panel
- Requires 10 PSI of incoming pressure to operate
  - Below 10 PSI the valve will not operate in Auto mode. The blue light will not be illuminated.
  - Manual mode will function below 10 PSI, however careful monitoring of intake is required
- In Auto mode the booster tank level is monitored. When the booster tank falls below 3/4, the valve opens. When the tank refills to 7/8 the valve shuts.

Rear Intake Assembly



Air Operated Tank to Pump Override

Crimson engines are equipped with an air operated tank-to-pump valve. The valve automatically opens when the pump goes into gear and defaults to open if the air supply fails. If the operator wishes to close this valve, just push the close button.

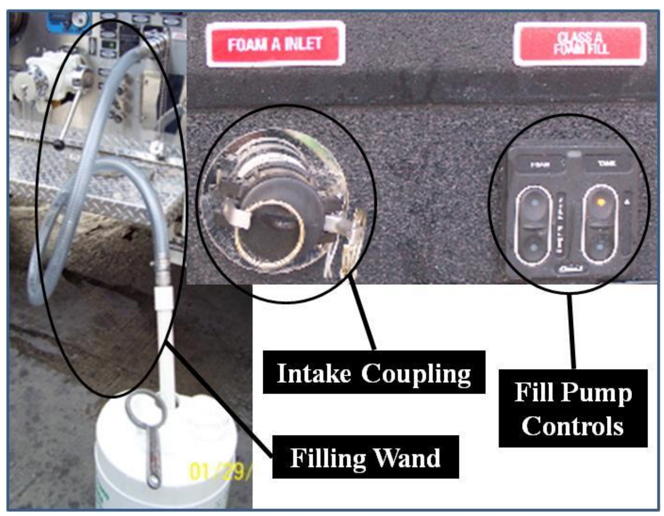
Why automatically open the tank to pump valve?

- It is preferential to run the CAFS using tank water to provide proper engine RPM to run the air compressor.
- The pump provides cooling water for the gear box and the air compressor. It is essential that the pump is *never* run without water in it.
- Engines are generally run with tank-to-pump valves open to facilitate rapid fire attack from tank water while water supply is being established. The operator need not remember to open the valve during the initial moments of arriving on a scene. Once water supply is established or when obtaining a draft during plain water operations, the operator may choose to close the tank-to-pump.

Total Pressure Master

In situations where the Direct Tank Fill may not be an option when receiving water from a pressurized source, the TPM can be adjusted to maintain the desired pump discharge pressure while increasing engine RPM to ensure adequate volume from the air compressor.

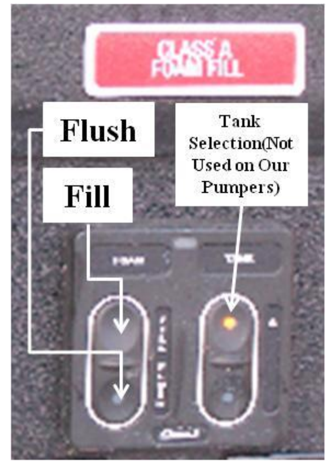
EZ-Fill



The EZ-Fill is an automatic foam cell refill system on the Crimson engines for the 25-gallons of Class A foam concentrate only. The EZ Fill system is comprised of:

- 5 GPM onboard transfer pump
    - Separate pump from FoamLogix injection pump
- Refilling Wand
    - connects to pump panel using an industrial type Cam-lock coupling hooks to pick up tube for insertion into foam bucket
- Class A Foam Refill and Class B refill connections are intentionally different to avoid contamination

Refill Pump Operations



1. Connect the refill wand to the pump panel and insert the wand into the Class A foam container
2. Push Fill to engage the foam transfer pump
   - Shuts off automatically after 60 seconds or when it senses foam cell is full
   - LED should be illuminated when pump is engaged
3. Disconnect the refill wand
4. Press Flush to engage the foam pump for 30 seconds and flush residual foam from the pump
5. Flush pickup tube after use with plain water and return to storage

The tank selection switch to the right of the Fill/Flush switch is not active on the Crimson engines. The EZ-Fill is only connected to the Class A foam cell. Class B foam concentrate is refilled from top of pumper directly into Class B cell. Never mix types or brands of foam within the onboard cells or foam systems.

