Firetrol®

# Fire Pump Controls Presentation

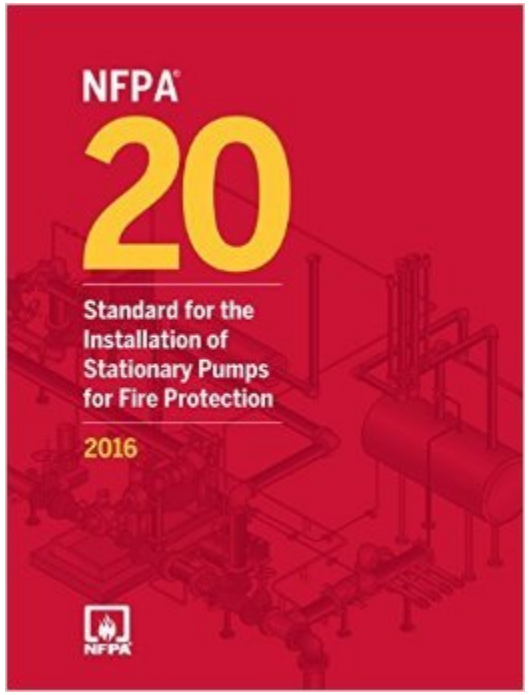
Presented by
Mike Bruce- AIC

AIC
Applied
Industrial
Controls

# *Firetrol Today Is:*

- Apex, NC
  - Sales and Marketing
  - Engineering
  - Field Service
- Manufacturing- Laval, Canada

# NFPA 20


NFPA
20
Standard for the Installation of Stationary Pumps for Fire Protection
2016
NFPA

# Why NFPA-20?

- ***The Standard* for** *the Installation of Stationary Pumps for Fire Protection*
- **Accepted & Adopted by ANSI**
- **Defines Performance of the:**
  - **Fire Pump**
  - **The Driver:  Engine or Electric Motor**
  - **Fire Pump Controller**

- **A <u>MINIMUM</u> Standard**
- **NEC 695 has similar language**

# The Two Basic Types of Pump Controllers:

**Controller per** NFPA-20

**Life Safety Equipment**

**Motor Starter- Per NEC**

**Non Life Safety**

# Primary Design

## Controller per NFPA-20

System operation is primary

Protection of connected motor is secondary

## Motor starter per NEC

Protection of connected motor is primary

System operation is secondary

# *Specific Component or Design Differences Include:*

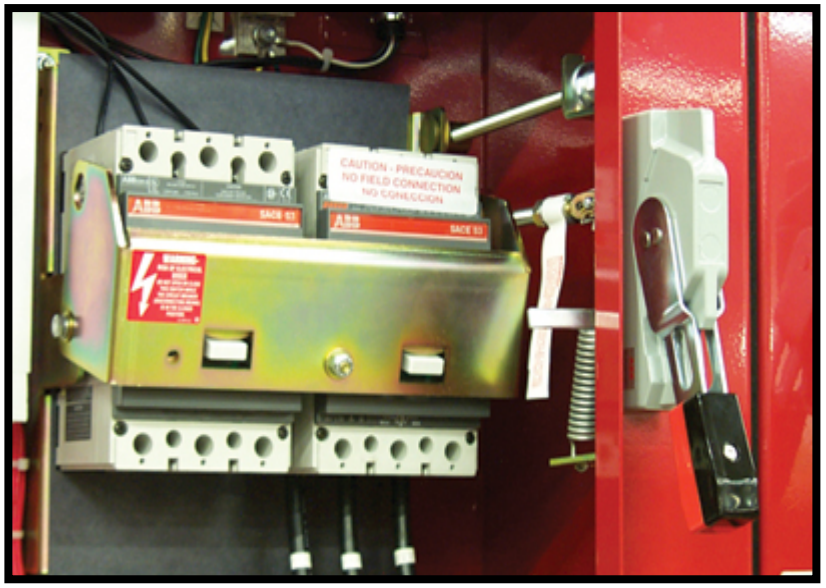
## Per NFPA 20, 2013

- Circuit Breakers
  - NFPA 20 10.4.3 thru 10.4.4
- Service Entrance Ratings
  - NFPA 20 10.1.2.4
- Short Circuit Current Ratings
  - NFPA 20 9.2.2-4(e)
- Motor Contactors
  - NFPA 20 10.4.5
- Starting Circuits
  - NFPA 20 10.5
- Pressure Sensing Devices
  - NFPA 20 10.5.2.1.1.1

Firetrol

# Fire Pump Circuit Breaker

- Fire pump controller circuit breaker
  - Magnetic only
  - Special trip curve per NFPA 20, 2013 10.4.4.1
- Trip characteristics
  - carry a minimum 300% MFLC for 3 minutes
  - trip at locked rotor in 8-20 seconds (600% Motor FLC)
  - Short circuit trip instantaneously
- Isolating switch and circuit breaker assembly
  - Note single handle operator




Firetrol

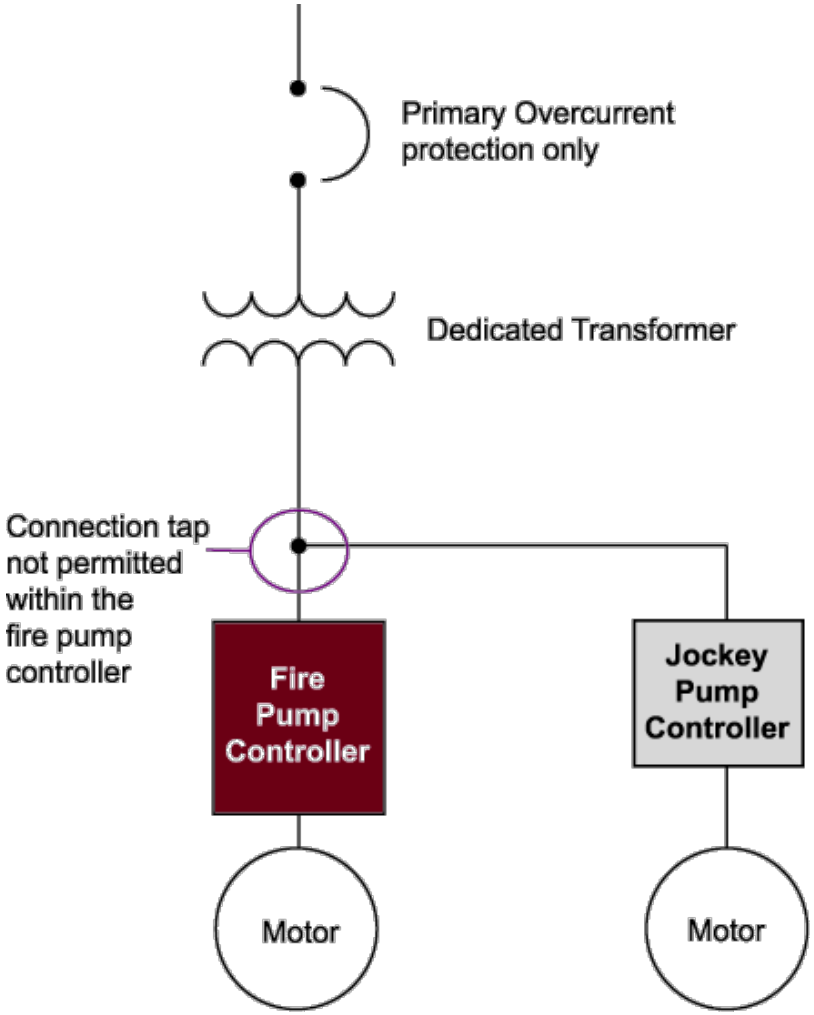
# Circuit Breaker Review

- Controller per **NFPA-20**
  - 300% Motor FLA MIN
  - 600% Motor FLA for 8-20 Seconds
  - 2000% Instantaneous Trip
- Motor Starter
  - Instantaneous Trip at 125%-150% Motor FLA

Firetrol

# Article 695, NEC

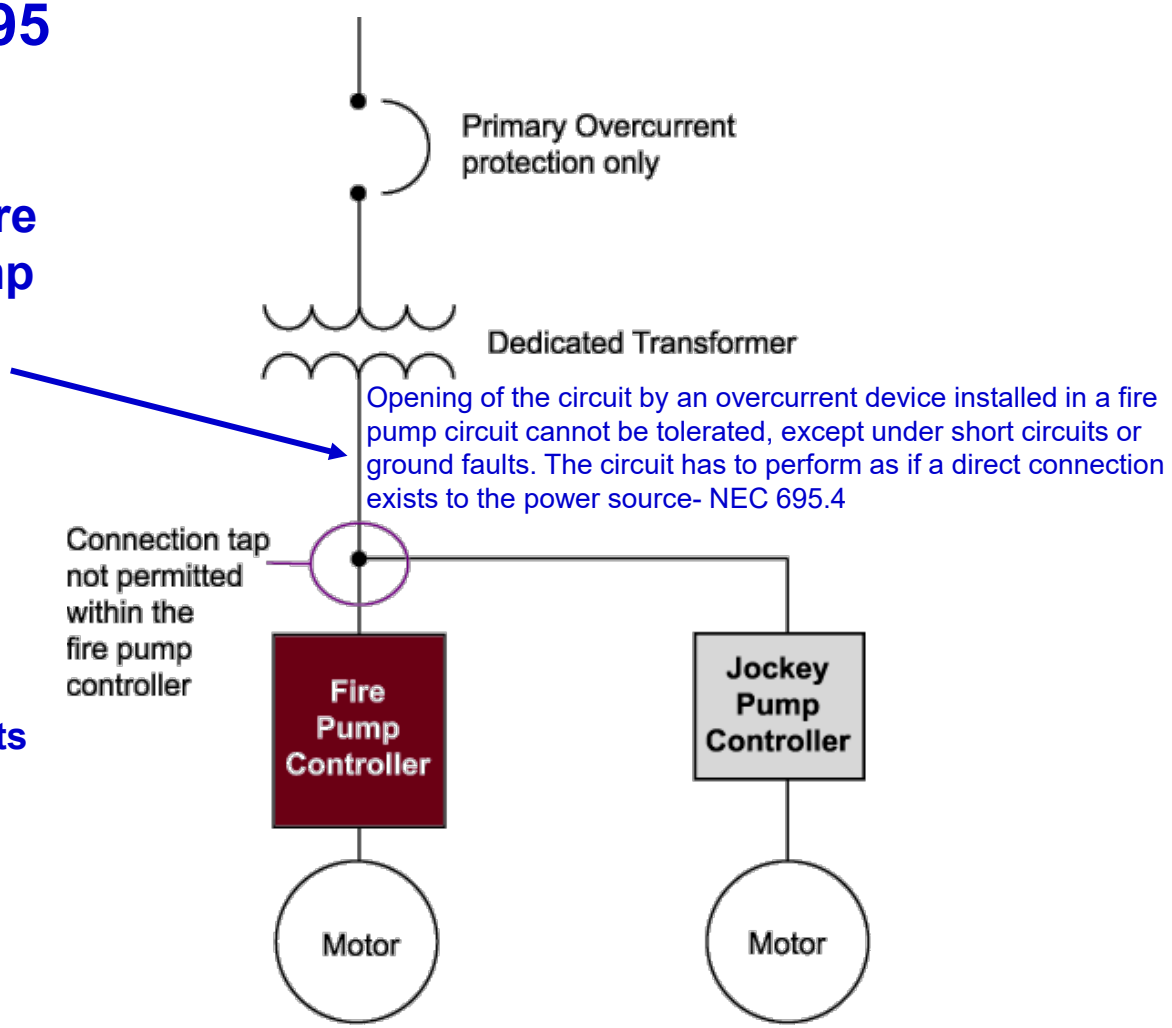
## Typical Power Arrangement



# Exceptions

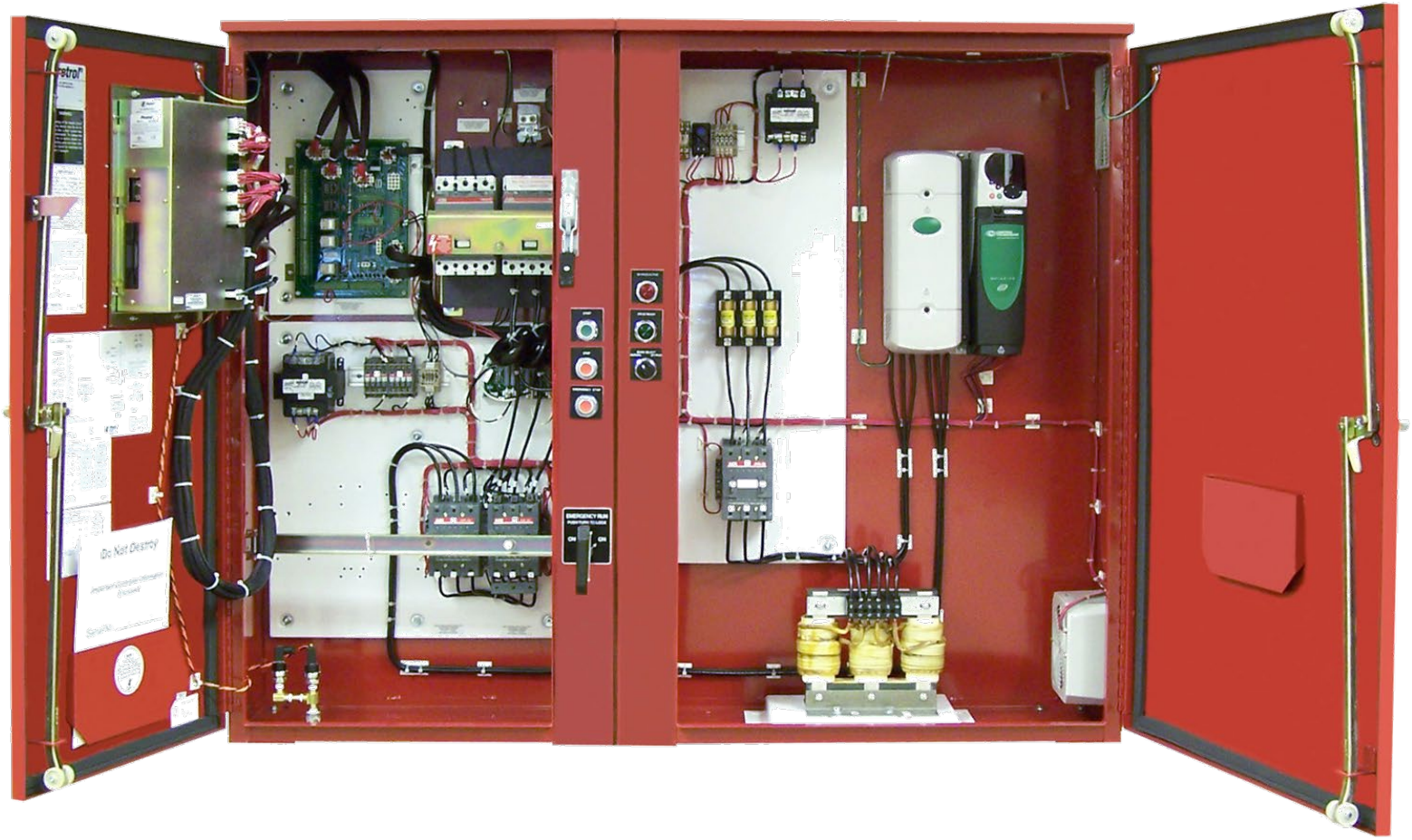
## NFPA 20 9.2.3 & NEC 695

**An OCPD rated to carry indefinitely the sum of the locked rotor current of the fire pump motor and jockey pump motor**




1. Rated as SE Equipment
2. Lockable Closed Position
3. Remote From Other Disconnects
4. Marked Fire Pump Disconnect
5. Monitored
6. Trip Point Not Field Adjustable

# Electric Driven Fire Pump Controllers




## *Starting Methods*

# What impact does the motor starting method have on the electrical system?

- The starting method provides control of the current inrush (Amperage) during motor starting.
- The current inrush (amperage) created by the motor reaches it's peak during motor starting. This high amperage load causes incoming voltage to drop.

## Amperage Load Example - Full Voltage Starting

100HP Fire Pump Motor operating at 480 volts

Full Load Amperage = 124 Amps

Across the Line Starting Amps = 6 x 124 = 774 Amps

# Choosing Starting Method

The high motor starting amperage load will effect many electrical system components……..

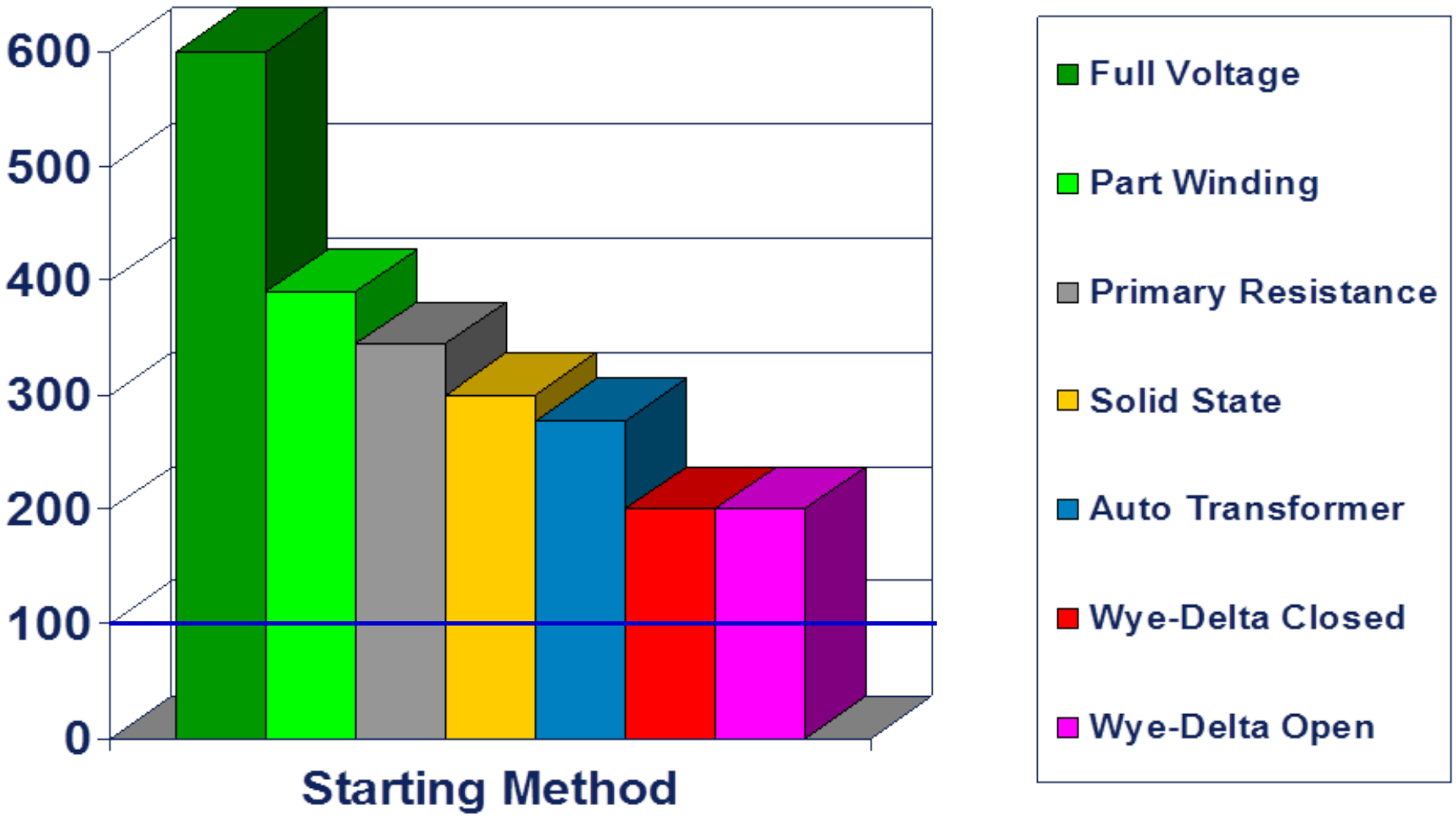
**Utility Transformer Size**

**Emergency Generator Size**

**Cable Size**

# Starting Methods

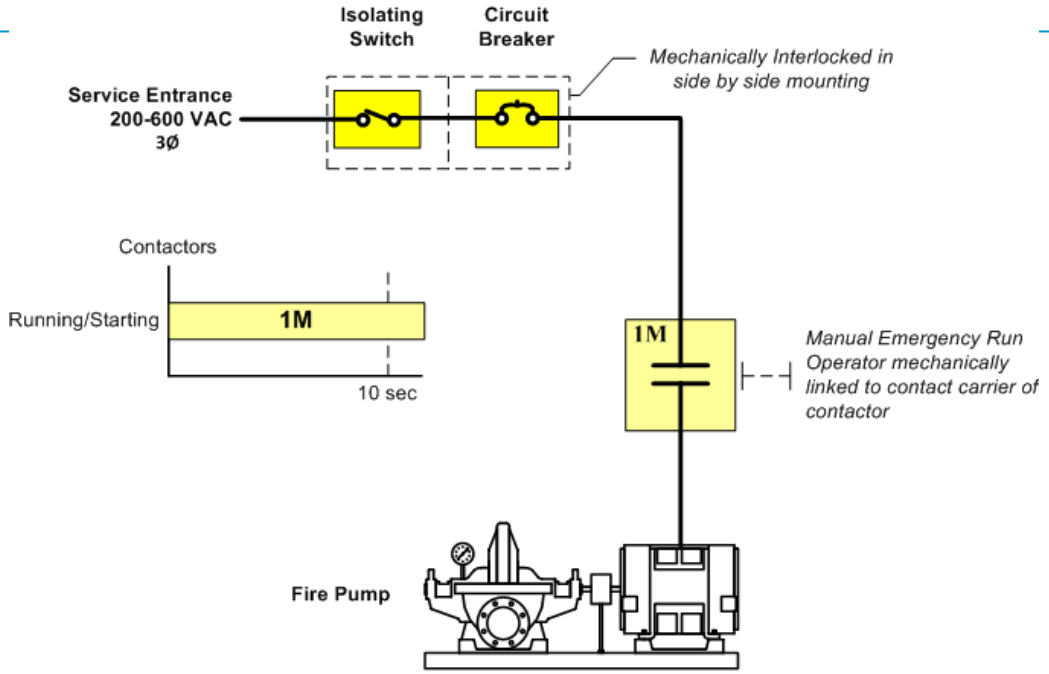
- Full Voltage (Across the Line)
- Part Winding Start
- Wye-Delta Open Transition
- Wye-Delta Closed Transition
- Primary Resistor
- Auto Transformer
- Soft Starting
- VFD

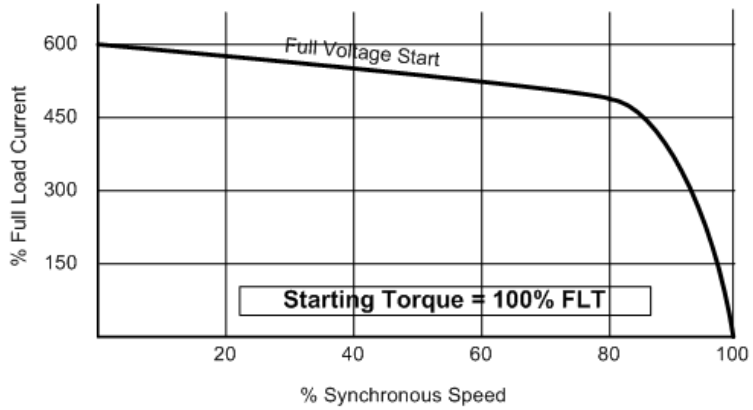

600
500
400
300
200
100
0
Starting Method
Full Voltage
Part Winding
Primary Resistance
Solid State
Auto Transformer
Wye-Delta Closed
Wye-Delta Open