COMPRESSED AIR FOAM SYSTEM CONTROLLERS

The CAFS foam concentration and air injection is managed by two controllers at the pump panel:

- **Foam Proportioning** - FoamLogix Concentrate Injection Control
- **Compressed Air Proportioning** - CAFSPro Air Injection Control

Both controllers are similar in appearance with operator controls oriented identically.

CAFSPro Air Injection Control


FoamLogix Concentrate Injection Control

<u>FoamLogix Controller Functions</u>

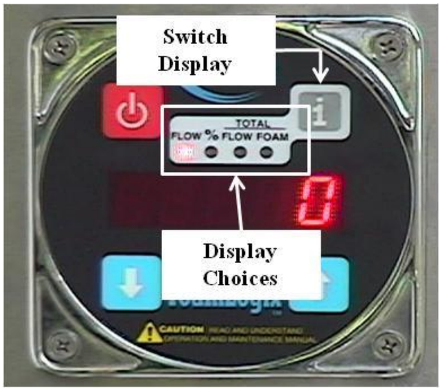
The FoamLogix Pump defaults to “on” when the fire pump is initially engaged.

The Foam Logix controller has the following general elements:

- On/Off Button
- Information Button
- Up and Down Arrows
- LED Bar Graph

The Information button scrolls through the following displays with the LED indicator illuminating for the respective screen:

- Flow
- % (Foam Injection)
- Total Flow
- Total Foam



Flow Display

Displays the total flow in GPM measured by the paddlewheel in the CAFS manifold at a moment in time. This represents the total flow and not the flow for individual discharges when operating multiple handlines.

Info Display - Flow

Info Display – Foam Injection Rate

% Display

Displays the foam percentage being injected into the system. The pump defaults to 0.3%, but may be changed using the arrow buttons within a range of 0.1 to 10.0%. It is not normal to need to adjust the rate. The "A" on the display indicates which foam cell is being used, which on a Crimson engine will always be "A".

Total Flow Display

Displays the total volume of water that has flowed through the Foam Manifold during a pumping session. The count begins when the fire pump is engage. Note: The totals automatically reset when the system is powered down.

Info Display – Total Gallons

Info Display – Total Foam

Total Foam Display

Displays the total volume of foam concentrate used during a pumping session. This may be useful during:

- o Foam cell refill
- o Insurance claims or reimbursement for fire department operations during extended or significant incidents
- o Usage tracking in the station

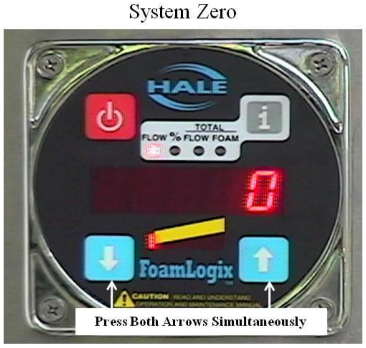
Note: The totals automatically reset when the system is powered down.

LED Bar Graph
Displays the amount of Foam Pump capacity being used and allows the operator to estimate capacity remaining during complex operations.

- A single LED lit indicates the foam pump is on and supplying concentrate.
- LED lit across the entire bar indicates all 5 GPM of foam pump capacity is being used.
    - No additional CAFS or foam solution can be produced

LED Bar Graph

System Zero



System Zero
If a reset of the Total Flow and Total Foam are desirable during an operation, press both arrows simultaneously. Note: The totals automatically reset when system is powered down.