# Electric Fire Pump Controllers

| Starting Method | % Motor Full Load Starting Amps | % Torque | Advantages | Disadvantages | Cost Index |
|---|---|---|---|---|---|
| Full Voltage | 600 | 100 | Low Cost<br>High Starting Torque<br>Uses Standard Motors | High Starting Current | 100 |
| Part Winding | 390 | 42 | Low Cost | Special Motors | 120 |
| Wye-Delta Open | 200 | 33 | Low Starting Current<br>Medium Starting Torque | Power Line Transients<br>Special Motors | 130 |
| Wye-Delta Closed | 200 | 33 | Low Starting Current<br>Medium Starting Torque<br>No Line Transients | More Expensive | 185 |
| Primary Resistor | 300 | 25 | Standard Motors<br>Low Starting Torque | High Starting Current<br>Resistive Heating | 150 |
| Auto Transformer | 150 – 50% Tap<br>252 – 65% Tap<br>384 – 80% Tap | 25<br>42<br>64 | Highest Starting Torque<br>Low Starting Current<br>Uses Standard Motors | Expensive | 200 |
| Solid State Soft Start | 300 | 15 | Soft Start & Soft Stop<br>Reduced Water Hammer<br>Redundant Power Circuit<br>Standard Motors | Expensive | 180 |
| VFD | 125 | 100 | Pressure Limiting<br>Soft Start & Stop<br>Reduced Water Hammer<br>Standard Motors<br>Redundant Power Circuit | Most Expensive<br>Large Footprint<br>VFD Rated Motor<br>Cannot Use Motor S.F. | 450 |

# Power Train
# FTA1000 Full Voltage Start



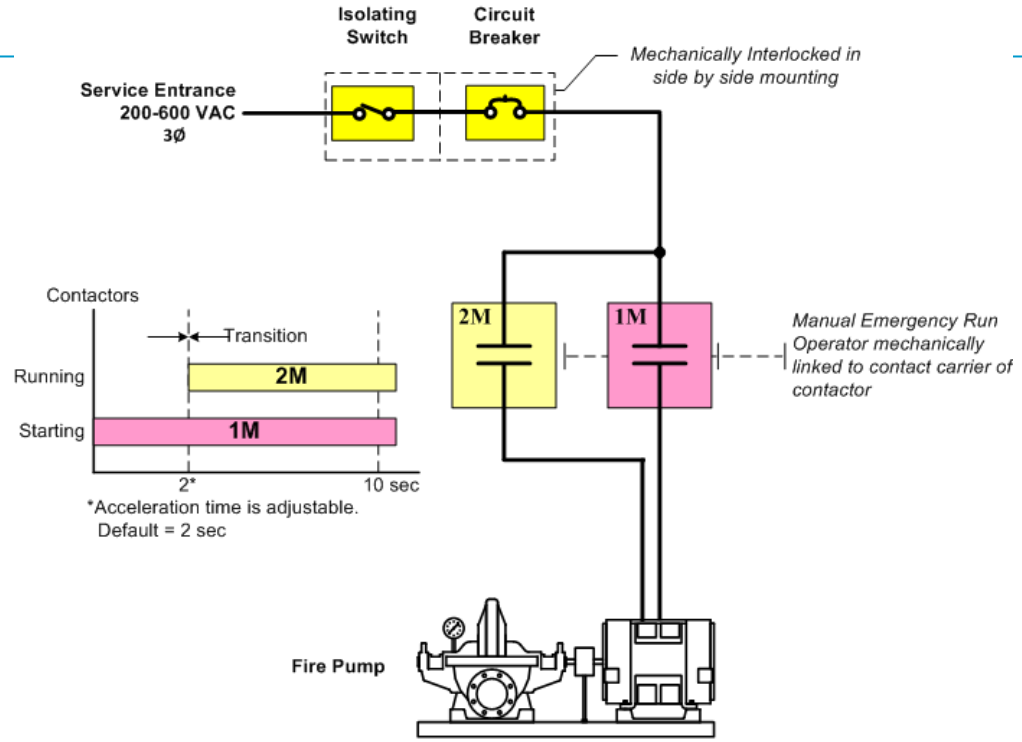

Firetrol

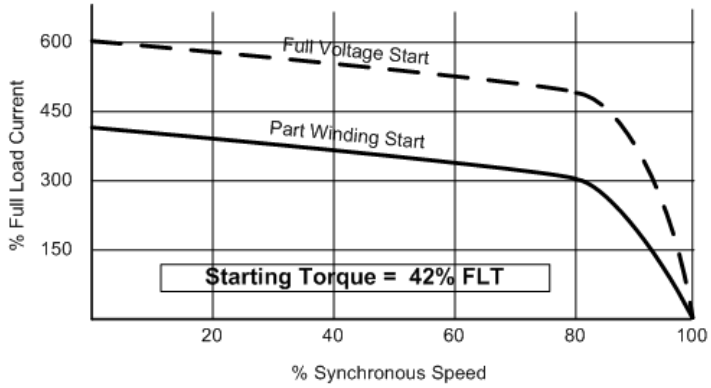
# Full Voltage

- **ADVANTAGES**
  - Preferred Method
  - Uses Standard Motors
  - Most Economical
  - Simplest Most Efficient
- **DISADVANTAGES**
  - High Starting Current - 600%

Firetrol

# Power Train
# FTA1250 Part Winding Start



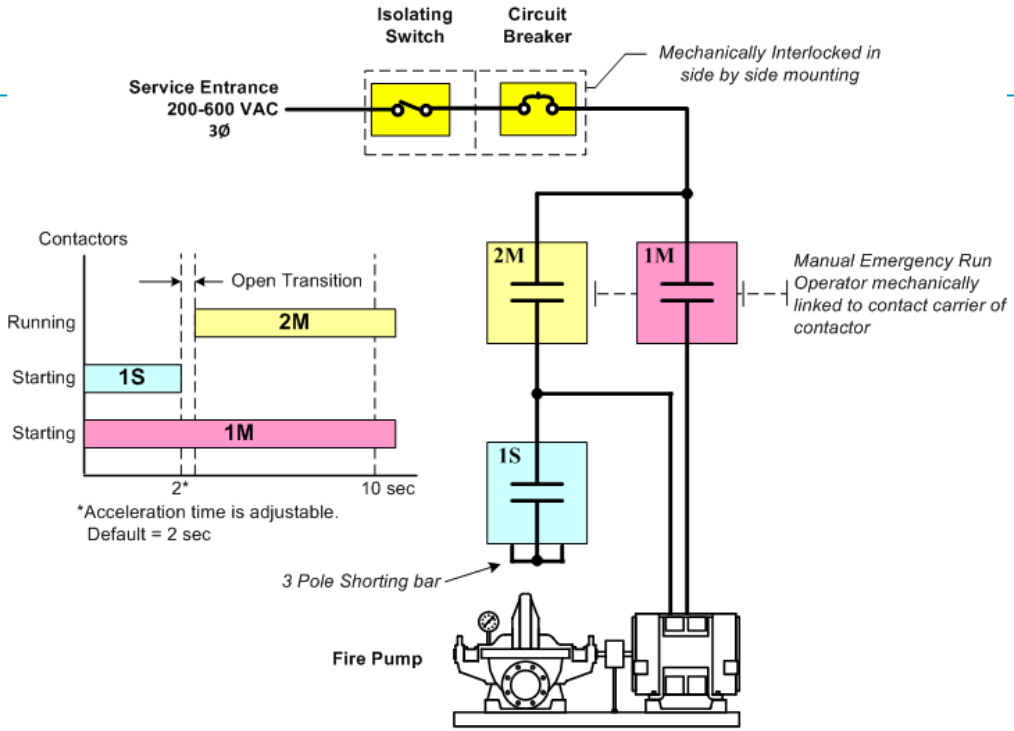

Firetrol

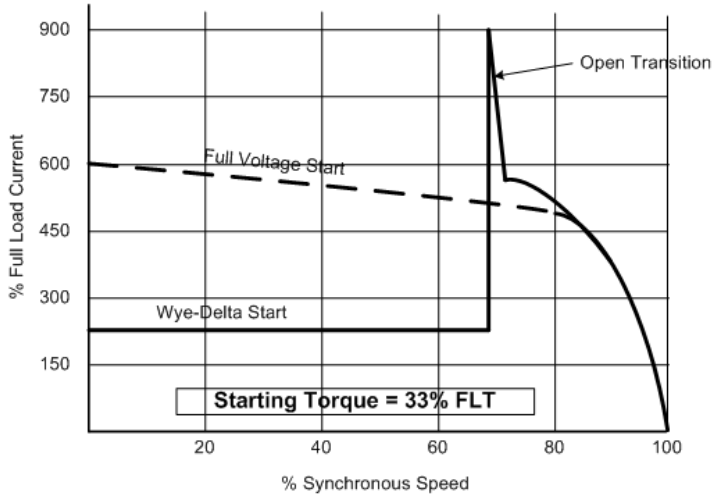
# Part Winding

- **ADVANTAGES**
  - Lower Starting Current - 390%
  - Economical
- **DISADVANTAGES**
  - Low in Preferrence- 10%
  - Requires 6 or 12 Lead Motors
  - Special at 200-208 and 440-480 Volts

Firetrol

# Power Train
# FTA1300 Wye-Delta Open Transition Start



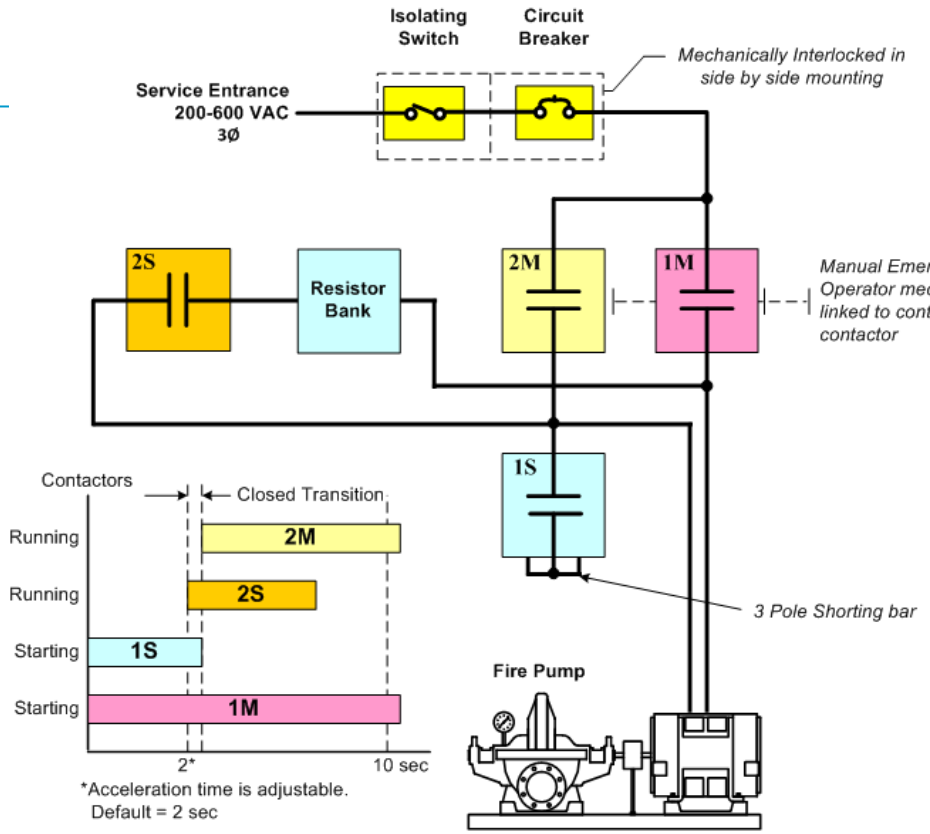



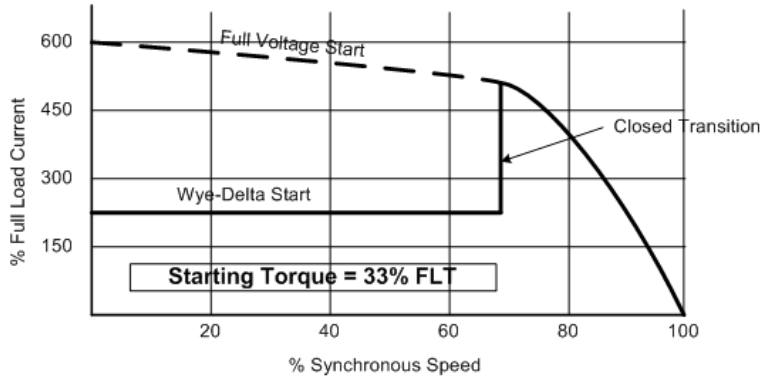

Firetrol

# Wye-Delta Open

- **ADVANTAGES**
  - Most used for Transfer Switch Applications
  - Low Starting Current- 200%
- **DISADVANTAGES**
  - Low Starting Torque- 33%
  - Requires 6 or 12 Lead Motors
  - Special at 200-208 Volts
  - Open Transition May Cause Line Disturbances

# Power Train
# FTA1350 Wye-Delta Closed Transition Start



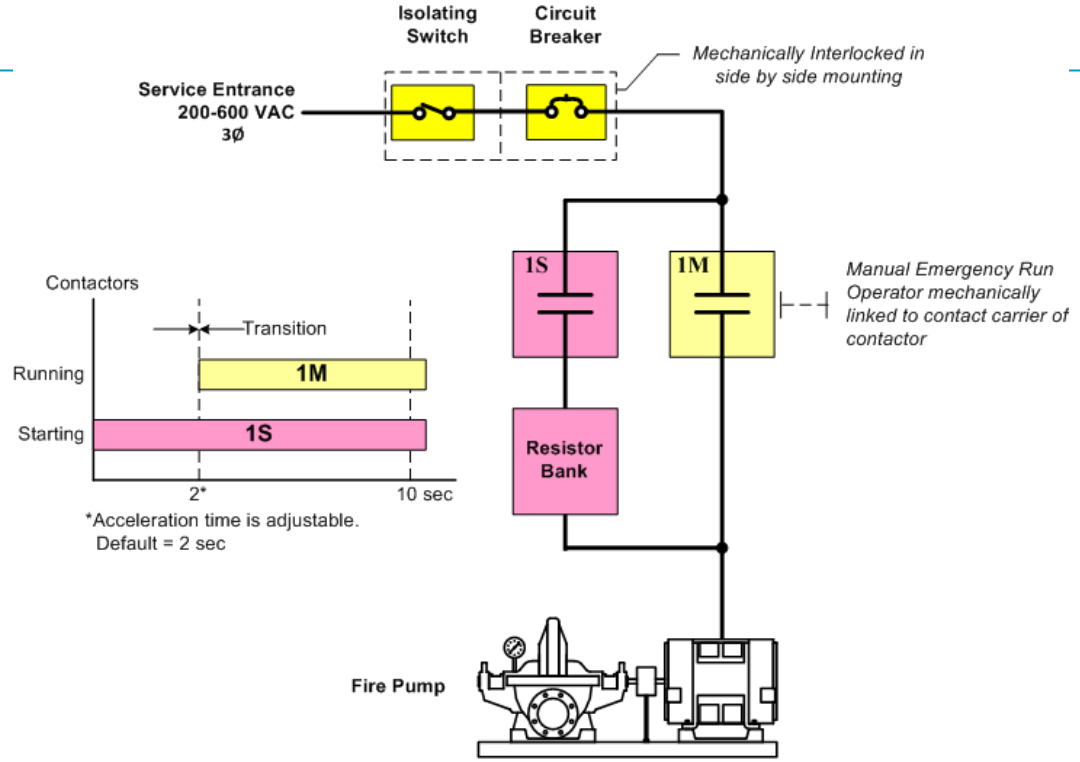

Firetrol

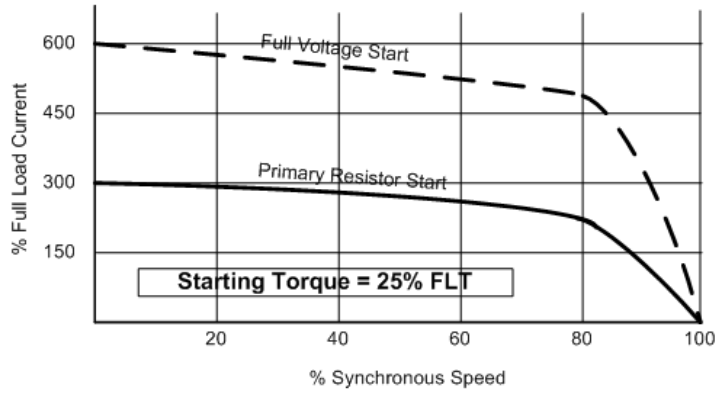
# Wye-Delta Closed

- **ADVANTAGES**
  - Low Starting Current - 200%
  - Closed Transition Eliminates Line Disturbances
  - Preferred starting method when coupled with power transfer switch
- **DISADVANTAGES**
  - Low Starting Torque
  - Requires 6 or 12 Lead Motors
  - Special at 200-208 Volts

Firetrol

# Power Train
# FTA1500 Primary Resistor Start




Firetrol

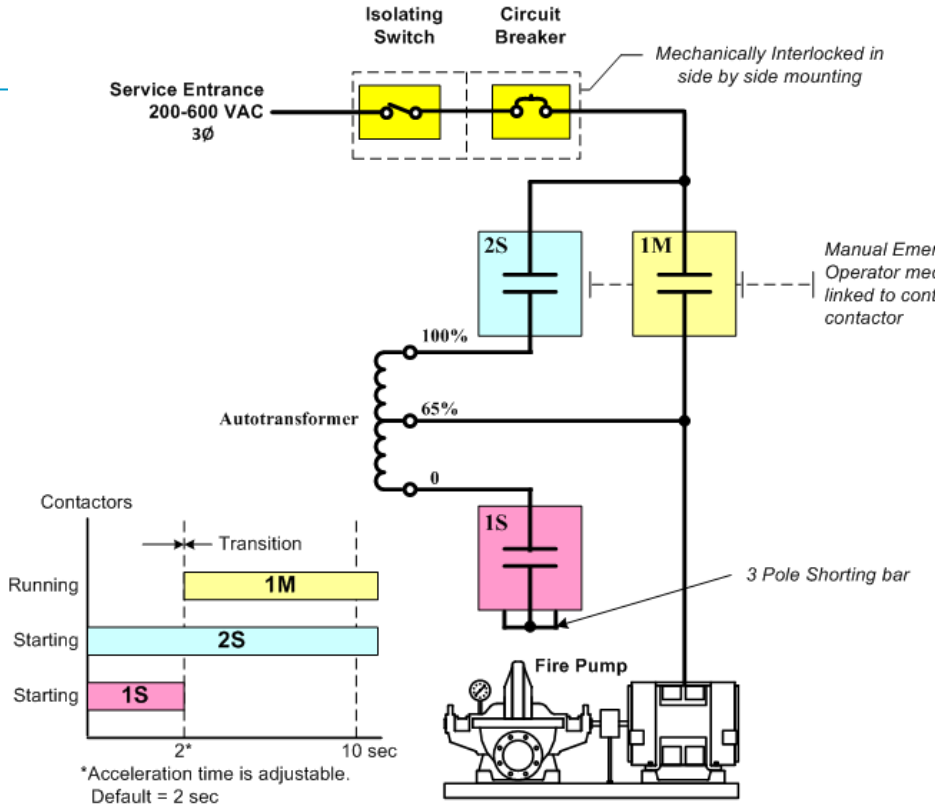
# Primary Resistance

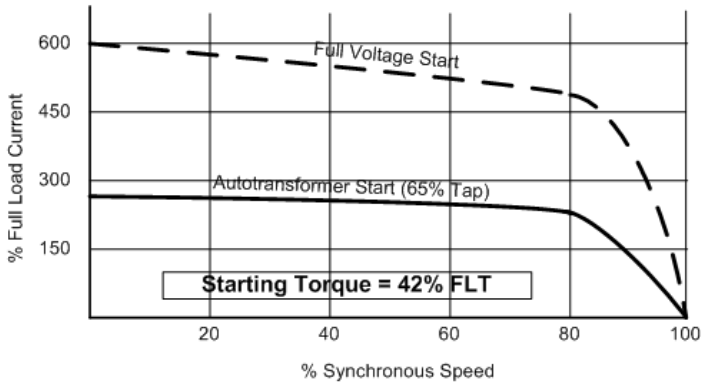
- **ADVANTAGES**
  - First Reduced Voltage Method Available
  - Uses Standard Motors
- **DISADVANTAGES**
  - Higher Starting Current - 300%
  - Lower Starting Torque - 25%
  - Risk of Resistor Overheating

**No Longer Made- Replace with Soft Start Controller**

Firetrol

# Power Train
# FTA1800 Autotransformer Start



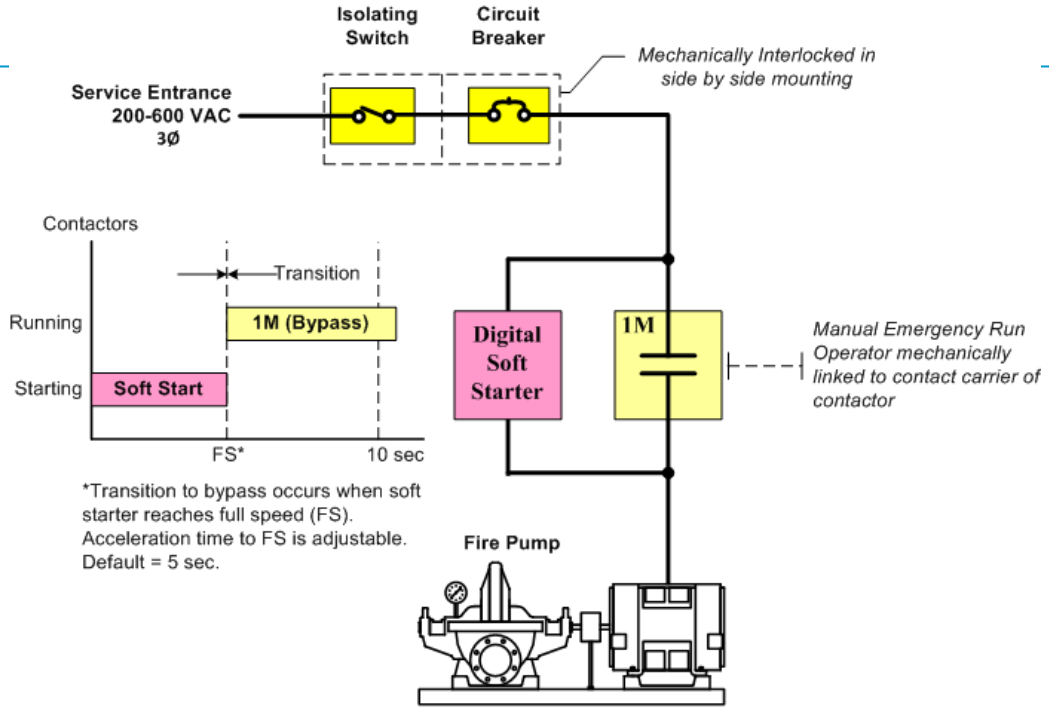

Firetrol

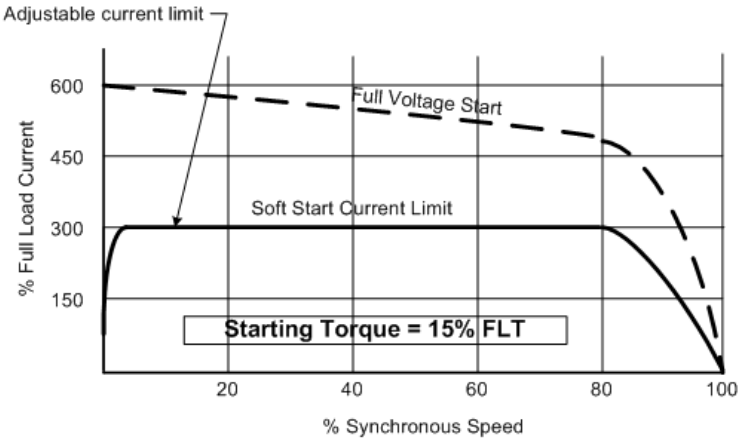
# Auto-Transformer

- **ADVANTAGES**
  - **Low Starting Current - 225%**
  - **Highest Starting Torque - 42%**
  - **Uses Standard Motors**
- **DISADVANTAGES**
  - **Cost**