CAFSProController Functions

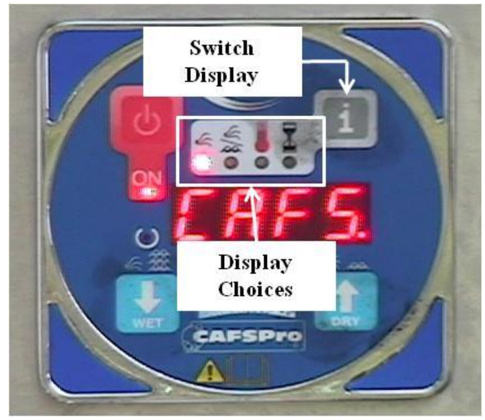
The CAFSPro controller (and CAFS air compressor) default to “on” when the fire pump is initially engaged.

The CAFSPro Controller has the following general elements:

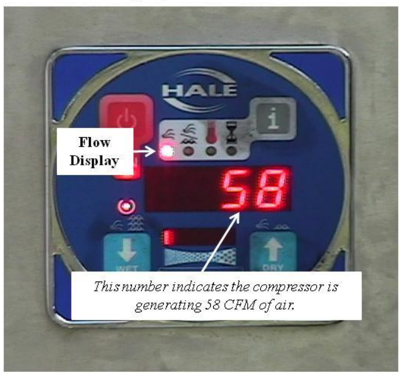
- On/Off Button
- Information Button
- Up and Down Arrows
- LED Bar Graph

The Information button scrolls through the following displays with the LED indicator illuminating for the respective screen:

- Air Flow (CFM)
- Air/Water Ratio
- Compressor Temperature
- Hours Run



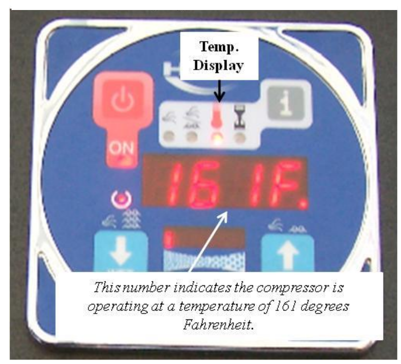
Info Display – Air Flow /CFM



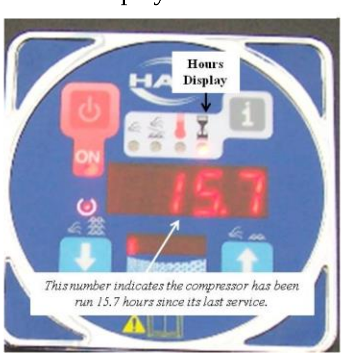
Air Flow Display
Displays the air flow to the CAFS manifold at a given moment in time. When flowing "wet" CAFS this should be approximately ½ the GPM of water flow.

Compressor Temperature Display
Allows the operator to monitor compressor status by displaying the current operating temperature of the CAFS air compressor. The audible alarm sounds at 205ºF.

Info Display – compressor temp



Info Display – total hours



Hours Run Display
Similar to the Engine Hours on fire apparatus, this display shows the total running hours for the CAFS Air Compressor.

Air to Water Display and LED Graph

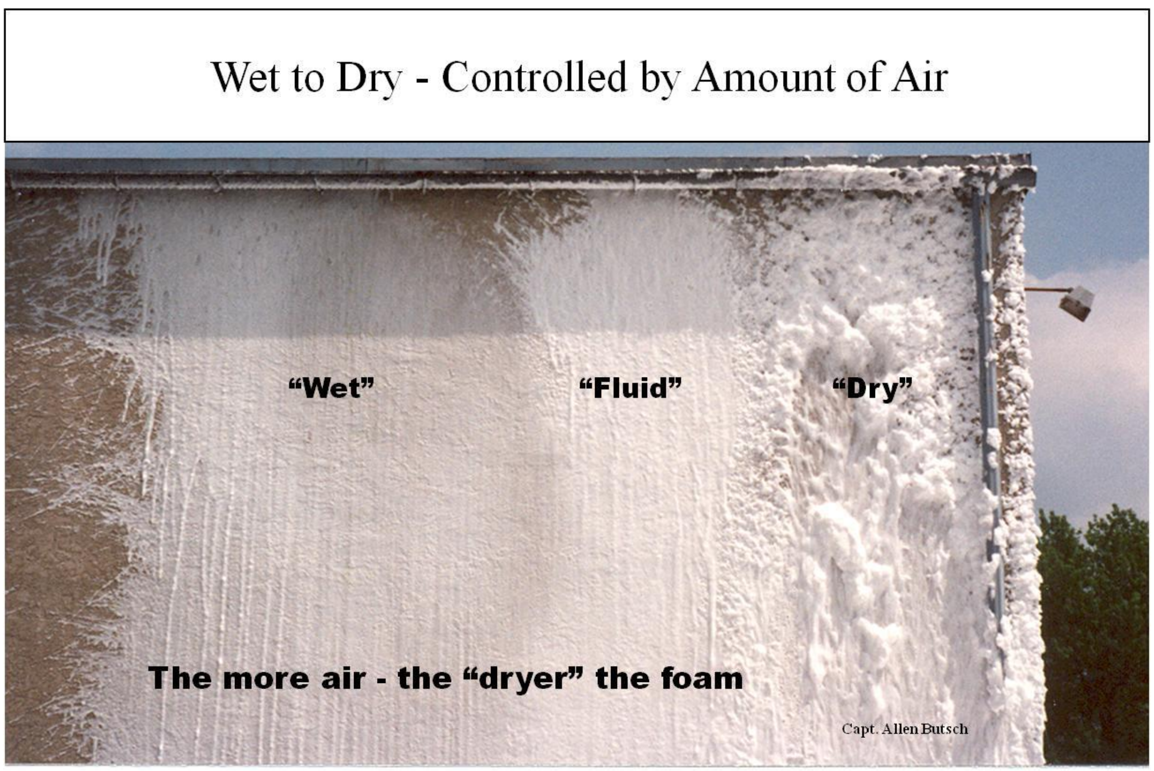
Displays the ratio of air injection to foam solution flow. This ratio may be adjusted using the "wet" and "dry" arrow buttons in a range from 0.5 to 11.0 with 0.5 being the default setting. The higher the ratio the more air is added and the finished CAFS is "dryer". NEVER increase the air ratio when crews are engaged in interior attack.

Type	Application	Ratio
Wet	Attack	0.5cfm/1gpm (default) 1.0cfm/1gpm 1.5cfm/1gpm
Medium or Fluid	Final Overhaul Immediate Exposure Protection	2.0cfm/1gpm
Dry	Long-term Exposure Protection	2.5cfm/1gpm 3.0cfm/1gpm 11.0cfm/1gpm

Info Display – Air to Water

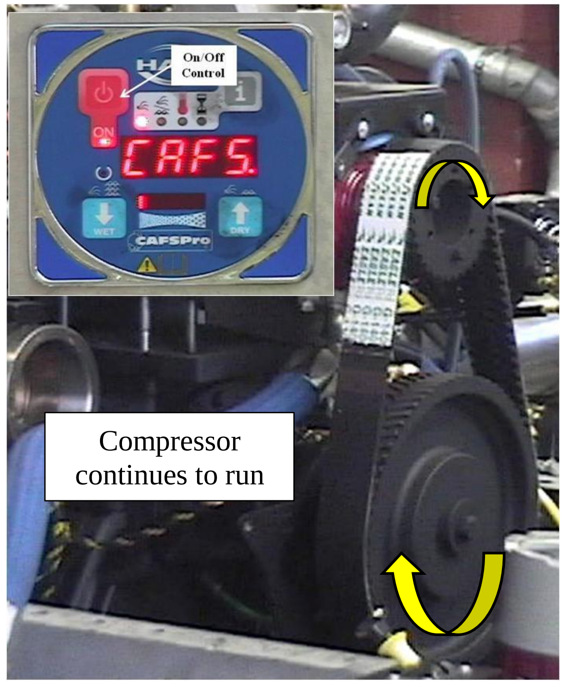
LED Bar Graph

Up / Down Arrows



COMPRESSOR MODES

The CAFS compressor defaults to "on" when the fire pump is engaged. There are situations where the operator needs to disengage the compressor to avoid overheating or damage.