Firetrol

# Power Train
# FTA1930 Digital Soft Start



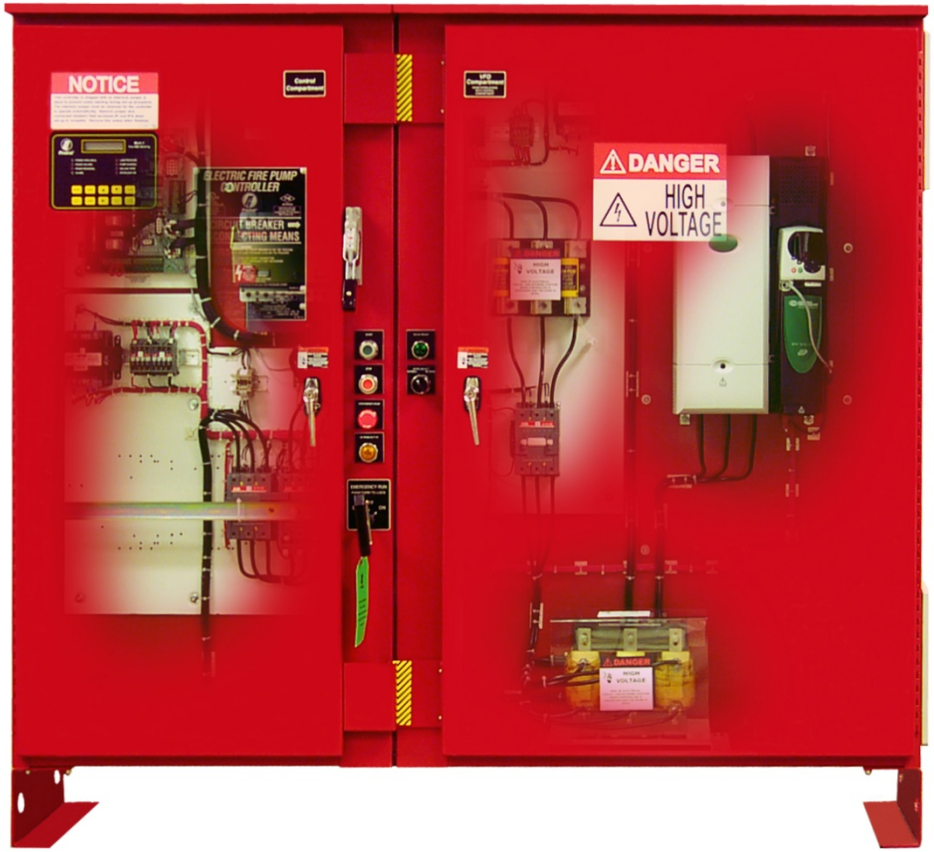

Firetrol

# Solid State Soft Starting

- **ADVANTAGES**
  - MECHANICAL BENEFIT OF LESS WATER HAMMER
  - RELATIVELY LOW STARTING CURRENT - APPROX…300%
  - USES STANDARD MOTORS
  - BEST OVERALL
  - Preferred when used with power transfer switch
- **DISADVANTAGES**
  - Cost

Firetrol

# FTA 3100 Variable Frequency Drive FPC

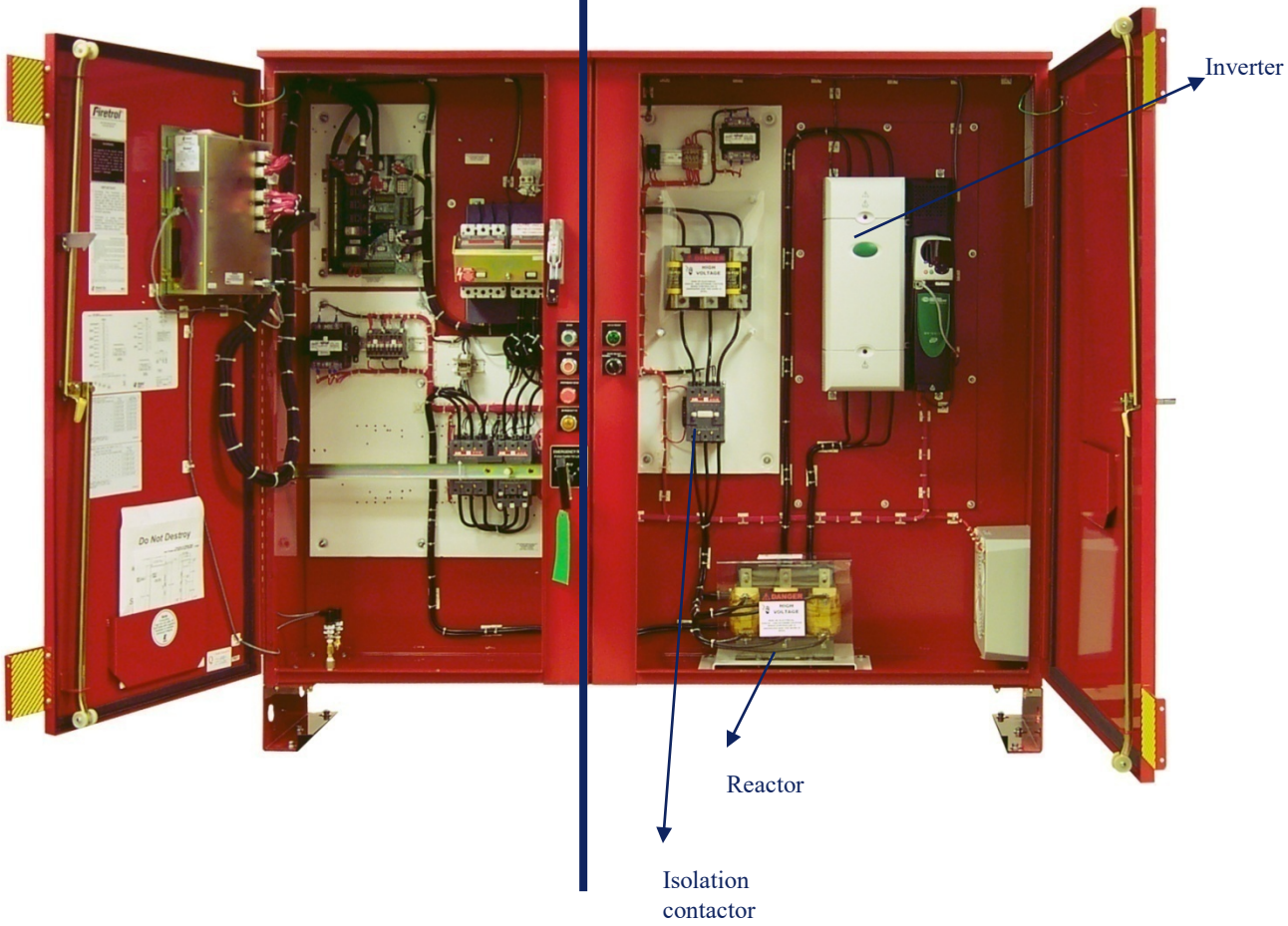



Firetrol

# 40 HP, 480 volt unit without ATS

FPC cabinet

VFD cabinet




Firetrol

# *Issues Solved by VFD based FPC…*

NFPA Code designation “Variable Speed Pressure Limiting Controller”

- Varying suction pressure
- Campus style pump setup
- Insufficient or older infrastructure being retrofitted with new pump system
- Pressure output must be limited

Firetrol

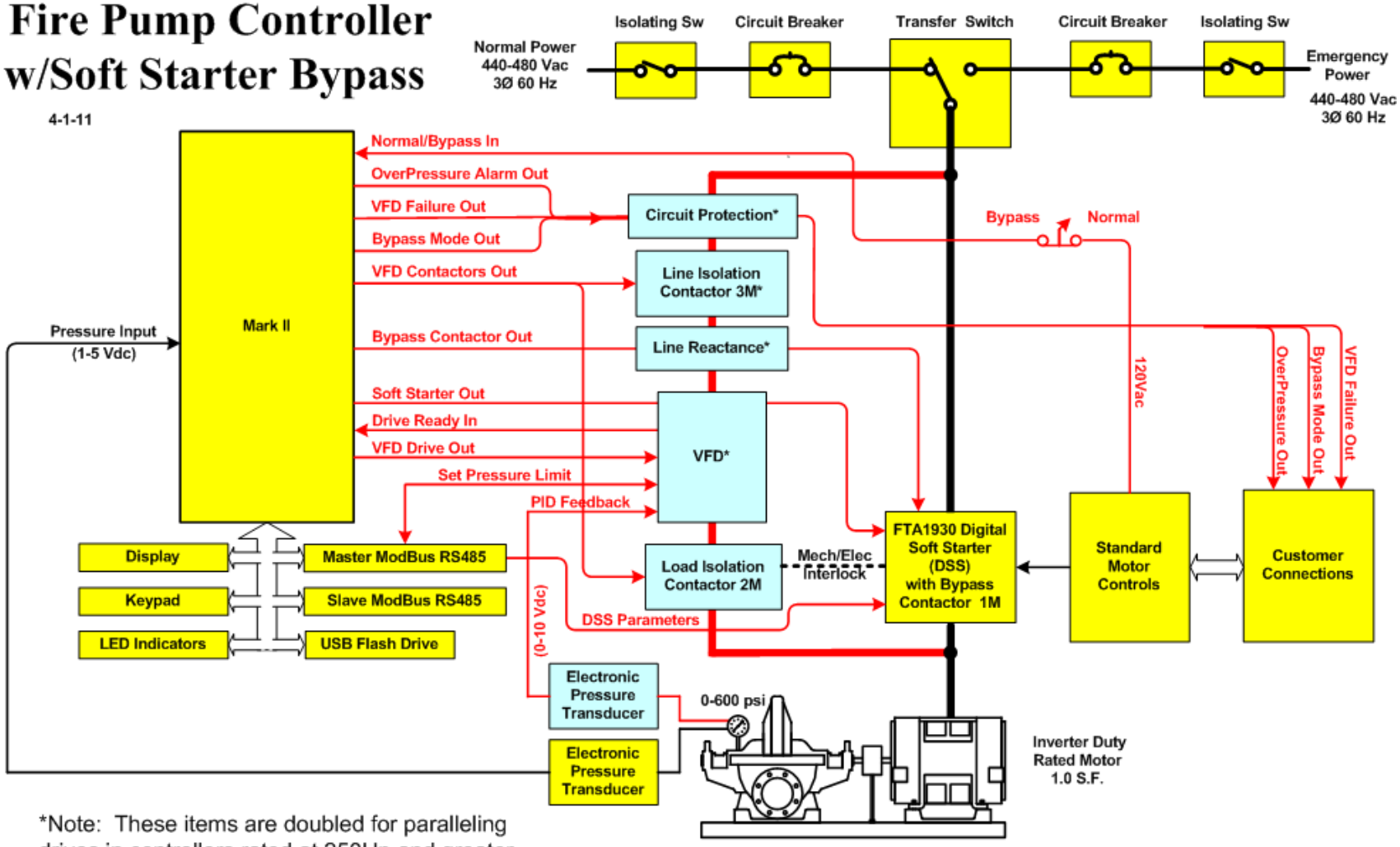
# *Mark IIXG Variable Speed Pressure Limiting Controller*

- The set point is the desired pressure limit for the system
  - expressed in psi (or bar)
  - Entered into the Mark IIXG as SET PRESSURE
- The output of the PID is connected to the speed input of the drive which controls the speed of the AC induction motor driving the pump to maintain the system pressure at the set point

Firetrol

# Mark II VFD Electric Fire Pump Controller w/Soft Starter Bypass

4-1-11

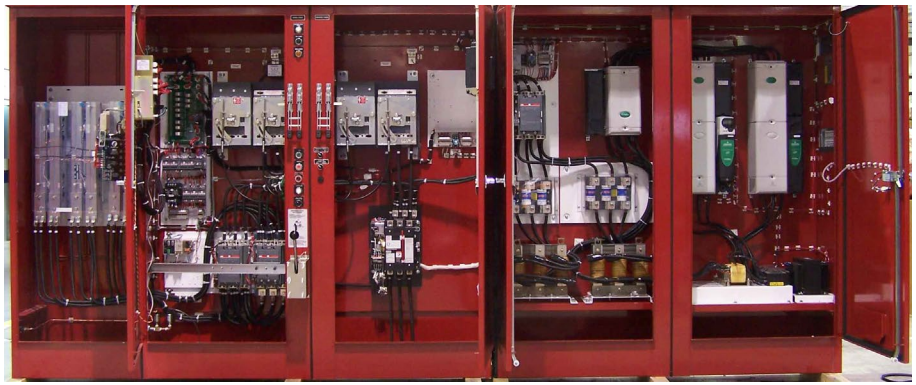


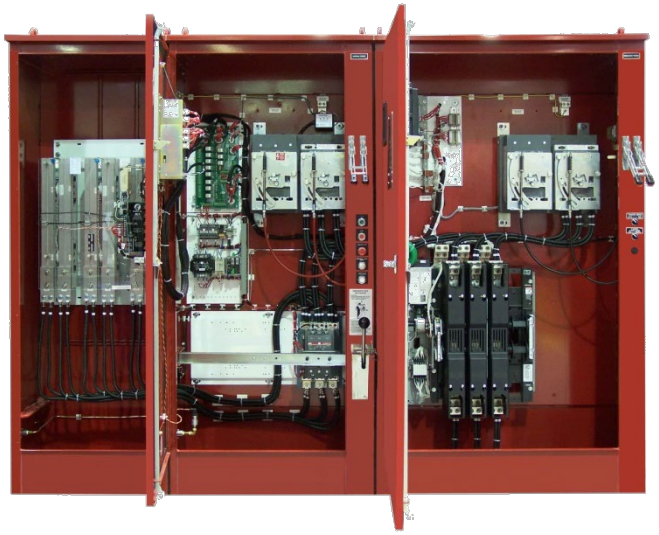

*Note: These items are doubled for paralleling drives in controllers rated at 250Hp and greater.