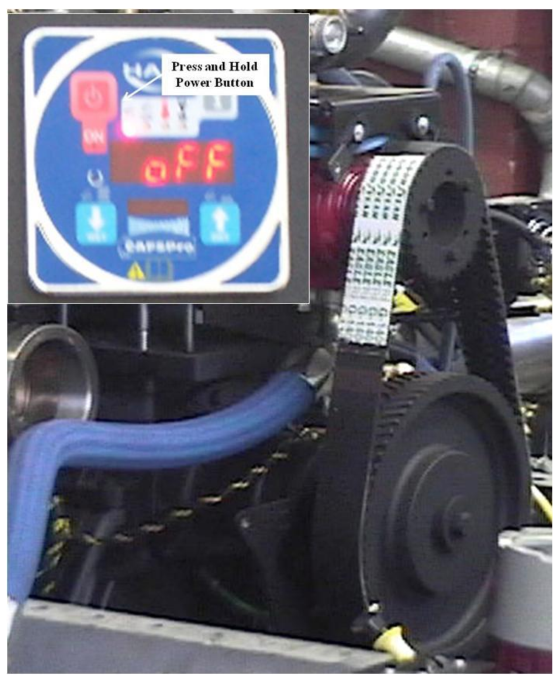


Standby

Used when CAFS is not currently needed, however there is an anticipation that it may be used. The compressor continues to run, however the air injection valve on the Foam Manifold closes. This mode allows the operator to transition from plain water or foam solution operations to CAFS immediately.

To place the compressor in standby mode:

1. Compressor is engaged and running
2. Operator presses the Power Button once and releases it.
3. Controller should display "Stby"
4. If CAFS is desired, depress the Power Button again to open the air injection valve.



Off

Used when there is no reasonable expectation that CAFS will be needed during the current operation. For additional guidance see the FCGO #17-14. Additionally, operators must shut off the compressor when:

- Plain water or foam solution is needed above 150 PSI pump discharge pressure
- If failure of foam system and safety interlock engage - slug flow & chatter
- Foam concentrate supply is exhausted

To turn the compressor off:

1. Compressor is engaged and turning
2. Reduce engine speed to idle!
3. Operator presses and holds the Power Button
   - Listen for 3 Beeps and the controller displays a count down: "3,2,1, oFF"
4. Compressor is now not turning; the pump must be taken out of gear to return the compressor to use. **There is no ability to immediately re-start**.

COMPRESSOR OUTPUT

Compressor output is integral to the creation of finished CAF. The compressor is driven by a belt connected to the pump gear box. If the apparatus motor is running too slowly, then the compressor will not generate the needed air volume (CFM). The apparatus motor must be turning at or above 1,000 RPM to provide sufficient power for the compressor. The motor RPM not only effects the air compressor, but is also directly tied to the pump impeller RPM. As impeller RPM increases, so does pump discharge pressure. This can create a conflict between the RPM desired for the compressor and the discharge pressure.

CAFS apparatus have two features that allow an operator to maintain adequate motor RPM when supplied by a pressurized water source:

- Option 1: Total Pressure Master Relief Valve System
- Option 2: Direct Tank Fill/Autofill Valve

The table below illustrates the concern. Note that Air Volume Discharge is insufficient when operating from a pressurized source.