FTA3130

Firetrol

# Large VFD Soft Starter with ATS

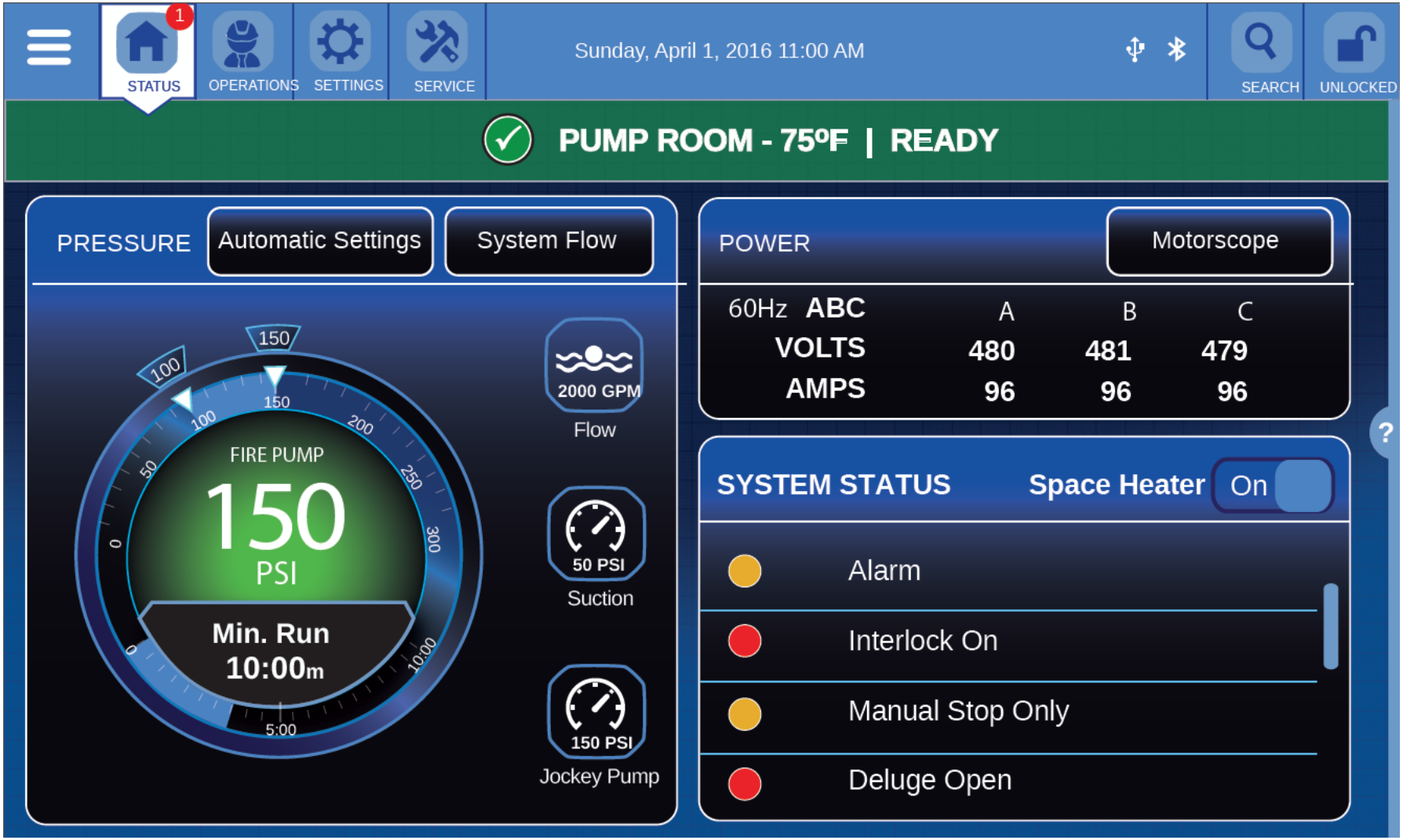




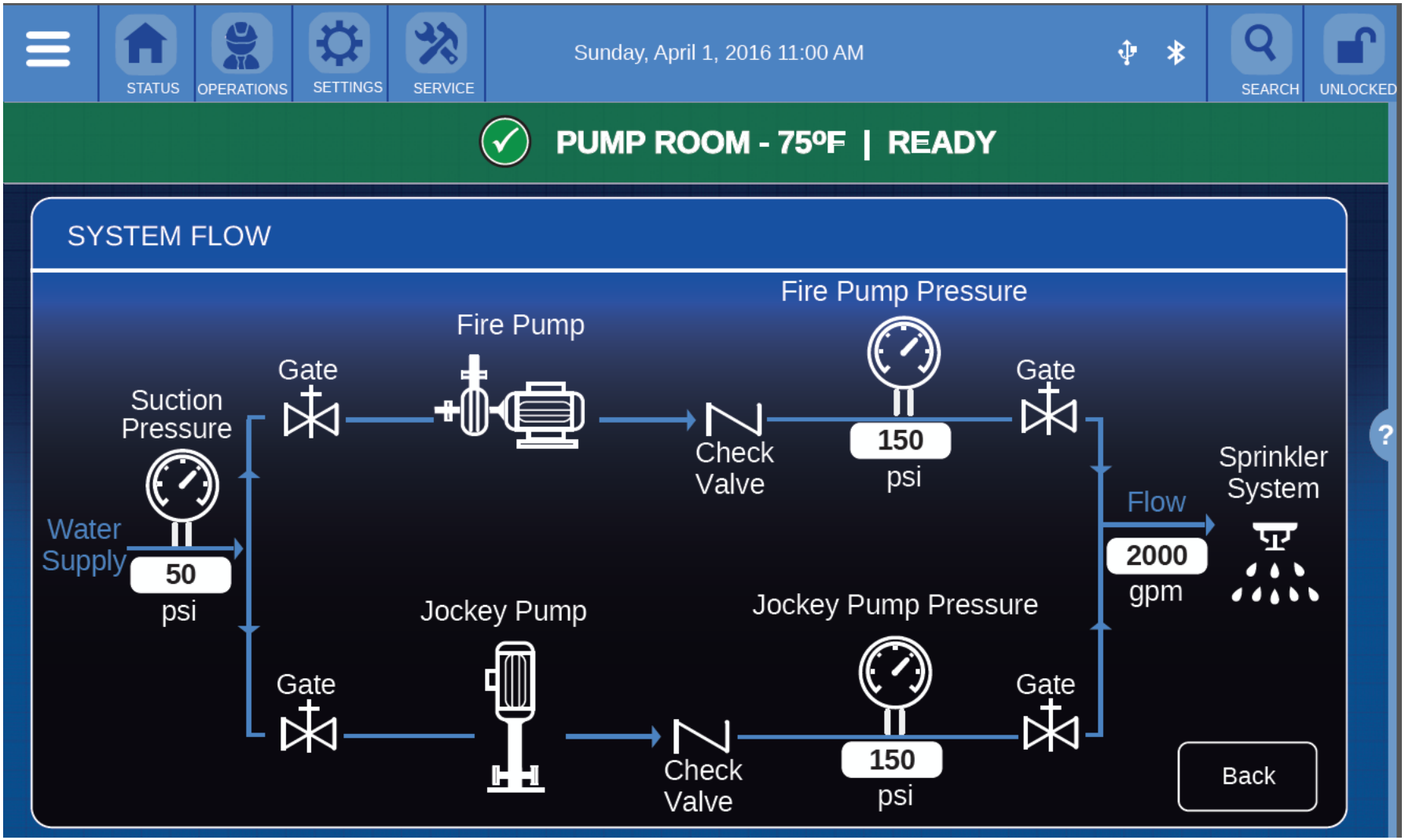
Firetrol

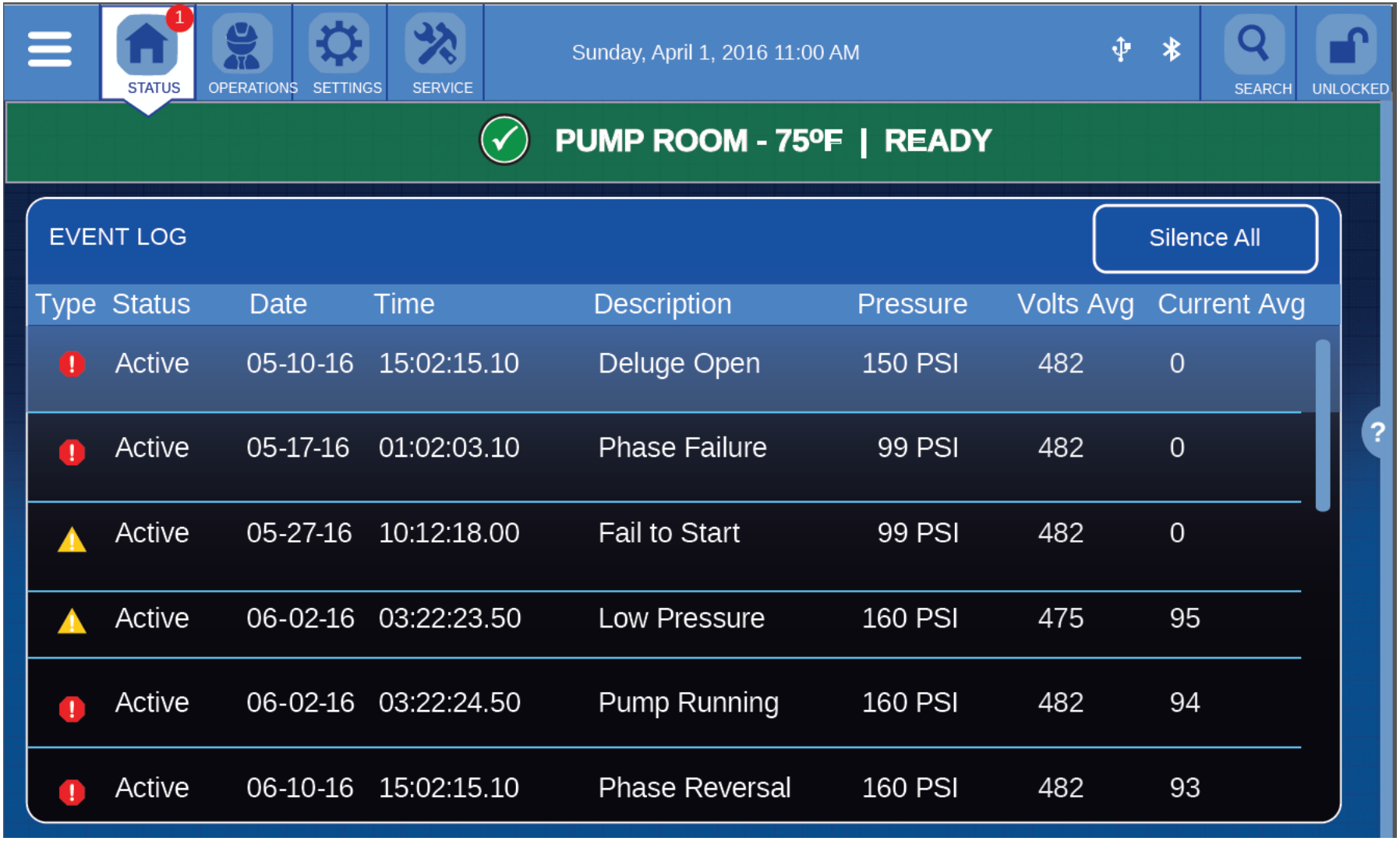
# Fire Pump Controller Features

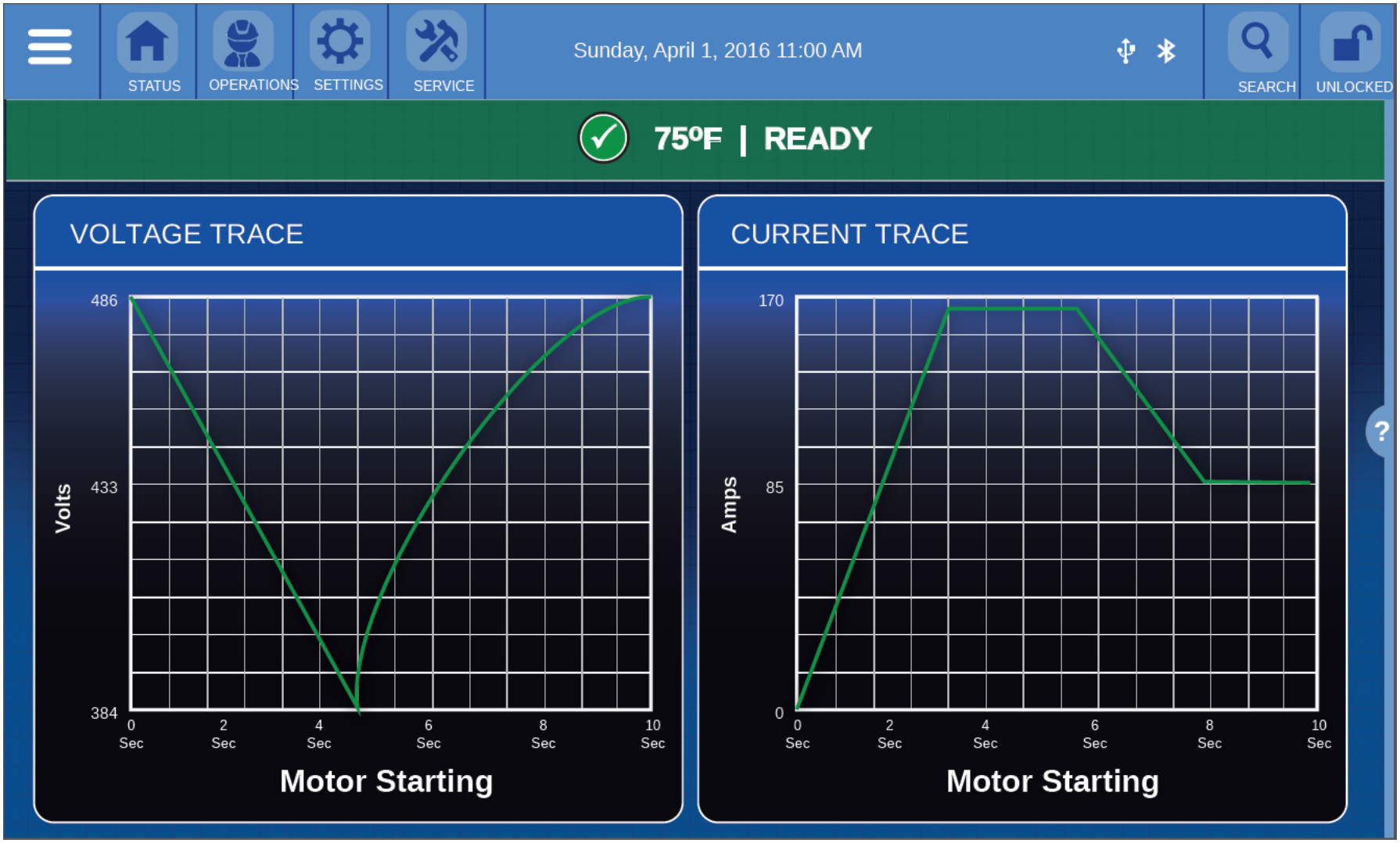
- 9” Full Color Touchscreen with Enhanced Graphics
- Simple, Intuitive Navigation
- Pump Room Animations
- 50,000 Event Memory
- 16 Input / 12 Relay Output Alarm Board
- Pull Apart, Pluggable Terminal Blocks
- Motorscope for Amps and Volts
- Jockey Talk
- Room Temperature Display & Alarms
- Suction Pressure Display & Alarms
- Additional Analog Inputs
- Modbus RS-485 or Optional TCP/IP
- Wifi- Flow Test Data, Event Access
- Phone App for Easy Controller Data Access
- Significantly Smaller Enclosure Size


STATUS
OPERATIONS
SETTINGS
SERVICE
Sunday, April 1, 2016 11:00 AM
SEARCH
UNLOCKED
PUMP ROOM - 75ºF | READY
PRESSURE
Automatic Settings
System Flow
FIRE PUMP
150
PSI
Min. Run
10:00m
2000 GPM
Flow
50 PSI
Suction
150 PSI
Jockey Pump
POWER
Motorscope
60Hz ABC A B C
VOLTS 480 481 479
AMPS 96 96 96
SYSTEM STATUS
Space Heater On
Alarm
Interlock On
Manual Stop Only
Deluge Open

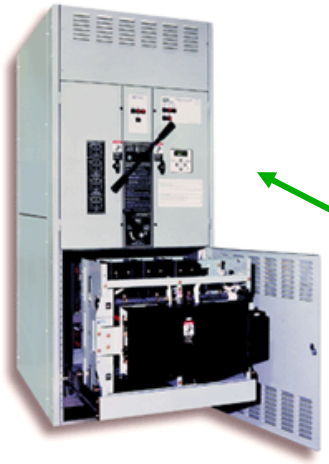

1
STATUS
OPERATIONS
SETTINGS
SERVICE
Sunday, April 1, 2016 11:00 AM
SEARCH
UNLOCKED
75ºF | READY
Alarm Limits
Motor & Power
Power Train
Calibrate
Model: FTA1300
HP: 75
Volts: 480
Hz: 60
Controller Type: Wye-Delta Open
Phase Sequence
ABC
Full Load Current (A)
85
Current Transfer Ratio
1200:5
Motor Overload Limit
105
Voltage Alarm
Enabled
Voltage Min Limit
250
Voltage Max Limit
350
Frequency Alarm
Enabled
Cancel
Save
?

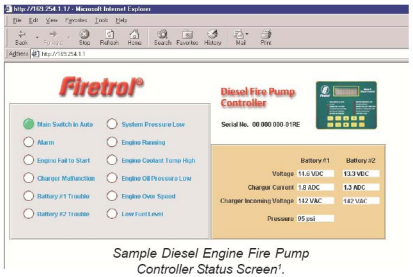

STATUS
OPERATIONS
SETTINGS
SERVICE
Sunday, April 1, 2016 11:00 AM
SEARCH
UNLOCKED
PUMP ROOM - 75ºF | READY
SYSTEM FLOW
Fire Pump Pressure
Fire Pump
Gate
Suction Pressure
Gate
Check Valve
150
psi
Gate
Sprinkler System
Flow
Water Supply
50
psi
2000
gpm
Jockey Pump
Jockey Pump Pressure
Gate
Gate
Check Valve
150
psi
Back


STATUS
OPERATIONS
SETTINGS
SERVICE
Sunday, April 1, 2016 11:00 AM
SEARCH
UNLOCKED
PUMP ROOM - 75ºF | READY
EVENT LOG
Silence All
Type Status Date Time Description Pressure Volts Avg Current Avg
Active 05-10-16 15:02:15.10 Deluge Open 150 PSI 482 0
Active 05-17-16 01:02:03.10 Phase Failure 99 PSI 482 0