Speed Comparisons Without Using TPM

Water Source	Intake Pressure	Engine RPMs	Compressor RPMs	Water Pressure Discharge	Air Volume Discharge
Pressurized Source	60 PSI	Idle	Idle	100 psi	Insufficient
Booster Tank	~ 0 to 1 psi	1050	Proper Range (*>1000*)	100 psi	Sufficient
Draft	-7 psi (Vacuum)	1100	Proper Range (*>1000*)	100 psi	Sufficient

Option 1: The Total Pressure Master (TPM) permits the operator to maintain motor RPM for compressor output while managing the discharge pressure when operating from a pressurized water source. The example below shows how setting the TPM at 100 PSI allows the operator to adjust engine speed to support the compressor.

Speed Comparisons Using TPM

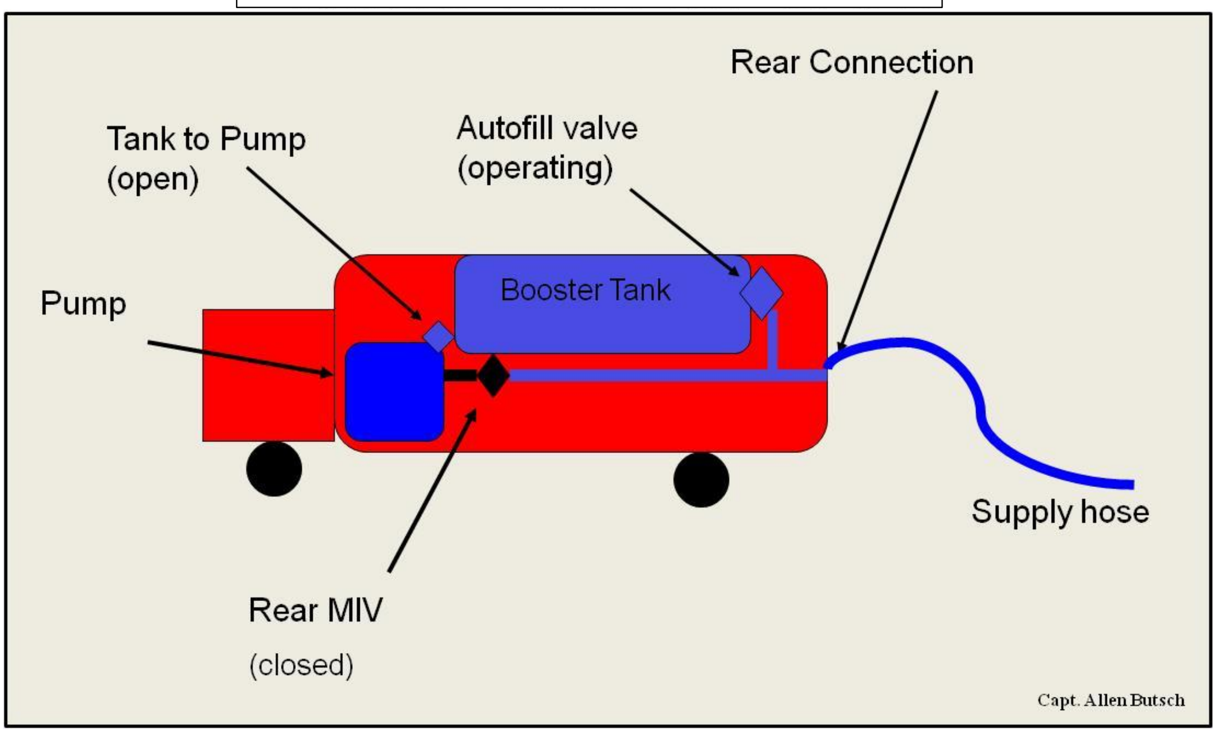
Source	Intake Pressure	Engine RPMs	Compressor RPMs	Water Pressure Discharge	Air Volume Discharge
Pressurized Source (NO TPM)	60 PSI	700	Not in Proper Range (<1000)	100 psi	Insufficient
Pressurized Source (TPM set at 100psi)	60 PSI	1000	Proper Range (>1000)	100 psi	Sufficient

Option 2: Operators can avoid the effects of intake pressure by operating from the onboard water tank (static source) rather than an intake. Most operations will require the establishment of a water supply larger than the quantity available in the water tank, therefore an outside source is needed. The Direct Tank Fill/Auto Fill supports receiving a pressurized water source by automatically directing incoming water to the water tank and not the pump. The MIV remains closed when the Auto Fill is engaged.

When using this option, the operator must remain aware of the following:

1. Th Direct Tank Fill is only connected to one intake, therefore that intake must be used for this option to function. On the Crimson engines this means using the rear intake during CAF operations.
2. Since the water supply is being directed into the water tank, there will be no positive pressure indication on the master intake gauge.
3. The operator must remain vigilant of the water tank level throughout the operation to identify sufficient water supply. There will be no immediate indication of any water supply problems. The supply line itself should be monitoring for signs of pressure loss or fluctuation. Another function to monitor is the Auto Fill. The blue Auto Mode indicator light should be illuminated if the water supply is present.

Preferred Water Supply Path for CAFS



Pump Configurations - CAFS vs. Plain Water

Pump Element	CAFS Mode	Plain Water Mode
Tank to Pump Valve	Open	*Closed*
Rear MIV	*Closed*	Open
Intake Gauge Reading	0	Indicates Pressure

BASIC CAF OPERATION FOR CRIMSON ENGINES

1. Position the apparatus and shift into Pump Gear. Pump functions default for CAFS use.
    - Tank to pump valve is automatically open
    - AutoFill is active.
    - CAFS functions (foam pump and compressor) are active.
2. Establish an external water supply via the Rear Intake.
    - Do NOT open Rear MIV when Auto Fill is engaged.
3. Deploy desired hoselines from CAFS-capable discharges and clear hosebeds.
4. Set TPM to desired PSI and increase throttle to develop desired discharge pressure for flow.
5. Open appropriate discharge valve slowly.
6. Monitor gauges, water tank level, foam tank level, Auto Fill status.
7. At the completion of operations, shut down foam pump and air compressor. Ensure water and air pressure are fully bled from the plumbing and hoselines. Flow plain water through the discharges and hoselines until signs of foam are gone.
8. Replenish water and foam tanks.

BASIC PLAIN WATER OPERATION FOR CRIMSON ENGINES

CAFSPro Air Injection Control

FoamLogix Concentrate Injection Control

1. Position the apparatus and shift into Pump Gear. Pump functions default for CAFS use.
2. Turn off Foam Pump and Air Compressor using the “Power” buttons on the FoamLogix and CAFSPro Controllers.
    - Pump is now in Plain Water mode.
3. Estabish an external water supply via convenient intake.
    - Intake selection is not dependent upon Auto Fill
    - Use the MIV to control water flow to the pump
4. Deploy desired hoselines from any discharge.
5. Set TPM to desired PSI and increase throttle to develop desired discharge pressure for flow.
6. Open appropriate discharge valve slowly.
7. Monitor gauges and water tank level.
8. At the completion of operations, ensure water and air pressure are fully bled from the plumbing and hoselines. Replenish tank water.

CAFS LIMITATIONS AND LINE REQUIREMENTS

Water	**Foam Concentrate**	**Compressed Air**
Foam Manifold capacity is 1,000gpm Limited by the number of discharges on the manifold	Foam Pump capacity is 5gpm	Compressor capacity is 210cfm
Fire Pump rated capacity is 1,500gpm Actual capacity of up to 2,250gpm	MCFRS system defaults to 0.3% injection rate for wet foam	

Crimson Engine Pre-Connected Attack Lines

Location	**Valve ID**	**Hose Diameter**	**Hose Length**	**Foam Capability**	**Nozzle Type**
Crosslay	#1	1 ¾”	200’	CAFS	Combination
	#2	1 ¾”	200’	CAFS	Combination
	#3	2”	250’	CAFS	Combination
Rear Hosebed	Left	2 ½”	250’	Solution	Portable Monitor
	Center	2”	300’	CAFS	Combination
	Right	2 ½”	250’	CAFS	Smooth Bore