Active 05-27-16 10:12:18.00 Fail to Start 99 PSI 482 0
Active 06-02-16 03:22:23.50 Low Pressure 160 PSI 475 95
Active 06-02-16 03:22:24.50 Pump Running 160 PSI 482 94
Active 06-10-16 15:02:15.10 Phase Reversal 160 PSI 482 93


STATUS
OPERATIONS
SETTINGS
SERVICE
Sunday, April 1, 2016 11:00 AM
SEARCH
UNLOCKED
75°F | READY
VOLTAGE TRACE
486
433
384
Volts
0 Sec
2 Sec
4 Sec
6 Sec
8 Sec
10 Sec
Motor Starting
CURRENT TRACE
170
85
0
Amps
0 Sec
2 Sec
4 Sec
6 Sec
8 Sec
10 Sec
Motor Starting

# Communications






*Sample Diesel Engine Fire Pump Controller Status Screen[1].*

# Event Log data

| | |
|---|---|
| Manual Save | 5/21/2007 9:07 |
| Charger 2 OK | 5/14/2007 12:04 |
| Battery 2 OK | 5/14/2007 12:04 |
| Charger 1 OK | 5/14/2007 12:04 |
| Off Mode | 5/14/2007 12:04 |
| Charger 2 Failure | 5/14/2007 12:04 |
| Battery 2 Trouble | 5/14/2007 12:04 |
| Charger 1 Failure | 5/14/2007 12:04 |
| Auto Mode | 5/14/2007 12:04 |
| Charger 2 OK | 5/14/2007 12:04 |
| Battery 2 OK | 5/14/2007 12:04 |
| Charger 1 OK | 5/14/2007 12:04 |
| Cranking Stopped | 5/14/2007 12:04 |
| Remote Start Off | 5/14/2007 12:04 |
| Off Mode | 5/14/2007 12:04 |
| Cranking on Batt#1 | 5/14/2007 12:04 |
| Call to Start | 5/14/2007 12:04 |
| Remote Start On | 5/14/2007 12:04 |
| Pressure: 66psi | 5/14/2007 12:02 |

| | |
|---|---|
| Logged Data | 5/21/2007 9:12 |
| Calls \| Starts | 77 \| 77 |
| Total Engine Run | 36:50:03 |
| Last Engine Run Time | 0:03 |
| Last Engine Start | 4/5/2007 13:23 |
| Last High Temp Alarm | 4/5/2007 13:23 |
| Last Lo Oil Pressure | 3/12/2007 14:14 |
| Last Low Fuel Alarm | 3/12/2007 14:20 |
| Last Charger Failure | 5/14/2007 12:04 |
| Last Battery Trouble | 5/14/2007 12:04 |
| Last Eng. Overspeed | 4/5/2007 13:23 |
| Minimum Voltages | 0.0 0.0 |
| Maximum Voltages | 30.8 31.0 |
| Total Unit Run Time | 9227:34 |
| Min/Max Pressure | 1 \| 198 |

# Diesel Controllers

# Components

- AC and DC circuit breakers
- Master USB Port
- Mark II
- Plug and Play Board
- Dual Battery Chargers
- Pressure transducer
  - No Mercury

# Pressure Limiting Diesels

- PLD Engines
  - Reduces pump speed to limit pump discharge and prevent over-pressure
  - Mechanical means to limit pressure
  - Diesel controller equivalent to electrical VFD

# Jockey Pump Controllers

**UL Industrial Grade Only**

**There is NO UL or FM Fire Protection Listing for a Jockey Pump or Controller**

**Listed under UL508A standard for industrial control devices**

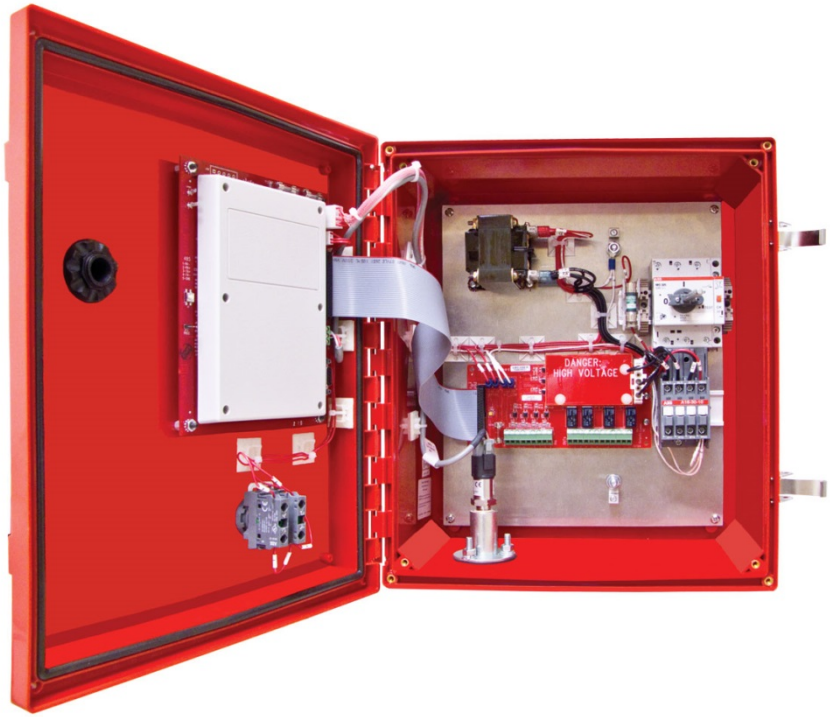
# Jockey Controller

## FTA550 JockeyXG


- Mark IIXG based jockey panel
- Digital display
- Front mounted HOA Switch
- LED indicators for
  - Power On
  - Pump Running
  - Alarm
- NEMA 2/12 Polycarbonate enclosure (non-metallic)

# Jockey XG Features

- 0-300 psi pressure transducer
- Control Circuit Transformer (24VAC control circuit)
- Overload Protection
- Service Entrance Rated



# Jockey XG features cont....

- Minimum Run timer
- On-Delay timer
- Pump restart timer
- Indication for:
  - Overpressure
  - Low Pressure
  - Failed to Start
  - Switch “Not in Auto”

- Pressure recording
- Data Log
- Event Log (3000 events)
- 2 user selectable status messages*
  - Start/Stop Pressures
  - Cycles/Period
  - Cycles Per Hour
  - Total Cycle Count
  - Pump Total Run Time

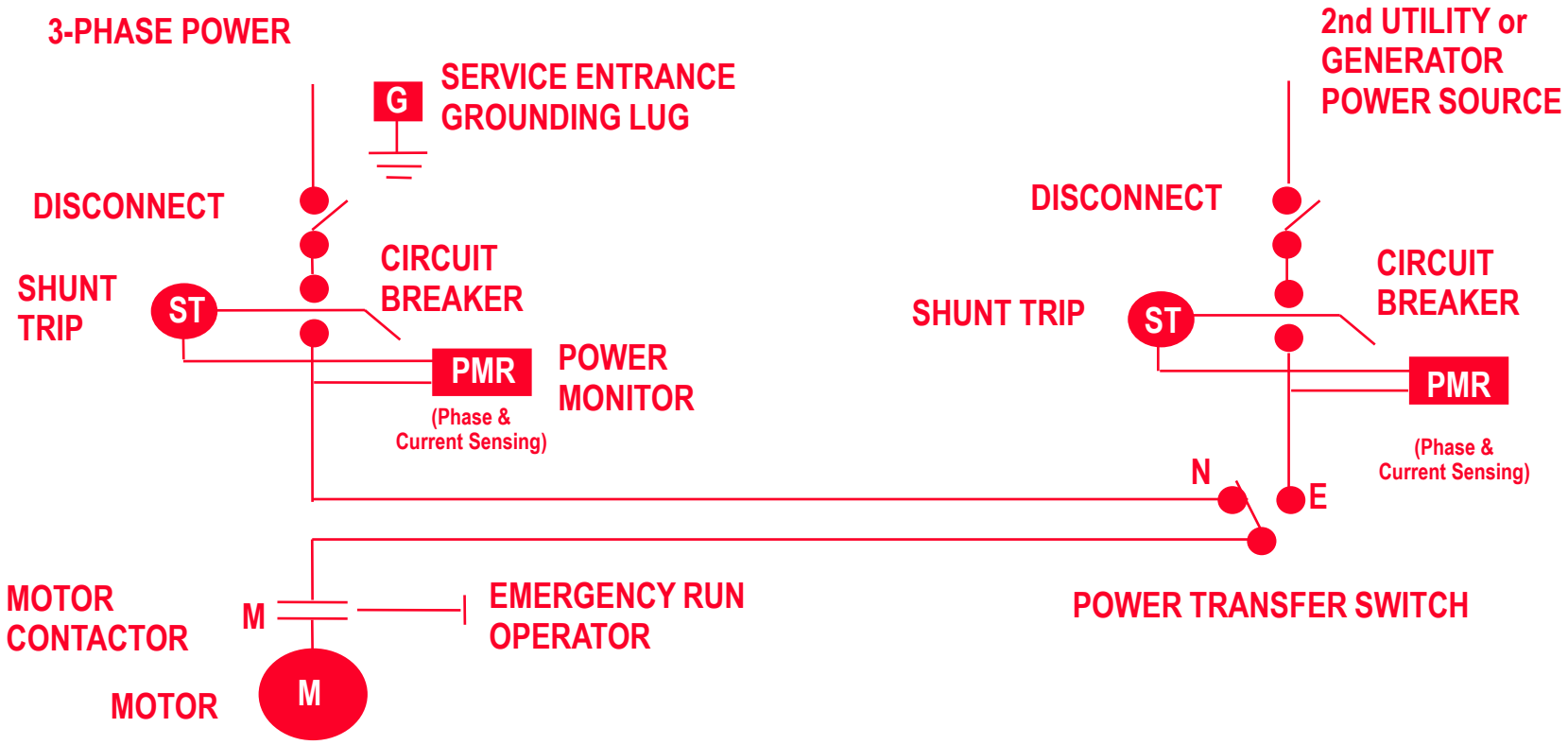
# What about Emergency Power?

# Transfer Switches

Fire Pump Controller


Automatic Transfer Switch

# Connection of Emergency Power-Traditional Transfer Switch



# Frequently Encountered Problems Involving Electric Controllers in the Pump Room

# Protective Service Devices

**If a Circuit Breaker is Installed in the Power Feed It Must Comply with NEC 695.4(B)(3)&(b-e) and Meet the Following:**

- **Electrical feeder circuit protective devices (circuit breakers or fused disconnects) are required to be sized at 6 times full load amps (locked rotor amps) plus the full load amps of all connected devices.**
- **These devices are required to be monitored.**
- **Must not be field adjustable. NFPA 20 9.2.3.4.1, NEC 695.4(2)d**
- **Labeled "Fire Pump Disconnect Switch," rated as suitable for Service Entrance, locked in ON position. NFPA 20 9.2.3.1, NEC 695.4(1-3)**
- **Not be located in the same enclosure, panelboard, switchboard, switchgear, or MCC that supplies loads other than the fire pump. ***

**The notion of keeping the fire pump disconnecting means "sufficiently remote" from other disconnecting means is to prevent interruption of fire pump supply through inadvertent operation of the disconnecting means. It is not practical to specify a distance as a rule; the AHJ must make this determination.*

# Field Wiring & Conduit

**Wire is too large to fit into the controller's LINE terminals. NEC 695, Table 430-50**

- **Caused by the electrical designer or installing personnel selecting wire size based on 6 times full load motor current (locked rotor) rating of service protective devices.**
- **Aluminum wire is used by electrician to save money. Aluminum wire is significantly larger than copper and many times will not fit into terminals. Copper is preferred and is on controller label.**
- **Lug (terminal) size based on 125% of full load amps (FLA) for 75 degree copper wire per NEC 695, Table 430-50.**
- **Conduit CAN come in the top of most electric controllers, although recommendation is for bottom or side. Waterproof hub is required by code to meet controller enclosure rating. NEC 695.6(J)1,2), NFPA 20 9.9.1, 2**

# Oversized wire continued

- Some installations with long distance between service transformer and controller will require wire larger than 125% to accommodate line loss, but lug wire size acceptability range usually will cover this.
  - Code does allow for a junction box electrically upstream of the controller where wire size reduction can be accomplished. NEC 695.7(I)
  - Reductions inside the controller constitute a junction.

# Motor connections

- 12 lead motors can be used for ‘across the line’ and ‘wye-delta’ starting configurations.
  - Across the line configurations include:
    - Across the line
    - Auto-transformer
    - Solid state soft starter
    - Primary resistance
- Motor should be wired for “Delta Run, Not Wye Start.”
- Motor winding connections incorrectly field connected for the service voltage.
- Motor winding connections incorrectly field connected for reduced voltage starting
- Wire Nuts are not allowed. NEC 695.6 (D)

# Remote alarm contacts not monitored

- Electric controllers- Required
  - Pump run NFPA2010.4.7.1
  - Power failure NFPA 10.4.7.2.2.1
  - Phase reversal NFPA 10.4.7.2.3
- Transfer switches- Optional
  - Transfer switch in emergency position
  - Transfer switch isolation switch open

# Sensing Lines

- Fire pump and jockey pump controller share the same sensing line.
  - Each controller is to have a dedicated sensing line connected between the discharge check valve and discharge control valve of the pump it controls. NFPA 20 4.30.1
- Jockey pump sensing line too close to the jockey pump discharge, causing rapid cycling of the jockey pump.
- This is resolved with the new FTA550 jockey pump controller with restart timer.

# Sensing line continued

- Undersized piping
  - Pipe size is to be 1/2 inch
- Incorrect pipe material
  - Black pipe, galvanized pipe, soft copper and plastic pipe are not acceptable.
- Correct pipe material
  - Solid copper, brass or stainless steel.

# Transfer Switches

- Generator start wires (70, 71) not connected to transfer switch. NFPA 10.8.3.12(2)
- Rotation from generator power does not match utility power supply.
- Generator not properly sized for starting method which can cause a voltage drop below the 15% allowance. This can cause contactor problems and retransfer under test conditions. NEC 695.7(A)

# Field Modified Controllers

- Modifications made by job site personnel may not meet the requirements of UL and/or FM.
  - Unauthorized modifications may void warranty.
  - Only factory authorized personnel should make modifications to the controllers.
- Fire pump controllers cannot be used as a junction box for other devices such as alarm modules, extra relays, and the jockey pump controller power feed.

# Frequently Encountered Diesel Problems in the Pump Room

# Diesel Engine Controllers

- Batteries filled and connected to controller well in advance of startup when charger has not been energized.
  - Results in dead batteries and start up delay.
- Insufficient number of engine run contacts to operate combustion air louvers and remote alarms.
- Wiring from controller to engine not correctly sized, marked or terminated.
  - Charging circuit needs to be 10 AWG. (Wires 6,7,8 and 11)

# Controllers Used As Junction Boxes

- Auxiliary loads such as jockey pump, lighting and heating circuits cannot be connected anywhere inside of the controller's enclosure.
- Miscellaneous alarm and other circuits cannot be connected to, be terminated in, or pass through the fire pump controller. To do so would constitute the controller being used as a junction box which is not allowed by NFPA 20. Only alarm functions furnished as a part of the controller are acceptable.
- Electricians sometimes install relays for louvers. This is an example of a field installed device that would violate the code.

NFPA 20 10.3.4.5.1 NEC 695.7(I)

# Field Wiring

- Field electrical connections at the controller AC and battery breaker terminals are found mechanically loose or inadequately torqued, posing a potential safety hazard.
- Charging circuit wires 6,8, and 11 are too small. Must be #10 because of the charging current they carry up to 10 amps. NFPA 20 12.3.5.1.1
- All wire between controller and engine shall be stranded.
- Controller not properly grounded
- Conduit connections CANNOT be routed through the top of a diesel controller. Drawing indicates entry points.

# Remote alarm contacts not monitored

- Diesel controllers
  - Pump operating NFPA 12.4.2.2, 3 (1)
  - Main switch mis-set- (Not left in Auto) NFPA 12.4.2.2, 3 (2)
  - Common engine trouble NFPA 12.4.2.2, 3 (3)

# Contact Information

- **Visit our website at www.firetrol.com**

**Contact Us:**

- mike@aic-controls.com
- www.aic-controls.com
- **770-614-7022 (O)  770-367-5196 (M)**

Thank you for your interest in our products!