CAF Hoseline Resource Requirements

Hoseline Details	Air/Water Mix	Water	Foam Concentrate	Compressed Air
1 ¾” preconnect	Wet	120gpm	0.6gpm	60cfm
2” preconnect	Dry	160gpm	0.8gpm	80cfm
2 ½” preconnect	Wet	240gpm	1.2gpm	120cfm
2 ½” preconnect	Dry	30gpm	0.3gpm	200+ cfm
3” portable master stream	Wet	340gpm	1.7gpm	170cfm
3” portable master stream	Dry	30gpm	0.3gpm	200+ cfm

Attack Line Management

The primary limiting factor of the CAFS is the capacity of the air compressor.

The CAFS components are capable of supplying large quantities of water and relatively high flows of foam concentrate, however as shown in the CAF Hoseline Resource Requirements table on the previous page, one "wet" 1 ¾" handline (the most common usage) requires almost 1/3 of the total capacity of the CAF air compressor. The compressor production requirements only increase as dryer mixtures are used.

When operating a Crimson engine, the following attack line configurations may be supported when the components are operating within their rated capacities:

Wet	Dry
Any combination of up to three 1 ¾" or 2" hoselines	One 1 ¾" hoseline
1 ¾" – 60cfm 1 ¾" – 60 cfm 2" – 70cfm 190cfm total	1 ¾" – 110cfm total
OR	*OR*
One 1 ¾" or 2" hoseline and one 2 ½" hoseline	One 2 ½" hoseline
1 ¾" – 60cfm 2 ½" – 120cfm 180cfm total	2 ½" – 200+ cfm
These are your configuration limitations when operating with CAFS!	

Application Techniques

Normal direct and indirect attack nozzle management techniques are appropriate when applying CAF. The higher energy within the stream permits longer "standoff" distances and more bounce. The nozzle operator should open and close the nozzle slowly due to the potential for increased nozzle reaction. After knocking a fire down, continue to apply CAF for same amount of time it took to achieve knockdown to continue to cool the fuel.

"Painting" is an older concept of denying the fire additional fuel by applying the foam to each surface in turn, usually starting with the ceiling. This technique was developed to cope with the limited flows that earlier CAFS systems produced. It is better to have the required fire flow to start to avoid using this technique. Painting is not recommended for interior firefighting.

A common misconception with CAF is that it requires less water flow. The fire flow requirements determined using the NFA and Iowa formulas still apply. The key difference is that CAF reduces the amount of time these flows are required to achieve knockdown. The flows are not reduced, only the total amount of water used.

PROBLEMS WITH CAFS

Slug Flow

Slug-flow refers to a condition caused when plain water instead of foam solution is injected with compressed air in the CAFS Manifold. It occurs when the foam liquid concentrate proportioning system is accidentally shut off, malfunctions, or runs out of liquid concentrate. The result is that only plain water and air fill the hose. Since plain water and air do not mix, they "slug" and separate as they move through the hoseline toward the nozzle, causing a rapid forward and aft pulsation, constituting a dangerous hose-handling situation, a totally useless fire stream, chafing of the hose`s exterior, and increasing stress on hose couplings.

Chatter

Some CAFS are not equipped with mixing chambers on the CAFS Manifold. The absence of a mixing chamber on the CAF system discharge will cause the first (and possibly the second) section of hoseline to vibrate as all three finished-foam components (air, water, and foam liquid concentrate) scrub together, making bubbles within the hoseline itself. The Crimson engines are equipped with mixing chambers to prevent this disjointed, separate mixture of air, water, and concentrate from being injected in the hoseline. Mixing chambers create finished foam within the device, discharging a homogenized mixture of foam bubbles into the hose, meaning that the hoseline does not have to do the scrubbing work, thereby preventing chatter and exterior hose chafing.

Insufficent Fire Flow

While CAFS generally requires less total water be discharged, the BTU being created by the fire still must be overcome by adequate water flow.